Development of the Domino Pericyclic Oxy-Cope/Ene /Claisen /Diels-Alder Reaction and the Synthesis of Complex Bicyclo[3.3.1]alkenones

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To my parents...

Abstract

This thesis is a dissertation to support the development of new domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder reaction, diversity oriented synthesis of PPAPs scaffold via sequential one pot cascade reaction and ethyl aluminum sesquichloride catalyzed highly hindered Diels-Alder reaction.

The first part concentrates on the domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder reaction. As a result of this study, we have developed a general methodology for rapidly constructing complex diterpenes and discovered a thermal oxy-Cope/ene/Claisen/Claisen rearrangement, applied to the synthesis of *trans* decalin benzofurans.

The second part involved the development of an efficient synthetic approach towards bicyclo[3.3.1]nonenone core found in many natural products, via a sequential Diels-Alder/gold(I)-catalyzed 6-endo-dig cyclization and its application to the synthesis of a diversified library of PPAPs.

Finally, we have developed an efficient synthetic methodology for the formation of cyclohexene rings bearing quaternary carbon centers via an ethyl aluminum sesquichloride mediated highly hindered Diels-Alder reaction. This method solved an important problem encountered in the synthesis of many natural products including PPAPs. This methodology opened new opportunities in the total synthesis of PPAPs.

Acknowledgements

First of all, I would like to specially thank my supervisor, Professor Louis Barriault. After my six months visit as an exchange student in his research laboratory from France, he gave me the opportunity to come back and do my Ph.D. with him. Thank you for providing me the freedom to do what I love every day. I am really grateful for your patience, understanding and guidance overs the last years.

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Thanks to the amazing people from the Barriault lab for the great chemistry and philosophical discussions, especially Francis Barabé and Jason Poulin. Thanks to Philippe McGee for your happiness every morning and for sharing good music. Thanks to Kassandra Lepack for making me smile even when I was unhappy. Thanks to Joel Marcotte for the fantastic high-tech discussions. Thanks to 92IZI.

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Introduction

The pharmaceutical industry has the power to bring an innovative thinking from research to improve patient's health by discovering and developing new therapies. The challenge of transforming new knowledge into healthcare solutions for patients elicits our greatest strength as researchers and keeps us committed.

The main goal of pharmaceutical research is to discover and design new compounds that are suitable for use as drugs. Natural products, obtained from animal, vegetable and mineral sources have been used since ancient times as drugs with variable potency and toxicity. From the beginning, drug development has been articulated around natural products, but as knowledge increased, a broader range of lead compounds were used as starting point for drug development. The latter starts with the discovery of new lead compounds with identified medical properties, and then follows the development of more effective and safer analogues. This process implicates synthesizing and testing a vast library of compounds until a suitable compound is chosen. It is currently estimated that for every 10000 compounds synthesized for drug discovery, one is suitable for medical use.

To my knowledge, the first rational synthetic drugs development was carried out by Paul Ehrlich and Sacachiro Hata, who produced the antiprotozoal arsphemamine in 1910 by connecting organic synthesis with biological screening and evaluation procedures[1]. They realized that the more potent drugs showed a greater selectivity for the target microorganism than its host.

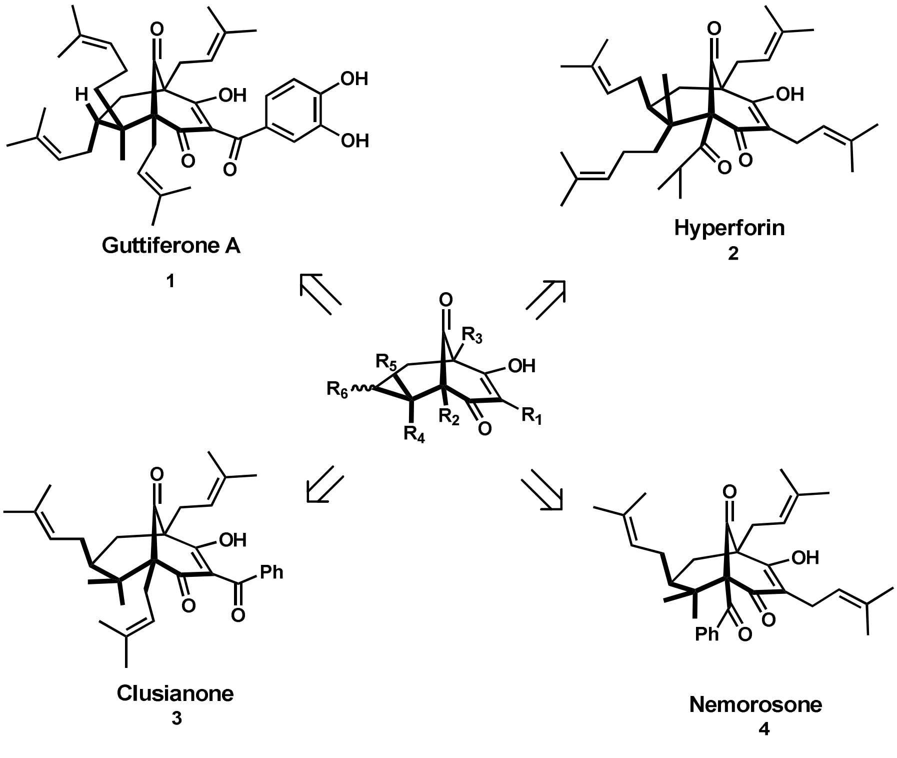
Structure-activity-relationship (SAR) is now used to describe Ehrlich's approach to drug discovery, which consisted of synthesizing and evaluating a library of structurally related compounds.

In 1905, an alternative approach was initiated by the work of John Langley[2]. The idea was receptive substances in the body could accept either a stimulating compound, which would cause a biological response, or non-stimulating compound, which would prevent a biological response. This is the premise of the understanding of the ligand-receptor system in biological organisms. A binding of a chemical to a receptor triggers biochemical events that result in a biological or pharmacological effect. This chemical acting as a drug is more potent when its structure molecular shape and stereoelectronic distribution, is complementary with the stereoelectronic structure of the receptor responsible for the desired biological action. Thus, the aim is to discover which parts or functional groups of the molecule are important to biological activity and which are not.

We want to therefore create powerful tools to synthesize highly complex chemical structures with a retrosynthetic strategy built to allow the incorporation of various functional groups. Our challenge in organic chemistry is to overcome synthetic efficiency and diversity in the construction of complex molecules. Architecturally complex bioactive natural products have been a source of inspiration for synthetic organic chemists for years.

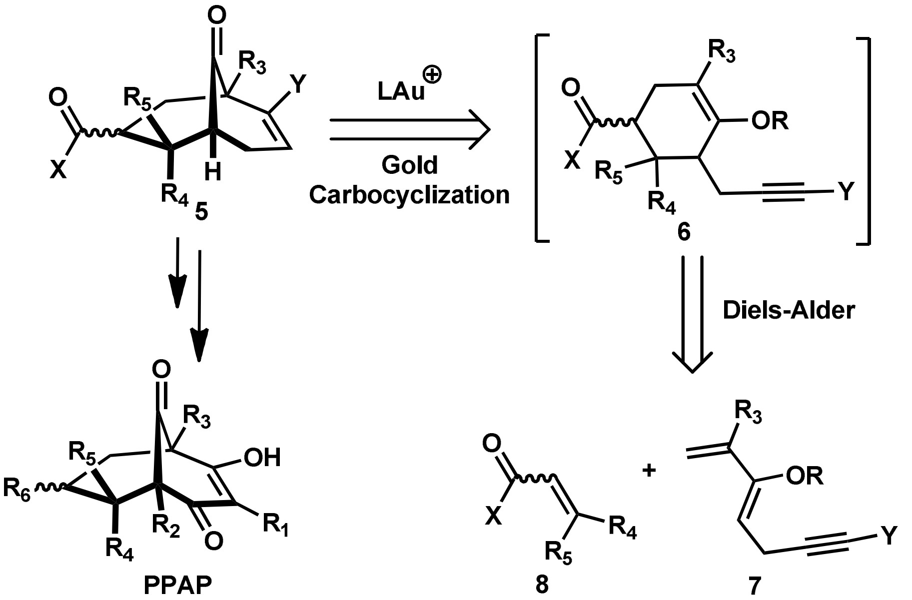
The therapeutic potential of polycyclic polyprenylated acylphloroglucinols (PPAPs) has attracted attention from several research groups[3]. Many PPAPs express different kind of biological activities not limited to antiviral, antimitotic, antioxidant and antidepressant activities. They act as modulators of neurotransmitters associated to nervous depression. Hyperforin is the major active molecule found in St. John's wort and is responsible for its antidepressant activity[4]. The mechanism is an inhibition of synaptosomal uptake of neurotransmitters[5], including serotonin, dopamine, norepinephrine, γ-aminobutyric acid (GABA), and L-glutamate, whith a low IC_{50} = 1.1 μg/mL. A recent report on inhibition of penicillin-resistant and methicillin-resistant *S. aureus* has increased the interest in hyperforin as an antibacterial agent[6]. Hyperforin has been reported to induce apoptosis in human and rat cancer cell lines, with IC_{50} = 3–15 μM,[7] in leukemic cells and brain glioblastoma cells[8].

The PPAPs complex chemical structure with a highly oxygenated and densely substituted bicyclo[3.3.1]nonane-1,3,5-trione core is quite challenging to access by synthetic organic chemistry[9]. The bicyclo[3.3.1]alkenone framework is found in many PPAPs and many bioactive natural products (**Scheme 1**).



Scheme 1 – Shared bicyclo[3.3.1]alkenone framework in PPAPs

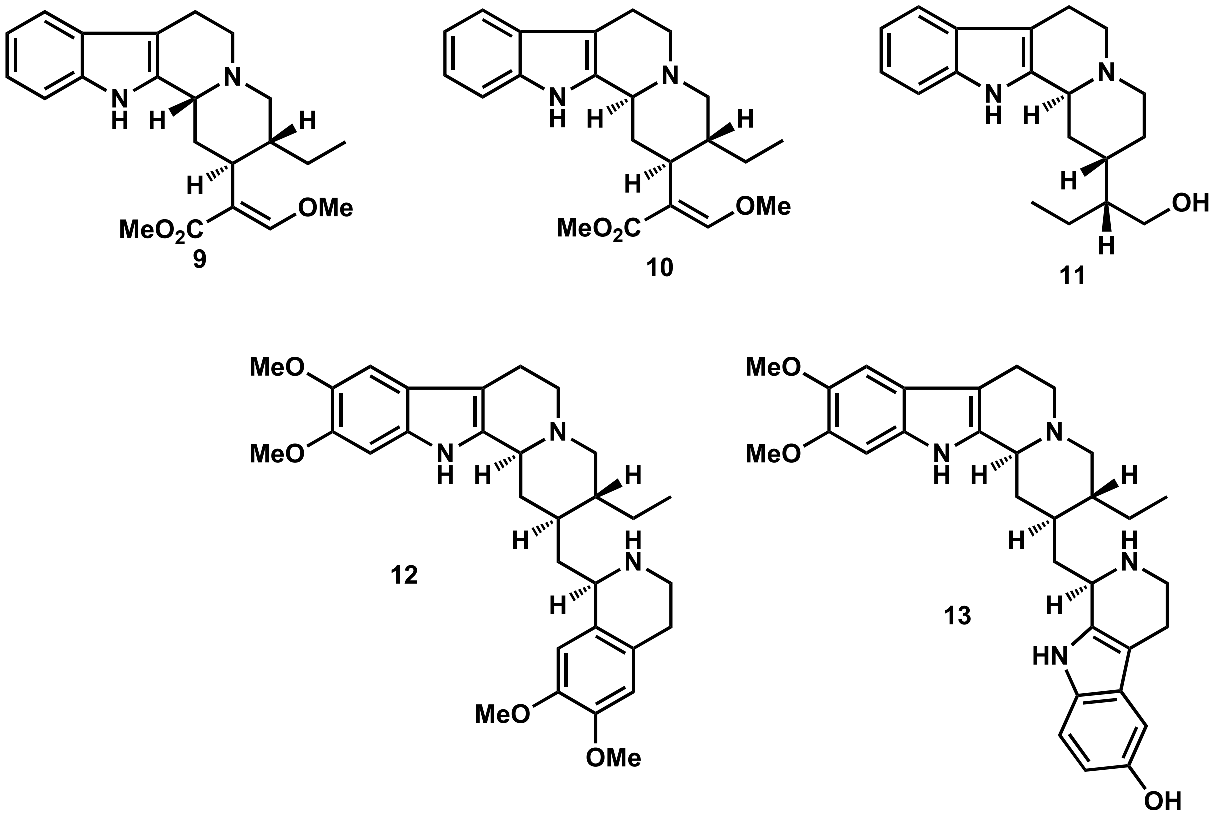
After a retrosynthetic analysis of the bicyclo[3.3.1]nonatrione core, we hypothesized that a domino Diels-Alder/gold carbocyclization synthesis of the core followed by adding the appropriate substitution would be a more diversity oriented synthesis towards PPAPs. It can allow the realization of diversified library for structure-activity-relationship studies in medicinal chemistry (**Scheme 2**).



Scheme 2 – Diversity oriented retrosynthetic analysis of PPAP's scaffold

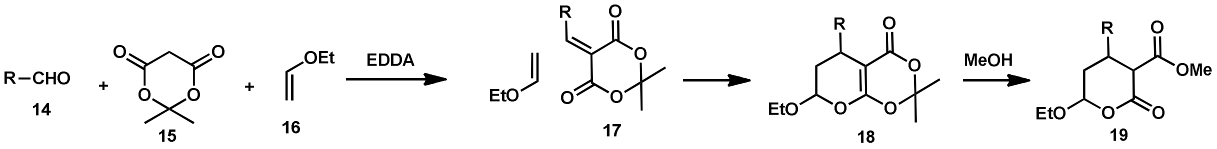
Studies of the biosynthesis of certain natural molecules described efficient processes by which nature can transform simple substrates into complex molecules containing numerous stereocenters, often done in a consecutive domino process[10]. Natural products and drug analogs synthesis is a substantial area of organic synthesis. To attain high efficiency, organic chemists have to develop new green reactions reducing the number of steps and waste, and also develop catalytic reactions. In the area of drug analogs synthesis, the chemist must integrate a diversity oriented synthesis to build a library of compounds. Domino reactions are an effective way to get access to a multitude of diversified molecules in a waste-minimizing process.

Domino Knoevenagel-hetero-Diels-Alder reaction, developed in the group of L. F. Tietze, is a powerful process that not only allows the efficient synthesis of complex compounds such as natural products starting from simple substrates, but also permits the preparation of highly diversified molecules[11]. Several alkaloids such as hirsutine (**9**), dihydrocorynantheine (**10**), dihydroantirhin (**11**), emetine (**12**), and tubulosine (**13**) have been synthesized using this reaction (**Scheme 3**).



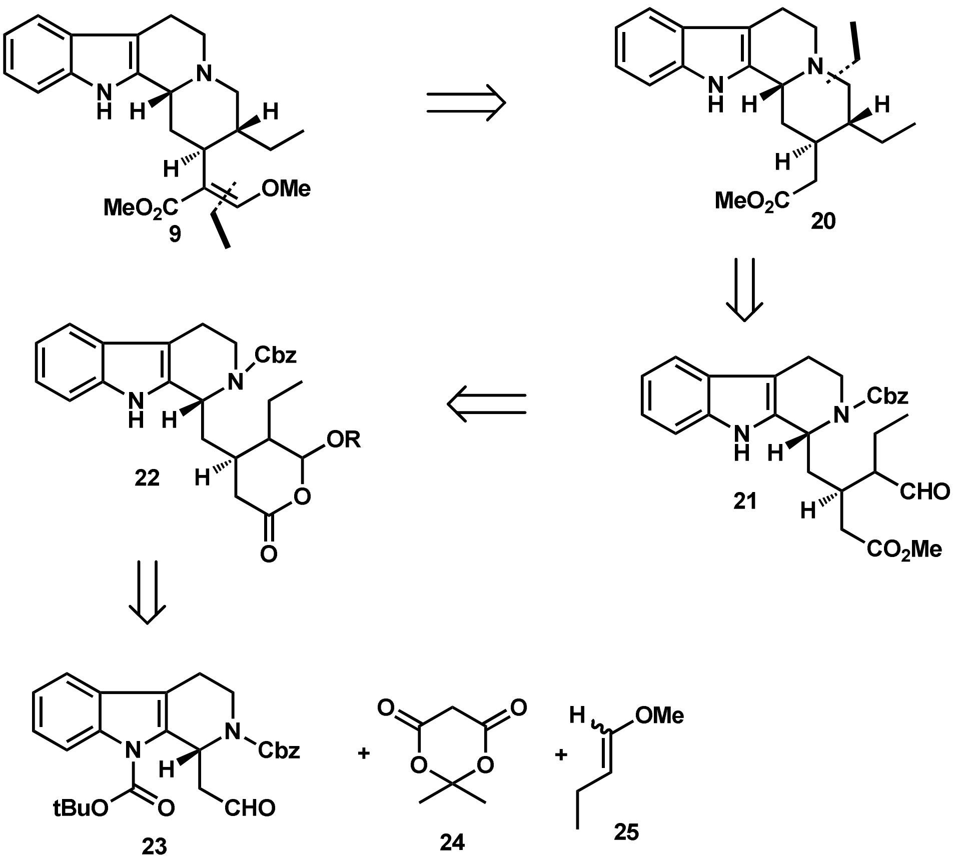
Scheme 3 - Alkaloids synthesized by domino Knoevenagel-hetero-Diels-Alder reaction

The domino Knoevenagel-hetero-Diels-Alder reaction consists of a Knoevenagel[12] condensation of an aldehyde (**14**) with a 1,3-dicarbonyl compound (**15**) in the presence of catalytic amounts of a weak base such as ethylene diammonium diacetate (EDDA). In the reaction, a 1-oxa-1,3-butadiene (**17**) is formed as intermediate which can undergo a hetero-Diels–Alder reaction[13] either with an enol ether (**16**) or an alkene (**Scheme 4**).



Scheme 4 - Domino Knoevenagel-hetero-Diels-Alder reaction

Alkaloid Hirsutine (**9**) was isolated from the plant *Uncaria rhynchophylla* and used for the preparation of the old Chinese folk medicine “Kampo”[14]. It is of pharmacological interest since it shows a strong inhibitory effect on the influenza A virus (subtype H3N2) with an EC_{50} = 0.40–0.57 μg/ml, which is about 11–20 times higher than the clinically used Ribavirin[15]. Retrosynthetic analysis of hirsutine (**9**) led to the (3*R*)-tetrahydro-β-carbolineacetaldehyde (**23**), Meldrum’s acid (**24**), and the enol ether (**25**) via the retrosynthetic intermediates (**20-23**) (**Scheme 5**).

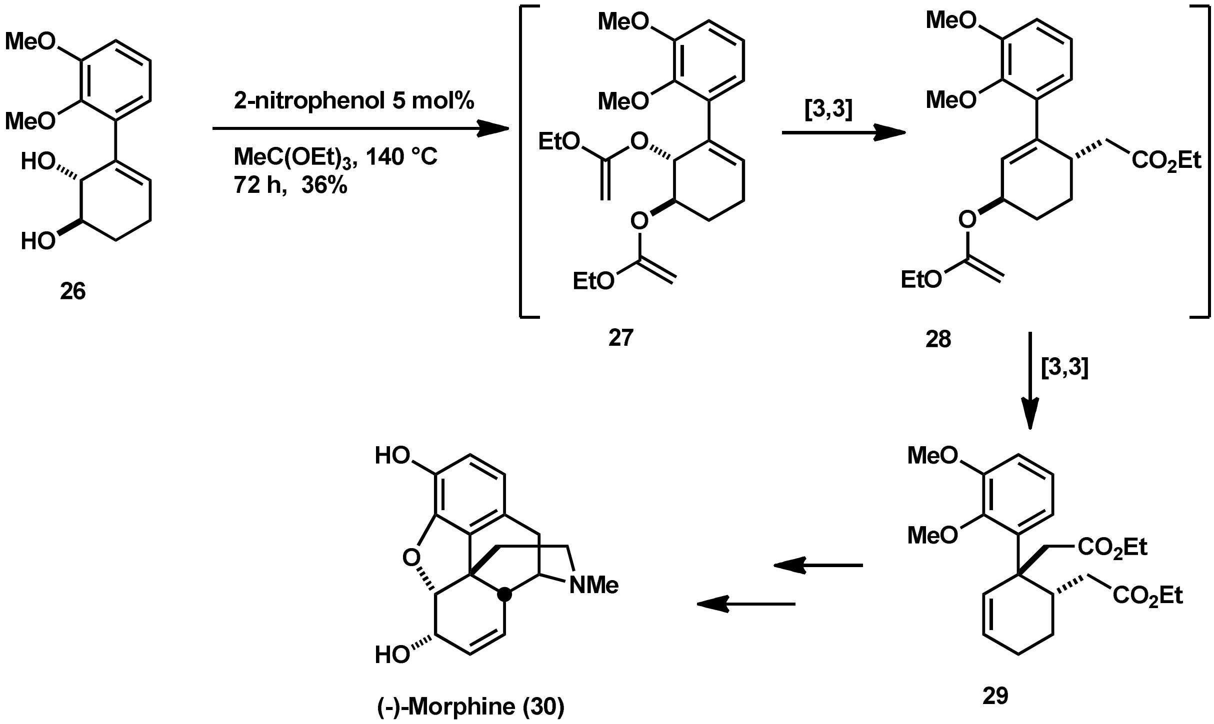


Scheme 5 - Retrosynthesis of hirsutine

This approach has also been applied to combinatorial chemistry for the preparation of different alkaloids.

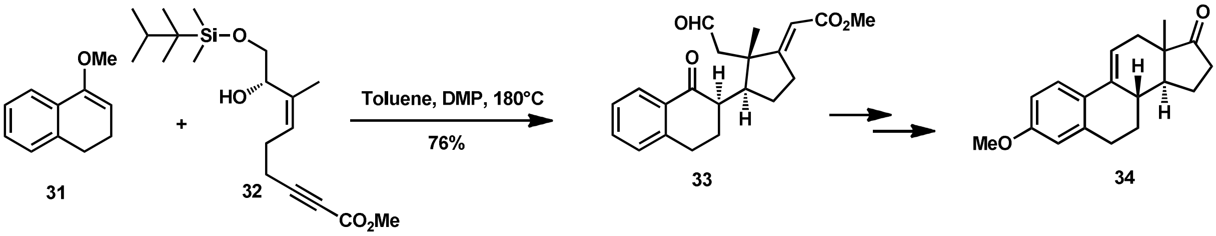
Sigmatropic rearrangements are widely used in multi-ring formation reactions with a proven efficiency, when combined in consecutive operations, the resulting processes are powerful synthetic transformations that can be considered as a component of more sustainable synthetic chemistry practices.[16]

Chida’s group reported a formal total synthesis of (-)-morphine (**30**) employing a double orthoester Johnson-Claisen rearrangement as a key step (**Scheme 6**).[17] Thus, *trans* diol (**26**) was treated with trimethylorthoacetate in the presence of a catalytic amount of 2-nitrophenol at 140 °C to give the corresponding substituted cyclohexene (**29**) in 36% yield. The reaction proceeds via intermediates (**27**) and (**28**), with complete transfer of stereogenicity from substrate to product.



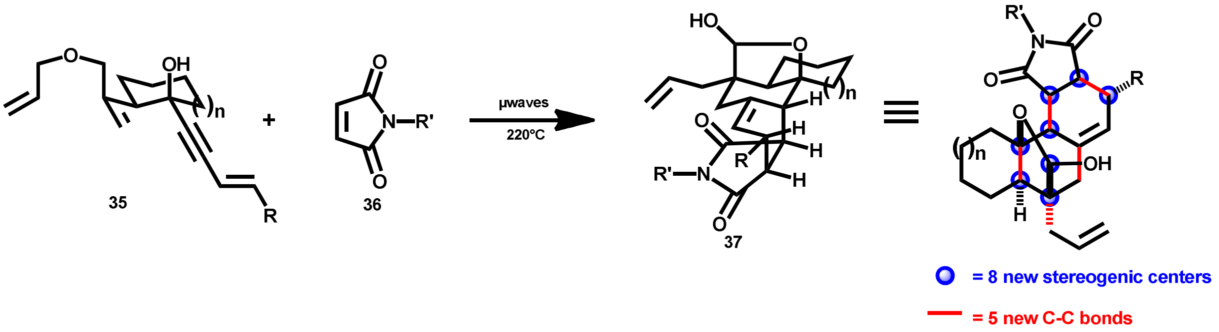
Scheme 6 - Morphine domino synthetic approach

A domino Claisen-ene strategy was used for the synthesis of (+)-9(11)-dehydroestrone methyl ether (**34**) starting from the cyclic enol ether (**31**) and an enantiopure allylic alcohol (**32**) (**Scheme 7**).[18] The reaction proceeds with a good stereocontrol giving a 90: 10 *syn/anti* selectivity in the first step and predominantly a 1,2-*trans* orientation in the following ene reaction.



Scheme 7 - Domino Claisen-Ene Synthesis of (+)-9(11)-Dehydroestrone Methyl Ether

To take advantage of the attractive features of the consecutive domino pericyclic reactions to generate, in one pot, new C–C bonds, new contiguous stereogenic centers leading to new carbocyclic frameworks, we decided to push a step further in direction of the synthesis of highly complex molecules bearing the terpenoid's framework. With the aspiration to develop a new domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder reaction (**Scheme 8**), we planned to use fairly simple linear starting materials, with the pi-bonds correctly positioned; the substrate should undergo multiple pericyclic reactions to afford the targeted product with diastereoselectivity of the newly formed stereocentres.



Scheme 8 - Domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder reaction

This thesis is a dissertation to support the development of a new domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder reaction, a diversity oriented synthesis of PPAPs scaffold via sequential one pot cascade reaction and a sesquichloride catalyzed highly hindered Diels-Alder reaction.

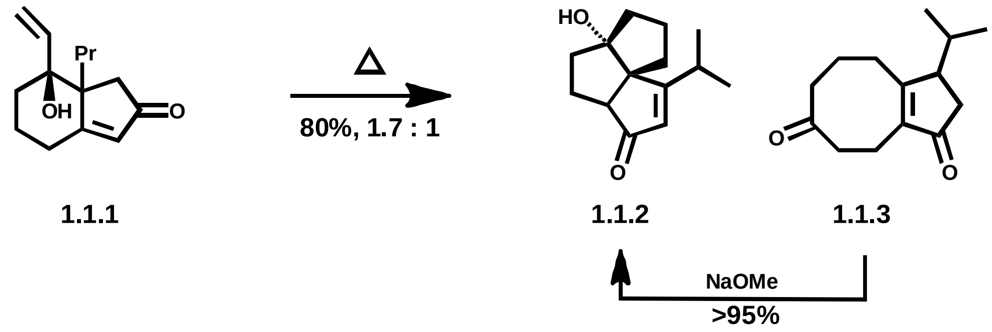
1. Development of the Domino Pericyclic Oxy-Cope/Ene /Claisen /Diels-Alder Reaction

1.1 Introduction

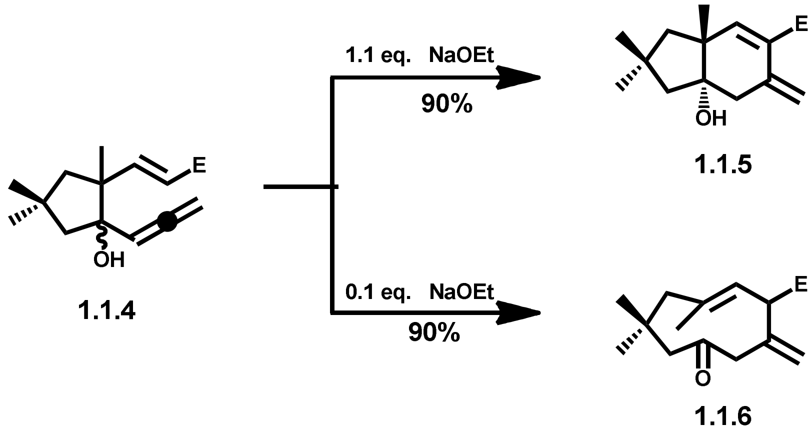
One of the most important challenges in organic chemistry is to overcome the synthetic efficiency and diversity in the construction of complex molecules. Architecturally complex natural products have been a source of inspiration for synthetic organic chemists for years. Studies into the biosynthesis of certain natural molecules described efficient processes by which nature can transform simple substrates into complex molecules containing numerous stereocenters, often done in a consecutive or domino processes[19]. Sigmatropic rearrangements are widely used in multi-ring formation reactions with a proven efficiency, when combined in consecutive operations, the resulting processes are powerful synthetic transformations that can be considered as a component of more sustainable synthetic chemistry practices.[20]

In 1991, Sutherland et al. reported[21] the formation of undesired angular triquinanes (**1.1.2**) in low yield while attempting anionic oxy-Cope rearrangement for the synthesis of bicyclo-[6.3.0]-cycloundecanes (**1.1.3**) (**Scheme 1.1.1**). However under basic conditions exposure, the oxy-Cope product (**1.1.3**) converts to the triquinane (**1.1.2**)

Later, Rajagopalan et al. described[22] a rapid synthesis of a bicyclo[4.3.0]nonane while attempting oxy-Cope rearrangements of substituted 1,2 divinyl cyclopentanols and cyclohexanols via allene intermediates (**Scheme 1.1.2**). They determined that the oxy-Cope product (**1.1.6**) could be produced efficiently by catalytic amounts of methoxide base to catalyze the oxy-Cope reaction, but stoichiometric amount of base produced exclusively the product of a cascade oxy-Cope/aldol-ene rearrangement (**1.1.5**) due to the deprotonation of the acidic hydrogen alpha to the ester. While reported as a side reaction, these reaction pathways were never explored and applied to the synthesis of polycyclic molecules.



Scheme 1.1.1 – Oxy-Cope/Ene Rearrangement (Sutherland, 1991)



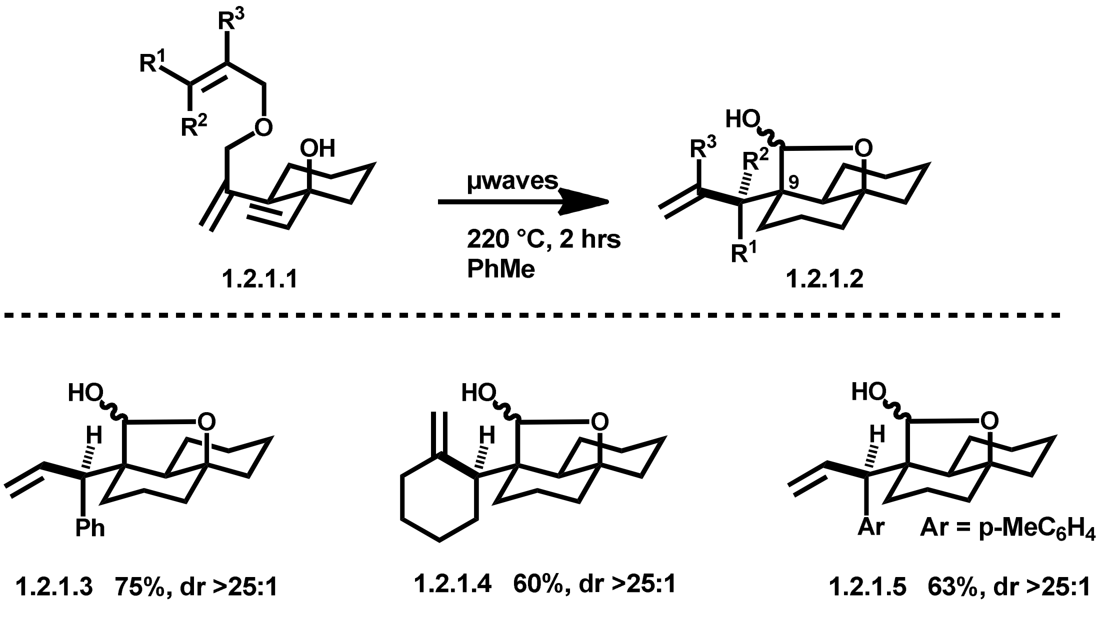
Scheme 1.1.2 – Oxy Cope/Ene Rearrangement (Rajagopalan, 1993)

1.2 Pioneering work

The Barriault group has focused on the development and application of domino pericyclic reactions.[23] In 2000, Barriault and Warrington reported an efficient access to polycyclic molecules by a consecutive oxy-Cope/ene reaction of 1,2- divinylcyclohexanols.[24] This methodology was applied to the total synthesis of (+)-arteannuin-M.[25] Following the success of the methodology to deliver the generation of highly complex molecules with stereocontrol, the Barriault group pursued the enhancement of their domino concept to attain new targets.

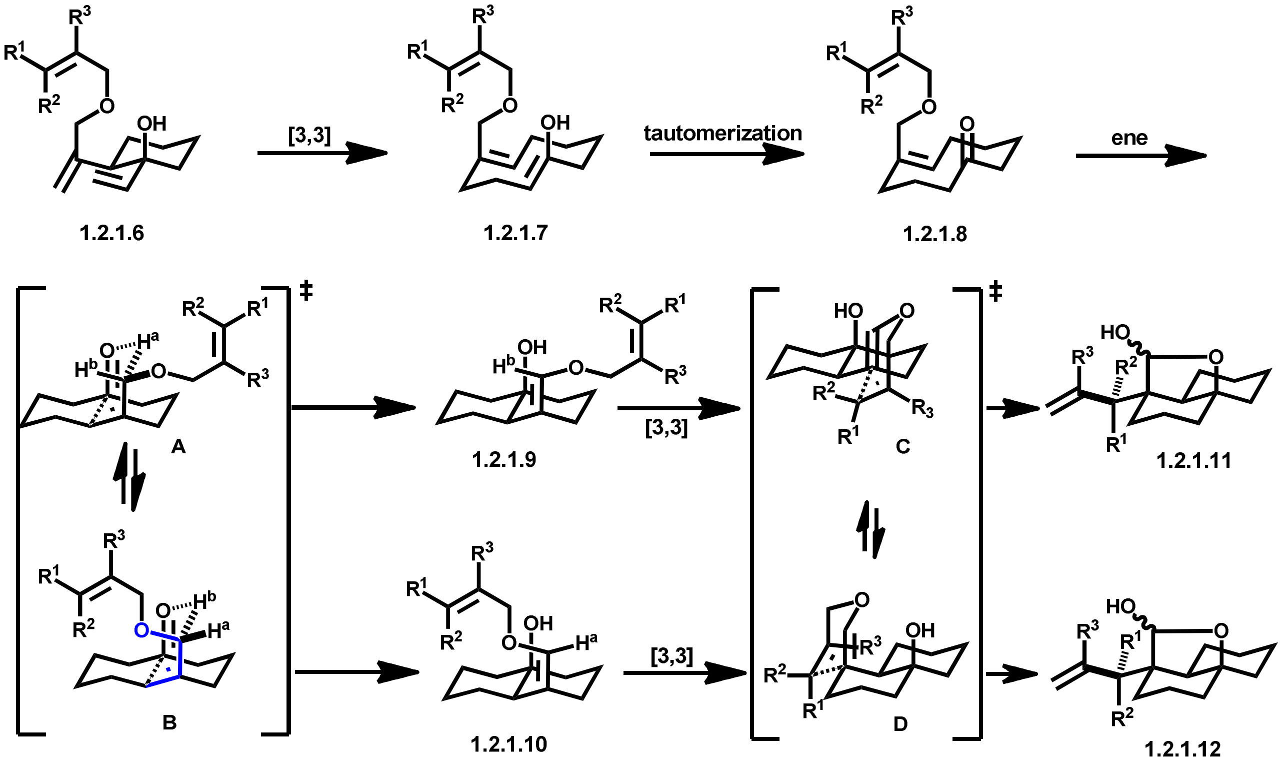
1.2.1 Oxy-Cope/Ene/Claisen

Barriault and Denissova described[26] a domino oxy-Cope/ene/Claisen reaction of allyl ether (**1.2.1.1**) to generate decalin frameworks (**1.2.1.2**) bearing contiguous stereocenters (**Scheme 1.2.1.1**). This methodology allowed the access of a broad scope and high diastereoselectivity.



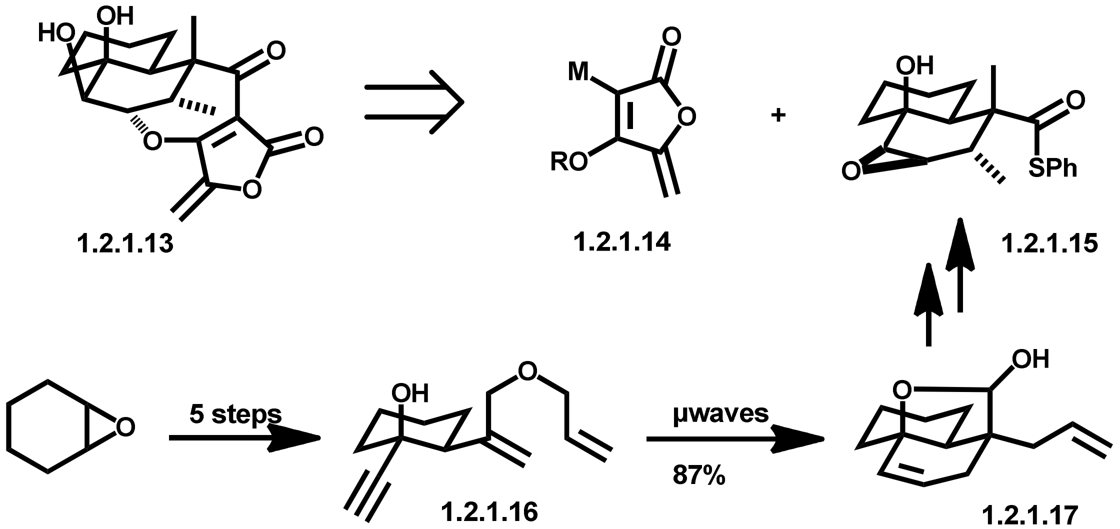
Scheme 1.2.1.1 - Oxy-Cope/Ene/Claisen

The high diastereoselectivity of the reaction can be explained by the following mechanism (**Scheme 1.2.1.2**). Microwave heating of 1,2-divinylcyclohexanol allyl ether (**1.2.1.6**) is proposed to give enol (**1.2.1.7**) through an oxy-Cope rearrangement, which after a rapid tautomerization would furnish ketone (**1.2.1.8**). There are two possible transition states (**A or B**) for the subsequent transannular ene reaction of ketone (**1.2.1.8**). The transition state **B**, however, reveals the presence of severe 1,3-allylic strain between the allyl ether group and the macrocyclic ring. Therefore, enol ether (**1.2.1.9**) is favored over the geometrical isomer (**1.2.1.10**). Finally, a Claisen rearrangement of (**1.2.1.9**) via transition state **C** gives a hydroxyaldehyde, which then cyclizes to form lactol (**1.2.1.11**).



Scheme 1.2.1.2 - Oxy-Cope/Ene/Claisen Mechanism

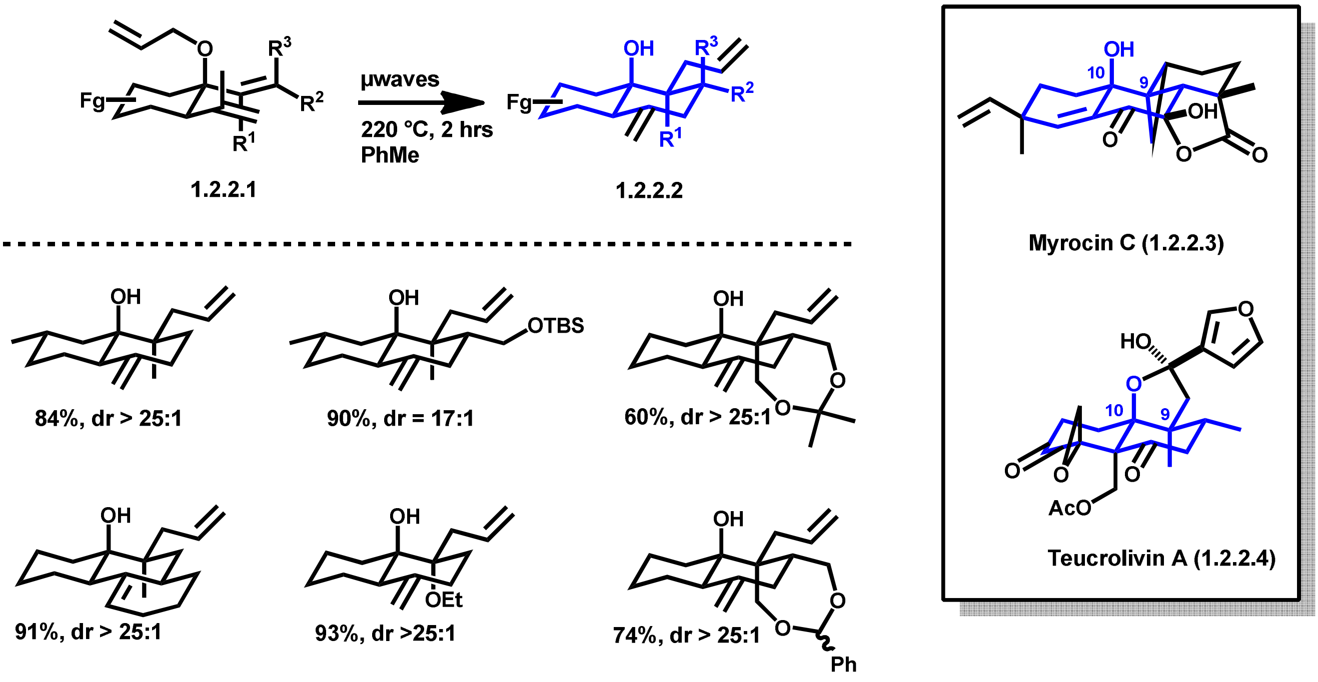
The domino oxy-Cope/ene/Claisen methodology has been used toward the total synthesis of tetradecamycin[27] (**1.2.1.13**) (**Scheme 1.2.1.3**). Barriault and Warrington reported the conversion of propargyl alcohol (**1.2.1.16**) to decalin (**1.2.1.17**) in 87% yield. The latter was transformed into advanced intermediate (**1.2.1.15**) through a short sequence.



Scheme 1.2.1.3 - Oxy-Cope/Ene/Claisen Application

1.2.2 Oxy-Cope/Claisen/Ene

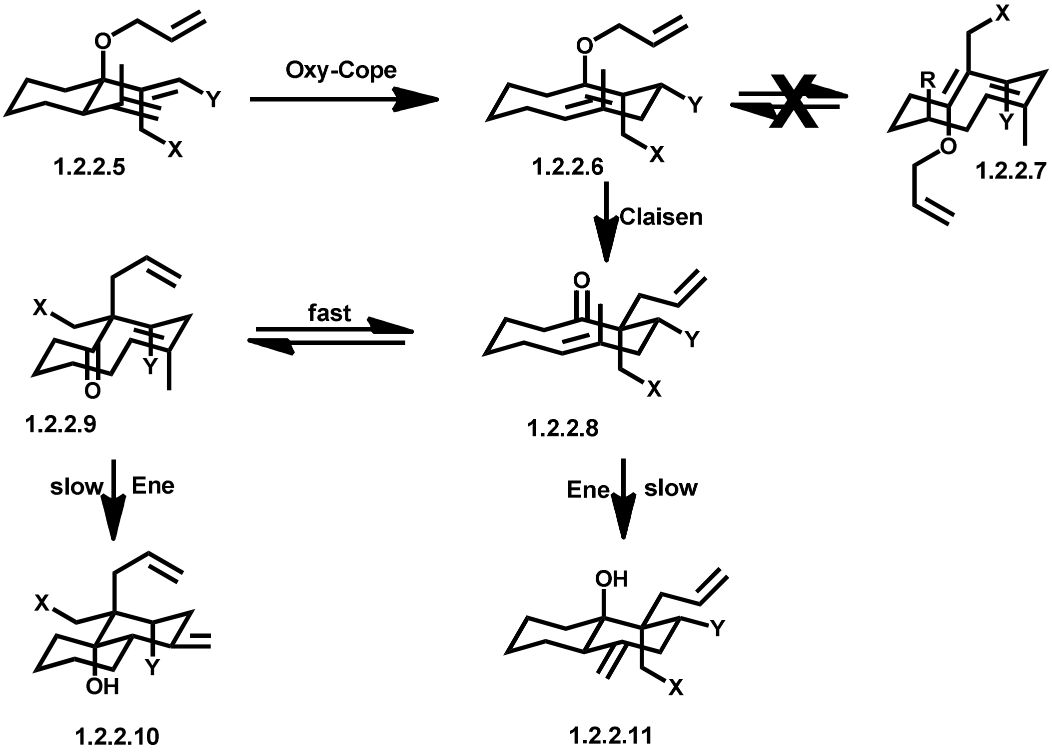
Further development led to the oxy-Cope/Claisen/ene domino reaction (**Scheme 1.2.2.1**). Barriault and Sauer developed[28] a domino oxy-Cope-Claisen-ene sequence that uses a preferential macrocyclic conformation in order to generate diastereoselectively, decalins bearing two adjacent quaternary centers. This methodology was used as the key step towards wiedemannic acid[29] and teucrolivin A.[30] The stereocontrolled formation of two or more contiguous quaternary stereocenters is a significant challenge, particularly in cyclic systems. The allyl ethers (**1.2.2.1**) produce decalins (**1.2.2.2**) possessing quaternary stereocenters in high yield and diastereoselectivity. This type of scaffold is found in several natural diterpenes including myrocin C[31] (**1.2.2.3**) and teucrolivin A (**1.2.2.4**) (**Scheme 1.2.2.1**).



Scheme 1.2.2.1 - Oxy-Cope/Claisen/Ene

Under microwave irradiation, allyl ether (**1.2.2.5**) undergoes via an oxy-Cope rearrangement to furnish enol ether (**1.2.2.6**) (**Scheme 1.2.2.2**). The latter will then undergo a Claisen rearrangement providing ketone (**1.2.2.8**). This can be directly converted into (**1.2.2.11**) or undergo a rapid conformational interchange to produce (**1.2.2.9**), which leads to the formation of (**1.2.2.10**). It is important to note that the conformational preference of macrocycles (**1.2.2.6**), (**1.2.2.8**) and (**1.2.2.9**) at the transition state dictates the stereochemical outcome of the final product.

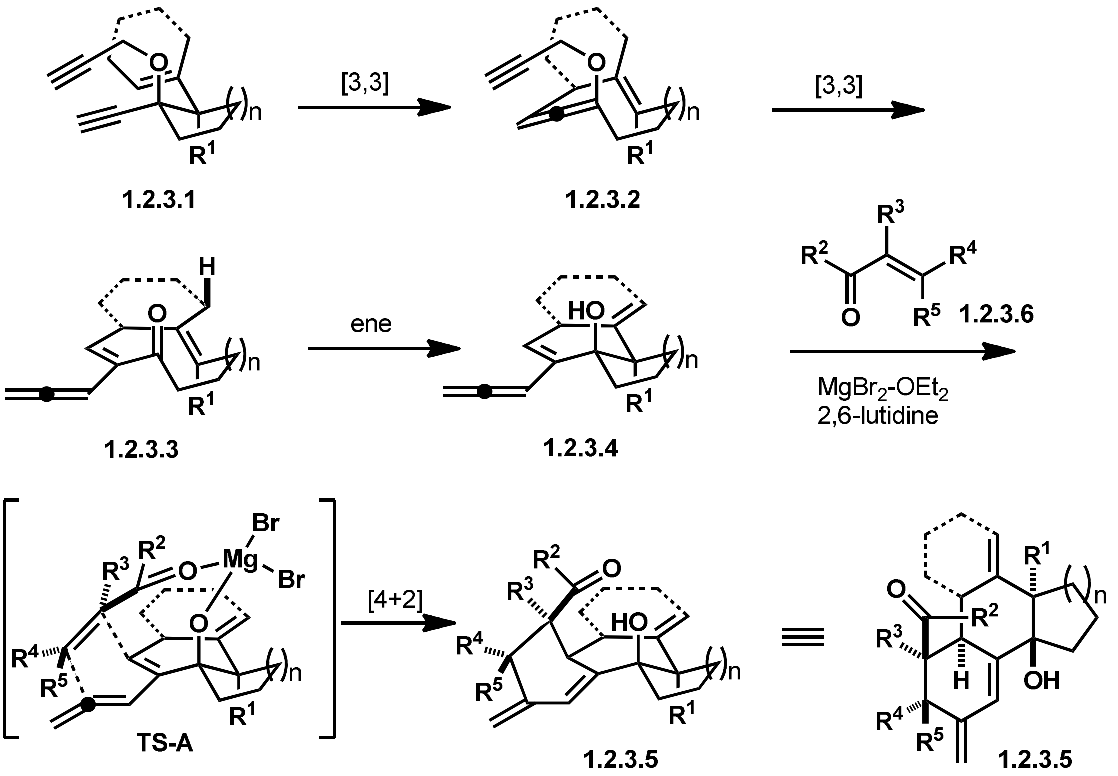
Experimental evidence and DFT[32] calculations demonstrated that the ring inversion of (**1.2.2.6**) to (**1.2.2.7**) does not occur at 220 °C. This is explained by the fact that the rotation energy barrier of the tetrasubstituted alkene is too high compared to the Claisen rearrangement of (**1.2.2.6**) to (**1.2.2.8**) being a much faster process. Conversely, the ring inversion of ketone (**1.2.2.8**) to (**1.2.2.9**) is a faster process than the ene reaction. Consequently, the diastereoselectivity of the mechanism can be rationalized using the Curtin-Hammett principle.



Scheme 1.2.2.2 - Oxy-Cope/Claisen/Ene Mechanism

1.2.3 Oxy-Cope/Ene/Claisen/Diels-Alder

In 2008, Barriault and co-workers reported[33] a stereoselective synthesis of complex carbocycles (**1.2.3.5**) from cyclic propargyl ethers (**1.2.3.1**) and dienophiles (**1.2.3.6**) via successive pericyclic reactions, a domino oxy-Cope-Claisen reaction and a subsequent hydroxyl-directed Diels-Alder reaction. Under microwave irradiation (**1.2.3.1**) rearranges via oxy-Cope reaction to produce allene (**1.2.3.2**) (**Scheme 1.2.3.1**). This highly strained macrocycle rearranges to generate enone (**1.2.3.3**) which undergoes a transannular ene reaction to deliver allene (**1.2.3.4**). The latter was treated with a magnesium-based Lewis acid and a dienophile (**1.2.3.6**) to give a single cycloadduct (**1.2.3.5**) in overall yields ranging from 36–48%. Transition state **TS-A** was proposed to account for the observed diastereoselectivity.



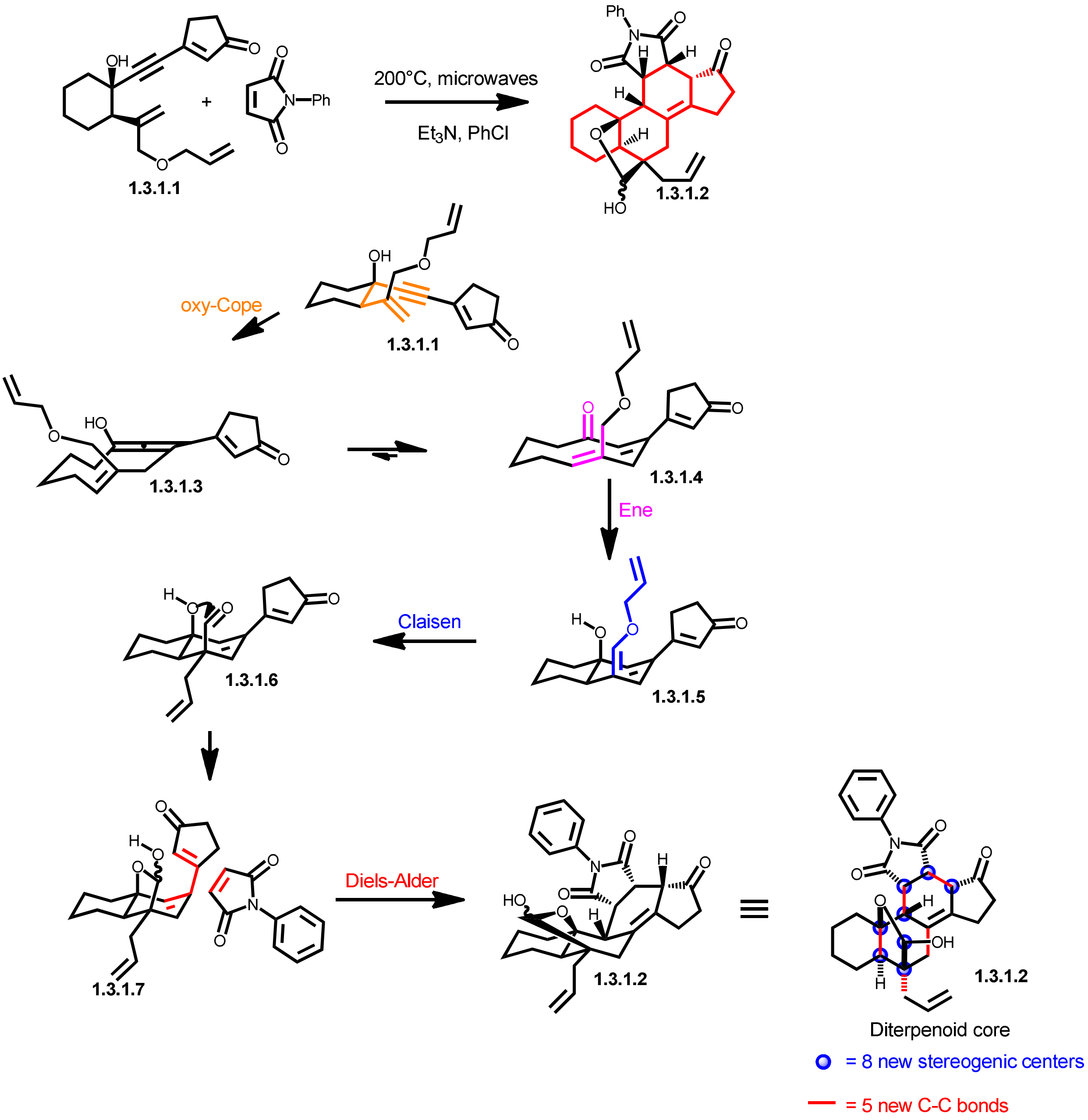
Scheme 1.2.3.1 - Oxy-Cope/Ene/Claisen/Diels-Alder Mechanism

1.3 Development of the New Domino Oxy-Cope/Ene/Claisen/Diels-Alder

Taking advantage of the domino pericyclic reactions overall efficiency, we decided to push the limit of the concept toward the synthesis of highly complex carbocycles in a single operation. Having the ambition to develop a new domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder reaction (**Scheme 1.3.1.1**), we planned to use readily available starting materials with π-bonds positioned to undergo multiple pericyclic reactions.

1.3.1 Proposed Mechanism for Domino Oxy-Cope/Ene/Claisen/Diels-Alder

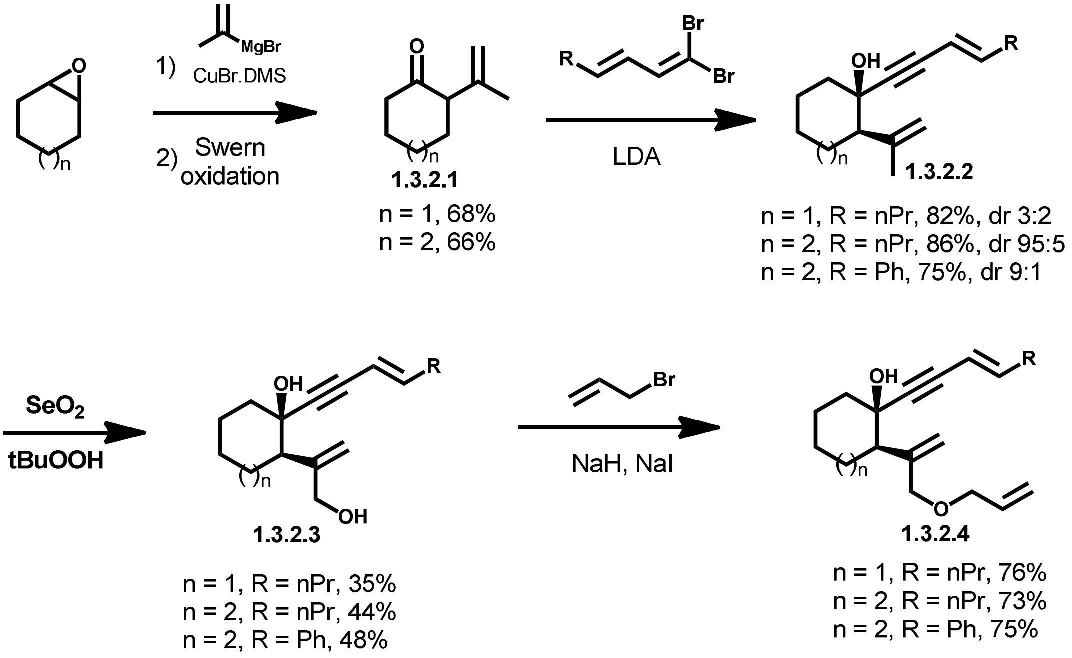
We hypothesized that enyne (**1.3.1.1**) bearing a tertiary alcohol will trigger the sigmatropic process by an anionic oxy-Cope under these reaction conditions. This should lead to the formation of the 10 membered ring enol (**1.3.1.3**) followed by a keto-enol tautomerization to give the enone (**1.3.1.4**). The macrocyclic enone (**1.3.1.4**) produce the trans decaline (**1.3.1.5**) by a transannular ene reaction. On the later, the allylic enol ether is well placed to react via a [3,3] sigmatropic Claisen rearrangement to give the aldehyde (**1.3.1.6**) and then form the lactol. Finaly, the resulting diene (**1.3.1.7**) undergoes [4+2] cycloaddition with the dienophile to form a diterpene core (**1.3.1.2**). This transformation can generate up to eight new stereogenic centers and the formation of five new C-C bonds.



Scheme 1.3.1.1 Proposed Domino Pericyclic Oxy-Cope/Ene/Claisen/Diels-Alder Mechanism

1.3.2 Precursors Synthesis

In order to validate our approach, various enynes were synthesized according the synthetic route depicted in scheme (**1.3.2.1**). Starting from cyclohexane oxide, an epoxide opening in the presence of copper (I) bromide, followed by a Swern oxidation,[34] gave ketones (**1.3.2.1**) in 66 and 68% yield. Then we performed a Corey-Fuchs alkylation to furnish the corresponding cyclohexanols (**1.3.2.2**) in 75, 82 and 86% yield. We encountered reproducibility problems and low yields (35, 44 and 48%) in the next step of allylic oxidation, no matter what substrate we tried it on. Finally, allylation with allyl bromide, potassium hydride and a catalytic amount of sodium iodide in DMF gave the desired domino reaction precursors (**1.3.2.4**) in moderate yields (73, 75 and 76%).



Scheme 1.3.2.1 – Precursors Synthesis

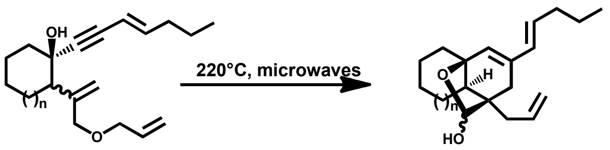
1.3.3 Initial attempts

Having the precursors (**1.3.2.4**) in hand, we first examined the domino oxy-Cope/ene/Claisen sequence to gain insight about the reaction mechanism and isolate the diene intermediate. Six and seven-membered rings enynes of having *syn* and *anti* stereochemistry were tested (**Table 1.3.3.2**). Heating of both *anti* cyclohenaxols (**1.3.3.3** and **1.3.3.4**) at 220°C (using a microwaves reactor) lead to a complex mixture of products from which no bicyclic compounds were detected by ^{1}H NMR (entries 1 and 2). One can rationalize that the alkyne bond is far from the alkene reacting in the oxy-Cope rearrangement then necessitating higher activation energy barrier compared to the *syn* isomer (**Figure 1.3.3.1**) thus engaging into unproductive reaction pathways.

1.3.3.1 **1.3.3.2**

Figure 1.3.3.1 – Syn vs. Anti Conformational Comparison

To our delight, the *syn* isomers (**1.3.3.5** and **1.3.3.7**) were converted to the desired compounds (**1.3.3.6** and **1.3.3.8**) in 65% and 60% yields respectively (entries 3 and 4).



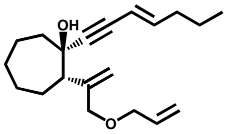
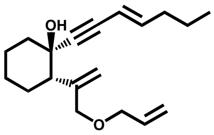
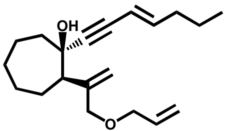
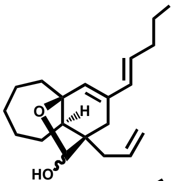
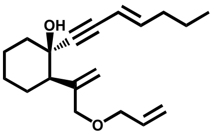
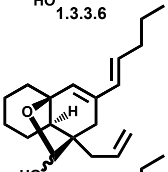
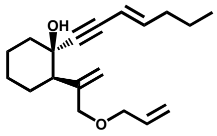
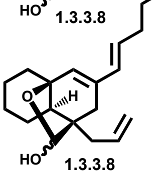
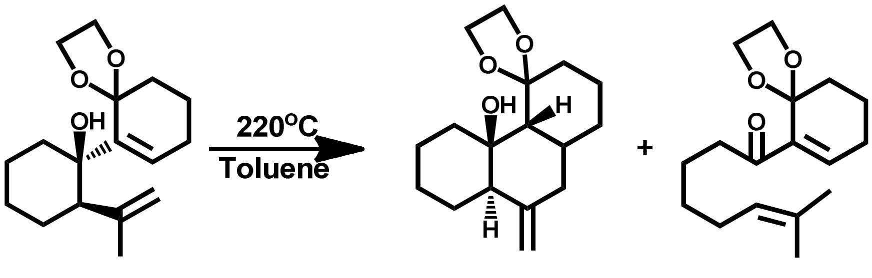
Entry	precursor	geometry	solvent	product	yield
1	 1.3.3.3	anti	Toluene	Decomposition	
2	 1.3.3.4	anti	Toluene	Decomposition	
3	 1.3.3.5	syn	Toluene	 1.3.3.6	65%
4	 1.3.3.7	syn	Toluene	 1.3.3.8	60%
5	 1.3.3.7	syn	Toluene and 1eq.Et_3N	 1.3.3.8	90%

Table 1.3.3.2 – First Attempts to Form the Diene Intermediate

Having the two π-systems in a closer proximity in the *syn* conformation allowed the oxy-Cope reaction to proceed followed by the ene/Claisen sigmatropic rearrangement. Rate accelerated anionic oxy-Cope reactions based on the addition of a strong base as DBU have been well documented by Evans and co-workers in the literature[35]. An amine base enhances the rate of the oxy-Cope rearrangement significantly, avoiding a retro-ene side reaction (**Table 1.3.3.3**) and an augmentation of product yield is observed.[36]



1.3.3.8 **1.3.3.10** **1.3.3.11**

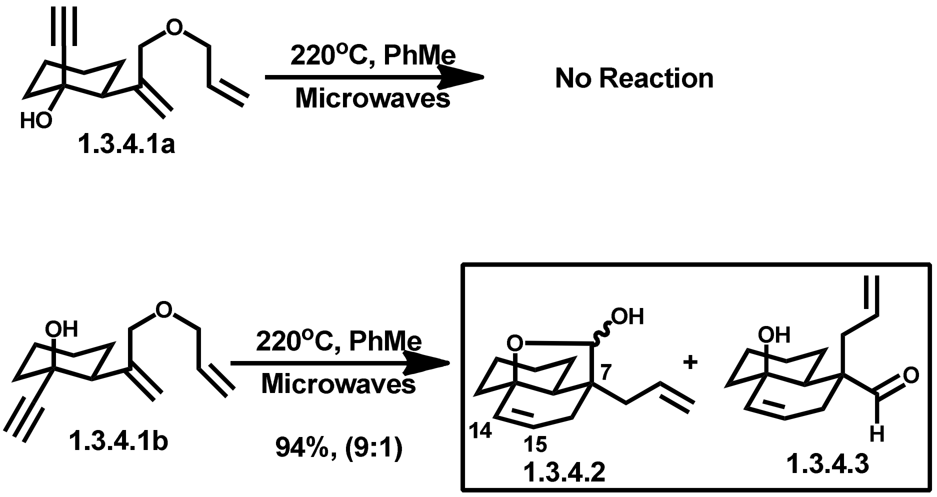
Additive	Product Ratio	Yield
No DBU	3.5 : 1	77%
20 equiv. DBU	20 : 1	75%

Table 1.3.3.3 – Oxy-Cope/Ene Rearrangements in the Presence of DBU

We noted a significant yield increase in entry 5 (**Table 1.3.3.2**) by using Et_3N as a base to promote an anionic oxy-Cope at 220°C in toluene. The bicyclic rings formed were a mixture of two diastereomers due to the hemiketal formation step.

1.3.4 Mechanism insights

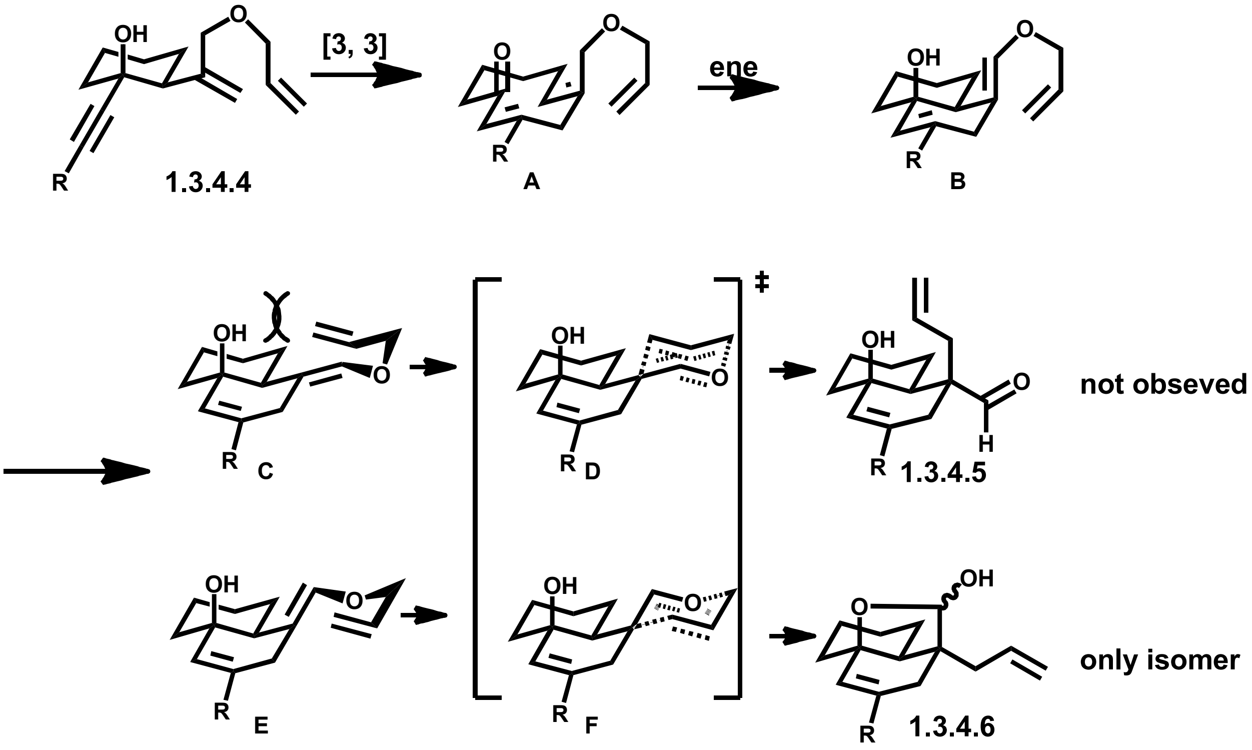
Barriault and Warrington proved (**Scheme 1.3.4.1**) that upon heating the mixture of allyl ethers (**1.3.4.1a** and **1.3.4.1b**) in the microwave reactor, isomer (**1.3.4.1b**) reacted cleanly to give decalin lactol (**1.3.4.2**) in 85% yield. Isomer (**1.3.4.1a**) failed to react and only starting material was recovered. The decalin lactol (**1.3.4.2**) formed was the result of a putative oxy-Cope/ene/Claisen sequence.



Scheme 1.3.4.1 - Oxy-Cope/Ene/Claisen Mechanism Insights

Interestingly, a minor compound (**1.3.4.3**) was also formed in 9% yield. It is believed that this compound arose from a *top* face Claisen rearrangement of the allyl enol ether tether following the oxy-Cope/ene rearrangement. Though Barriault and Denissova had not observed this type of product in 2002,[37] the systems they had studied did not contain a triple bond.

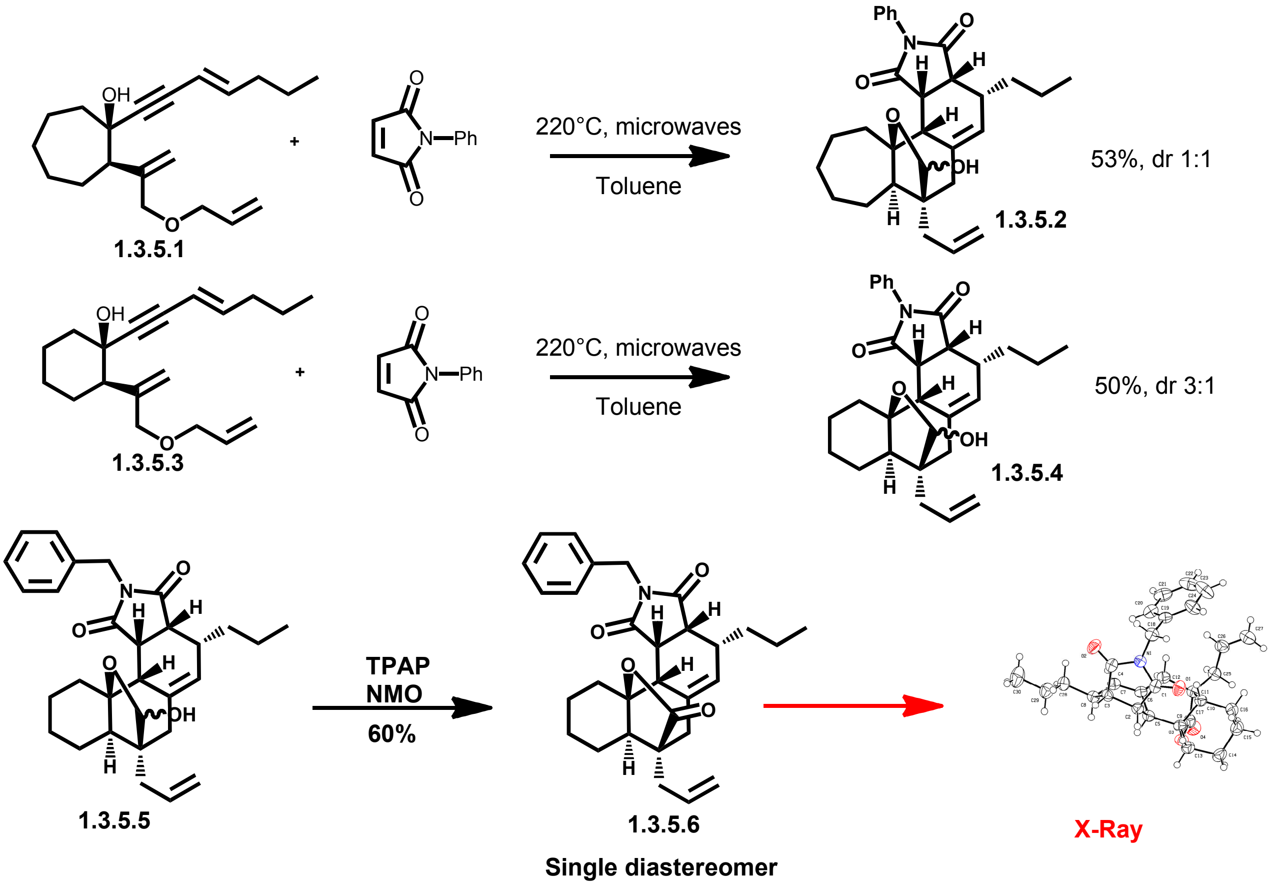
Following the oxy-Cope rearrangement of allyl ether (**1.3.4.4**) (**Scheme 1.3.4.2**), the macrocyclic ketone (**A**) undergoes transannular ene to give enol ether **B**. This enol ether can then undergo Claisen rearrangement from the top face (**C** → **D** → **1.3.4.5**) or the bottom face (**E** → **F** → **1.3.4.6**) of the decalin ring system. Transannular steric interactions between the allyl chain and tertiary alcohol disfavours Claisen rearrangement from the top face (via transition state **D**). Therefore the bottom face rearrangement (via transition state **F**) is preferred – furnishing the only observed product (**1.3.4.6**).



Scheme 1.3.4.2 – Mechanism of Oxy-Cope/Ene/Claisen Rearrangement

1.3.5 Proof of concept

We were now ready to try the initial hypothesis, with no intermediate isolation; the precursors were submitted to microwave irradiation to perform the new one pot domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder (**Scheme 1.3.5.1**). The dienophile chosen was *N*-phenylmaleimide for its reactivity and availability.

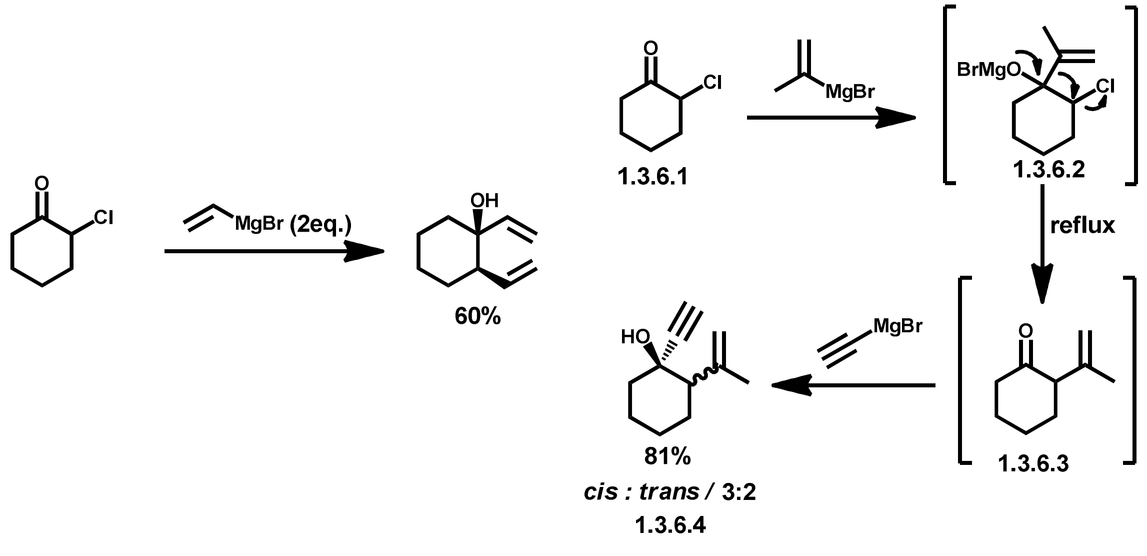


Scheme 1.3.5.1 Proof of Concept

We obtained, starting from six (**1.3.5.3**) and seven (**1.3.5.1**) membered ring precursors, the expected products (**1.3.5.2** and **1.3.5.4**) of domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder. In each case, the formation of two diastereomers was observed. However, we speculated that was probably due to the formation of the hemiketal ring. The attack of the tertiary alcohol onto the aldehyde is not diastereoselective. An experiment has been performed by Dr. Jason Poulin to oxidize the hemiketal (**1.3.5.5**) with TPAP/NMO[38] to a lactone (**1.3.5.6**) in order to eliminate that stereocenter. And, as a result, one single diastereomer has been observed and characterize by X-ray. This outcome proves the complete diastereoselectivity of the consecutive pericyclic reactions.

1.3.6 Optimization of Substrate Synthesis

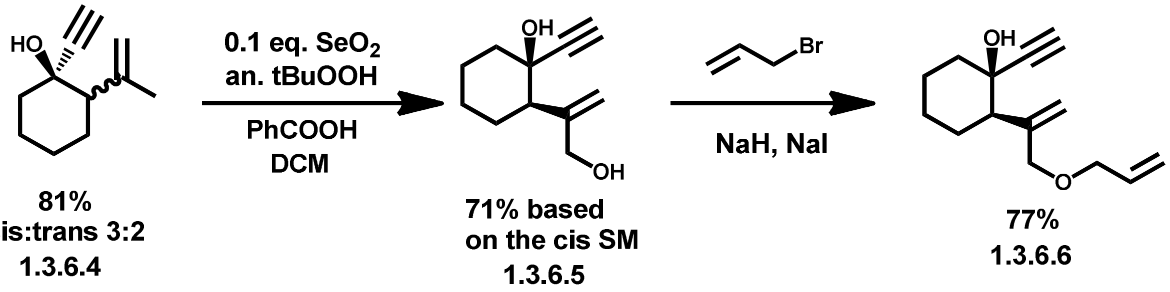
Having established the feasibility of the domino sequence, we needed to optimize the synthesis route (**Scheme 1.3.6.1**) of the precursors. In 1980, Holt et al. report[39] the synthesis of divinylcyclohenanol and 2-(prop-1-en-2-yl)cyclohexanone from 2-chlorocyclohexanone via a 1,2-shift. Drawing inspiration from this work, we elaborated a short synthesis of cyclohexanol (**1.3.6.4**)



Scheme 1.3.6.1 - Optimization of the Synthetic Route

To a solution 2-chlorocyclohexanone (**1.3.6.1**) in THF, we added one equivalent of isopropenylmagnesium bromide and heated the solution to reflux. The alkoxide intermediate (**1.3.6.2**) undergoes 1,2 carbon shift and chlorine elimination then the 2-(prop-1-en-2-

yl)cyclohexanone intermediate (**1.3.6.3**) is formed. To the latter reaction mixture was added ethynylmagnesium bromide to afford in one step a mixture of *cis/trans* 1-ethynyl-2-(prop-1-en-2-yl)cyclohexanol (**1.3.6.4**). This mixture is then submitted to the newly optimized allylic oxidation condition (**Scheme 1.3.6.2**) to afford the mixture of diol (**1.3.6.5**) that can easily be separated by flash chromatography.

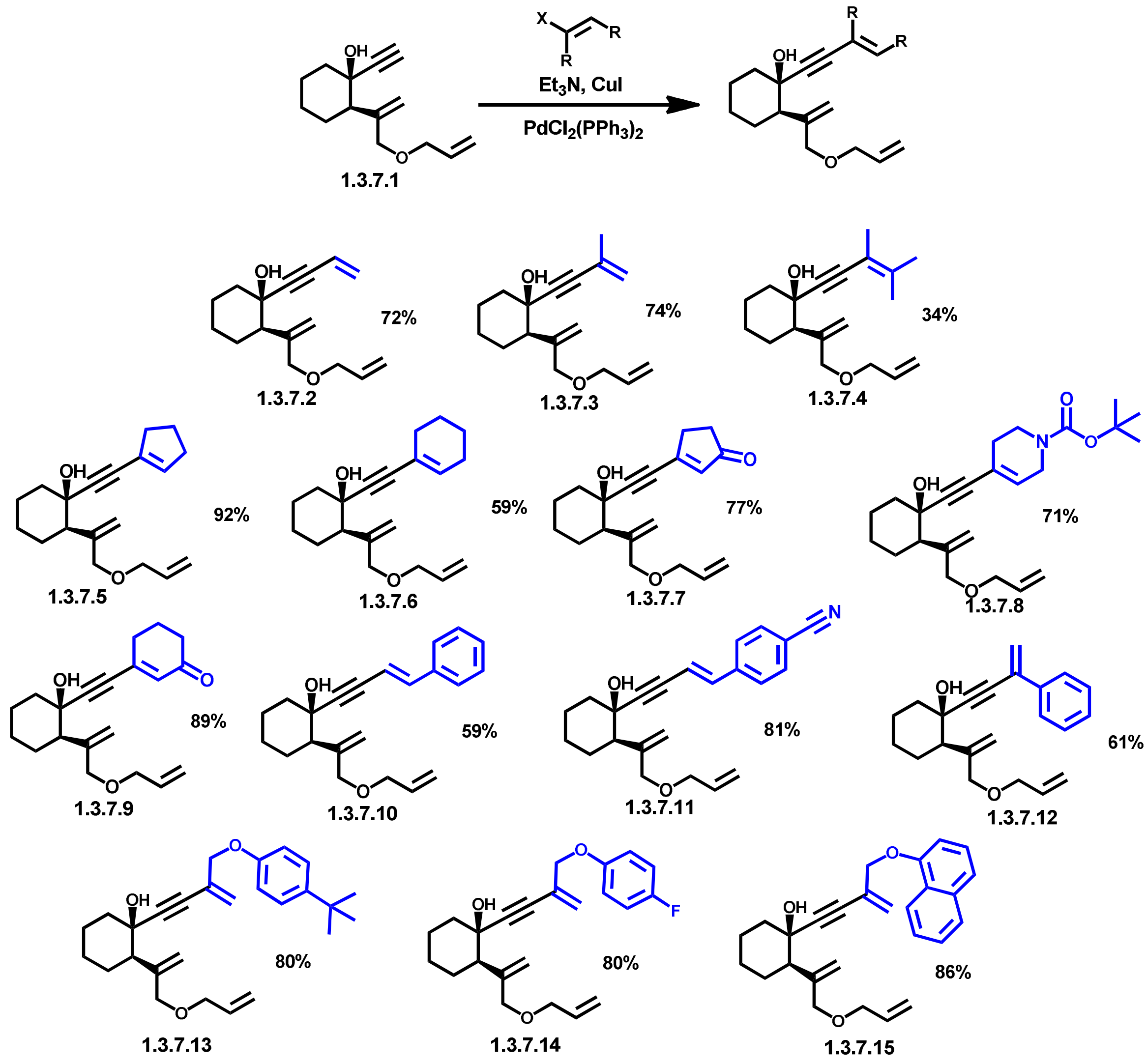


Scheme 1.3.6.2 - Optimization of the Synthetic Route

Finally, allylation with allyl bromide, sodium hydride and a catalytic amount of sodium iodide in THF/DMF gave the desired allyl ether intermediate (**1.3.6.6**) in 77% yields. This single intermediate will be the entry point of the synthesis of all of the domino precursors.

1.3.7 Diversification of the substrate

The diversification was performed using the Sonogashira[40] palladium catalyzed cross-coupling reaction. The allyl ether (**1.3.7.1**) is solubilized in toluene and carefully degased with argon to avoid the Glaser coupling[41]. To attain a broad scope in terms of electronics, sterics and ring size, we prepared a variety of substrates (**Scheme 1.3.7.1**).



Scheme 1.3.7.1 Intermediate Synthesis by Sonogashira Coupling

1.3.8 Diene intermediate formation via an oxy-Cope/ene/Claisen

Having demonstrated the efficient formation of the desired diene intermediate in the preliminary tests, we next evaluated the scope of the oxy-Cope/ene/Claisen with electronically different functional groups (**Scheme 1.3.8.1**). The starting materials were submitted to the newly optimized conditions with 3 equivalents of Et_3N, chlorobenzene as a polar solvent for better microwaves absorption[42] and heated at 200°C. Electron-rich, electron-neutral and electron-poor groups linked to the alkyne were tolerated giving good yields and selectivity. To prove once again that the domino pericyclic oxy-Cope/ene/Claisen cascade was entirely stereoselective, we performed a TPAP/NMO oxidation to eliminate the hemiketal stereocenter and form a single lactone isomer.

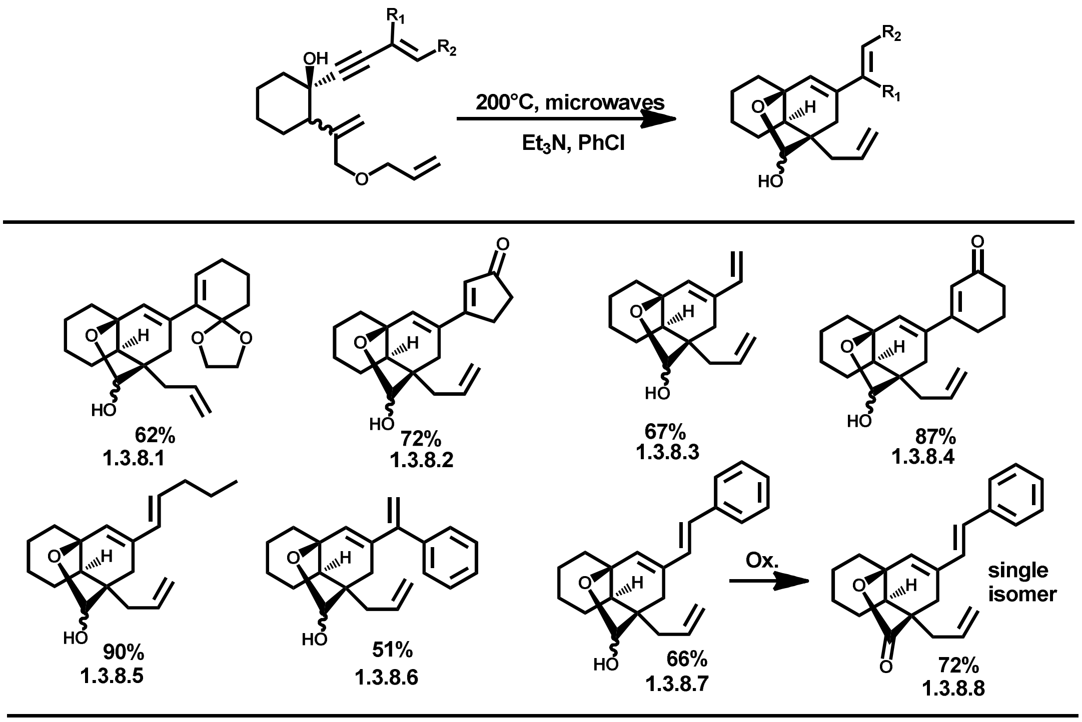
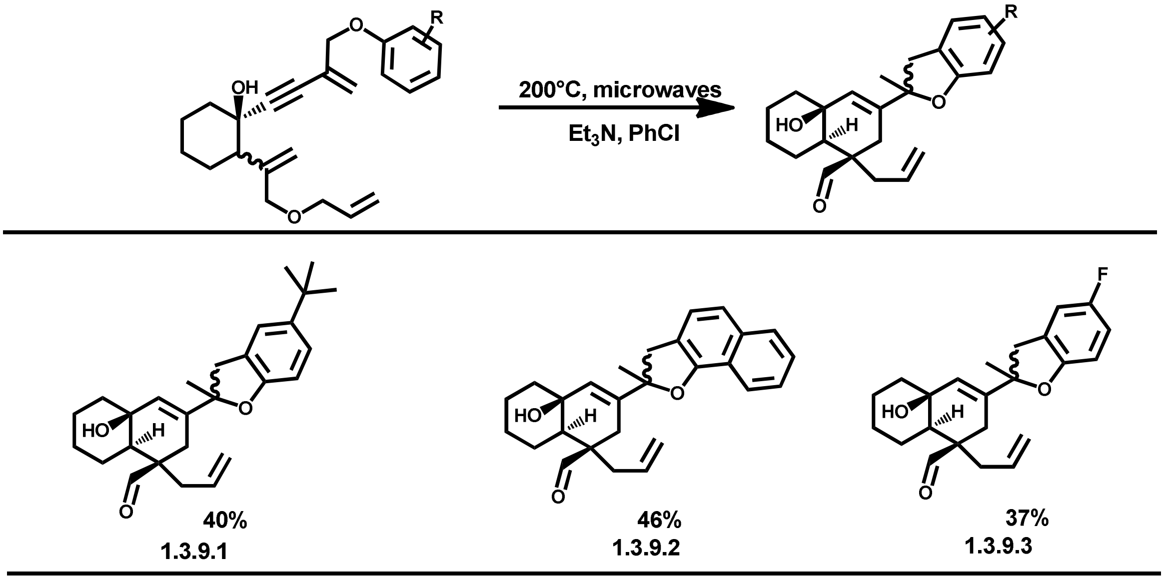


Table 1.3.8.1 - Scope Studies for the Domino Pericyclic Oxy-Cope/Ene/Claisen Cascade

1.3.9 The unexpected Domino Pericyclic Oxy-Cope/Ene/Claisen/Claisen

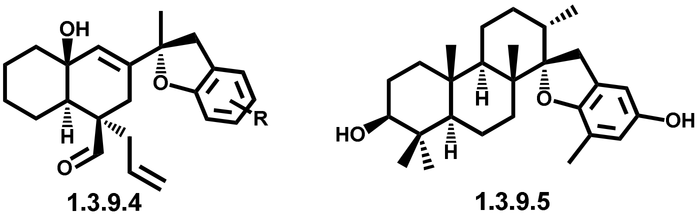
We then substituted the R_1 position with phenolic ethers to push the limits of the domino process (**Scheme 1.3.9.1**) by placing strategically a phenol ring that might undergo an additional Claisen rearrangement (oxy-Cope/ene/Claisen/Claisen) or react as the previous substrates via the classic oxy-Cope/ene/Claisen.



Scheme 1.3.9.1 - Scope Studies for the Domino Pericyclic Oxy-Cope/Ene/Claisen/Claisen cascade.

The starting material underwent the unexpected oxy-Cope/ene/Claisen/Claisen followed by a five *exo* trig cyclization of the phenolic ring to give the benzofurans bearing three quaternary centers in a mixture of two diastereoisomers. In this case all the products formed were aldehyde so none of them went a further cyclization to give the hemiketal. This trend can be explained by the formation of the quaternary center of the benzofuran ring, which is sterically hindered and so will affect the conformation of the bicyclic system. This conformation will have the aldehyde far from the tertiary hydroxyl group to condense on it. Indeed, if we compare that to the previous dienes under their hemiketal form, the carbon bearing R_1 is on a pi-system and is less sterically hindered, allowing hemiketal formation.

The diterpene-benzofuran core is scarcely found in nature but exist as secondary diterpene metabolites (stypodiol, epistypodiol, and stypotriol) excreted by the tropical brown algae *Stypopodium zonale Papenfuss*[43]. These natural compounds have strong cytotoxic properties and can inhibit cell division in marine embryos and in mammalian cell cultures, through a polymerization inhibition of tubulin into microtubes[44].



1.3.9.4

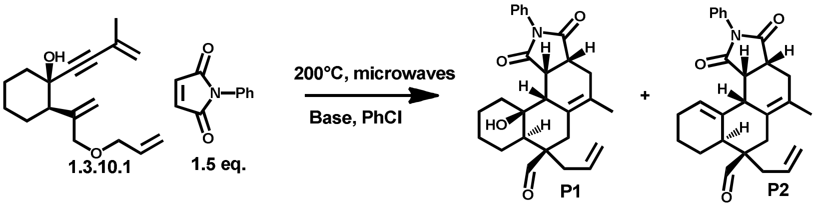
1.3.9.5
Stypodiol

Figure 1.3.9.2 - Diterpene-Benzofuran core in the nature

One can recognize that the core (**1.3.9.4**) in figure (**1.3.9.2**) is embedded in stypodiol. In a drug discovery point of view, a structure-activity relationship study would be interesting to test the biological activity of our substrates, which are easily accessible from simple starting materials. This transformation could be further developed and applied to the synthesis of benzofuran scaffolds.

1.3.10 Domino Pericyclic Oxy-Cope/Ene/Claisen/Diels-Alder Cascade Optimization

Once we established the thermal formation of diene, we pursued our investigation to develop a one pot domino oxy-Cope/ene/Claisen/Diels-Alder using *N*-phenylmaleimide as a dienophile. This reaction needed to be optimized (**Table 1.3.10.1**) since the reaction did not proceed very well without the use of a base giving a mediocre 47% yield (entry 1). The use of DBU proved to be unsatisfactory (entry 2). The low yield could be attributed to the fact that *N*-phenylmaleimide in presence of DBU at 100°C in chlorobenzene under microwave irradiation causes a progressive degradation of the dienophile.[45] Based on this, we turned our attention toward a sterically congested base, the 1,2,2,6,6-pentamethylpiperidine. We noted an increase in terms of yield but also the apparition of the by-product P2 resulting from the tertiary alcohol elimination. With 0.2 equivalent (entry 3) we saw a small yield increase compared with the absence of base (entry 1). Since the 1,2,2,6,6-Pentamethylpiperidine is less nucleophilic toward N-phenylmaleimide, we got cleaner reactions with less decomposition of the dienophile as expected (entry 4). When we used 1 equivalent of Et_3N, we noted a decrease in yield as with 1 equivalent of DBU matching with the expected decomposition of the dienophile in presence of an amine base. However when we increased the amount of Et_3N to 2 equivalents, we recorded an increase in yield compared to the baseline (entry 1). The gain can be attributed to the acceleration of the pericyclic reactions, which is correlated to a faster formation of the diene and then faster consumption of the dienophile before decomposition.



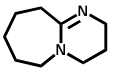
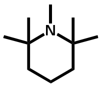
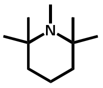
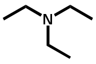
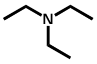
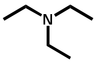
Entry	Base	equiv. of base	Yield	Products
1	-	-	47%	P1
2		1 eq.	38%	P1
3		0.2 eq.	51%	P1
4		1 eq.	55 %	P1/P2 ratio 9/1
		1 eq.	42 %	P1
5		2 eq.	64 %	P1
6		3 eq.	58 %	P1

Table 1.3.10.1 - Reaction Optimization for the Domino Pericyclic Oxy-Cope/Ene/Claisen/Diels-Alder Cascade

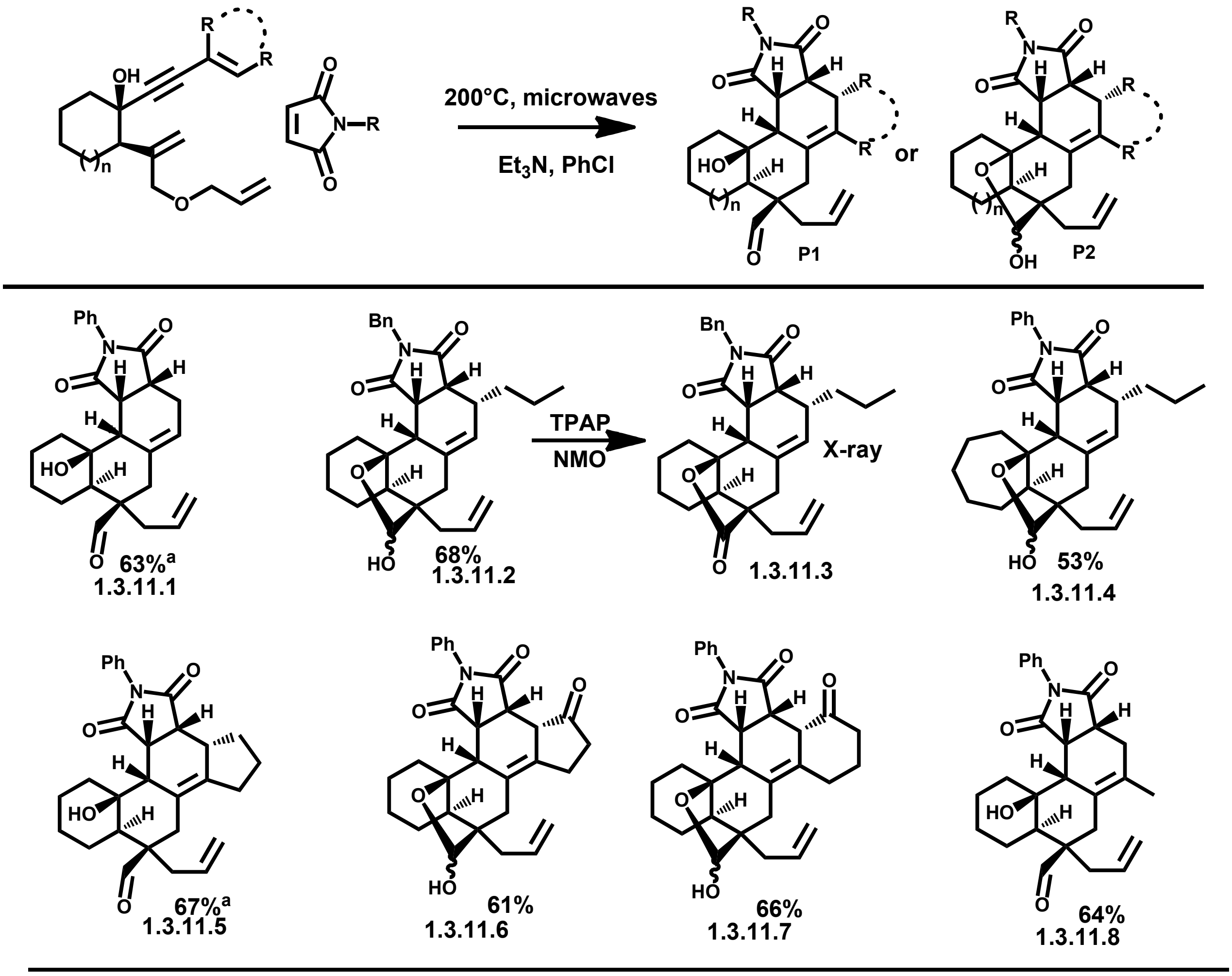
The best yield was obtained with the use of two equivalent of Et_3N. No further investigation with other type of bases was undertaken.

1.3.11 Scope Studies for the Domino Pericyclic Oxy-Cope/Ene/Claisen/ Diels-Alder Cascade

In order to address the diversity attainable by the domino oxy-Cope/ene/Claisen/Diels-Alder cascade, we tested a large variety of precursors and the results obtained are presented below (**Scheme 1.3.11.1**). The formation of the products occurred with good yields (85-92 % yield average per transformation) and high stereoselectivity. Precursor (**1.3.7.2**) underwent the domino cascade to furnish the aldehyde (**1.3.11.1**) in 63% yield as a single diastereomer. When a propyl group was added to the precursor (**1.3.3.7**) we formed the hemiketal polycycle (**1.3.11.2**) in 68% yield in two diastereomer due to the hemiketal stereogenic centre. The hemiketal formation could be explained by a conformation change of the polycycle because of the propyl substitution, allowing the tertiary alcohol to add to the aldehyde. When the hemiketal was formed, we isolated two diastereoisomers which can be further oxidized using TPAP/NMO procedure to get the lactone and thus obtain by this method one single diastereomer characterized by X-ray (**1.3.11.3**). The domino transformation can also work on seven membered-ring precursor (**1.3.3.5**) to produce the compound (**1.3.11.4**) in 53% yield. One of the most important applications of this method was the synthesis of diterpenes compounds (**1.3.11.5**), (**1.3.11.6**) and (**1.3.11.7**) in 67%, 61% and 66% yield respectively. From a medicinal chemistry stand point; this method can be an interesting entry point to develop a steroid and/or diterpenes library. From the methyl substituted vinyl precursor (**1.3.7.3**), the reaction afforded the aldehyde (**1.3.11.8**) in 64% yield.

Nuclear overhauser experiments showed that the Diels-Alder reaction was *endo* selective as expected. This table shows the highly valuable structures that can be reached quickly from simple starting materials. The synthesis of diversified diterpenes cores has been accomplished.

One can recognize that the one pot domino pericyclic oxy-Cope/ene/Claisen/Diels-Alder cascade is efficient and reliable to be utilized for the synthesis of highly complex diterpenes.



a : 1,2,2,6,6-Pentamethylpiperidine used as the base.

Scheme 1.3.11.1 Scope Studies for the Domino Pericyclic Oxy-Cope/Ene/Claisen/ Diels-Alder Cascade

1.4 Conclusion

In conclusion, we have developed a powerful waste-minimizing process for the synthesis of highly functionalized diterpenes cores bearing up to eight contiguous stereocentres, including the formation of four carbon-carbon bonds, using simple starting materials, by a microwave assisted domino oxy-Cope/ene/Claisen/Diels-Alder. Through a comprehensive study of the latter rearrangement, we have demonstrated its utility in generating highly complex decalin cores with diverse stereochemical properties, with highly predictable stereochemical outcome and with an 85-92% average yield per transformation. We were successful in generating diterpene cores that can be interesting from a medicinal chemistry point of view.

Moreover, we have observed a new oxy-Cope/ene/Claisen/Claisen reaction that can be used to gain access to the sparsely described synthesis of diterpenes bearing a benzofuran ring. Further investigation is ongoing on this subject.

2. Sequential Diels-Alder/Gold(I) Catalyzed 6-endo-dig Cyclization for the Synthesis of Complex Bicyclo[3.3.1]alkenone Framework

2.1 Introduction

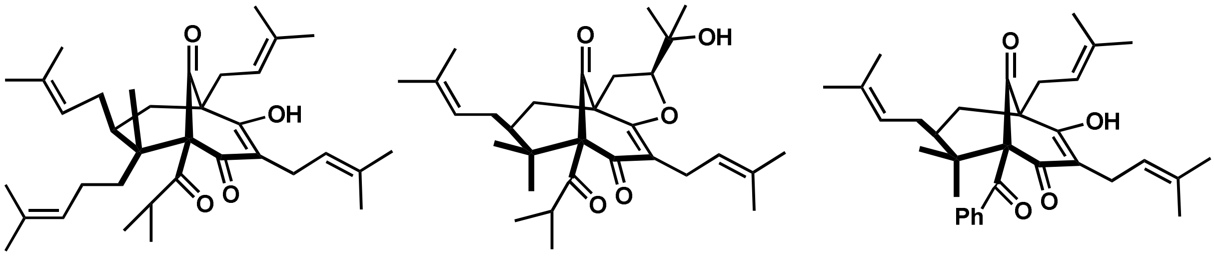
Plants have always been a major source of biologically active compounds from ancient medicine to the modern drug discovery. One of the first pharmacologically active molecule known as morphine[46] was isolated over 200 years ago and this discovery opened the studies of active compounds derived from plants. Later, the expansion of synthetic organic chemistry gave rise to new drug discoveries inspired by natural products. The therapeutic potential of polycyclic polyprenylated acylphloroglucinols (PPAPs) has attracted attention from several research groups.[47] Isolated from *Guttiferae* plants, PPAPs bear complex chemical structure with a highly oxygenated and densely substituted bicyclo[3.3.1]nonane-1,3,5-trione core which is very challenging to access by synthetic organic chemistry[48]. In this chapter, the development of an efficient methodology to rapidly access a wide variety of PPAPs frameworks is described.

2.2 Biological Activity and Biosynthesis

2.2.1 Biological activity

Many PPAPs express different kinds of biological activities not limited to antiviral, antimitotic, antioxidant and antidepressant activities. They act as modulators of neurotransmitters associated to nervous depression. Hyperforin (**Figure 2.2.1.1**) is the major active molecule found in St. John's wort and is responsible for its antidepressant activity[49]. The mechanism is an inhibition of synaptosomal uptake of neurotransmitters[50], including serotonin, dopamine, norepinephrine, γ-aminobutyric acid (GABA), and L-glutamate, whith a low IC_{50} = 1.1 μg/mL. A recent report on inhibition of penicillin-resistant and methicillin-resistant *S. aureus* has increased the interest in hyperforin as an antibacterial agent.[51] Hyperforin has been reported to induce apoptosis in human and rat cancer cell lines, with IC_{50} = 3–15 μM,[52] in leukemic cells and brain glioblastoma cells.[53] Nemorosone (**Figure 2.2.1.1**) is the major constituent of *Clusia* species resin that is responsible for its antimicrobial activity.[54] nn Besides antimicrobial activity, nemorosone has been reported to have cytotoxic and antioxidant activity[55] as well as an EC_{50} of 0.8 μM against HIV infection of C8166 human T lymphoblastoid cells.[56]

Garsubellin A (**Figure 2.2.1.1**), isolated from *Garcinia subelliptica*, has been reported to increase the concentration of choline acetyltransferase (ChAT) in rat septal neuron cultures[57], this is associated with neurodegenerative diseases like Alzheimer's disease and also has anti-inflammatory activity.[58]

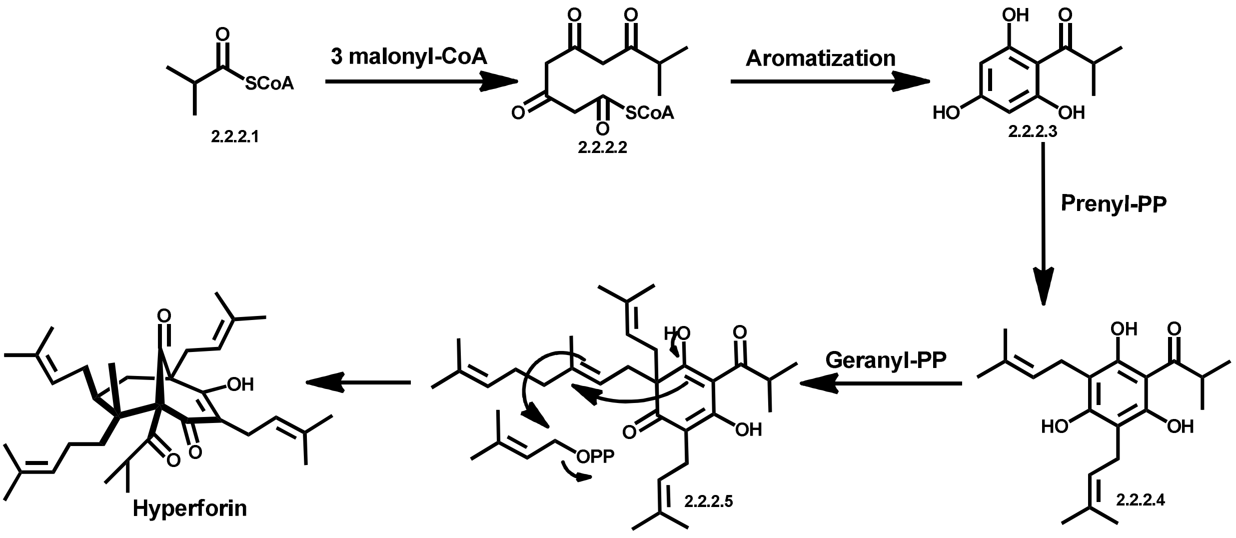


Hyperforin **Garsubellin A** **Nemorosone**

Figure 2.2.1.1 – PPAPs

2.2.2 Biosynthesis

The biosynthesis of PPAPs (**Scheme 2.2.2.1**) such as hyperforin begins with the condensation of one acyl-CoA and three malonyl-CoAs to give the intermediate (**2.2.2.2**). A subsequent Claisen condensation affords the acylphloroglucinol[59]. Electrophilic aromatic substitution to the latter will furnish the prenylated and geranylated acylphloroglucinol. A prenylation followed by a 6-endo cyclization will then form the bicyclo[3.3.1]nonane-1,3,5-trione core to afford hyperforin.



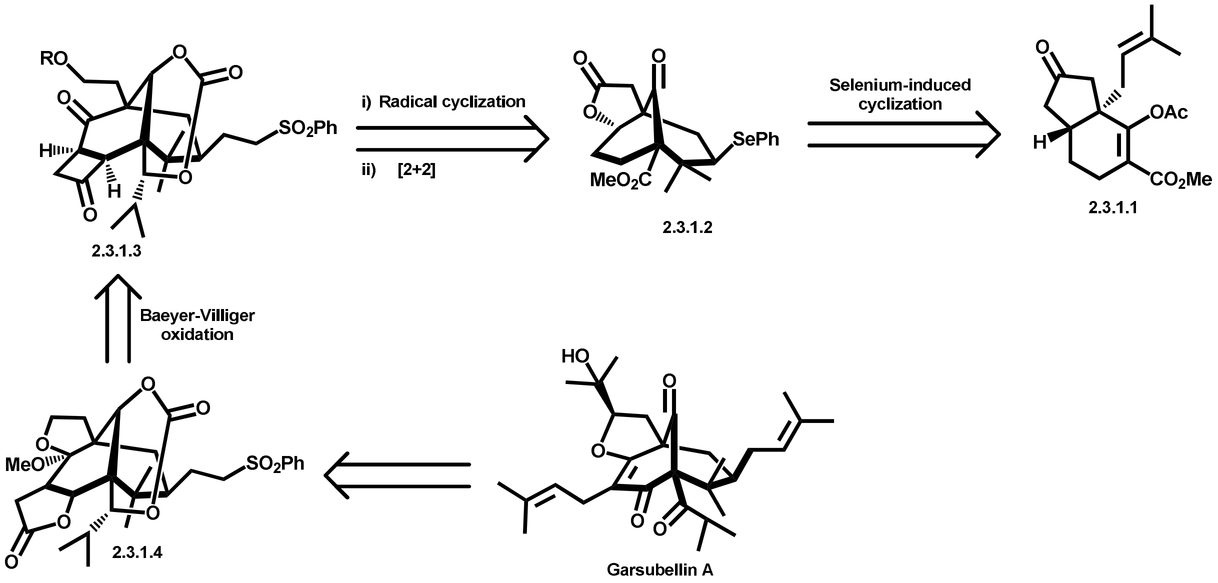
Scheme 2.2.2.1 – Biosynthesis of Hyperforin

2.3 PPAP Core Synthetic Approaches

The therapeutic activity and the complex chemical structure of polycyclic polyprenylated acylphloroglucinols (PPAPs) has attracted attention from several research groups. Many approaches to the synthesis of the acylbicyclo[3.3.1]nonane-2,4,9-trione structure have been published[60].

2.3.1 Nicolaou’s Selenium mediated electrophilic cyclization

Nicolaou was the first to attempt to synthesize the framework of Garsubellin A[61], a PPAP bearing the bicycle-ketone core (**Scheme 2.3.1.1**). The latter was synthesized from the enol-acetate (**2.3.1.1**) by a selenium mediated electrophilic cyclization.

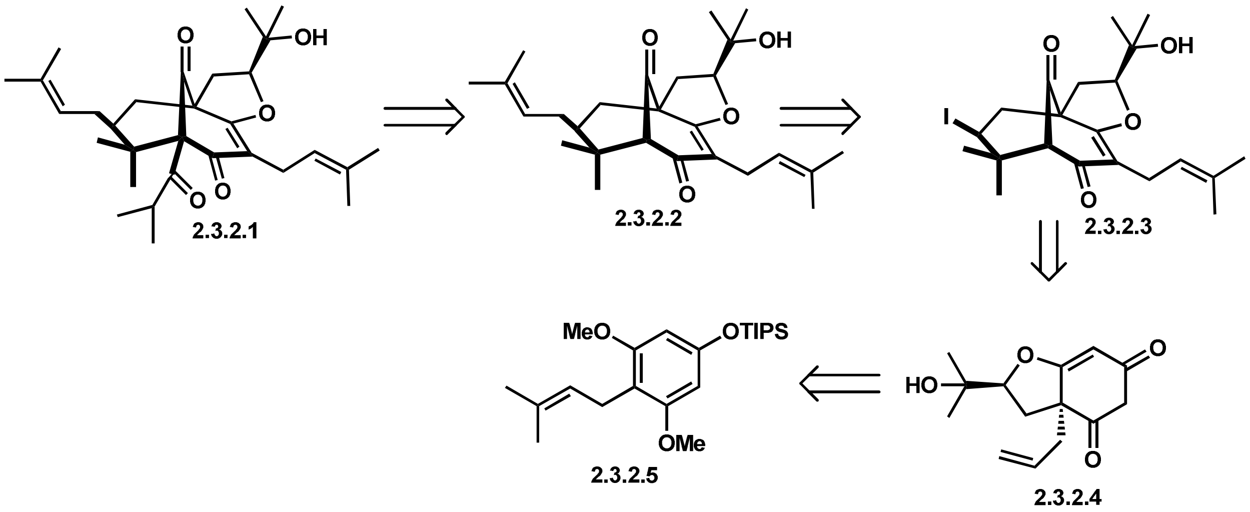


Scheme 2.3.1.1 - Nicolaou's Selenium mediated electrophilic cyclization

The synthesis started with a 1,3-diketone transformed to the intermediate (**2.3.1.1**) by a series of simple known synthetic transformations, including alkylation and cyclization. The compound (**2.3.1.1**) was submitted to the key step cyclization in the presence of *N*-(phenylseleno)phthalimide and tin tetrachloride as a Lewis acid to furnish the bicyclo[3.3.1]nonane-2,4,9-trione core (**2.3.1.2**) in 95% yield. Several steps later including a remarkable photo-induced radical cyclization afforded the advanced intermediate (**2.3.1.3**), however they were not successful to access garsubellin A using this approaches.

2.3.2 Danishefsky’s Iodine mediated electrophilic cyclization

The group of Danishefsky reported the first total synthesis of garsubellin A[62] (**Scheme 2.3.2.1**) using an iodine mediated electrophilic cyclization.

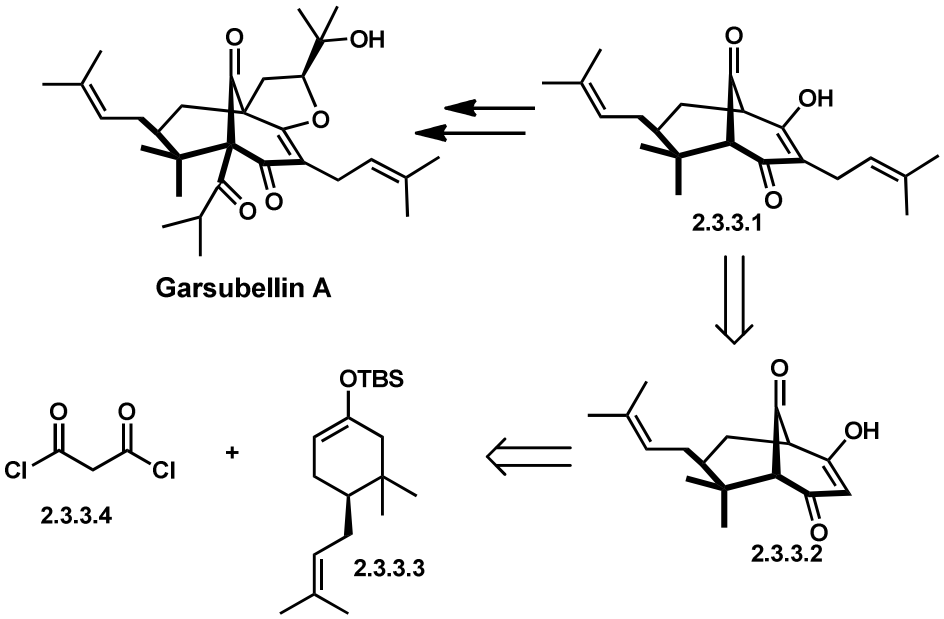


Scheme 2.3.2.1 - Danishefsky’s Iodine mediated electrophilic cyclization

The synthesis started with the protected phloroglucinol (**2.3.2.5**), which gave the bicyclic system (**2.3.2.4**) via an alkylative dearomatization. The bicyclo[3.3.1]nonane-2,4,9-trione core was synthesized via an iodocyclization. From this intermediate, they concluded the synthesis of garsubellin A through a clever de-iodination/re-iodination process and a challenging alkylation at the bridgehead carbon albeit in poor yields. Despite low yield, their synthetic route was challenging and innovative.

2.3.3 Stoltz’s Claisen–Dieckmann approach

Stoltz’s group reported a PPAP synthesis[63] that used an efficient Effenberg[64] cyclization to install the diketone moiety in one single step (**Scheme 2.3.3.1**).

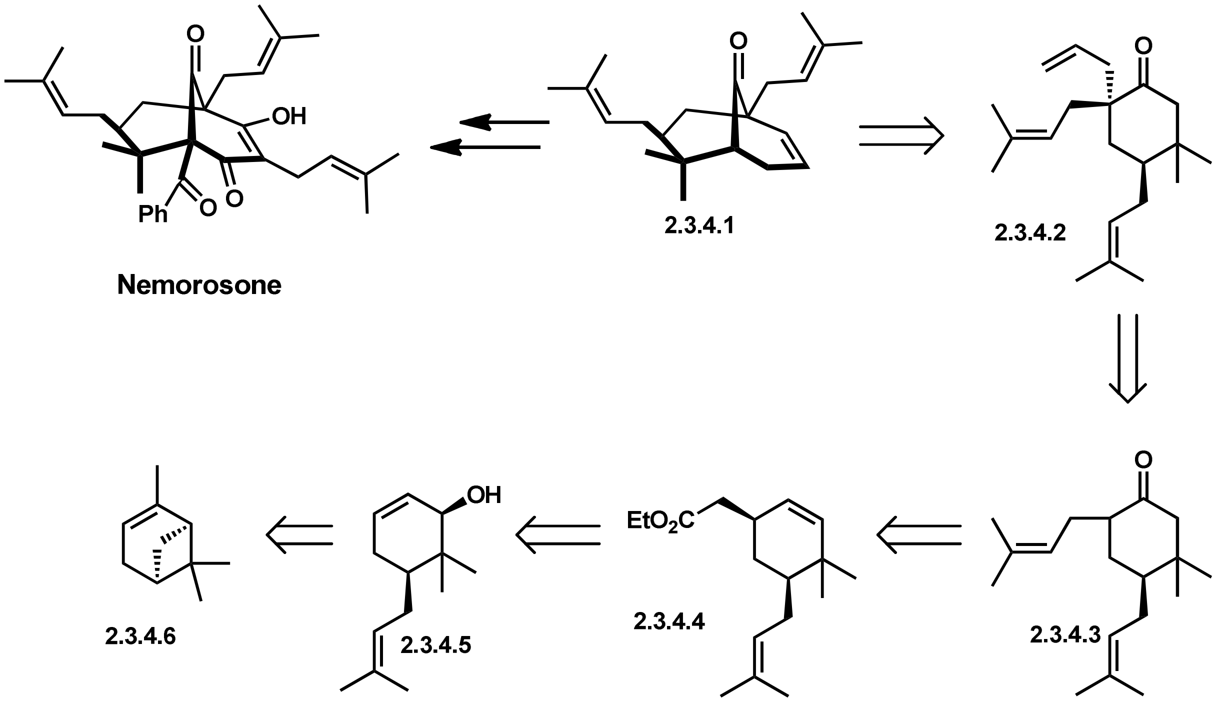


Scheme 2.3.3.1 - Stoltz’s Claisen–Dieckmann approach

From a 1,3-diketone, a series of alkylation lead to the cyclohexyl-enolether (**2.3.3.3**), subsequently it was added to a solution of malonyl chloride to furnish the bicyclo[3.3.1]nonane-2,4,9-trione core by α,α′-annulation in 36% yield. One can imagine a simple straightforward route of alkylation to functionalize the remaining carbons. They succeed in the functionalization of the diketone moiety but any trial to introduce an alkyl group on the bridgehead carbon failed. Steric hindrance can explain the serious impediment to form an anion or an enolate at that position.

2.3.4 Mehta’s Pd-mediated oxidative cyclization approach

Mehta described an approach to nemorosone[65] via a palladium mediated oxidative approach starting from an enantiopure (–)-α-pinene (**Scheme 2.3.4.1**).

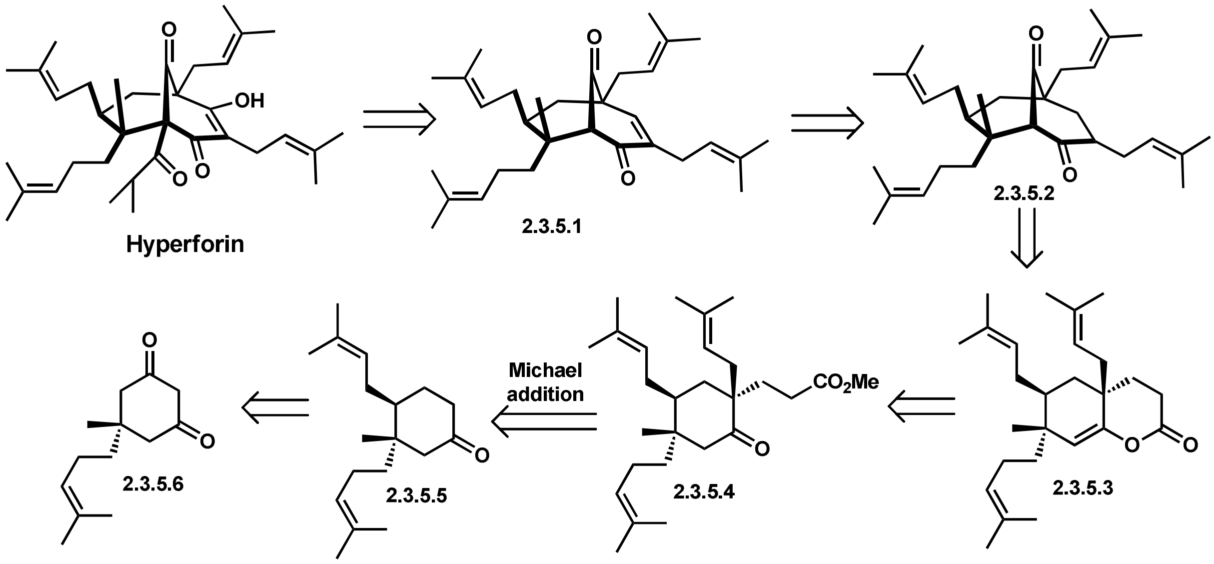


Scheme 2.3.4.1 - Mehta’s Pd-mediated oxidative cyclization approach

They transformed the sparsely functionalized (–)-α-pinene to the advanced intermediate (**2.3.4.5**) through a sequence including a series of alkylation and oxidation. The diprenylated ketone (**2.3.4.2**) was subjected to the key step palladium mediated 6-endo-trig cyclization, using Pd(OAc)$_2$ as a catalyst. The reaction furnished 30% of the desired product and recovered starting material. The advantage of this approach resides in the enantiopur synthesis of the bicyclo[3.3.1]nonane-2,4,9-trione core.

2.3.5 Mehta's Aldol cyclization approach

In 2009, Mehta's group came back with a different approach to PPAPs[66], targeting this time the more structurally complex hyperforin (**Scheme 2.3.5.1**). They followed a more conservation approach dominated by aldol chemistry.

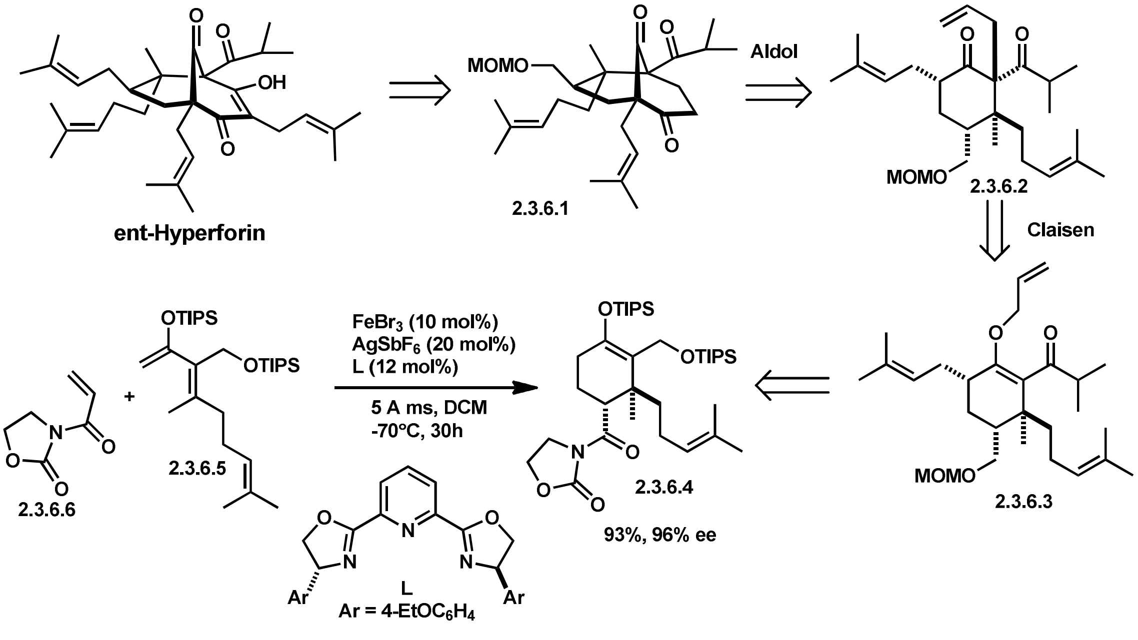


Scheme 2.3.5.1 - Mehta's Aldol cyclization approach

Once again, it took several steps to produce the polyprenylated ketone (**2.3.5.5**). To install stereoselectively the quaternary carbon center by 1,3-stereoinduction, they formed the anion of the latter ketone submitted it to Michael addition with methyl acrylate to form the molecule (**2.3.5.4**). A hydrolysis of the methyl ester followed by the condensation of the enolate on the carboxylic acid gave the bicyclic enol lactone (**2.3.5.3**). They then executed the key retro-aldol/re-aldol reaction cascade. Thus, reduction of enol lactone (**2.3.5.3**) with DIBAL-H triggered the structural reconstitution and delivered the bicyclo[3.3.1]nonane-2,4,9-trione core derivative as a mixture of C-2 hydroxy epimers. The epimeric mixture was next oxidized with PCC to afford the bicyclic diketone (**2.3.5.2**) having the key substitution of the hyperforin core. Further transformations towards the target gave them the highly functionalized core (**2.3.5.1**) with the right stereochemistry compared to hyperforin.

2.3.6 Shibasaki's Diels-Alder /Vinylogous Pummerer reactions approach

An approach using an iron complex catalyzed Diels-Alder reaction to generate a functionalized cyclohexyl silyl enol ether scaffold was developed by the group of Shibasaki[67] (**Scheme 2.3.6.1**). In addition to the high yield (93%), the reaction proves to be highly enantioselective (96% ee) and completely exo selective (d.r. > 33:1). They thus planned a synthetic route based on this efficient [4+2] reaction toward ent-hyperforin[68].



Scheme 2.3.6.1 - Shibasaki's Diels-Alder/Vinylogous Pummerer approach

The intermediate (**2.3.6.4**) was converted into allyl enol ether (**2.3.6.3**) which underwent a sigmatropic Claisen rearrangement to afford the polyalkylated cyclohexanone (**2.3.6.2**). The C8 quaternary stereocenter was found to be crucial on the reactivity and stereoselectivity of the sigmatropic Claisen rearrangement.[69] This stereoselectivity was attributable to the pseudoaxial methyl group at C8 blocking the α face of the intermediate (**Figure 2.3.6.2**).

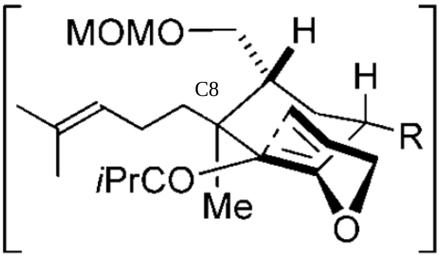
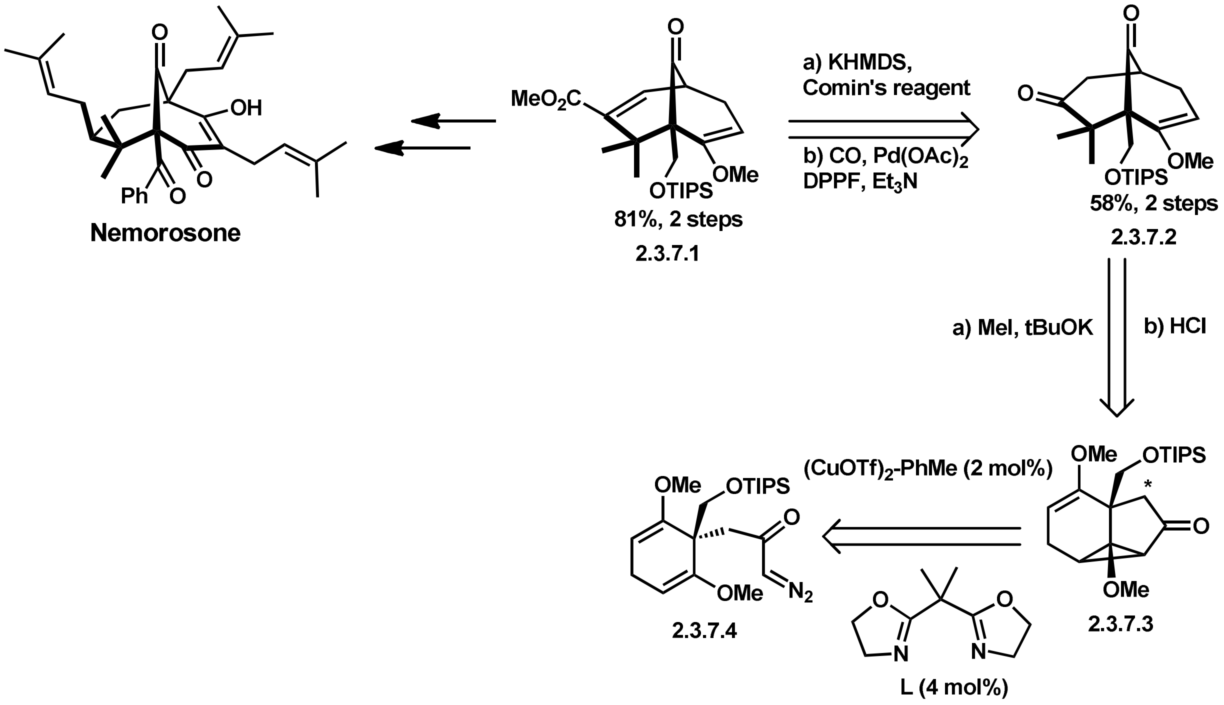


Figure 2.3.6.2 – Stereoselectivity of the Claisen rearrangement

They have accomplished a really low overall yield synthesis of ent-hyperforin carrying out more than 50 steps. However new chemistry has been developed on the route of the quite complex hyperforin structure.

2.3.7 Nakada's acid-mediated cyclopropane ring opening

Nakada's group developed a completely new approach to synthesize the bicyclo[3.3.1]nonanone core (**Scheme 2.3.7.1**) compared to what has been reported above[70]. They proposed an acid-mediated cyclopropane ring opening reaction to access the key bicyclo[3.3.1]nonanone core (**2.3.7.2**).

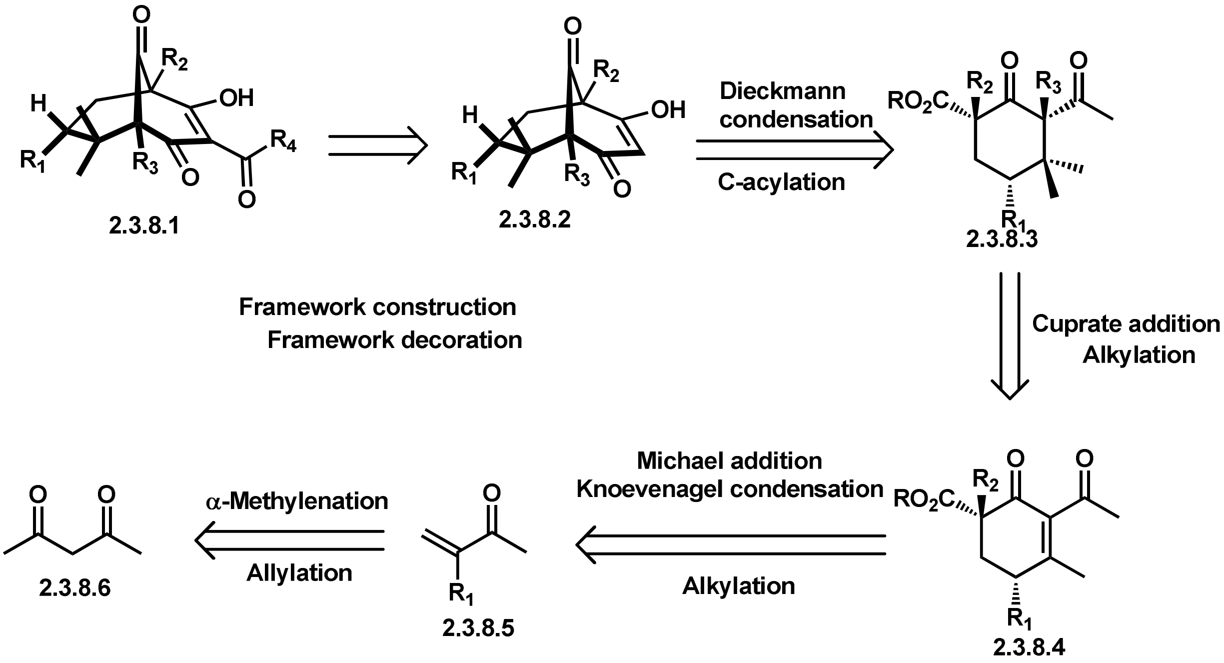


Scheme 2.3.7.1 - Nakada's acid-mediated cyclopropane ring opening

After a Birch reduction to obtain the diazoketone (**2.3.7.4**), they performed a copper catalyzed intramolecular cyclopropanation that furnished the precursor (**2.3.7.3**). Note that this reaction can be further developed to an asymmetric version[71]. Dimethylation of ketone (**2.3.7.3**) was followed by the key step acid-mediated cyclopropane ring opening to give the bicyclo[3.3.1]nonanone (**2.3.7.2**). Despite the fact that the synthesis was long, they realized a remarkable diastereoselective transformation including a substituted bridgehead, avoiding low yielding multistep reactions to subsequently functionalize it.

2.3.8 Plietker's Dieckmann condensation approach

Plietker's group reported several PPAPs[72] (hyperpapuanone, hyperibone L, epi-clusianone and oblongifolin A) syntheses using a common strategy by a Dieckmann cyclization approach (**Scheme 2.3.8.1**) to form the bicyclo[3.3.1]nonanone framework.

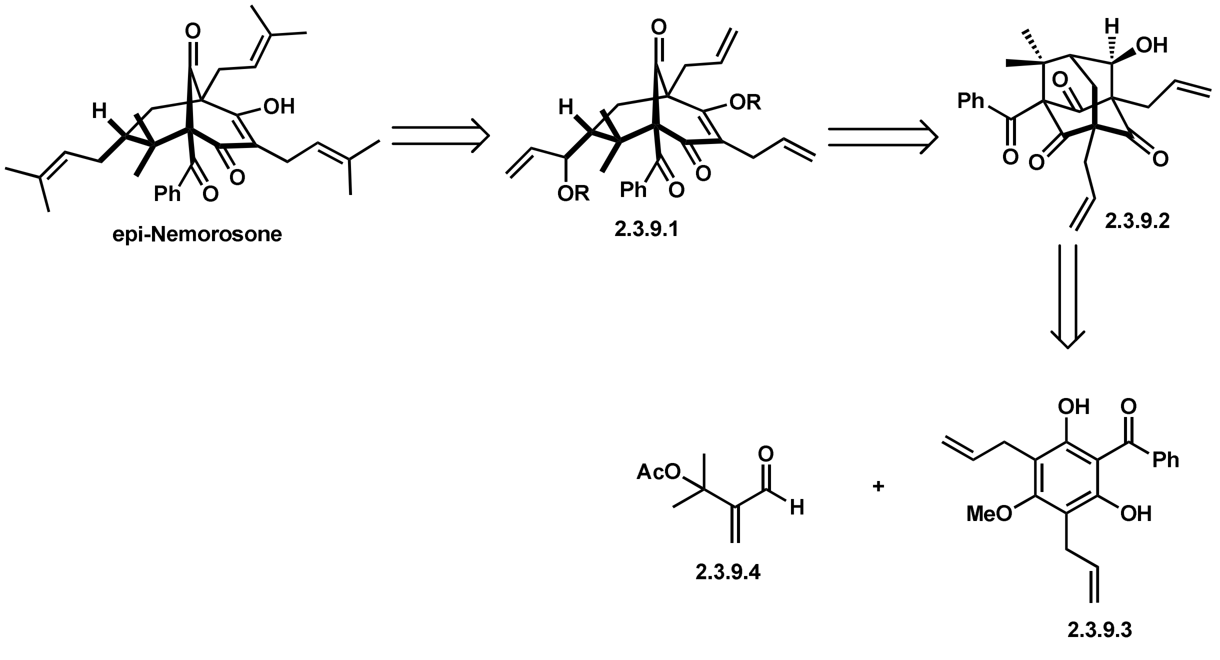


Scheme 2.3.8.1 - Plietker's Dieckmann condensation approach

They synthesized α,β-unsaturated ketones (**2.3.8.5**) in good yields from acetylacetone. Thus, they subsequently performed a tandem Michael addition–Knoevenagel condensation to give the cyclohexenone cores (**2.3.8.4**). After functionalization of the cyclohexene cores, the compounds (**2.3.8.3**) were submitted to basic conditions using potassium tert-butoxide (KO-tBu) to perform the Dieckmann cyclization. To achieve the desired C–C bond formation, the cyclohexanone ring needs to flip from the thermodynamically more stable chair-like into the more reactive boat-like conformation, which brings the reactive centers in close proximity towards each other. The transformation gave the desired product (**2.3.8.2**) in good yield. Noteworthy that the key bicyclo[3.3.1]nonanone framework (**2.3.8.2**)was achieved without the use of protecting groups, employing a practicable and convergent strategy.

2.3.9 Porco's retro-aldol-vinyl cerium addition

Porco and co-workers reported the first total synthesis of (±)-7-epi-nemorosone (**Scheme 2.3.9.1**) via elaboration of a hydroxyl adamantane core scaffold[73]. The bicyclo[3.3.1]nonanone framework (**2.3.9.1**) was derived from organocerium-mediated retro-aldol/vinyl metal addition to adamantane alcohol (**2.3.9.2**).

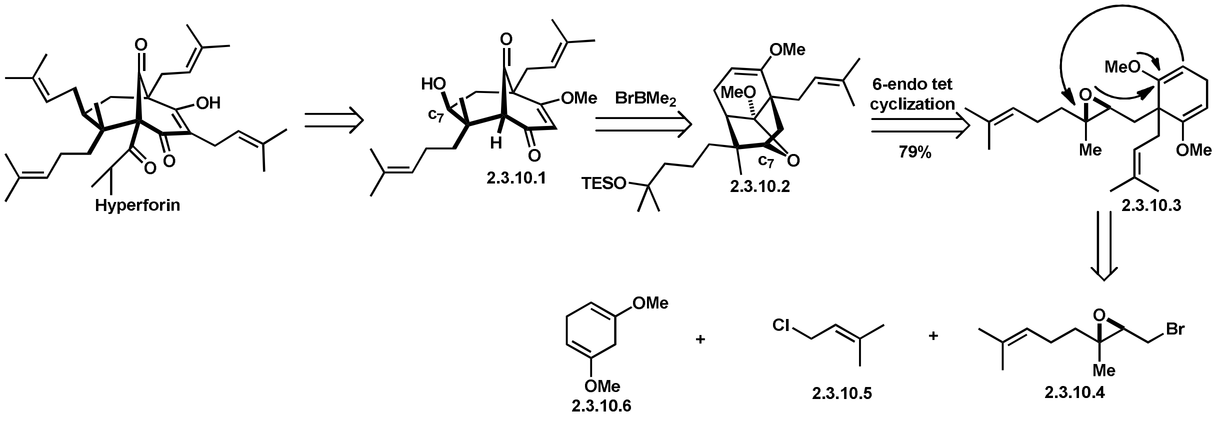


Scheme 2.3.9.1 - Porco's retro-aldol-vinyl cerium addition

The synthesis started with the allylated acylphloroglucinol (**2.3.9.3**) which is dearomatized by conjugated addition to aldehyde (**2.3.9.4**) under basic condition. Then, immediate submission to acidic conditions yielded the key precursor adamantine alcohol (**2.3.9.2**). The bicyclo[3.3.1]nonanone framework (**2.3.9.1**) was obtained by exposure of the adamantane precursor to a preactivated $CeCl_3$/vinylmagnesium bromide mixture which triggered the key tandem retro-aldol condensation/Grignard transformation. After several more transformations, including a palladium-mediated deoxygenation, they achieved the total synthesis of ((±)-7-epi-nemorosone.

2.3.10 Shair's Lewis acid-catalyzed epoxide-opening cascade cyclization

The group of Shair reported the first enantioselective total synthesis of hyperforin[74] via a Lewis-acid catalyzed epoxide-opening cascade cyclization (**Scheme 2.3.10.1**) to form the bicyclo[3.3.1]nonanone scaffold (**2.3.10.1**).

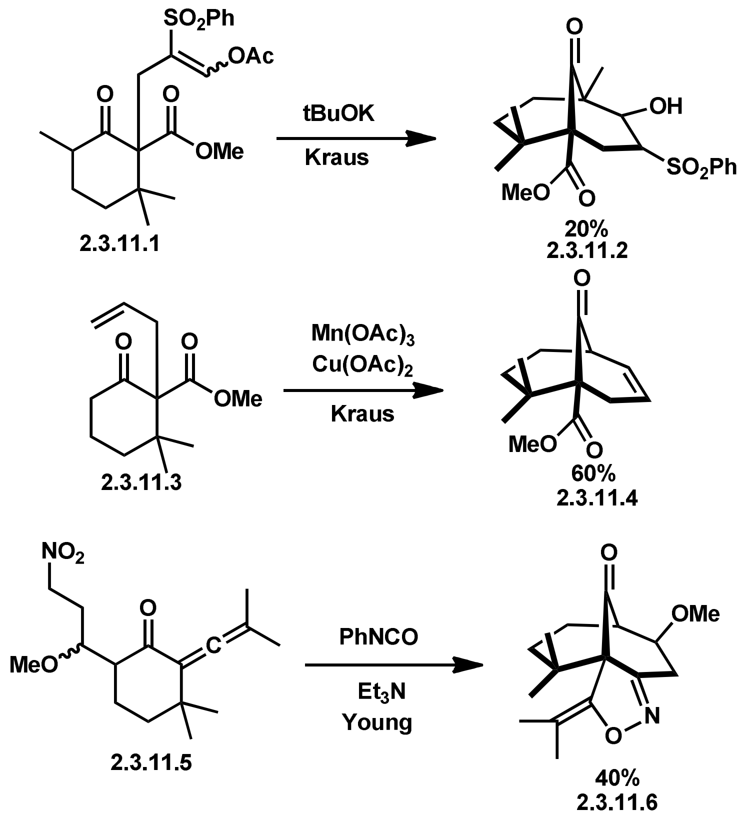


Scheme 2.3.10.1 - Shair's Lewis acid-catalyzed epoxide-opening cascade cyclization

Inspired by the biosynthesis of Hyperforin, the synthesis started with the prenylation of the diene (**2.3.10.5**), followed by a key alkylation to introduce the epoxide moiety (**2.3.10.3**). Then a diastereoselective 6-endo-tet cyclization furnished the unexpected ketal (**2.3.10.2**) with 2 quaternary centers established in 79% yield. The ketal formation happened to be advantageous since it safeguarded the C7 carbinol during the subsequent allylic oxidation step, using TBHP, $PhI(O_2CCF_3)_2$, and O_2 to afford a vinylogous ester. Treatment of the latter with $BrBMe_2$[75] followed by LiTMP to extrude methanol and formed the bicyclo[3.3.1]nonanone scaffold (**2.3.10.1**). Futher chemical transformations including a Keck radical allylation allowed the completion of the first total synthesis of Hyperforin. It is noteworthy that this approach is scalable and took advantage of the latent symmetry elements to get the bicyclo[3.3.1]nonanone core.

2.3.11 Other approaches

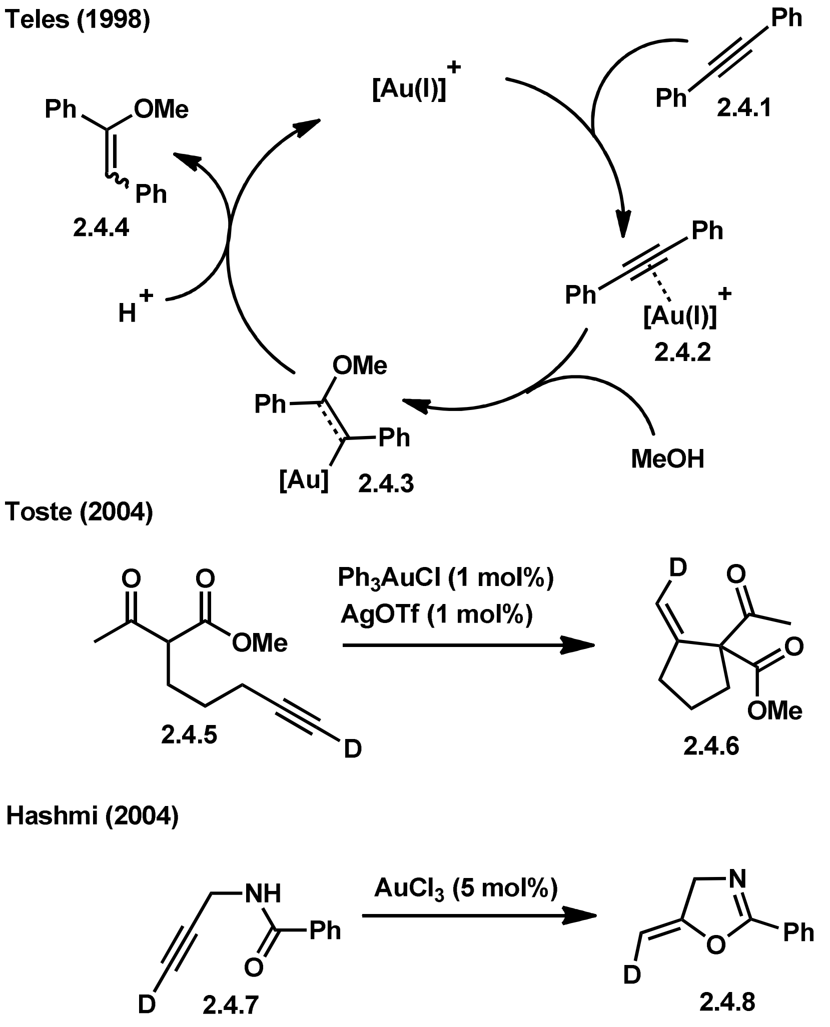
Above, we described a non-exhaustive list of all the effort that has been encountered on PPAP's synthesis. However it is important mentioning Kraus's addition-elimination on sulphonyl ester approach[76], Kraus's manganese(III) mediated oxidative free-radical cyclization of unsaturated β-ketoester[77] and Young's original nitrile-allene cycloaddition[78].



Scheme 2.3.11.1 – Additional PPAP's synthesis approaches

2.4 Gold-Catalyzed Synthesis of Carbon-Bridged Medium-Sized Rings

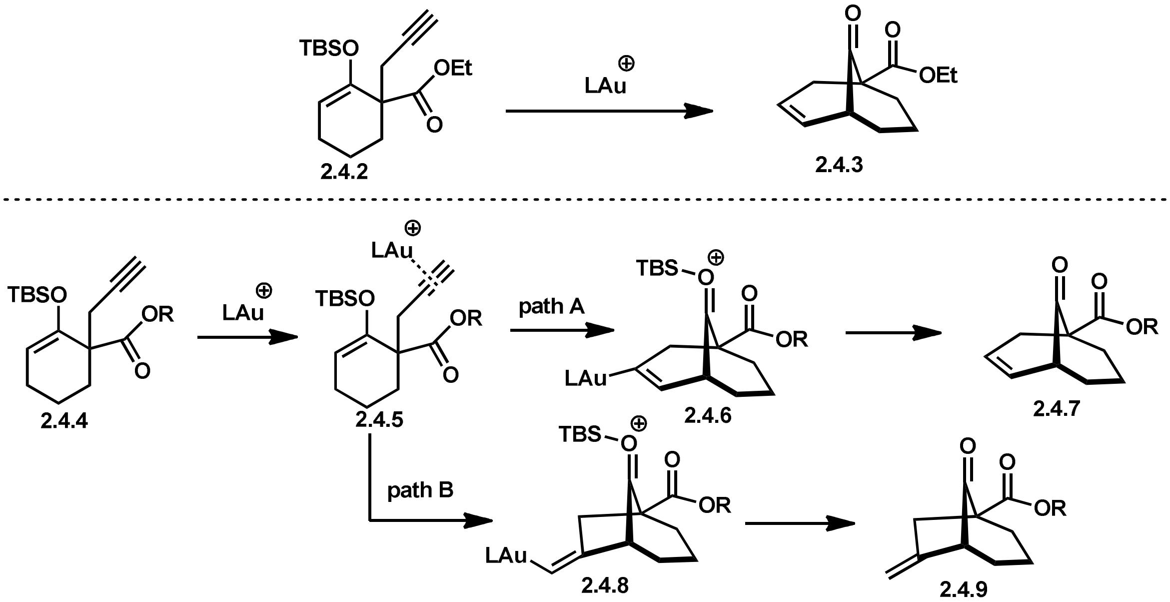
Gold (Au) was believed to be catalytically inactive for C-C bonds formation for quite some time. It was later shown that Au(I) or (III) complexes were more chemoselective and reactive than other soft Lewis acids. Cationic phosphino-gold(I) complexes are selective to π-system, specially alkynes, allenes and alkenes. The activation of π-system with cationic phosphino-gold(I) complexes can be explained by the relativistic effect whereby the contracted 6s and expanded 5d orbitals account for the activity of gold(I) catalysts[79]. The pioneer work of Teles[80] demonstrated that cationic gold(I) complexes catalyze the addition of MeOH to alkynes by lowering the LUMO energy of the Au-alkyne complex (**Scheme 2.4.1**). Thus, protodeauration afford the corresponding enol ether. The reaction mechanism has been detailed by experiments performed independently by Toste[81] and Hashmi[82]. They reveal a mechanism in agreement with an *anti*-addition of the nucleophile and gold complex across the alkyne (cf. intermediate **2.4.3**)



Scheme 2.4.1 - Examples of gold-catalyzed addition of nucleophile into alkynes

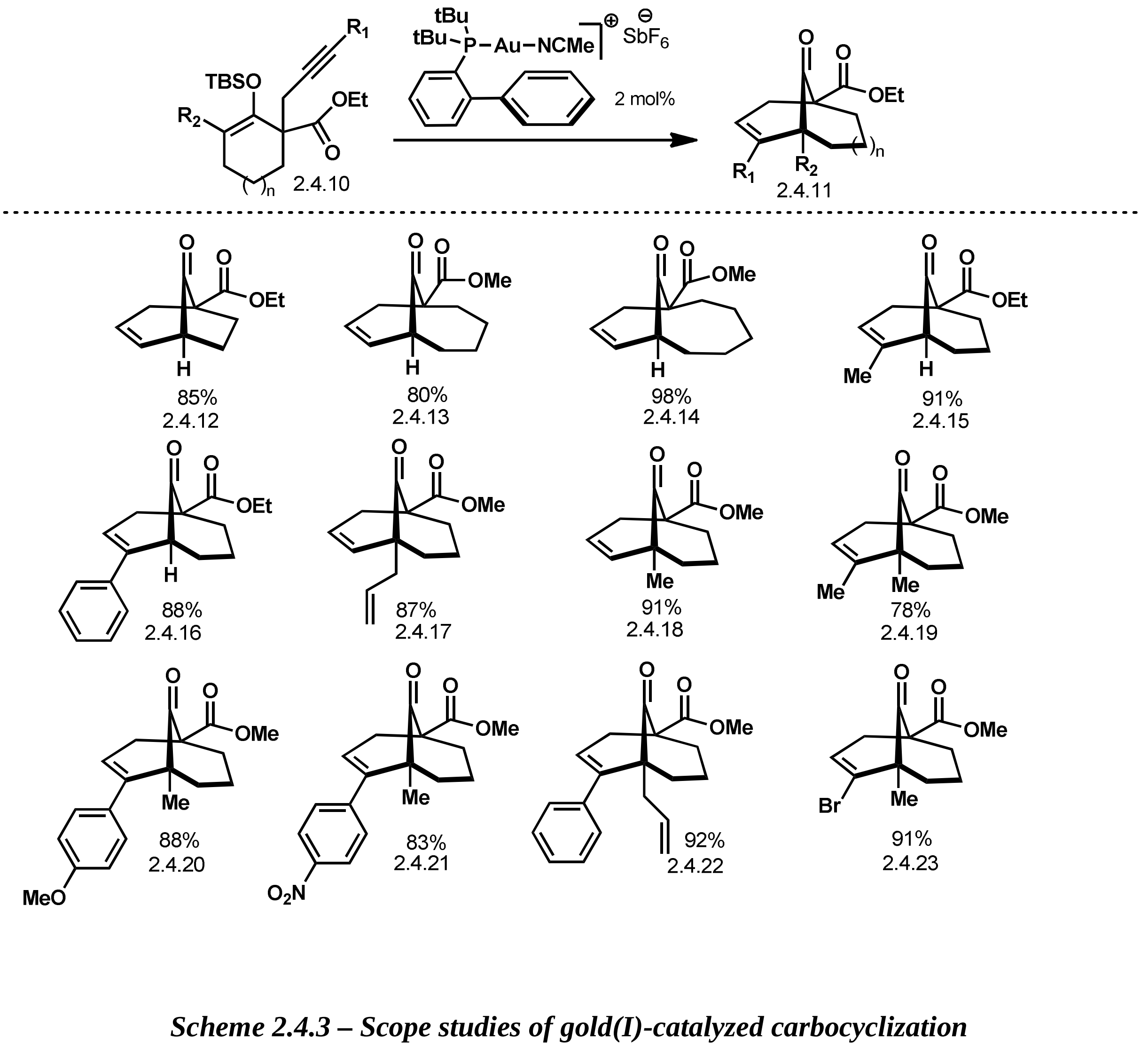
Echavarren and co-workers demonstrated that cationic phosphino gold(I) complexes are versatile catalysts for cycloisomerization of 1,6-enynes[83]. Based on the knowledge of the unique reactivity offered by phosphino gold(I) complex, we envisioned a general strategy to synthesize bridged carbocycles via *6-endo* dig cyclization.

In 2009 Barriault and co-workers reported an efficient method to prepare bicyclo[3.3.1]nonanone core via a gold-catalyzed carbocyclization (**Scheme 2.4.2**)[84]. After activation of the alkyne group by the cationic phosphine gold(I) complex, the cyclic enol ether (**2.4.2**) undergo a 6-endo-dig carbocyclization to furnish the corresponding bicyclo[3.3.1]nonanone (**2.4.3**). The cyclization mechanism can proceed via a 6-*endo* dig process to produce intermediate (**2.4.6**) which after a protodeauration furnishes the desired product (**2.4.7**). However, a competitive 5-*exo* dig cyclization of (**2.4.5**) followed by protodeauration could in principle generate product (**2.4.9**).



Scheme 2.4.2 - Proposed mechanism for the gold(I)-catalyzed carbocyclization

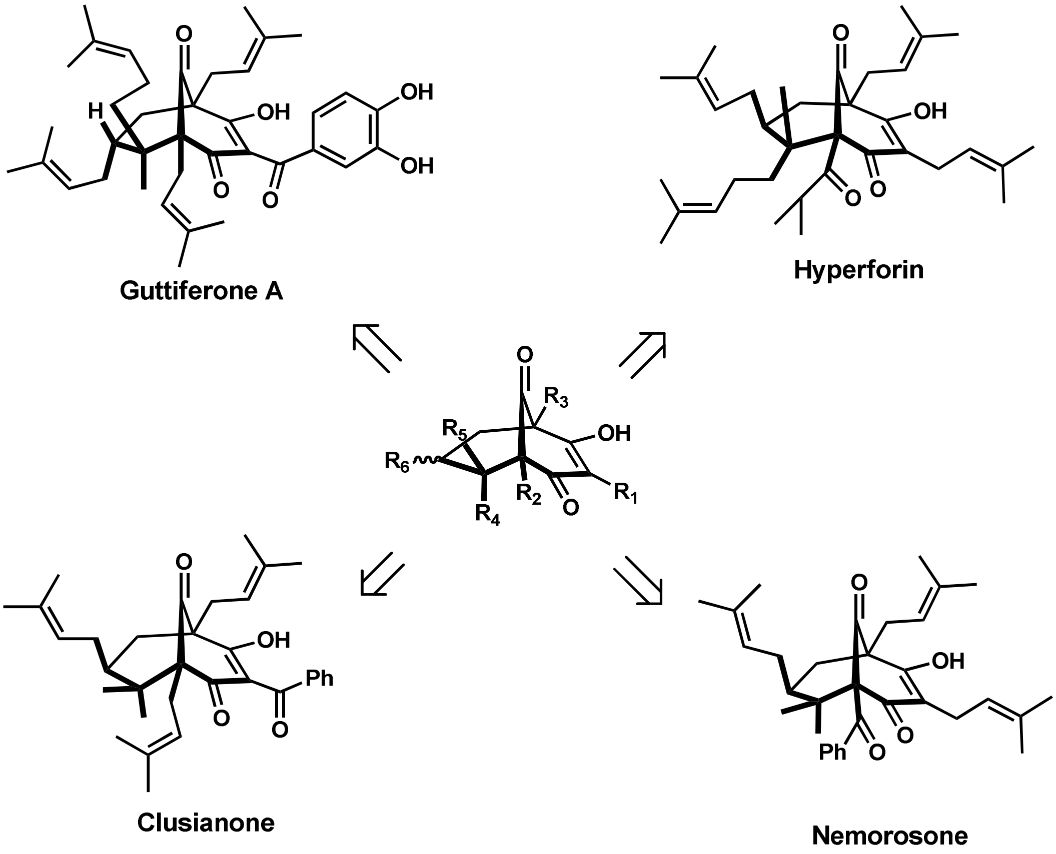
Scope studies of the reaction were performed, showing cyclization of 5, 7 and 8 membered-ring enol ethers to afford the corresponding bridged bicycloalkenones (**2.4.12 – 2.4.23**) in good yields. The carbocyclization of substrates having tetrasubstituted enol ether and internal alkyne gave the desired bicyclo[3.3.1]nonanones with a quaternary carbon center established in high yield.



Scheme 2.4.3 – Scope studies of gold(I)-catalyzed carbocyclization

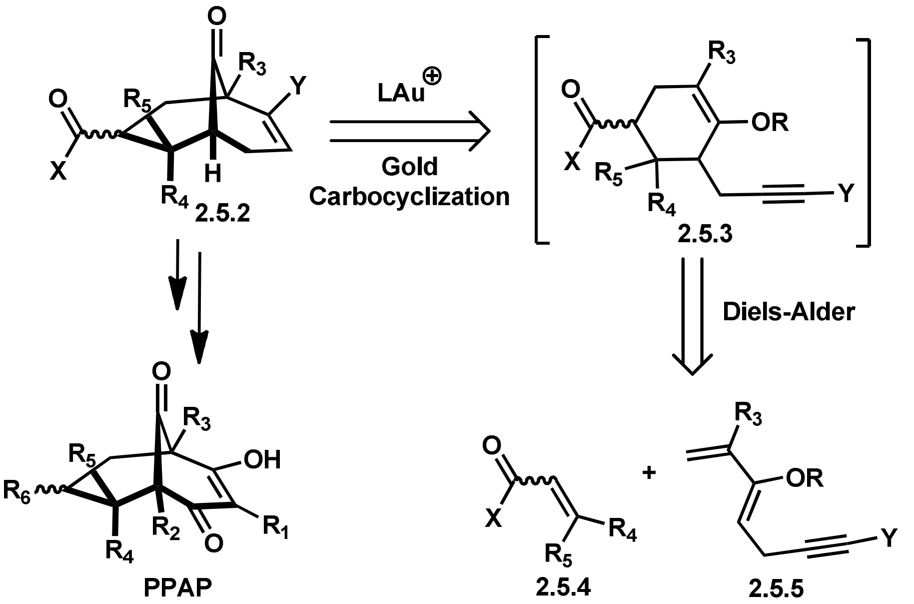
2.5 Retrosynthetic Analysis and New Synthetic Approach of Bicycle[3.3.1]alkenones

The bicyclo[3.3.1]alkenone framework is found in many PPAPs and many bioactive natural products (**Scheme 2.5.1**). The remarkable element of complexity resides on the bridged ketone bearing two quaternary carbon centers. Several methods have been reported tackling the synthesis of the bicyclo[3.3.1]alkenone framework but most of them were specific to a particular scaffold.



Scheme 2.5.1 – Shared bicyclo[3.3.1]alkenone framework in PPAPs

After a retrosynthetic analysis of the bicyclo[3.3.1]nonatrione core, we realized that we can execute a more diversity oriented synthesis of PPAPs by building the core prior to adding substitution. This approach might allow the realization of diversified library for structure activity relationship studies in medicinal chemistry (**Scheme 2.5.2**).



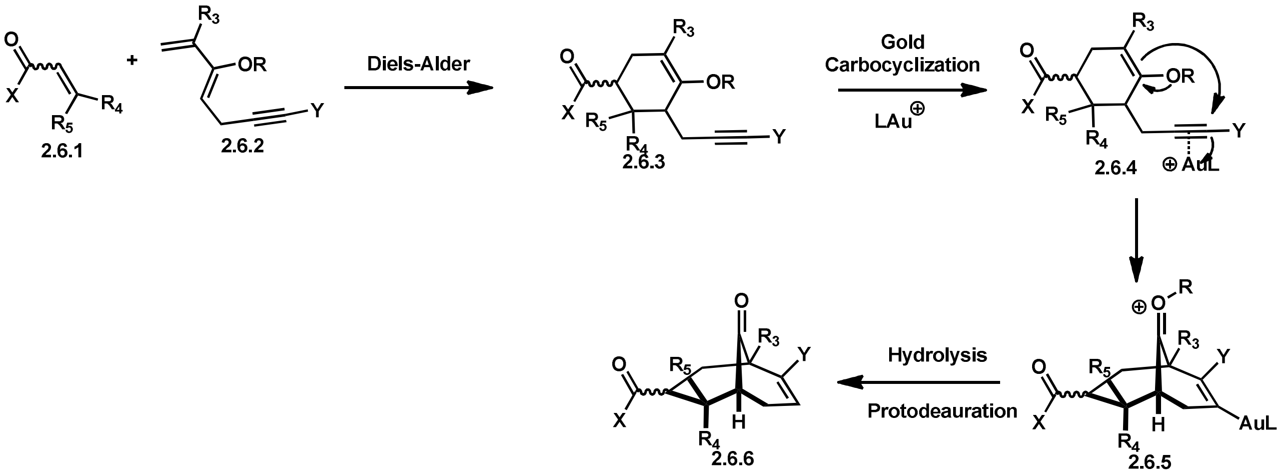
Scheme 2.5.2 – Diversity oriented retrosynthetic analysis of PPAP's scaffold

2.6 One-pot Synthesis of Complex Bicycle[3.3.1]nonenones via a Diels-Alder Cycloaddition/Gold(I)-Catalyzed Carbocyclization

We envisaged a combination of Diels-Alder reaction followed by gold(I)-catalyzed 6-endo-dig cyclization to afford the bicyclo[3.3.1]nonatrione core in a single operation (**Scheme 2.6.1**). Subsequently, the introduction of functional groups onto the core can be done using known transformations.

Proposed Mechanism

The readily available diene (**2.6.2**) would undergo [4+2] cycloaddition to afford the silyl enol ether intermediate (**2.6.3**) which, in the presence of a cationic gold(I) complex, would undergo a 6-endo-dig carbocyclization to furnish the desired bicyclo[3.3.1]alkenone core (**2.6.6**). Futhermore, having the endo or exo cyclo-adduct is fortuitous because we can therefore have access to different PPAPs epimers (example of hyperforin and guttiferone A).

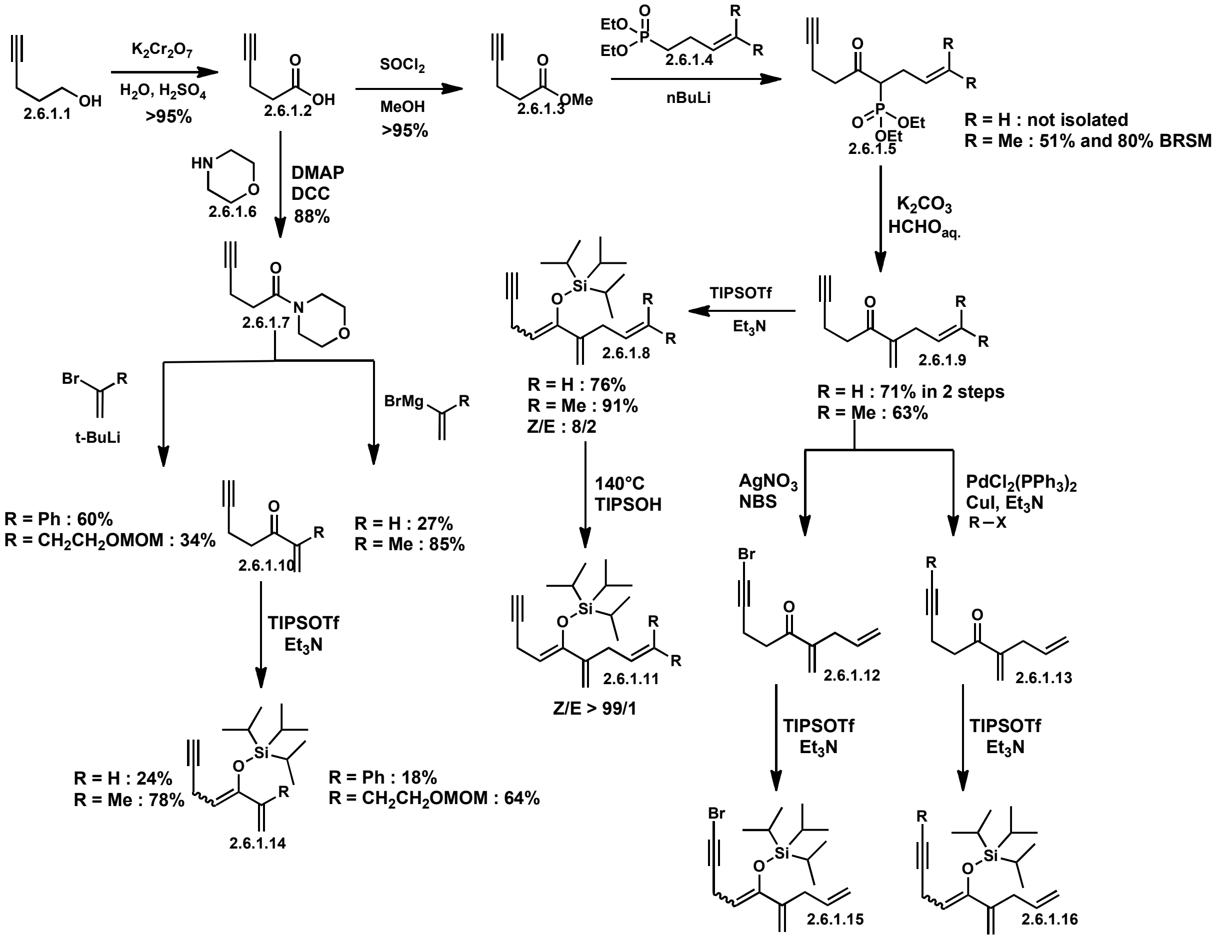


Scheme 2.6.1 – Proposed mechanism of the one pot Diels-Alder/Au(I)-catalyzed 6-endo-dig carbocyclization

2.6.1 Precursors Synthesis

Two main routes were established to reach different functionalities that we wanted to include to the dienes (**Scheme 2.6.1.1**). 4-pentyn-1-ol is oxidized to the carboxylic acid (**2.6.1.2**) with potassium dichromate in quantitative yield. Then it is transformed to amide (**2.6.1.7**) through an amide coupling reaction with DCC with 85% yield. Firstly, the ketones (**2.6.1.10**) with R= H, Me were synthesized via the commercially available Grignard reagents. Then, when R= Ph, -CH_2CH_2OMOM, the alkenyllithium species were prior synthesized. The last step was the formation of the silyl-enol-ether with TIPSOTf and triethylamine.

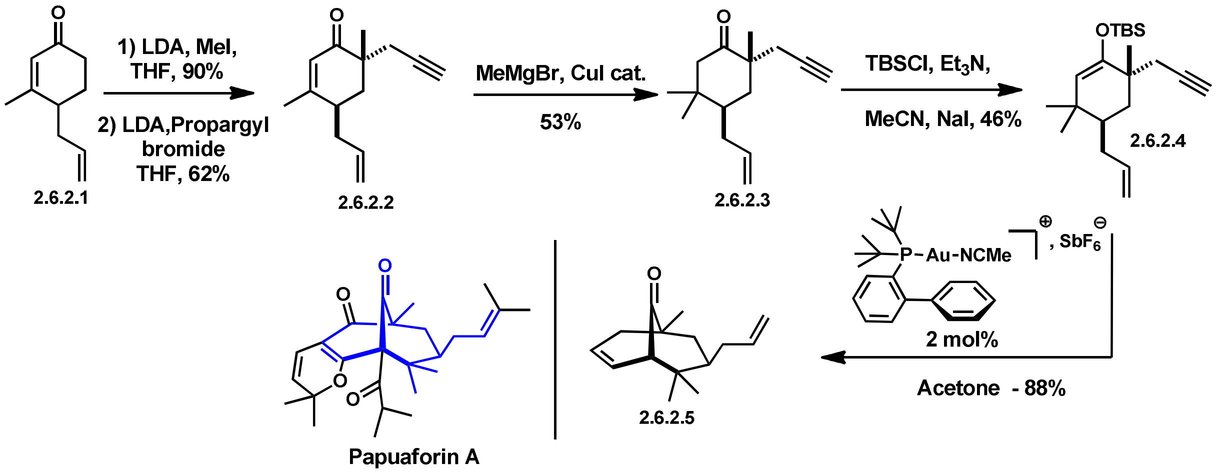
Secondly, another route was used to synthesize the dienes bearing an allyl functionality. The carboxylic acid, common to both routes, was transformed to the methylester quantitatively (**2.6.1.3**). To introduce the enone functionality, an allyl-phosphonate (**2.6.1.4**) is deprotonated with n-BuLi and the methylester was added to the reaction mixture to form the phosphonate (**2.6.1.5**). The crude mixture is submitted to the mild olefination condition using formaldehyde and water to furnish ketones (**2.6.1.9**) in 63% and 71% yield. The alkynyl-aryle compounds (**2.6.1.16**) were synthesized through a palladium catalyzed Sonogashira cross-coupling reaction. The alkynylbromide substrate was formed by a silver catalyzed bromination of the corresponding ketone. The last step was also the formation of the silyl-enol-ether with TIPSOTf and triethylamine.



Scheme 2.6.1.1 – Silyl enol ether dienes synthesis

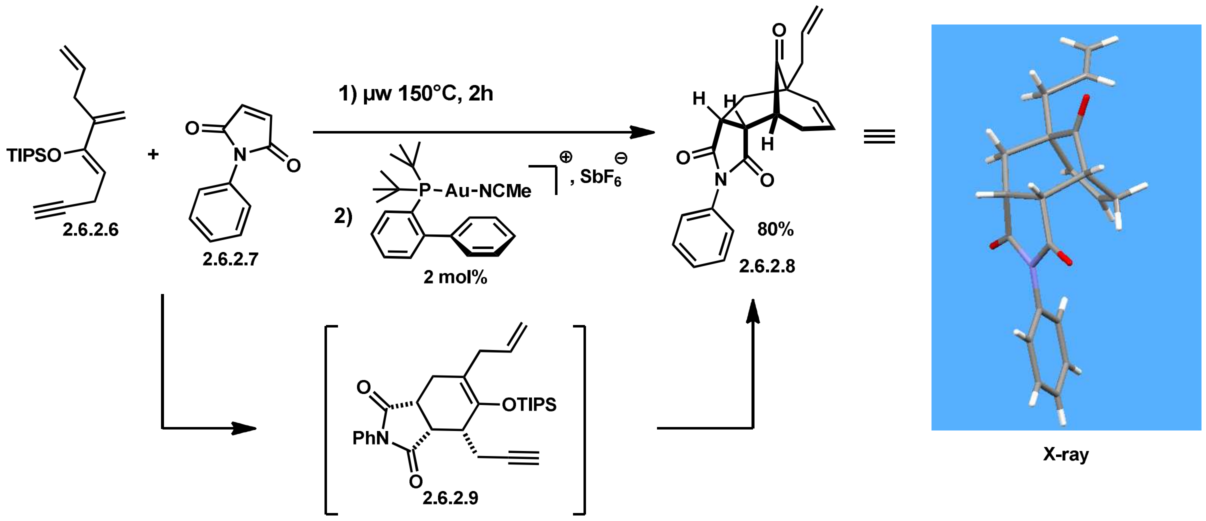
2.6.2 Proof of Concept

As a proof of concept, graduate students G. Bellavance and F. Barabe decided to synthesize the papuaforin B bicyclo[3.3.1]alkenone framework to establish the viability of the the gold(I)-catalyzed 6-endo-dig carbocyclization (**Scheme 2.6.2.1**). The synthesis began by a *C*-alkylation of enone (**2.6.2.1**) using LDA and MeI to give the corresponding ketone in 90% yield. A second alkylation to install the propargyl chain was achieved using LDA and propargyl bromide to give (**2.6.2.2**) in 62% yield as an inseparable mixture of diastereomers (dr = 3:1). Next, conjugate addition of methylmagnesium bromide in the presence of a catalytic amount of CuI provided the corresponding ketone (**2.6.2.3**) in 53% yield. The latter was treated with TBSCl, NaI and triethylamine to give the desired silylenol ether (**2.6.2.4**) in 46% yield which upon exposure to Au(I) complex (2 mol%) provided the desired bicyclo[3.3.1]nonenone (**2.6.2.5**) in 88% yield. It is important to note that the Au(I)-catalyzed cyclization proceed in high yields in a sterically congested environment. The core of papuaforin was achieved in 5 steps from enone (**2.6.2.1**).



Scheme 2.6.2.1 – Papuaforin A core synthesis

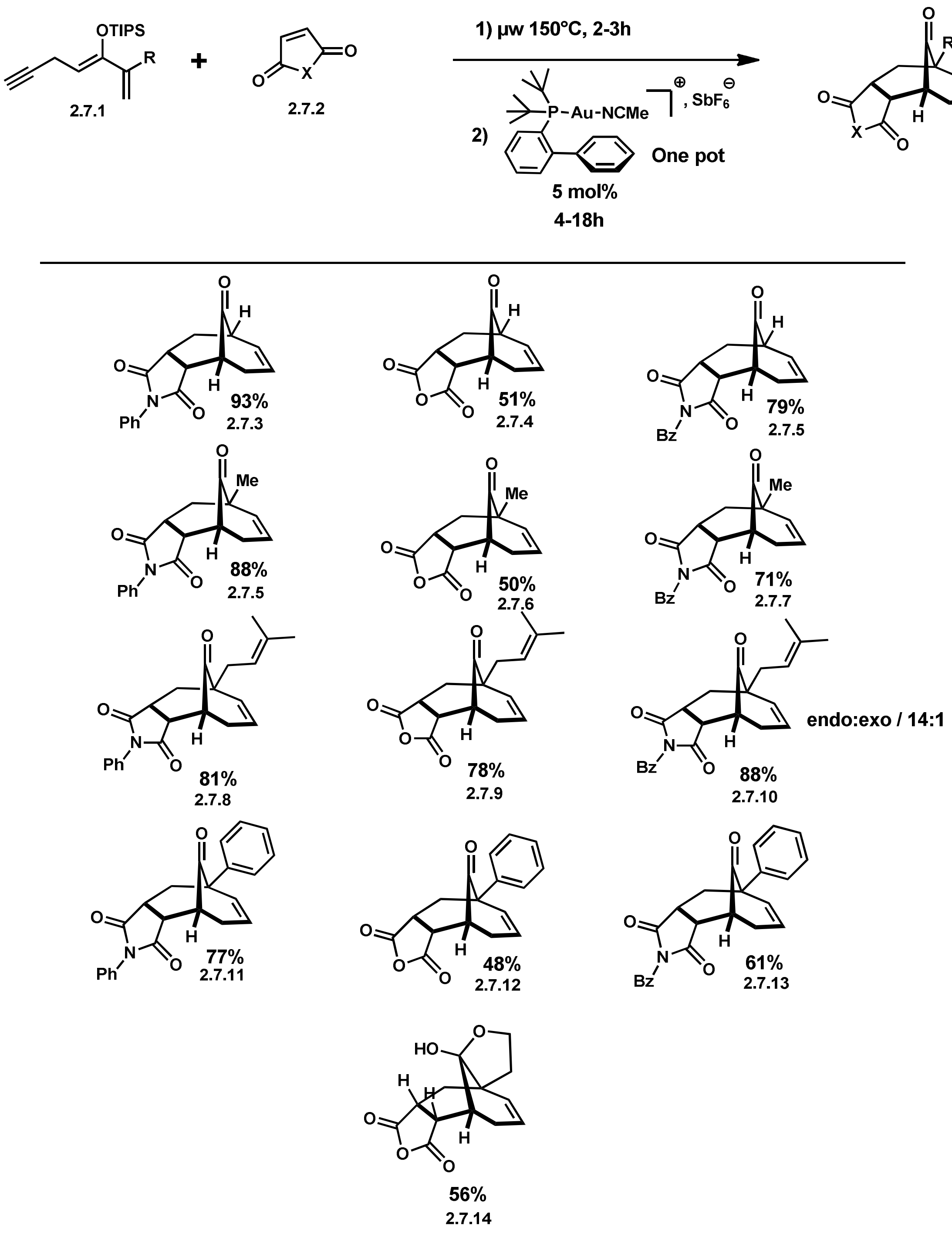
Having established the viability of the the gold(I)-catalyzed 6-endo-dig carbocyclization for the PPAPs core synthesis, we needed to demonstrate that the bicyclo[3.3.1]nonenone core can be directly obtained through a one-pot intermolecular Diels-Alder reaction/Au(I)-catalyzed *6-endo* dig cyclization (**Scheme 2.6.2.2**). Cycloaddition between diene (**2.6.2.6**) and dienophile (**2.6.2.7**) provides cyclohexene (**2.6.2.9**) which in the presence of [LAuNCMe]SbF_6 undergoes a *6-endo* dig cyclization to afford the bridgehead ketone (**2.6.2.8**). To confirm the hypothesis, a solution of diene (**2.6.2.6**) and *N*-phenylmaleimide was heated in toluene at 150°C using microwave irradiation. After stirring for 2 h, the solution containing (**2.6.2.9**) was cooled to room temperature and the gold(I) catalyst [LAuNCMe]SbF_6 was added. The desired ketone (**2.6.2.8**) was isolated in 80% yield (**Scheme 2.6.2.2**), with the relative stereochemistry confirmed by X-ray analysis.



Scheme 2.6.2.2 - Sequential Diels-Alder/Au(I)-catalyzed cyclization

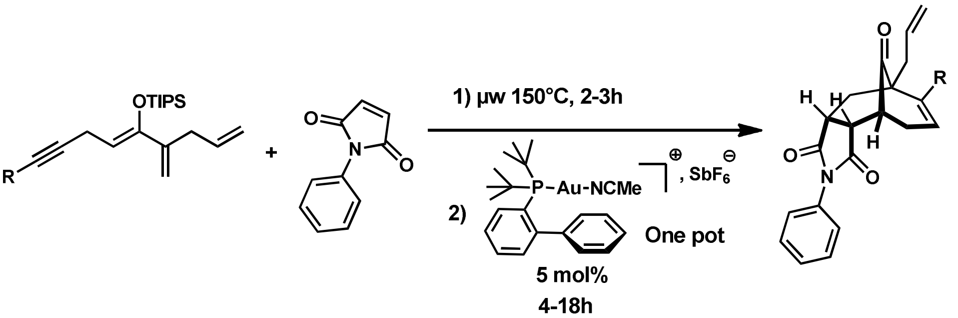
2.7 Scope Studies and Limitations

Next, we evaluated the scope of the reaction (**Scheme 2.7.1**). One pot cycloaddition/cyclization using dienes (**2.7.1**) with dienophiles (**2.7.2**) gave the corresponding ketones in high yields as single diastereomers. The use of maleic anhydride as the dienophile provided the desired products in lower yields of 50-78%. Prenylated diene was smoothly converted to the corresponding ketones in 78-88% yields. Dienes bearing a phenyl group at C2 can be stereoselectively transformed into the desired bridgehead ketones in 48-78% yield. Interestingly, acetal (**2.7.14**) was isolated in 56% yield suggesting that the MOM group was cleaved during the Au(I)-catalyzed carbocyclization. It is important to mention that the *E* isomer of the dienes does not react with the dienophile in the reaction conditions but rather isomerizes to the *Z* form.



Scheme 2.7.1 – Scope studies of the Diels-Alder/Au(I)-catalyzed cyclization

To further extend the scope of the reaction, dienes possessing internal alkynes were also investigated (**Table 2.7.2**). At first glance, large substituents on the alkyne did not affect the reaction. Intermolecular cycloaddition/Au(I)-catalyzed cyclization of aryl acetylene dienes provided the desired ketone (**2.7.16-2.7.18**) in yields ranging from 68% to 91%. Remarkably, enyne (entry 5) was converted to diene (**2.7.19**) in 79% yield.



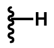
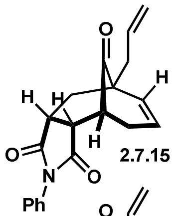
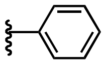
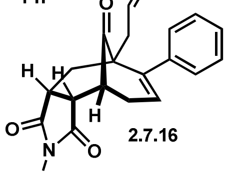
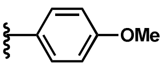
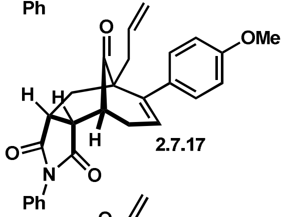
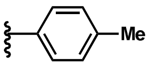
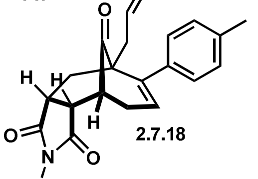
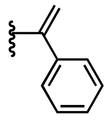
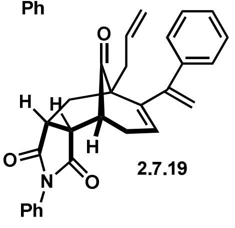
Entry	R	Product	Yield
1		 2.7.15	80%
2		 2.7.16	68%
3		 2.7.17	74%
4		 2.7.18	91%
5		 2.7.19	79%

Table 2.7.2 - One pot Diels-Alder cycloaddition/Au(I)-catalyzed carbocyclization of internal alkynes

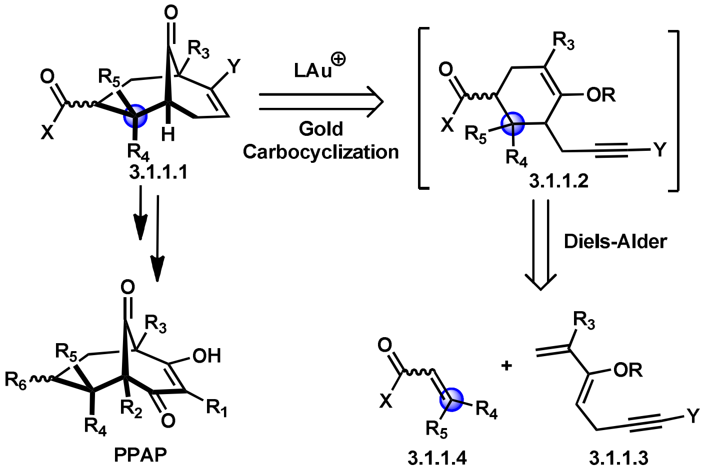
2.8 Conclusion

In summary, we have developed an efficient synthetic approach towards the bicyclo[3.3.1]nonenone core. The attractive feature of this method resides in its ability to construct carbon bridged-medium rings of various sizes, the tolerance towards sterically crowded environment as well as the installment of quaternary carbon centers adjacent to the bridgehead ketone. This one pot Diels-Alder/Au(I)-catalyzed carbocyclization process provides quick access to a library of PPAPs for structure-activity relationships studies.

3. *Framework Design of PPAPs via Highly Hindered Diels-Alder*

3.1 Introduction

The therapeutic activity of polycyclic polyprenylated acylphloroglucinols (PPAPs) has attracted attention from several research groups. Isolated from *Guttiferae* plants, PPAPs are complex chemical structures having a highly oxygenated and densely substituted bicyclo[3.3.1]nonane-1,3,5-trione core which represent significant synthetic challenge for organic chemists. In a retrosynthetic point of view, the bicycle core possesses a sterically hindered quaternary carbon center that could be installed via a direct highly hindered [4+2] cycloaddition between dienophile (**3.1.1.4**) and silyloxydiene (**3.1.1.3**).

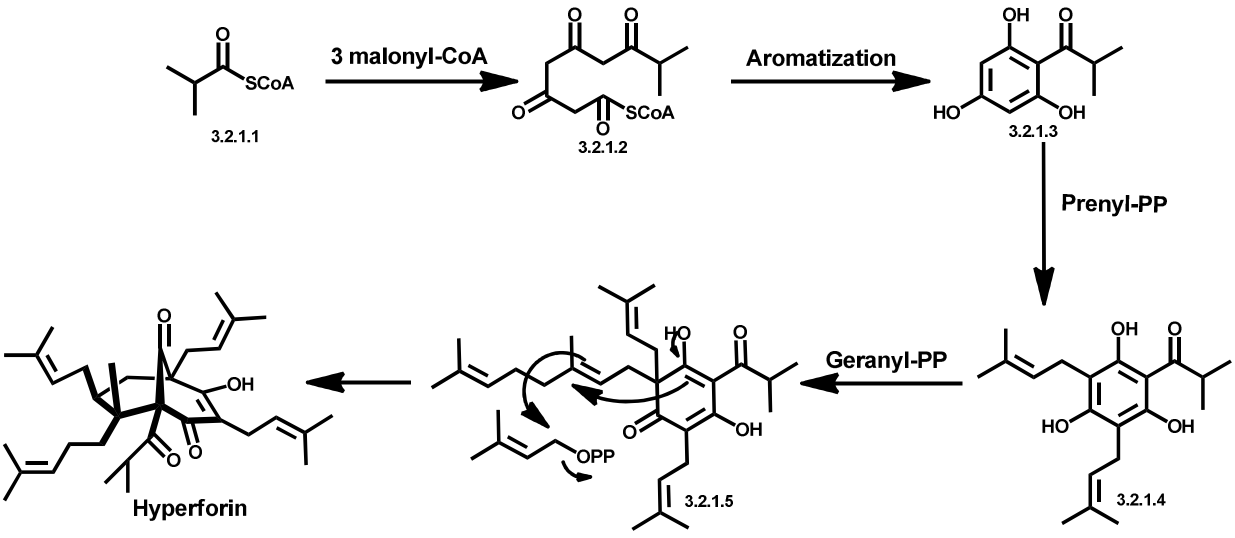


Scheme 3.1.1 – Retrosynthetic analysis of PPAP's scaffold via Highly hindered Diels-Alder

The Diels-Alder reaction is without contradiction a powerful tool for synthetic organic chemistry practitioners to generate stereoselectively six-membered rings. The development of the above method is a significant task owing to severe steric hindrance encountered with highly substituted dienes and dienophiles at the transition state for concerted cycloadditions[85,86,87]. After a thorough review of the literature, we realized that there is a conspicuous paucity of intermolecular Diels-Alder reactions employing an alkyl-β,β-disubstituted dienophile. The very few examples found in the literature required the use of cyclic dienophiles[88], autoclave temperatures[89], high pressure[90] and Lewis acids[91]. In this chapter, the development of a new efficient method for the Diels-Alder reaction of sterically hindered dienophiles aimed at constructing PPAPs frameworks is discussed.

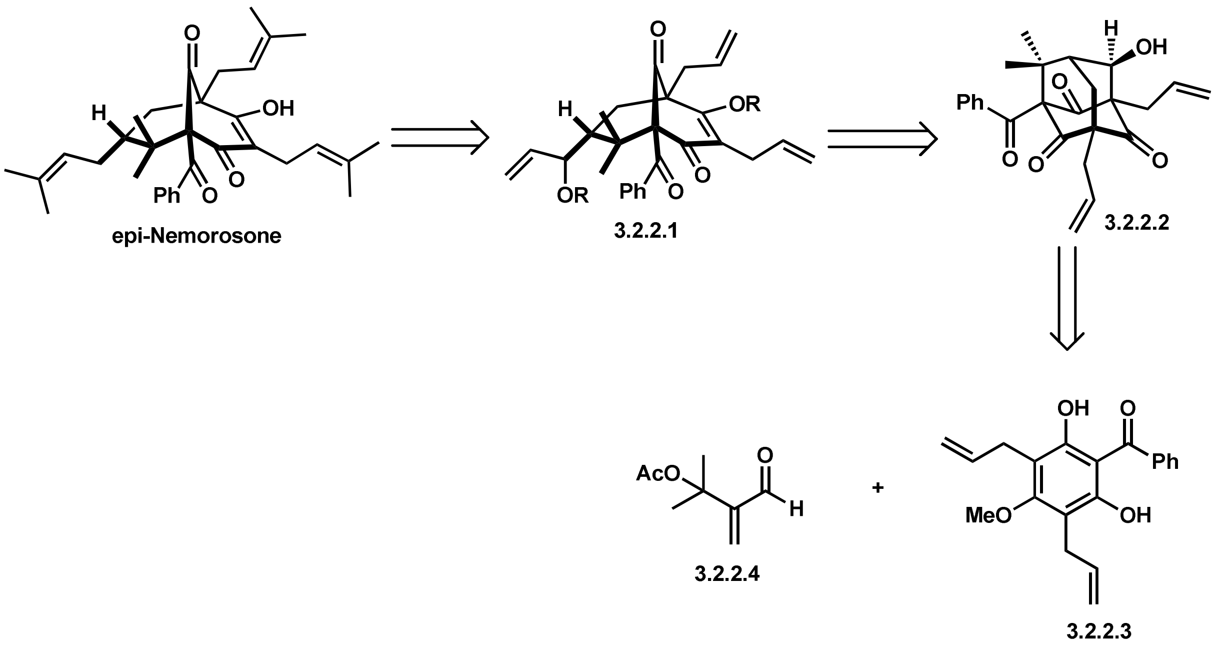
3.2 PPAPs scaffold synthesis via a dearomatization approach

The biosynthesis of PPAPs (**Scheme 3.2.1**) begins with the condensation of one acyl-CoA and three malonyl-CoAs to give the intermediate (**3.2.1.2**). A subsequent Claisen condensation affords the acylphloroglucinol[92]. Electrophilic aromatic substitution of the latter furnishes the prenylated and geranylated acylphloroglucinol (**3.2.1.5**). A *6-endo* trig cyclization produces the bicyclo[3.3.1]nonane-1,3,5-trione core, which is immediately alkylated to afford hyperforin.



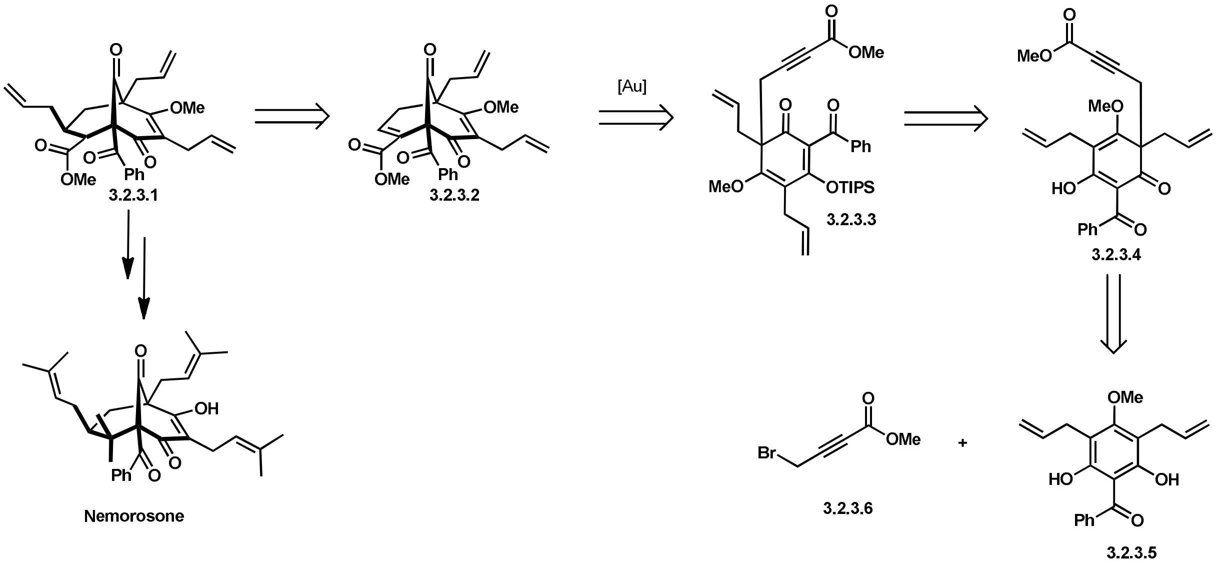
Scheme 3.2.1 – Biosynthesis of Hyperforin

Drawing inspiration of the PPAPs biogenesis, Porco and co-workers designed a very clever approach for the total synthesis of (±)-7-epi-nemorosone using electrophilic dearomatization of alcohol (**3.2.2.3**) (**Scheme 3.2.2**)[93]. They dearomatized the allylated acylphloroglucinol (**3.2.2.3**) by conjugated addition to aldehyde (**3.2.2.4**) under basic condition. Then, immediate submission to acidic conditions yielded the key precursor adamantine alcohol (**3.2.2.2**). The bicyclo[3.3.1]nonanone framework (**3.2.2.1**) was obtained by exposure of the adamantane precursor to a preactivated $CeCl_3$/vinylmagnesium bromide mixture which triggered the key tandem retro-aldol condensation/Grignard transformation. After several more transformations, including a palladium-mediated deoxygenation, they achieved the total synthesis of ((±)-7-epi-nemorosone.



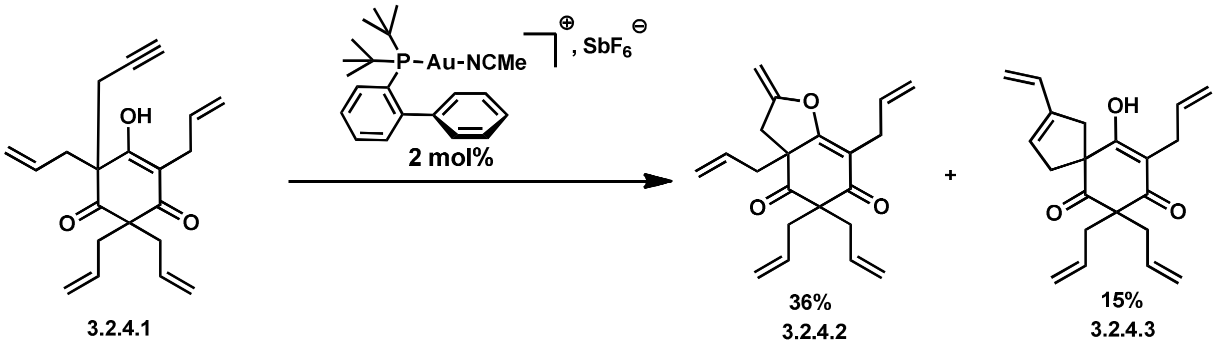
Scheme 3.2.2 - Porco’s retro-aldol-vinyl cerium addition

We envisioned to use our gold catalyzed 6-*endo* dig cyclization reaction on a dearomatized phloroglucinol by a propargyl bromide alkylation to install the functionalization on the second part of the bicyclo[3.3.1]nonane-1,3,5-trione core bearing the quaternary carbon center. Phloroglucinol (**3.2.3.5**) and propargyl bromide (**3.2.3.5**) will undergo electrophilic aromatic substitution to afford the dearomatized intermediate (**3.2.3.4**). Thus silyl enol ether formation is performed to afford the key product (**3.2.3.3**). Gold(I)-catalyzed 6-*endo* dig cyclization would afford the desired bicyclo[3.3.1]alkenone core that can be further easily functionalized to reach the targeted nemorosone.



Scheme 3.2.3 – Dearomatization / Gold cyclization approach

In spite of a promising retrosynthetic analysis, unexpected results depicted in scheme (**3.2.4**) led us to question the further viability of the gold catalyzed carbocyclization in this approach. Much to our chagrin, the gold(I)-catalyzed cyclization of alkyne (**3.2.4.1**) gave a mixture of *5-exo* dig and cycloisomerization products (**3.2.4.2** and **3.2.4.3**) in 36% and 15% yields respectively. Given that we wanted to use a propargyl group bearing an electron withdrawing moiety, the cycloisomerization side reaction will become a major competitive pathway.

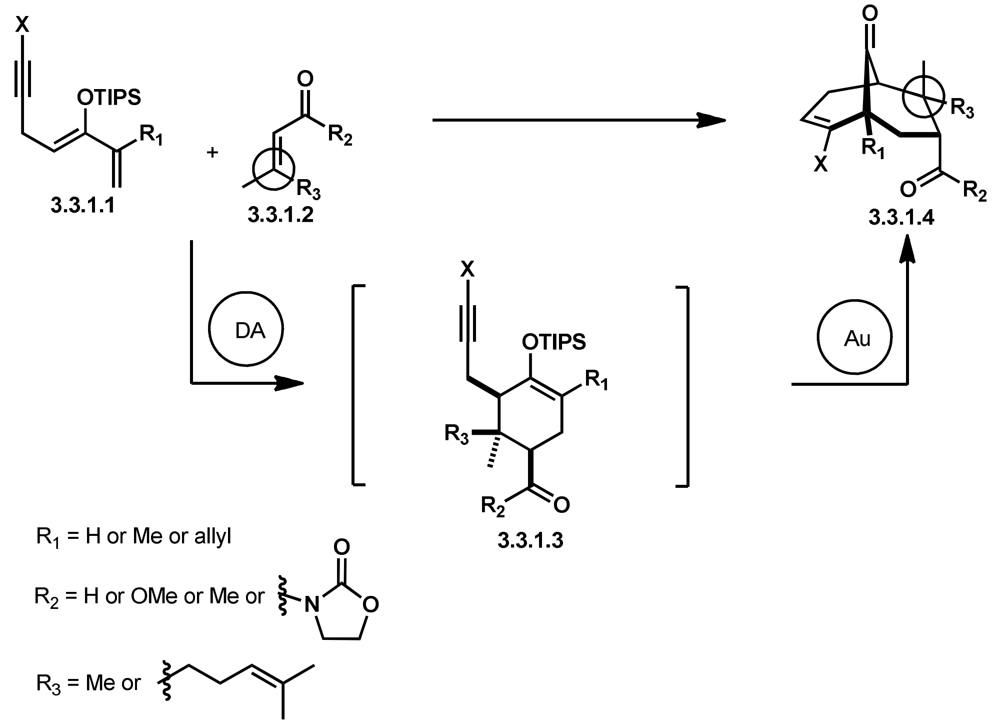


Scheme 3.2.4 – Unexpected 5-exo dig and cycloisomerization reactions

Based on this observation, we have decided to put this approach on hold and developed another strategy in which the bicyclo[3.3.1]alkenone core bearing the quaternary carbon center will be constructed first by the [4+2] cycloaddition followed by a electrophilic reaction (**Scheme 3.1.1**).

3.3 PPAPs scaffold synthesis via a highly hindered Diels-Alder approach

As previously described in chapter two, we were able to build the bicyclo[3.3.1]alkenone framework with a sequential Diels-Alder cycloaddition/gold(I)-catalyzed carbocyclization in a broad scope. However, it remains the challenging formation of the quaternary carbon center via the [4+2] cycloaddition. There are two obstacles to achieve the realization of this goal; the steric hindrance and the electron donation to the LUMO caused by the β,β–dialkyl-substitution on the dienophile. These factors make the formation of the intermediate (**3.3.1.3**) very difficult to realize (**Scheme 3.3.1**). The development of new reaction conditions to make feasible such highly hindered Diels-Alder is of paramount importance.

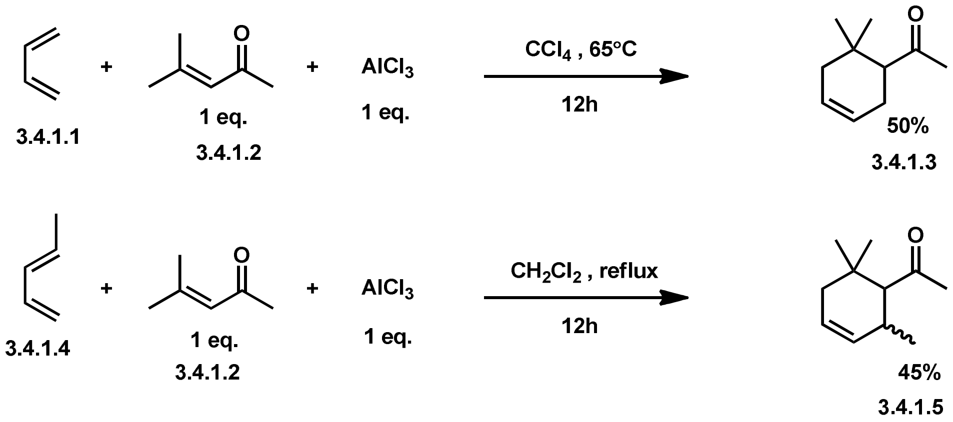


Scheme 3.3.1 - PPAPs scaffold synthesis via a highly hindered Diels-Alder approach

3.4 Literature survey of highly hindered Diels-Alder

It is well established that intermolecular Diels-Alder reactions employing alkyl-β,β-disubstituted dienophiles are difficult, often leading to the cycloadduct in very low yield. Owing to this inherent difficulty, there are very few examples reported in the literature. Most of them required cyclic dienophiles, autoclave temperatures, high pressure and strong Lewis acids. Steric hindrance is the main source of the problem.

Cookson et al. synthesized Damascone (**Scheme 3.4.1**) via a Diels-Alder reaction requiring the use of a strong Lewis acid and heat concurrently[94]. The reaction provided adequate yields but these forcing reaction conditions induced high polymerization rate of the diene.

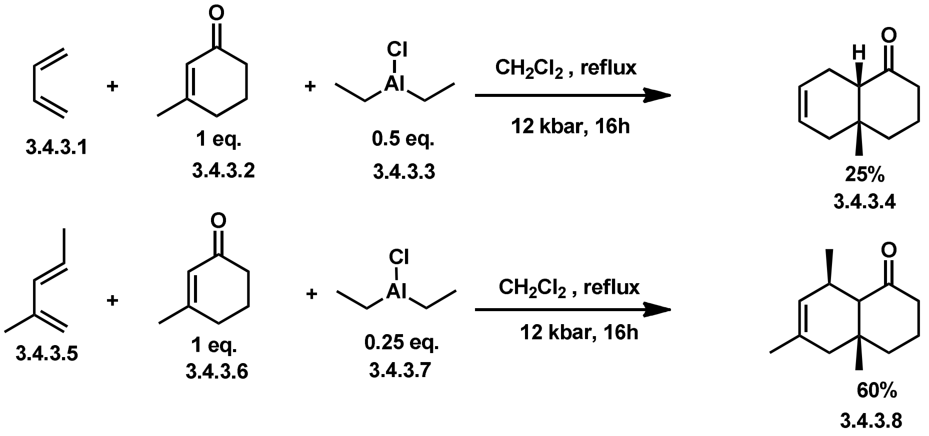


Scheme 3.4.1 – Synthesis of 6-Damascone

More recently, the use of ionic liquids (**Scheme 3.4.2**) coupled with zinc Lewis acid at high temperature has been reported to shorten the reaction time in sterically demanding Diels-Alder reaction.[95]

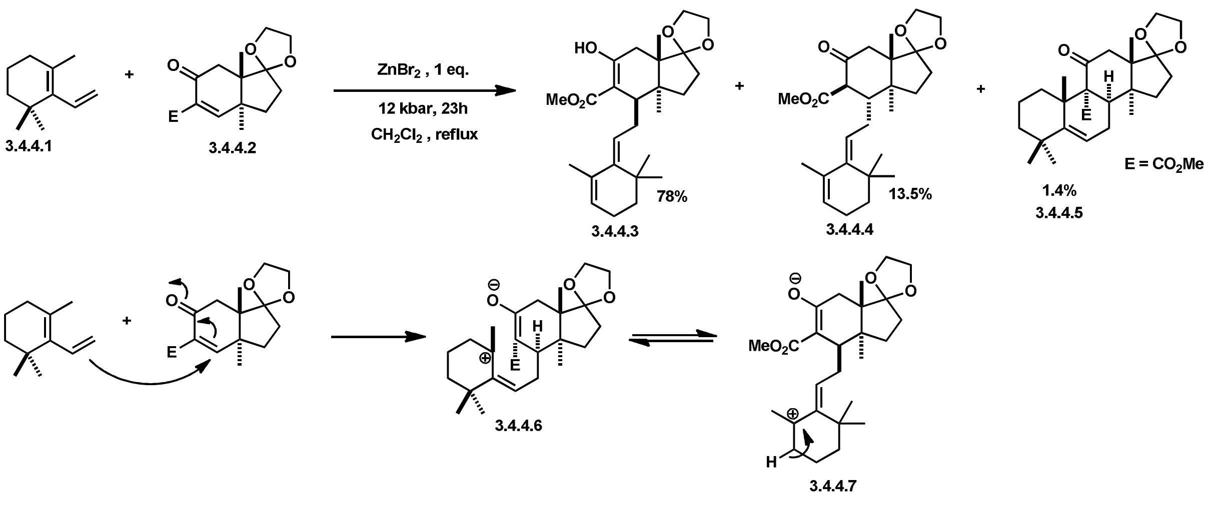
Scheme 3.4.2 – Highly hindered Diels-Alder using ionic liquids

Cyclohexenones are less reactive dienophiles for the Diels-Alder reaction due to the twist chair ring conformation. [4+2] Cycloaddition between methyl cyclohexenone (**3.4.3.2**) and butadienes (**3.4.3.1**) and (**3.4.3.5**) required the use of not only boiling dichloromethane, Et_2AlCl but also 12 kbar high pressure setup to furnish the cycloadduct (**3.4.3.4**) and (**3.4.3.7**) in low to average yields[96] (**Scheme 3.4.3**).



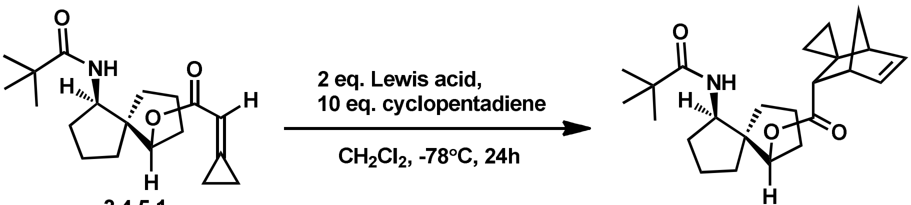
Scheme 3.4.3 – Diethylaluminum mediated highly hindered Diels-Alder reactions

Engler et al. described an approach towards tetra- and pentacyclic triterpenes employing a highly hindered Diels-Alder reaction between diene (**3.4.4.1**) and a highly activated dienophile (**3.4.4.2**) (**Scheme 3.4.4**).[97] Forcing conditions such as refluxing dichloromethane, high pressure and 100 mol% of $ZnBr_2$ were used to furnish only trace amounts of the desired cycloadduct (**3.4.4.5**). Most of the conversion led to products of Michael addition followed by proton transfer (**3.4.4.3** and **3.4.4.4**). The sterically encumbered transition state for the Diels-Alder reaction must be higher in energy compared to the one for the Michael addition.



Scheme 3.4.4 – Synthetic approach towards triterpenes

In order to have access to cycloadducts containing a dimethyl quaternary carbon center, Keay's group used a cyclopropylidene-containing dienophile[98] (**Scheme 3.4.5**). The Diels-Alder reaction with dienophile (**3.4.5.1**) provided the spiro-cycloadduct (**3.4.5.2**) in which the cyclopropyl ring is hydrogenated to provide the *gem*-dimethyl moiety. However, the reaction required two equivalent of BBr_3 as Lewis acid available. Noteworthy, Et_2AlCl gave only 10% conversion, showing the limits of the reaction.



3.4.5.1

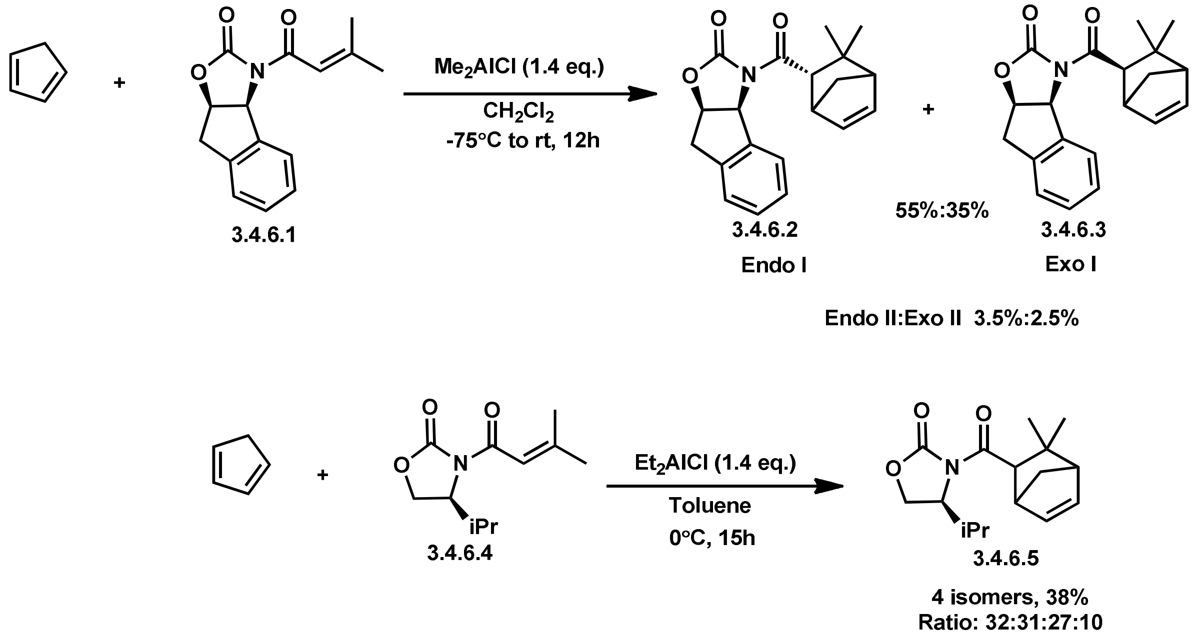
3.4.5.2

Lewis acid	conversion (%)
BBr_3	100
$AlCl_3$	100
BCl_3	87
$EtAlCl_2$	90
Et_2AlCl	10

Scheme 3.4.5 – Diels-Alder with cyclopropylidene-containing dienophile

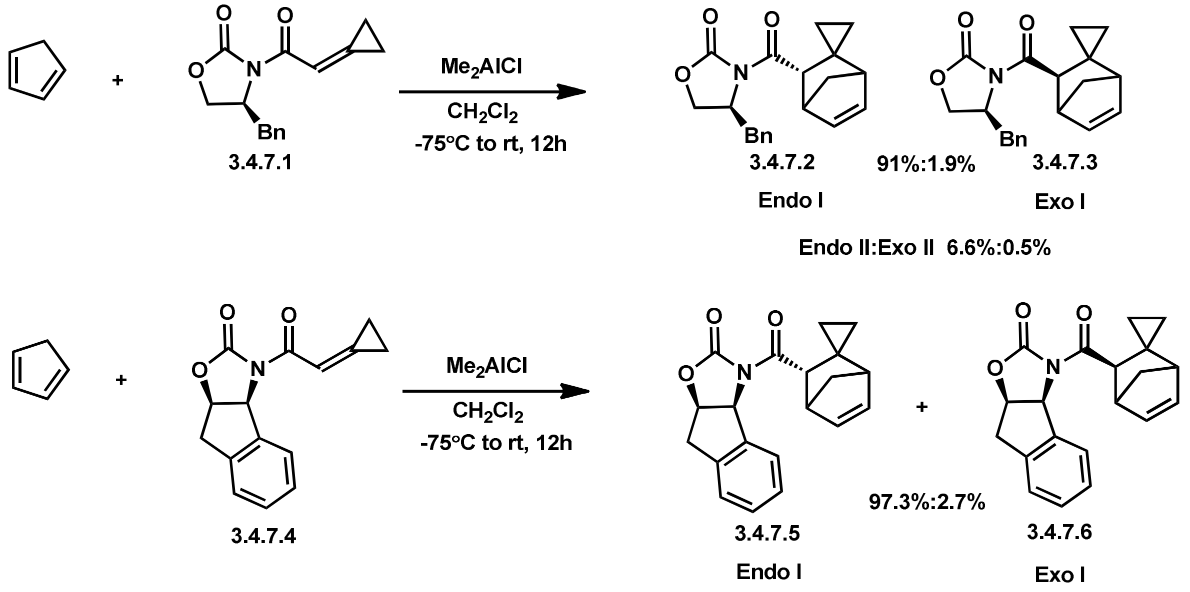
Process chemists in the Merck research department, developed an efficient route for the construction of the *gem*-dimethylnorbornyl carboxylic acid (**Scheme 3.4.6**). They have employed an asymmetric Diels-Alder reaction between *β,β*-cyclopropyl-α,β-unsaturated *N*-acyloxazolidinones and cyclopentadiene to offer a rapid method for the preparation of spirocyclopropyl norbornyl carboxylic acid[99].

Treatment of dienophile (**3.4.6.1**) with Me_2AlCl in the presence of cyclopentadiene at low temperature resulted in no reaction. Upon warming to room temperature and stirring for 12 h, the reaction afforded the mixture of cycloadduct diastereomers in a 53:35:3.5:2.5 ratio and 79% combined yield that you can directly compared to the reported Diels-Alder reaction performed on a dimethyl *N*-acyloxaxolidinone by the Evans group[100]. This result demonstrated that the conformationally constrained *cis*-aminoindanone auxiliary provided a bias for approach of the dienophile, however no real facial selectivity was observed.



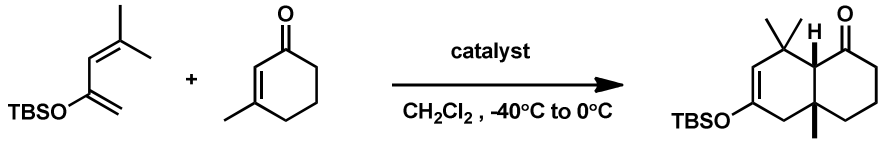
Scheme 3.4.6 – Highly Hindered Diels-Alder with β,β-dimethyl containing dienophile

Using the *β,β*-cyclopropyl-α,β-unsaturated *N*-acyloxazolidinone (**3.4.7.1**) bearing a benzyl group, they were able to increase the reactivity and the diastereoselectivity of the reaction (**Scheme 3.4.7**). This result is related to the fact that the cyclopropyl ring applies less steric hindrance and is probably less inductively electron donating than a *gem*-dimethyl. Combination of the cyclopropyl strategy with the conformationally constrained *cis*-aminoindanone auxiliary solved the issue of facial selectivity.



Scheme 3.4.7 – Highly Hindered Diels-Alder with β,β-cyclopropyl containing dienophile

Jung's group developed another powerful methodology[101,102,103] (**Scheme 3.4.8**) limited to conjugated ketones using triflimide aluminum as catalyst. The reaction is fast, diastereoselective and proceeds with high yields.



entry	catalyst	time (h)	yield (%)
1	Tf_2NH (5 mol%)	4	92
2	$MeAl(NTf_2)_2$ (5 mol%)	0.5	94
3	$AlBr_3/AlMe_3$ (50 mol%)	48	82

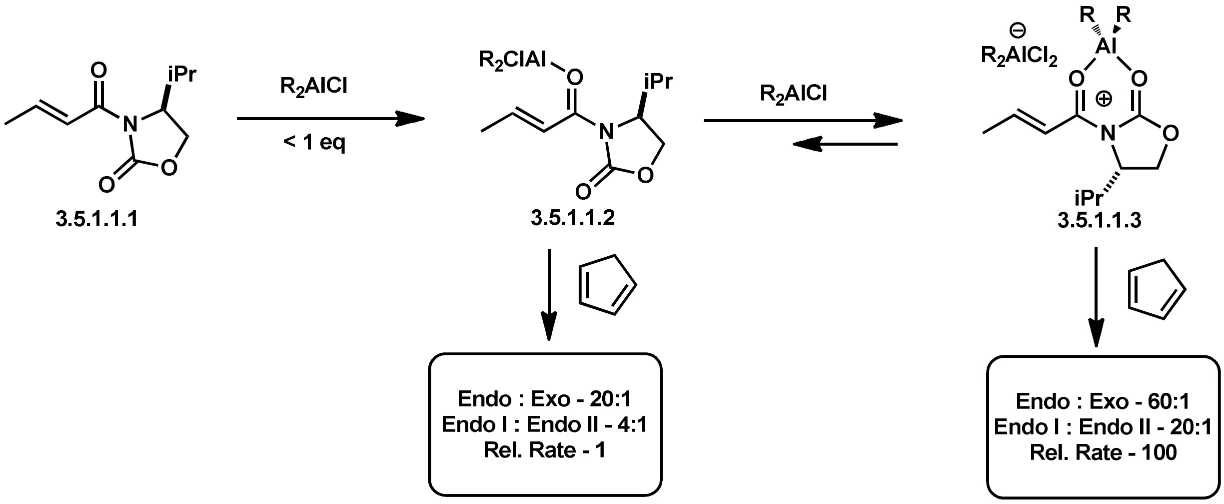
Scheme 3.4.8 – Highly Hindered Diels-Alder with conjugated cyclic ketones

3.5 Aluminum sesquichloride

3.5.1 Aluminum catalyzed asymmetric Diels-Alder cycloaddition with α,β-unsaturated N-acyloxazolidinones

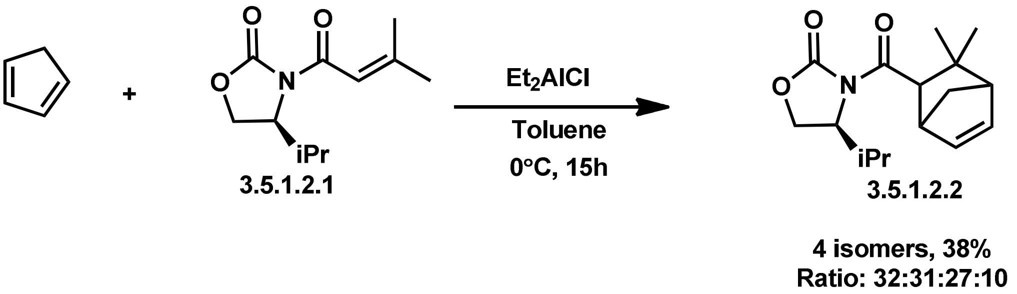
The Lewis acidity of organoaluminum compounds is well understood. The aluminum atom in organoaluminum monomers has a tendency to complete electron octets. The strong Lewis acidity of organoaluminum compounds seems to account for their great affinity for various heteroatoms in organic molecules, particularly oxygen. These organometallic complexes generate a 1:1 coordination complexes with lone pair donors as ethers. This oxaphilicity is a great value in the design of selective synthetic reactions[104]. On coordination with an oxygen-containing substrate the aluminum atom serves primarily as the coordination site for the substrate, while the nucleophilic center attached to the aluminum atom can be activated by the formation of the coordination complex facilitating the nucleophilic attack on the substrate.

Homogeneous alkylaluminum chlorides have been extensively utilized in Lewis acid-catalyzed [4+2] cycloadditions and happened to be the most efficient reagents. Evans and co-workers discovered that chiral α,β-unsaturated *N*-acyl oxazolidinones result in high diastereofacial selection in Diels-Alder reactions (**Scheme 3.5.1.1**), particularly those conducted in the presence of Et$_2$AlCl.[105] They have reported that the cationic Lewis acid-dienophile complex (**3.5.1.1.3**) is proposed to account for the observed exceptional reactivity and endo/exo selectivities. The use of 1 equivalent of dialkylaluminum chloride triggers a slow reaction from one of several possible conformations of 1:1 complex (**3.5.1.1.2**), leading to a mixture of diastereomeric products. But in the presence of an excess of dialkylaluminum chloride (≥ 1 equiv), both dienophile reactivity and reaction diastereoselectivity dramatically increase as a consequence of ionization of the 1:1 complex (**3.5.1.1.2**). The resulting ionic dienophile (**3.5.1.1.3**) is both exceptionally reactive and highly organized. Cycloaddition occurs selectively from the ***si*** face of the crotonyl imide, leading to the desired cycloadduct.



Scheme 3.5.1.1 – Cationic intermediate formation in dialkylaluminum catalyzed Diels-Alder reaction

They have also investigated the reaction of β,β-dimethylacryloyl imide[106] (**3.5.1.2.1**) with cyclopentadiene (**Scheme 3.5.1.2.2**). The reaction failed to occur at low temperature, and after 2 h at 0°C and 15 h at ambient temperature, a 38% yield of a mixture of cycloadducts was obtained. No attempts were made to determine the identity of the individual products.

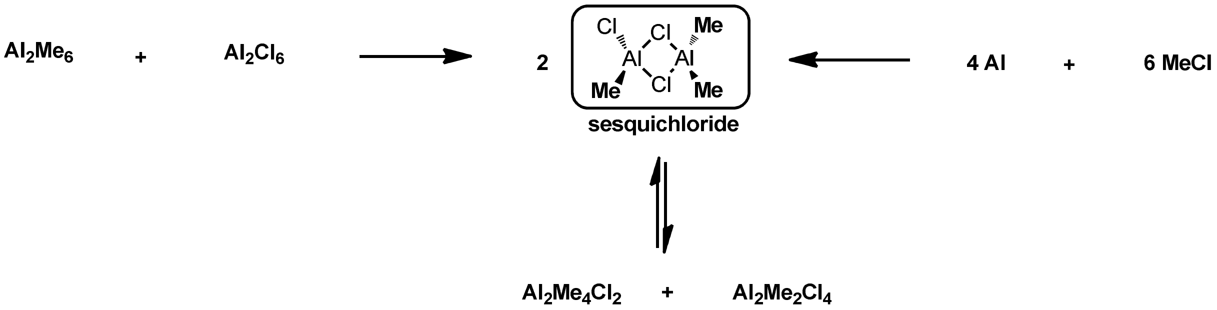


Scheme 3.5.1.2 – Diethylaluminum catalyzed highly hindered Diels-Alder reaction

Based on these results, we investigated the development of a facile and efficient method for the Diels-Alder reaction between highly substituted dienes and dienophiles.

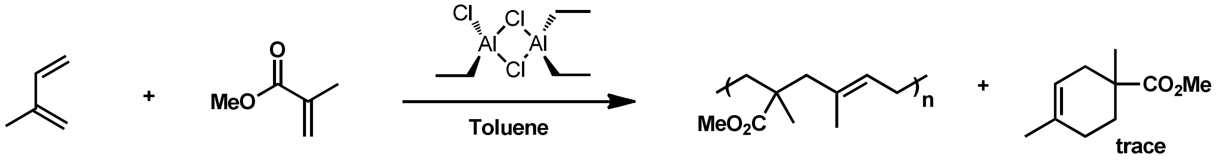
3.5.2 Aluminum sesquichloride

It was reported that the reaction of Al_2Me_6 with Al_2Cl_6 gives the ternary sesquichloride dimers in equilibrium with the binary dimers resulting from disproportionation (**Scheme 3.5.2.1**). This mixture, industrially produced from Al and MeCl, is also used for the synthesis of Al_2Me_6.[107]



Scheme 3.5.2.1 – Ternary sesquichloride formation

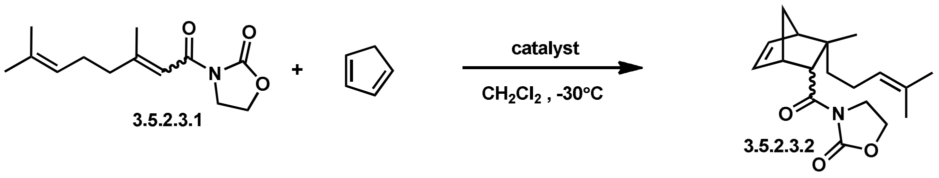
Ethyl aluminum sesquichloride is used in polyene copolymerization with acrylates[108] and as a co-catalyst for Ziegler-Natta polymerizations of α-olefins[109]. Gabbott and co-workers have isolated trace amounts of Diels-Alder cycloadduct during the co-polymerization of methyl methacrylate and isoprene (**Scheme 3.5.2.2**) using ethyl aluminum sesquichloride[110].



Scheme 3.5.2.2 – Sesquichloride mediated Ziegler-Natta polymerization

Since the ethyl aluminum sesquichloride is capable of catalyzing cationic polymerization reactions as well as [4+2] cycloadditions, we postulated that this catalyst might be more reactive than common aluminum Lewis acids because of the presence of two aluminum centers. Thus, we wanted develop new Diels-Alder reaction conditions involving the use of ethyl aluminum sesquichloride.

Initial results were obtained using cyclopentadiene and the geranyl-oxaxolidinone (**3.5.2.3.1**) (**Table 3.5.2.3**). At -30°C for 20h, the ethyl aluminum sesquichloride (70% mol) gave a 77% yield of the desired cycloadduct (**3.5.2.3.2**). At first glance, one can recognize it is a superior system compared to $AlCl_3$ and $EtAlCl_2$ that use twice the amount of the aluminum catalyst.



3.5.2.3.1

3.5.2.3.2

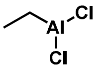
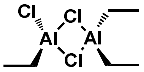
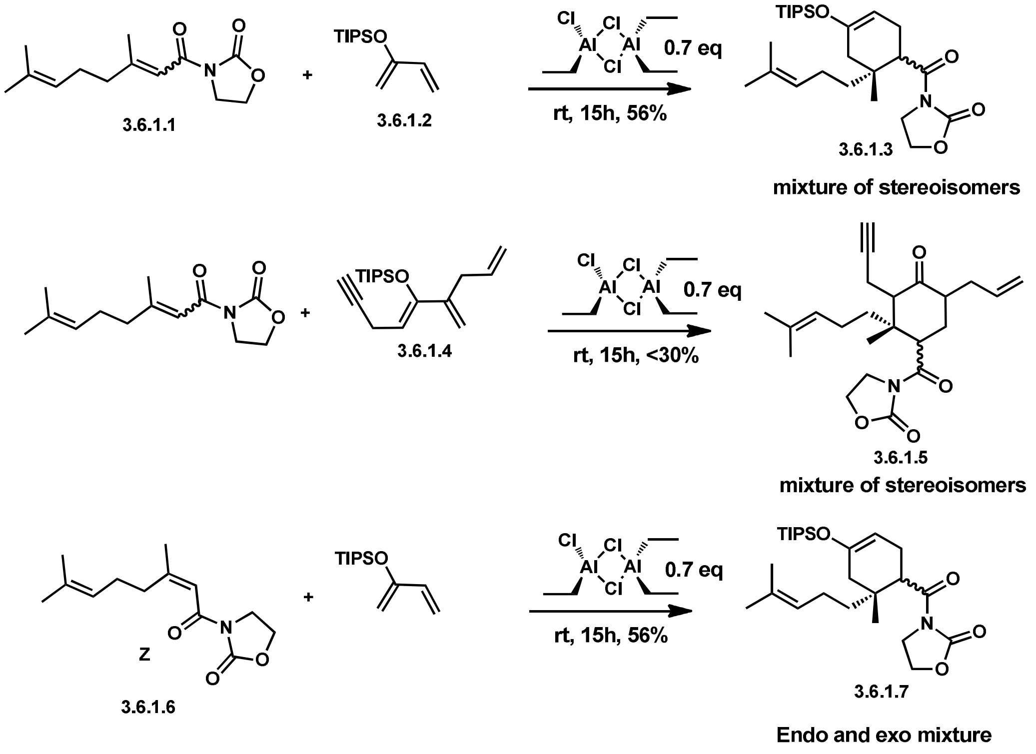
entry	catalyst	time (h)	yield (%)
1	$AlCl_3$ (1.4 eq)	20	53
2	 (1.4 eq)	20	89
3	 (0.7 eq)	20	77

Table 3.5.2.3 – Aluminum catalysts reactivity

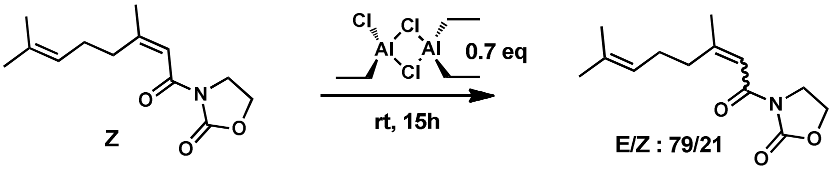
3.6 Lewis acid promoted isomerization

The next step was to apply these reactions conditions to a cycloadditon involving an acid sensitive diene (**Scheme 3.6.1**). After stirring for 15h at room temperature, the reaction between the silyl enol ether diene (**3.6.1.2**) and dienophile (**3.6.1.1**) furnished the cycloadduct (**3.6.1.3**) in 56% yield . Since we started with an isomer mixture (*E/Z*) of the dienophile (**3.6.1.1**), we were not surprised to get a mixture of diastereoisomers. We also applied the same reaction conditions to a more substituted diene (**3.6.1.4**) and got again a diastereomeric mixture with deprotection of the silyl enol ether. The deprotection was probably due to the temperature of the reaction but at that point we did not optimized yet the reaction conditions. Thus, we purified the isomeric mixture of dienophile to obtain the pure *Z* isomer (**3.6.1.6**) on which we performed the same reaction and once again we obtained a mixture of *endo* and *exo* cycloadduct. This outcome can be explained by the fact that either the [4+2] cycloaddition is not stereoselective, or there was an isomerization of the dienophile before the cycloaddition happens.



Scheme 3.6.1 – Sesquichloride catalyzed highly hindered Diels-Alder using silyl enol ether diene

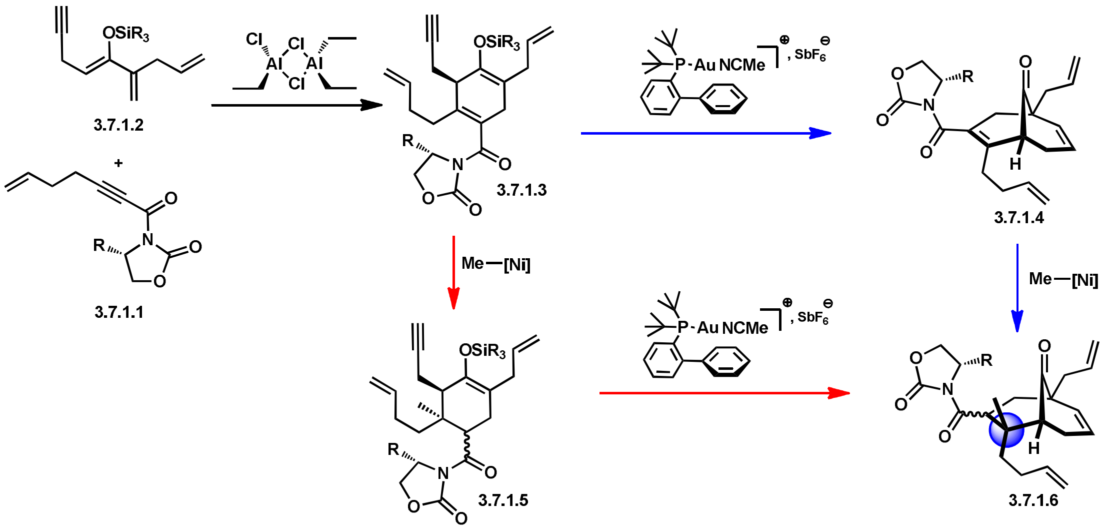
To explain the stereoselectivity of the reaction, the dienophile (**3.6.1.6**) (*Z/E* > 98:2) was exposed to the reaction conditions without the diene to monitor any isomerization issue. We recorded an immediate isomerization in favor of the more stable dienophile *E*.



Scheme 3.6.2 - Lewis acid promoted isomerization

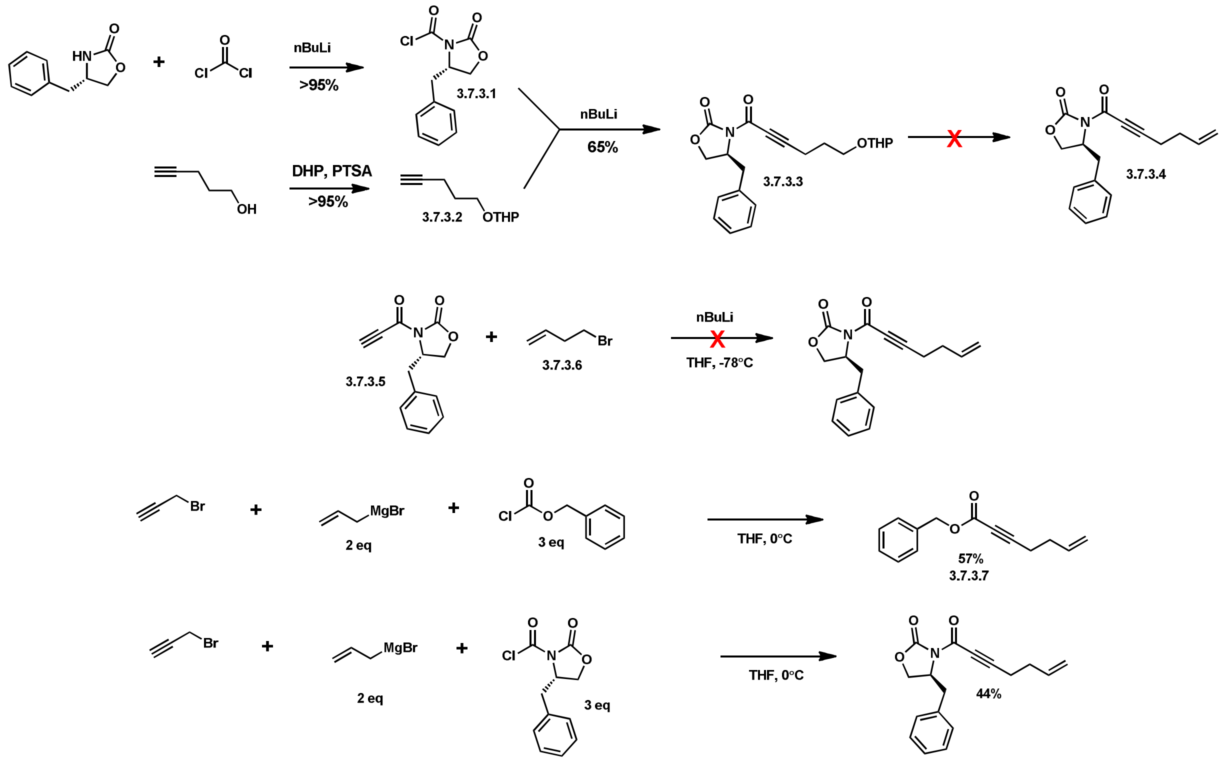
3.7 Conjugated Alkyne dienophile

After having the unexpected *E/Z* isomerization issue, we examined other conjugated alkynyl-dienophiles as Diels-Alder partners (**Scheme 3.7.1**). The idea was to avoid the isomerization issue by developing a two steps process composed by a [4+2] cycloaddition on the alkyne (**3.7.1.1**) to furnish the α,β-unsaturated oxaxolidinone intermediate (**3.7.1.3**) on which Michael addition can be performed to install the desired quaternary carbon center, or execute the gold(I)-mediated 6-*endo* dig carbocyclization prior to carry out the Michael addition.



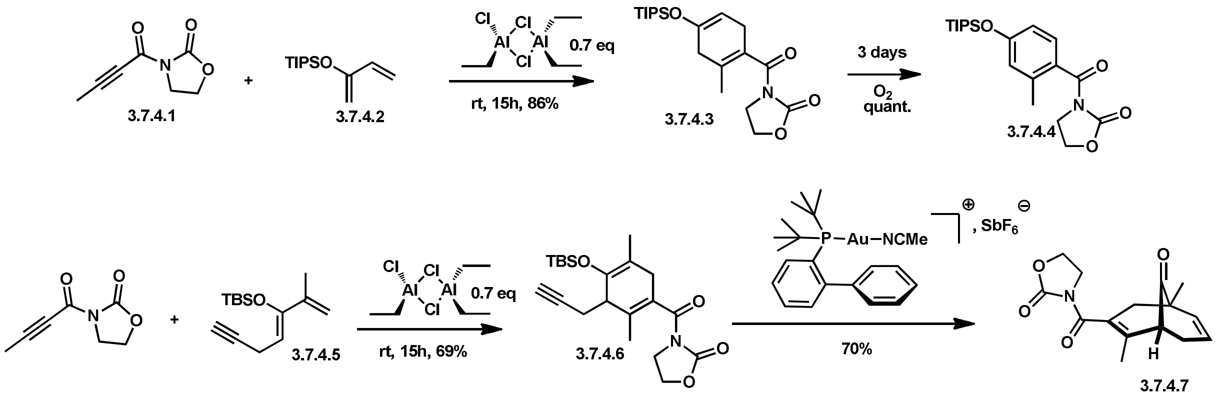
Scheme 3.7.1 - Conjugated alkyne dienophile approach towards Hyperforin

To verify our hypothesis, the synthesis of alkynyl-oxaxolidinone (**3.7.1.1**) was put forward (**Scheme 3.7.3**). The reaction between carbonyl chloride (**3.7.3.1**) and the alkyne (**3.7.3.2**) afforded the alkynyl-oxaxolidinone (**3.7.3.3**) in 65% yield. Further attempts to transform this latter to the desired product (**3.7.3.4**) were not successful. We eventually had success in the formation of homoallyl-propargyl-magnesium bromide which was added to the carbonyl chloride (**3.7.3.1**) to furnish the desired dienophile (**3.7.3.4**) in 44% yield.



Scheme 3.7.3 - Conjugated homoallylalkyne dienophile synthesis

At this point, we were ready to try our concept consisting in a Diels-Alder reaction between a silyl enol ether diene and an alkynyl-dienophile followed by a gold(I)-mediated 6-*endo* dig carbocyclization (**Scheme 3.7.4**). The Diels-Alder between the diene (**3.7.4.2**) and the dienophile (**3.7.4.1**) gave the expected cycloadduct (**3.7.4.3**) in 86% yield and furthermore can be oxidized over the air to form aromatic compound (**3.7.4.4**). Finally, we performed the Diels-Alder reaction between the substituted diene (**3.7.4.5**) and the dienophile (**3.7.4.1**) to form the expected product (**3.7.4.6**) bearing a terminal alkyne in 69% yield. The subsequent gold(I)-mediated 6-*endo* dig carbocyclization using the Echavarren catalyst furnished the desired bicyclo[3.3.1]alkenone (**3.7.4.7**) in 70% yield. With this result, the first objective was met; the synthesis of the bicyclo[3.3.1]alkenone core and the next objective was to develop the Michael addition to install the quaternary carbon center.

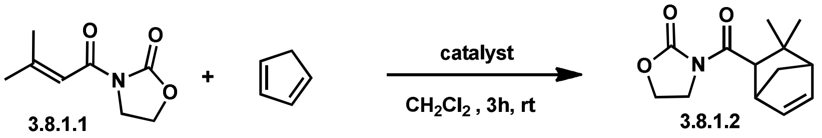


Scheme 3.7.4 – Sesquichloride catalyzed Diels-Alder with methylalkyne dienophile

3.8 Ethyl aluminum sesquichloride catalyzed [4+2] cycloaddition reactions

In order to further probe the reactivity of the ethyl aluminum sesquichloride as catalyst (**Table 3.8.1**), we examined the Diels-Alder reaction between cyclopentadiene and the dienophile (**3.8.1.1**). To our delight, the desired cycloadduct (**3.8.1.2**) was obtained in 92% yield as a mixture of endo/exo employing 0.7 equivalent aluminum sesquichloride. Then we wondered if a 1.4 equivalents equimolar mixture of $EtAlCl_2$ and Et_2AlCl which are two different monomers would give the exact same reaction outcome as 1.4 equivalents of aluminum sesquichloride which is a dimer in solution. Comparison of entry 2 to entry 1 shows a different catalyst activity at 0.7 equivalent since we observed a difference in *endo* selectivity. This result indicates that we might have the formation of a different reactive intermediate. When we compare entry 1 to entry

3, we can see that increasing the catalyst load is counterproductive for the reaction. Comparing 48% conversion yield to 29% isolated yield suggests that the excess of catalyst might cause actually degradation of the cycloadduct formed.



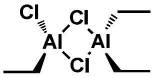
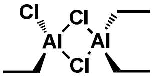
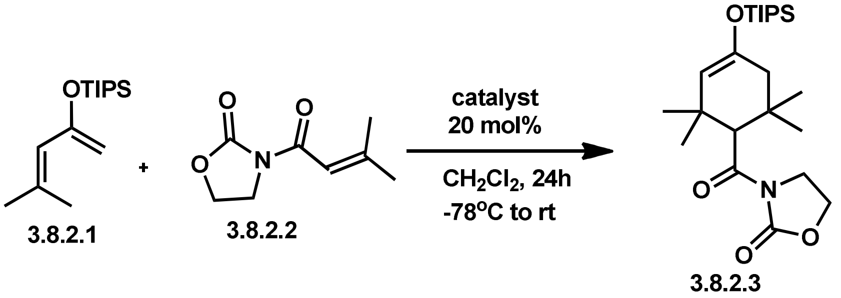
Entry	Catalyst	Endo : Exo	Conversion (%)	Isolated yield (%)
1	 (0.7 eq)	1.1 : 1	97	92
2	$EtAlCl_2$ (0.7 eq) + Et_2AlCl (0.7 eq)	2.1 : 1	93	86
3	 (1.4 eq)	0.3 : 1	48	29

Table 3.8.1 – Aluminum sesquichloride reactivity

With this preliminary result in hand, we investigated the scope and limitation of the ethyl aluminum sesquichloride mediated Diels-Alder reaction. First, we screened various Lewis and Bronsted acids without success (entries1-4). It confirmed that ethyl aluminum sesquichloride is the only reactive catalyst for this transformation (**Table 3.8.2**).



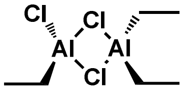
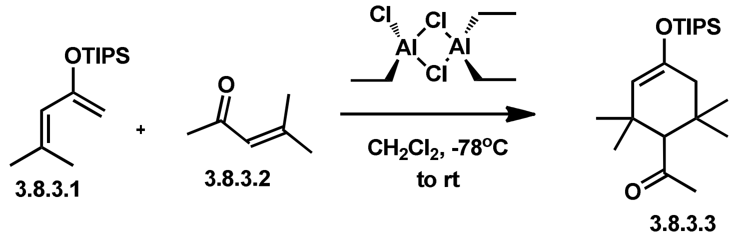
entry	catalyst load	yield
1	$FeBr_3$	-
2	$AlBr_3/AlMe_3$	-
3	$AlCl_3$	-
4	Tf_2NH	-
5		91%

Table 3.8.2 – Lewis acid screening for highly hindered Diels-Alder reaction

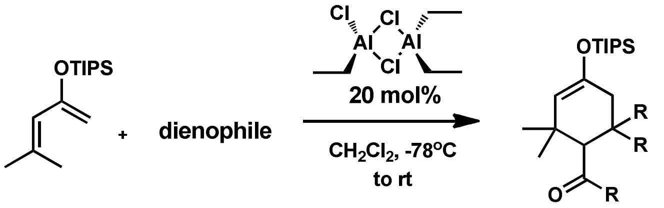
Then, the catalyst load was examined on the ketone dienophile (**3.8.3.2**) (**Table 3.8.3**). Control experiment in entry 1 showed the inertia of the system without the ethyl aluminum sesquichloride catalyst. Increasing the catalyst load showed a regular progression of the reaction yield accordingly. Eventually 20 mol% of catalyst load gave the best isolated yield at 92% in two hours.



entry	catalyst load	time	yield
1	0 mol%	7 days	-
2	1 mol%	7 days	10%
3	10 mol%	2h	38%
4	20 mol%	2h	92%

Table 3.8.3 - Catalyst load study of the sesquichloride catalyzed Diels-Alder reaction on hindered conjugated ketones

To expand the applicability of the newly developed methodology, we applied the system to different synthetically interesting dienophiles in regard to the polyprenylated acylphloroglucinol's framework (**Table 3.8.4**). Interestingly, entry 2 shows a highly hindered Diels-Alder reaction on the unusual dienophile (**3.8.4.3**) with no reaction after the first double bond has reacted. The less reactive cyclohexenone (**3.8.4.5**) due to ring conformation furnished an excellent 96% yield of the cis cycloadduct (**3.8.4.6**). The [4+2] cycloaddition of the homoprenyl dienophile is really exciting since no isomerization was identified and this moiety is found on several PPAPs like hyperforin.



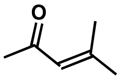
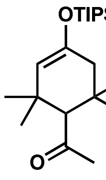
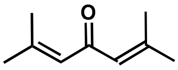
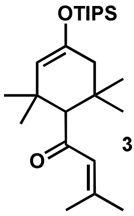
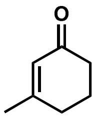
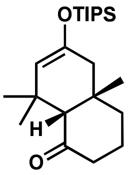
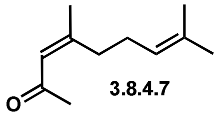
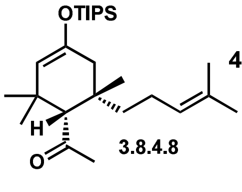
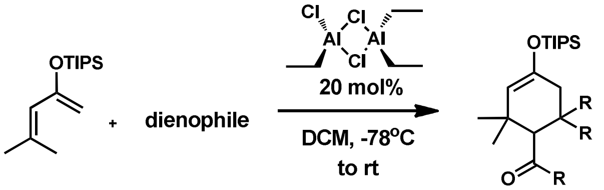
entry	dienophile	time	product	yield
1	 3.8.4.1	2h	 3.8.4.2	92%
2	 3.8.4.3	8h	 3.8.4.4	88%
3	 3.8.4.5	6h	 3.8.4.6	96%
4	 3.8.4.7	6h	 3.8.4.8	47%

Table 3.8.4 – Scope studies of the sesquichloride catalyzed Diels-Alder reaction on hindered conjugated ketones

In order to develop an asymmetric version of the methodology, we applied the reaction conditions to dienophiles bearing an oxaxolidinone group (**Table 3.8.5**). Methyl ester dienophile (**3.8.5.1**) failed to react properly because of a rapid decomposition in the reaction conditions. Entry 3 and 4 furnished good yields and more importantly high diastereoselectivities with the phenyl-oxaxolidinone dienophile (**3.8.5.5**) and the isopropyl-oxaxolidinone dienophile (**3.8.5.7**) giving respectively 9:1 and 7:3 diastereomeric ratios. Higher stereoselectivities were obtained with the phenyl-oxaxolidinone dienophile due to the participation of the phenyl group in lowering the activation energy barrier of the transition state by pi-stacking. Entry 5 shows that alkynyl dienophiles work as well and the unsaturated oxaxolidinone cycloadduct (**3.8.5.10**) formed can be further used for functionalization by Michael addition.



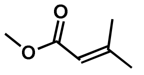
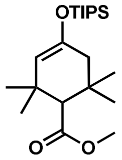
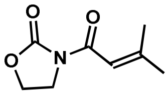
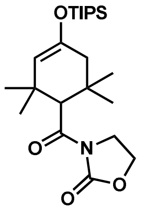
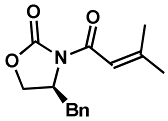
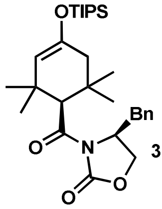
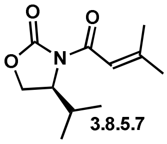
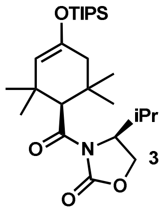
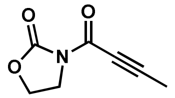
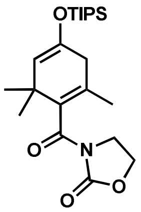
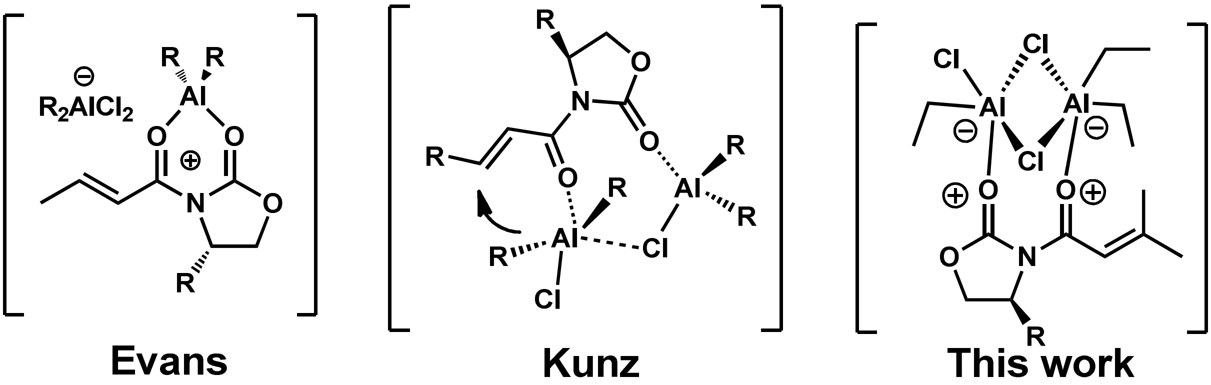
entry	dienophile	time	product	yield	d.r.
1	 3.8.5.1	15h	 3.8.5.2	<10%	
2	 3.8.5.3	24h	 3.8.5.4	91%	
3	 3.8.5.5	36h	 3.8.5.6	76%	9:1
4	 3.8.5.7	36h	 3.8.5.8	73%	7:3
5	 3.8.5.9	24h	 3.8.5.10	81%	

Table 3.8.5 - Scope studies of the sesquichloride catalyzed Diels-Alder reaction on hindered dienophiles

3.9 Mechanism

In terms of mechanism, it is hard to say if the reaction is an asynchronous Diels-Alder cycloaddition or a double Michael 1,4 addition. However, some mechanistic consideration should be outlined. Currently, we are trying to isolate the intermediate formed between the dienophile and the ethyl aluminum sesquichloride. However, the fact that we can have complete conversion with only 20 mol% catalyst suggest that we have a different kind of intermediate compared to the one reported by Evans[111] where more than one equivalent of alkylaluminum catalyst is needed. Based on NMR data, Castellino et al.[112] reported that they could not rule out the existence of a complex between a bridged dialkylaluminum chloride dimer and two carbonyl oxygens of the N-acyloxaxolidinone. In 1993, Kunz[113] and co-workers reported the formation of the intermediate (**B**) during highly facial selective Michael addition between di-alkyl aluminum chloride and acyl-oxaxolidinones. On that basis, we hypothesized the Diels-Alder reaction proceeds via the formation of intermediate (**C**).



Evans **(A)**

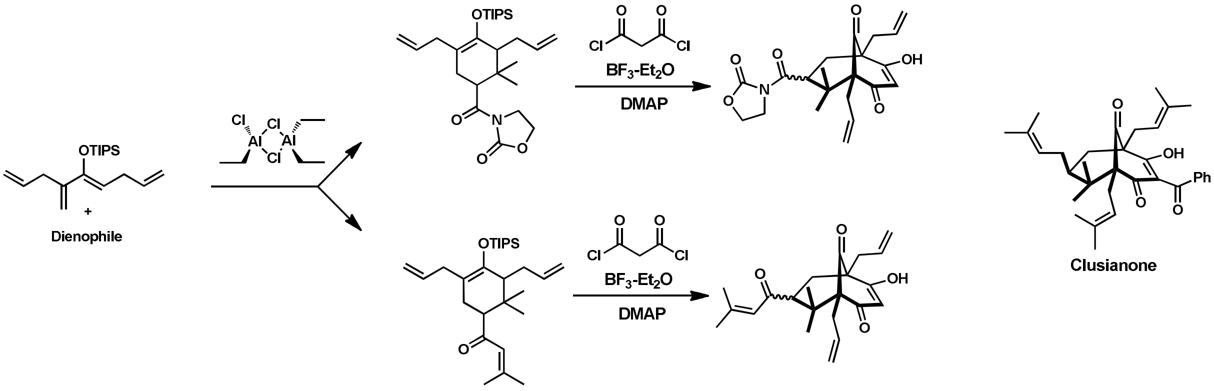
Kunz **(B)**

This work **(C)**

Figure 3.9.1 - Reactive intermediates

3.10Perspectives

With this methodology in hand, we can now envision a broad range of natural products bearing quaternary carbon center accessible from a Diels-Alder reaction. The two approaches shown below are already undertaken in our laboratory for the total synthesis of clusianone (**Scheme 3.11.1**). The installation of the quaternary carbon center happened to be among the most difficult task in the PPAP synthesis. The ethyl aluminum sesquichloride mediated highly hindered Diels-Alder reaction constitutes now a solid basis that we can integrate to the PPAPs retrosynthesis.



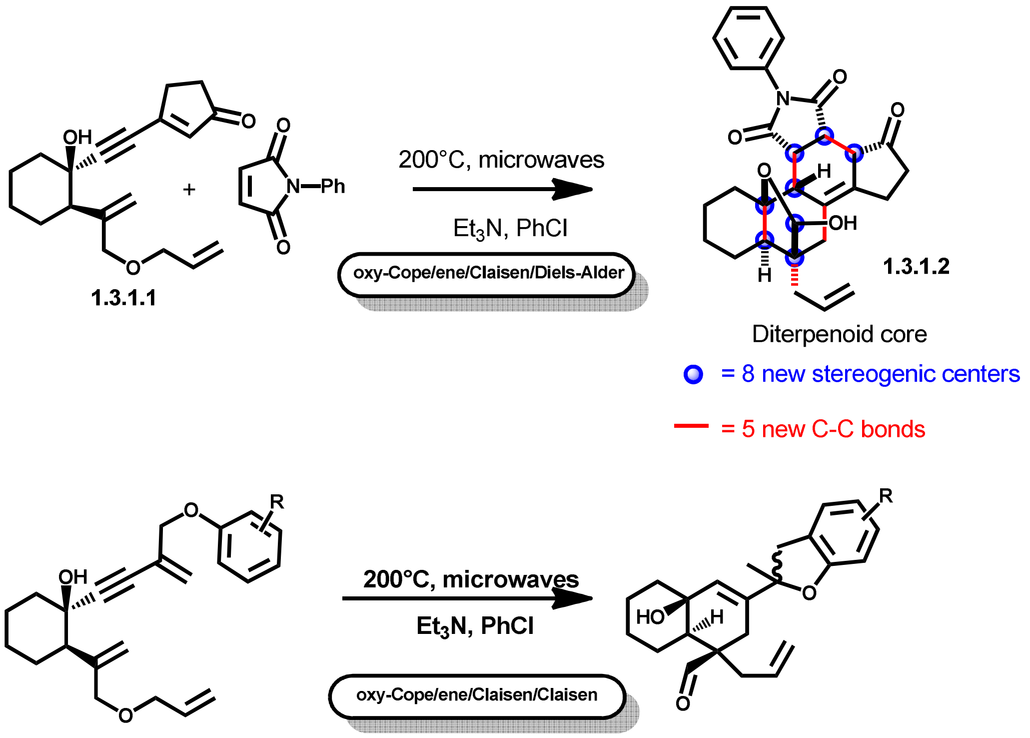
Scheme 3.11.1 – Ongoing synthesis towards PPAPs

3.11 Conclusion

We have developed an efficient synthetic methodology for the formation quaternary carbon centers via an ethyl aluminum sesquichloride mediated highly hindered Diels-Alder reaction. However, significant work must be done to gain a better understanding of the reactive intermediates and reaction mechanism. The attractive features of this method reside in its ability to construct highly hindered cycloadduct in one step, to activate unreactive dienophiles due to steric encumbrance. This methodology opens new opportunities in the total synthesis of PPAPs.

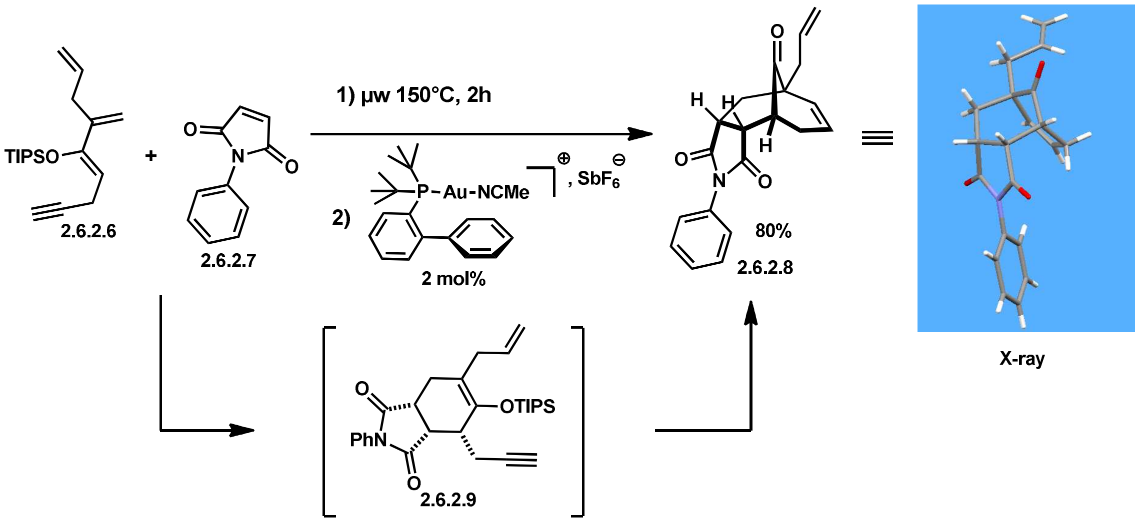
4. *Summary and Outlook*

The studies in our laboratory have resulted in the development of the oxy-Cope/ene/Claisen/Diels-Alder and the oxy-Cope/ene/Claisen/Claisen reactions (**Scheme 4.1**). They have challenging synthetic problems which are the stereoselective synthesis of diterpenes and the synthesis of complex *trans* decalins bearing benzofurans. The oxy-Cope/ene/Claisen/Diels-Alder has been proven as a powerful tool, providing general access to a number of polycyclic decalins, with tertiary alcohol at ring junction – it has also seen use in our laboratory for the synthesis of complex diterpenes.



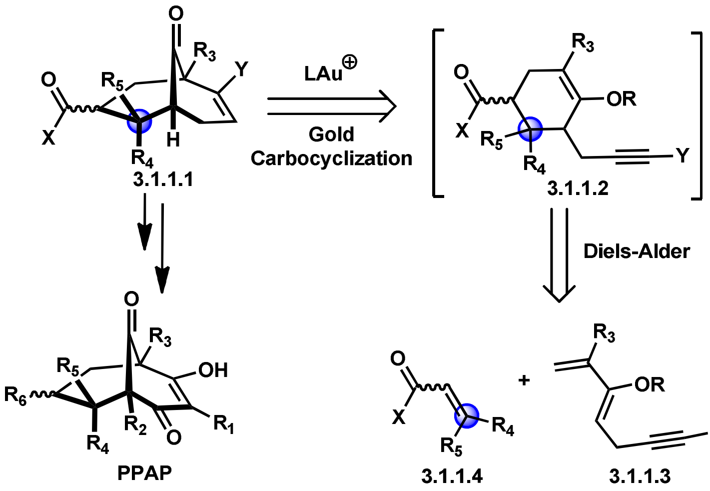
Scheme 4.1 - New domino processes

On the road of PPAP's framework synthesis, we have developed an efficient synthetic approach towards the bicyclo[3.3.1]nonenone core. We achieved the challenging construction of carbon bridged rings of various sizes, with tolerance towards sterically crowded environment by sequential Diels-Alder/gold(I)-catalyzed 6-endo-dig cyclization (**Scheme 4.2**). This method provides quick access to a library of PPAPs for structure-activity relationships studies.



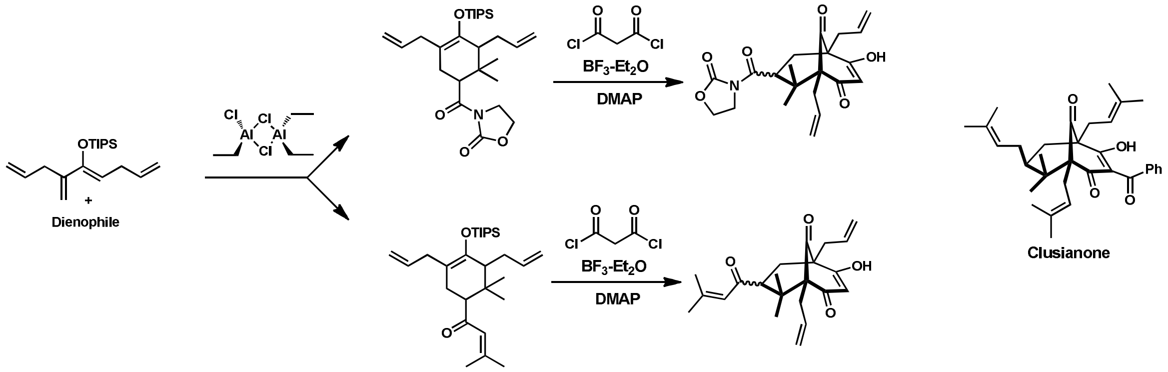
Scheme 4.2 - Sequential Diels-Alder/Au(I)-catalyzed cyclization

Thus, we achieved the installment of the quaternary carbon centers adjacent to the bridgehead ketone by developing an efficient synthetic methodology for the formation of cyclohexene rings bearing quaternary carbon centers via an ethyl aluminum sesquichloride mediated highly hindered Diels-Alder reaction (**Scheme 4.3**). However, significant work must be done to gain a better understanding of the reactive intermediates and reaction mechanism.



Scheme 4.3 – Retrosynthetic analysis of PPAP's scaffold via Highly hindered Diels-Alder

Many lessons have been learned along the way of PPAPs scaffold synthesis and we have now developed two approaches already undertaken in our laboratory for the total synthesis of clusianone (**Scheme 4.4**). The installation of the quaternary carbon center happened to be among the most difficult task in the PPAP synthesis. The ethyl aluminum sesquichloride mediated highly hindered Diels-Alder reaction constitutes now a solid basis that we can integrate to the PPAPs retrosynthesis.



Scheme 4.4 - Ongoing synthesis towards PPAP

5. *Claims to Original Research*

1. Developed the thermal oxy-Cope/ene/Claisen/Diels-Alder rearrangement on a variety of substrates
2. Applied the thermal oxy-Cope/ene/Claisen/Diels-Alder rearrangement to complex diterpenes synthesis
3. Discovery of a thermal oxy-Cope/ene/Claisen/Claisen rearrangement, and application to the synthesis of *trans* decalin benzofurans
4. Developed an efficient synthetic approach towards the bicyclo[3.3.1]nonenone core via a sequential Diels-Alder/gold(I)-catalyzed 6-endo-dig cyclization and applied it to the synthesis of a diversified library of PPAPs
5. Developed an efficient synthetic methodology for the formation of cyclohexene rings bearing quaternary carbon centers via an ethyl aluminum sesquichloride mediated highly hindered Diels-Alder reaction

Publications From This Work

Sow, B.; Bellavance, G.; Barabé, F.; Barriault, L. "One-pot Diels–Alder cycloaddition/gold(I)-catalyzed 6-endo-dig cyclization for the synthesis of the complex bicyclo[3.3.1]alkenone framework." *Beilstein J. Org. Chem.* **2011,** *7,* 1007–1013.

Barabé, F.; Levesque, P.; Sow, B.; Bellavance, G.; Bétournay, G.; Barriault, L. "Gold(I)-catalyzed formation of bridged and fused carbocycles." *Pure and Applied Chemistry* **2013,** *85,* 1161–1173.

Barriault, L.; Sow, B.; Sherburn, M.S. "Consecutive Sigmatropic Rearrangements", *Comprehensive Organic Synthesis 2nd Edition, 2014 (accepted)*

6. *Experimental*

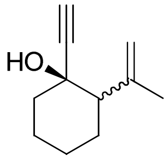
General remarks

Unless otherwise indicated, all reactions were performed under either an argon or nitrogen atmosphere in flame-dried glassware equipped with a Teflon coated magnetic stir bar and a rubber septum. Where no temperature is specified, the reactions were run at ambient temperature (23°C). Reagent quantities (mmol) were calculated based on their reported purities. Anhydrous THF and Et2O were obtained by distillation over sodium/benzophenone under nitrogen and used as freshly distilled. Et_3N and CH2Cl2 were distilled from CaH2. Commercially available reagents were used as received unless otherwise stated. *n*-Butyllithium and *tert*-butyllithium were titrated using 2,6-di-*tert*-butyl-4-methylphenol and fluorene. Grignard reagents were titrated according to Love's protocol. Microwave reactions were performed using a CEM Model ESP-1500 Plus microwave oven equipped with a pressure monitoring device and an EST-300 Plus fiber optic temperature probe. The reaction vessel was a quartz tube to which was added the reaction mixture as well as a carboflonTM to aid in the absorption of microwave radiation. Reactions were monitored by

TLC analysis using glass plates pre-coated (250 μm thickness) with ultra- pure silica gel (60A, SiliCycle). TLC plates were viewed using UV light and stained with either *p*-anisaldehyde, potassium permanganate, or phosphomolybdic acid staining solutions. Flash chromatography was carried out on 230–400 mesh silica gel (60A, SiliCycle). When mentioned, triethylamine was added to the slurry of silica gel until a persistent odor was maintained. Once the basified slurry was loaded on the column, an equal volume of eluent (without triethylamine) was passed through prior to substrate loading.

^{1}H and ^{13}C NMR, spectra were recorded on either Bruker Avance 300 MHz, Bruker Avance 500 MHz, Bruker AMX 500 or Varian INOVA 500 MHz spectrometers in the specified deuterated solvents. IR spectra were recorded on a Bomen Michaelson 100 FTIR spectrometer. HRMS spectra were obtained using a Kratos Analytical Concept spectrometer. Melting points were recorded using a Gallenkamp P1106G Melting Point Apparatus. The crystals were mounted on thin glass fibers using paraffin oil and cooled to 200.15 °K. Data were collected on a Bruker AXS SMART single crystal diffractometer equipped with a sealed Mo tube source (wavelength 0.71073 Å) APEX II CCD detector. Raw data collection and processing were performed with APEX II software package from BRUKER AXS.

Development of the Domino Pericyclic Oxy-Cope/Ene /Claisen /Diels-Alder Reaction



cis:trans / 3:2

1-ethynyl-2-(prop-1-en-2-yl)cyclohexanol

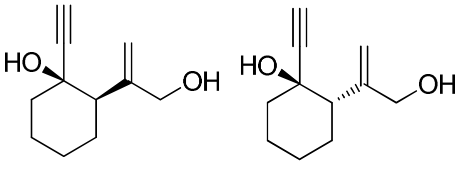
A dry 1L flask was charged with THF (70 mL), followed by the 2-chlorocyclohexanone (6.00g, 45.25 mmol, 1 eq.) and isopropenyl magnesium bromide (0.5M in THF, 47.51 mmol, 1.05 eq.). The mixture was stirred at room temperature for 20 minutes. Ethynyl magnesium bromide (0.5M in THF, 90.50 mmol, 2.0 eq.) was then added and the mixture was refluxed for 3 hours. The mixture was cooled down to room temperature and quenched with a saturated NH_4Cl solution. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (10% Et_2O in hexanes) to give the product as a yellow oil (6.1 g, 82%). A small amount of the desired *cis* ring junction was repurified for characterization to give 1-ethynyl-2-(prop-1-en-2-yl)cyclohexanol as a colorless oil.

^{1}H NMR (CDCl$_3$, 300 MHz) δ_{ppm} = 5.20 (br s, 1H), 5.03 (br s, 1H), 2.39 (s, 1H), 2.25-2.09 (m, 3H), 1.95 (s, 3H), 1.75-1.42 (m, 6H), 1.35-1.07 (m, 1H)

^{13}C NMR (CDCl$_3$, 75 MHz) δ_{ppm} = 148.5 (C), 112.7 (CH$_2$), 89.0 (C), 71.6 (CH), 67.3 (C), 52.8 (CH), 40.0 (CH$_2$), 27.0 (CH$_2$), 26.2 (CH$_3$), 26.0 (CH$_2$), 20.8 (CH$_2$)

IR (FTIR, cm^{-1}) = 3734, 2924, 1558, 1540, 1507

HRMS (EI) Expected for $C_{11}H_{16}O_1$ (M^+): 164.1201, found: 164.1186



cis (44%) **trans** (29%)

1-ethynyl-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol

A dry 250 mL round bottom flask fitted with a magnetic stirrer was charged with CH$_2$Cl$_2$ (100 mL) under argon, 1-ethynyl-2-(prop-1-en-2-yl)cyclohexanol (6.4g, 42.6 mmol, 1 eq.), SeO$_2$ (0.47 g, 4.26 mmol, 0.1 eq.) with stirring, followed by *tert*-butyl hydroperoxide (0.64 g/mL dry solution in CH$_2$Cl$_2$, 18 mL, 128 mmol, 3 eq.) and then benzoic acid (2.6 g, 21.3 mmol, 0.5 eq.). The reaction was allowed to stir for 12 hours at room temperature and SeO$_2$ (0.47 g, 4.26 mmol, 0.1 eq.) was added again. After 24 hours of overall reaction time, most of the starting material had been consumed. The CH$_2$Cl$_2$ was reduced to a minimum quantity. The residue was diluted with EtOAc (200 mL), washed with a 10% KOH solution until a basic pH was reached for the aqueous phase, brine, and dried over MgSO$_4$ and filtered. Silica was added prior to removal of the volatiles. The dry powder was subjected to flash chromatography (0-30% EtOAc in hexanes in 3 steps) to give a total yield of 5.1g, 73%. The desired *cis* ring junction 1-ethynyl-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol was obtained as a light yellow oil (3.1 g, 44%). The minor diastereomer *trans* 1-ethynyl-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol was recovered by increasing the polarity to 40% EtOAc in hexanes (2.05g, 29%).

Data for ***cis***:

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 5.17 (s, 1H), 5.06 (s, 1H), 4.41 (br s, 1H), 4.13 (m, 2H), 2.87 (br s, 1H), 2.41 (s, 1H), 2.34 (dd, *J*= 12.9, 3.4 Hz, 1H) 2.14-2.06 (m, 1H), 1.87-1.24 (m, 3H), 1.50-1.17 (m, 4H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 148.5 (C), 117.4 (CH_2), 88.5 (C), 71.8 (C), 67.6 (CH), 64.8 (CH_2), 52.4 (CH) 39.5 (CH_2) 26.0 (CH_2), 25.6 (CH_2), 20.4 (CH_2)

IR (FTIR, cm^{-1}) = 3200, 2927, 2847, 1654

HRMS (EI) [$(M-H_2O)^+$]: *m/z* calc. for $C_{11}H_{14}O$: 162.1045, found: 162.1050

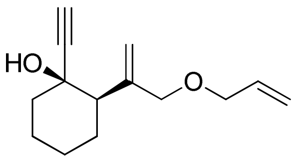
Data for ***trans***:

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 5.25 (s, 1H), 5.19 (s, 1H), 4.36 (s, 1H), 4.18 (d, *J*=12.4Hz, 1H), 4.02 (d, *J*=12.4Hz, 1H), 3.18 (s, 1H), 2.49 (s, 1H) 2.18-2.05 (m, 2H), 1.77-1.47 (m, 6H) 1.32-1.13 (m, 1H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 148.2 (C), 116.0 (CH_2), 85.2 (C), 74.7 (CH), 72.0 (C), 67.4 (CH_2), 51.7 (CH), 41.3 (CH_2), 30.0 (CH_2), 25.7 (CH_2) 23.7 (CH_2)

IR (FTIR, cm^{-1}) = 3300, 2934, 2859, 1651, 1445, 1124, 1064, 1004, 906

HRMS (EI) Expected for $C_{11}H_{16}O_2$ (M^+) = 180.1150, found: 180.1146



(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol

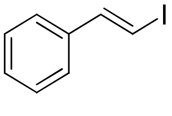
A solution of *cis* 1-ethynyl-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol (15.3g, 84.7 mmol, 1 eq.) in a mixture of dry THF (200 mL) and DMF (20 mL) was cooled to 0°C, NaI (1.2g, 8.5 mmol, 0.05 eq.) and freshly distilled allyl bromide (9.18 mL, 101 mmol, 1.1 eq.) was added. The mixture was allowed to stir at 0°C for 50 minutes. NaH (60% w/w, 101 mmol, 1.1 eq.) was added in small portions, resulting in a copious release of H_2 gas. The orange mixture was stirred for 3 hours at 0°C, and quenched by very slow addition of $NH_4Cl_{(aq)}$ (40 mL), extracted with Et_2O (4 x), dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (0 to 10% Et_2O in hexanes) to give (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol as a pale yellow oil (14.2g, 77%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 5.92-5.79 (m, 1H), 5.24 (d, *J*= 17.2Hz, 1H), 5.17-5.13 (m, 3H), 4.48 (s, 1H), 4.11-4.06 (m, 2H), 3.91-3.78 (m, 2H), 2.35-2.27 (m, 2H), 2.10-2.04 (m, 1H), 1.83-1.50 (m, 4H), 1.48-1.13 (m, 3H).

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 114.8 (C) 133.6 (CH), 119.6 (CH_2), 117.7 (CH_2), 88.5 (C), 71.5 (CH_2), 71.2 (C), 70.4 (CH_2), 67.3 (CH), 52.9 (CH), 39.4 (CH_2), 25.7 (2 x CH_2), 20.3 (CH_2).

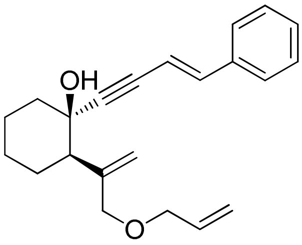
IR (FTIR, cm^{-1}) = 3306, 3300, 3079, 2936, 2857, 1644, 1446, 1351, 1144, 1070, 977, 922, 648.

HRMS (EI) Expected for $C_{11}H_{14}O$ [$(M-C_3H_6O)^+$]: 162.1045, found 162.1061.



(E)-(2-iodovinyl)benzene

A 5mL round-bottom flask was charged with THF (1.5mL) and diiodomethane (0.48 mL, 6 mmol, 1.5 eq.). A 100mL round-bottom flask was charged with NaHMDS (2.20g, 12 mmol, 3 eq.), THF (8mL) and Et_2O (8mL). The diiodomethane solution was added dropwise at -78˚C to the NaHMDS solution. The mixture was stirred for 20 minutes. Benzyl bromide (0.48 mL, 4.00 mmol) in THF (3mL) was added dropwise and the mixture was stirred for 90 minutes before being warmed up to room temperature over 30 minutes. DBU (0.6 mL, 4 mmol, 1 eq.) was added dropwise and the mixture was stirred for 1 hour. Et_2O (50 mL) was added to dilute the mixture and filtration over celite/silica gel pad was performed. The crude was subjected to flash chromatography (100% hexanes) to give (E)-(2-iodovinyl)benzene as a colorless oil (519 mg, 56%). Spectral data available from: Bull J.A., Mousseau J.J., Charette A.B. *Org. Lett.*, **2008**, 10, 23, 5485.



(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-4-phenylbut-3-en-1-yn-1-yl)cyclohexanol

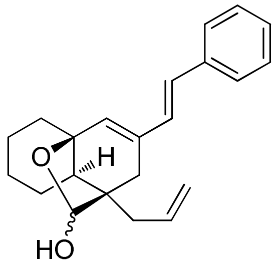
A 25 mL round-bottom flask was charged with THF (5 mL) and Et_2NH (0.71 mL, 6.84 mmol, 5 eq.) and the mixture was degassed for 15 minutes. (E)-(2-iodovinyl)benzene (345 mg, 1.5 mmol, 1.1 eq.), CuI (26 mg, 0.14 mmol, 0.01 eq.) and $PdCl_2(PPh_3)_2$ (48 mg, 0.068 mmol, 0.05 eq.) were added at 0˚C. The substrate (300 mg, 1.37 mmol) was added and the mixture was stirred and allowed to warm up to room temperature over 4 hours. The mixture was quenched with saturated NH_4Cl. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (5% Et_2O in hexanes) to give (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-4-phenylbut-3-en-1-yn-1-yl)cyclohexanol as a yellow oil (260 mg, 59%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm}= 7.41-7.25 (m, 5H), 6.86(d, *J* = 16 Hz, 1H), 6.17 (d, *J*= 16 Hz, 1H), 5.92(m, 1H), 5.31(dq, *J* = 16 Hz,1.5 Hz, 1H), 5.22 (s, 2H), 5.21 (dq, *J* = 14 Hz, 1.5 Hz, 1H), 4.39 (d, *J* = 2Hz, 1H), 4.20 (dd, *J* = 16Hz, 1Hz, 1H), 4.17 (ddt, *J* = 13Hz, 6Hz, 1.5 Hz, 1H), 3.94 (ddt, *J* = 16Hz, 6Hz, 1.5 Hz, 1H), 3.92 (d, *J* = 16Hz, 1H) 2.45 (dd, *J*= 16 Hz, 3 Hz, 1H), 2.17(m,1H), 1.95-1.17 (m, 8H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm}= 145.6 (C), 140.8 (CH), 136.5 (C), 134.1 (CH), 128.8 (2CH), 128.6 (CH), 126.3 (2CH), 119.4 (CH_2), 117.9 (CH_2), 108.2 (CH), 96.7 (C), 82.9 (C), 72.0 (CH_2), 70.7 (CH_2), 68.2 (C), 53.1 (CH), 39.7 (CH_2), 26.1 (CH_2), 26.0 (CH_2), 20.8 (CH_2)

IR (FTIR, cm^{-1}) = 3381, 3082, 3025, 2935, 2851.

HRMS: *m/z* calculated for $C_{22}H_{26}O_2$ (M+) = 322.1933, found 322.2029.



(1R,4aS,8aR)-1-allyl-3-((E)-styryl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol

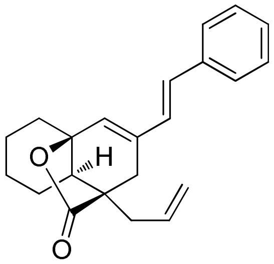
To a solution of (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-4-phenylbut-3-en-1-yn-1-yl)cyclohexanol (0.191 g, 0.59 mmol) in PhCl (10 mL) was added Et_3N (0.3 mL, 2.01 mmol). The solution was degassed with argon for 10 minutes and then heated with microwaves at 200 °C, 300W for 2 hours. The PhCl was evaporated and the crude product was flashed with 20% EtOAc in hexanes to yield (1R,4aS,8aR)-1-allyl-3-((E)-styryl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol as a white solid (mixture of diastereomers) (0.13 g, 66%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 7.40-7.12 (m, 5H), 6.78- 6.55 (m, 2H), 5.94-5.74 (m, 2H), 5.30-4.96 (m, 3H), 3.12-2.09 (m, 4H), 2.03-1.17 (m, 10H);

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 137.3, 137.2, 137.2, 136.2, 135.2, 134.8, 134.6, 130.1, 129.7, 128.6, 128.4, 137.7, 127.5, 126.5, 126.3, 117.8, 117.8, 104.7, 103.7, 78.9, 49.3, 49.2, 49.1, 46.4, 37.6, 37.4, 35.4, 32.7, 32.5, 32.3, 24.9, 24.7, 23.3, 21.1, 20.9;

IR (FTIR, cm^{-1}) = 3381, 3067, 3029, 2929, 2856, 1944, 1878, 1830, 1640, 1619, 1595, 1446, 1142, 1107;

HRMS (EI) *m/z* calculated for $C_{22}H_{26}O_2$ (M+) = 322.1933, found: 322.1916



(1R,4aS,8aR)-1-allyl-3-((E)-styryl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-one

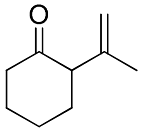
To a round-bottom flask containing TPAP (2 mg, 0.0052 mmol), NMO (18.4 mg, 0.157 mmol), and 4Å molecular sieves (50 mg), and a stirring bar, was added (1R,4aS,8aR)-1-allyl-3-((E)-styryl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol (33.7 mg, 0.105 mmol) in CH_2Cl_2 (5 mL). The reaction mixture was stirred for 30 minutes, then filtered through a pad of silica and washed with EtOAc. The solvent was evaporated leaving the crude product which was flashed with 10% EtOAc in hexanes to give the lactone (1R,4aS,8aR)-1-allyl-3-((E)-styryl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-one as a white crystal (23.6 mg, 71 %).

^{1}H NMR ($CDCl_3$, 500 MHz) δ_{ppm} = 7.39-7.20 (m, 5H), 6.69 (d, *J*= 16.3Hz, 1H), 6.53 (d, *J*= 16.3Hz, 1H), 5.91 (s, 1H), 5.86-5.78 (m, 1H), 5.27-5.19 (m, 2H), 2.65 (dd, *J*= 17.8, 1.4 Hz, 1H), 2.48-2.40 (m, 3H), 2.26 -2.23 (m, 1H), 2.08-2.02 (m, 1H), 1.86-1.77 (m, 2H), 1.65-1.44 (m, 3H), 1.27 -1.14 (m, 2H)

^{13}C NMR ($CDCl_3$, 125 MHz) δ_{ppm} = 180.6, 137.4, 136.7, 133.5, 132.9, 129.3, 128.74, 128.67, 128.3, 127.9, 126.6, 119.4, 80.8, 50.8, 47.2, 35.1, 33.4, 31.9, 24.0, 23.8, 20.3

IR (FTIR, cm^{-1}) = 2935, 2859, 1765, 1493, 1165, 1126

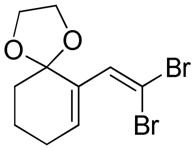
HRMS (EI) *m/z* calculated for $C_{22}H_{24}O_2$ (M+) = 320.1776, found: 320.1757



2-(prop-1-en-2-yl)cyclohexanone

A dry 500 mL round-bottom flask was charged with PhMe (120 mL), followed by 2-chlorocyclohexanone (3.38g, 25.5 mmol) and isopropenyl magnesium bromide (0.5M in THF, 26.8 mmol, 1.05 eq.). The mixture was stirred at room temperature for 20 minutes (until full addition of the Grignard reagent). The mixture was then brought to reflux for 2 hours. It was cooled down to room temperature and $NaHCO_3$ was added to quench the reaction. The organic layers were extracted with Et_2O, washed with brine and dried over $MgSO_4$. The crude mixture was subjected to flash chromatography (2-5% EtOAc in hexanes) to give 2-(prop-1-en-2-yl)cyclohexanone as a yellow oil (3.05g, 86%).

Spectral data available from: Barriault, L.; Warrington, J.; Yap, G. P. *Org. Lett.* **2000**, *2*, 663.



6-(2,2-dibromovinyl)-1,4-dioxaspiro[4.5]dec-6-ene

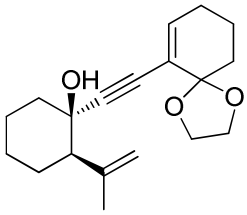
To zinc dust (1.15 g, 17.65 mmol) and PPh_3 (4.63 g, 17.65 mmol) stirring in CH_2Cl_2 (20mL) at 0 °C was added, via a cannula, CBr_4 (5.85 g, 17.65 mmol) in CH_2Cl_2 (15 mL). The resulting dark green solution was allowed to warm up to room temperature and stirred for 24 hours resulting in a pink solution. 1,4-dioxaspiro[4.5]dec-6-ene-6-carbaldehyde (0.74 g, 4.41 mmol) in CH_2Cl_2 (15 mL) was then canulated into the flask and stirred for 3 hours. The solution was then diluted with petroleum ether (200 mL) and filtered through a pad of celite. The solution was then concentrated and flashed with 15% EtOAc in hexanes to yield 6-(2,2-dibromovinyl)-1,4-dioxaspiro[4.5]dec-6-ene as a yellow oil (0.92 g, 65%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 6.89-6.88 (m, 1H), 6.36 (dt, *J*= 2.7, 1.3 Hz, 1H), 3.96 (s, 4H), 2.12-2.09 (m, 2H), 1.75-1.72 (m, 2H);

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 135.5, 134.5, 133.8, 106.2, 89.8, 65.1, 33.5, 25.3, 20.0

IR (FTIR, cm^{-1}) = 2946, 2880, 1586, 1438, 1365, 1340, 1265, 1174, 1117, 1071, 1021, 946;

HRMS (EI) *m/z* calculated for $C_8H_8Br_2O_2$ [$(M - C_2H_4)^+$] = 293.8891, found: 293.8895.



(1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(prop-1-en-2-yl)cyclohexanol

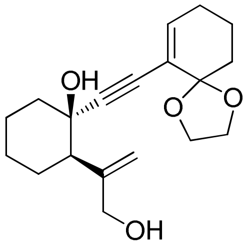
To a solution of 6-(2,2-dibromovinyl)-1,4-dioxaspiro[4.5]dec-6-ene (0.9 g, 2.77 mmol) stirring in THF (5 mL) at -78°C was added n-BuLi (2.26 mL, 5.54 mmol). The solution was stirred for 45 minutes allowing the formation of the alkynyl lithium *in situ.* To this was added a solution of 2-(prop-1-en-2-yl)cyclohexanone (0.27 g, 1.94 mmol) in THF (5 mL). This was stirred for 1 hour, warmed up to room temperature and quenched with NH_4Cl (sat. aq.). The mixture was extracted with EtOAc (3x) and the combined organic layers were dried over $MgSO_4$ and concentrated. Flash chromatography with 10% EtOAc in hexanes gave (1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(prop-1-en-2-yl)cyclohexanol as a white solid (0.24 g, 41 %).

^{1}H NMR ($CDCl_3$, 500 MHz) δ_{ppm} = 6.21 (t, *J*= 4.1Hz, 1H), 4.94 (s, 1H), 4.81 (s, 1H), 4.18-4.12 (m, 2H), 3.97-3.92 (m, 2H), 2.2-1.9 (m, 5H), 1.74 (s, 3H), 1.75-1.4 (m, 9H)

^{13}C NMR ($CDCl_3$, 125 MHz) δ_{ppm} = 148.4, 139.8, 123.9, 112.1, 105.9, 93.4, 81.0, 67.3, 65.7, 52.7, 39.8, 34.4, 26.8, 25.77, 25.76, 25.6, 20.6, 20.2

IR (FTIR, cm^{-1}) = 3464, 2937, 1639, 1442, 1352, 1268, 1176, 1073

HRMS (EI) *m/z* calculated for $C_{19}H_{26}O_3$ (M+) = 302.1882, found: 302.1879



<u>(1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol</u>

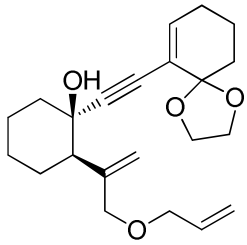
A dry 250 mL round-bottom flask was charged with (1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(prop-1-en-2-yl)cyclohexanol (1.39 g, 5.23 mmol) in CH_2Cl_2 (70 mL). Then, *t*-BuOOH (2.5 mL, 21.58 mmol) and SeO_2 (291 mg, 2.62 mmol) was added to it. The solution was diluted with CH_2Cl_2 (70 mL) after 4 days of stirring and quenched with $NaHCO_3$ (sat. aq). The organic phase was washed with $NaHCO_3$, water (2x) and brine. The combined organic phases were dried over $MgSO_4$, filtered and concentrated. Purification by flash chromatography (60% EtOAc in hexanes) yielded a mixture of C11 and the corresponding aldehyde. Luche reduction was thus performed on the isolated product where the mixture of the *cis* and *trans* isomers (760.1 mg, 2.4 mmol) was dissolved in MeOH (125 mL) in a 250 mL dry round bottom flask. $CeCl_3 \cdot 7H_2O$ (1.07g, 2.89 mmol) was added to the solution and stirred 15 minutes. $NaBH_4$ (185 mg, 4.89 mmol) was then added at 0°C and the solution was stirred 3 hours and quenched with water. The solution was extracted with Et_2O (3x), washed with brine and dried by the addition of $MgSO_4$. Filtration and evaporation gave (1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol (258 mg, 17%) as a yellow oil.

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 6.24 (t, *J*=4.1 Hz, 1H), 5.18 (s,1H), 5.07 (d, *J*= 1.7 Hz, 1H), 4.18 (s, 2H), 4.16 (m, 2H), 3.95 (m, 2H), (s, 2H), 2.38 (dd, *J*=12.8 Hz, *J*= 3.4 Hz, 1H), 2.10 (m, 3H), 1.2-1 (m, 13H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 150.1, 140.1, 123.4, 115.8, 105.9, 93.6, 81.5, 67.8, 65.7, 65.5, 52, 39.5, 34.2, 26.5, 25.8, 25.5, 20.6, 20.2;

IR (FTIR, cm^{-1}) = 3358, 2935, 2859, 2247, 1675, 1442, 1353, 1261, 1180, 110, 1072, 1015, 975, 947, 907, 818, 726, 641, 540;

MS (EI) *m/z* calculated for $C_{19}H_{26}O_4$ (M+) = 318.1831, found: 318.1765



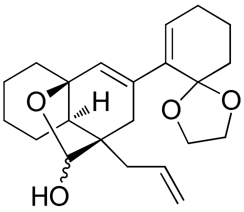
(1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(3-(allyloxy)prop-1-en-2-yl)cyclohexanol

A dry 50 mL round-bottom flask was charged with (1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol (275.9 mg, 0.87 mmol) and THF (27 mL). NaH (88.4 mg, 2.21 mmol) was added to the solution at 0°C and the whole was stirred for 30 minutes. Allyl bromide (120 µL, 1.39 mmol) was added to the solution and it was left stirring overnight. The solution was quenched with NH_4Cl (sat., aq.) and extracted with EtOAc. The combined organic phases were dried over $MgSO_4$, filtered and concentrated. Purification by flash chromatography (20% EtOAc in hexanes) yielded (1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(3-(allyloxy)prop-1-en-2-yl)cyclohexanol (199.6 mg, 64%) as a yellow oil.

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 6.20 (t, *J*=4.0 Hz, 1H), 5.92 (m, 1H), 5.30 (qd, *J*=17.0, 1.7 Hz, 1H), 5.22-5.15 (m, 3H), 4.3-3.8 (m, 4H), 2.40 (m, 1H), 2.15-2.05 (m, 3H), 2.0-0.6 (m, 15H); **^{13}C NMR** ($CDCl_3$, 75 MHz) δ_{ppm} = 145.4, 139.8, 134.2, 124.1, 117.7, 117 4, 105 9, 90.4, 84.3, 74.7, 72.1, 71.1, 65.7, 59.5, 53.1, 41.2, 38.2, 34.4, 31.9, 31 2, 30.3, 29.7, 29.4, 25.9, 25.6, 23.9, 22.7, 20.3, 15.4; presence of extra peaks due to decomposition overnight in the NMR tube.

IR (FTIR, cm^{-1}) = 3382, 2919, 2851, 1744, 1583, 1539, 1450, 1241, 1152, 1071, 1028, 943, 906, 818, 693, 609, 500

HRMS (EI) *m/z* calculated for $C_{22}H_{30}O_4$ (M+) = 358.2144, found: 358.2340.



(1R,4aS,8aR)-1-allyl-3-(1,4-dioxaspiro[4.5]dec-6-en-6-yl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol

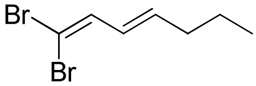
To a dry vial was added (1R,2R)-1-(1,4-dioxaspiro[4.5]dec-6-en-6-ylethynyl)-2-(3-(allyloxy)prop-1-en-2-yl)cyclohexanol (28.4 mg, 79.3 µmol) and dissolved in PhCl (3 mL). The solution was degassed for 20 minutes with argon. Et_3N (55 µL, 395 µmol) was added. The microwave vial was then capped under argon and heated in a microwave oven for 3 hours at 200°C. The solution was concentrated and purified by flash chromatography to obtain (1R,4aS,8aR)-1-allyl-3-(1,4-dioxaspiro[4.5]dec-6-en-6-yl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol (17.6 mg, 62%) as a yellow oil.

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 5.84 (t, *J*= 3.72Hz, 1H), 5.78 (m, 1H), 5.67 (s, 1H), 5.14 (d, *J*= 12.7Hz, 1H), 5.06 (qd, J= 5.1, 1.4Hz, 1H), 5.01 (s, 1H), 4.06 (m, 2H), 3.99 (m, 2H), 3.77 (d, *J*= 12.7 Hz, 1H), 2.29 (m, 2H), 2.22 (m, 2H), 2.07 (m, 2H), 1.9 (m, 2H), 1 0-1.8 (m, 15H).

^{13}C NMR DEPT 135 ($CDCl_3$, 75 MHz) δ_{ppm} = 135.0 (CH), 134.8 (CH), 131.5 (CH), 117.4 (CH_2), 105.9 (CH), 64.1 (CH_2), 63.9 (CH_2), 48.8 (CH), 37.7 (CH_2), 37.6 (CH_2), 32.5 (CH_2), 32.4 (CH_2), 25.1 (CH_2), 24.8 (CH_2), 23.3 (CH_2), 20.8 (CH_2), 19.9 (CH_2);

IR (FTIR, cm^{-1}) = 3426, 2927, 2851, 1711, 1671, 1635, 1582, 1539, 1434, 1354, 1338, 1297, 1265, 1220, 1176, 1112, 1068, 1023, 995, 947, 906, 854, 798, 734, 553;

HRMS (EI) *m/z* calculated for $C_{22}H_{30}O_4$ (M+) = 358.2144, found: 358.2120.



(E)-1,1-dibromohepta-1,3-diene

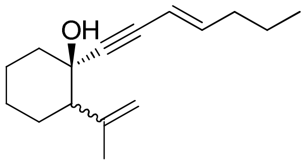
CBr_4 (8.06 g, 24.3 mmol) was slowly added to a solution of PPh_3 (12.06 g, 45.98 mmol) in CH_2Cl_2 (15 mL) at 0°C, and the mixture was stirred for 30 min. A solution of (*E*)-hex-2-enal (1.00 g, 10.19 mmol) in CH_2Cl_2 (10 mL) was then added and stirring was maintained for 1 hour. The mixture was diluted with petroleum ether and filtered through celite. The filtrate was washed with $NaHCO_3$ (sat. aq.), H_2O, brine, dried over $MgSO_4$, and concentrated. Flash chromatography with 1% EtOAc in hexanes gave (E)-1,1-dibromohepta-1,3-diene as a yellow oil (1.96 g, 76%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 6.87 (d, *J*= 9.9 Hz, 1H), 6.11-6.01 (m, 1H), 5.93- 5.83 (m, 1H), 2.09-2.02 (m, 2H), 1.53-1.18 (m, 2H), 0.89 (t, *J*= 7.4Hz, 3H);

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 139.4, 137.1, 127.2, 88.3, 35.0, 22.0, 13.7;

IR (FTIR, cm^{-1}) = 2960, 2932, 2873, 1706, 1651, 1463;

HRMS (EI) *m/z* calculated for $C_7H_{10}Br_2$ (M+) = 251.9149, found: 251.9152.



(1R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(prop-1-en-2-yl)cyclohexanol

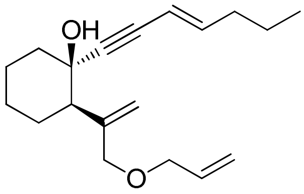
To a solution of (E)-1,1-dibromohepta-1,3-diene (0.5 g, 1.97 mmol) stirring in THF (15 mL) at -78°C was added n-BuLi (1.75 mL, 4.14 mmol). The solution was stirred for 45 minutes allowing the formation of the alkynyl lithium *in situ*. To this was added a solution of 2-(prop-1-en-2-yl)cyclohexanone (0.24 g, 1.77 mmol) in THF (5 mL). This was stirred for 1 hour, warmed up to room temperature and quenched with NH_4Cl (sat. aq.). The mixture was extracted with EtOAc (3x) and the combined organic layers were dried over $MgSO_4$ and concentrated. Flash chromatography with 10% EtOAc in hexanes gave (1R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(prop-1-en-2-yl)cyclohexanol (mixture of diastereomers) as a colorless oil (0.12 g, 29%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 6.05 (dt, *J*= 15.9, 7.1 Hz, 1H), 5.43 (dt, *J*= 15.9, 1.6 Hz, 1H), 4.97 (t, *J*= 1.6 Hz, 1H), 4.81 (s, 1H), 2.23-1.94 (m, 7H), 1.77-1.15 (m, 10H), 0.87 (t, *J*= 7.3Hz, 3H);

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 148.4, 144.5, 112.1, 109.1, 92.4, 81.9, 67.2, 52.6, 39.6, 35.1, 26.7, 26.0, 25.8, 21.9, 20.6, 13.6;

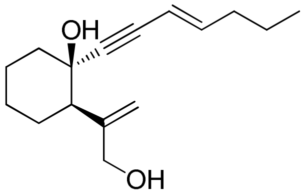
IR (FTIR, cm^{-1}) = 3556, 3079, 2934, 1638, 1447, 1371, 1266, 1177, 1138, 1070;

HRMS (EI) *m/z* calculated for $C_{16}H_{24}O$ (M+) = 232.1827, found: 232.1840.



(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-hept-3-en-1-yn-1-yl)cyclohexanol

Step1:



(1R,2R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol

A dry 50 mL round-bottom flask fitted with a magnetic stirrer was charged with CH_2Cl_2 (25 mL) under argon, (1R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(prop-1-en-2-yl)cyclohexanol (1g, 4.3 mmol, 1 eq.), SeO_2 (0.24 g, 2.15 mmol, 0.5 eq.) with stirring, followed by *tert*-butyl hydroperoxide 30% solution in water (2.87 mL, 12.91 mmol, 3 eq.). The reaction was allowed to stir for 48 hours. The CH_2Cl_2 was reduced to a minimum quantity. The residue was diluted with EtOAc, washed with water, brine, and dried over $MgSO_4$ and filtered. Silica was added prior to removal of the volatiles. The dry powder was subjected to flash chromatography (0-30% EtOAc in 3 steps) to give the desired (1R,2R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol as an oil (0.33 g, 31%) and the undesired diastereomer (0.17g, 16%).

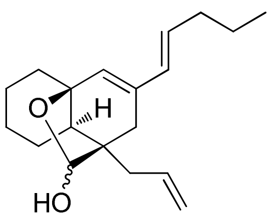
Step2:

A dry 100 mL round-bottom flask was charged with (1R,2R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(3-hydroxyprop-1-en-2-yl)cyclohexanol (562 mg, 2.26 mmol) and THF (55mL). NaH (202.4 mg, 5.06 mmol) was added to the solution at 0°C and the whole was stirred for 30 minutes. Allyl bromide (295 µL, 3.41 mmol) was added to the solution and left stirring overnight. The solution was quenched with NH_4Cl and extracted in EtOAc (3x). The combined organic phases were dried over $MgSO_4$, filtered and concentrated. Purification by flash chromatography (10% EtOAc in hexanes) gave (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-hept-3-en-1-yn-1-yl)cyclohexanol (329 mg, 50%) as yellow oil.

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 6.05 (dt, *J*=15.8, 7.1Hz, 1H), 5.99 - 5.85 (m, 1H), 5.45 (dt, *J*=15.8, 1.6 Hz, 1H), 5.34 - 5.25 (m, 1H), 5.14 - 5.24 (m, 3H), 4.21-4.1 (m, 2H), 3.96-3.85 (m, 2H), 2.39 (dd, *J*=12.9, 3.3Hz, 1H), 2.12 (m, 1H), 2.05 (qd, *J*=7.3, 1.6 Hz, 2H), 1.88-1.6 (m, 4H), 1.46-1.34 (m, 3H), 0.89 (t, *J*=7.4 Hz, 3H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 145.8 (C), 144.3 (CH), 134.2(CH), 118.9 (CH_2), 117.8 (CH_2), 109.6 (CH), 90.2 (C), 82.5 (C), 72.2 (CH_2), 70.6 (CH_2), 68 (C), 52.9 (CH), 39.8 (CH_2), 35.2 (CH_2), 26.3 (CH_2), 26 (CH_2), 22.1 (CH_2), 20.8 (CH_2), 13.8 (CH_3)

HRMS (EI) *m/z* calculated for $C_{16}H_{23}O_2$ $[(M – C_3H_5)^+]$ = 247.1776, found: 247.1635



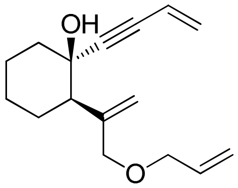
<u>(1R,4aS,8aR)-1-allyl-3-((E)-pent-1-en-1-yl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol</u>

A solution of (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-hept-3-en-1-yn-1-yl)cyclohexanol (13.2 mg, 0.046 mmol, 1 eq.) in PhCl (2.5 mL) in a microwave vessel was degassed with argon for 20 minutes followed by the addition of Et_3N (30 µL, 0.23 mmol, 5 eq.). The mixture was heated at 200°C using microwave irradiation for 3 hours. The solvent was evaporated and the product purified by flash chromatography (20% EtOAc in hexanes) to yield (1R,4aS,8aR)-1-allyl-3-((E)-pent-1-en-1-yl)-2,5,6,7,8,8a-hexahydro-1H-4a,1 (epoxymethano)naphthalen-10-ol as colorless solid (12.5 mg, 94%).

^{1}H NMR (C_6D_6, 300 MHz) δ_{ppm} = 6.06 (br s, 0.4H), 6.00 (br s, 0.6H), 5.88-5.58 (m, 3H), 5.25 (d, *J*=6.2Hz, 0.6H), 5.16-5.01 (m, 2H), 4.94 (d, *J*=3.7 Hz, 0.4H), 3.01 (d, *J*=3.7 Hz, 0.4H), 2.88 (d, *J*=6.7 Hz, 0.6H), 2.48-2.35 (m, 1H), 2.32-2.09 (m, 2H), 2.06-1.94 (m, 3H), 1.91-1.73 (m, 1H), 1.71-1.54 (m, 2H), 1.50-0.92 (m, 8H), 0.86 (t, *J*=7.2Hz, 1.2H), 0.84 (t, *J*=7.4Hz, 1.8H);
^{13}C NMR (C_6D_6, 75 MHz) δ_{ppm} = 136.6 (2 C), 136.3 (CH), 135.6 (CH), 135.4 (CH), 134.9 (CH), 132.4 (CH), 132.2 CH), 130.2 (CH), 129.6 (CH), 117.3 (2 CH_2), 105.0 (CH), 104.0 (CH), 78.8 (2 C), 49.5 (CH), 49.3 (2 C), 47.0 (CH), 38.4 (CH_2), 37.9 (CH_2), 36.0 (CH_2), 35.4 (CH_2), 35.3

(CH_2), 33.3 (CH_2), 33.1 (2 CH_2), 25.5 (CH_2), 25.2 (CH_2), 23.6 (CH_2), 23.5 (CH_2), 23.0 (CH_2), 22.9 (CH_2), 21.6 (CH_2), 21.4 (CH_2), 13.9 (CH_3) ;

HRMS (EI) *m/z* calculated for $C_{19}H_{28}O_2$ (M^+) = 288.2089, found: 288.2074.



(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(but-3-en-1-yn-1-yl)cyclohexanol

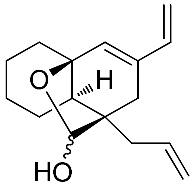
A 25 mL flask was charged with THF (5 mL) and Et_3N (0.95 mL, 6.84 mmol, 5 eq.) and the mixture was degassed for 15 minutes. Vinyl bromide (1M in THF, 4.10 mmol, 3 eq.), CuI (26 mg, 0.14 mmol, 0.01 eq.) and $PdCl_2(PPh_3)_2$ (48 mg, 0.068 mmol, 0.05 eq.) were added at 0˚C. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (300 mg, 1.37 mmol, 1 eq.) was added and the mixture was stirred and allowed to warm up to room temperature over 4 hours. The mixture was quenched with saturated NH_4Cl_{aq}. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (10% Et_2O in hexanes) to give (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(but-3-en-1-yn-1-yl)cyclohexanol as a yellow oil (301 mg, 89%).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 5.91 (m, 1H), 5.78 (dd, *J*= 18, 11Hz, 1H), 5.54 (dd, *J*= 18, 2.3Hz, 1H), 5.39 (dd, *J*= 11, 2.3Hz, 1H), 5.29 (dq, *J*=17, 2Hz, 1H), 5.20 (dq, *J*=17, 1.5Hz, 1H) 5.18 (s, 2H), 4.34 (d, *J*= 2Hz, 1H), 4.18 (dd, *J*=16, 1Hz, 1H), 4.14 (ddt, *J*=16, 6, 1.5 Hz, 1H), 3.91(ddt, *J*=16, 6, 1.5 Hz, 1H), 3.86 (d, *J*=12Hz, 1H), 2.40 (dd, *J*= 13, 3.3Hz, 1H), 2.17-2.09 (m, 1H), 1.91-1.20 (m, 8H)

^{13}C NMR (CDCl$_3$, 100 MHz) δ_{ppm} = 145.5 (C), 134.0 (CH), 126.4 (CH$_2$), 119.4 (CH$_2$), 117.9 (CH), 117.2 (CH$_2$), 95.0 (C), 82.4 (C), 72.0 (CH$_2$), 70.6 (CH$_2$), 68.0 (C), 53.0 (CH), 39.6 (CH$_2$), 26.1 (CH$_2$), 26.0 (CH$_2$), 20.7 (CH$_2$)

IR (FTIR, cm-1) = 3387, 3086, 2933, 2859

HRMS (EI) *m/z* calculated for $C_{16}H_{20}O$ [(M – H$_2$O)$^+$] = 228.1620, found: 228.1452.



<u>(1R,4aS,8aR)-1-allyl-3-vinyl-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol</u>

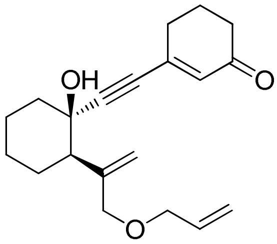
A solution of (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(but-3-en-1-yn-1-yl)cyclohexanol (30 mg, 0.122 mmol) in PhCl (2.5 mL) in a microwave vessel was degassed with argon for 20 minutes followed by the addition of Et$_3$N (34 µL, 0.244 mmol, 2 eq.). The mixture was heated at 200°C using microwave irradiation for 3 hours. The solvent was evaporated and the product purified by flash chromatography (20% EtOAC in hexanes) to yield (1R,4aS,8aR)-1-allyl-3-vinyl-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol (mixture of diastereomers) as a yellow oil (20 mg, 67%).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = **Major** 6.25(d, *J*=10.6Hz, 1H), 5.73 (m, 1H), 5.60 (s, 1H), 5.22-4.83 (m, 5H), 2.71-0.82 (m, 13H) **Minor** 6.3 (d, *J*= 10.6Hz, 1H) 5.73(m, 1H) 5.62 (s, 1H), 5.22- 4.83 (m, 5H), 2.71-0.82 (m, 13H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 138.3/137.8 (CH), 137.1/136.9 (CH), 136.5 (C), 135.3/134.8 (CH), 117.9 (CH_2), 114.1/113.3 (CH_2), 105.0/104.0 (CH), 78.9 (C), 77.4 (C), 49.4/46.6 (CH), 37.59/37.2 (CH_2), 35.5/32.9 (CH_2), 32.6/31.9 (CH_2), 25.1/24.9 (CH_2), 23.5 (CH_2), 21.2/21.0 (CH_2)

IR (FTIR, cm^{-1}) = 3386, 3074, 3005, 2925, 2853, 1636, 1605, 1442

HRMS (EI) *m/z* calculated for $C_{16}H_{22}O_2$ (M+) = 246.1620, found: 246.1605.



3-(((1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclohex-2-enone

A 50 mL round-bottom flask was charged with PhMe (25 mL) and Et_3N (1.15 mL, 8.17 mmol, 3 eq.) and the mixture was degassed for 15 minutes. 3-iodocyclohex-2-enone (726 mg, 3.27 mmol, 1.2 eq.), CuI (12.97 mg, 0.068 mmol, 0.025 eq) and $PdCl_2(PPh_3)_2$ (96 mg, 0.136 mmol, 0.05 eq) were added at 0˚C. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (600 mg, 2.72 mmol, 1 eq.) was added and the mixture was stirred and allowed to warm up to room temperature over 8 hours. The mixture was quenched with saturated NH_4Cl_{aq}. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (10-30% EtOAc in hexanes) to give 3-(((1R,2R)-2-(3-

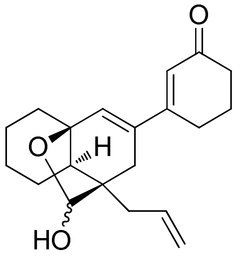
(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclohex-2-enone as a yellow oil (702 mg, 82%).

^{1}**H NMR** ($CDCl_3$, 400 MHz) δ_{ppm} = 6.12 (s, 1H), 5.94-5.85 (m , 1H), 5.29 (ddt, *J*= 17.2, 1.6, 1.6 Hz, 1H), 5.22 (ddt, *J*= 10.4, 1.6, 1.2Hz, 1H), 5.18 (d, *J*= 1.9 Hz, 1H), 5.17 (d, *J*= 1.9 Hz, 1H), 4.88 (s, 1H), 4.15 (d, *J*= 11.6 Hz, 1H), 4.12 (ddt, *J*= 12.5, 5.3, 1.5, 1H), 3.92 (ddt, *J*= 12.5, 6.0, 1.4, 1H), 3.81 (d, *J*= 11.4Hz, 1H), 2.45 (dd, *J*= 12.9, 3.3Hz, 1H), 2.41-2.37 (m, 4H), 2.14 (dd, *J*= 12.9, 1.4Hz, 1H), 1.99 (d, *J*= 6.3Hz, 2H), 1.90-1.73 (m, 2H), 1.72-1.60 (m, 2H), 1.57-1.51 (m, 1H), 1.48-1.42 (m, 1H), 1.31 (dt, *J*= 12.5, 3.5 Hz, 1H)

^{13}**C NMR** ($CDCl_3$, 100 MHz) δ_{ppm} = 198.9 (C), 144.8 (C), 143.8 (C), 133.7 (CH), 132.4 (CH), 120.6 (CH_2), 118.2 (CH_2), 105.3 (C), 83.1 (C), 71.5 (CH_2), 70.7 (CH_2), 68.4 (C), 53.7 (CH), 39.3 (CH_2), 37.4 (CH_2), 30.7 (CH_2), 25.9 (CH_2), 25.7 (CH_2), 22.7 (CH_2), 20.6 (CH_2).

IR (FTIR, cm^{-1}) = 3363, 2934, 2857, 2209, 1675, 1590, 1422, 1237, 1132

HRMS (EI) *m/z* calculated for $C_{20}H_{26}O_3$ (M+) = 314.1882, found: 314.1879.



3-((1R,4aS,8aR)-1-allyl-10-hydroxy-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-3-yl)cyclohex-2-enone

A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.3 mL, 2.2 mmol, 3 eq.) and 3-(((1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclohex-2-enone (230 mg, 0.73 mmol, 1 eq.) were added. The mixture was degassed for 10 minutes before being irradiated by microwaves (200˚C, 300 W) for 2 hours. The crude was concentrated and flash chromatography (20-40% EtOAC in hexanes) was performed to give 3-((1R,4aS,8aR)-1-allyl-10-hydroxy-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-3-yl)cyclohex-2-enone (mixture of diastereomers) as a yellow solid (200 mg, 87%).

Major diastereomer:

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 6.23 (s, 1H), 6.12 (s, 1H), 5.84-5.71 (m, 1H), 5.32 (s, 1H), 5.11 (d, *J*= 17.0 Hz, 1H), 5.10 (d, *J*= 10.3, 1H), 2.62-2.22 (m, 8 H), 2.07-1.98 (m, 3H), 1.87-1.72 (m, 3H), 1.61-1.47 (m, 3H), 1.45-1.25 (m, 2H), 1.21-1.10 (m, 1H);

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 200.8 (C), 157.3 (C), 138.5 (CH), 136.6 (C), 134.2 (CH), 124.6 (CH), 118.4 (CH_2), 104.6 (CH), 78.4 (C), 49.3 (C), 48.6 (CH), 37.6 (CH_2), 37.4 (CH_2), 33.2 (CH_2), 33.1 (CH_2), 25.5 (CH_2), 24.7 (CH_2), 23.4 (CH_2), 22.5 (CH_2), 21.0 (CH_2).

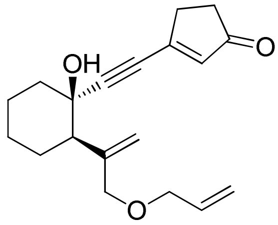
Minor diastereomer:

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 6.23 (s, 1H), 6.04 (s, 1H), 5.84-5.71 (m, 1H), 5.14 (dd, *J*= 17.6, 1.8 Hz, 1H), 5.12 (dd, *J*= 8.2, 1.6 Hz, 1H), 4.93 (s, 1H), 2.62-2.22 (m, 8 H), 2.07-1.98 (m, 3H), 1.87-1.72 (m, 3H), 1.61-1.47 (m, 3H), 1.45-1.25 (m, 2H), 1.21-1.10 (m, 1H);

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 200.8 (C), 157.7 (C), 139.0 (CH), 135.1 (C), 134.7 (CH), 124.2 (CH), 118.4 (CH_2), 103.8 (CH), 77.4 (C), 49.3 (C), 45.9 (CH), 38.5 (CH_2), 37.6 (CH_2), 35.5 (CH_2), 32.9 (CH_2), 25.5 (CH_2), 24.9 (CH_2), 23.3 (CH_2), 22.5 (CH_2), 21.1 (CH_2).

IR (FTIR, cm^{-1}) = 2935, 1655, 1580, 1433, 1099, 980, 814, 729 cm^{-1}.

HRMS (EI) *m/z* calculated for $C_{20}H_{26}O_3$ (M+) = 314.1882, found: 314.1903.



3-(((1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclopent-2-enone

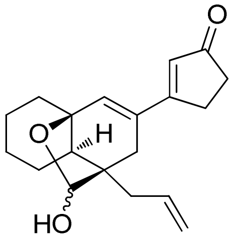
A 25 mL round-bottom flask was charged with THF (11 mL) and Et_3N (2.31 mL, 16.6 mmol, 5 eq.) and the mixture was degassed for 15 minutes. The 3-iodocyclopent-2-enone (688 mg, 3.31 mmol, 1 eq.), CuI (63 mg, 0.33 mmol, 0.01 eq.) and $PdCl_2(PPh_3)_2$ (116 mg, 0.17 mmol, 0.05 eq.) were added at 0˚C. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (726 mg, 3.31 mmol) was added and the mixture was stirred and allowed to warm up to room temperature over 2 hours. The mixture was quenched with saturated NH_4Cl_{aq}. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (50% Et_2O in hexanes) to give 3-(((1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclopent-2-enone as an orange oil (697 mg, 70%).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 6.20 (t, *J*=2.0 Hz, 1H), 5.90 (m, 1H), 5.29 (dq, *J*=17, 1.6Hz, 2H) 5.18 (s, 2H), 4.97 (br s, 1H),4.17 (d, *J*= 12Hz, 1H), 4.13 (ddt, *J*=13, 6, 1.5Hz, 1H), 3.93 (ddt, *J*=13, 6, 1.5Hz, 1H) 3.81 (d, *J*= 12Hz, 1H), 2.69 (m, 2H), 2.48 (dd, *J*= 13, 3.3Hz, 1H), 2.40 (m, 2H), 2.18 (m, 1H), 1.9-1.25 (m, 10H)

^{13}**C NMR** ($CDCl_3$, 100 MHz) δ_{ppm} = 209.7 (C), 157.5 (C), 144.6 (C), 134.9 (CH), 133.6 (CH), 120.8 (CH_2), 118.2 (CH_2), 110.5 (C), 79.8 (C), 71.4 (CH_2), 70.7 (CH_2), 68.6(C), 53.7 (CH), 39.1, 34.8(CH_2), 32.7(CH_2), 25.9(CH_2), 25.7(CH_2), 20.5 (CH_2)

IR (FTIR, cm^{-1}) = 3356, 2941, 2851, 2209, 1700, 1576, 1270

HRMS (EI) *m/z* calculated for $C_{19}H_{24}O_3$ (M+) = 300.1725, found: 300.1696



3-((1R,4aS,8aR)-1-allyl-10-hydroxy-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-3-yl)cyclopent-2-enone

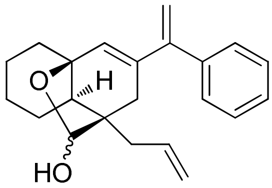
A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (75 µL, 0.48 mmol, 3 eq.) and 3-(((1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclopent-2-enone (50 mg, 0.16 mmol) were added. The mixture was degassed for 10 minutes before being irradiated by microwaves (200˚C, 300 W) for 2 hours. The crude was concentrated and flash chromatography (20-40% EtOAC in hexanes) was performed to give 3-((1R,4aS,8aR)-1-allyl-10-hydroxy-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-3-yl)cyclopent-2-enone (mixture of diastereomers) as a yellow solid (36 mg, 72%).

^{1}**H NMR** ($CDCl_3$, 400 MHz) δ_{ppm} = **Major** 6.24 (s, 1H), 6.12 (s, 1H), 5.83-5.73 (m, 1H), 5.35 (2s, 1H), 5.18-5.07 (m, 2H), 3.35 (br s, 1H), 2.82-2.64 (m, 3H) 2.48-2.19 (5H), 2.10-1.99 (m, 1H), 1.91-1.10 (m, 9H), **Minor** 6.12 (s, 1H), 5.83-5.73 (m, 1H), 5.18-5.07 (m, 2H), 4.97 (s, 1H), 3.54 (br s, 1H), 2.82-2.64 (m 3H), 2.48-2.19 (m, 2H), 2.10-1.99 (m, 1H), 1.91-1.10 (m, 9H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = **Major** 210.0 (C), 173.1 (C), 138.9 (CH), 134.4 (C), 134.3(CH), 128.3 (CH), 118.2 (CH_2), 104.5 (CH), 78.4 (C), 49.1 (C), 48.7 (CH), 37.0 (CH_2), 35.0 (CH_2), 34.8 (CH_2), 33.6 (CH_2), 27.3 (CH_2), 24.7 (CH_2), 23.4 (CH_2), 21.0 (CH_2) **Minor** 209.9 (C), 173.3 (C), 139.6 (CH), 134.8 (CH), 132.8(C), 127.9 (CH), 118.3 (CH_2), 103.9 (CH), 78.4 (C), 49.2 (C), 46.0 (CH), 39.0 (CH_2), 35.3 (CH_2), 35.0 (CH_2), 32.7 (CH_2), 27.3 (CH_2), 24.9 (CH_2), 23.2 (CH_2), 21.1 (CH_2)

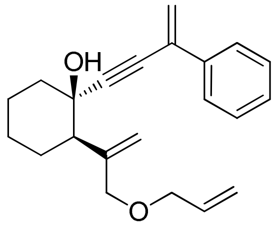
IR (FTIR, cm^{-1}) = 3368, 2933, 2859, 1701, 1673, 1626, 1572, 1435, 1259

HRMS (EI) *m/z* calculated for $C_{19}H_{24}O_3$ (M+) = 300.1725, found: 300.1733



(1R,4aS,8aR)-1-allyl-3-(1-phenylvinyl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol

Step 1:



<u>(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-phenylbut-3-en-1-yn-1-yl)cyclohexanol</u>

A 25 mL round-bottom flask was charged with PhMe (10 mL) and Et_3N (0.51 mL, 3.63 mmol, 2 eq.) and the mixture was degassed for 15 minutes. α-bromostyrene (665 mg, 3.63 mmol, 2 eq.), CuI (8.64 mg, 0.045 mmol, 0.025 eq.) and $PdCl_2(PPh_3)_2$ (105 mg, 0.091 mmol, 0.05 eq.) were added at 0˚C. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (400 mg, 1.816 mmol, 1 eq.) was added and the mixture was stirred and allowed to warm up to room temperature over 8 hours. The mixture was quenched with saturated NH_4Cl_{aq}. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude (468 mg, 80%) was subjected to the domino reaction without further purification.

Step 2:

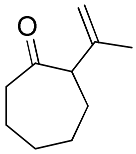
A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.13 mL, 0.93 mmol, 3 eq.) and the crude above (100 mg, 0.31 mmol, 1 eq.) were added. The mixture was degassed with argon for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 3 hours. The crude was concentrated and flash chromatography (10% EtOAC in hexanes) was performed to give (1R,4aS,8aR)-1-allyl-3-(1-phenylvinyl)-2,5,6,7,8,8a-hexahydro-1H-4a,1-(epoxymethano)naphthalen-10-ol (mixture of diastereomers) as a yellow oil (51 mg, 51%).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 7.44-7.26 (m, 5 H), 5.9-5.75 (m, 1H), 5.6 (s, 1H), 5.37-5.23 (m, 2H), 5.21-5.07 (m, 3H), 5.09 (s, 1H), 2.7-2.56 (m, 2H), 2.53-2.23 (m, 4H), 1.79-1.7 (m, 3H), 1.69-1.64 (m, 2H), 1.5-1.45 (m, 2H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 149.6 (C), 141.2 (C), 136.8 (CH), 136.4 (C), 129.9 (CH), 128.9 (CH), 128.0 (CH), 127.6 (CH), 127.4 (CH), 127.4 (CH), 118 (CH_2), 114.2 (CH_2), 105 (CH), 79.1 (C), 49.7 (C), 49.1 (CH), 37.6 (CH_2), 34.4 (CH_2), 24.9 (CH_2), 23.4 (CH_2), 21 (CH_2)

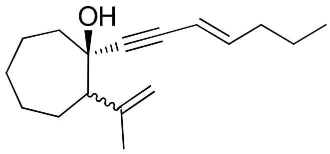
IR (FTIR, cm^{-1}) = 2924, 2363, 1697, 1445, 1267, 1088, 912, 733, 696

HRMS (EI) *m/z* calculated for $C_{22}H_{26}O_2$ (M+) = 322.1933, found: 300.1941



2-(prop-1-en-2-yl)cycloheptanone

Described in: *Org. Lett.*, **2006**, *8*, 5905–5908.



(1R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(prop-1-en-2-yl)cycloheptanol

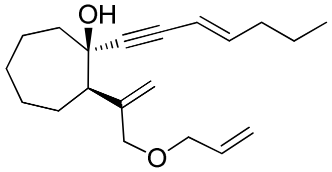
To a solution of (E)-1,1-dibromohepta-1,3-diene (6.7 g, 26.4 mmol) stirring in THF (100 mL) at -78°C was added n-BuLi (32.6 mL, 55.4 mmol, 2.1 eq.) and HMPA (5.51 mL, 31.7 mmol, 1.2 eq.). The solution was stirred for 45 minutes allowing the formation of the alkynyl lithium *in situ*. To this was added a solution of 2-(prop-1-en-2-yl)cycloheptanone (1.21 g, 8 mmol, 1 eq.) in THF (150 mL). This was stirred for 1 hour, warmed to room temperature and quenched with saturated NH_4Cl_{aq}. The mixture was extracted with EtOAc (3x) and the combined organic layers were dried over $MgSO_4$ and concentrated. Flash chromatography with 10% EtOAc in hexanes gave (1R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(prop-1-en-2-yl)cycloheptanol (mixture of diastereomers) as a colorless oil (1.7 g, 86 %).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 6.08 (dt, *J*=15.9, 7.1Hz, 1H), 5.46 (dt, *J*=15.8, 1.6 Hz, 1H), 5.03 (t, *J*=1.5 Hz, 1H), 4.80 (t, *J*=0.8 Hz, 1H), 2.44 (d, *J*=10.1Hz, 1H), 2.40 (s, 1H), 2.23-2.18 (m, 1H), 2.06 (qd, *J*=7.3, 1.6 Hz, 2H), 1.99 (dd, *J*=1.3, 0.8 Hz, 3H), 1.91-1.72 (m, 5H), 1.55-1.34 (m, 4H), 1.40 (q, *J*=7.4Hz, 2H), 0.90 (t, *J*=7.4Hz, 3H);

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 150.1 (C), 144.5 (CH), 113.7 (CH_2), 109.4 (CH), 93.8 (C), 81.5 (C), 70.4 (C), 57.2 (CH), 42.1 (CH_2), 35.2 (CH_2), 29.5 (CH_2), 29.4 (CH_2), 28.8 (CH_2), 25.6 (CH_3), 22.1 (CH_2), 21.8 (CH_2), 13.8 (CH_3);

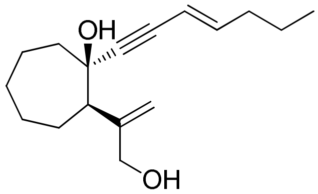
IR (FTIR, cm^{-1}) = 3389, 2935, 2847, 1063;

HRMS (EI) *m/z* calculated for $C_{17}H_{26}O$ (M+) = 246.1984, found: 246.1972



(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-hept-3-en-1-yn-1-yl)cycloheptanol

Step1:



(1R,2R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(3-hydroxyprop-1-en-2-yl)cycloheptanol

A dry 150 mL round-bottom flask fitted with a magnetic stirrer was charged with CH_2Cl_2 (75 mL) under argon, (1R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(prop-1-en-2-yl)cycloheptanol (1.62g, 6.58 mmol, 1 eq.), SeO_2 (0.365 g, 3.29 mmol, 0.5 eq.) with stirring, followed by *tert*-butyl hydroperoxide $_{aq}$ 30% solution (5.85 mL, 26.3 mmol, 4 eq.). The reaction was allowed to stir for 48 hours. The CH_2Cl_2 was reduced to a minimum quantity. The residue was diluted with EtOAc, washed with water, brine, and dried over $MgSO_4$ and filtered. Silica was added prior to removal of the volatiles. The dry powder was subjected to flash chromatography (0-30% EtOAc in 3 steps) to give the desired (1R,2R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(3-hydroxyprop-1-en-2-yl)cycloheptanol as yellow oil (0.5 g, 30%) and the undesired alcohol (0.26g, 15%).

Step2:

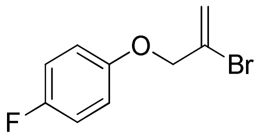
A dry 25 mL round-bottom was charged with (1R,2R)-1-((E)-hept-3-en-1-yn-1-yl)-2-(3-hydroxyprop-1-en-2-yl)cycloheptanol (486 mg, 1.85 mmol, 1 eq.) and THF (10mL). NaH 60% (47 mg, 2.04 mmol, 1.1 eq.) and NaI (13.88 mg, 0.093 mmol, 0.05 eq.) was added to the solution at 0°C and the whole was stirred for 30 minutes. Allyl bromide (0.18 mL, 2.04 mmol, 1.1 eq.) was added to solution and was left stirring overnight. The solution was quenched with saturated NH_4Cl_{aq} and extracted in EtOAc (3x). Combined organic phases were dried over $MgSO_4$, filtered and concentrated. Purification by flash chromatography (10% EtOAc in hexanes) yielded (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-hept-3-en-1-yn-1-yl)cycloheptanol as yellow oil (403 mg, 72%) as yellow oil.

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 6.04 (dt, *J*=15.9, 7.1Hz, 1H), 5.97-5.85 (m, 1H), 5.45 (dt, *J*=15.9, 1.6 Hz, 1H), 5.29 (dq, *J*=17.2, 1.6 Hz, 1H), 5.21-5.17 (m, 2H), 5.11 (d, *J*=1.9 Hz, 1H), 4.18 (dd, *J*=12.3, 1.0 Hz, 1H), 4.11 (ddt, *J*=12.6, 5.4, 1.4Hz, 1H), 3.96-3.90 (m, 3H), 2.50 (d, *J*=10.3Hz, 1H), 2.13-1.91 (m, 5H), 1.85-1.75 (m, 2H), 1.74-1.65 (m, 1H), 1.53-1.35 (m, 4H), 1.39 (q, *J*=7.4Hz, 2H), 0.89 (t, *J*=7.4Hz, 3H);

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 147.9 (C), 144.2 (CH), 134.4 (CH), 117.9 (CH_2), 117.6 (CH_2), 109.6 (CH), 93.7 (C), 82.1 (C), 72.6 (CH_2), 70.8 (CH_2), 70.7 (C), 55.7 (CH), 42.5 (CH_2), 35.2 (CH_2), 28.6 (CH_2), 28.3 (CH_2), 27.7 (CH_2), 22.1 (CH_2), 21.3 (CH_2), 13.8 (CH_3);

IR (FTIR, cm^{-1}) = 3384, 2931, 2850, 1057;

HRMS (EI) *m/z* calculated for $C_{20}H_{30}O_2$ (M+) = 302.2246, found: 302.2238



1-((2-bromoallyl)oxy)-4-fluorobenzene

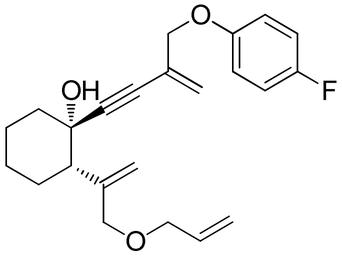
A dry 100 mL round-bottom flask was charged with 4-fluorophenol (1.62 g, 14.41 mmol, 1.2 eq.), KI (0.4 g, 2.4 mmol, 0.2 eq.) and EtOH (30mL). Then 2,3-dibromoprop-1-ene (1.5 mL, 12 mmol, 1 eq.) and DBU (3.59 mL, 24.02 mmol, 2 eq.) was added dropwise to the solution at room temperature and the whole was stirred for 18 hours. The reaction was quenched with NH_4Cl and extracted in EtOAc (3x). Combined organic phases were dried over $MgSO_4$, filtered and concentrated. Purification by flash chromatography (5% EtOAc in hexanes) yielded 1-((2-bromoallyl)oxy)-4-fluorobenzene as a colorless oil (2.36g, 85%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 7.03-6.95 (m, 2H), 6.91-6.84 (m, 2H), 5.99 (dt, *J* = 2.1, 1.7 Hz, 1H), 5.69 (dt, *J* = 2.2, 1.3Hz, 1H), 4.61 (dd, *J* = 1.5, 1.4Hz, 2H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 159.4 (C), 156.2 (C), 154.0 (d, *J*= 2.0 Hz, C), 118.0 (CH_2), 116.3 (CH), 116.2 (2 CH), 115.9 (CH), 72.5 (CH_2)

IR (FTIR, cm^{-1}) = 1506, 1202, 1040, 897, 824, 773, 727

HRMS (EI) *m/z* calculated for C_9H_8BrFO (M+) = 229.9743, found: 229.9783



(1S,2S)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-((4-fluorophenoxy)methyl)but-3-en-1-yn-1-yl)cyclohexanol

A 25 mL round-bottom flask was charged with PhMe (10 mL) and Et_3N (0.51 mL, 3.63 mmol, 2 eq.) and the mixture was degassed for 15 minutes. 1-((2-bromoallyl)oxy)-4-fluorobenzene (671 mg, 2.91 mmol, 1.6 eq.), CuI (8.64 mg, 0.045 mmol, 0.025 eq) and $PdCl_2(PPh_3)_2$ (105 mg, 0.091 mmol, 0.05 eq) were added at 0˚C. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (400 mg, 1.82 mmol, 1 eq.) was added and the mixture was stirred and allowed to warm up to room temperature over 8 hours. The mixture was quenched with saturated NH_4Cl_{aq}. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (10% EtOAc in hexanes) to give (1S,2S)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-((4-fluorophenoxy)methyl)but-3-en-1-yn-1-yl)cyclohexanol as a yellow oil (538 mg, 80%).

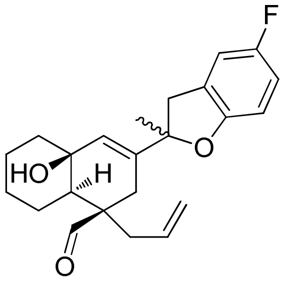
^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 6.98-6.93 (m, 2H), 6.86-6.81 (m, 2H), 5.90 (m, 1H), 5.51 (dq, *J*= 1.5Hz, 15.1Hz, 2H), 5.30 (dq, *J*=1.5Hz, 15.1Hz, 1H), 5.20 (dq, *J*=1.5Hz, 15.1Hz, 1H), 5.17 (s, 2H), 4.58 (br s, 1H), 4.44 (t, *J*= 1.5Hz, 2H), 4.17 (d, *J*=12.0Hz, 1H), 4.14 (ddt, *J*=1.5

Hz, 5.9Hz, 12.5Hz, 1H), 3.91 (ddt, *J*=1.5H, 5.9Hz, 12.5Hz, 1H), 3.83 (d, *J*=11.8Hz, 1H), 2.43, (dd, *J*=3.3Hz, 12.9Hz, 1H), 2.15 (dd, *J*=1.9Hz, 12.2Hz, 1H), 1.92-1.23 (m, 7H).

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 157.3 (d, *J*= 241Hz, C), 154.3 (C), 145.0 (C), 144.9 (C), 133.7 (CH), 126.7 (C), 121.4 (CH_2), 119.7 (CH_2), 115.9 (d, *J*= 1.7Hz, 2 CH), 115.6 (d, *J*= 17.1Hz, 2 CH), 95.8 (C), 81.0 (C), 71.5 (CH_2), 70.3 (CH_2), 70.2 (CH_2), 67.8 (C), 53.2 (CH), 39.4 (CH_2), 25.9 (CH_2), 25.8 (CH_2), 20.5 (CH_2)

IR (FTIR, cm^{-1}) = 2941, 2365, 1502, 1202, 1043, 976, 912, 824,729

HRMS (EI) *m/z* calculated for $C_{23}H_{27}FO_3$ (M+) = 370.1944, found: 370.1930



<u>(1R,4aS,8aR)-1-allyl-3-(5-fluoro-2-methyl-2,3-dihydrobenzofuran-2-yl)-4a-hydroxy-1,2,4a,5,6,7,8,8a-octahydronaphthalene-1-carbaldehyde</u>

A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.13 mL, 0.81 mmol, 3 eq.) and (1S,2S)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-((4-fluorophenoxy)methyl)but-3-en-1-yn-1-yl)cyclohexanol (100 mg, 0.27 mmol, 1 eq.) were added. The mixture was degassed with argon for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 2 hours. The crude was concentrated and flash chromatography (10% EtOAC in hexanes and then 100% CH_2Cl_2) was performed to give (1R,4aS,8aR)-1-allyl-3-(5-fluoro-2-methyl-2,3-

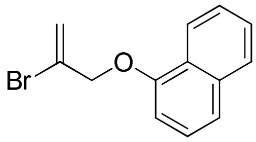
dihydrobenzofuran-2-yl)-4a-hydroxy-1,2,4a,5,6,7,8,8a-octahydronaphthalene-1-carbaldehyde as a yellow oil (37 mg, 37%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 9.59 (s, 1H), 7.03-6.62 (m, 3H), 6.17 (s, 1H), 5.88-5.56 (m, 1H), 5.20-4.91 (m, 2H), 3.12 (d, *J*=15.9 Hz, 1H), 2.89 (d, *J*=16.2Hz, 1H), 2.61-2.49 (m, 1H), 2.48-1.98 (m, 9 H), 1.97-1.69 (m, 4H), 1.51 (s, 3H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 206.5 (CH), 157.5 (d, *J*=233.3Hz, C-F), 155 (C), 137.2 (C), 134.7 (C), 132.7 (CH), 129.1 (CH), 124.7 (CH), 119.4 (CH_2), 114.4 (CH), 112.4 (CH), 109.6 (CH), 90.3 (C), 77.3 (C), 50.8 (C), 41.7 (CH_2), 40.1 (CH), 37.1 (CH_2), 31.8 (CH_2), 26 (CH_3), 25.8 (CH_2), 23.4 (CH_2), 22.7 (CH_2)

IR (FTIR, cm^{-1}) = 2924, 2363, 1717, 1479, 1437, 1223, 912, 735, 700

HRMS (EI) *m/z* calculated for $C_{23}H_{27}FO_3$ (M+) = 370.1944, found: 370.1945



<u>1-((2-bromoallyl)oxy)naphthalene</u>

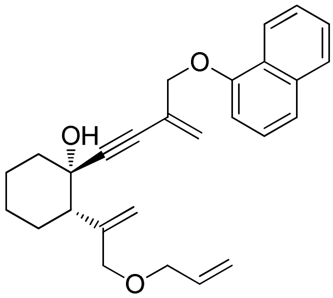
A dry 100 mL round-bottom flask was charged with the naphthalen-1-ol (2.08 g, 14.41 mmol, 1.2 eq.), KI (0.4 g, 2.4 mmol, 0.2 eq.) and EtOH (30mL). Then 2,3-dibromoprop-1-ene (1.5 mL, 12 mmol, 1 eq.) and DBU (3.59 mL, 24.02 mmol, 2 eq.) was added dropwise to the solution at room temperature and the whole was stirred for 18 hours. The reaction was quenched with NH4Cl and extracted in EtOAc (3x). Combined organic phases were dried over $MgSO_4$, filtered and concentrated. Punfication by flash chromatography (5% EtOAc in hexanes) yielded 1-((2-bromoallyl)oxy)naphthalene as a colorless oil (2.88g, 91%).

^{1}H NMR (CDCl$_3$, 400 MHz) δ_{ppm} = 8.38-8.35 (m, 1H), 7.87-7.83 (m, 1H), 7.54 (d, *J*= 9.6 Hz, 1H), 7.54 (dd, *J*= 3.0, 1.2Hz, 1H), 7.51 (d, *J*= 8.4Hz, 1H), 7.39 (dd, *J*= 8.1, 7.7 Hz, 1H), 6.82 (d, *J*= 7.6 Hz, 1H), 6.14 (dt, *J*= 1.7, 1.4Hz, 1H), 5.77 (dt, *J*= 1.7, 1.2Hz, 1H), 4.85 (dd, *J*= 1.4, 1.2Hz, 2H)

^{13}C NMR (CDCl$_3$, 100 MHz) δ_{ppm} = 153.5 (C), 134.7 (C), 127.6 (CH), 127.1 (C), 126.7 (CH), 125.8 (CH), 125.7 (C), 125.6 (CH), 122.1 (CH), 121.3 (CH), 117.9 (CH$_2$), 105.6 (CH), 71.9 (CH$_2$).

IR (FTIR, cm^{-1}) = 1595, 1580, 1506, 1396, 1267, 1230, 1067, 1094, 893, 768

HRMS (EI) *m/z* calculated for $C_{13}H_{11}BrO$ (M+) = 261.9993, found: 261.9977



(1S,2S)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-((naphthalen-1-yloxy)methyl)but-3-en-1-yn-1-yl)cyclohexanol

A 25 mL round-bottom flask was charged with Toluene (10 mL) and Et$_3$N (0.51 mL, 3.63 mmol, 2 eq.) and the mixture was degassed for 15 minutes. 1-((2-bromoallyl)oxy)naphthalene (764 mg, 2.91 mmol, 1.6 eq.), CuI (8.64 mg, 0.045 mmol, 0.025 eq) and PdCl$_2$(PPh$_3$)$_2$ (105 mg, 0.091

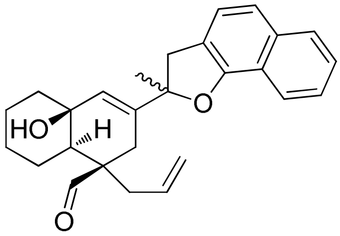
mmol, 0.05 eq) were added at 0˚C. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (400 mg, 1.82 mmol, 1 eq.) was added and the mixture was stirred and allowed to warm up to room temperature over 8 hours. The mixture was quenched with saturated NH_4Cl_{aq}. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (10% EtOAc in hexanes) to give (1S,2S)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-((naphthalen-1-yloxy)methyl)but-3-en-1-yn-1-yl)cyclohexanol as a yellow oil (629 mg, 86%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 8.38-8.35 (m, 1H), 7.85-7.82 (m, 1H), 7.55-7.36 (m, 4H), 6.81 (d, *J* = 7.6 Hz, 1H), 5.92 (m, 1H), 5.73 (q, *J* = 1.5Hz, 1H), 5.59 (q, *J* = 1.5Hz, 1H), 5.30 (dq, *J*=1.5Hz, 17.3Hz, 1H), 5.22 (dq, *J* = 1.5Hz, 17.5 Hz, 1H), 5.18 (m, 2H), 4.70 (m, 2H), 4.62 (br s, 1H), 4.20 (d, *J* = 11.6 Hz, 1H), 4.17 (ddt, *J* = 12.7, 5.2, 1.2 Hz, 1H), 3.92 (ddt, *J* = 12.5, 5.9, 1.2 Hz, 1H), 4.17 (d, *J* = 11.8 Hz, 1H), 2.46 (dd, *J* = 12.9, 3.4 Hz 1H), 2.21 (dd, 11.7, 1.9 Hz, 1H), 1.95-1.20 (m, 7H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 153.8 (C), 144.9 (2C), 134.4 (C), 133.7 (CH), 127.4 (CH), 126.8 (C), 126.3 (CH), 125.7 (CH), 125.2 (CH), 122.0 (CH), 121.3 (CH_2), 120.6 (CH), 119.7 (CH_2), 117.7 (CH_2), 105.2 (CH), 95.7 (C), 81.2 (C), 71.5 (CH_2), 70.3 (CH_2), 69.6 (CH_2), 67.9 (C), 53.2 (CH), 39.4 (CH_2), 25.8 (CH_2), 25.7 (CH_2), 20.5 (CH_2)

IR (FTIR, cm^{-1}) = 2941, 2860, 2345, 1398, 1267, 1234, 1148, 1095, 1067, 916, 764

HRMS (EI) *m/z* calculated for $C_{27}H_{30}O_3$ (M+) = 402.2195, found: 402.2199



(1R,4aS,8aR)-1-allyl-4a-hydroxy-3-(2-methyl-2,3-dihydronaphtho[1,2-b]furan-2-yl)-1,2,4a,5,6,7,8,8a-octahydronaphthalene-1-carbaldehyde

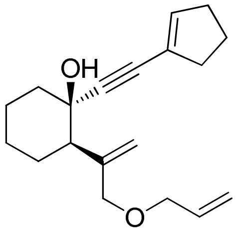
A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.13 mL, 0.75 mmol, 3 eq.) and (1S,2S)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-((naphthalen-1-yloxy)methyl)but-3-en-1-yn-1-yl)cyclohexanol (100 mg, 0.25 mmol, 1 eq.) were added. The mixture was degassed with argon for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 2 hours. The crude was concentrated and flash chromatography (10% EtOAC in hexanes and then 100% CH_2Cl_2) was performed to give (1R,4aS,8aR)-1-allyl-4a-hydroxy-3-(2-methyl-2,3-dihydronaphtho[1,2-b]furan-2-yl)-1,2,4a,5,6,7,8,8a-octahydronaphthalene-1-carbaldehyde as a yellow oil (46 mg, 46%).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 9.63 (s, 1H), 8.03-7.96 (m, 1H), 7.83-7.77 (m, 1H), 7.45-7.4 (m, 2H), 7.39-7.34 (m, 1H), 7.32-7.26 (m, 1H), 6.29 (s, 1H), 5.74-5.64 (m, 1H), 5.18-4.95 (m, 2H), 3.47 (d, J=15.7 Hz, 1H), 3.15 (d, J=15.5 Hz, 1H), 2.65-2.5 (m, 1H), 2.5-2.4 (m, 1H), 2.4-2.3 (m, 2H), 2.3-2.1 (m, 3H), 2.1-1.73 (m, 4H), 1.65 (s, 3H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 206.6 (CH), 154.3 (C), 137.7 (C), 134.7 (C), 134.1 (C), 132.6 (CH), 128.9 (CH), 128 (CH), 125.6 (CH), 124.6 (CH), 123.2 (CH), 121.7 (CH), 121.8 (C), 121 (C), 120 (CH), 119.3 (CH_2), 90.4 (C), 77.4 (C), 51.9 (C), 42.5 (CH_2), 40.1 (CH), 37 (CH_2), 31.8 (CH_2), 26.3 (CH_3), 25.8 (CH_2), 23.6 (CH_2), 22.7 (CH_2)

IR (FTIR, cm^{-1}) = 2935, 2357, 1717, 1393, 1377, 1290, 1055, 912, 797, 733, 702

HRMS (EI) *m/z* calculated for $C_{27}H_{30}O_3$ (M+) = 402.2195, found: 384.2108 (M - H_2O)



(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(cyclopent-1-en-1-ylethynyl)cyclohexanol

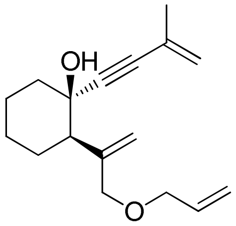
A 10 mL round-bottom flask was charged with THF (3 mL) and Et_2NH (0.47 mL, 4.56 mmol, 5 eq.) and the mixture was degassed for 15 minutes. Cyclopent-1-en-1-yl trifluoromethanesulfonate (295 mg, 1.37 mmol, 1.5 eq.), CuI (17mg, 0.091 mmol, 0.01 eq.) and $PdCl_2(PPh_3)_2$ (32 mg, 0.046 mmol, 0.05 eq.) were added at room temperature. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (200 mg, 0.912 mmol) was added and the mixture was stirred overnight. The mixture was quenched with saturated NH_4Cl_{aq}. The organic layers were extracted with Et_2O, washed with brine, dried over $MgSO_4$ and concentrated. The crude was subjected to flash chromatography (5% Et_2O in hexanes) to give (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(cyclopent-1-en-1-ylethynyl)cyclohexanol as a yellow oil (150 mg, 57%).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 5.96-5.88 (m, 1H), 5.94 (s, 1H), 5.32-5.26 (dq, *J* = 17.21.6 Hz, 1H), 5.21-5.17 (dq, *J* = 14.4, 1.6 Hz, 1H) 5.18 (s, 2H), 4.21-4.17 (dd, *J* =12.1Hz, 0.8Hz, 1H), 4.17-4.12 (ddt, *J* = 12.5, 5.3,1.5 Hz, 1H) 3.94-3.88 (ddt, *J* = 12.5,5.3, 1.5 Hz, 1H), 3.89-3.86 (d, *J* = 12.1 Hz, 1H) 2.42-2.36 (m, 5H), 2.16-2.11 (m, 1H), 1.90- 1.23 (m, 9H)

^{13}C NMR (CDCl$_3$, 100 MHz) δ_{ppm} = 145.7 (C), 137.2 (CH), 134.2 (CH), 124.5 (C), 119.0 (CH$_2$), 117.8 (CH$_2$), 95.5 (C), 81.0 (C), 72.1 (CH$_2$), 70.5 (CH$_2$), 68.3 (C), 53.0 (CH), 39.7 (CH$_2$), 36.6 (CH$_2$), 33.3 (CH$_2$), 26.2 (CH$_2$), 26.0 (CH$_2$), 23.4 (CH$_2$), 20.8 (CH$_2$)

IR (FTIR, cm^{-1}) = 3390, 3078, 2930, 2853, 1639, 1441

HRMS (EI) *m/z* calculated for $C_{19}H_{26}O_2$ (M+) = 286.1933, found: 286.1927



(1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-methylbut-3-en-1-yn-1-yl)cyclohexanol

A 25 mL round-bottom flask was charged with THF (5 mL) and Et$_3$N (0.95 mL, 6.84 mmol, 5 eq.) and the mixture was degassed for 15 minutes. Isopropenyl bromide (0.365 mL, 4.1 mmol, 3 eq.), CuI (26 mg, 0.14 mmol, 0.01 eq.) and PdCl2(PPh3)2 (48 mg, 0.068 mmol, 0.05) were added at 0˚C. (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-ethynylcyclohexanol (300 mg, 1.37 mmol) was added and the mixture was stirred and allowed to warm up to room temperature over 4 hours. The mixture was quenched with saturated NH4Cl$_{aq}$. The organic layers were extracted with Et$_2$O, washed with brine, dried over MgSO4 and concentrated. The crude was subjected to flash chromatography (10% Et2O in hexanes) to give (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-methylbut-3-en-1-yn-1-yl)cyclohexanol as a yellow oil (223 mg, 62%).

^{1}H NMR (CDCl$_3$, 400 MHz) δ_{ppm} = 5.90 (m, 1H), 5.28 (m, 2H), 5.18 (m, 2H), 5.16 (s, 2H), 4.32 (d, *J* = 2 Hz, 1H), 4.18 (dd, *J*=12, 1 Hz, 1H), 4.14 (ddt, *J*=12Hz, 6Hz, 1.4Hz, 1H), 3.90 (ddt, *J*=

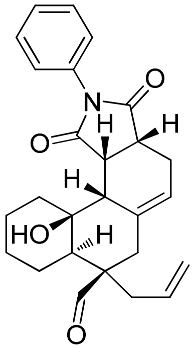
12Hz, 6 Hz, 1.4Hz, 1H), 3.84 (d, *J*=12Hz, 1H), 2.39 (dd, *J*= 13Hz, 3.3Hz, 1H), 2.12 (m, 1H), 1.84 (s, 3H), 1.90-1.23 (m, 8H)

^{13}C NMR (CDCl$_3$, 100 MHz) δ_{ppm} = 145.5 (C), 134.1 (CH), 126.8 (C), 121.3 (CH2), 119.3 (CH2), 117.8 (CH2), 93.4 (C), 84.9 (C), 72.0 (CH2), 70.5 (CH2), 67.9 (C), 53.2 (CH), 39.7 (CH2), 26.1 (CH2), 26.0 (CH2), 23.7 (CH3), 20.8 (CH2)

IR (FTIR, cm^{-1}) = 3379, 3078, 2936, 2860

LRMS (EI) *m/z* calculated for $C_{19}H_{24}O_2$ (M+) = 260.18, found 260.16

Domino Pericyclic Oxy-Cope/Ene/Claisen/Diels-Alder Products



(3aR,7R,7aR,11aR,11bR,11cS)-7-allyl-11a-hydroxy-1,3-dioxo-2-phenyl-2,3,3a,4,6,7,7a,8,9,10,11,11a,11b,11c-tetradecahydro-1H-naphtho[1,2-e]isoindole-7-carbaldehyde

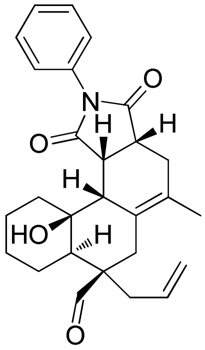
A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.17 mL, 1.22 mmol, 3 eq.), N-Phenylmaleimide (141 mg, 0.81 mmol, 2 eq.) and (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(but-3-en-1-yn-1-yl)cyclohexanol (100 mg, 0.41 mmol) were added. The mixture was degassed with argon for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 2Hours. The crude was concentrated and flash chromatography (10% EtOAC in hexanes and then 100% CH_2Cl_2) was performed to give (3aR,7R,7aR,11aR,11bR,11cS)-7-allyl-11a-hydroxy-1,3-dioxo-2-phenyl-2,3,3a,4,6,7,7a,8,9,10,11,11a,11b,11c-tetradecahydro-1H-naphtho[1,2-e]isoindole-7-carbaldehyde as a yellow oil (107 mg, 63%).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 9.89 (s, 1H), 7.53-7.32 (m, 5H), 5.84-5.71 (m, 2H), 5.22-5.03 (m, 2H), 3.21-3.13 (m, 1H), 2.83-2.69 (m, 2H), 2.55-2.43 (m, 2H), 2.11-1.66 (m, 10H), 1.44-1.34 (m, 1H)

^{13}C NMR ($CDCl_3$, 125 MHz) δ_{ppm} = 208 (CH), 178.2 (C), 175.4 (C), 136.3 (C), 132.8 (CH), 131.9 (C), 129.3 (CH), 128.8 (CH), 128.8 (CH), 126.6 (CH), 119.6 (CH_2), 52.4 (C), 46.2 (CH), 39 (CH), 37.6 (CH), 37.2 (CH_2), 33.6 (CH_2), 28.1 (CH_2), 25.4 (CH_2), 24.5 (CH_2) 24.3 (CH_2), 22.1 (CH_2)

IR (FTIR, cm^{-1}) = 2929, 2856, 1714, 1498, 1379, 1179

HRMS (EI) *m/z* calculated for $C_{25}H_{27}NO_2$ [$(M - CH_2O_2)^+$] = 373.2097, found 373.2082



(3aR,7R,7aR,11aR,11bR,11cS)-7-allyl-11a-hydroxy-5-methyl-1,3-dioxo-2-phenyl-2,3,3a,4,6,7,7a,8,9,10,11,11a,11b,11c-tetradecahydro-1H-naphtho[1,2-e]isoindole-7-carbaldehyde

A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (21 µL, 0.15 mmol, 1 eq.), N-Phenylmaleimide (133mg, 0.77 mmol, 5 eq.) and (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(3-methylbut-3-en-1-yn-1-yl)cyclohexanol (40 mg, 0.15 mmol) were added. The mixture was degassed with argon for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 2 hours. The crude was concentrated and flash chromatography (10% EtOAC in hexanes and then 100% CH_2Cl_2) was performed to give (3aR,7R,7aR,11aR,11bR,11cS)-7-allyl-11a-hydroxy-

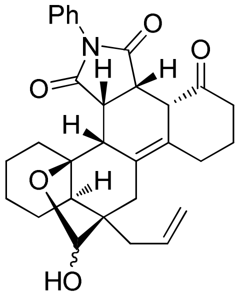
5-methyl-1,3-dioxo-2-phenyl-2,3,3a,4,6,7,7a,8,9,10,11,11a,11b,11c-tetradecahydro-1H-naphtho[1,2-e]isoindole-7-carbaldehyde as a yellow oil (24 mg, 36%).

^{1}H NMR (C_6D_6, 400 MHz) δ_{ppm} = 9.34 (s, 1H), 7.33-7.31 (m, 2H), 7.04-7.00 (m, 2H), 6.91-6.87 (m, 1H), 5.52-5.43 (m, 1H), 4.87-4.79 (m, 2H), 3.37-3.35 (d, *J*=8.4Hz, 1H)

^{13}C NMR (C_6D_6, 100 MHz) δ_{ppm} = 204.6 (C), 177.4 (C), 174.9 (C), 139.3 (C), 133.5 (CH), 128.8 (C), 128.7 (2 CH), 127.8 (CH), 126.2 (2 CH), 126.0 (C), 123.1 (C), 118.7 (CH_2), 118.4 (C), 50.9 (C), 45.2 (CH), 41.3 (CH), 39.1 (CH), 37.7 (CH_2), 32.7 (CH_2), 30.4 (CH_2), 30.0 (CH_2), 29.0 (CH_2), 28.0 (CH_2), 26.5 (CH_2), 19.7 (CH_3)

IR (FTIR, cm^{-1}) = 2929, 2853, 1713, 1501, 1381, 1179

HRMS (EI) *m/z* calculated for $C_{27}H_{29}NO_3$ [$(M - H_2O)^+$] = 415.2253, found: 415.2109



(6R,6aR,10aR,10bR,10cS,13aR,13bS)-6-allyl-15-hydroxy-12-phenyl-3,4,6,6a,7,8,9,10,10c,12,13a,13b-dodecahydro-10a,6-(epoxymethano)benzo[e]naphtho[2,1-g]isoindole-1,11,13(2H,5H,10bH)-trione

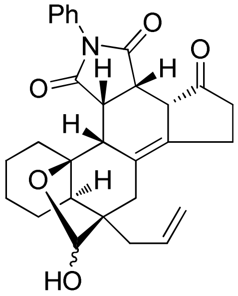
A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.13 mL, 0.93 mmol, 3 eq.), N-Phenylmaleimide (110 mg, 0.64 mmol, 2 eq.) and 3-(((1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclohex-2-enone (100 mg, 0.32 mmol, 1 eq.) were added. The mixture was degassed for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 3 hours. The crude was concentrated and flash chromatography (10-30% EtOAC in hexanes) was performed to give (6R,6aR,10aR,10bR,10cS,13aR,13bS)-6-allyl-15-hydroxy-12-phenyl-3,4,6,6a,7,8,9,10,10c,12,13a,13b-dodecahydro-10a,6-(epoxymethano)benzo[e]naphtho[2,1-g]isoindole-1,11,13(2H,5H,10bH)-trione (mixture of diastereomers) as a yellow oil (102 mg, 66%).

Major diastereomer:

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 7.52-7.19 (m, 5H), 5.83-5.44 (m, 1H), 5.18-4.93 (m, 2H), 4.68-4.52 (m, 1H), 3.90-3.11 (m, 3H), 2.79-2.25 (m, 8H), 2.06-1.38 (m, 12H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 196.6 (C), 177.7 (C), 175.6 (C), 134.5 (CH), 132 (C), 129.3 (CH), 129.2 (CH), 129.1 (CH), 128.9 (CH), 128.8 (CH), 126.5 (CH), 126.4 (CH), 118.5 (CH_2), 101.3 (CH), 87.3 (C), 53.9 (C), 51(C), 48.6 (CH), 45.7 (CH), 43.6 (CH), 40.6 (CH), 38.6 (CH), 37.5 (CH_2), 35.3 (CH_2), 31.1 (CH_2), 29.4 (CH_2), 23.2 (CH_2), 22 (CH_2), 21.7 (CH_2)

LRMS (EI) *m/z* calculated for $C_{30}H_{34}NO_5$ [$(M+H)^+$] = 488.2359, found: 488.5



(5R,5aR,9aR,9bR,9cS,12aR,12bS)-5-allyl-14-hydroxy-11-phenyl-2,3,5,5a,6,7,8,9,9c,11,12a,12b-dodecahydro-1H-9a,5-(epoxymethano)cyclopenta[e]naphtho[2,1-g]isoindole-1,10,12(4H,9bH)-trione

A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.13 mL, 0.93 mmol, 3 eq.), N-Phenylmaleimide (115 mg, 0.67 mmol, 2 eq.) and 3-(((1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-hydroxycyclohexyl)ethynyl)cyclopent-2-enone (100 mg, 0.33 mmol, 1 eq.) were added. The mixture was degassed for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 3 hours. The crude was concentrated and flash chromatography (10-30% EtOAC in hexanes) was performed to give (5R,5aR,9aR,9bR,9cS,12aR,12bS)-5-allyl-14-hydroxy-11-phenyl-2,3,5,5a,6,7,8,9,9c,11,12a,12b-dodecahydro-1H-9a,5-(epoxymethano)cyclopenta[e]naphtho[2,1-g]isoindole-1,10,12(4H,9bH)-trione (mixture of diastereomers) as a yellow oil (96 mg, 61%).

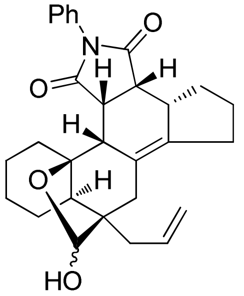
Major diastereomer:

^{1}H NMR (CDCl$_3$, 300 MHz) δ_{ppm} = 7.49-7.34 (m, 3H), 7.23-7.16 (m, 2H), 5.82-5.67 (m, 1H), 5.49 (s, 1H), 5.11-4.99 (m, 2H), 4.03-3.95 (m, 1H), 3.77 (s, 1H), 3.64-3.55 (m, 1H), 3.28 (qd, *J*=7.2, 5.7 Hz, 1H), 2.53-2.45 (m, 3H), 2.36-2.19 (m, 3H), 2.14-2.02 (m, 1H), 1.96-1.84 (m, 1H), 1.34-1.16 (m, 10 H)

^{13}C NMR (CDCl$_3$, 125 MHz) δ_{ppm} = 205.4 (C), 178.7 (C), 176.1 (C), 134.8 (CH), 132 (C), 129.3 (CH), 129.2 (CH), 129.1 (CH), 128.9 (CH), 128.8 (CH), 126.7 (CH), 126.5 (CH), 118.2 (CH2), 101.6 (CH), 87.1 (C), 53.9 (C), 51(C), 48.1 (CH), 46.2 (CH), 44.7 (CH), 41.3 (CH), 38.9 (CH), 36.6 (CH$_2$), 35.3 (CH$_2$), 31.8 (CH$_2$), 28.5 (CH$_2$), 24.3 (CH$_2$), 23.7 (CH$_2$) 21.7 (CH$_2$)

IR (FTIR, cm^{-1}) = 2357, 2336, 1707, 1499, 1379, 1182, 993, 729, 689.

HRMS (EI) *m/z* calculated for $C_{29}H_{32}NO_5$ [(M+H)$^+$] = 474.2202, found: 474.2272



(5R,5aR,9aR,9bR,9cS,12aR,12bS)-5-allyl-14-hydroxy-11-phenyl-2,3,5,5a,6,7,8,9,9c,11,12a,12b-dodecahydro-1H-9a,5-(epoxymethano)cyclopenta[e]naphtho[2,1-g]isoindole-10,12(4H,9bH)-dione

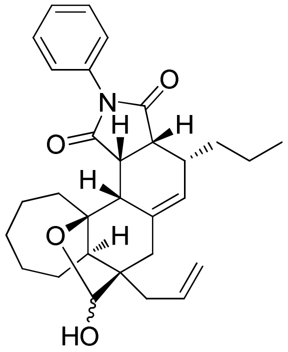
A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.2 mL, 1.38 mmol, 2 eq.), N-Phenylmaleimide (239 mg, 1.38 mmol, 2 eq.) and (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-(cyclopent-1-en-1-ylethynyl)cyclohexanol (198 mg, 0.69 mmol, 1 eq.) were added. The mixture was degassed for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 3 hours. The crude was concentrated and flash chromatography (10% EtOAC in hexanes) was performed to give (5R,5aR,9aR,9bR,9cS,12aR,12bS)-5-allyl-14-hydroxy-11-phenyl-2,3,5,5a,6,7,8,9,9c,11,12a,12b-dodecahydro-1H-9a,5-(epoxymethano)cyclopenta[e]naphtho[2,1-g]isoindole-10,12(4H,9bH)-dione as a yellow oil (213 mg, 67%).

^{1}H NMR ($CDCl_3$, 500 MHz) δ_{ppm} = 9.56 (s, 1H), 7.51-7.24 (m, 5H), 5.85-5.62 (m, 1H), 5.2-4.96 (m, 2H), 3.59-3.45 (m, 1H), 3.42-3.26 (m, 1H) 3.17-3.06 (m, 1H), 2.86-2.68 (m, 1H), 2.66-2.56 (m, 2H), 2.47-0.93 (m, 18H)

^{13}C NMR ($CDCl_3$, 125 MHz) δ_{ppm} = 207.1 (C), 177 (C), 176.3 (C), 138.4 (C), 133.4 (CH), 132.1 (CH), 129.3 (CH), 129.1 (CH), 128.6 (CH), 126.6 (CH), 126.5 (CH), 119.1 (CH_2), 101.6 (CH), 77 (C), 51 (C), 44.7 (CH), 44 (CH), 43.3 (CH), 42.5 (CH), 39.4 (CH), 37.2 (CH_2), 33.8 (CH_2), 31.6 (CH_2), 29.7 (CH_2), 29.3 (CH_2), 28.9 (CH_2) 26.7 (CH_2), 26.6 (CH_2), 25.6 (CH_2)

IR (FTIR, cm^{-1}) = 3477, 2930, 2857, 1767, 1715, 1500, 1383, 1092

LRMS (EI) *m/z* calculated for $C_{29}H_{33}NO_4$ (M+) = 459.24, found: 459.21



<u>(3aR,4R,7R,7aR,12aR,12bR,12cS)-7-allyl-14-hydroxy-2-phenyl-4-propyl-3a,4,6,7,7a,8,9,10,11,12,12b,12c-dodecahydro-1H-12a,7-(epoxymethano)cyclohepta[5,6]benzo[1,2-e]isoindole-1,3(2H)-dione</u>

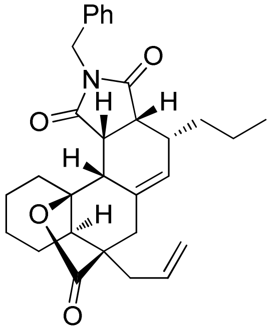
A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.14 mL, 1 mmol, 3 eq.), N-Phenylmaleimide (115 mg, 0.67 mmol, 2 eq.) and (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-hept-3-en-1-yn-1-yl)cycloheptanol (100 mg, 0.33 mmol, 1 eq.) were added. The mixture was degassed for ten minutes before being irradiated by microwaves (200˚C, 300 W) for 3 hours. The crude was concentrated and flash chromatography (10% EtOAC in hexanes) was performed to give (3aR,4R,7R,7aR,12aR,12bR,12cS)-7-allyl-14-hydroxy-2-phenyl-4-propyl-3a,4,6,7,7a,8,9,10,11,12,12b,12c-dodecahydro-1H-12a,7-(epoxymethano)cyclohepta[5,6]benzo[1,2-e]isoindole-1,3(2H)-dione (mixture of diastereomers) as yellow oil (83 mg, 53%).

^{1}**H NMR** (C_6D_6, 300 MHz) δ_{ppm} = 7.47-7.41 (m, 2H), 7.15-6.94 (m, 3H), 5.84 (ddt, *J*=17.2, 10.5, 5.2Hz, 1H), 5.76 (d, *J*=5.3Hz, 1H), 5.29-5.2 (m, 1H), 5.09-4.98 (m, 2H), 3.93 (d, *J*=11.2Hz, 1H), 3.87-3.79 (m, 1H), 3.78-3.70 (m, 3H), 3.3 (d, *J*=12.6 Hz, 1H), 2.64-2.56 (m, 1H), 2.56-2.48 (m, 2H), 2.42 (d, *J*=12.6 Hz, 1H), 2.27 (dd, *J*=8.9, 1.7 Hz, 1H), 2.19-2.09 (m, 1H), 1.99-1.79 (m, 4H), 1.79-1.69 (m, 1H), 1.66-1.42 (m, 5 H), 1.11-1.01 (m, 1H), 0.98 (t, *J*=7.2Hz, 1H), 0.96-0.92 (m, 1H)

^{13}**C NMR** (C_6D_6, 100 MHz) δ_{ppm} = 207.9 (C), 178.5 (C), 177.2 (C), 136.1 (CH), 132.9 (CH), 132.3 (CH), 130.3 (CH), 129.4 (CH), 128.7 (CH), 128.6 (CH), 126.7 (CH), 116.4 (CH_2), 108.2 (CH), 71.2 (C), 53.9 (C), 51(C), 48.1 (CH), 46.6 (CH_2), 43.6 (CH), 42.6 (CH), 40.6 (CH_2), 40.2 (CH), 37.1 (CH), 29.2 (CH_2), 26.2 (CH_2), 24.4 (CH_2), 24.2 (CH_2) 21.3 (CH_3)

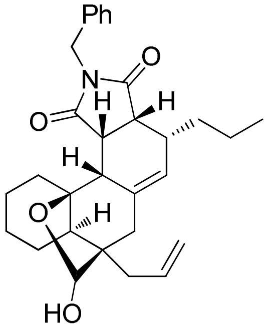
IR (FTIR, cm^{-1}) = 2952, 2857, 1713, 1504, 1382, 1177, 1070, 918, 744, 687.

HRMS (EI) *m/z* calculated for $C_{30}H_{37}NO_4$ (M+) = 475.2723, found: 475.2726



<u>(3aR,4R,7R,7aR,11aR,11bR,11cS)-7-allyl-2-benzyl-4-propyl-3a,4,7,7a,8,9,10,11,11b,11c-decahydro-11a,7-(epoxymethano)naphtho[1,2-e]isoindole-1,3,13(2H,6H)-trione</u>

Step 1:



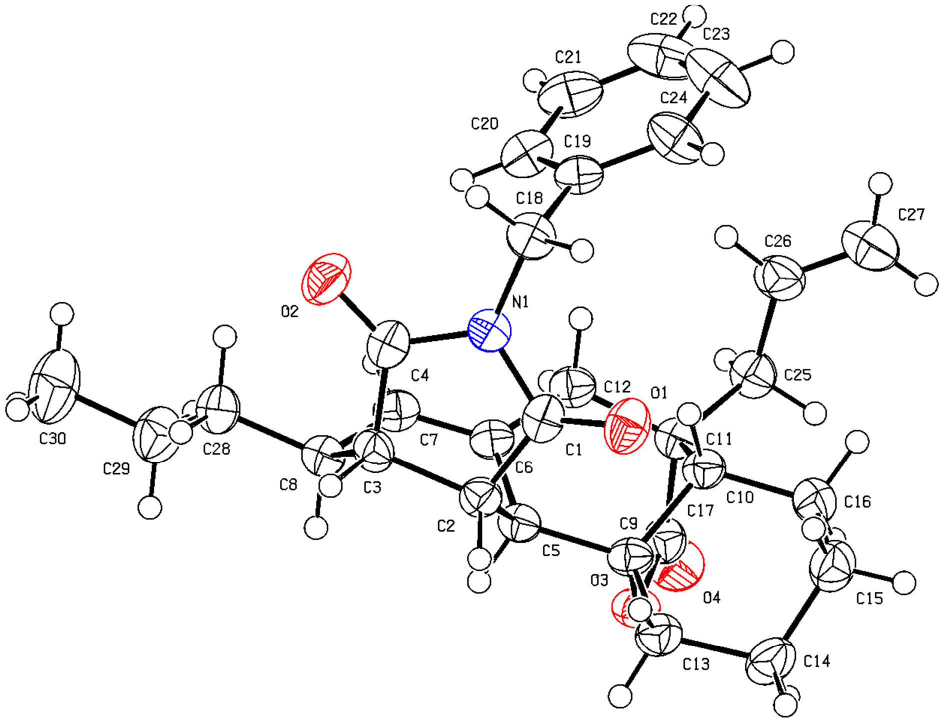
<u>(3aR,4R,7R,7aR,11aR,11bR,11cS,13R)-7-allyl-2-benzyl-13-hydroxy-4-propyl-3a,4,7,7a,8,9,10,11,11b,11c-decahydro-11a,7-(epoxymethano)naphtho[1,2-e]isoindole-1,3(2H,6H)-dione</u>

A microwave tube was flame dried and freshly distilled PhCl (3 mL), Et_3N (0.14 mL, 1 mmol, 3 eq.), N-Phenylmaleimide (130 mg, 0.7 mmol, 2 eq.) and (1R,2R)-2-(3-(allyloxy)prop-1-en-2-yl)-1-((E)-hept-3-en-1-yn-1-yl)cyclohexanol (100 mg, 0.35 mmol, 1 eq.) were added. The mixture was degassed for ten minutes before being irradiated by microwaves (200˚C, 300W) for 3 hours. The crude was concentrated to furnish (3aR,4R,7R,7aR,11aR,11bR,11cS,13R)-7-allyl-2-benzyl-13-hydroxy-4-propyl-3a,4,7,7a,8,9,10,11,11b,11c-decahydro-11a,7-(epoxymethano)naphtho[1,2-e]isoindole-1,3(2H,6H)-dione (mixture of diastereomers) a yellow oil (112 mg, 68%).

Step 2:

To a flask containing TPAP (3.7 mg, 10.5 umol, 0.05 eq.), NMO (37 mg ,0.32 mmol, 1.5 eq.), 4Å molecular sieves (50 mg) and a stirring bar, was added the crude above (100 mg, 0.21 mmol, 1 eq.) in CH_2Cl_2 (3 mL). This was stirred for 30 minutes and then the reaction mixture was filtered through a pad of silica and washed with EtOAc. The solvent was evaporated leaving the crude product which was purified by flash chromatography (10% EtOAc in hexanes) to give (3aR,4R,7R,7aR,11aR,11bR,11cS)-7-allyl-2-benzyl-4-propyl-3a,4,7,7a,8,9,10,11,11b,11c-decahydro-11a,7-(epoxymethano)naphtho[1,2-e]isoindole-1,3,13(2H,6H)-trione as a white solid (59 mg, 60 %).

Identification by X-Ray


C22
C23
C21
C24
C20
C19
C18
C27
C26
O2
N1
C12
O1
C25
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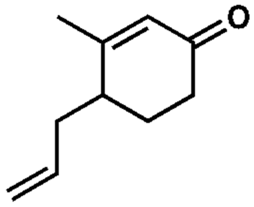
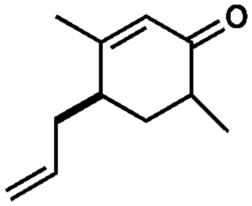
C30
C28
C7
C11
C29
C8
C3
C6
C1
C10
C16
C17
C2
C9
C5
O3
O4
C15
C13
C14

Sequential Diels-Alder/Gold(I) Catalyzed 6-endo-dig Cyclization for the Synthesis of Complex Bicyclo[3.3.1]alkenone Framework



4-Allyl-3-methylcyclohex-2-enone

A solution of methyllithium (1.0 M in hexanes, 139.5 mL, 139.5 mmol) was added dropwise to a solution of 6-allyl-3-methoxycyclohex-2-enone (19.31 g, 116.2 mmol) in dry ether at −78 °C for 30 min. The mixture was then stirred at rt for 1 h. An aqueous solution of 1 N HCl was added. After stirring for 1 h at rt, water was added. The aqueous layer was extracted with ethyl acetate (3x), and the combined organic phases were dried over anhydrous magnesium sulphate, filtered and concentrated. The crude oil was distilled under reduced pressure and purified by chromatography (10% EtOAc:hexanes) to give 14.48 g (83%) of 4-Allyl-3-methylcyclohex-2-enone as a clear yellow oil. Spectral data is in accordance with reported data and full characterization is available through the literature [1].



4-Allyl-3,6-dimethylcyclohex-2-enone

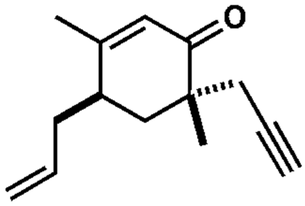
A solution of *n*-BuLi (1.6 M in hexanes, 21.8 mL, 34.95 mmol) was added slowly to diisopropylamine (5.17 mL, 36.61 mmol) in THF(150 mL) at −78 °C for 45 min. 4-Allyl-3-methylcyclohex-2-enone (5 g, 33.28 mmol) was added at −78 °C for 60 min and then iodomethane (2.49 mL, 39.94 mmol). The mixture was stirred at rt for 3 h. An aqueous saturated solution of NH4Cl was added and the aqueous layers were extracted with ethyl acetate (3x). The combined organic phases were dried over anhydrous magnesium sulfate, filtered and the solvent was evaporated. The crude residue was purified by flash chromatography (10% EtOAc:hexanes) to give 4.92 g (90%) of a yellow-orange oil of 4-allyl-3,6-dimethylcyclohex-2-enone.

^{1}**H NMR** (400 MHz, CDCl3) δ 5.81(m, 1H), 5.79(s, 1H), 5.11(m,2H), 2.43 (m,2H), 2.27 (m,2H), 1.99 (ddd, *J* = 13.5 Hz, 4.8 Hz, 2.8 Hz, 1H), 1.95(s, 3H), 1.76(m, 1H), 1.09 (d, *J* = 6.9 Hz, 3H);

^{13}C NMR (400 MHz, $CDCl_3$) δ 201.9 (C), 164.0 (C), 136.5(CH), 126.4 (CH), 117.1 (CH_2), 39.2 (CH), 35.9 (CH), 35.6 (CH_2), 34.5 (CH_2), 22.9 (CH_3), 15.4 (CH_3);

IR (FTIR, cm-1) = 3077, 2964, 2930, 2872, 1673, 1639, 1443, 1378;

HRMS (EI) *m/z* calculated for $C_{11}H_{16}O$ [M^+] 164.1201, found: 164.1205.



4-Allyl-3,6-dimethyl-6-(prop-2-ynyl)cyclohex-2-enone

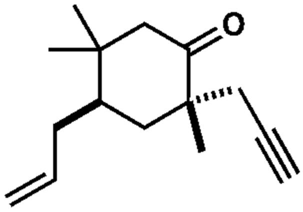
A solution of *n*-BuLi (1.6 M in hexanes, 1.59 mL, 2.55 mmol) was added slowly to a solution of diisopropylamine (0.38 mL, 2.67 mmol) in THF (15 mL) at −78 °C for 45 min. 4-Allyl-3,6-dimethylcyclohex-2-enone (0.4 g, 2.44 mmol) was added at −78°C. After stirring for 60 min, propargyl bromide (0.33 mL, 2.92 mmol) was added and the mixture was stirred at rt for 3 h. The resulting mixture was quenched with a saturated solution of NH_4Cl. The aqueous layer was extracted with ethyl acetate (3x). The combined organic phases were dried over anhydrous magnesium sulfate, filtered and concentrated. The crude residue was purified by chromatography (10% EtOAc:hexanes) to give 4-Allyl-3,6-dimethyl-6-(prop-2-ynyl)cyclohex-2-enone 0.31 g (62%) as a yellow-orange oil.

^{1}**H NMR**, (400 MHz, $CDCl_3$) δ 5.78 (s,1H), 5.69 (m,1H), 5.10 (m,2H), 2.49 (m,2H), 2.35 (m, 1H), 2.15 (m,3H), 2.01 (t, *J* = 2.6 Hz, 1H), 1.93 (s, 3H), 1.57 (dd, *J* = 13.8, 10.3 Hz, 1H), 1.16 (s, 3H);

^{13}**C NMR** (400 MHz, $CDCl_3$) δ 202.6 (C), 162.9 (C), 135.3 (CH), 126.5 (CH), 118.1 (CH_2), 80.5 (C), 71.4 (CH), 43.9 (C), 38.5 (CH_2), 36.9 (CH), 36.7 (CH_2), 26.8 (CH_2), 22.3 (2xCH_3);

IR (FTIR, cm-1) = 3305, 3077, 2976, 2930, 1674;

HRMS (EI) *m/z* calculated for $C_{14}H_{18}O$ [M^+] 202.1358, found: 202.1379.



<u>4-Allyl-2,5,5-trimethyl-2-(prop-2-ynyl)cyclohexanone</u>

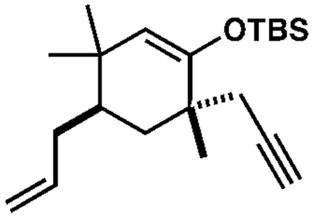
To a solution of CuI (63 mg, 0.33 mmol) and 4-Allyl-3,6-dimethyl-6-(prop-2-ynyl)cyclohex-2-enone (306.7 mg, 1.52 mmol) in THF (15 mL) and Me_2S (1.5 mL) at 0 °C was slowly added a solution of MeMgBr (1.11 mL, 3.0 M in Et_2O, 3.33 mmol) over 1 h. The mixture was then stirred for 1 h at 0 °C. An aqueous saturated solution of NH_4Cl was added. The mixture was extracted with Et_2O (3x). The organic phase was dried over $MgSO_4$ and concentrated in vacuo. The residue was purified by column chromatography (10% EtOAc:hexanes) to provide the desired ketone (175.9 mg, 53%) as a dark orange oil (mixture of two conformers).

^{1}H NMR, (400 MHz, $CDCl_3$) δ 5.76 (m, 1H), 5.02 (m, 2H), 2.49 (0.5H), 2.45 (m, 1H), 2.37 (m, 2H), 2.33 (m, 0.5H), 2.00 (m, 2.5), 1.70 (m, 2.5 H), 1.26 (t, 1H), 1.09 (s,3H), 1.04 (s, 3H), 0.96 (m, 1H), 0.73 (m, 3H);

^{13}C NMR (400 MHz, $CDCl_3$) δ 213.2 (C), 137.6 (CH), 116.3 (CH_2), 79.5 (C), 71.5 (CH), 52.9 (CH_2), 48.0 (C), 41.5 (CH), 40.0 (CH_2), 39.3 (C), 34.2 (CH_2), 29.8 (CH_3), 27.8 (CH_2), 22.2 (CH_3), 20.1 (CH_3);

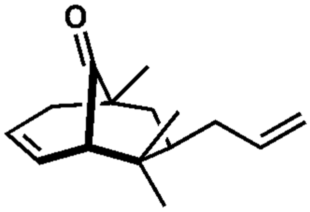
IR (FTIR, cm-1) = 3310, 3076, 2965, 2931, 2871, 2124, 1716, 1640, 1436;

HRMS (EI) *m/z* calculated for $C_{15}H_{22}O$ [M^+] 218.1671, found: 218.1659.



(4-Allyl-3,3,6-trimethyl-6-(prop-2-ynyl)cyclohex-1-enyloxy)(tert-butyl)dimethylsilane

4-Allyl-2,5,5-trimethyl-2-(prop-2-ynyl)cyclohexanone (300 mg, 1.37 mmol) was dissolved in acetonitrile (30 mL), and Et_3N (0.383 mL, 2.74 mmol) was added. Then flame-dried NaI (0.309 g, 2.04 mmol) and TBSCl (310 mg, 2.04 mmol) were added. The reaction mixture was allowed to reflux overnight and was then quenched with $NaHCO_3$ saturated solution, and the aqueous phase was extracted with DCM (3x). The organic phases were then combined and concentrated. The resulting mixture was filtered through a small silica pad and washed with solution of 7% EtOAc in hexanes and concentrated again. The crude enol ether (4-Allyl-3,3,6-trimethyl-6-(prop-2-ynyl)cyclohex-1-enyloxy)(tert-butyl)dimethylsilane (209 mg, 46%) was then directly used for the next reaction.



7-Allyl-5,8,8-trimethylbicyclo[3.3.1]non-2-en-9-one

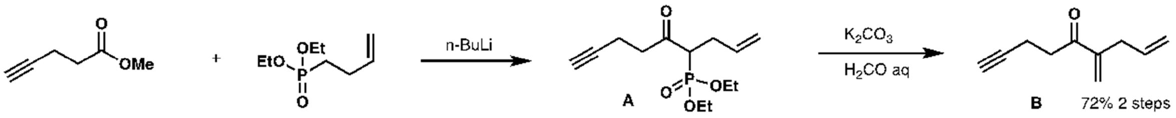
A solution of silyl enol ether (4-Allyl-3,3,6-trimethyl-6-(prop-2-ynyl)cyclohex-1-enyloxy)(tert-butyl)dimethylsilane (20 mg, 0.060 mmol) and (acetonitrile)[(2-biphenyl)di- *tert*-butylphosphine]gold(I) (0.92 mg, 0.0012 mmol) in DCM (1 mL) was stirred for 6 h at rt. The solvent was evaporated and the residue was purified by flash column chromatography on silica (10% EtOAc:hexanes) to give 88% of the desired product as a white solid.

^{1}**H NMR**, (400 MHz, CDCl3) δ 5.82 (m, 1H), 5.76 (m, 1H), 5.63 (dddd, *J* = 9.5, 6, 1.9 Hz, 1.9 Hz, 1H), 5.03 (m, 1H), 2.41 (m, 3H), 2.25 (m, 1H), 2.03 (m, 1H), 1.82 (dd, *J* = 13.9 Hz, 4.5 Hz, 1H), 1.59 (ddd, *J* = 13.7, 10.8, 8.6 Hz, 2H), 1.28 (m, 4H), 1.02 (s, 3H), 0.99 (s, 3H), 0.79 (s, 3H);

^{13}C NMR (400 MHz, CDCl3) δ 216.50 (C), 138.03 (CH), 129.80 (CH), 126.55 (CH), 115.96 (CH2), 60.27 (CH), 45.96 (CH2), 45.61 (CH2), 42.35 (C), 38.09 (CH), 34.09 (C), 29.71 (CH2), 26.09 (CH3), 23.50 (CH3), 20.79 (CH3);

IR (FTIR, cm-1) = 3081, 3039, 2967, 2921, 1709;

HRMS (EI) *m/z* calculated for $C_{15}H_{22}O$ [M+] 218.1671, found: 218.1652.



4-Methylenenon-1-en-8-yn-5-one (B)

To a solution of homoallylphosphonate (5 g, 26 mmol,) in THF (50 mL) at −78 °C, under an argon atmosphere, was added dropwise a solution of *n*-BuLi (2.45 M in hexanes, 12.74 mL, 31.2 mmol). The reaction mixture was stirred for 3 h and then a solution of methyl pent-4-ynoate (4.38 g, 39 mmol) in THF (10mL) was added to the prepared mixture. After 1 h, the temperature was raised to rt. The reaction was quenched with a saturated solution of NH4Cl. The mixture was extracted three times with Et2O, washed with water and concentrated at reduced pressure to furnish the diethyl 5-oxonon-1-en-8-yn-4-ylphosphonate (**A**) as brown oil. The crude product was taken into the next step without further purification.

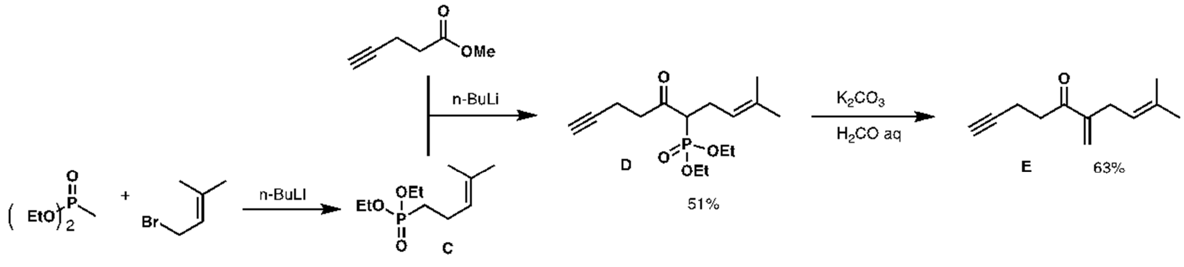
A mixture of diethyl 5-oxonon-1-en-8-yn-4-ylphosphonate **A** (7.0 g, 24.4 mmol), water (100 mL), potassium carbonate (10.1 g, 73.3 mmol) and aqueous 37% formaldehyde (2.18 mL, 29.3 mmol) was stirred at rt for 3 h. The mixture was then extracted with Et2O, washed with water, saturated solution of NaCl and concentrated under reduced pressure to furnish a yellow oil. Purification by flash chromatography over silica gel (hexanes/EtOAc in gradient 5–10% of EtOAc) gave the 4-methylenenon-1-en-8-yn-5- one **B** (2.6 g, 72%) as a colorless oil.

^{1}**H NMR** (300 MHz, CDCl3) δ 6.06 (s, 1 H), 5.87 - 5.70 (m, 2 H), 5.09 - 5.05 (m, 1 H), 5.05 - 4.99 (m, 1 H), 3.04 - 2.98 (m, 2 H), 2.97 - 2.90 (m, 2 H), 2.52 - 2.42 (m, 2 H), 1.94 (t, *J* = 2.7 Hz, 1 H).

^{13}**C NMR** (75 MHz, CDCl3) δ 198.8, 146.8, 135.3, 125.2, 117.0, 83.4, 68.8, 36.7, 34.9, 13.4.

IR (FTIR, cm-1) = 3300, 2919, 2120, 1642, 1628, 1415.

HRMS (ESI) *m/z* cald for $C_{10}H_{12}ONa^{+}$ 148.0888, found: 148.1206.



9-Methyl-6-methylenedec-8-en-1-yn-5-one (E)

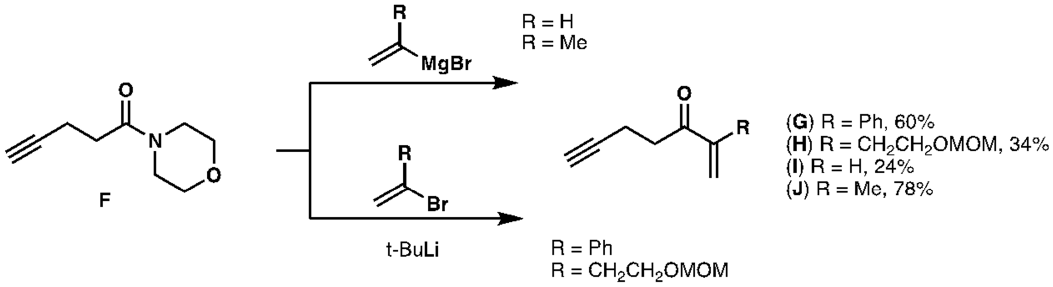
To a solution of diethyl 4-methylpent-3-enylphosphonate [2] **C** (2.43 g, 11.03 mmol) in THF (20 mL) at −78 °C, under an argon atmosphere, was added dropwise *n*-BuLi (1.7 M in hexanes, 7.79 mL, 13.24 mmol). The reaction mixture was stirred for 3 h and then a solution of methyl pent-4-ynoate (1.86 g, 16.5 mmol) in THF (5 mL) was added. After stirring for 1 h, the temperature was raised to rt. The reaction was quenched with a saturated solution of NH_4Cl. The mixture was extracted three times with Et_2O, washed with water and concentrated at reduced pressure to furnish the diethyl 5-oxonon-1-en-8-yn-4-ylphosphonate **D** as a brown oil. The crude product was taken into the next step without further purification. A mixture of diethyl 2-methyl-6-oxodec-2-en-9-yn-5-ylphosphonate **D** (1.7 g, 5.66 mmol, 1 equiv), water (25 mL), potassium/carbonate (2.35 g, 17 mmol, 3 equiv) and aqueous 37% formaldehyde (0.46 mL, 6.23 mmol, 1.1 equiv) was stirred at rt for 3 h. The mixture was then extracted with Et_2O, washed with water and a sat. solution of NaCl and concentrated at reduced pressure to furnish a yellow oil. Purification by flash chromatography over silica gel (Hexanes/EtOAc in gradient 5 - 10% of EtOAc) gave the 9-methyl-6-methylenedec-8-en-1-yn-5-one **E** (0.63 g, 63%) as colorless oil.

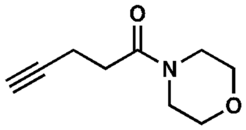
^{1}H NMR (300 MHz ,$CDCl_3$) δ 6.01 (s, 1 H), 5.75 (dt, *J* = 1.6 Hz, 0.3, 1 H), 5.12 (sptt, *J* = 1.4, 7.3 Hz, 1 H), 2.95 (d, *J* = 7.6 Hz, 2 H), 2.97 (t, *J* = 6.4 Hz, 2 H), 2.56 - 2.43 (m, 2 H), 1.95 (t, *J* = 2.7 Hz, 1H), 1.73 (s, 3 H), 1.61 (s, 3 H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 199.4, 147.6, 134.4, 124.4, 120.7, 83.6, 68.8, 36.9, 29.3, 25.9, 17.8, 13.5.

IR (FTIR, cm^{-1}) = 3295, 2968, 2918, 2124, 1680, 1623.

HRMS (ESI) m/z calculated for $C_{12}H_{16}ONa^+$ 176.1201, found: 176.1196.





Morpholinopent-4-yn-1-one (F)

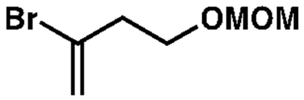
Pent-4-ynoic acid (17.5 g, 176 mmol), morpholine (12.9 mL, 149 mmol) and DMAP (1.82 g, 149 mmol) were dissolved in DCM (325 mL). The solution was cooled to 0 °C and DCC (36.8 g, 178 mmol) was added slowly and the solution warmed up to rt. The reaction was stirred overnight. The resulting mixture is filtered over silica to remove 1,3-dicyclohexylurea, which was insoluble in DCM, and then washed with DCM. The filtrate was concentrated and the residue was purified by flash chromatography (40% EtOAc/hexanes). The yellow solid was then recrystallized from diisopropyl ether to afford 1-morpholinopent-4-yn-1-one **F** (19 g, 0.114 mol) a fluffy white solid in 85% yield.

^{1}H NMR (400 MHz, CDCl3) δ ppm 2.0 (m, 1 H), 2.5 (d, *J* = 1.2 Hz, 4 H), 3.5 (m, 2 H), 3.6 (m, 6 H);

^{13}C NMR (101 MHz, CDCl3) δ ppm 169.6(C), 83.4(C), 68.9 (CH), 67.0 (CH2), 66.6 (CH2), 45.9 (CH2), 42.1(CH2), 32.0 (CH2), 14.5 (CH2);

IR (FTIR, cm-1) = 3250, 2925, 2857, 1644, 1436;

HRMS (EI) *m/z* calculated for C9H13NO2 [M+] 167.0946, found: 167.0934. mp = 81–82 °C.



2-Bromo-4-(methoxymethoxy)butene

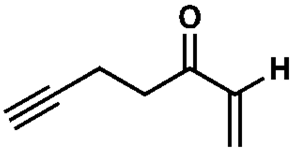
Methoxymethyl chloride (7.21 mL, 95 mmol) was added to 3-bromobut-3-en-1-ol (3.14 mL, 31.7 mmol) in DCM (150 mL). N,N-diisopropylethylamine (22.6 mL, 158 mmol) was added to the mixture. The resulting mixture was stirred at rt for 3 h after which all the starting material was consumed. The solution was concentrated and the residue was purified by chromatography using 10% EtOAc in hexanes to afford 2-bromo-4-(methoxymethoxy)but-1-ene as a clear oil in 92% yield.

^{1}H NMR (400 MHz, CDCl3) δ ppm 2.69 (td, *J* = 6.3, 0.8 Hz, 2 H) 3.36 (s, 3 H) 3.72 (t, *J* = 6.3 Hz, 2 H) 4.63 (s, 2 H) 5.49 (d, *J* = 1.6 Hz, 1 H) 5.68 (q, *J* = 1.2 Hz, 1 H);

^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 41.7 (CH_2), 55.3 (CH_3), 65.1 (CH_2), 96.5 (CH_2), 118.5 (CH_2), 130.7 (C);

IR (FTIR, cm^{-1}) = 2925, 2852, 2336, 1729, 1279;

HRMS (EI) *m/z* calculated for C_4H_4OBr [M^+ ($-CH_2OCH_3$)] 148.9602, found: 149.0249.



Hept-1-en-6-yn-3-one (I)

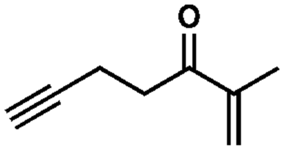
A solution of 1-morpholinopent-4-yn-1-one (4.0 g, 23.92 mmol) in THF (159 mL) was cooled to 0 °C and vinylmagnesium bromide 1 M in THF (60 mL, 59.8 mmol) was added dropwise. The solution was warmed to 23 °C and stirred overnight. The resulting mixture was quenched with a saturated solution of NH_4Cl. The aqueous phase was extracted with Et_2O (3x), the combined organic phases were dried over $MgSO_4$ and concentrated at 25 °C. The crude was purified by flash chromatography at 10% Et_2O in hexanes to afford hept-1-en-6-yn-3-one **I** (0.7 g, 27%) as a clear oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 1.95 (t, *J* = 2.7 Hz, 1 H) 2.51 (m, 2 H) 2.85 (m, 2 H) 5.87 (dd, *J* = 10.4, 1.2 Hz, 1 H) 6.24 (dd, *J*=17.7, 1.1 Hz, 1 H) 6.35 (dd, *J* = 20.7, 7.3 Hz, 1 H);

^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 12.9 (CH_2), 38.3 (CH_2), 68.7 (CH), 83.1 (C), 128.7 (CH_2), 136.2 (CH), 198.2 (C);

IR (FTIR, cm-1) = 3524, 3296, 3091, 2925, 2121 1934, 1688;

HRMS (EI) *m/z* calculated for C_7H_8O [M+] 108.0575, found: 108.0545.



Methylhept-1-en-6-yn-3-one (J)

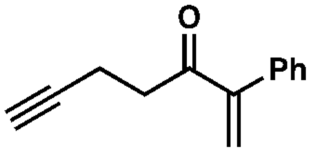
A solution of 1-morpholinopent-4-yn-1-one (4 g, 23.92 mmol) in THF (159 mL) was cooled to 0 °C and a solution of isopropenylmagnesium bromide 0.5 M in THF (120 mL, 59.8 mmol) was added dropwise. The solution was stirred overnight at rt. The resulting mixture was quenched with a saturated solution of NH_4Cl, extracted with Et_2O (3x), dried over $MgSO_4$ and concentrated. The crude was purified by flash chromatography (10% EtOAc/hexanes) to afford 2-methylhept-1-en-6-yn-3-one **J** (3 g, 85%) as clear oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 1.85 (dd, *J* = 1.4, 0.9 Hz, 3 H), 1.93 (t, *J* = 2.6 Hz, 1H), 2.47 (ddd, *J* = 8.2, 6.6, 2.6 Hz, 2 H), 2.93 (m, 2 H), 5.78 (d, *J* = 1.1 Hz, 1H), 5.96 (s, 1 H);

^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 13.3 (CH_3), 17.4 (CH_2), 36.4 (CH_2), 68.6 (CH), 83.3(C), 124.9(CH_2), 144.1 (C), 199.3 (C);

IR (FTIR, cm-1) = 3303, 3098, 2963, 2925, 2114, 1688;

HRMS (EI) *m/z* calculated for $C_8H_{10}O$ [M+] 122.0732, found: 122.0695.



2-Phenylhept-1-en-6-yn-3-one (G)

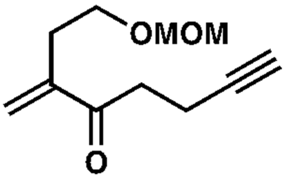
A solution of (1-bromovinyl)benzene (90%, 3.83 g, 18.84 mmol) in THF (90 mL) was cooled to −78 °C followed by the addition of *t*-BuLi 1.7 M in pentane (21.2 mL, 37.7 mmol). The mixture was stirred for 30 min which after a solution of 1- morpholinopent-4-yn-1-one (3 g, 17.9 mmol) in THF (10 mL) was added through a cannula to the reaction mixture. After stirring for 2 h, the resulting mixture was quenched with a saturated solution of NH_4Cl and then extracted with Et_2O (3x). The combined organic phases were dried over $MgSO_4$ and concentrated. The residue was purified by flash chromatography (10% EtOAc/hexanes) to afford 2-phenylhept- 1-en-6-yn-3-one **G** (2 g, 60%) as a pale yellow oil.

^{1}**H NMR** (400 MHz, $CDCl_3$) δ ppm 1.96 (t, *J* = 2.7 Hz, 1 H), 2.54 (m, 2 H), 3.00 (m, 2H), 5.92 (s, 1 H), 6.15 (s, 1 H), 7.25 (dt, *J* = 5.3, 2.1 Hz, 2 H), 7.34 (m, 3 H);

^{13}**C NMR** (101 MHz, $CDCl_3$) δ ppm 13.4 (CH_2), 38.5 (CH_2), 68.8 (CH), 83.1 (C), 125.0 (CH_2), 128.2 (CH), 128.3 (CH x 2), 128.4 (CH x 2), 136.9 (C), 149.0 (C), 199.4 (C);

IR (FTIR, cm^{-1}) = 3295, 3057, 3026, 2921, 2119, 1686;

HRMS (EI) *m/z* calculated for $C_{13}H_{12}O$ [M+] 184.0888, found: 184.0845.



1-(Methoxymethoxy)-3-methyleneoct-7-yn-4-one (H)

A solution of 2-bromo-4-(methoxymethoxy)but-1-ene (0.392 g, 2 mmol) in THF (5 mL) was cooled to −78 °C followed by the addition of *t*-BuLi 1.7 M in pentane (2.41 mL, 4.11 mmol). After stirring for 30 min, a solution of 1-morpholinopent-4-yn-1-one (0.16 g, 0.957 mmol) in THF (3 mL) was added through a cannula and the mixture was stirred for 2 h. The reaction was quenched with a saturated solution of NH_4Cl. The mixture was extracted with Et_2O (3x), dried over $MgSO_4$ and then concentrated. The crude residue was purified by flash chromatography (10–15% EtOAc/hexanes) to afford 1-(methoxymethoxy)-3-methyleneoct-7-yn-4-one **H** (0.645 g, 34%) as clear oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 1.94 (t, *J* = 2.7 Hz, 1 H), 2.50 (ddd, *J* = 8.2, 6.5, 2.7 Hz, 2 H), 2.59 (td, *J* = 6.5, 0.9 Hz, 2 H), 3.96 (m, 2 H), 3.33 (s, 3 H), 3.61 (t, *J*=6.6 Hz, 2 H), 4.58 (s, 2 H), 5.89 (t, *J*=1.2 Hz, 1 H), 6.09 (s, 1 H);

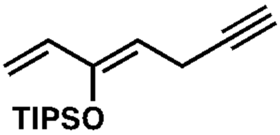
^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 13.3 (CH_2), 31.3 (CH_2), 36.6 (CH_2), 55.2 (CH_3), 66.1 (CH_2), 68.7 (CH), 83.3 (C), 96.4 (CH_2), 126.0 (CH_2), 145.4 (C), 199.0 (C);

IR (FTIR, cm-1) = 3287, 2932, 2885, 2114, 1679;

HRMS (EI) *m/z* calculated for $C_9H_{11}O_2$ [M+ (- CH_2OCH_3)] 151.0759, found: 151.0758.

General procedure for the formation of dienes 16, 19–22 and 32–35

To a solution of enone (1 mmol) in DCM (5 mL) was added Et_3N (3 mmol) and TIPSOTf (2 mmol). The solution was then heated at reflux overnight. The reaction was quenched with a saturated solution of $NaHCO_3$. The aqueous phase was extracted with DCM (2x), the organic phases were combined and dried over $MgSO_4$. The solution was concentrated and the residue was purified by flash chromatography (1% EtOAc:hexanes or 5% Et_2O:hexanes) to give the corresponding diene as a mixture of *Z/E* isomers ranging from 4 to 9:1.



(Z)-(Hepta-1,3-dien-6-yn-3-yloxy)triisopropylsilane

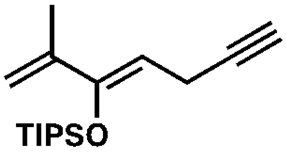
Yield 24%;

^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 1.10 (d *J* = 6.66 Hz, 18 H), 1.20 (m, 3 H), 1.94 (t, *J* = 2.7 Hz, 1 H), 3.06 (dd, *J*=7.1, 2.7 Hz, 2 H), 4.82 (t, *J* = 7.1 Hz, 1 H), 5.03 (dd, *J* = 10.8, 1.0 Hz, 1 H), 5.38 (dd, *J* = 17.2, 1.0 Hz, 1 H), 6.14 (dd, *J* = 17.2, 10.8 Hz, 1 H);

^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 13.7 (CH x 3), 15.9 (CH_2), 18.0 (CH_3 x 6), 67.7 (CH), 82.9 (C), 106.9 (CH), 113.7 (CH_2), 135.3 (CH), 150.5 (C);

IR (FTIR, cm^{-1}) = 3313, 2946, 2868, 2121, 1647;

HRMS (EI) *m/z* calculated for $C_{16}H_{28}OSi$ [M^+] 264.1909, found: 264.1921



(Z)-Triisopropyl(2-methylhepta-1,3-dien-6-yn-3-yloxy)silane

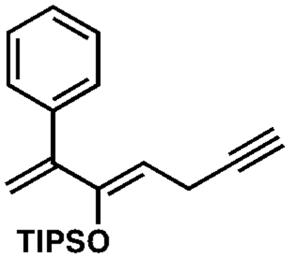
Yield 78%;

^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 1.10 (d, *J* = 6.6 Hz, 18H), 1.20(m, 3H), 1.87(m, 3H), 1.95 (t, *J* = 2.7 Hz, 1H), 3.07 (dd, *J* = 6.9, 2.74 Hz, 2H), 4.89 (t, *J* = 6.9 Hz, 1H), 4.92 (m, 1H), 5.26 (m, 1H);

^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 13.9 (CH x3), 15.9 (CH_2), 18.0 (CH_3 x6), 20.3 (CH_3), 67.7 (CH), 83.1 (C), 104.7 (CH), 113.0 (CH_2), 140.7 (C), 152.0 (C);

IR (FTIR, cm^{-1}) = 3314, 2947, 2866, 2124, 1612, 1464;

HRMS (EI) *m/z* calculated for $C_{17}H_{30}OSi$ [M^+] 278.2066, found: 278.2066.



(Z)-Triisopropyl(2-phenylhepta-1,3-dien-6-yn-3-yloxy)silane

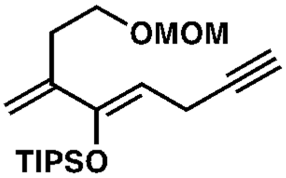
Yield 18%;

^{1}**H NMR** (400 MHz, $CDCl_3$) δ ppm 1.00 (d, *J* = 6.1 Hz, 18 H), 1.09 (m, 3 H), 1.93 (t, *J* = 2.7 Hz, 1 H), 3.09 (dd, *J* = 6.9, 2.7 Hz, 2 H), 4.86 (t, *J* = 6.9 Hz, 1 H), 5.25 (d, *J* = 1.6 Hz, 1 H), 5.42 (d, *J* = 1.6 Hz, 1 H), 7.31 (m, 3 H), 7.37 (m, 2 H);

^{13}**C NMR** (101 MHz, $CDCl_3$) δ ppm 13.5 (CH x 3), 15.7 (CH_2), 17.9 (CH_3 x 6), 67.7 (CH), 83.0 (C), 108.3 (CH), 114.2 (CH_2), 127.7 (CH), 128.1 (CH x 2), 128.1 (CH x 2), 139.3 (C), 147.9 (C), 151.7 (C);

IR (FTIR, cm-1) = 3311, 3082, 3060, 3026, 2945, 2867, 2120, 1948, 1875, 1799, 1720;

HRMS (EI) *m/z* calculated for $C_{22}H_{32}OSi$ 340.2222 [M+], found: 340.2225



(Z)-8-(But-3-ynylidene)-10,10-diisopropyl-11-methyl-7-methylene-2,4,9-trioxa-10-siladodecane

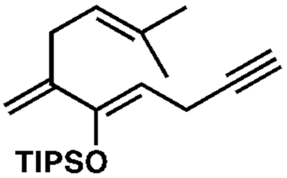
Yield 64%;

^{1}**H NMR** (300 MHz, $CDCl_3$) δ ppm 1.09 (d, *J* = 6.1 Hz, 18 H), 1.18 (m, 3 H), 1.94 (t, *J* = 2.7 Hz, 1 H), 2.52 (td, *J* = 7.1, 0.9 Hz, 2 H), 3.05 (dd, *J* = 6.9, 2.8 Hz, 2 H), 3.36 (s, 3 H), 3.65 (t, *J* = 7.2 Hz, 2 H), 4.62 (s, 2 H), 4.91 (t, *J* = 6.9 Hz, 1 H), 4.97 (d, *J* = 1.2 Hz, 1 H), 5.32 (d, *J* = 1.4 Hz, 1 H);

^{13}**C NMR** (101 MHz, $CDCl_3$) δ ppm 13.8 (CH x 3), 15.8 (CH_2), 18.0 (CH_3 x 6), 33.6 (CH_2), 55.2 (CH_3), 66.6 (CH_2), 67.8 (CH), 83.0 (C), 96.5 (CH_2), 104.8 (CH), 113.7 (CH_2), 142.5 (C), 151.3 (C);

IR (FTIR, cm-1) = 3400, 3311, 2945, 2868, 2100, 1698, 1618, 1464;

HRMS (EI) *m/z* calculated for $C_{20}H_{36}O_3Si$ [M+ ($CH(CH_3)_2$)] 309.1886, found: 309.1993.



(Z)-Triisopropyl(9-methyl-6-methylenedeca-4,8-dien-1-yn-5-yloxy)silane

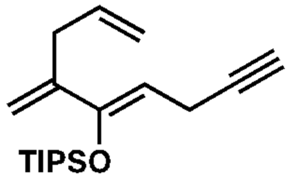
To a solution of 9-methyl-6-methylenedec-8-en-1-yn-5-one **E** (560 mg, 3.18 mmol) in DCE (30 mL) at rt, under an argon atmosphere, was added Et_3N (2.23 mL, 15.9 mmol) and then TIPSOTf (2.56 mL, 9.53 mmol). The reaction mixture was stirred for 8h at reflux. The reaction was quenched with a saturated solution of $NaHCO_3$. The mixture was extracted two times with DCM, washed with water, dried over $MgSO_4$ and concentrated at reduced pressure to furnish brown oil. Purification by flash chromatography over silica gel (hexanes/EtOAc in gradient 1 - 5% of EtOAc) gave the product (962 mg, 91%) as yellow oil.

^{1}H NMR (300 MHz,$CDCl_3$) δ 5.29 (d, *J* = 1.6 Hz, 1 H), 5.23 - 5.14 (m, 1H), 4.95 - 4.86 (m, 1 H), 4.90 (t, *J* = 7.1 Hz, 1 H), 3.07 (dd, *J* = 2.7, 6.9 Hz, 2 H), 2.97 - 2.83 (m, 2 H), 1.95 (t, *J* = 2.7 Hz, 1 H), 1.72 (d, *J* = 1.1 Hz, 3 H), 1.62 (d, *J* = 0.9 Hz, 3 H);

^{13}C NMR (75 MHz, $CDCl_3$) δ 151.8, 144.6, 133.3, 121.8, 112.5, 104.7, 83.4, 67.8, 32.1, 25.9, 18.3 16.0;

IR (FTIR, cm-1) = 3315, 2962, 2945, 2868, 2121, 1549;

HRMS (EI) *m/z* calculated for $C_{18}H_{29}OSi$ [M+ (-C_3H_7)] 289.1988, found: 289.2169.



(Z)-Triisopropyl(6-methylenenona-4,8-dien-1-yn-5-yloxy)silane

To a solution of 4-methylenenon-1-en-8-yn-5-one **B** (300 mg, 2.02 mmol) in DCE (20 mL) at rt, under an argon atmosphere, was added Et_3N (1.42 mL, 10.1 mmol) and then TIPSOTf (1.63 mL, 6.07 mmol). The reaction mixture was stirred for 8 h at reflux. The reaction was quenched with a saturation of solution of $NaHCO_3$. The mixture was extracted two times with DCM, washed with water, dried over $MgSO_4$ and concentrated at reduced pressure to furnish a brown oil. Purification by flash chromatography over silica gel (hexanes/EtOAc in gradient 1–5% of EtOAc) gave the product (469 mg, 76%) as yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 5.85 (ddt, *J* = 16.9, 10.1, 6.9 Hz, 1 H), 5.34 (d, *J* = 1.3 Hz, 1 H), 5.12 - 5.03 (m, 2 H), 4.96 (d, *J* = 1.2 Hz, 1 H), 4.92 (t, *J* = 6.9 Hz, 1 H), 3.07 (dd, *J* = 6.9, 2.7 Hz, 2 H), 2.96 (dd, *J* = 6.8, 0.9 Hz, 2 H), 1.95 (t, *J* = 2.7 Hz, 1 H), 1.25 - 1.15 (m, 3 H), 1.12 - 1.09 (m, 18 H).

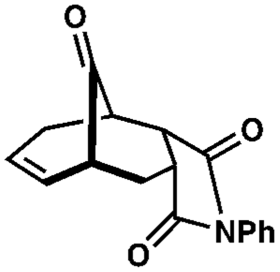
^{13}C NMR (75 MHz, $CDCl_3$) δ 151.5, 144.0, 136.2, 116.5, 113.2, 105.0, 83.2, 67.9, 37.8, 18.3, 18.2, 16.0, 14.0, 13.6;

IR (FTIR, cm^{-1}) = 3314, 2945, 2868, 2121;

HRMS *m/z* calculated for $C_{16}H_{25}OSi$ [M^+ (-C_3H_7)] 261.1675, found: 261.1695.

General procedure for the Diels–Alder reaction/gold cyclization process

Diene (1 equiv) was charged into a microwave quartz tube (the tube was washed in a base bath and dried). *N*-phenylmaleimide (2 equiv) was added and then toluene (0.1 M) was added. The mixture was heated to 150 °C at 300 W in the microwave for 2 h. After cooling down to rt, catalyst **6** (5 mol%) was added to the mixture with a minimal amount of acetone to solubilize the catalyst. After stirring overnight, the solution was concentrated and purified by flash chromatography (25–40% EtOAc in hexanes) to afford the desired ketone.



4-Phenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene- 3,5,12-trione

Yield 93% (35 mg);

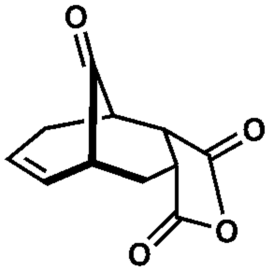
^{1}**H NMR** (400 MHz, CDCl3) δ ppm 2.33 (ddd, *J* = 14.5, 7.9, 4.2 Hz, 1 H), 2.64 (t, *J* = 3.1 Hz, 2 H), 2.95 (m, *J* = 2.5 Hz, 1 H), 3.03 (m, 3 H), 3.68 (t, *J* = 8.9 Hz, 1 H), 5.72 (m, 1 H), 5.82 (dt, *J* = 9.6, 3.4 Hz, 1 H), 7.27 (m, 2 H), 7.39 (m, 1 H), 7.50 (m, 2 H);

^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 31.0 (CH_2), 32.6 (CH_2), 36.3 (CH), 44.0 (CH), 45.7 (CH), 47.5 (CH), 126.1 (CH x2), 127.0 (CH), 128.8 (CH), 129.3 (CH x2), 130.2 (CH), 131.7 (C), 175.6 (C), 177.4 (C), 212.1 (C);

IR (neat, cm^{-1}) ν_{max} 3483, 3074, 3036, 2930, 2864, 1711;

HRMS (EI) *m/z* calculated for $C_{17}H_{15}NO_3$ [M+] 281.1052, found: 281.1061;

mp = 155-160 °C.



4-Oxatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12- trione

Yield 51% (11 mg);

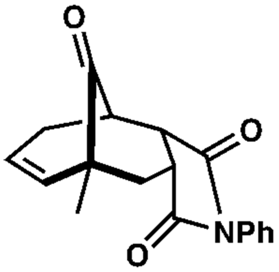
^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 2.36 (ddd, *J*=14.6, 7.5, 4.2 Hz, 1 H), 2.57 (m, 1 H), 2.70 (m, 1 H), 2.87 (dd, *J* = 14.6, 2.1 Hz, 1 H), 2.97 (m, 2 H), 3.18 (ddd, *J* = 9.9, 7.7, 1.0 Hz, 1H), 3.74 (t, 1 H), 5.69 (ddd, *J*=9.5, 4.9, 3.0 Hz, 1 H), 5.82 (m, *J* = 9.6, 4.9, 2.1 Hz, 1H);

^{13}C NMR (101 MHz, $CDCl_3$) δ ppm 30.9 (CH_2), 33.0 (CH_2), 36.5 (CH), 43.2 (CH), 45.2 (CH), 48.0 (CH), 127.7 (CH), 129.6 (CH), 170.1 (C), 172.5 (C), 210.1 (C);

IR (FTIR, cm-1) = 2926, 2854, 1857, 1700, 1447;

HRMS (EI) *m/z* calculated for $C_{11}H_{10}O_4$ [M+] 206.0579, found: 206.0547;

mp = 132–135 °C.



8-Methyl-4-phenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12-trione

Yield 88% (75 mg);

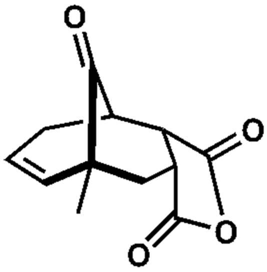
^{1}**H NMR** (400 MHz, $CDCl_3$) δ ppm 1.17 (s, 3 H), 2.4 (dd, *J* = 14.4, 7.7 Hz, 1 H), 2.62 (m, 2 H), 2.90 (d, *J* = 14.3 Hz, 1 H), 3.00 (ddd, *J* = 9.0, 7.8, 0.9 Hz, 1 H), 3.11 (m, 1 H), 3.68 (t, *J* = 9.0 Hz, 1 H), 5.50 (ddd, *J* = 9.5, 2.1, 1.1 Hz, 1 H), 5.75 (m, 1 H), 7.26 (m, 2 H), 7.42 (m, 1 H), 7.50 (m, 2 H);

^{13}**C NMR** (101 MHz, $CDCl_3$) δ ppm 20.5 (CH_3), 32.6 (CH_2), 37.7 (CH), 38.4 (CH_2), 44.4 (CH), 46.1 (C), 47.4 (CH), 125.8 (CH), 126.1 (CH x2), 128.8 (CH), 129.3 (CH x2), 131.7 (C), 135.8 (CH), 175.7 (C), 177.4 (C), 212.8 (C);

IR (FTIR, cm-1) = 2960, 2924, 2854, 1709, 1377;

HRMS (EI) *m/z* calculated for $C_{18}H_{17}NO_3$ [M+] 295.1208, found: 295.1228;

mp = 189– 192 °C.



8-Methyl-4-oxatricyclo[6.3.1.0^{2,6}]dodec-9-ene- 3,5,12-trione

Yield, 50% (30 mg);

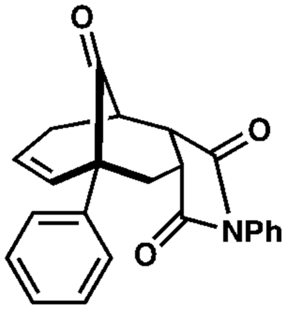
^{1}H NMR (400 MHz, CDCl3) δ ppm 1.13 (s, 3 H), 2.06 (dd, *J* = 14.5, 7.6 Hz, 1 H), 2.59 (ddd, *J* = 19.1, 4.9, 1.9 Hz, 1 H), 2.68 (m, 1 H,) 2.71 (d, *J* = 14.5 Hz, 1 H), 3.03 (m, 1 H), 3.19 (ddd, *J* = 9.9, 7.5, 1.0 Hz, 1 H), 3.73 (dd, *J* = 9.7, 8.9 Hz, 1 H), 5.46 (dd, *J* = 9.4, 2.9 Hz, 1 H), 5.76 (m, 1 H);

^{13}C NMR (101 MHz, CDCl3) δ ppm 20.2 (CH3), 33.0 (CH2), 38.0 (CH), 38.2 (CH2), 43.5 (CH), 45.9 (C), 47.9 (CH), 126.4 (CH), 135.3 (CH), 170.2 (C), 172.5 (C), 210.9 (C);

IR (FTIR, cm-1) = 2928, 2866, 2138, 1860, 1455;

HRMS (EI) *m/z* calculated for $C_{12}H_{12}O_4$ [M+] 220.0736, found: 220.0717;

mp=101-105˚C.



4,8-Diphenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12-trione

Yield 77% (24 mg);

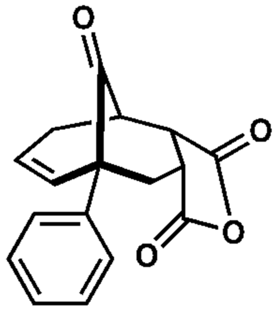
^{1}**H NMR** (400 MHz, CDCl3) δ ppm 2.80 (m, 3 H) 3.26 (m, 3 H) 3.80 (t, *J* = 9.2 Hz, 1 H) 5.71 (dd, *J* = 9.6, 2.5 Hz, 1 H) 5.98 (m, 1 H) 7.21 (m, 2 H) 7.32 (m, 3 H) 7.38 (m, 3 H) 7.52 (m, 2H);

^{13}**C NMR** (101 MHz, CDCl3) δ ppm 32.0 (CH2) 34.9 (CH2) 37.9 (CH) 45.3 (CH) 47.2 (CH) 54.5 (C) 126.1 (CHx2) 126.5 (CH) 127.4 (CHx2) 127.6 (CH) 128.4 (CHx2) 128.8 (CH) 129.4 (CHx2) 131.8 (C) 135.2 (CH) 138.7 (C) 175.5 (C) 177.3 (C) 210.5 (C);

IR (FTIR, cm-1) = 3061, 3030, 2926, 2855, 1781;

HRMS (EI) *m/z* calculated for $C_{23}H_{19}NO_3$ 357.1365, found 357.1358;

mp = 221–224 °C



Phenyl-4-oxatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12-trione

Yield 48% (18 mg);

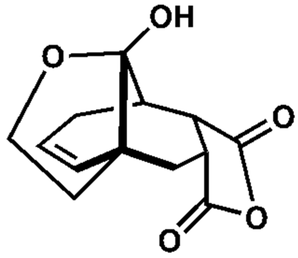
^{1}H NMR (400 MHz, CDCl3) δ ppm 2.71 (ddd, *J* = 19.1, 5.3, 1.9 Hz, 1 H), 2.83 (dd, *J* = 14.2, 7.5 Hz, 1 H), 2.90 (m, 1H), 3.10 (d, *J* = 13.7 Hz, 1 H), 3.18 (m, 1 H), 3.40 (ddd, *J* = 10.1, 7.5, 0.8 Hz, 1 H), 3.85 (m, 1 H), 5.71 (dd, *J* = 9.6, 3.1 Hz, 1 H), 6.02 (m, 1H), 7.18 (m, 2 H), 7.33 (m, 1 H), 7.38 (m, 2 H);

^{13}C NMR (101 MHz, CDCl3) δ ppm 32.4 (CH2), 34.9 (CH2), 38.3 (CH), 44.5 (CH), 47.7 (CH), 54.3 (C), 127.2 (CH), 127.3 (CH x2), 127.9 (CH), 128.5 (CH x2), 134.9 (CH), 137.9 (C), 170.1 (C), 172.5 (C), 208.8 (C);

IR (FTIR, cm-1) = 2980, 2928, 2901, 2859, 1851, 1778, 1724;

HRMS (EI) *m/z* calculated for C17H14O4 [M+] 282.0892, found: 282.0892;

mp = 205–208 °C.



Hydroxy-5,10- dioxatetracyclo[6.4.3.0^{1,9}.0^{3,7}]pentadec-3-ene-4,6-dione

Yield 56% (10 mg);

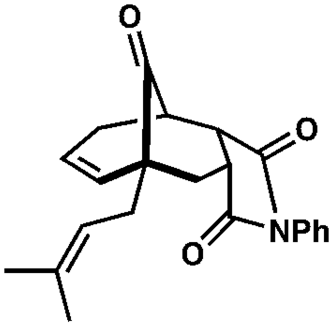
^{1}**H NMR** (400 MHz, CDCl3) δ ppm 1.79 (dd, *J* = 11.9, 6.9 Hz, 1 H), 2.08 (m, 2 H), 2.23 (m, 2H), 2.45 (d, *J* = 13.7 Hz, 2 H), 2.66 (m, 1 H), 3.18 (m, 1 H), 3.60 (dd, *J* = 9.9, 8.3 Hz, 1H), 3.79 (ddd, *J* = 10.1, 8.0, 7.2 Hz, 1 H), 4.06 (m, 1 H), 5.22 (dd, *J* = 9.6, 2.9 Hz, 1 H), 5.65 (m, 1 H);

^{13}**C NMR** (101 MHz, CDCl3) δ ppm 27.1 (CH2), 29.4 (CH2), 32.1 (CH2), 37.4 (CH), 39.0 (CH), 45.4 (CH), 45.5 (C), 66.9 (CH2), 102.7 (C), 126.8 (CH), 132.3 (CH), 172.9 (C), 173.9 (C);

IR (FTIR, cm-1) = 3493, 2927, 1852, 1774, 1716;

HRMS (EI) *m/z* calculated for C13H14O5 [M+] 250.0841, found: 250.0831;

mp=63-65˚C.



8-(2-Methyl-2-butene)-allyl-4-phenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12- trione

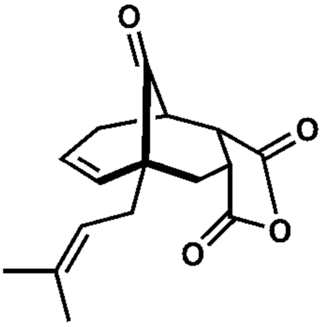
Yield: 81% (17 mg);

^{1}H NMR (300 MHz, CDCl3) δ 7.56 - 7.36 (m, 3 H), 7.30 - 7.25 (m, 2 H), 5.85 - 5.75 (m, 1 H), 5.54 (dd, *J* = 1.6, 9.4 Hz, 1 H), 5.14 - 5.04 (m, 1 H), 3.69 (t, *J* = 9.0 Hz, 1 H), 3.14 - 3.00 (m, 2 H), 2.93 (d, *J* = 14.4 Hz, 1 H), 2.70 - 2.52 (m, 2 H), 2.38 (dd, *J* = 7.6, 14.8 Hz, 1 H), 2.19 (dd, *J* = 7.5, 14.7 Hz, 1 H), 2.04 (dd, *J* = 7.9, 14.4 Hz, 1 H), 1.71 (d, *J* = 0.9 Hz, 3 H), 1.63 (s, 3 H).

^{13}C NMR (75 MHz, CDCl3) δ 212.8, 177.6, 175.9, 135.0, 134.2, 131.9, 129.4, 128.9, 126.4, 126.2, 118.6, 49.9, 47.7, 44.9, 37.7, 37.0, 32.5, 32.4, 26.2, 18.1;

IR (FTIR, cm-1) = 2967, 2941, 1713, 1529;

MS (EI) *m/z* calculated for C22H23NO3 [M+] 349.1678, found: 349.1678.



8-(2-Methylbutenyl)-4-oxatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12-trione

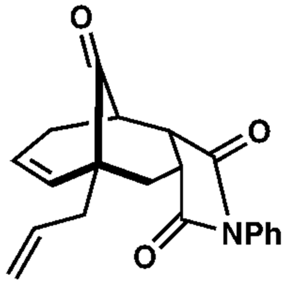
Yield: 78% (67 mg);

^{1}**H NMR** (500 MHz, CDCl3) δ 6.27 (ddd, *J* = 1.2, 7.3, 8.4 Hz, 1 H), 6.20 (dd, *J* = 7.7, 7.9 Hz, 1 H), 4.98 (dd, *J* = 1.4, 7.2 Hz, 1 H), 3.48 (dd, *J* = 5.8, 7.0 Hz, 1 H), 3.34 (dd, *J* = 3.7, 5.5 Hz, 1 H), 3.21 (dd, *J* = 3.7, 5.7 Hz, 1 H), 2.86 (d, *J* = 7.3 Hz, 1 H), 2.54 (dd, *J* = 6.2, 14.9 Hz, 1 H), 2.26 (dd, *J* = 8.0, 14.8 Hz, 1 H), 2.04 (dd, *J* = 4.4, 13.1 Hz, 1 H), 1.85 (d, *J* = 13.1 Hz, 1 H), 1.67 (s, 3 H), 1.63 (s, 3 H).

^{13}**C NMR** (75 MHz, CDCl3) □= 209.9, 169.6, 135.6, 133.1, 131.5, 118.5, 55.9, 55.2, 51.6, 51.4, 49.4, 38.0, 30.7, 26.1, 17.9, 17.8.

IR (neat, cm^{-1}) ν_{max} 2946, 2869, 1751, 1731, 1715, 1464;

LRMS (EI) *m/z* calculated for $C_{15}H_{18}O_{3}$[M+ (-CO)] 246.1256, found: 246.1378.



8-Allyl-4-phenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12-trione

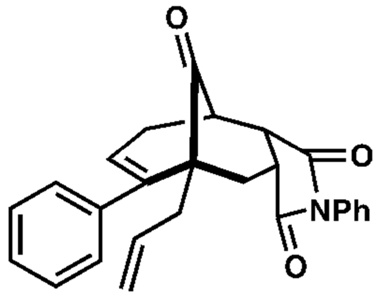
Yield: 80% (211 mg);

^{1}H NMR (300 MHz, CDCl3) δ 7.54 - 7.35 (m, 3 H), 7.30 - 7.22 (m, 2 H), 5.87 - 5.64 (m, 2 H), 5.53 (d, *J* = 9.8 Hz, 1 H), 5.11 (d, *J* = 3.9 Hz, 1 H), 5.06 (s, 1 H), 3.66 (t, *J* = 8.9 Hz, 1 H), 3.14 - 2.97 (m, 2 H), 2.87 (d, *J* = 14.3 Hz, 1 H), 2.59 (br. s., 2 H), 2.47 (dd, *J* = 6.9, 14.0 Hz, 1 H), 2.20 (dd, *J* = 7.6, 14.0 Hz, 1 H), 2.03 (dd, *J* = 7.8, 14.4 Hz, 1 H).

^{13}C NMR (75 MHz, CDCl3) δ 212.1, 177.5, 175.8, 133.8, 133.2, 131.8, 129.4, 128.8, 126.6, 126.2, 118.7, 49.1, 47.6, 44.8, 38.5, 37.6, 37.0, 32.3;

IR (FTIR, cm-1) = 3078, 2921, 1712;

HRMS (EI) *m/z* calculated C20H19NO3 [M+] 321.1365, found: 321.1364.



4,9-Diphenyl-8-allyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12-trione

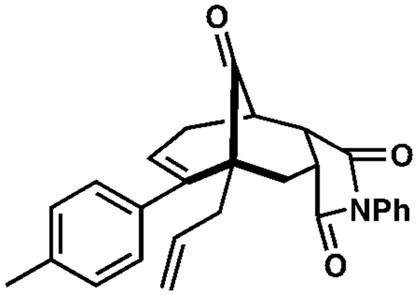
Yield: 68% (178 mg);

^{1}**H NMR** (500 MHz, CDCl3) δ 7.49 - 7.40 (m, 4 H), 7.40 - 7.34 (m, 1 H), 7.34 - 7.27 (m, 3 H), 7.23 - 7.16 (m, 2 H), 5.86 (dd, *J* = 2.7, 4.4 Hz, 1 H), 5.56 (tdd, *J* = 6.8, 10.3, 17.1 Hz, 1 H), 4.85 (d, *J* = 10.3 Hz, 1 H), 4.63 (dd, *J* = 2.0, 17.1 Hz, 1 H), 3.76 (t, *J* = 9.0 Hz, 1 H), 3.39 (d, *J* = 14.9 Hz, 1 H), 3.28 - 3.13 (m, 2 H), 2.79 - 2.65 (m, 2 H), 2.30 - 2.12 (m, 3 H).

^{13}**C NMR** (101MHz, CDCl3) δ 211.4, 176.7, 175.8, 143.8, 139.9, 133.6, 131.8, 129.4, 129.1, 128.9, 128.1, 127.8, 127.6, 126.3, 118.4, 51.2, 47.6, 44.0, 37.6, 37.6, 36.5, 31.5;

IR (FTIR, cm-1) = 3072, 2931, 1777, 1713, 1636, 1500, 1445.

HRMS *m/z* calculated for $C_{26}H_{23}NO_3$ [M+] 397.1678, found: 397.1685.



8-Allyl-9-(4-methylphenyl)-4-phenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12-trione

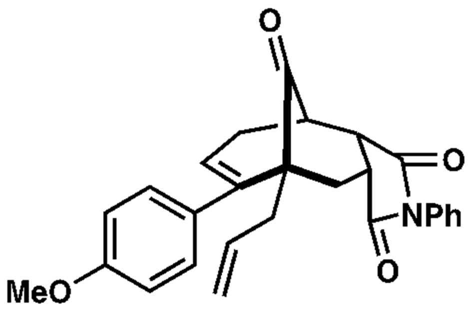
Yield: 91% (237 mg);

^{1}**H NMR** (500 MHz, CDCl3) δ 7.47 - 7.39 (m, 2 H), 7.39 - 7.29 (m, 3 H), 7.19 (d, *J* = 7.6 Hz, 2H), 7.11 (d, *J* = 7.8 Hz, 2 H), 5.84 (t, *J* = 3.9 Hz, 1 H), 5.56 (ddt, *J* = 7.1, 10.3, 16.9 Hz, 1 H), 4.86 (dd, *J* = 1.2, 10.3 Hz, 1 H), 4.67 (dd, *J* = 1.2, 17.1 Hz, 1 H), 3.74 (t, *J* = 9.0 Hz, 1 H), 3.37 (d, *J* = 15.1 Hz, 1 H), 3.25 - 3.12 (m, 2 H), 2.78 - 2.63 (m, 2H), 2.34 (s, 3 H), 2.30 - 2.24 (m, 2 H), 2.20 (dd, *J* = 7.8, 14.9 Hz, 1 H);

^{13}**C NMR** (126 MHz, CDCl3) δ 211.5, 176.6, 175.9, 143.6, 137.4, 137.0, 133.7, 131.7, 129.4, 128.9, 128.8, 128.7, 127.2, 126.2, 118.3, 51.3, 47.5, 44.0, 37.6, 37.5, 36.4, 31.4;

IR (FTIR, cm-1) = 3072, 2924, 1714, 1593, 1500.

HRMS (EI) m/z calculated for C27H25NO3 [M+] 411.1834, found: 411.1807.



8-Allyl-9-(4-methoxyphenyl)-4-phenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12- trione

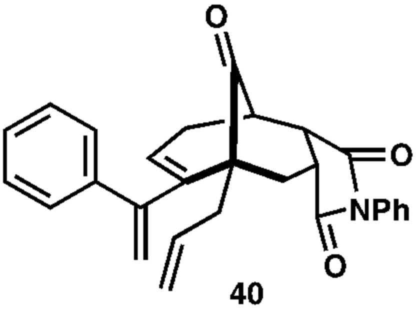
Yield: 74% (192 mg);

^{1}**H NMR** (400 MHz, CDCl3) δ 7.46 - 7.40 (m, 2 H), 7.39 - 7.33 (m, 3 H), 7.24 - 7.15 (m, 2 H), 6.84 (d, *J* = 8.8 Hz, 2 H), 5.83 (t, *J* = 3.2 Hz, 1 H), 5.55 (ddt, *J* = 6.9, 10.3, 17.1 Hz, 1 H), 4.85 (dd, *J* = 2.0, 10.2 Hz, 1 H), 4.66 (dd, *J* = 2.0, 17.1 Hz, 1 H), 3.80 (s, 3 H), 3.75 (t, *J* = 8.8 Hz, 1 H), 3.36 (d, *J* = 14.9 Hz, 1 H), 3.26 - 3.13 (m, 2 H), 2.78 - 2.59 (m, 2 H), 2.34 - 2.14 (m, 3 H).

^{13}**C NMR** (101 MHz, CDCl3) δ 211.5, 176.7, 175.9, 159.2, 143.4, 133.7, 132.5, 131.8, 130.2, 129.4, 128.8, 127.2, 126.3, 118.3, 113.4, 55.3, 51.4, 47.6, 44.1, 37.7, 37.5, 36.5, 31.4;

IR (FTIR, cm-1) = 2939, 2254, 1780, 1714, 1605, 1512;

HRMS (EI) *m/z* calculated for C27H25NO4 [M+] 427.1784, found: 427.1795.



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8-Allyl-9-(1-phenylethenyl)-4-phenyl-4-azatricyclo[6.3.1.0^{2,6}]dodec-9-ene-3,5,12- trione

Yield: 79% (259 mg);

^{1}H NMR (400 MHz, CDCl3) δ 7.50 - 7.38 (m, 4 H), 7.33 - 7.27 (m, 4 H), 7.25 - 7.22 (m, 2 H), 5.78 (tdd, *J* = 7.4, 10.5, 18.4 Hz, 1 H), 5.70 (dd, *J* = 2.1, 4.9 Hz, 1 H), 5.68 (s, 1 H), 5.53 (s, 1 H), 5.02 - 4.92 (m, 2 H), 3.70 (t, *J* = 8.8 Hz, 1 H), 3.24 - 3.12 (m, 2 H), 2.76 (ddd, *J* = 2.3, 5.9, 19.5 Hz, 1 H), 2.59 (ddd, *J* = 1.2, 4.7, 19.1 Hz, 1 H), 2.48 (dd, *J* = 6.6, 14.1 Hz, 1 H), 2.24 (dt, *J* = 8.2, 15.2 Hz, 3 H);

^{13}C NMR (101 MHz, CDCl3) δ 211.5, 176.6, 175.9, 146.5, 142.7, 141.9, 134.2, 131.8, 129.5, 129.3, 129.0, 128.4, 127.8, 127.5, 126.4, 118.8, 117.0, 51.1, 47.4, 43.9, 37.3, 37.0, 34.6, 31.8;

IR (FTIR, cm-1) = 2957, 2922, 2855, 1712;

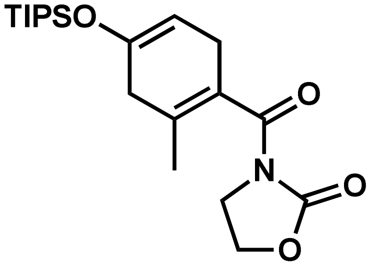
HRMS (EI) *m/z* calculated for C28H25NO3 [M+] 423.1834, found: 423.1840.

References

[1] Ahmad, N. M.; Rodeschini, V.; Simpkins, N. S.; Ward, S. E.; Blake, A. J. *J. Org Chem.* **2007,** *72*, 4803.

[2] Savignac, P.; Bréque, A. *Synth. Comm.* **1979,** *9*, 487.

Framework Design of PPAPs via Highly Hindered Diels-Alder



3-(2-methyl-4-((triisopropylsilyl)oxy)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one

A dry 10 mL round bottom flask fitted with a magnetic stirrer was charged with $CHCl_3$+CH_3CN (2+2 mL) under argon, 3-(but-2-ynoyl)oxazolidin-2-one (50 mg, 0.33 mmol, 1 eq.), (buta-1,3-dien-2-yloxy)triisopropylsilane (222 mg, 0.98 mmol, 3 eq.) with stirring. This mixture was cooled to 0°C and the ethyl aluminum sesquichloride (0.57 mL, 0.23 mmol, 0.7 eq.) was added dropwise. The reaction was allowed to stir for 15 hours from 0°C to room temperature. The reaction was quenched with $NaHCO_3$, diluted with EtOAc, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil was subjected to flash chromatography (0-

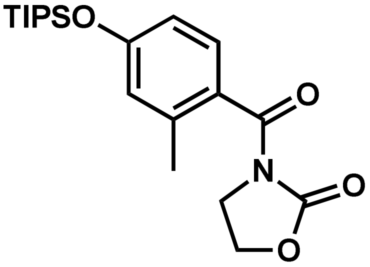
30% EtOAc in hexanes) to give 3-(2-methyl-4-((triisopropylsilyl)oxy)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one as white solid (70 mg, 56% yield).

^{1}H NMR (CDCl$_3$, 300 MHz) δ_{ppm} = 4.85 (t, *J* = 3.5 Hz, 1 H), 4.43 (dd, *J*= 7.8, 7.8 Hz, 2 H), 4.07 (dd, *J*= 8.4, 8.4 Hz, 2 H), 2.99 - 2.87 (m, 2 H), 2.77 - 2.65 (m, 2 H), 1.67 (s, 3 H), 1.11 - 1.03 (m, 21 H)

^{13}C NMR (CDCl$_3$, 100 MHz) δ_{ppm} = 171.6, 152.2, 147.1, 131.9, 124.9, 98.6, 62.1, 42.5, 36.2, 28.7, 20.0, 18.1, 12.8

IR (FTIR, cm^{-1}) = 2945, 2868, 1792, 1703, 1675, 1458, 1387, 1229, 1192, 1086, 883

HRMS (EI) *m/z* calculated for $C_{20}H_{33}NO_4Si$ (M+) = 379.2179, found: 379.2177



3-(2-methyl-4-((triisopropylsilyl)oxy)benzoyl)oxazolidin-2-one

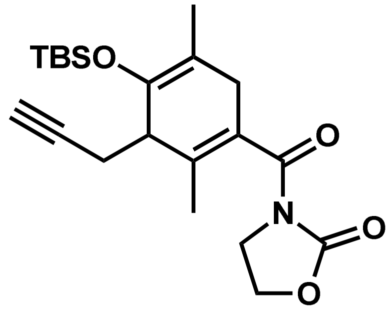
Oxidation over the air after 3 days of 3-(2-methyl-4-((triisopropylsilyl)oxy)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one gave quantitatively 3-(2-methyl-4-((triisopropylsilyl)oxy)benzoyl)oxazolidin-2-one.

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 7.21 (d, *J* = 8.1 Hz, 1 H), 6.76 - 6.66 (m, 2 H), 4.50 - 4.37 (m, 2 H), 4.22 - 4.09 (m, 2 H), 2.33 (s, 3 H), 1.26 (d, *J* = 1.1 Hz, 3 H), 1.13 - 1.04 (m, 18 H)

^{13}C NMR ($CDCl_3$, 75 MHz) δ_{ppm} = 158.4, 152.8, 130.1, 125.9, 122.2, 116.8, 62.1, 43.3, 19.9, 18.0, 12.8

IR (FTIR, cm^{-1}) = 2953, 2862, 1787, 1681, 1602, 1497, 1309, 1188, 816

HRMS (EI) *m/z* calculated for $C_{20}H_{31}NO_4Si$ (M+) = 377.2022, found: 377.2017



3-(4-((tert-butyldimethylsilyl)oxy)-2,5-dimethyl-3-(prop-2-yn-1-yl)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one

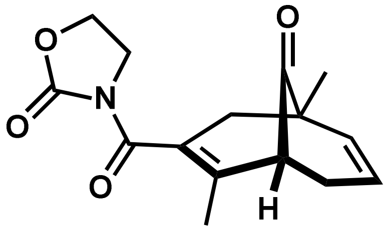
A dry 10 mL round bottom flask fitted with a magnetic stirrer was charged with CH_2Cl_2+CH_3CN(2+2 mL) under argon, 3-(but-2-ynoyl)oxazolidin-2-one (40 mg, 0.26 mmol, 1 eq.), (Z)-tert-butyldimethyl((2-methylhepta-1,3-dien-6-yn-3-yl)oxy)silane (185 mg, 0.78 mmol, 3 eq.) with stirring. This mixture was cooled to 0°C and the ethyl aluminum sesquichloride (0.46 mL, 0.18 mmol, 0.7 eq.) was added dropwise. The reaction was allowed to stir for 15 hours from 0°C to room temperature. The reaction was quenched with $NaHCO_3$, diluted with EtOAc, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil was subjected to flash chromatography (0-30% EtOAc in hexanes) to give 3-(4-((tert-butyldimethylsilyl)oxy)-2,5-dimethyl-3-(prop-2-yn-1-yl)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one (71 mg, 69% yield).

^{1}H NMR (CDCl$_3$, 300 MHz) δ_{ppm} = 4.43 (dd, *J*= 8.1, 8.0 Hz, 2 H), 4.07 (dd, *J*= 8.3, 7.7 Hz, 2 H), 3.04 - 2.88 (m, 1 H), 2.75 - 2.59 (m, 3 H), 2.56 - 2.43 (m, 1 H), 1.95 (t, *J* = 2.7 Hz, 1 H), 1.80 (s, 3 H), 1.62 (s, 3 H), 1.00 - 0.92 (m, 9 H), 0.18 - 0.11 (m, 6 H)

^{13}C NMR (CDCl$_3$, 100 MHz) δ_{ppm} = 171.0, 152.2, 141.6, 134.3, 127.1, 109.9, 118.0, 82.7, 70.0, 62.1, 45.4, 42.5, 34.0, 26.0, 21.7, 18.9, 18.4, 15.9, -3.8, -3.9

IR (FTIR, cm^{-1}) = 3287, 2956, 2858, 1786, 1687, 1473, 1362, 1222, 839

HRMS (EI) *m/z* calculated for $C_{21}H_{31}NO_4Si$ (M+) = 389.2022, found: 389.2003



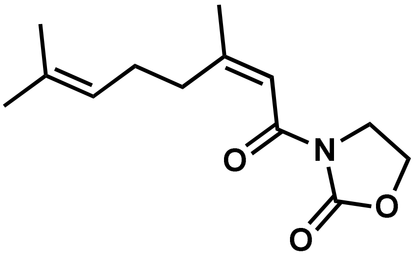
3-(4-((tert-butyldimethylsilyl)oxy)-2,5-dimethyl-3-(prop-2-yn-1-yl)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one

A dry 5 mL round bottom flask fitted with a magnetic stirrer was charged with acetone (1 mL) under argon , 3-(4-((tert-butyldimethylsilyl)oxy)-2,5-dimethyl-3-(prop-2-yn-1-yl)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one (30 mg, 0.08 mmol, 1 eq.) and gold catalyst (x) (3 mg, 3.8 µmol, 0.05 eq.). The reaction was allowed to stir overnight at room temperature. The reaction was quenched with NH_4Cl, diluted with EtOAc, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil was subjected to flash chromatography (0-30% EtOAc in hexanes) to give 3-(4-((tert-butyldimethylsilyl)oxy)-2,5-dimethyl-3-(prop-2-yn-1-yl)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one as white solid (15 mg, 70% yield).

^{1}H NMR ($CDCl_3$, 500 MHz) δ_{ppm} = 5.74 - 5.71 (m, 1 H), 5.49 (ddd, *J*= 9.4, 2.5, 0.8 Hz, 1 H), 4.43 (t, *J*= 8.1 Hz, 2 H), 4.05 (t, *J*= 8.1Hz, 2 H), 2.82 (d, *J* = 4.8 Hz, 1 H), 2.74 - 2.60 (m, 2 H), 2.58 (br. s., 2 H), 1.70 (t, *J* = 1.9 Hz, 3 H), 1.14 (s, 3 H)

^{13}C NMR ($CDCl_3$, 126 MHz) δ_{ppm} = 212.0, 170.0, 152.1, 137.0, 135.3, 126.9, 124.8, 62.2, 51.1, 45.7, 44.5, 42.5, 34.4, 20.1, 18.8.

HRMS (EI) *m/z* calculated for $C_{15}H_{17}NO_4$ (M+) = 275.1158, found: 275.1158.

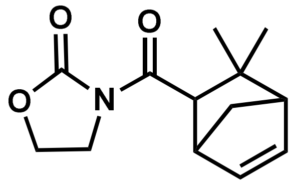


(Z)-3-(3,7-dimethylocta-2,6-dienoyl)oxazolidin-2-one

Same procedure as 3-(3,3-dimethylbicyclo[2.2.1]hept-5-ene-2-carbonyl)oxazolidin-2-one.

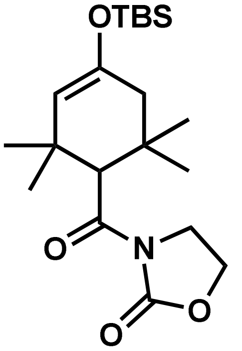
^{1}H NMR ($CDCl_3$, 500 MHz) δ_{ppm} = 6.89 (d, *J* = 0.9 Hz, 1 H), 5.14 (tdt, *J* = 1.4, 2.9, 5.8 Hz, 1 H), 4.38 (t, *J* = 8.1 Hz, 2 H), 4.03 (t, *J* = 8.1 Hz, 2 H), 2.59 (t, *J* = 7.6 Hz, 2 H), 2.17 (q, *J* = 7.6 Hz, 2 H), 1.97 (d, *J* = 1.3 Hz, 3 H), 1.67 (d, *J* = 0.9 Hz, 3 H), 1.61 (s, 3 H)

^{13}C NMR ($CDCl_3$, 126 MHz) δ_{ppm} = 164.9, 163.1, 153.6, 132.4, 123.7, 115.4, 61.9, 42.8, 34.7, 26.8, 26.2, 25.8, 17.8



3-(3,3-dimethylbicyclo[2.2.1]hept-5-ene-2-carbonyl)oxazolidin-2-one

See: Daniel Newbury Master Thesis.



3-(4-((tert-butyldimethylsilyl)oxy)-2,2,6,6-tetramethylcyclohex-3-enecarbonyl)oxazolidin-2-one

General procedure A for Diels-Alder reaction: A dry 10 mL round bottom flask fitted with a magnetic stirrer was charged with CH_2Cl_2 (5 mL) under argon, 3-(3-methylbut-2-enoyl)oxazolidin-2-one (200 mg, 1.18 mmol, 1 eq.), tert-butyldimethyl((4-methylpenta-1,3-dien-

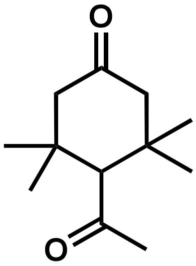
2-yl)oxy)silane (377 mg, 1.77 mmol, 1.5 eq.) with stirring. This mixture was cooled to 0°C and the ethyl aluminum sesquichloride (0.6 mL, 0.24 mmol, 0.2 eq.) was added dropwise. The reaction was allowed to stir for 24 hours from -78°C to room temperature. The reaction was quenched with $NaHCO_3$, diluted with EtOAc, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil was subjected to flash chromatography (0-30% EtOAc in hexanes) to give 3-(4-((tert-butyldimethylsilyl)oxy)-2,2,6,6-tetramethylcyclohex-3-enecarbonyl)oxazolidin-2-one as white solid (411 mg, 91% yield).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 4.57 (s, 1 H), 4.34 (dt, *J* = 2.0, 8.1 Hz, 2 H), 4.05 (s, 1 H), 4.02 (dd, *J* = 7.5, 8.7 Hz, 2 H), 2.01 - 1.84 (m, 2 H), 1.11 (s, 3 H), 1.09 (s, 3 H), 1.01 (s, 3 H), 1.01 (s, 3 H), 0.90 (s, 9 H), 0.12 (s, 3 H), 0.12 (s, 3 H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 174.5, 153.7, 147.6, 114.0, 61.3, 52.9, 43.9, 43.0, 35.9, 35.1, 32.4, 30.2, 27.5, 25.9, 25.7, 18.2, -4.2, -4.2

IR (FTIR, cm^{-1}) = 2958, 2904, 1772, 1695, 1670, 1379, 1369, 1208, 1195, 1041, 833

HRMS (EI) *m/z* calculated for $C_{20}H_{35}NO_4Si$ (M+) = 381.2335, found: 381.2321



4-acetyl-3,3,5,5-tetramethylcyclohexanone

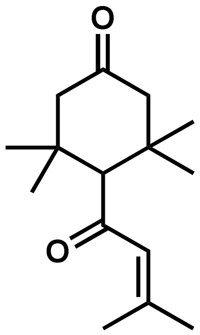
General procedure B for Diels-Alder reaction: A dry 10 mL round bottom flask fitted with a magnetic stirrer was charged with CH_2Cl_2 (5 mL) under argon, 4-methylpent-3-en-2-one (150 mg, 1.53 mmol, 1 eq.), triisopropyl((4-methylpenta-1,3-dien-2-yl)oxy)silane (506 mg, 1.99 mmol, 1.3 eq.) with stirring. This mixture was cooled to 0°C and the ethyl aluminum sesquichloride (0.76 mL, 0.31 mmol, 0.2 eq.) was added dropwise. The reaction was allowed to stir for 2 hours from -78°C to room temperature. The reaction was quenched with $NaHCO_3$, diluted with EtOAc, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil was subjected to silyl group deprotection by adding an excess of tetra-n-butylammonium fluoride solution (1M in THF). The reaction was allowed to stir for 10 hours at room temperature. The reaction was quenched with $NaHCO_3$, diluted with EtOAc, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil is subjected to flash chromatography (0-10% EtOAc in hexanes) to give 4-acetyl-3,3,5,5-tetramethylcyclohexanone as yellow oil (276 mg, 92% yield).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 2.73 (s, 1 H), 2.41 (d, J = 13.0 Hz, 2 H), 2.21 (s, 3 H), 2.03 (d, J = 13.0 Hz, 2 H), 1.02 (s, 6 H), 0.97 (s, 6 H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 212.5, 210.8, 64.9, 53.4, 38.8, 36.8, 32.1, 26.6

IR (FTIR, cm^{-1}) = 2948, 2933, 1701, 1652, 1456, 1373, 1355, 1226, 1272, 1190, 970

HRMS (EI) *m/z* calculated for $C_{12}H_{20}O_2$ (M+) = 196.1463, found: 196.15



(3,3,5,5-tetramethyl-4-(3-methylbut-2-enoyl)cyclohexanone

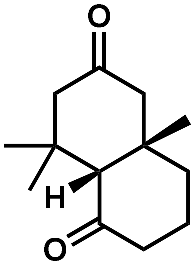
Following general procedure B for Diels-Alder reaction gave (3,3,5,5-tetramethyl-4-(3-methylbut-2-enoyl)cyclohexanone as yellow oil (451 mg, 88% yield).

^{1}H NMR (CDCl$_3$, 400 MHz) δ_{ppm} = 6.12 - 6.09 (m, 1 H), 2.63 (s, 1 H), 2.49 (d, J = 13.0 Hz, 2 H), 2.10 (d, J = 1.0 Hz, 3 H), 2.06 (d, J = 12.9 Hz, 2 H), 1.86 (d, J = 1.0 Hz, 3 H), 1.03 (s, 6 H), 1.01 (s, 6 H)

^{13}C NMR (CDCl$_3$, 100 MHz) δ_{ppm} = 211.6, 204.3, 155.1, 128.5, 65.4, 54.0, 39.4, 32.4, 27.9, 27.0, 20.7

IR (FTIR, cm^{-1}) = 2966, 2898, 2368, 2322, 1704, 1683, 1676, 1610, 1446, 1355, 1286, 1103, 1027, 769

HRMS (EI) *m/z* calculated for $C_{15}H_{24}O_2$ (M+) = 236.1776, found: 236.1758



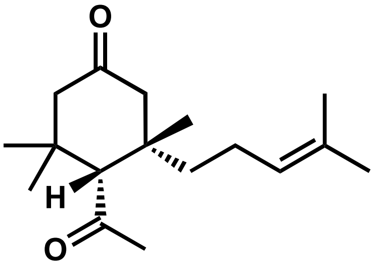
(4aS,8aR)-4a,8,8-trimethylhexahydronaphthalene-1,6(2H,7H)-dione

Following general procedure B for Diels-Alder reaction gave (4aS,8aR)-4a,8,8-trimethylhexahydronaphthalene-1,6(2H,7H)-dione as yellow oil (545 mg, 96% yield).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 2.39 - 2.20 (m, 5 H), 2.13 (dd, *J* = 1.7, 13.1 Hz, 1 H), 1.92 - 1.86 (m, 1 H), 1.86 - 1.77 (m, 3 H), 1.34 - 1.25 (m, 1 H), 1.03 (s, 6 H), 1.01 (s, 3 H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 212.3, 209.8, 65.7, 55.3, 54.0, 41.7, 40.2, 38.4, 33.2, 32.9, 30.5, 27.2, 20.6

HRMS (EI) *m/z* calculated for $C_{13}H_{20}O_2$ (M+) = 208.1463, found: 208.1433



(4R,5S)-4-acetyl-3,3,5-trimethyl-5-(4-methylpent-3-en-1-yl)cyclohexanone

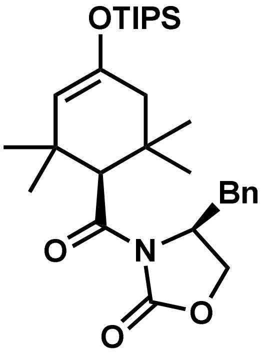
Following general procedure B for Diels-Alder reaction gave (4R,5S)-4-acetyl-3,3,5-trimethyl-5-(4-methylpent-3-en-1-yl)cyclohexanone as yellow oil (148 mg, 47% yield).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 5.01 (t, J = 7.0 Hz, 1 H), 2.90 (s, 1 H), 2.51 (dd, J = 8.3, 12.2 Hz, 2 H), 2.29 (s, 3 H), 2.12 (dd, J = 3.4, 12.8 Hz, 2 H), 1.98 - 1.91 (m, 2 H), 1.66 (s, 3 H), 1.58 (s, 3 H), 1.50 - 1.41 (m, 1 H), 1.34 - 1.24 (m, 1 H), 1.12 (s, 3 H), 1.06 (s, 3 H), 1.06 (s, 3 H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 212.5, 211.0, 132.2, 123.6, 62.6, 53.9, 51.9, 43.7, 41.9, 39.0, 37.1, 32.1, 26.9, 25.8, 23.5, 22.6, 17.8

IR (FTIR, cm^{-1}) = 2954, 2860, 2358, 2329, 1701, 1683, 1662, 1456, 1355, 1284, 1151, 916

HRMS (EI) *m/z* calculated for $C_{17}H_{28}O_2$ (M+) = 264.2089, found: 264.2098



(S)-4-benzyl-3-((R)-2,2,6,6-tetramethyl-4-((triisopropylsilyl)oxy)cyclohex-3-enecarbonyl)oxazolidin-2-one

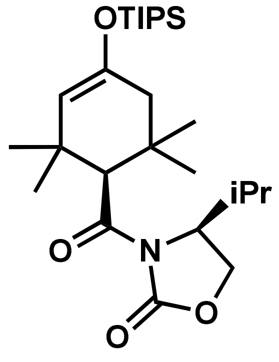
Following general procedure A for Diels-Alder reaction gave (S)-4-benzyl-3-((R)-2,2,6,6-tetramethyl-4-((triisopropylsilyl)oxy)cyclohex-3-enecarbonyl)oxazolidin-2-one as white solid (452 mg, 76% yield, mixture of diastereomers 9:1).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 7.37 - 7.24 (m, 5 H), 4.79 - 4.66 (m, 1 H), 4.58 (d, *J* = 4.4 Hz, 1 H), 4.15 - 4.04 (m, 3 H), 3.43 (ddd, *J* = 3.5, 7.2, 13.0 Hz, 1 H), 2.60 (ddd, *J* = 6.8, 10.7, 13.0 Hz, 1 H), 2.06 - 1.97 (m, 2 H), 1.19 - 0.98 (m, 33 H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 174.3, 174.2, 153.7, 153.7, 147.7, 147.6, 135.8, 135.8, 129.6, 129.5, 129.1, 129.1, 127.4, 112.7, 112.6, 65.6, 65.5, 56.2, 55.9, 52.9, 52.7, 44.6, 44.3, 38.6, 38.1, 36.2, 36.0, 35.4, 35.1, 32.7, 32.5, 31.7, 30.2, 30.0, 27.5, 27.2, 25.4, 25.1, 22.8, 20.9, 18.2, 17.9, 14.3, 12.8, 12.4

IR (FTIR, cm^{-1}) = 2941, 2864, 1772, 1695, 1652, 1379, 1348, 1209, 1145, 1093, 881

HRMS (EI) *m/z* calculated for $C_{30}H_{47}NO_4Si$ (M+) = 513.3274, found: 513.3252



(S)-4-isopropyl-3-((R)-2,2,6,6-tetramethyl-4-((triisopropylsilyl)oxy)cyclohex-3-enecarbonyl)oxazolidin-2-one

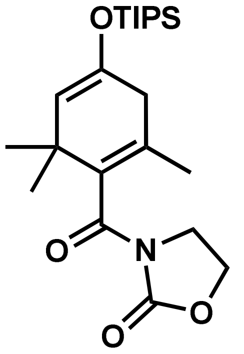
Following general procedure A for Diels-Alder reaction gave (S)-4-isopropyl-3-((R)-2,2,6,6-tetramethyl-4-((triisopropylsilyl)oxy)cyclohex-3-enecarbonyl)oxazolidin-2-one as white solid (483 mg, 73% yield, mixture of diastereomers 7:3).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 4.56 - 4.42 (m, 2 H), 4.20 - 4.12 (m, 2 H), 4.09 (d, *J* = 13.0 Hz, 1 H), 2.45 - 2.28 (m, 1 H), 2.01 - 1.90 (m, 2 H), 1.07 - 1.01 (m, 40 H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 174.2, 174.1, 154.3, 154.3, 147.7, 147.6, 112.7, 112.5, 62.6, 62.4, 59.1, 58.9, 52.6, 52.5, 44.4, 44.3, 36.1, 35.9, 35.3, 35.1, 32.6, 32.6, 30.0, 30.0, 28.8, 28.4, 27.4, 27.2, 25.3, 25.2, 18.2, 17.8, 12.8, 12.4

IR (FTIR, cm^{-1}) = 2945, 2893, 2368, 1772, 1697, 1652, 1456, 1363, 1191, 995, 883

HRMS (EI) *m/z* calculated for $C_{26}H_{47}NO_4Si$ (M+) = 465.3274, found: 465.3309.



3-(2,6,6-trimethyl-4-((triisopropylsilyl)oxy)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one

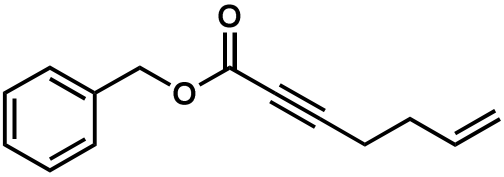
Following general procedure A for Diels-Alder reaction gave 3-(2,6,6-trimethyl-4-((triisopropylsilyl)oxy)cyclohexa-1,4-dienecarbonyl)oxazolidin-2-one as white solid (431 mg, 81% yield).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 4.68 (dd, *J* = 1.3, 1.3 Hz, 1 H), 4.37 (dd, *J* = 7.9, 7.9 Hz, 2 H), 4.08 (dd, *J* = 8.4, 8.4 Hz, 2 H), 2.66 (s, 2 H), 1.60 (s, 3 H), 1.09 - 1.07 (m, 14 H), 1.06 (br. s., 13 H)

^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 171.0, 156.2, 152.4, 132.0, 125.5, 104.3, 61.6, 44.8, 42.6, 36.7, 26.5, 19.7, 18.1, 12.8

IR (FTIR, cm^{-1}) = 2943, 2893, 1782, 1679, 1652, 1593, 1458, 1163, 881

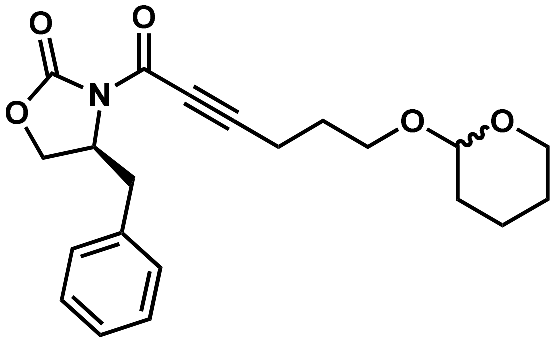
HRMS (EI) *m/z* calculated for $C_{22}H_{37}NO_4Si$ (M+) = 407.2492, found: 407.2478.



benzyl hept-6-en-2-ynoate

A dry 250 mL round bottom flask fitted with a magnetic stirrer was charged with diethyl ether (40 mL) under argon, 3-bromoprop-1-yne (2.97 g, 20 mmol, 1 eq.), allylmagnesium bromide (40 mL, 40 mmol, 1M, 2 eq.) with stirring. The reaction was allowed to stir for 2 hours at 0°C. Then benzyl carbonochloridate (13.7 g, 80 mmol, 4 eq.) in 10 mL of diethyl ether was added dropwise. The reaction was quenched with NH_4Cl, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil was subjected to flash chromatography (0-10% EtOAc in hexanes) to give benzyl hept-6-en-2-ynoate as colorless oil (2.44 g, 57% yield).

^{1}H NMR ($CDCl_3$, 300 MHz) δ_{ppm} = 7.39 - 7.36 (m, 5 H), 5.83 (tdd, *J* = 6.5, 10.3, 17.0 Hz, 1 H), 5.19 (s, 2 H), 5.13 - 5.03 (m, 2 H), 2.47 - 2.37 (m, 2 H), 2.37 - 2.26 (m, 2 H)



(4S)-4-benzyl-3-(6-((tetrahydro-2H-pyran-2-yl)oxy)hex-2-ynoyl)oxazolidin-2-one

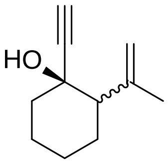
A dry 10 mL round bottom flask fitted with a magnetic stirrer was charged with THF (3 mL) under argon, 2-(pent-4-yn-1-yloxy)tetrahydro-2H-pyran (60 mg, 0.34 mmol, 1 eq.), n-butyl lithium (0.23 mL, 0.41 mmol, 1.8 M, 1.2 eq.) with stirring.. The reaction was allowed to stir for 2 hours at -78°C. Then (S)-4-benzyl-2-oxooxazolidine-3-carbonyl chloride (122 mg, 0.51 mmol, 1.5 eq.) in 2 mL of THF was added dropwise. After completion, the reaction was quenched with NH_4Cl, washed with brine, and dried over $MgSO_4$ and filtered. After evaporation, the crude oil was subjected to flash chromatography (0-10% EtOAc in hexanes) to give (4S)-4-benzyl-3-(6-((tetrahydro-2H-pyran-2-yl)oxy)hex-2-ynoyl)oxazolidin-2-one as yellow oil (82 mg, 65% yield).

^{1}H NMR ($CDCl_3$, 400 MHz) δ_{ppm} = 7.37 - 7.31 (m, 5 H), 7.25 - 7.19 (m, 5 H), 4.74 - 4.63 (m, 3 H), 4.63 - 4.57 (m, 1 H), 4.31 - 4.24 (m, 1 H), 4.22 - 4.09 (m, 6 H), 3.89 - 3.82 (m, 3 H), 3.58 - 3.43 (m, 5 H), 3.33 (dd, *J* = 3.3, 13.5 Hz, 2 H), 2.86 - 2.73 (m, 2 H), 2.60 (dt, *J* = 3.7, 7.1 Hz, 2 H), 2.04 (s, 2 H), 1.99 - 1.89 (m, 2 H), 1.88 - 1.76 (m, 2 H), 1.75 - 1.66 (m, 2 H), 1.64 - 1.61 (m, 2 H), 1.60 - 1.48 (m, 5 H)

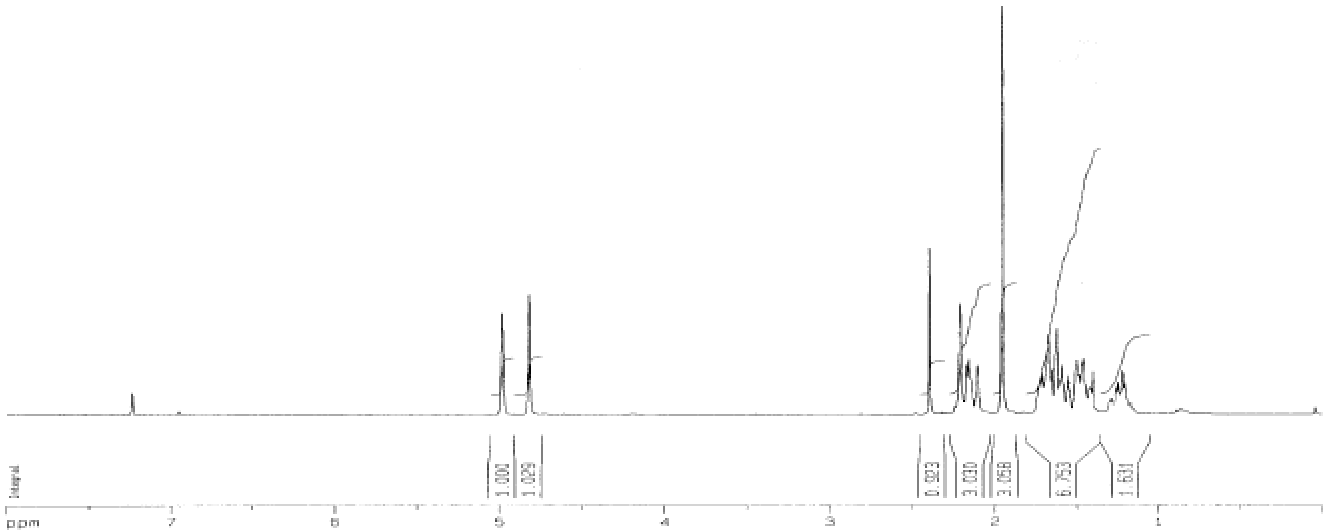
^{13}C NMR ($CDCl_3$, 100 MHz) δ_{ppm} = 152.2, 152.0, 150.8, 149.6, 135.1, 135.0, 129.5, 129.3, 129.1, 129.1, 127.6, 127.5, 99.0, 98.3, 73.8, 67.4, 66.0, 65.7, 62.4, 56.5, 55.2, 38.2, 37.7, 30.7, 27.9, 25.6, 19.6, 16.5

HRMS (EI) *m/z* calculated for $C_{21}H_{26}NO_5$ [(M+H)+] = 372.1811, found: 372.1816.

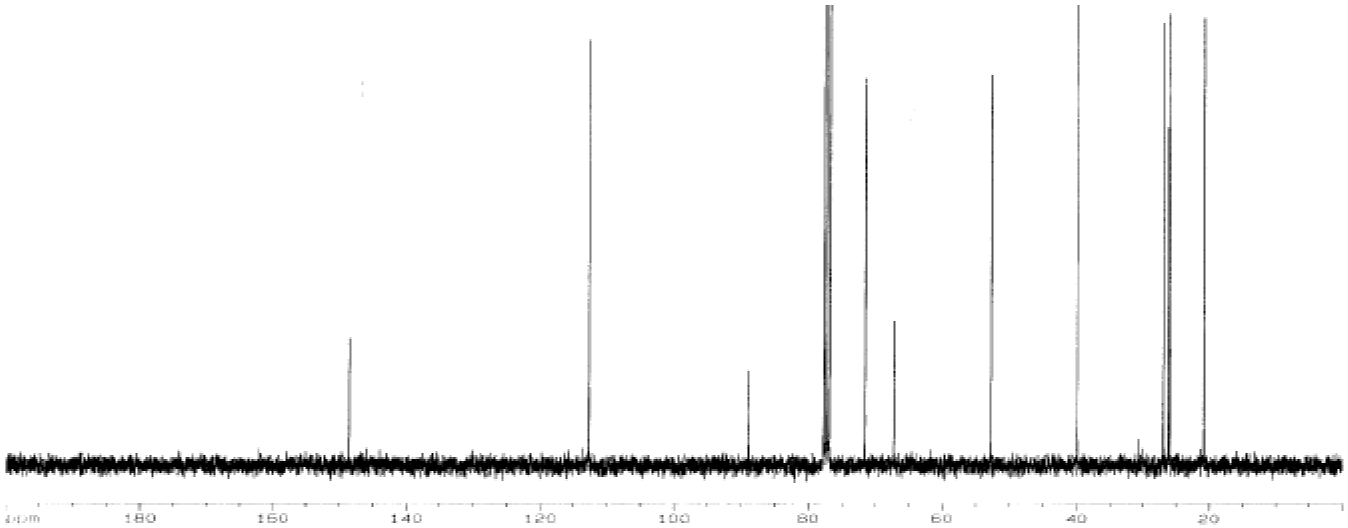
NMR Spectra

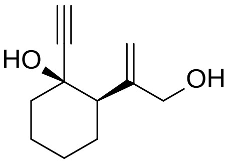


^{1}H NMR (CDCl$_3$, 300 MHz)

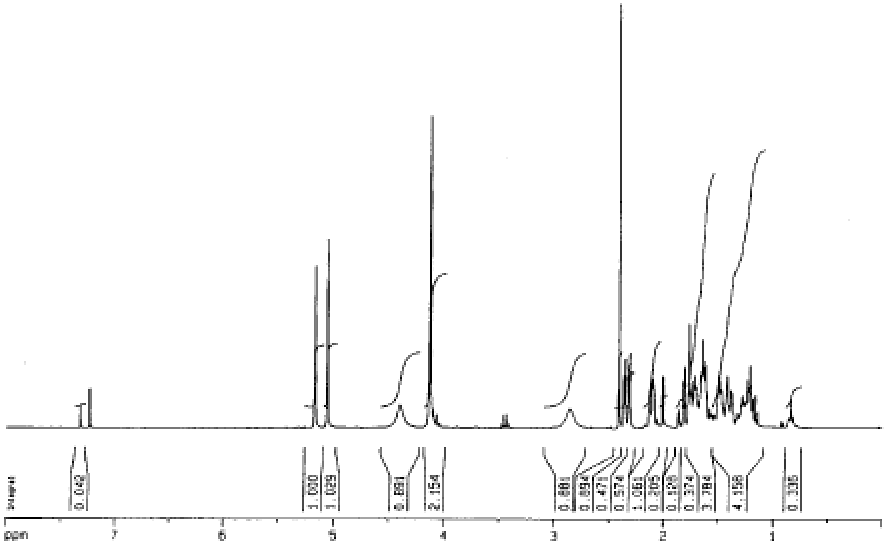


^{13}C NMR (CDCl$_3$, 75 MHz)

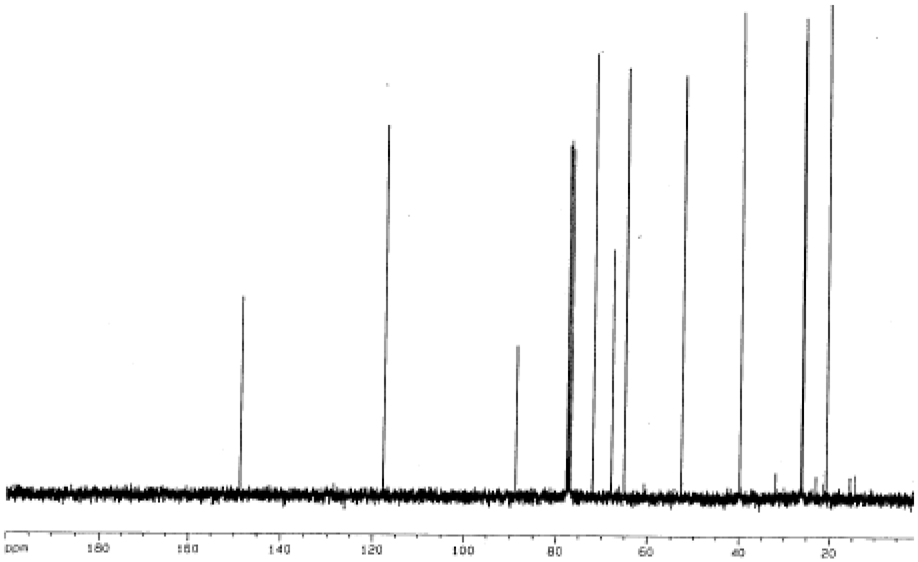


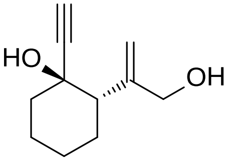


^{1}H NMR (CDCl$_3$, 300 MHz)

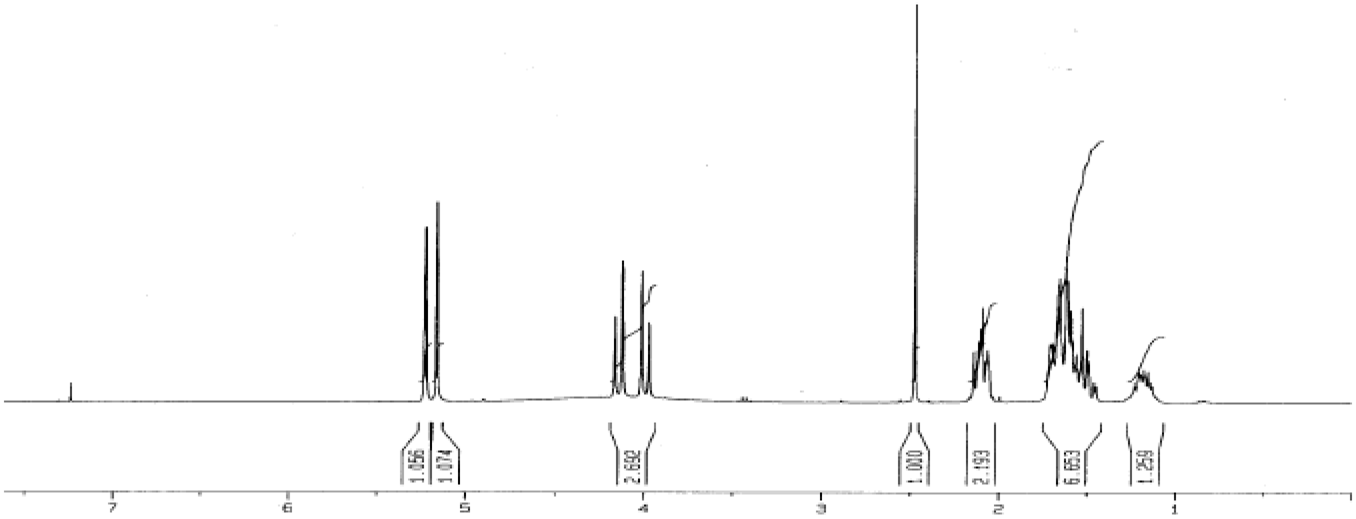


^{13}C NMR (CDCl$_3$, 75 MHz)

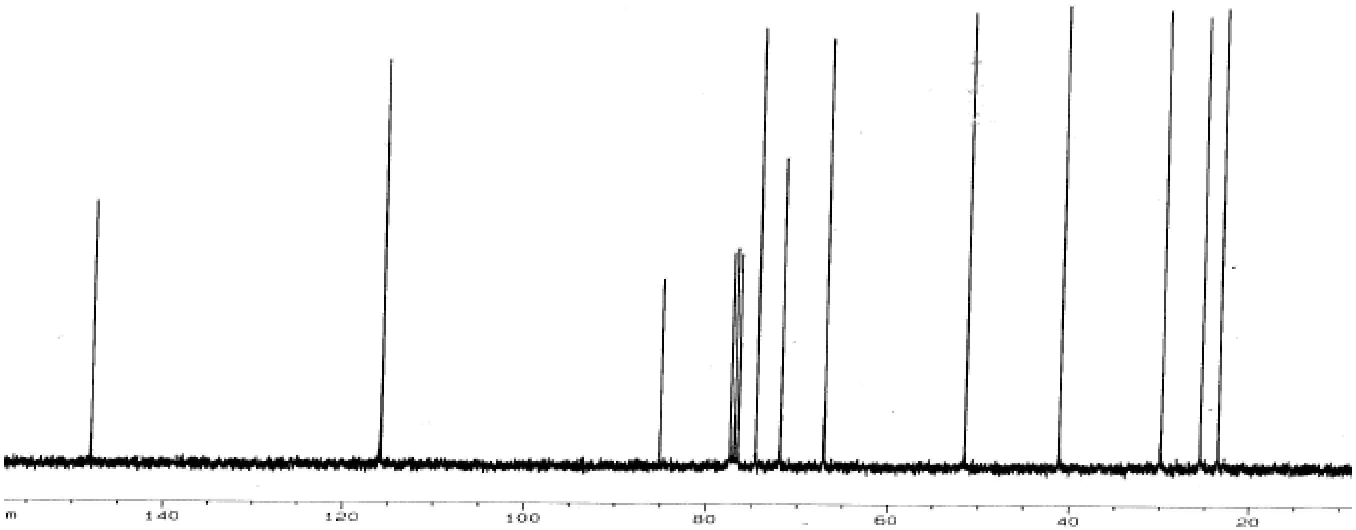


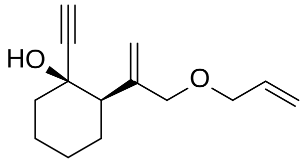


^{1}H NMR (CDCl$_3$, 300 MHz)

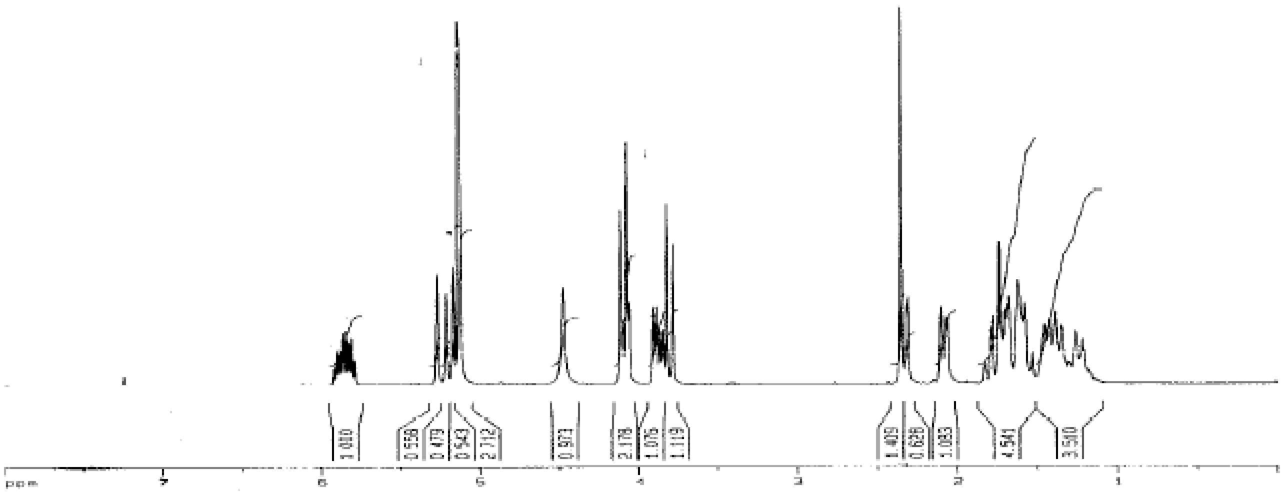


^{13}C NMR (CDCl$_3$, 75 MHz)

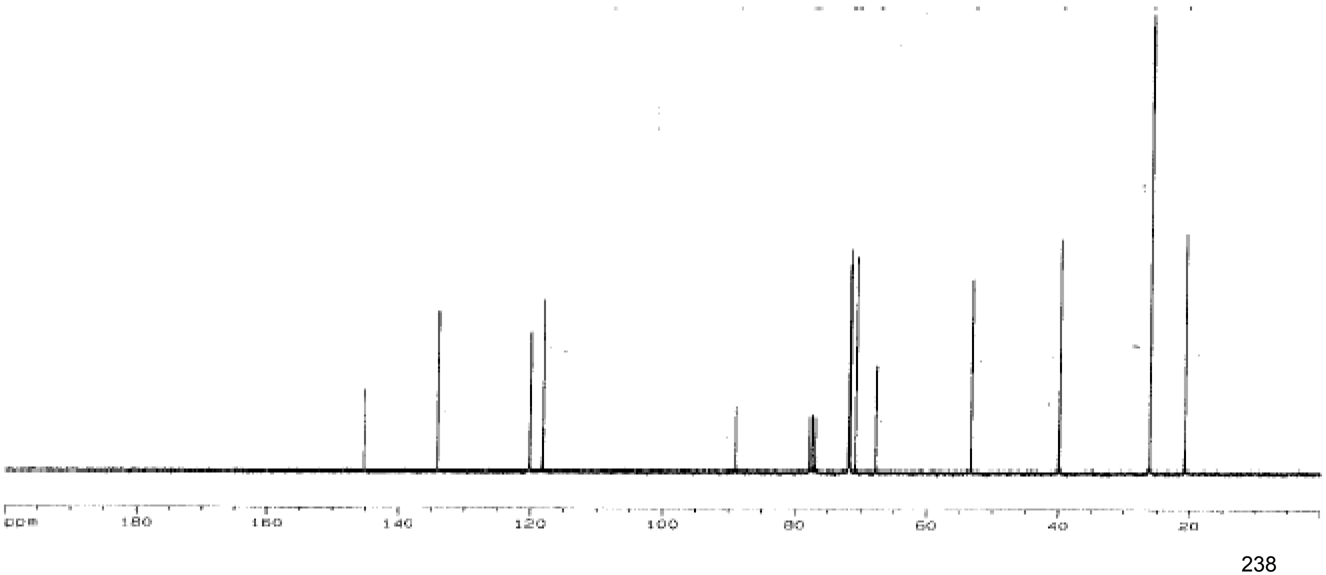


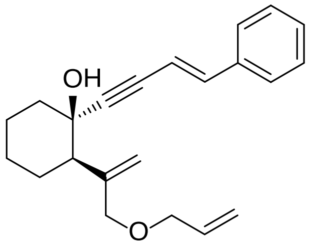


^{1}H NMR (CDCl$_3$, 300 MHz)



^{13}C NMR (CDCl$_3$, 75 MHz)

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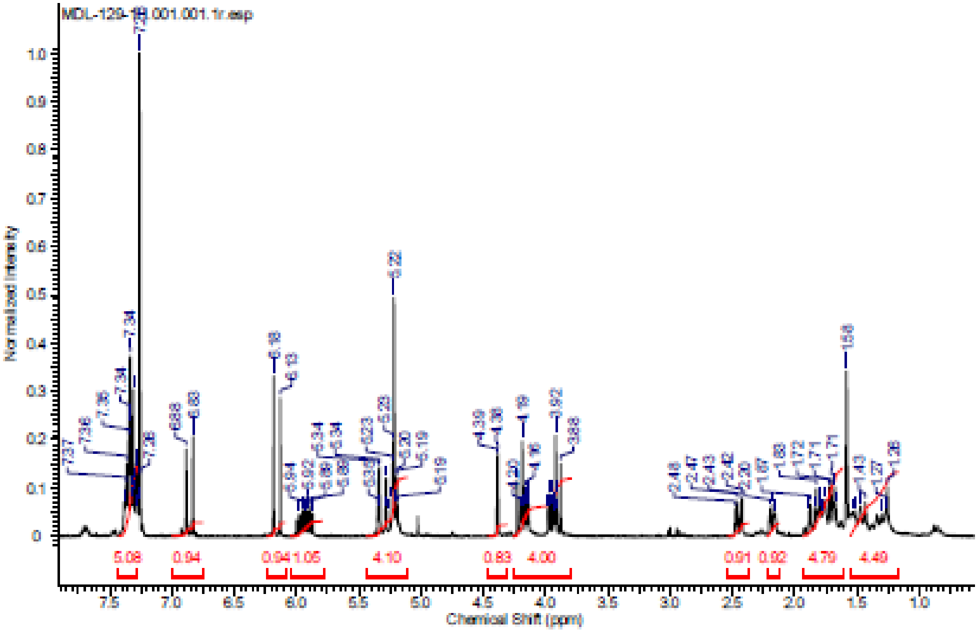
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5.88
5.34
5.34
5.33
5.23
5.23
5.22
5.20
5.19
5.19
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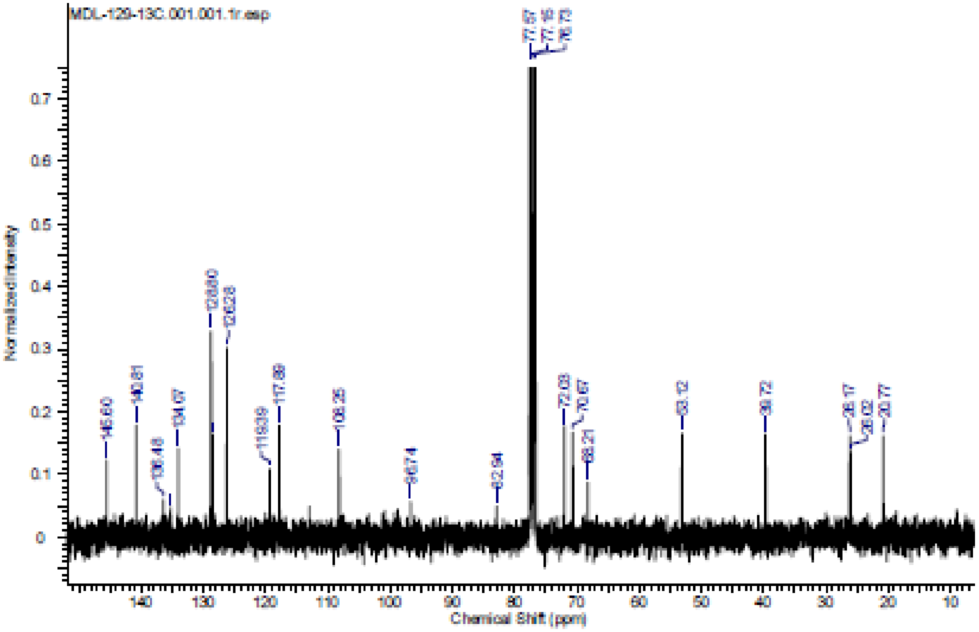
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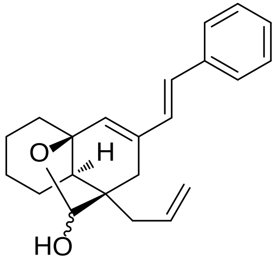
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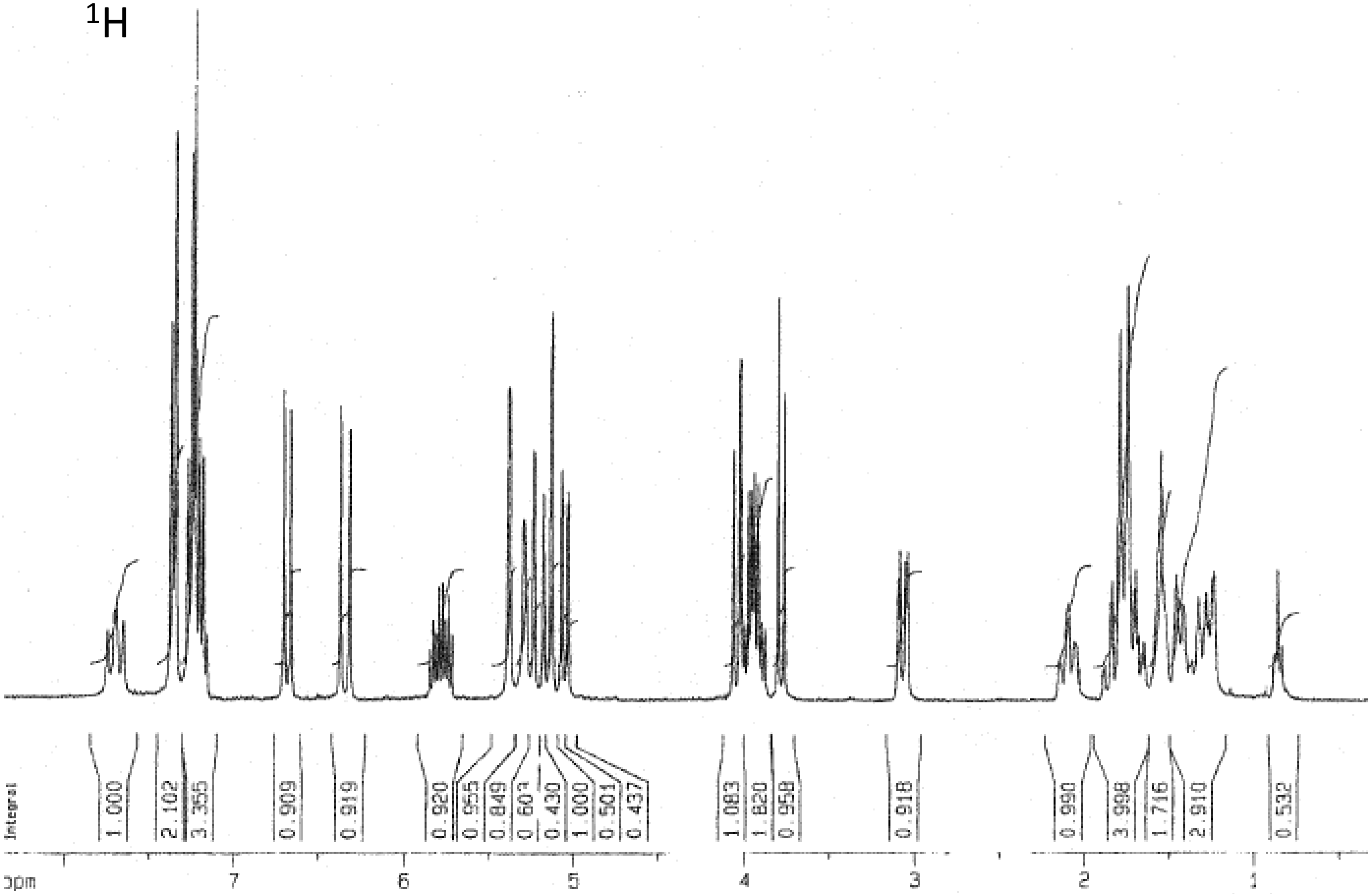
H
HO

^{1}H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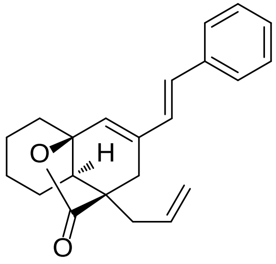
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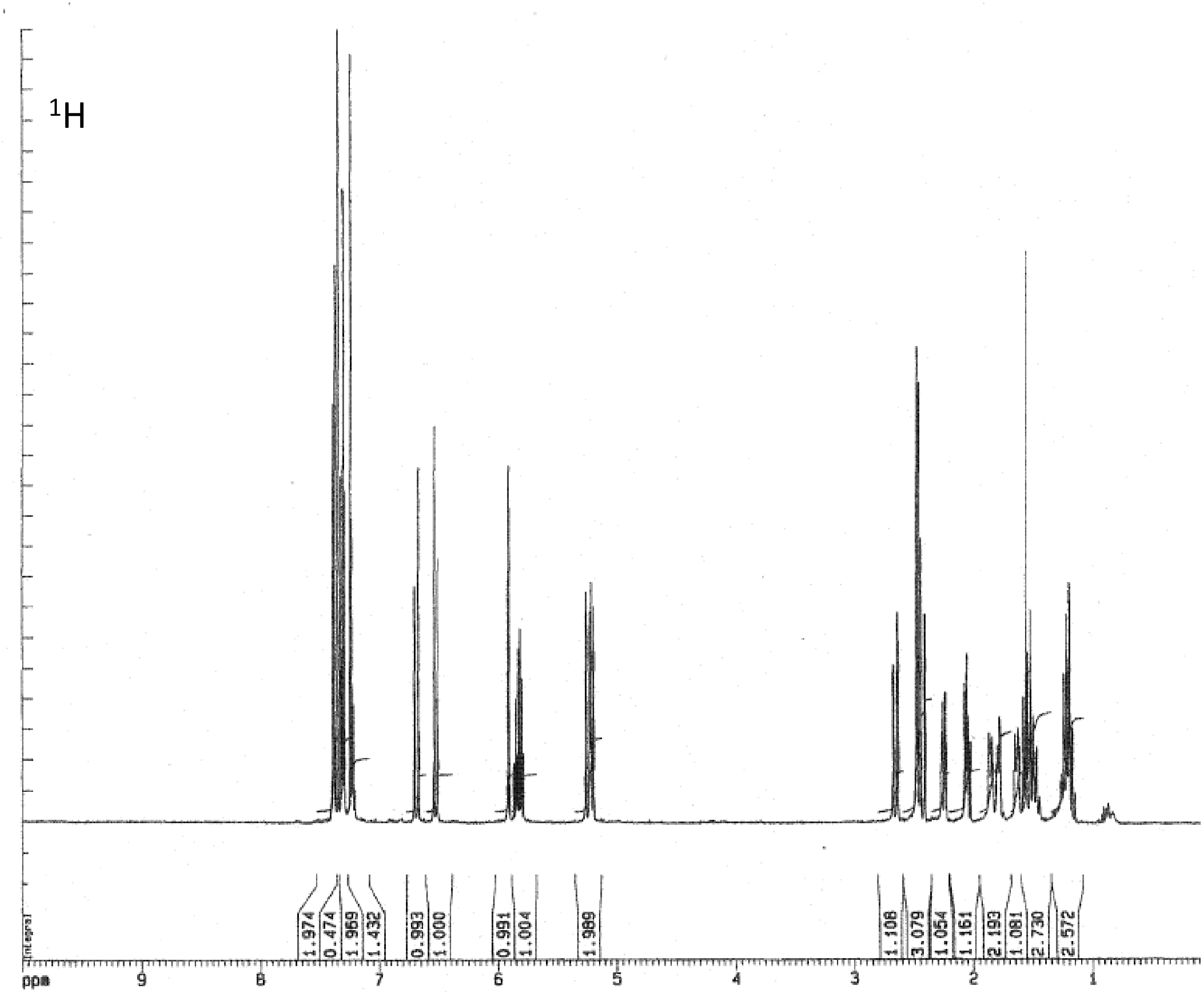
H
O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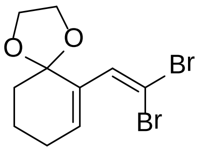

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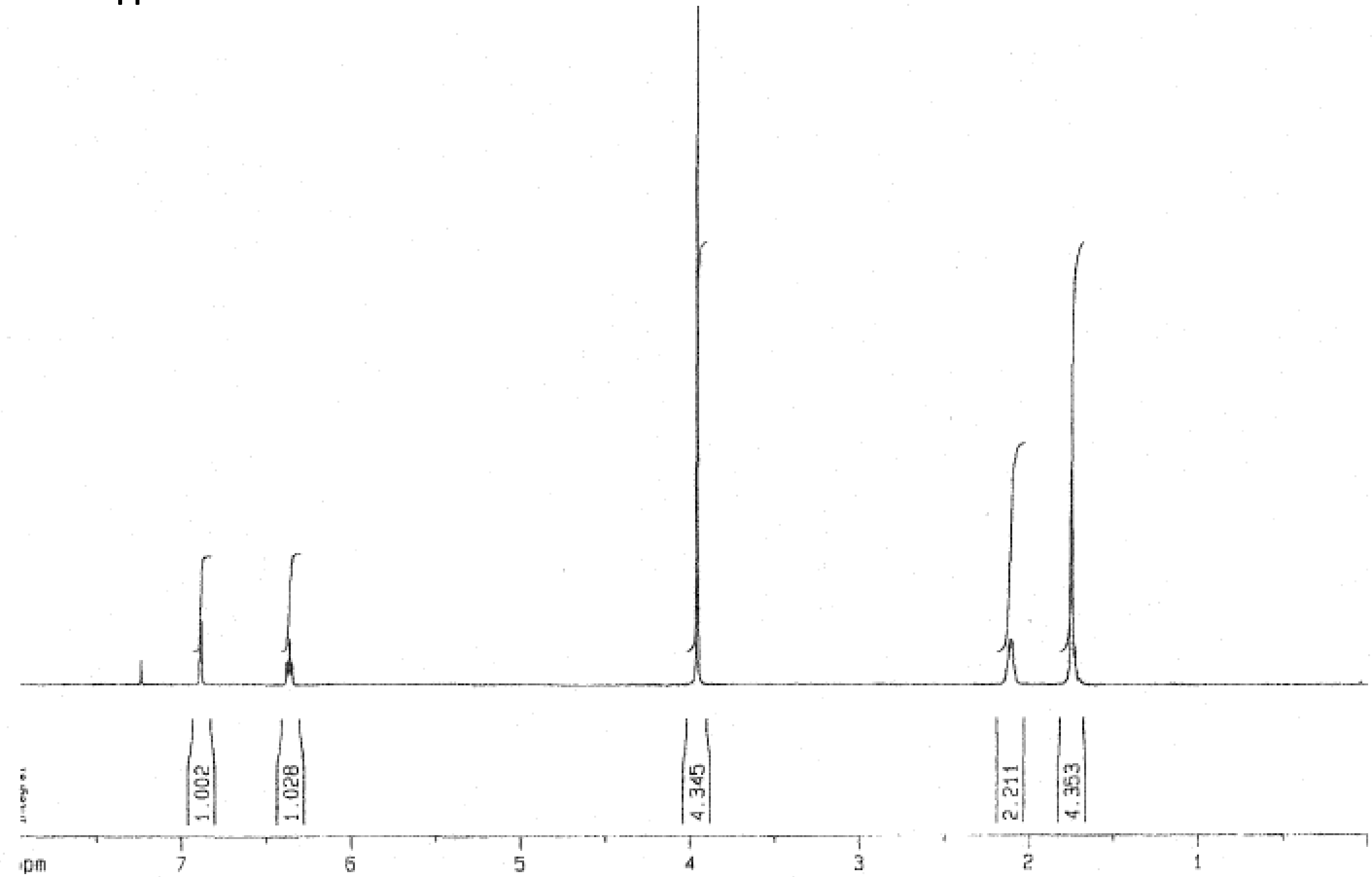

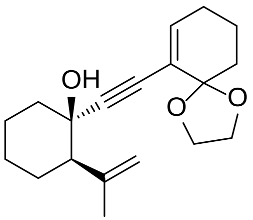
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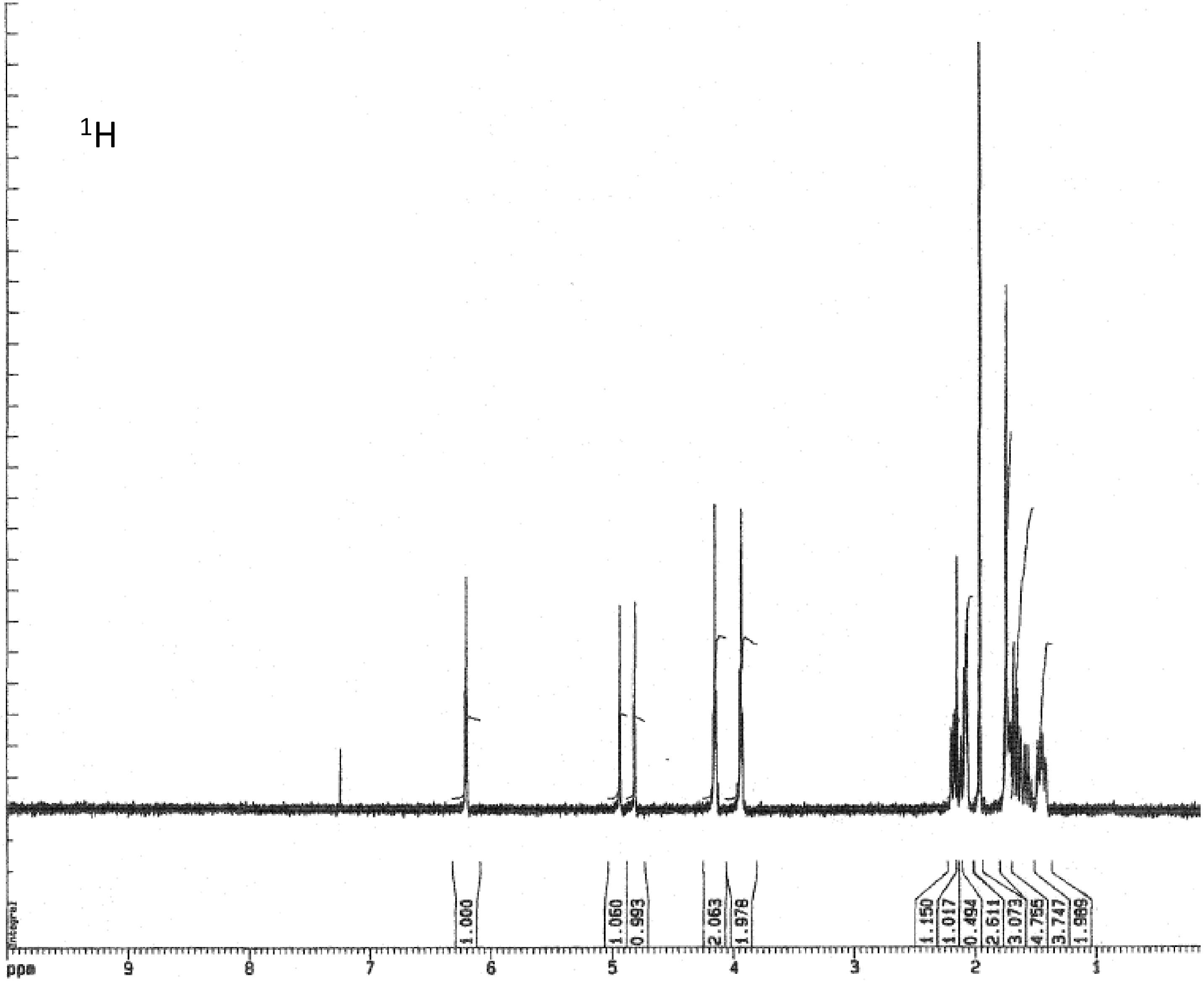
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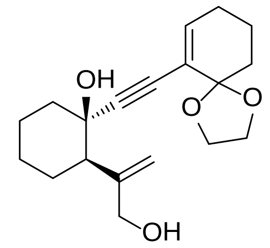
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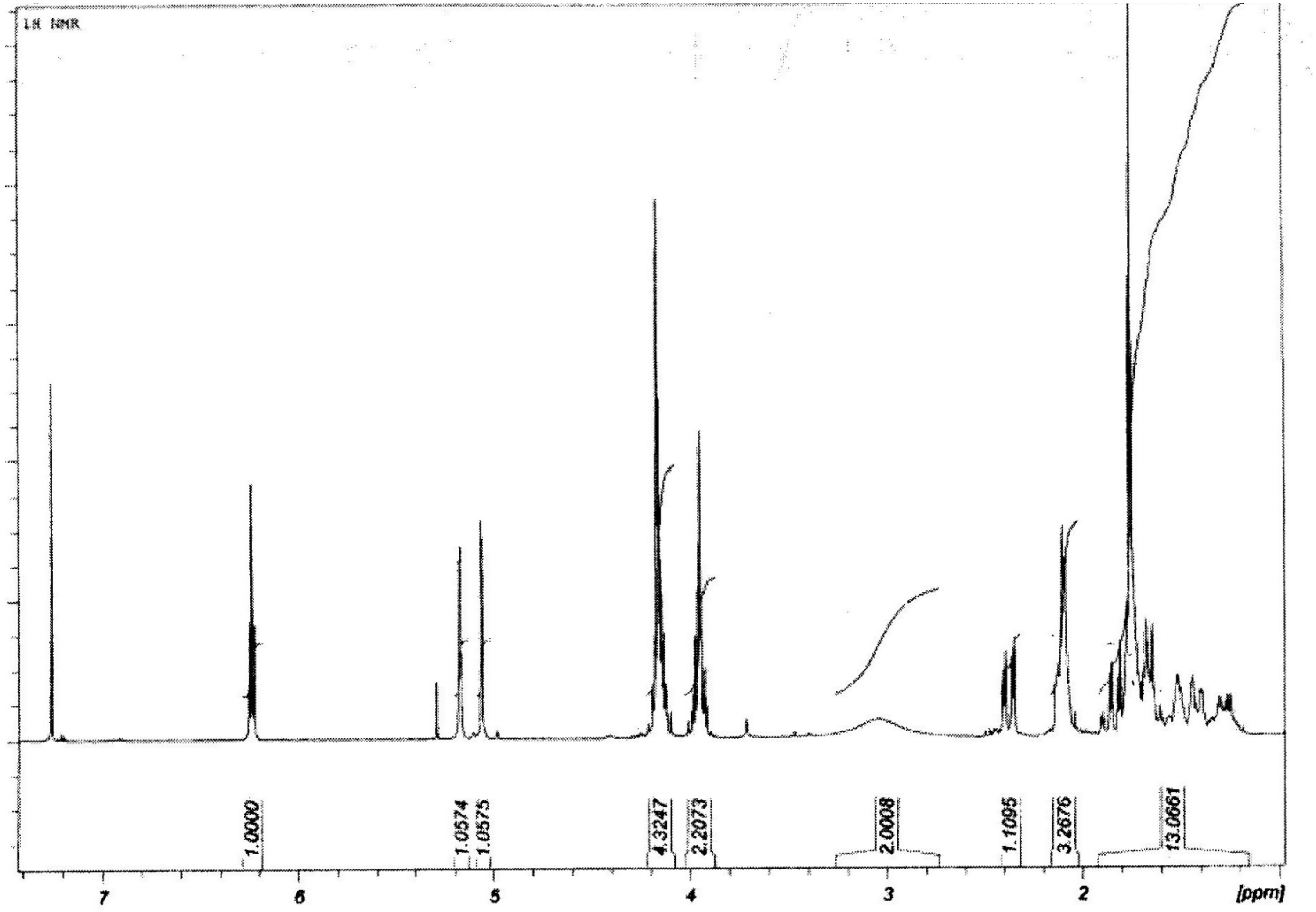
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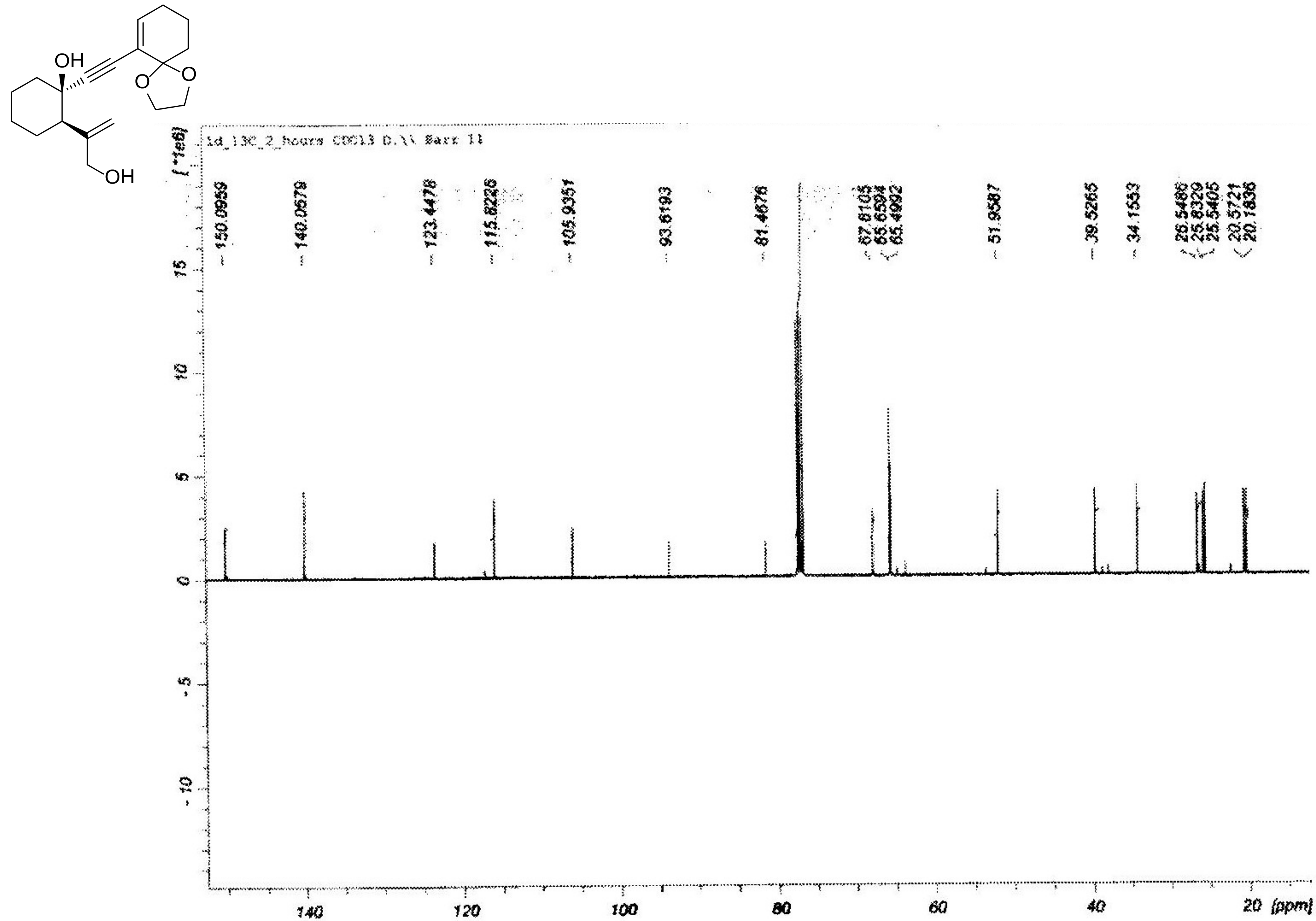
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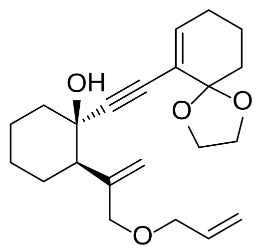

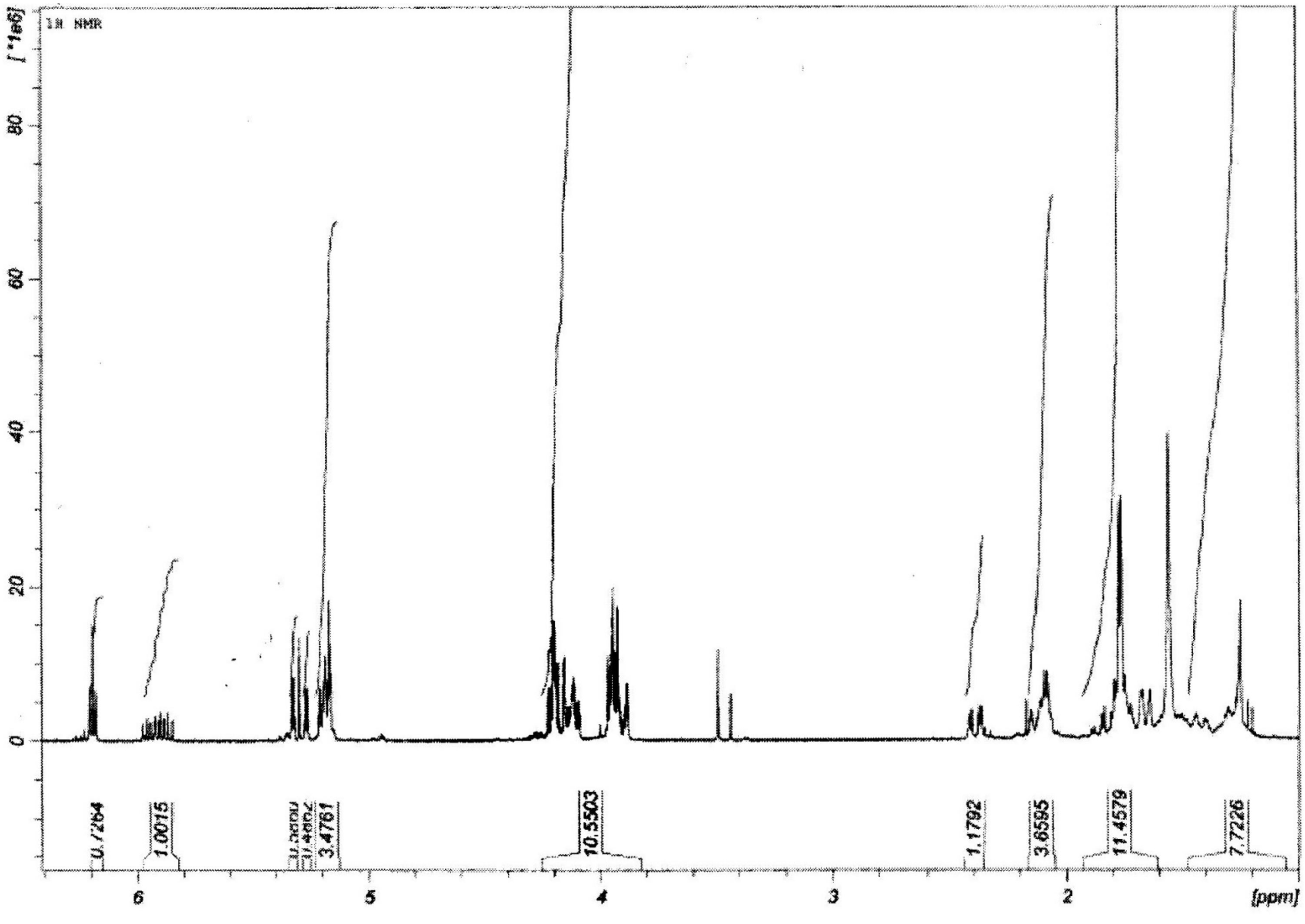
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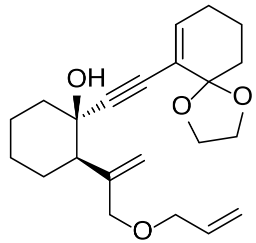
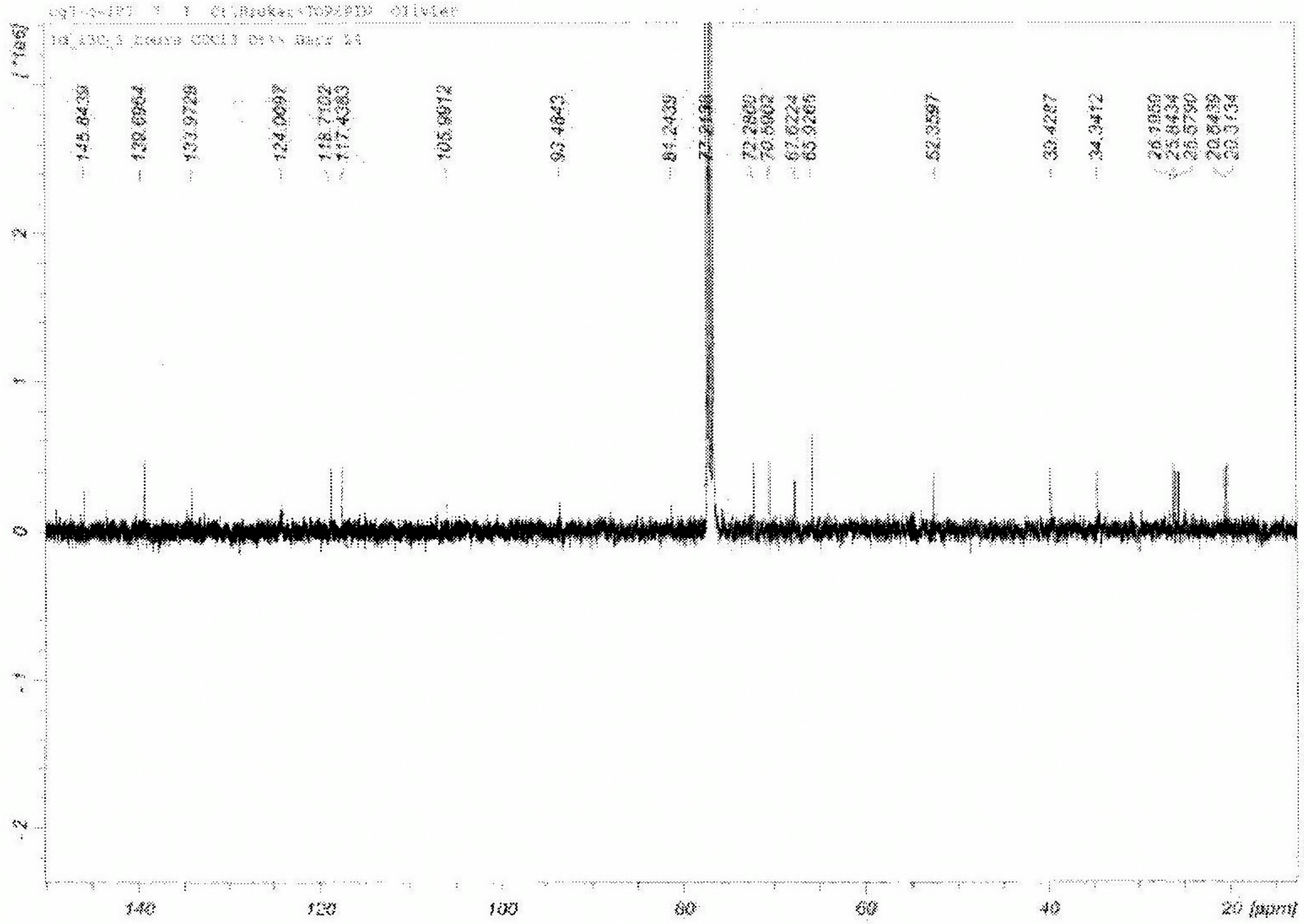
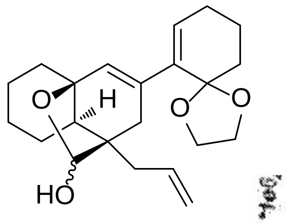
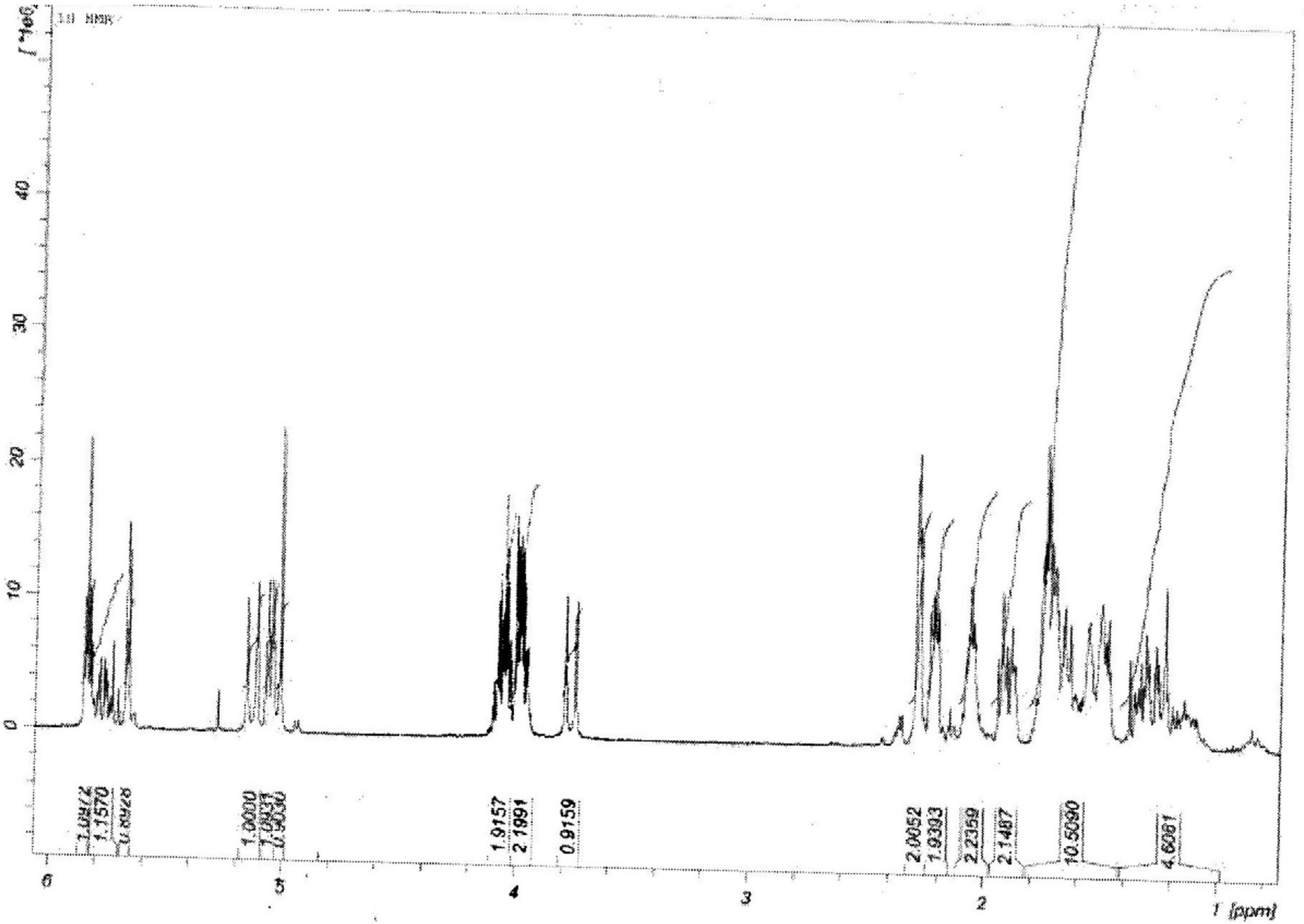
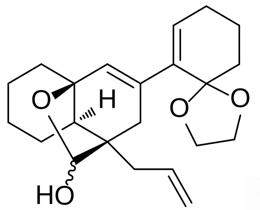
2
[ppm]

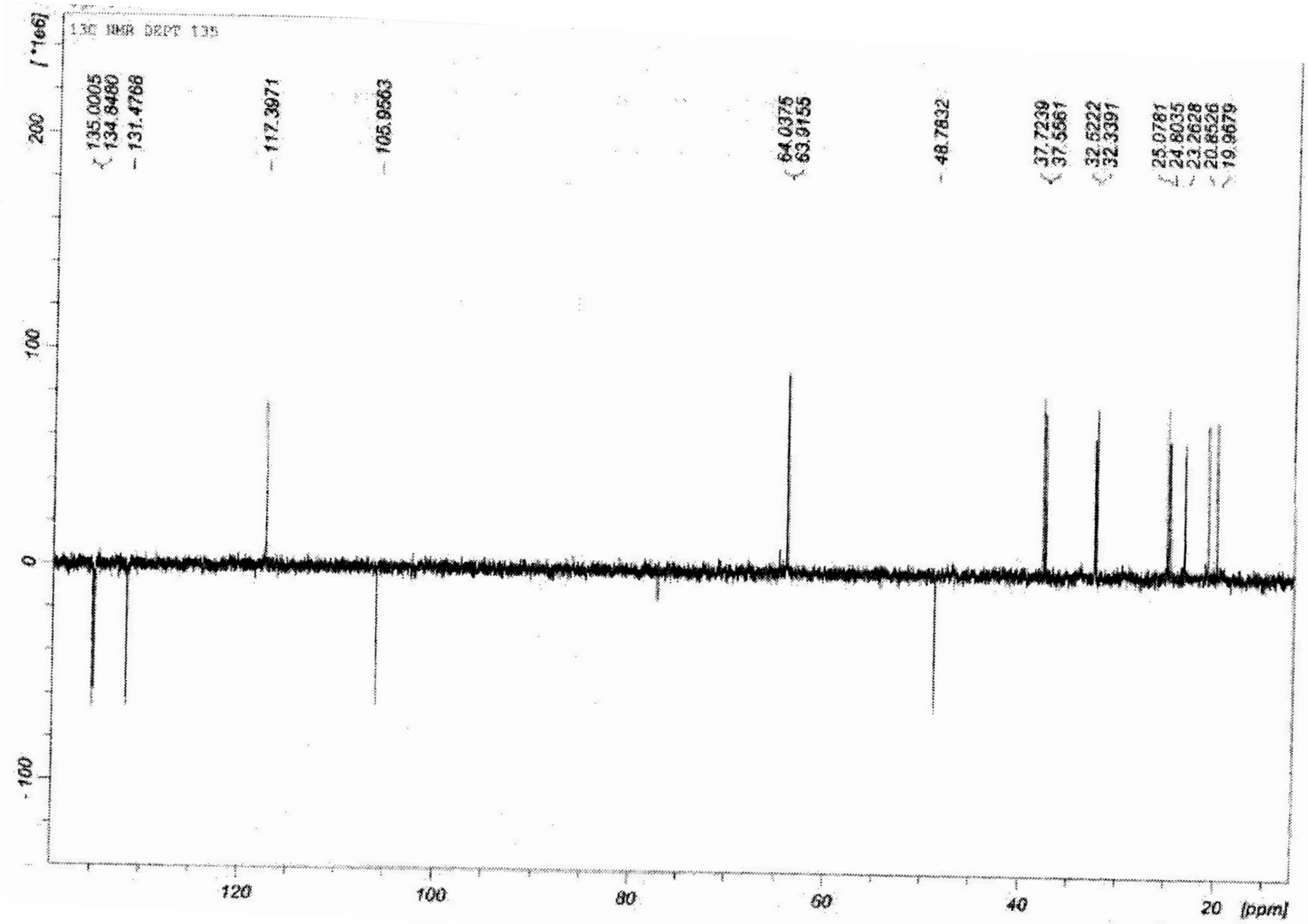


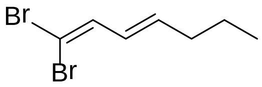

[*1e6]
145.8439
139.6864
133.9729
124.0097
118.7102
117.4383
105.9912
93.4843
81.2439
77.2138
72.2860
70.5902
67.6224
65.9266
52.3597
39.4287
34.3412
26.1959
25.8434
25.5790
20.8439
20.3134
2
1
0
-1
-2
140
120
100
80
60
40
20 [ppm]


O
H
O
O
HO

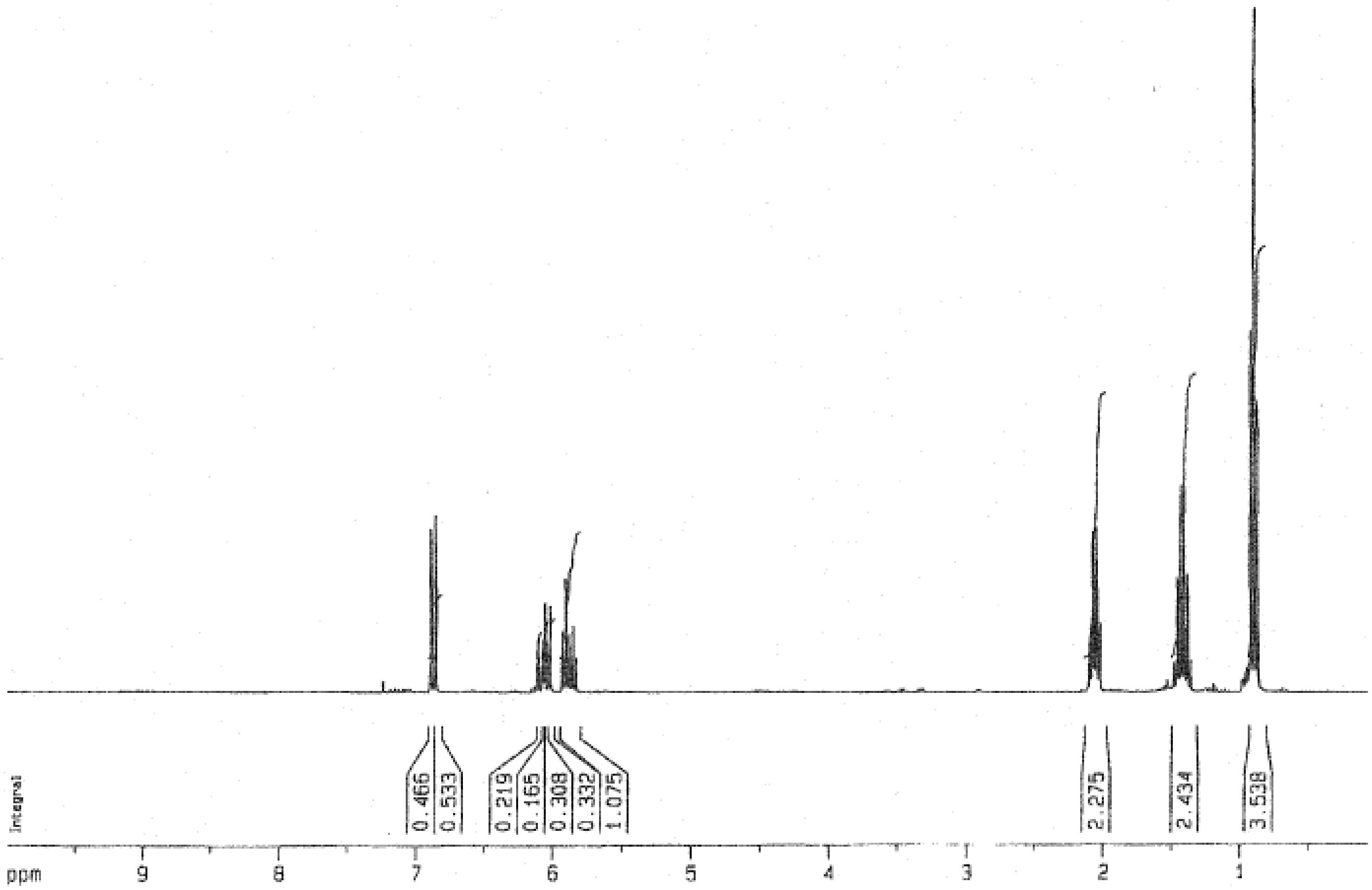

1H NMR
[*1e6]
0
10
20
30
40
1.0472
1.1570
0.8428
1.0000
1.0837
0.9030
1.9157
2.1991
0.9159
2.0052
1.9393
2.2359
2.1487
10.5090
4.6081
6
5
4
3
2
1 [ppm]

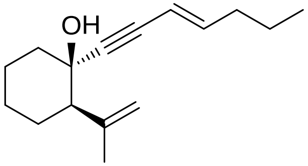

O
H
O
O
HO

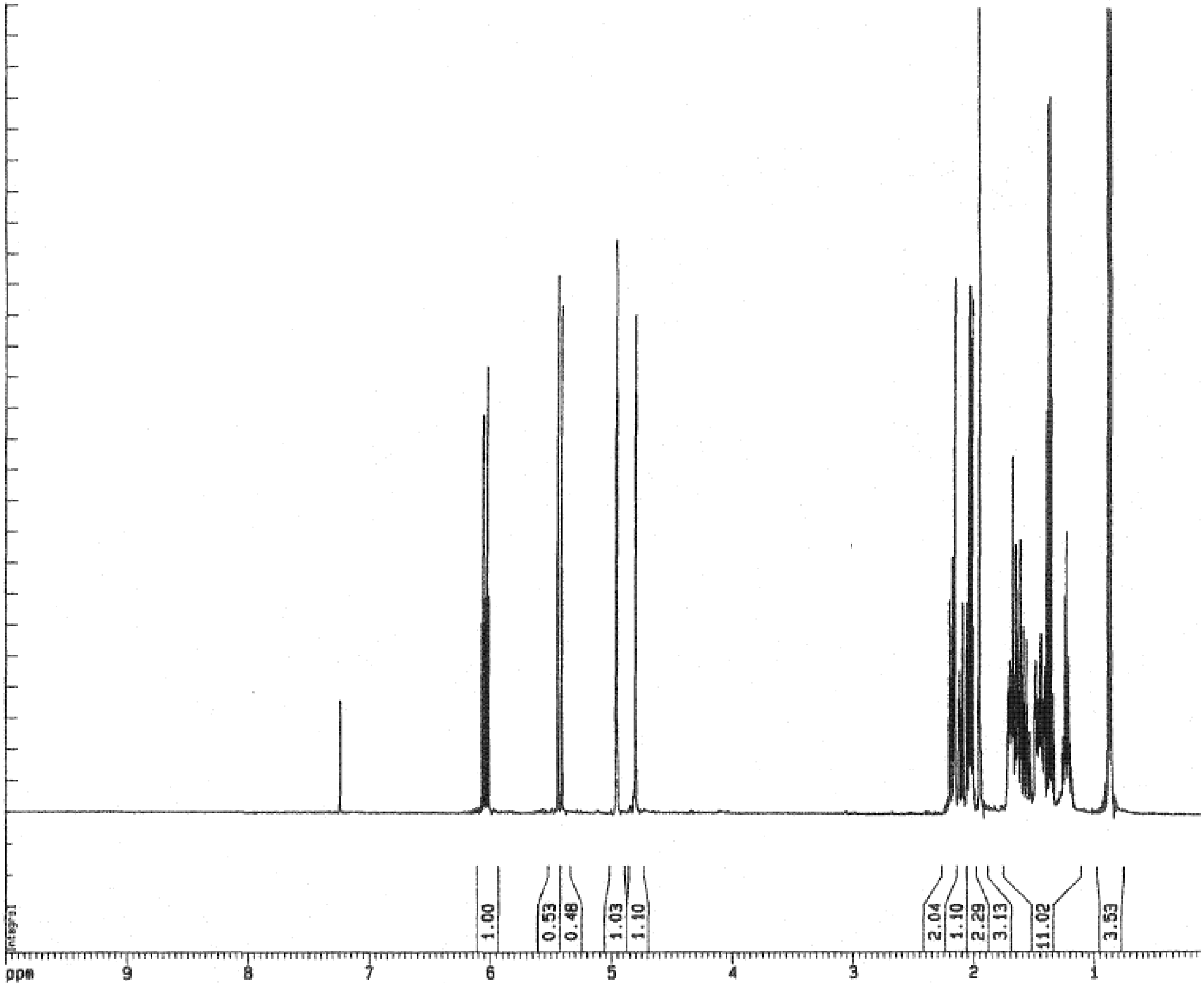

13C NMR DEPT 135
[*1e6]
200
100
0
-100
135.0005
134.8480
131.4768
117.3971
105.9563
64.0375
63.9155
48.7832
37.7239
37.5561
32.5222
32.3391
25.0781
24.8035
23.2628
20.8526
19.9679
120
100
80
60
40
20
[ppm]

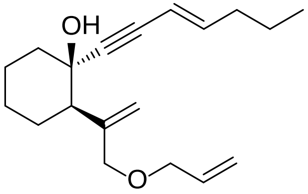

Br
Br

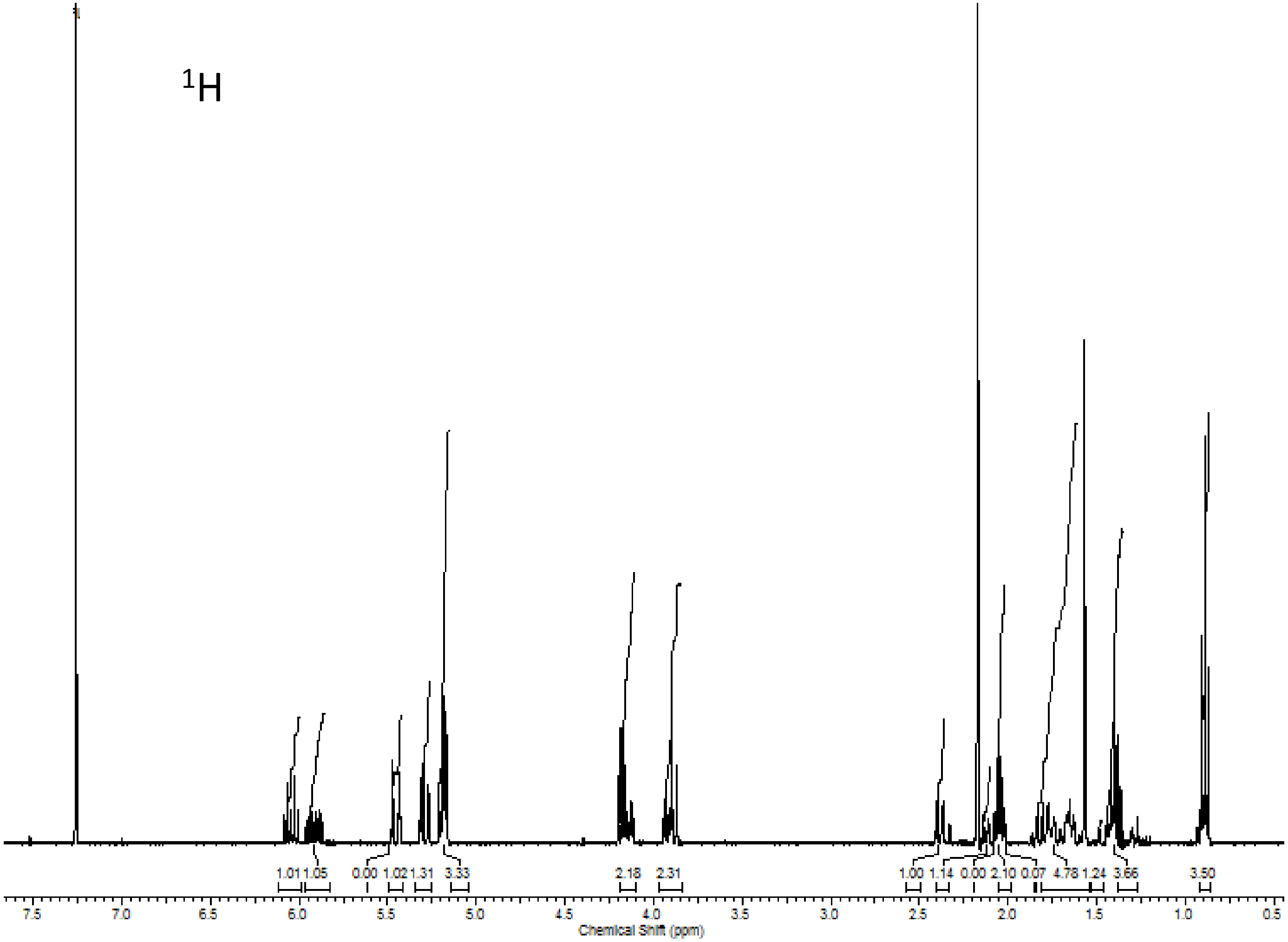
^{1}H

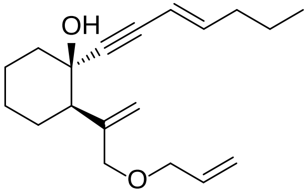

Integral
0.466
0.533
0.219
0.165
0.308
0.332
1.075
2.275
2.434
3.538
ppm
9
8
7
6
5
4
3
2
1


OH

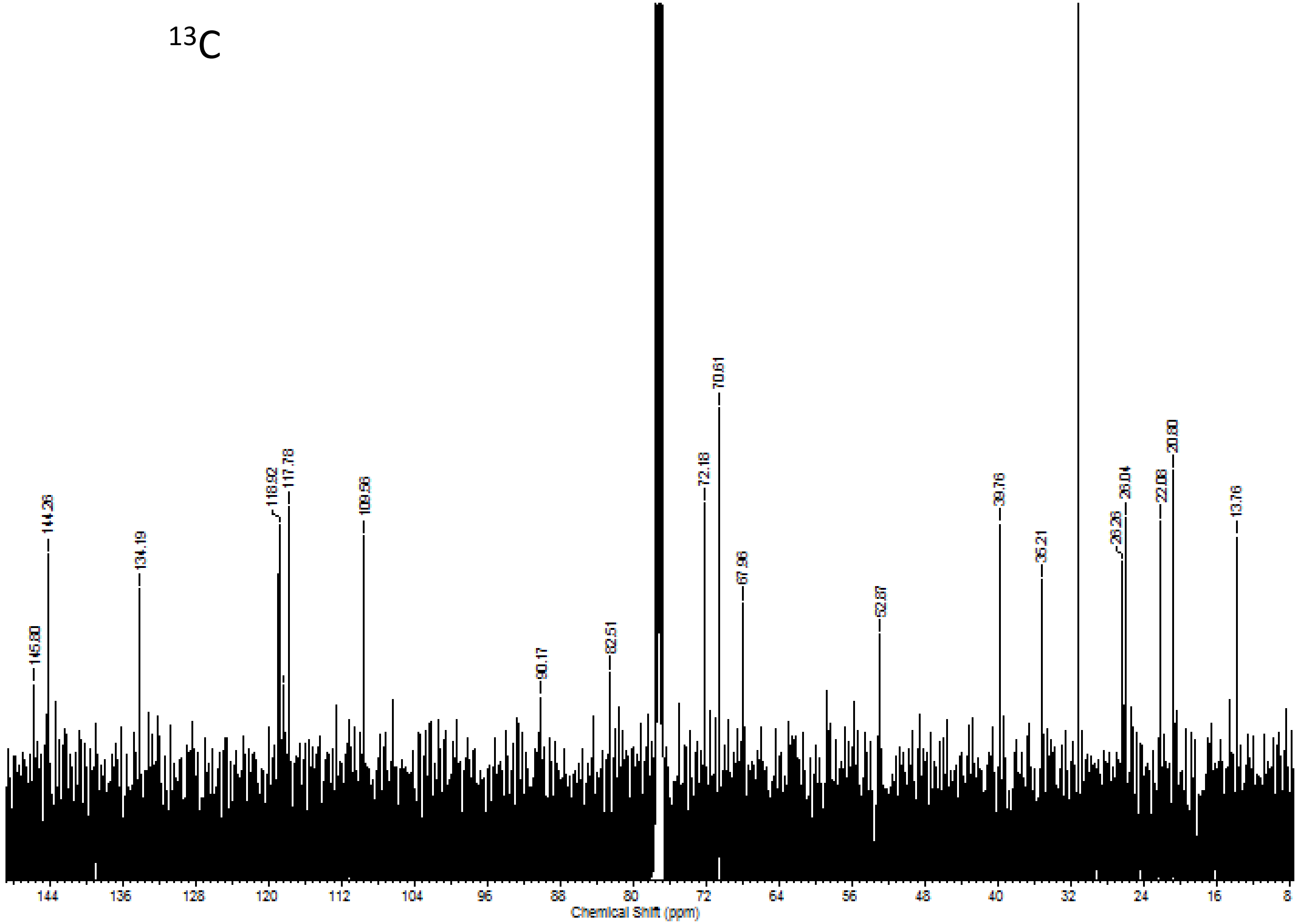

1.00
0.53
0.48
1.03
1.10
2.04
1.10
2.29
3.13
11.02
3.53
Integral
ppm
9
8
7
6
5
4
3
2
1

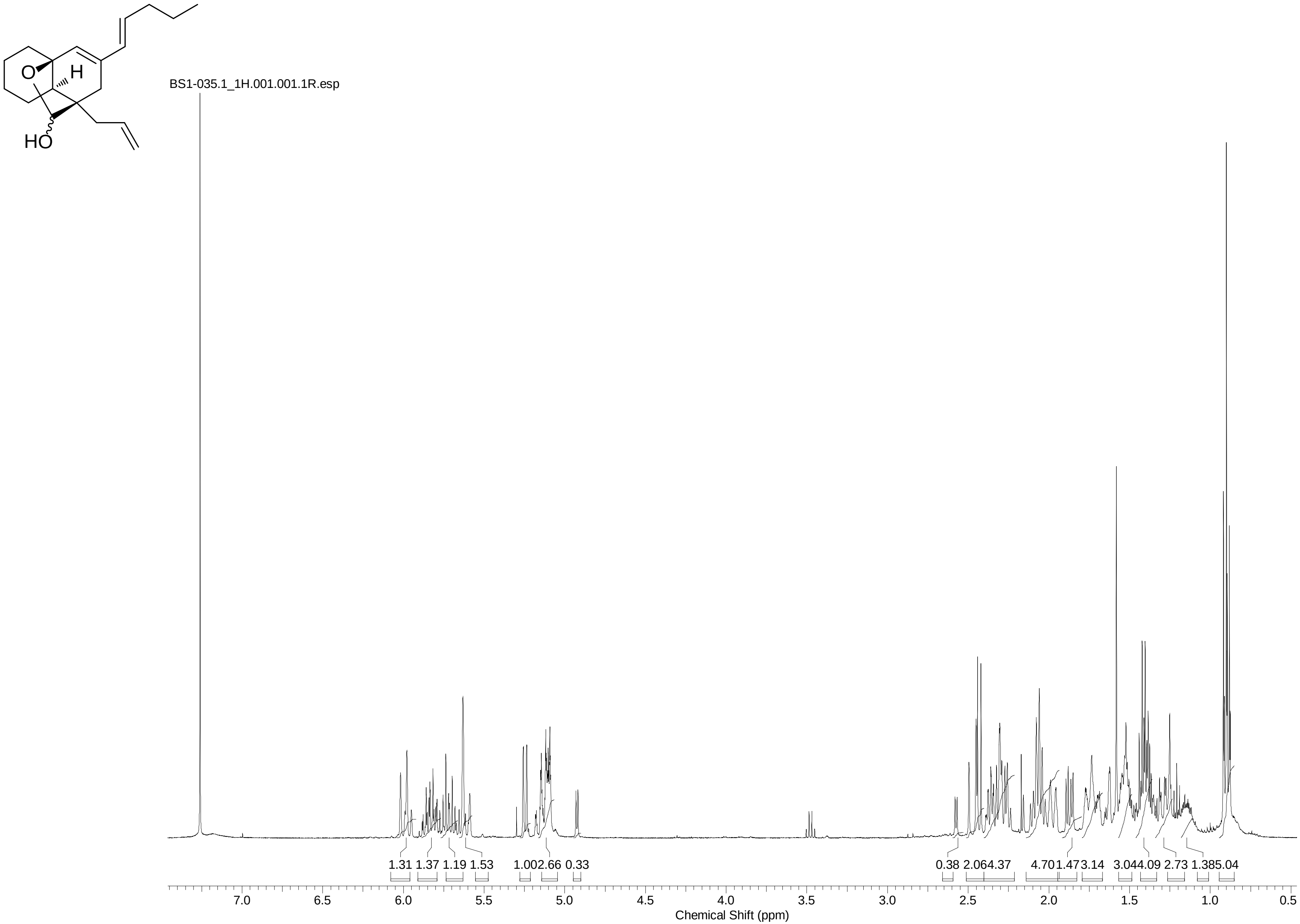

OH
O

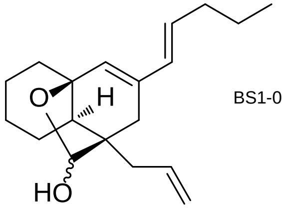

1H
1.01
1.05
0.00
1.02
1.31
3.33
2.18
2.31
1.00
1.14
0.00
2.10
0.07
4.78
1.24
3.66
3.50
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

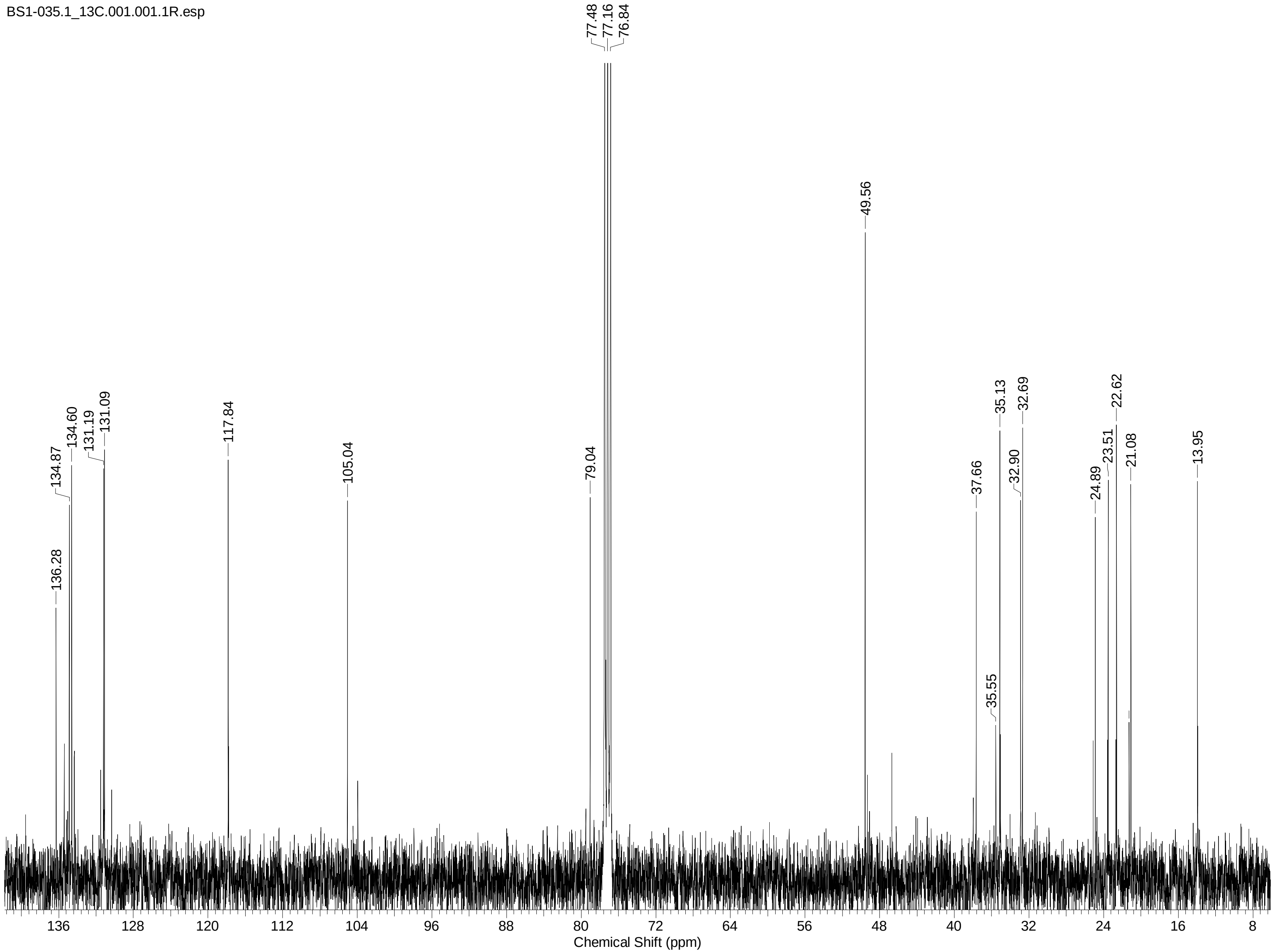

OH
O

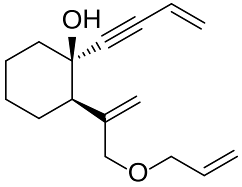
^{13}C

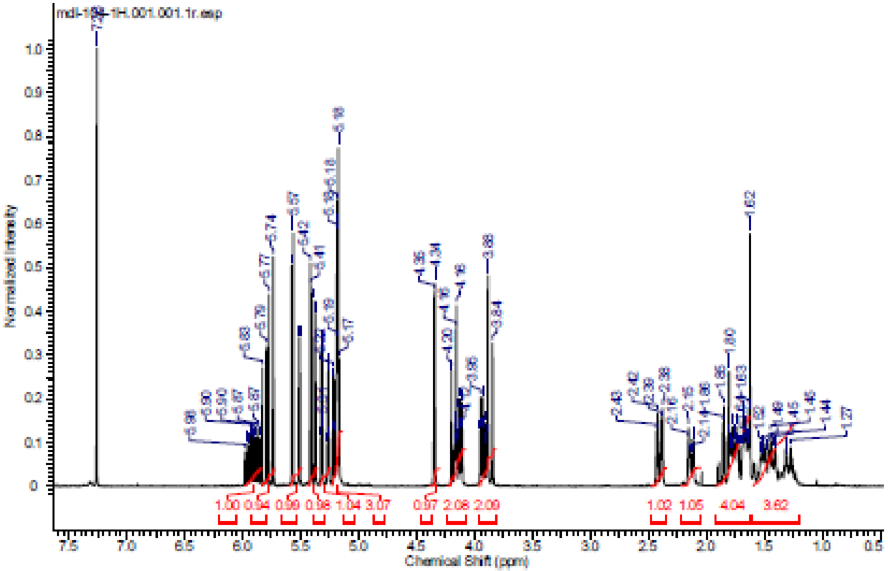

145.80
144.26
134.19
118.92
117.78
109.56
90.17
82.51
72.18
70.61
67.96
52.87
39.76
35.21
26.26
26.04
22.08
20.80
13.78
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

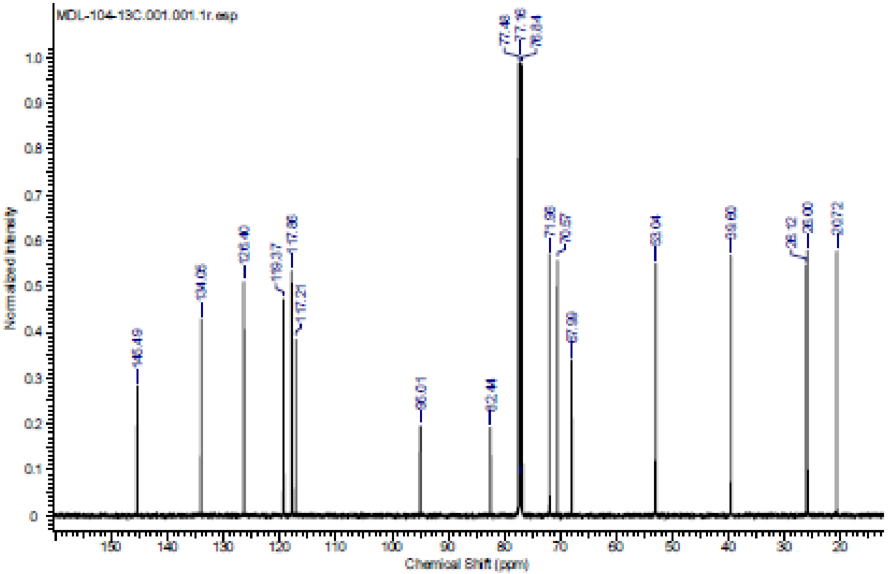

O
H
HO
BS1-035.1_1H.001.001.1R.esp
1.31
1.37
1.19
1.53
1.00
2.66
0.33
0.38
2.06
4.37
4.70
1.47
3.14
3.04
4.09
2.73
1.38
5.04
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

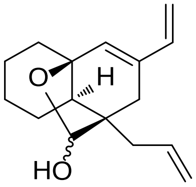

O
H
HO


BS1-035.1_13C.001.001.1R.esp
77.48
77.16
76.84
49.56
136.28
134.87
134.60
131.19
131.09
117.84
105.04
79.04
37.66
35.55
35.13
32.90
32.69
24.89
23.51
22.62
21.08
13.95
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

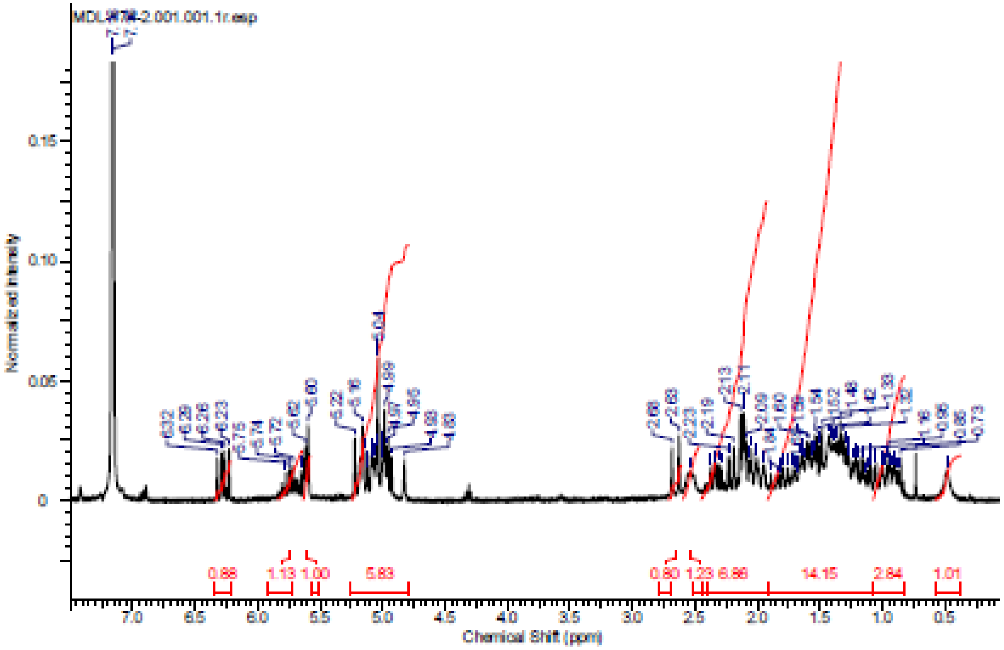

OH
O


mdl-104-1H.001.001.1r.esp
Normalized Intensity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
7.26
5.98
5.90
5.90
5.87
5.87
5.83
5.79
5.77
5.74
5.57
5.42
5.41
5.18
5.18
5.18
5.18
5.17
4.36
4.34
4.20
4.16
4.16
3.86
3.88
3.84
2.43
2.42
2.39
2.38
2.16
2.16
2.14
1.88
1.86
1.80
1.63
1.52
1.49
1.45
1.46
1.44
1.27
1.62
1.00
0.94
0.99
0.98
1.04
3.07
0.97
2.08
2.09
1.02
1.05
4.04
3.62
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

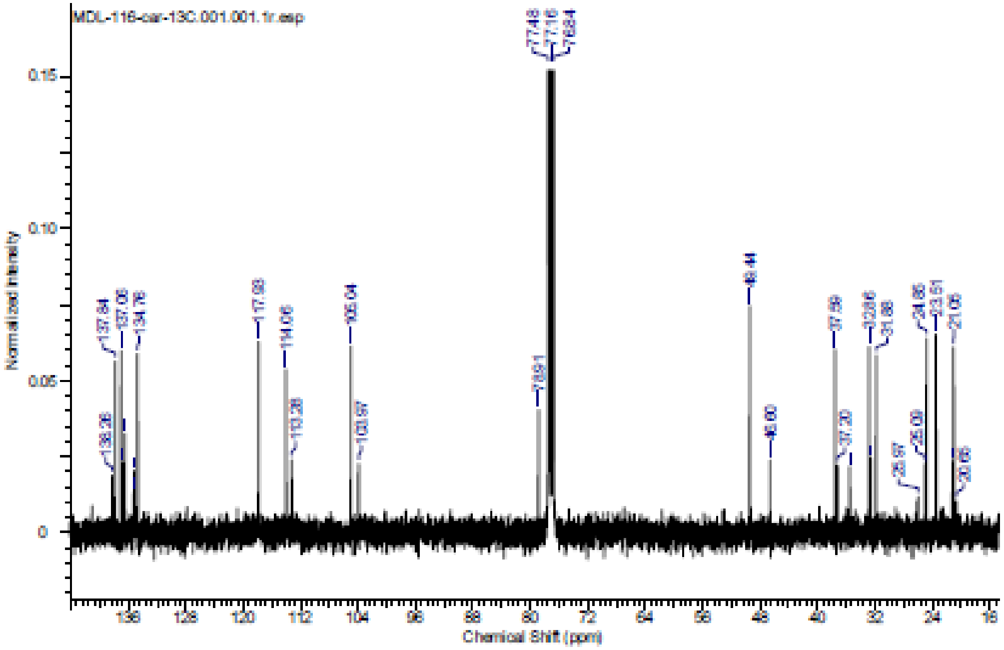

MDL-104-13C.001.001.1r.esp
Normalized Intensity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
145.49
134.05
126.40
119.37
117.86
117.21
95.01
82.44
77.48
77.16
76.84
71.96
70.57
67.99
53.04
39.60
26.12
26.00
20.72
150
140
130
120
110
100
90
80
70
60
50
40
30
20
Chemical Shift (ppm)



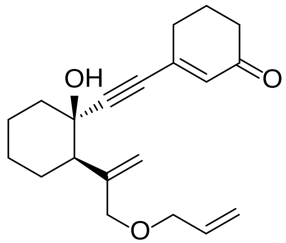
O
H
HO

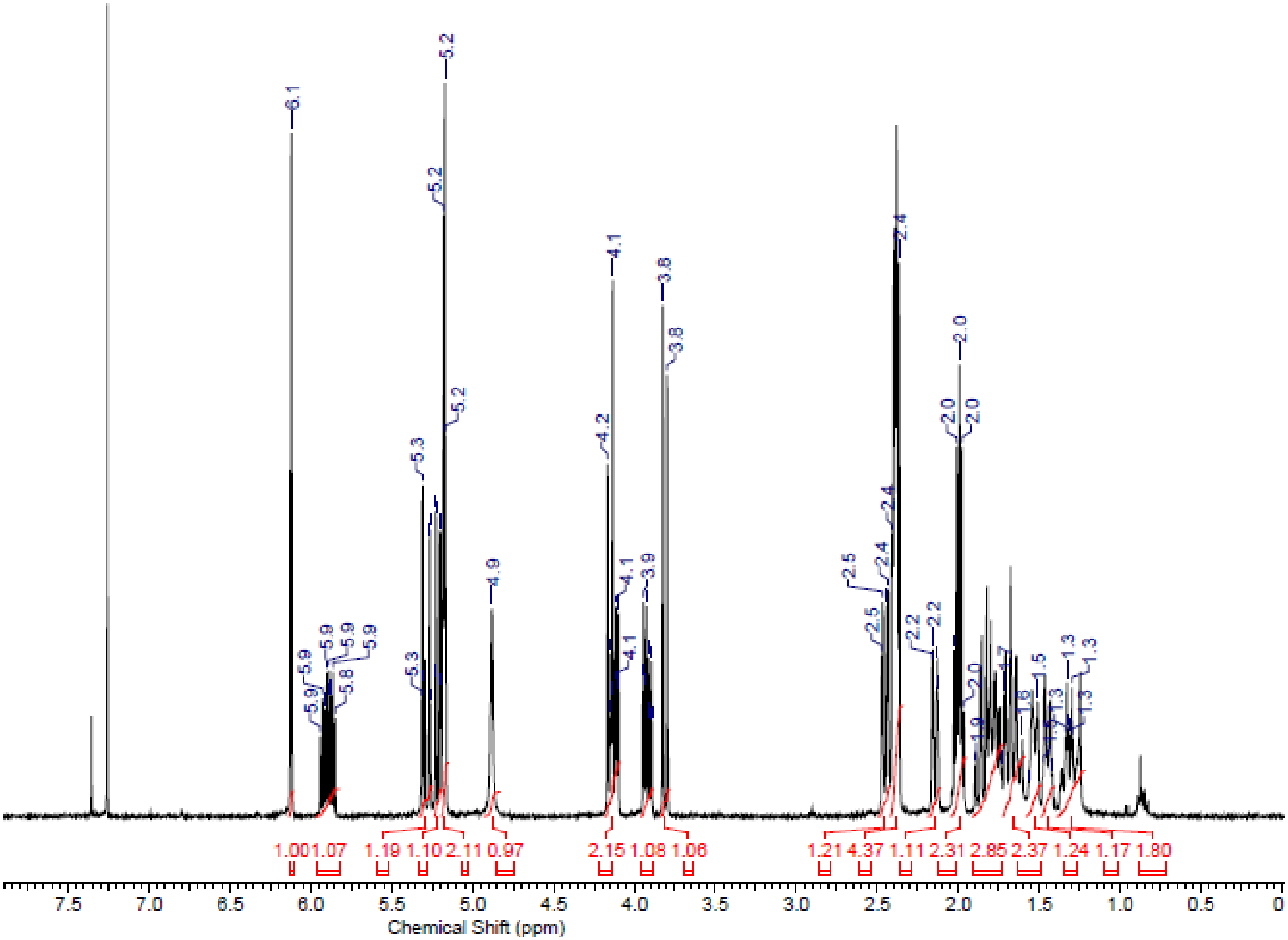


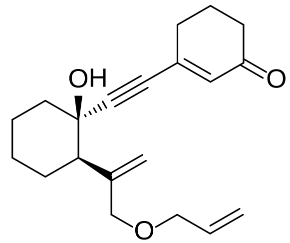
MDL-...-2.001.001.1r.esp
7.16
6.32
6.29
6.26
6.23
5.75
5.74
5.72
5.62
5.60
5.22
5.16
5.04
4.99
4.97
4.86
4.83
4.80
2.68
2.63
2.23
2.19
2.13
2.11
2.09
1.84
1.60
1.56
1.54
1.52
1.48
1.42
1.33
1.32
1.16
0.96
0.86
0.73
0.88
1.13
1.00
5.83
0.80
1.23
6.86
14.15
2.84
1.01
Normalized Intensity
0.15
0.10
0.05
0
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

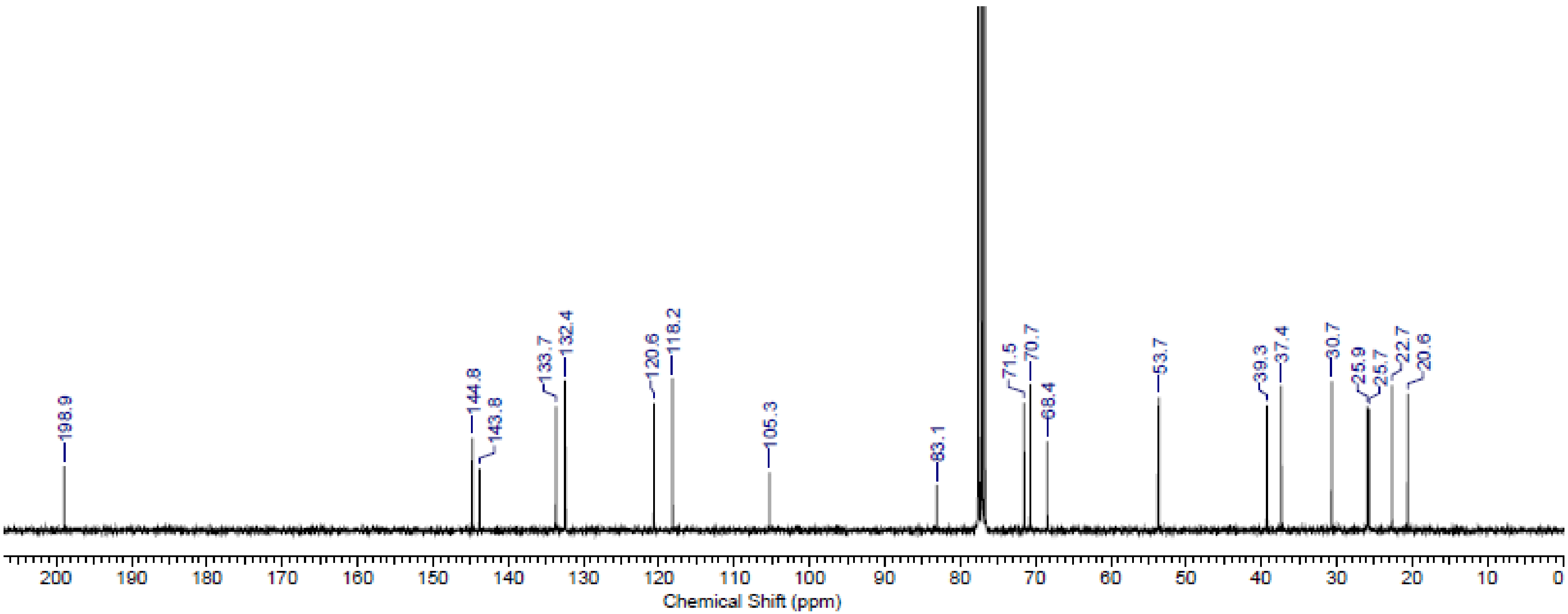


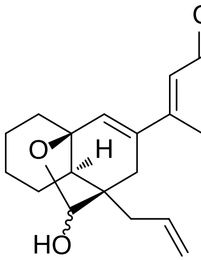
MDL-116-car-13C.001.001.1r.esp
77.48
77.16
76.84
138.26
137.84
137.06
134.76
117.93
114.06
113.28
105.04
103.97
78.91
49.44
46.00
37.89
37.20
32.86
31.88
25.97
26.09
24.86
23.61
21.09
20.66
Normalized Intensity
0.15
0.10
0.05
0
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

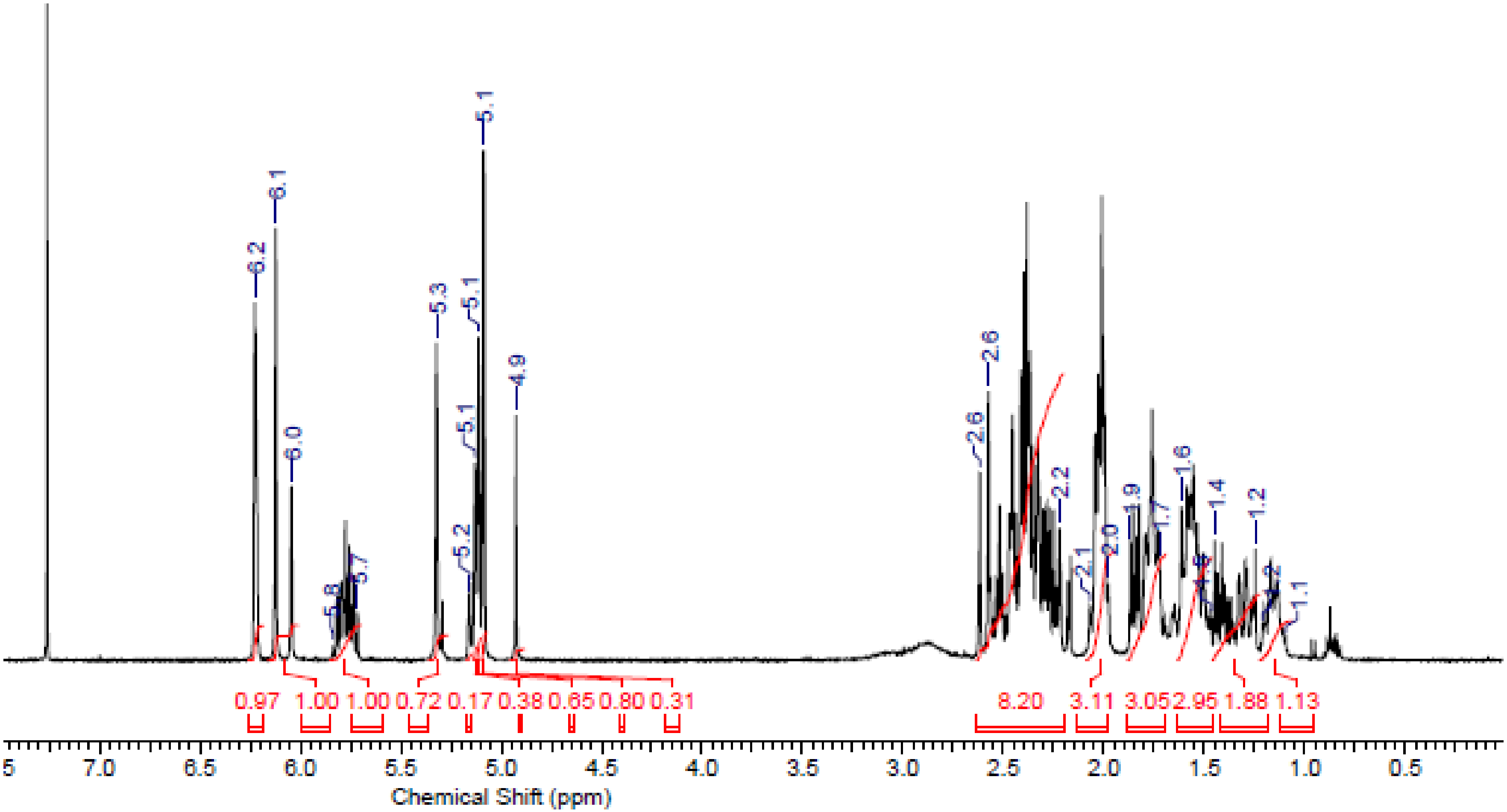

OH
O
O

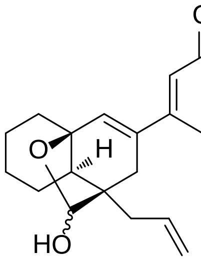

6.1
5.9
5.9
5.9
5.9
5.9
5.8
5.3
5.3
5.2
5.2
5.2
4.9
4.2
4.1
4.1
4.1
3.9
3.8
3.8
2.5
2.5
2.4
2.4
2.4
2.2
2.2
2.0
2.0
2.0
2.0
1.9
1.7
1.6
1.5
1.5
1.3
1.3
1.3
1.3
1.00
1.07
1.19
1.10
2.11
0.97
2.15
1.08
1.06
1.21
4.37
1.11
2.31
2.85
2.37
1.24
1.17
1.80
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Chemical Shift (ppm)

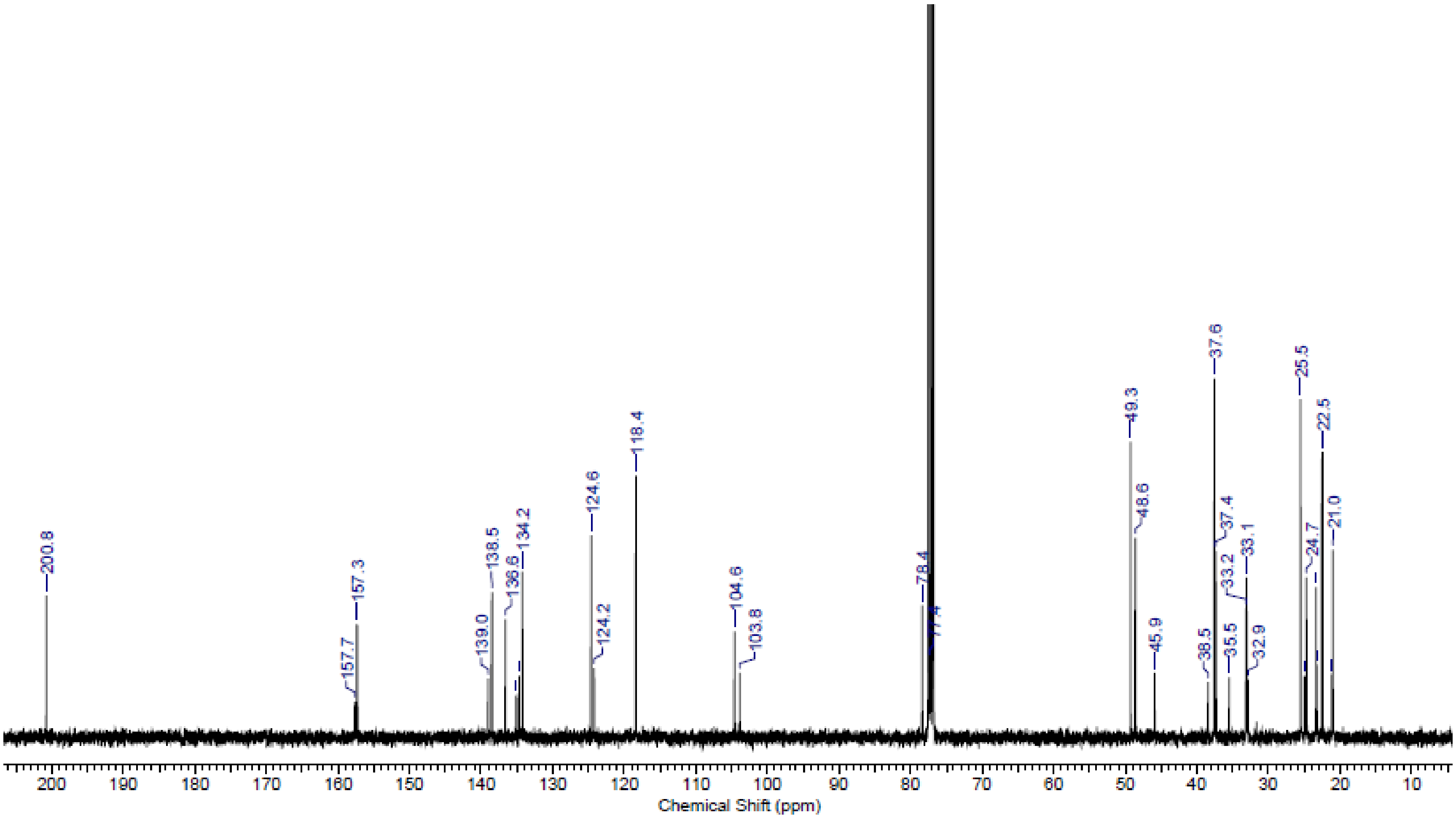

OH
O
O

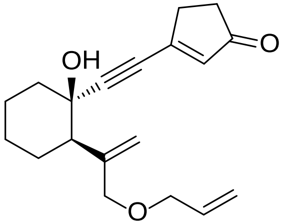

198.9
144.8
143.8
133.7
132.4
120.6
118.2
105.3
83.1
71.5
70.7
68.4
53.7
39.3
37.4
30.7
25.9
25.7
22.7
20.6
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Chemical Shift (ppm)


O
O
H
HO

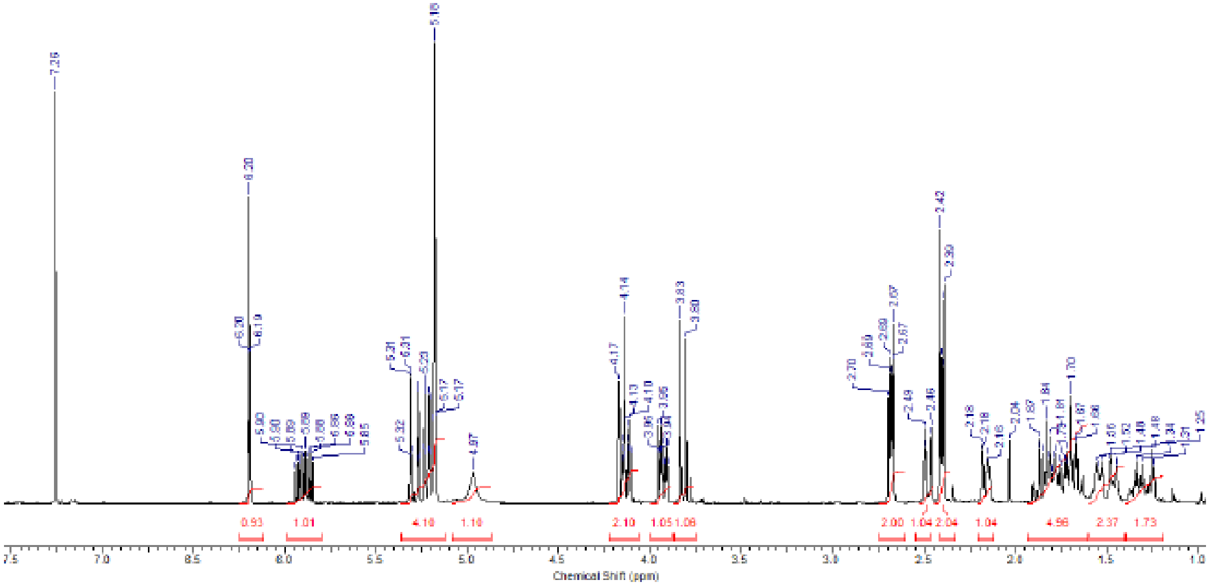

6.2
6.1
6.0
5.8
5.7
5.3
5.2
5.1
5.1
5.1
4.9
2.6
2.6
2.2
2.1
2.0
1.9
1.7
1.6
1.6
1.4
1.2
1.2
1.1
0.97
1.00
1.00
0.72
0.17
0.38
0.65
0.80
0.31
8.20
3.11
3.05
2.95
1.88
1.13
5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)


O
O
H
HO

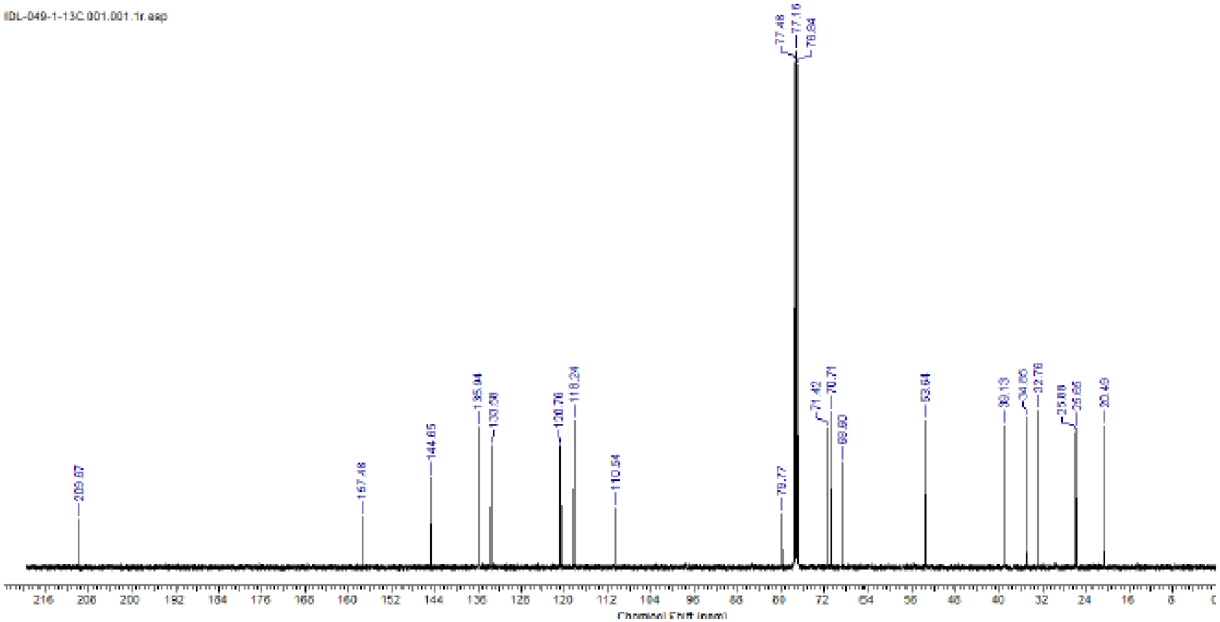

200.8
157.7
157.3
139.0
138.5
136.6
134.2
124.6
124.2
118.4
104.6
103.8
78.4
77.4
49.3
48.6
45.9
38.5
37.6
37.4
35.5
33.2
33.1
32.9
25.5
24.7
22.5
21.0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Chemical Shift (ppm)



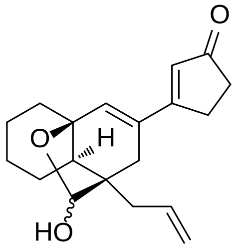
OH
O
O

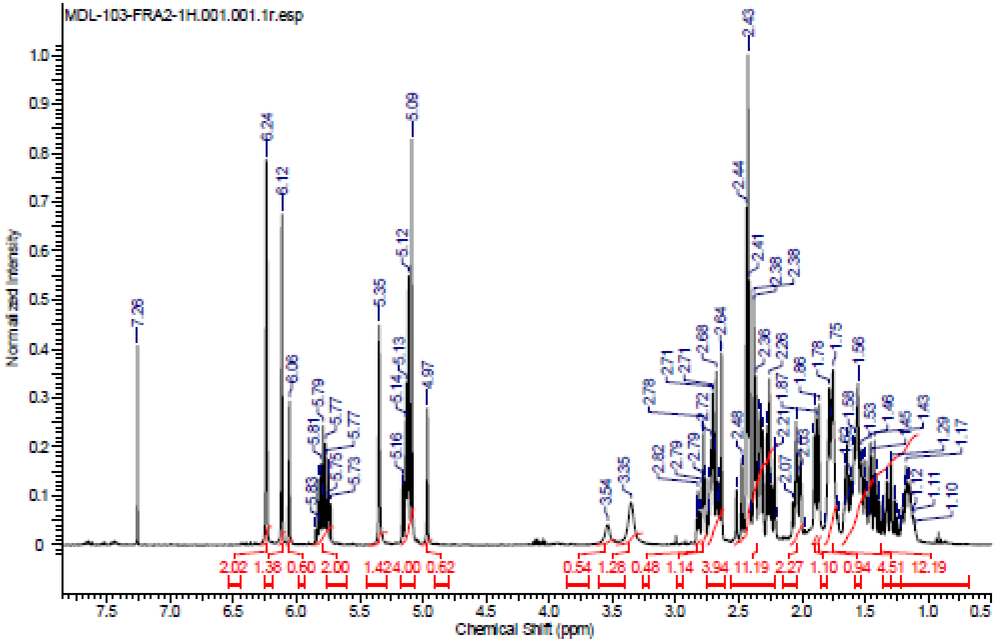


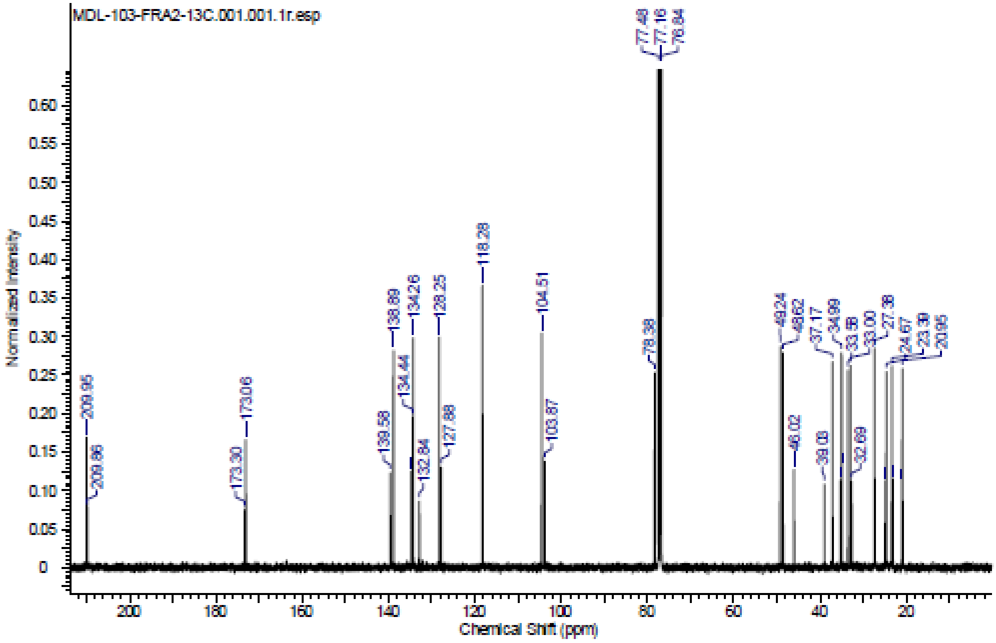
7.26
6.20
6.20
6.19
5.90
5.90
5.89
5.89
5.88
5.86
5.86
5.85
5.32
5.31
5.31
5.23
5.18
5.17
5.17
4.97
4.17
4.14
4.13
4.10
3.96
3.95
3.94
3.83
3.80
2.70
2.69
2.69
2.67
2.67
2.49
2.46
2.42
2.39
2.18
2.18
2.16
2.04
1.87
1.84
1.81
1.79
1.70
1.67
1.66
1.56
1.52
1.48
1.48
1.34
1.31
1.25
0.93
1.01
4.10
1.10
2.10
1.05
1.08
2.00
1.04
2.04
1.04
4.98
2.37
1.73
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Chemical Shift (ppm)

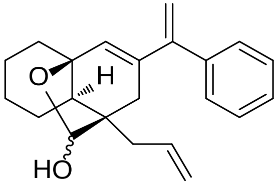


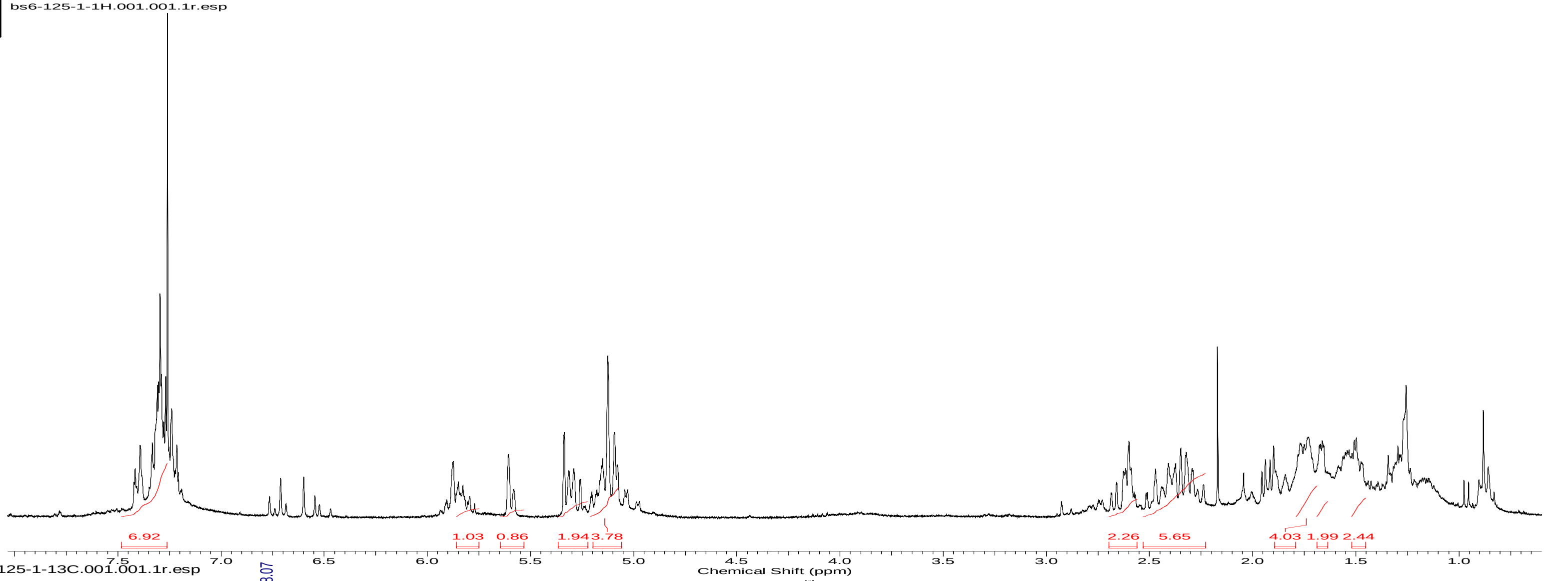
IDL-049-1-13C.001.001.1r.esp
209.67
157.48
144.65
135.94
133.58
120.78
118.24
110.54
79.77
77.48
77.16
76.84
71.42
70.71
69.60
53.64
39.13
34.65
32.78
25.88
25.65
20.49
216
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
0
Chemical Shift (ppm)


O
O
H
HO

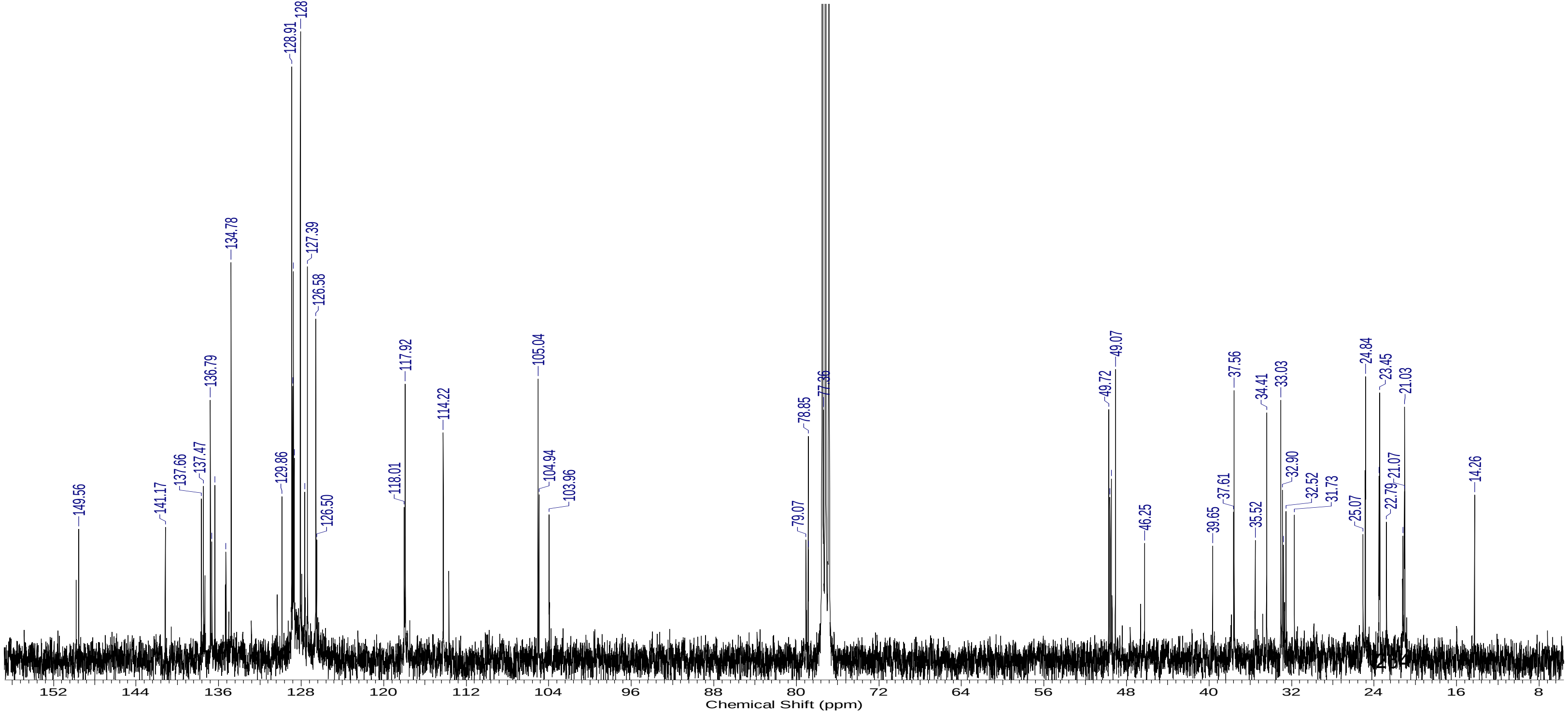

MDL-103-FRA2-1H.001.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
7.26
6.24
6.12
6.06
5.83
5.81
5.79
5.77
5.77
5.75
5.73
5.35
5.16
5.14
5.13
5.12
5.09
4.97
3.54
3.35
2.82
2.79
2.79
2.78
2.72
2.71
2.71
2.68
2.64
2.48
2.44
2.43
2.41
2.38
2.38
2.36
2.26
2.21
2.07
2.03
1.87
1.86
1.78
1.75
1.63
1.58
1.56
1.53
1.46
1.45
1.43
1.29
1.17
1.12
1.11
1.10
2.02
1.38
0.60
2.00
1.42
4.00
0.62
0.54
1.28
0.48
1.14
3.94
11.19
2.27
1.10
0.94
4.51
12.19

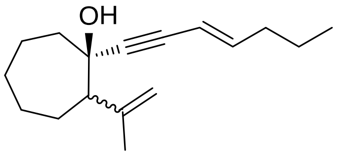

MDL-103-FRA2-13C.001.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
209.95
209.86
173.30
173.06
139.58
138.89
134.44
134.26
132.84
128.25
127.88
118.28
104.51
103.87
78.38
77.48
77.16
76.84
49.24
48.62
46.02
39.03
37.17
34.99
33.58
33.00
32.69
27.38
24.67
23.39
20.95

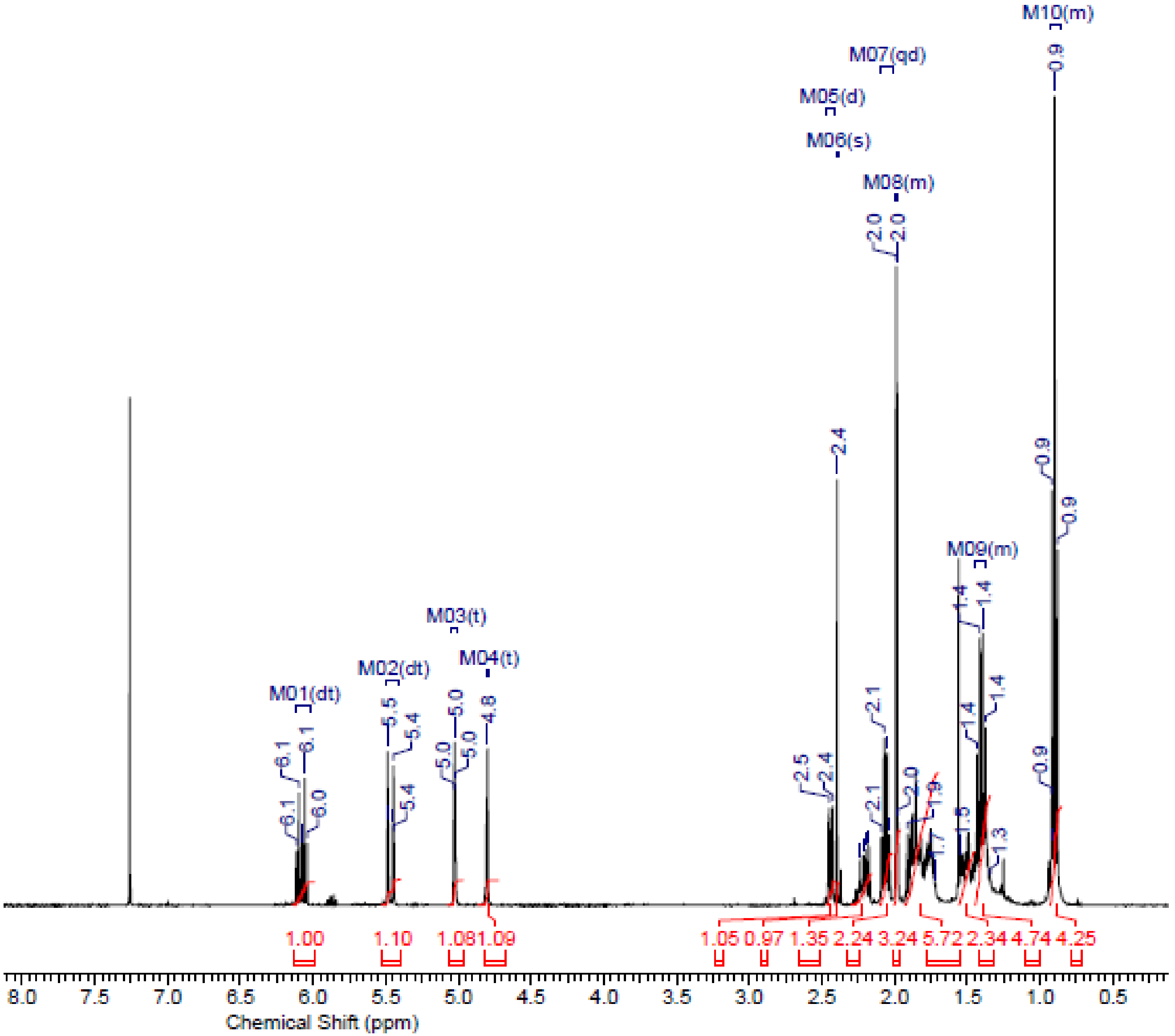


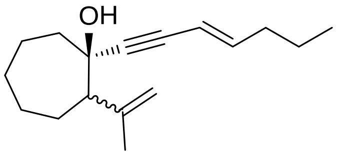


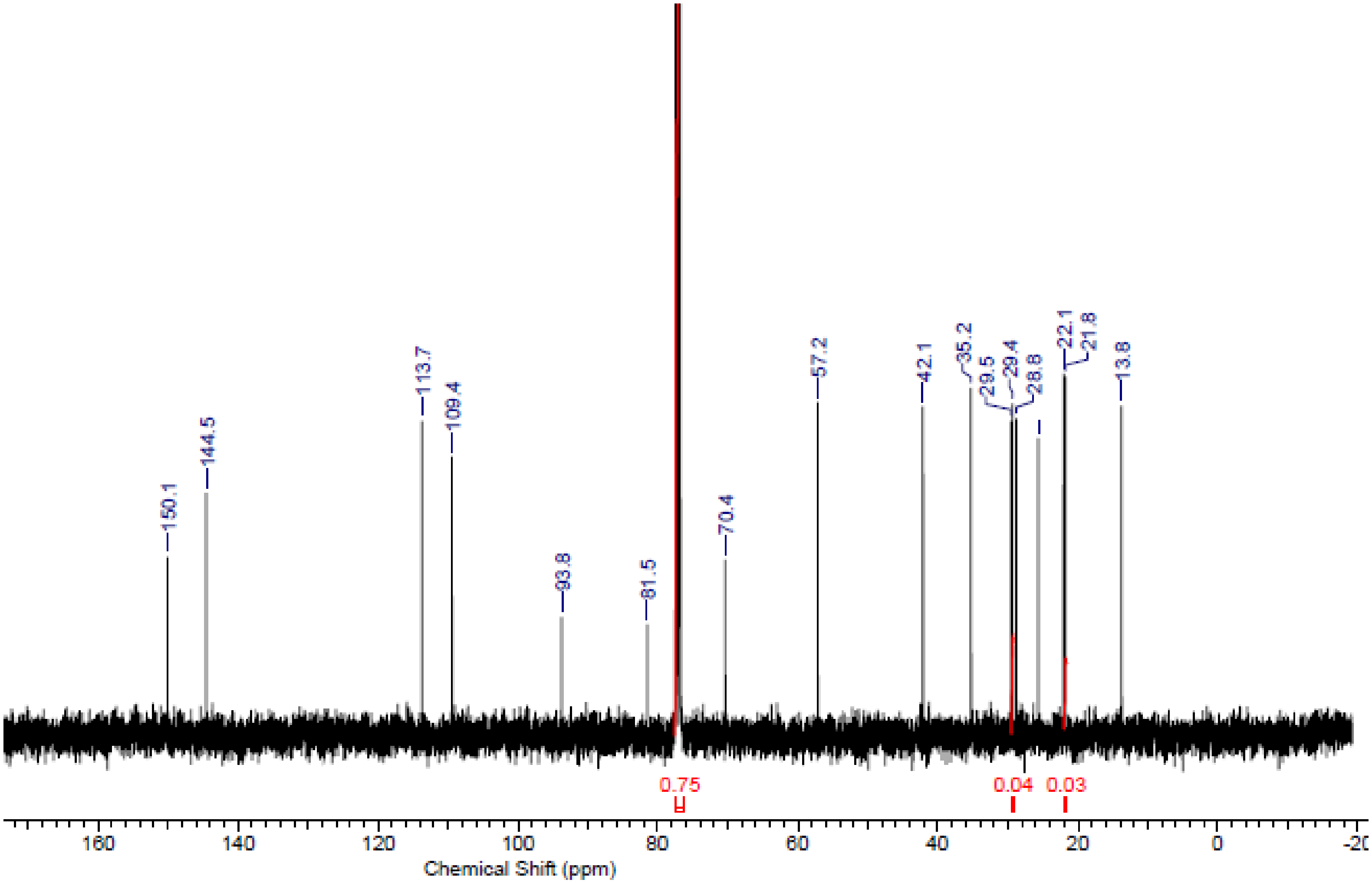
bs6-125-1-13C.001.001.1r.esp

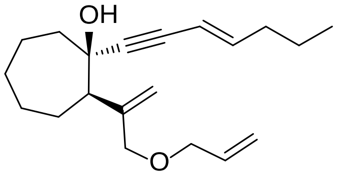


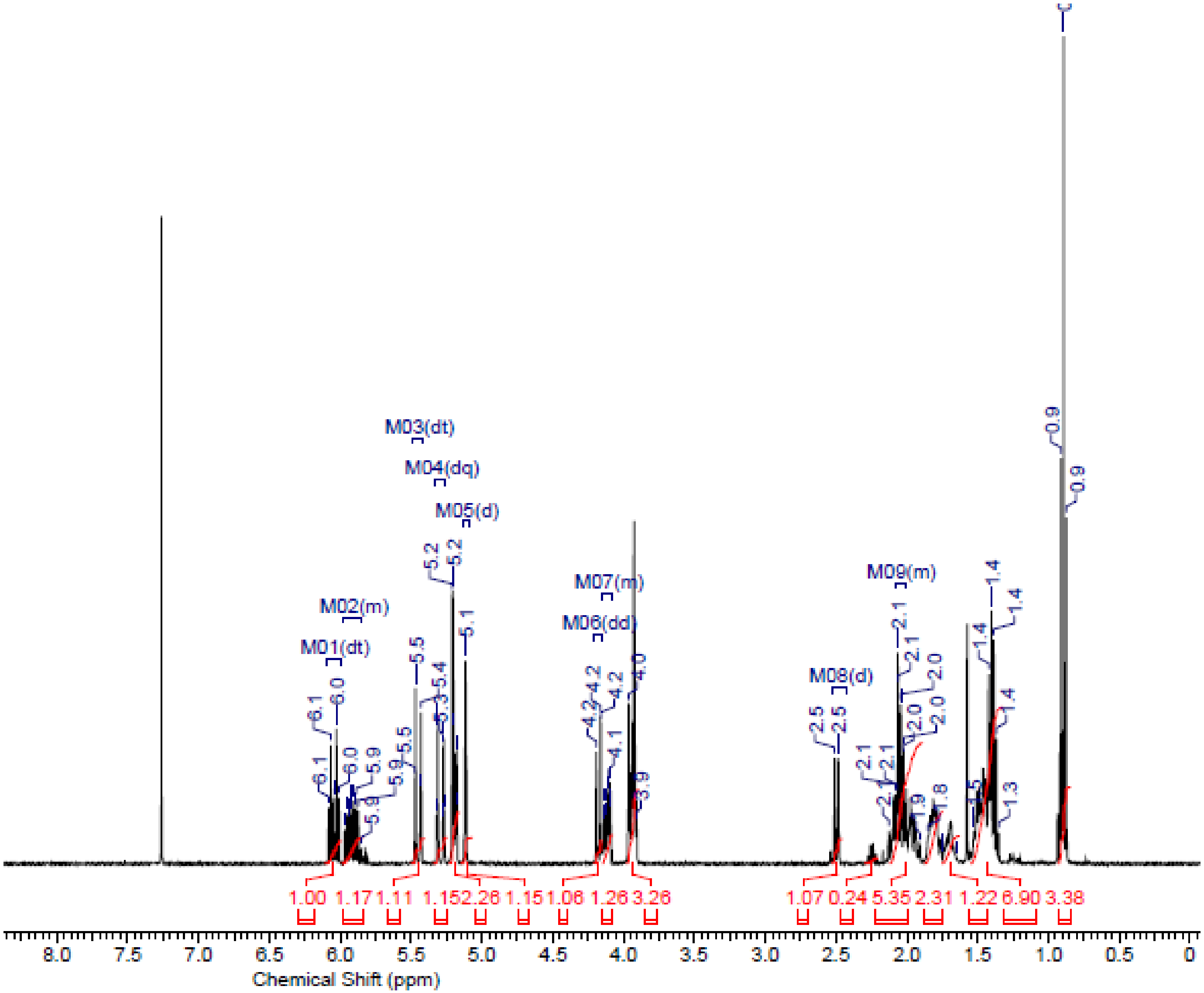

OH

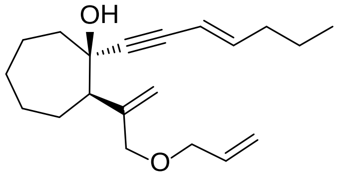

M01(dt)
M02(dt)
M03(t)
M04(t)
M05(d)
M06(s)
M07(qd)
M08(m)
M09(m)
M10(m)
6.1
6.1
6.1
6.0
5.5
5.4
5.4
5.0
5.0
5.0
4.8
2.5
2.4
2.4
2.1
2.1
2.0
2.0
2.0
1.9
1.7
1.5
1.4
1.4
1.4
1.4
1.3
0.9
0.9
0.9
0.9
1.00
1.10
1.08
1.09
1.05
0.97
1.35
2.24
3.24
5.72
2.34
4.74
4.25
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

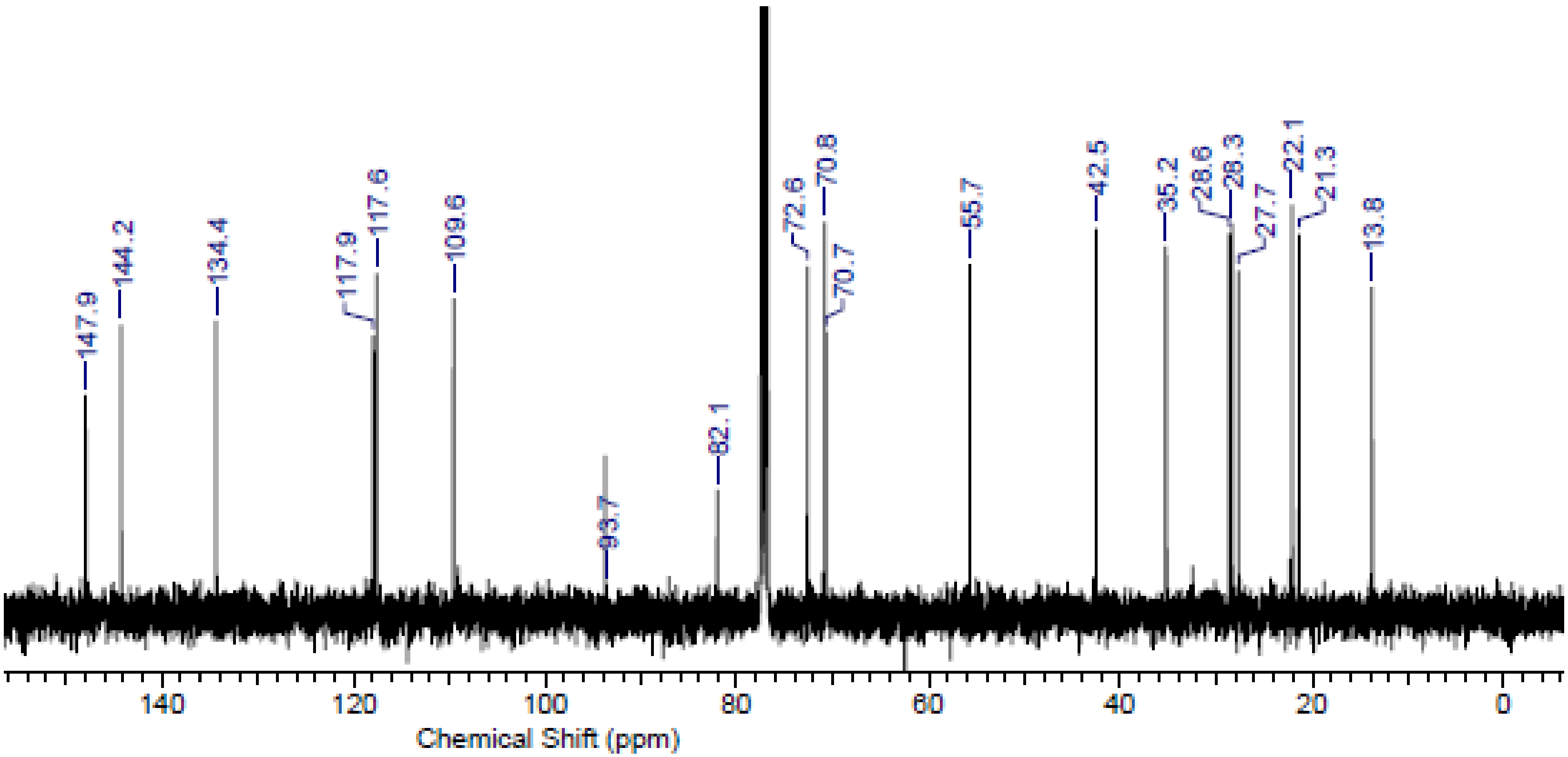

OH

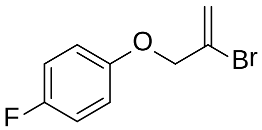

150.1
144.5
113.7
109.4
93.8
81.5
70.4
57.2
42.1
35.2
29.5
29.4
28.8
22.1
21.8
13.8
0.75
0.04
0.03
160
140
120
100
80
60
40
20
0
-20
Chemical Shift (ppm)

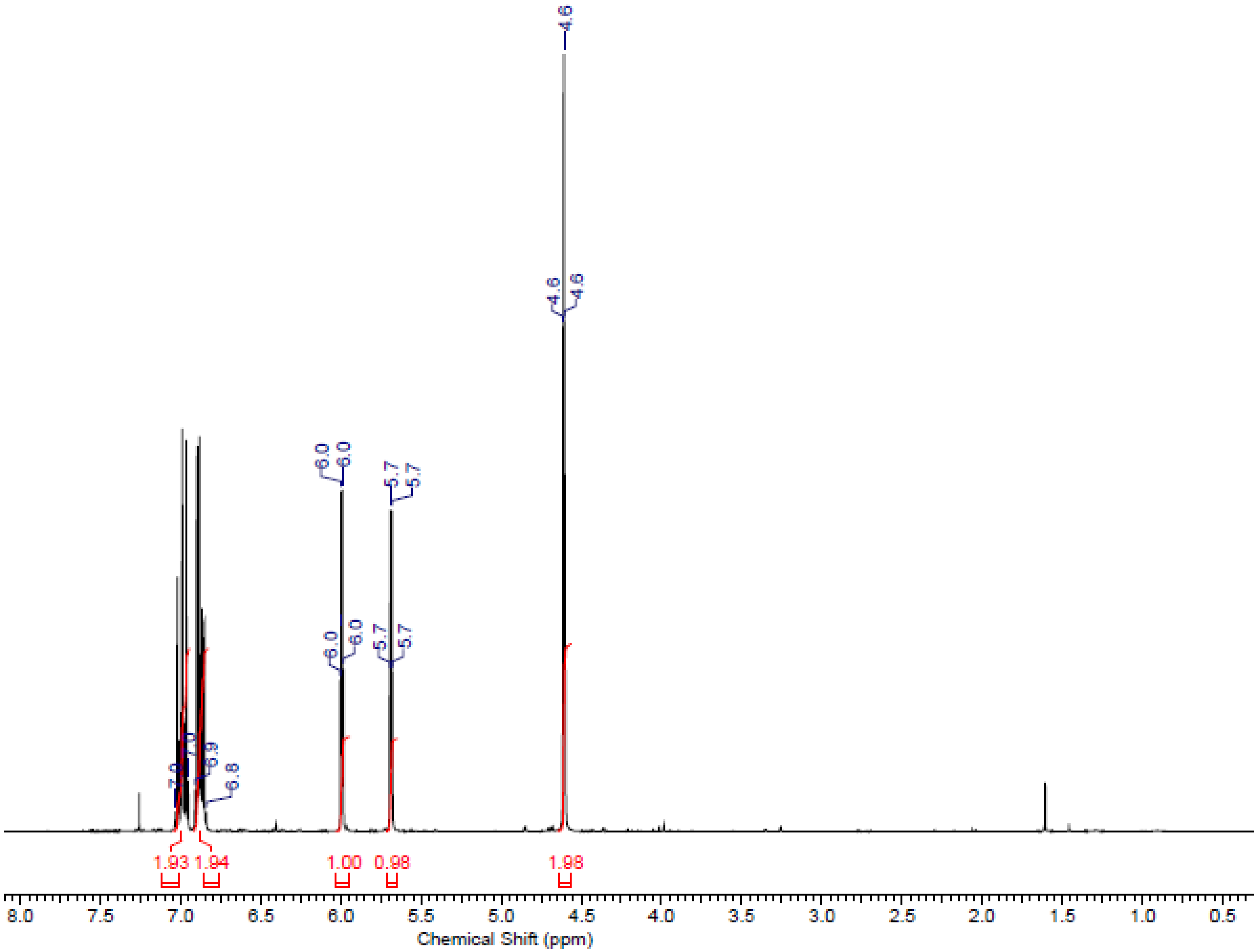

OH
O

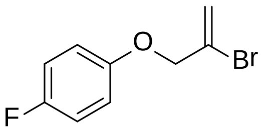

M01(dt)
M02(m)
M03(dt)
M04(dq)
M05(d)
M06(dd)
M07(m)
M08(d)
M09(m)
1.00
1.17
1.11
1.15
2.26
1.15
1.06
1.26
3.26
1.07
0.24
5.35
2.31
1.22
6.90
3.38
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Chemical Shift (ppm)

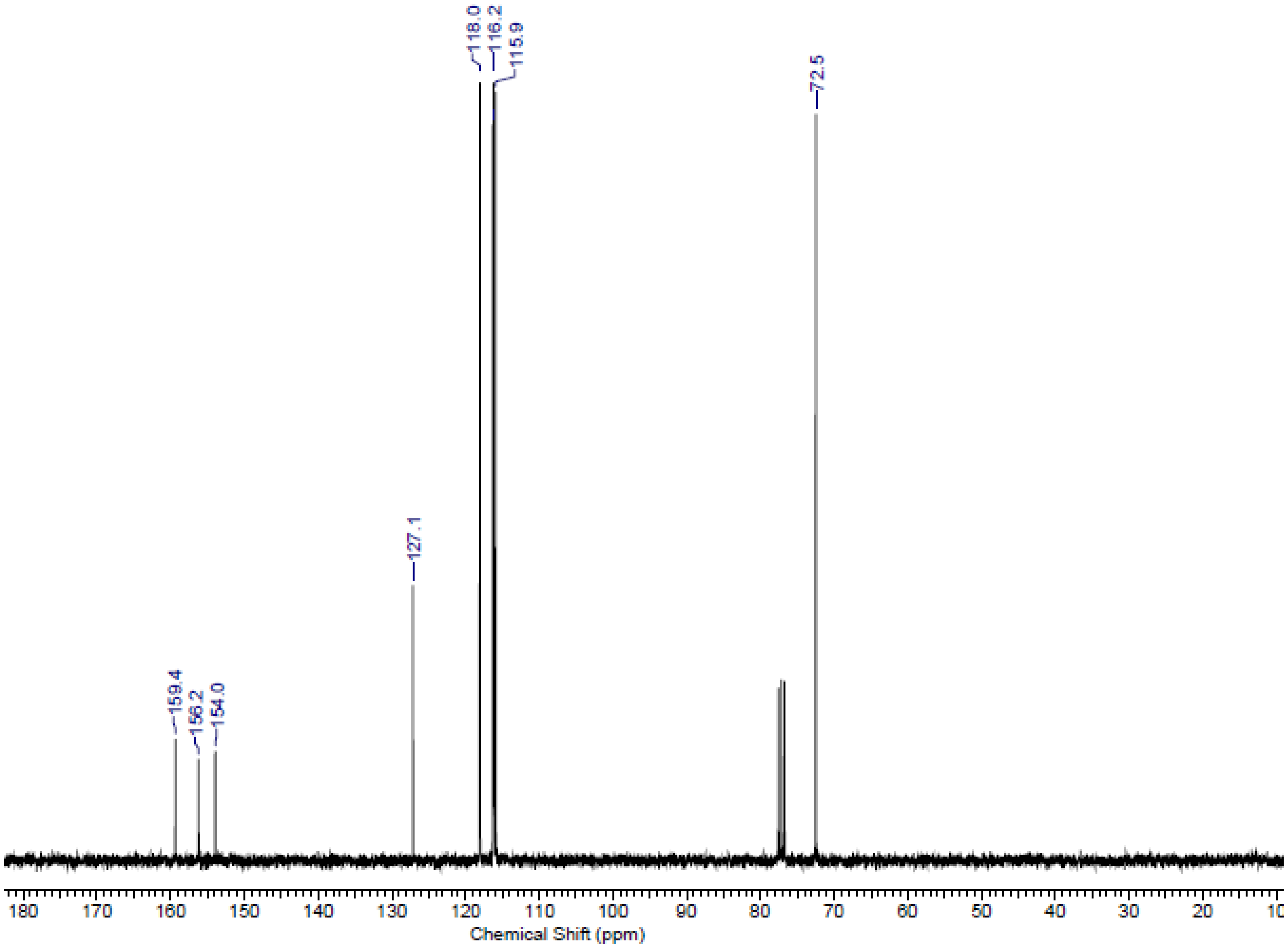

OH
O

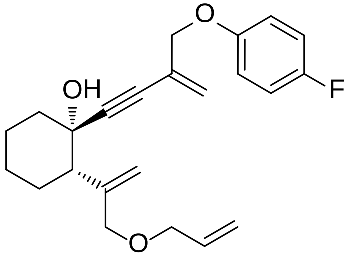

147.9
144.2
134.4
117.9
117.6
109.6
93.7
82.1
72.6
70.8
70.7
55.7
42.5
35.2
28.6
28.3
27.7
22.1
21.3
13.8
140
120
100
80
60
40
20
0
Chemical Shift (ppm)

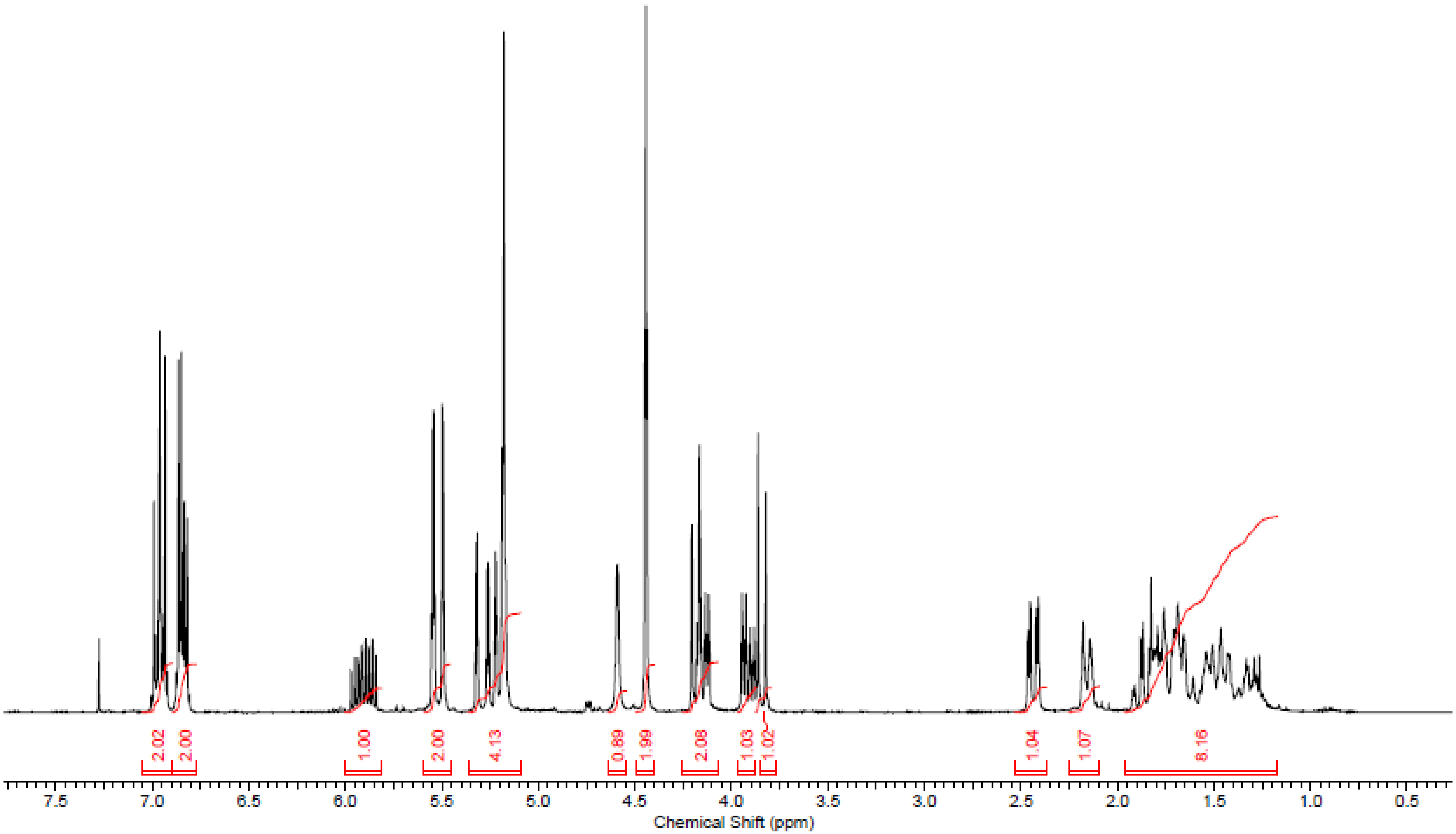

O
Br
F

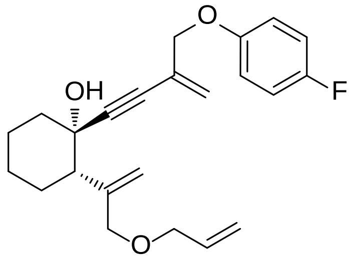

4.6
4.6
4.6
6.0
6.0
6.0
6.0
5.7
5.7
5.7
5.7
7.0
7.0
6.9
6.8
1.93
1.94
1.00
0.98
1.98
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

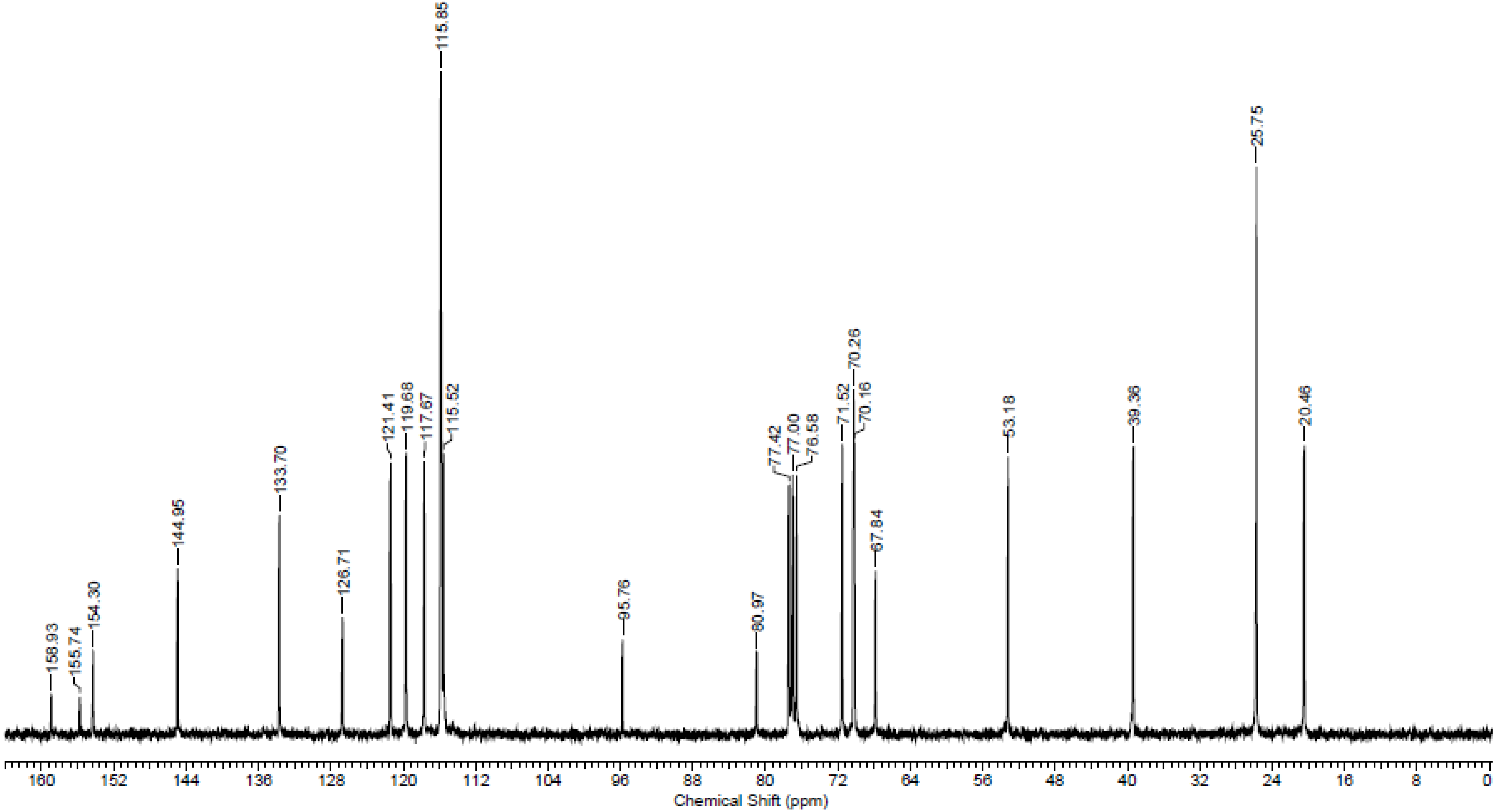

O
Br
F

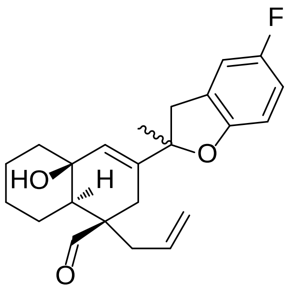

159.4
156.2
154.0
127.1
118.0
116.2
115.9
72.5
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Chemical Shift (ppm)

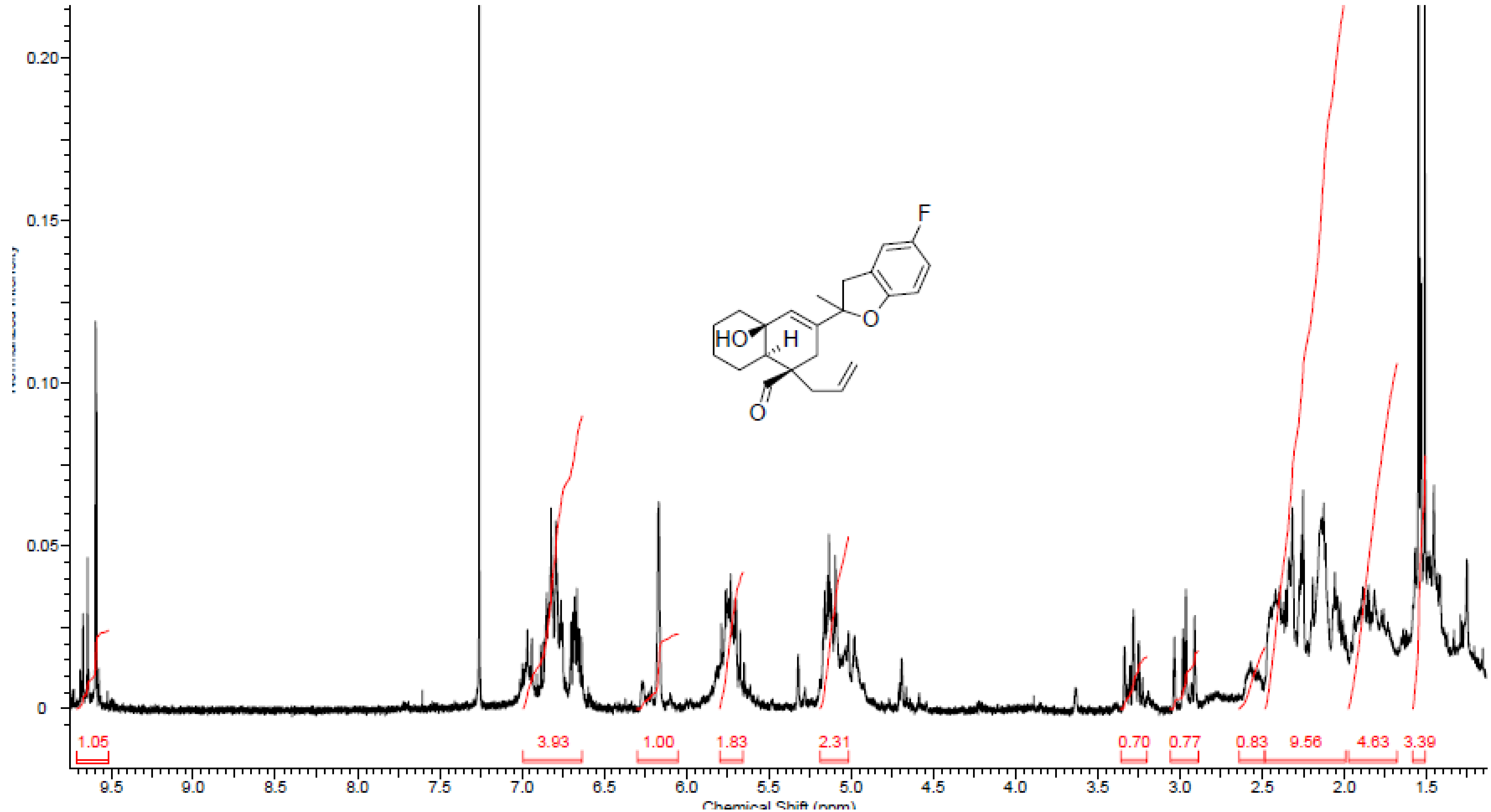

O
OH
F
O

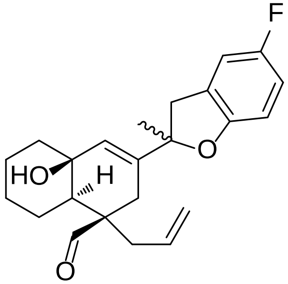

2.02
2.00
1.00
2.00
4.13
0.89
1.99
2.08
1.03
1.02
1.04
1.07
8.16
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

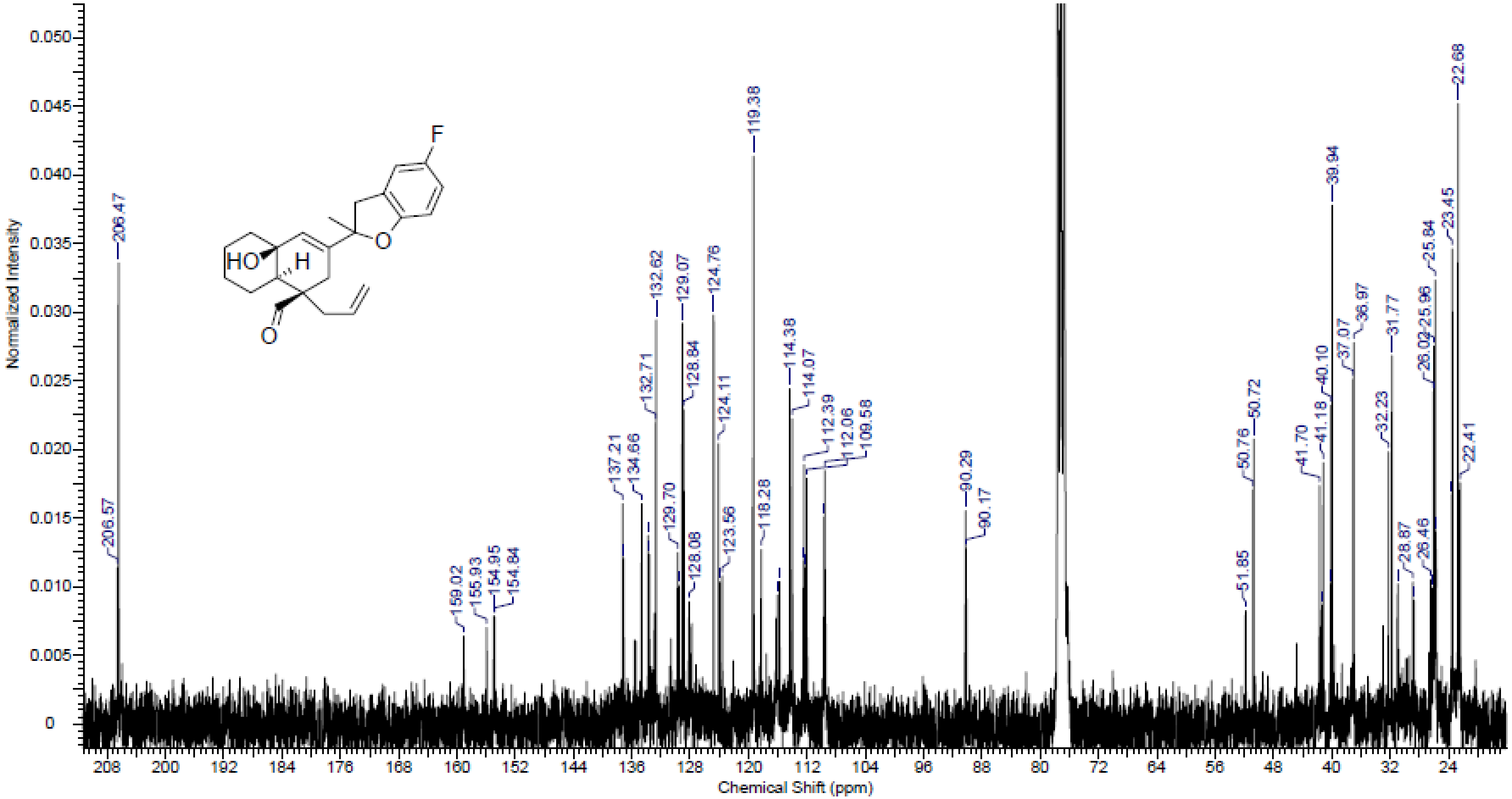

O
OH
F
O

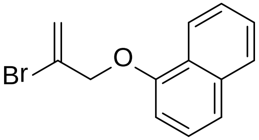

115.85
25.75
70.26
70.16
71.52
77.42
77.00
76.58
121.41
119.68
117.67
115.52
133.70
144.95
126.71
154.30
155.74
158.93
95.76
80.97
67.84
53.18
39.36
20.46
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
0
Chemical Shift (ppm)

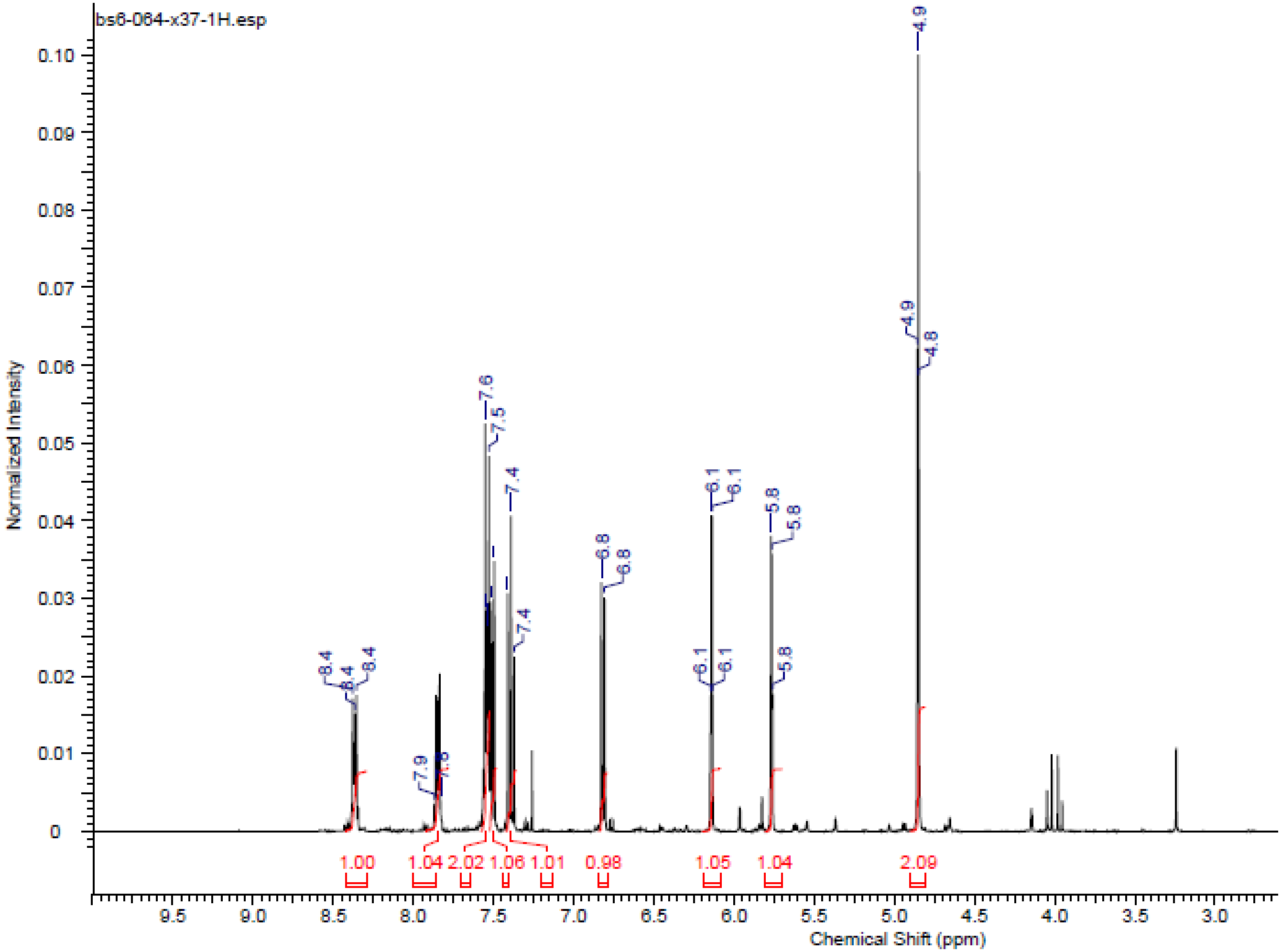

F
O
HO
H
O

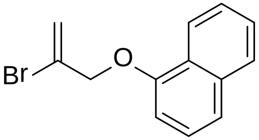

Normalized Intensity
0.20
0.15
0.10
0.05
0
F
O
HO
H
O
1.05
3.93
1.00
1.83
2.31
0.70
0.77
0.83
9.56
4.63
3.39
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
Chemical Shift (ppm)


F
O
HO
H
O

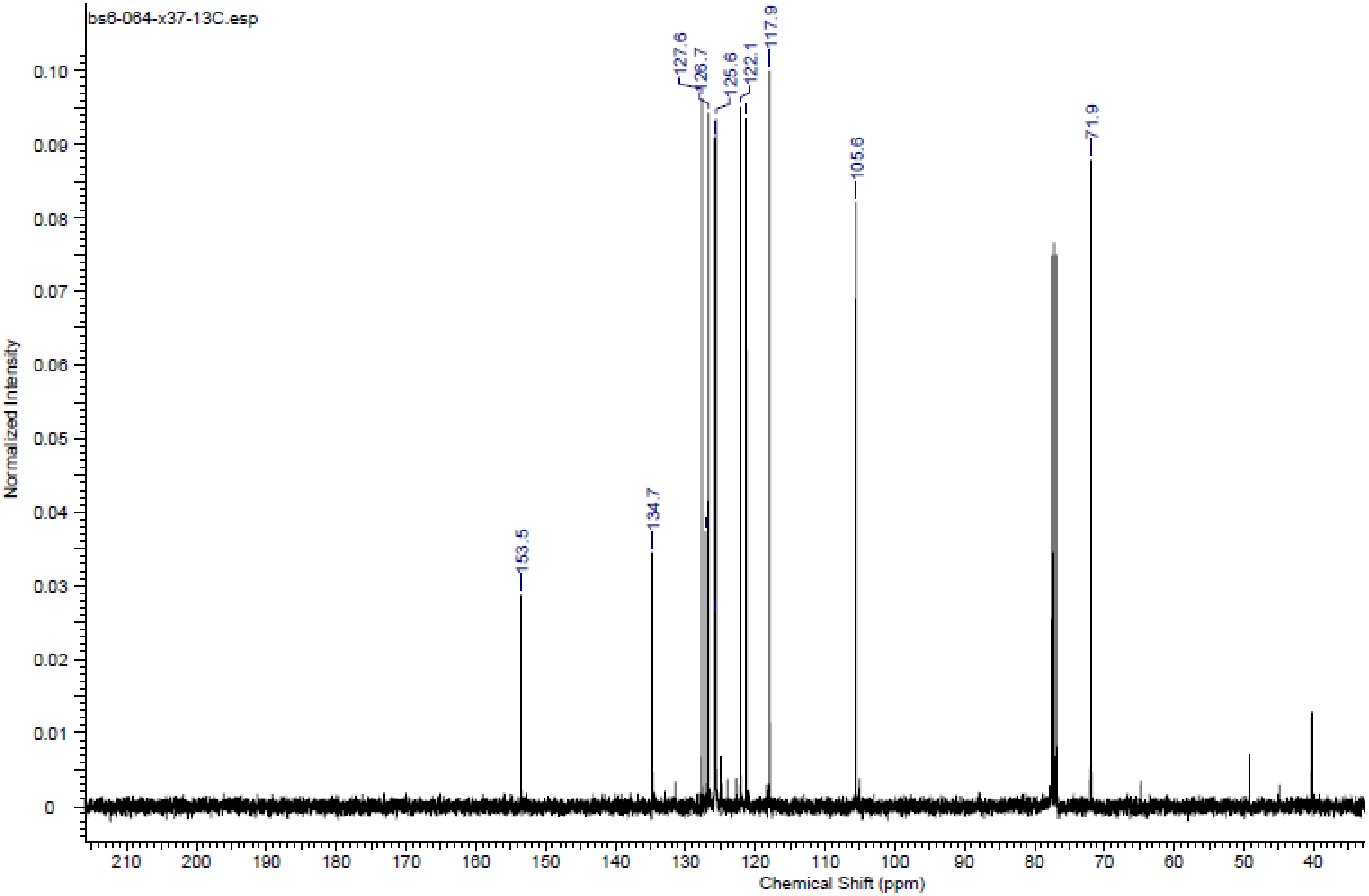

Normalized Intensity
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0
206.57
206.47
159.02
155.93
154.95
154.84
137.21
134.66
132.71
132.62
129.70
129.07
128.84
128.08
124.76
124.11
123.56
119.38
118.28
114.38
114.07
112.39
112.06
109.58
90.29
90.17
51.85
50.76
50.72
41.70
41.18
40.10
39.94
37.07
36.97
32.23
31.77
28.87
26.46
26.02
25.96
25.84
23.45
22.68
22.41
F
O
HO
H
O
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
Chemical Shift (ppm)



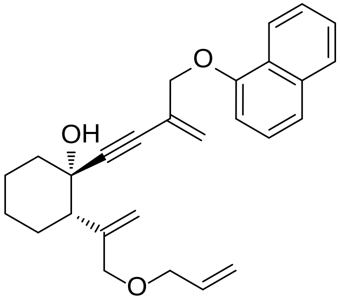

bs6-064-x37-1H.esp
Normalized Intensity
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
8.4
8.4
8.4
7.9
7.8
7.6
7.5
7.4
7.4
6.8
6.8
6.1
6.1
6.1
6.1
5.8
5.8
5.8
4.9
4.9
4.8
1.00
1.04
2.02
1.06
1.01
0.98
1.05
1.04
2.09
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
Chemical Shift (ppm)

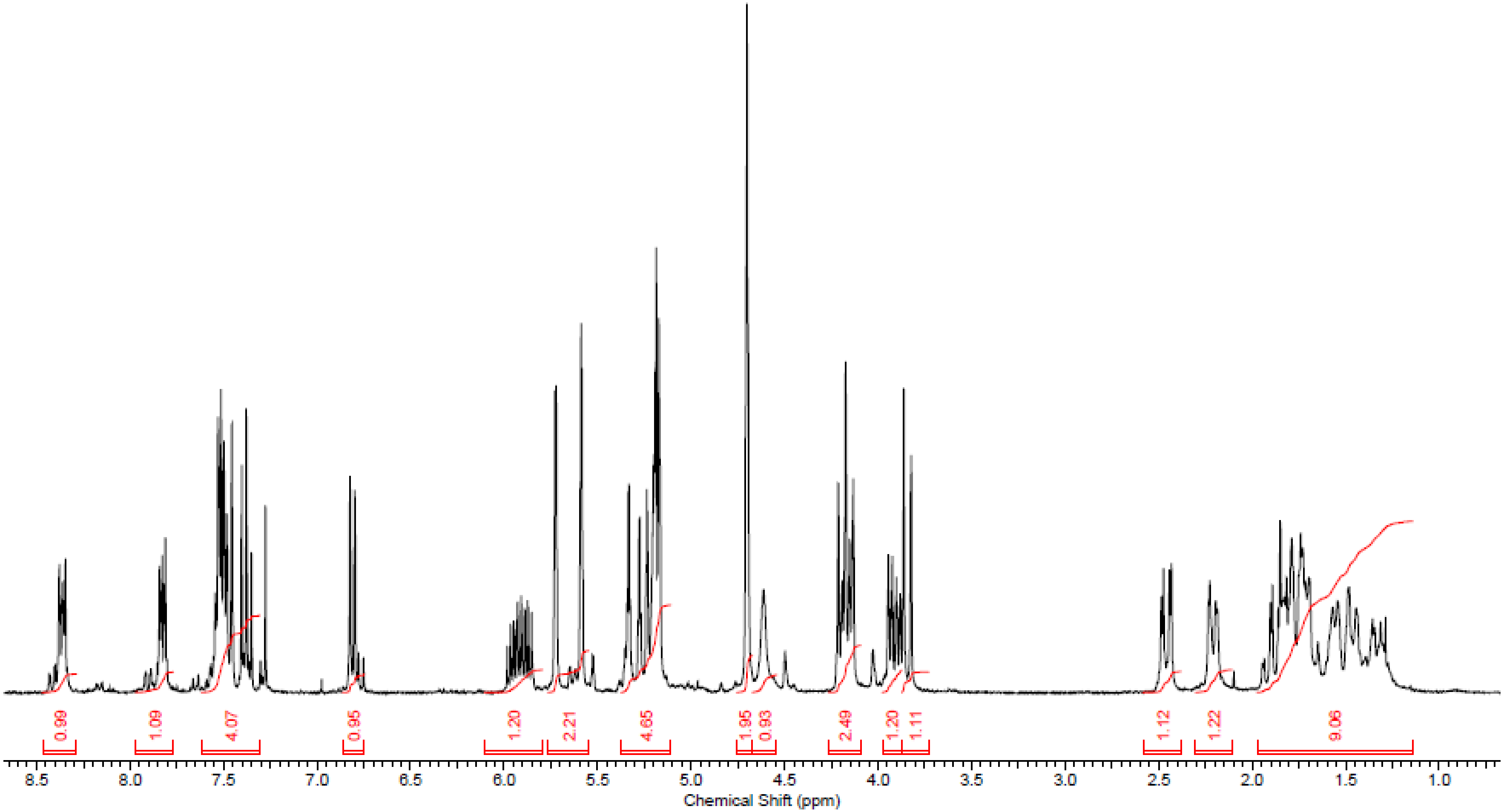


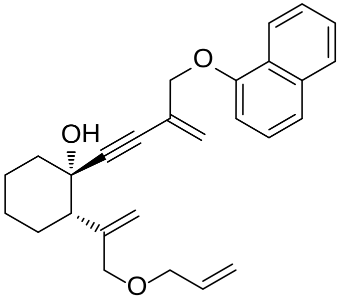
Br
O

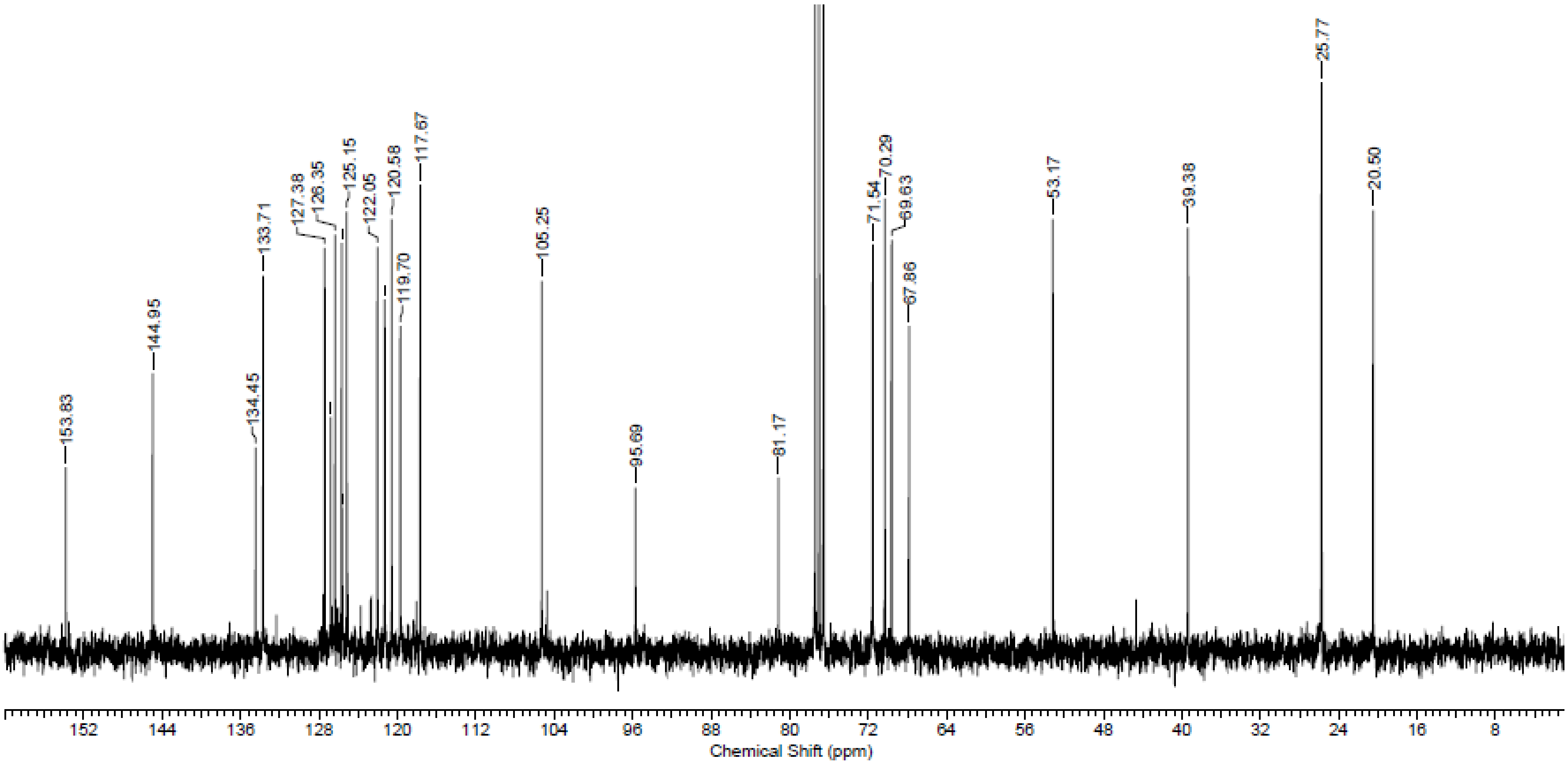


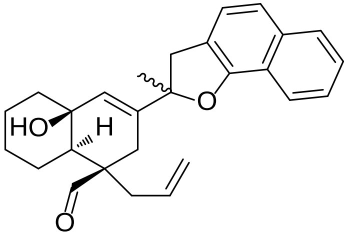
bs6-064-x37-13C.esp
153.5
134.7
127.6
26.7
125.6
122.1
117.9
105.6
71.9
Normalized Intensity
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
Chemical Shift (ppm)

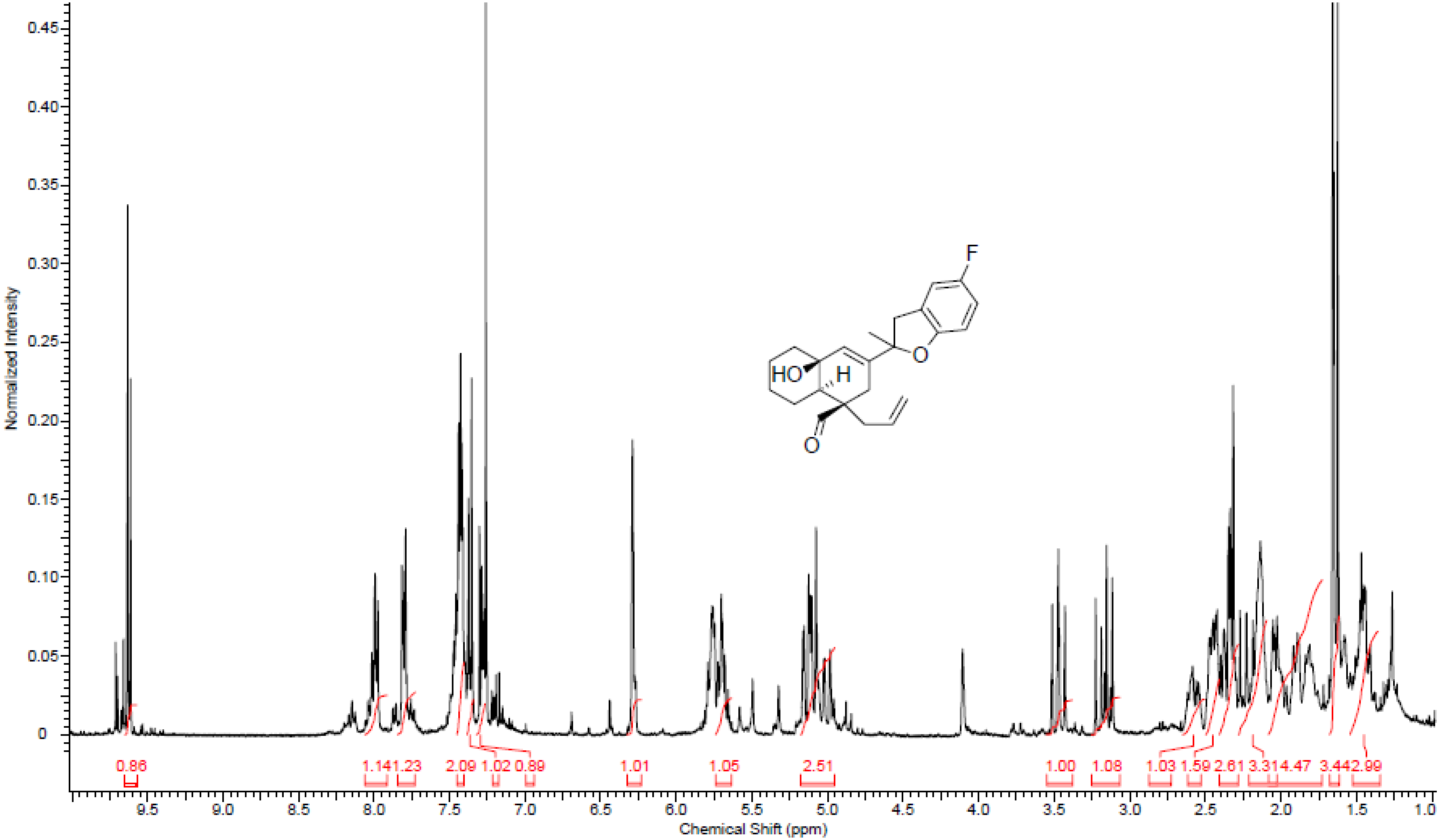

OH
O
O

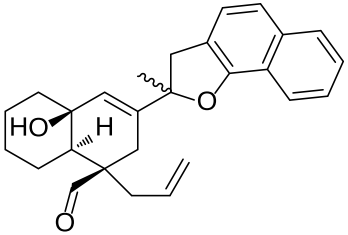

0.99
1.09
4.07
0.95
1.20
2.21
4.65
1.95
0.93
2.49
1.20
1.11
1.12
1.22
9.06
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Chemical Shift (ppm)


O
OH
O

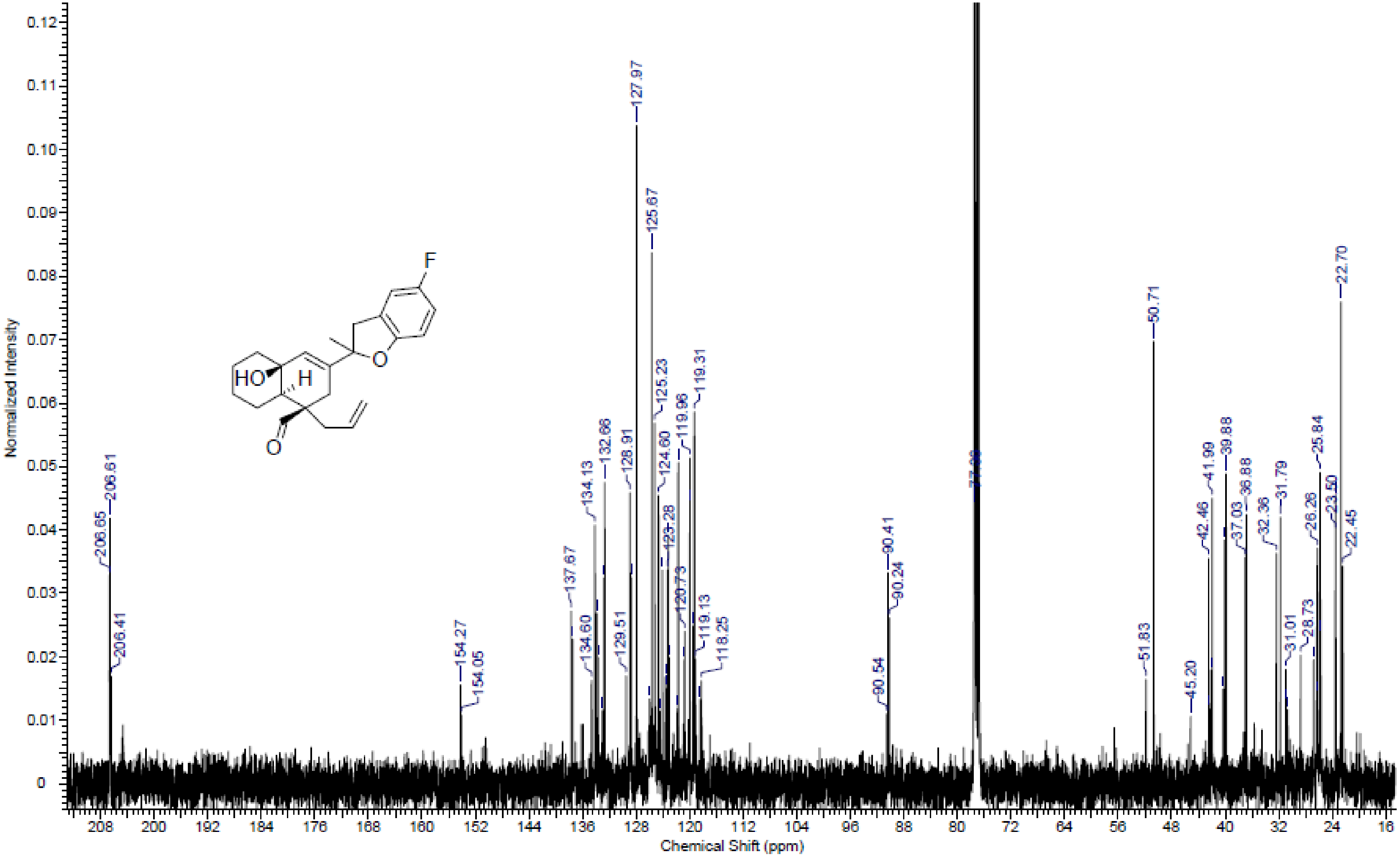

153.83
144.95
134.45
133.71
127.38
126.35
125.15
122.05
120.58
119.70
117.67
105.25
95.69
81.17
71.54
70.29
69.63
67.86
53.17
39.38
25.77
20.50
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


HO
H
O
O

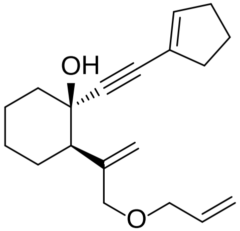

F
O
HO
H
O
Normalized Intensity
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
0.86
1.14
1.23
2.09
1.02
0.89
1.01
1.05
2.51
1.00
1.08
1.03
1.59
2.61
3.31
4.47
3.44
2.99
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Chemical Shift (ppm)

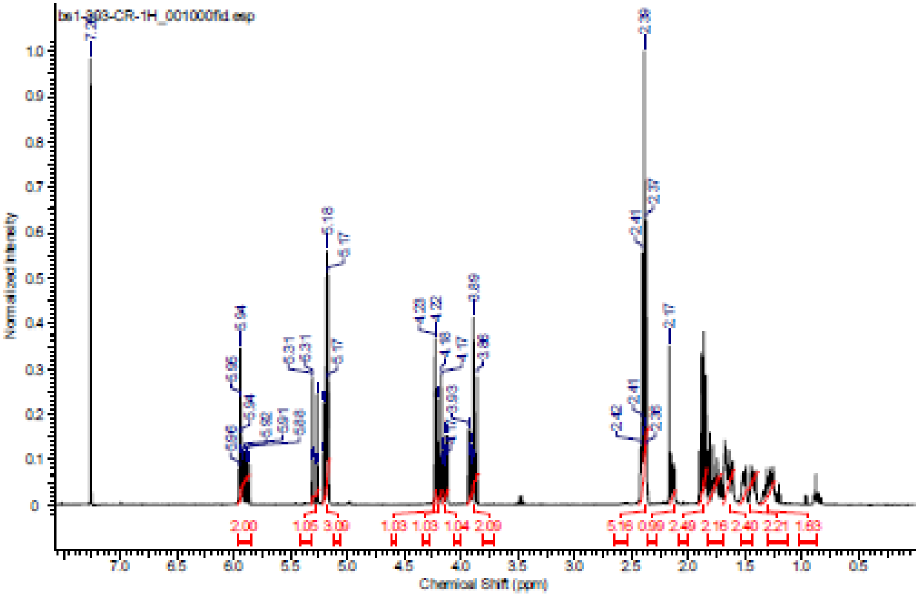


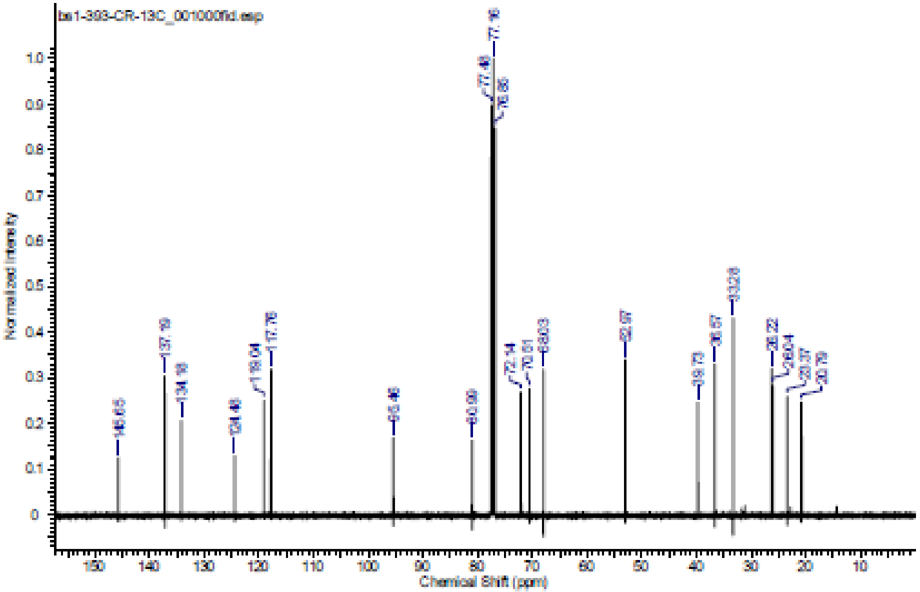
O
HO
H
O

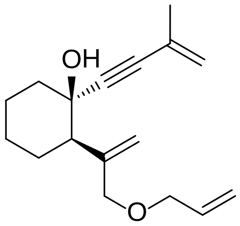


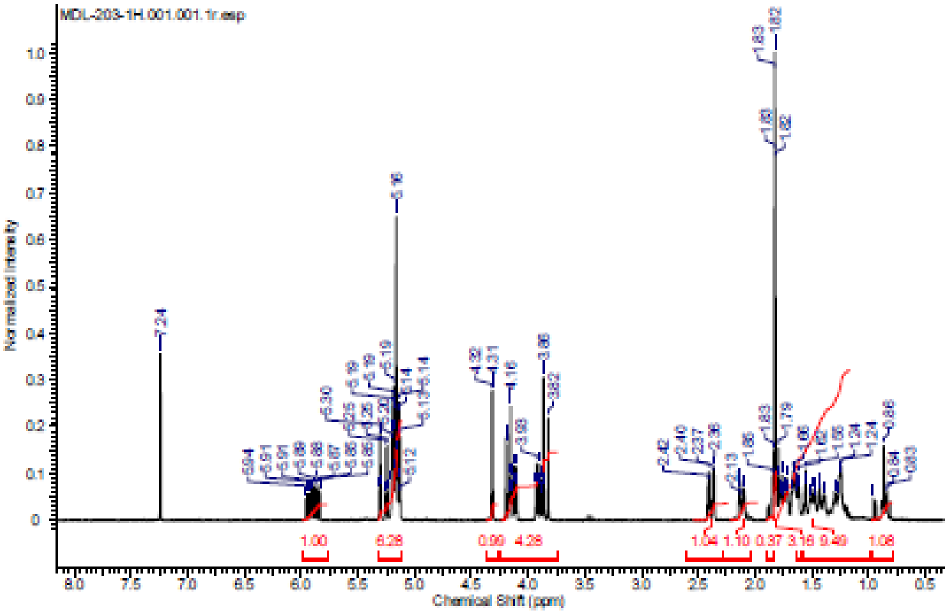
F
HO
H
O
O
Normalized Intensity
Chemical Shift (ppm)
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
206.65
206.61
206.41
154.27
154.05
137.67
134.60
134.13
132.66
129.51
128.91
127.97
125.67
125.23
124.60
123.28
120.73
119.96
119.31
119.13
118.25
90.54
90.41
90.24
77.00
51.83
50.71
45.20
42.46
41.99
39.88
37.03
36.88
32.36
31.79
31.01
28.73
26.26
25.84
23.50
22.70
22.45

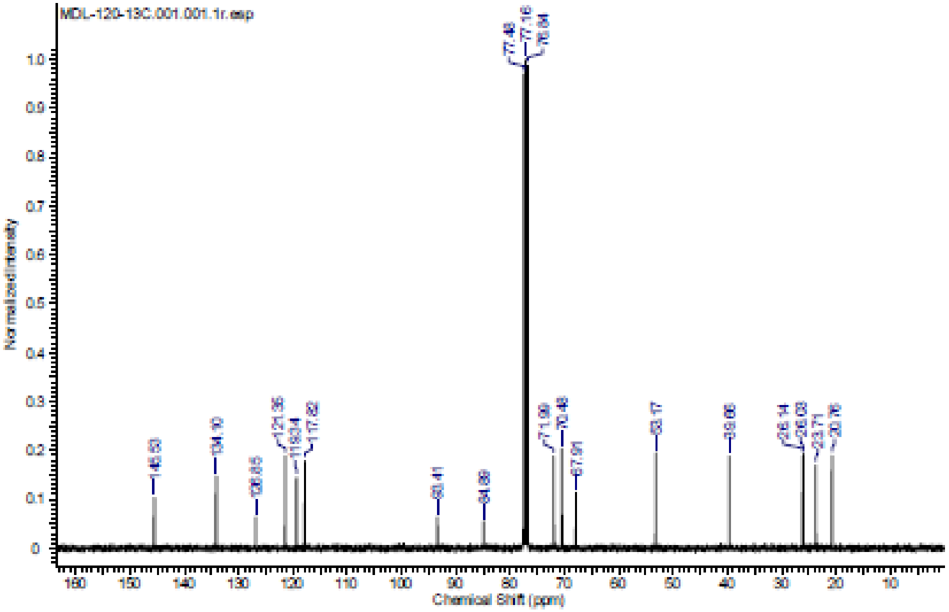

OH
O

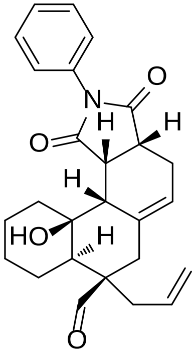

bs1-393-CR-1H_001000fid.esp
Normalized Intensity
Chemical Shift (ppm)
7.26
5.96
5.95
5.94
5.94
5.92
5.91
5.88
5.31
5.31
5.18
5.17
5.17
4.23
4.22
4.19
4.17
4.17
3.93
3.89
3.86
2.42
2.41
2.41
2.39
2.37
2.36
2.17
2.00
1.05
3.09
1.03
1.03
1.04
2.09
5.16
0.99
2.40
2.16
2.40
2.21
1.83


bs1-393-CR-13C_001000fid.esp
Normalized Intensity
Chemical Shift (ppm)
145.65
137.19
134.16
124.40
119.04
117.76
95.46
80.99
77.48
77.16
76.85
72.14
70.61
68.03
52.97
39.73
36.67
33.28
26.22
26.04
23.37
20.79

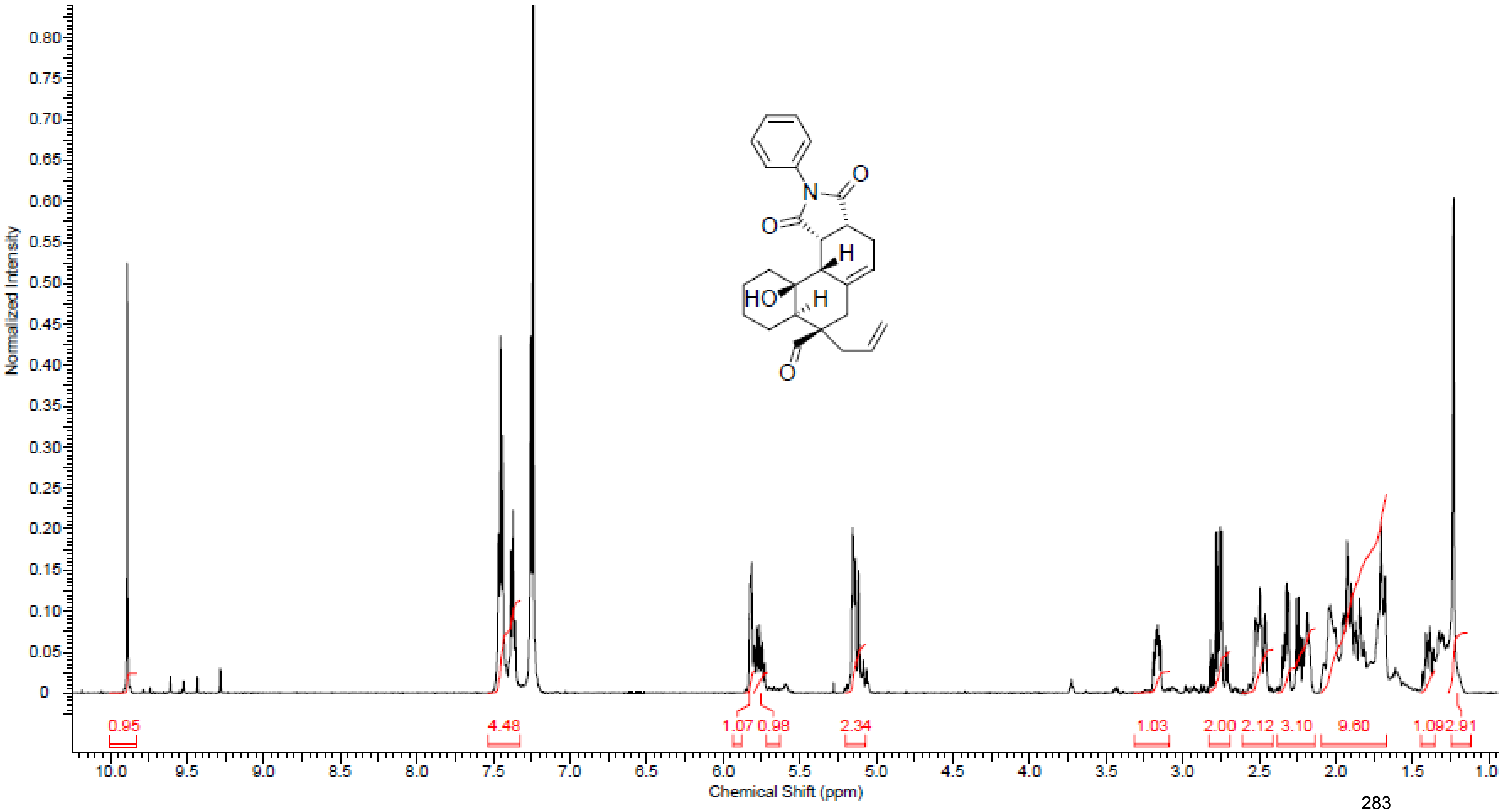

OH
O


MDL-203-1H.001.001.1r.esp
Normalized Intensity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
7.24
5.94
5.91
5.91
5.89
5.88
5.87
5.86
5.85
5.30
5.25
5.20
5.20
5.19
5.19
5.19
5.16
5.14
5.14
5.13
5.12
4.32
4.31
4.16
3.93
3.86
3.82
2.42
2.40
2.37
2.36
2.13
1.86
1.83
1.83
1.82
1.83
1.82
1.79
1.66
1.62
1.58
1.24
1.24
0.86
0.84
0.83
1.00
6.28
0.99
4.28
1.04
1.10
0.37
3.16
9.49
1.08
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

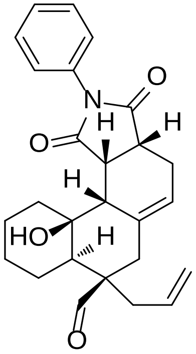

MDL-120-13C.001.001.1r.esp
Normalized Intensity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
145.53
134.10
126.65
121.36
119.34
117.82
93.41
84.89
77.48
77.16
76.84
71.99
70.48
67.91
53.17
39.66
26.14
26.03
23.71
20.76
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Chemical Shift (ppm)

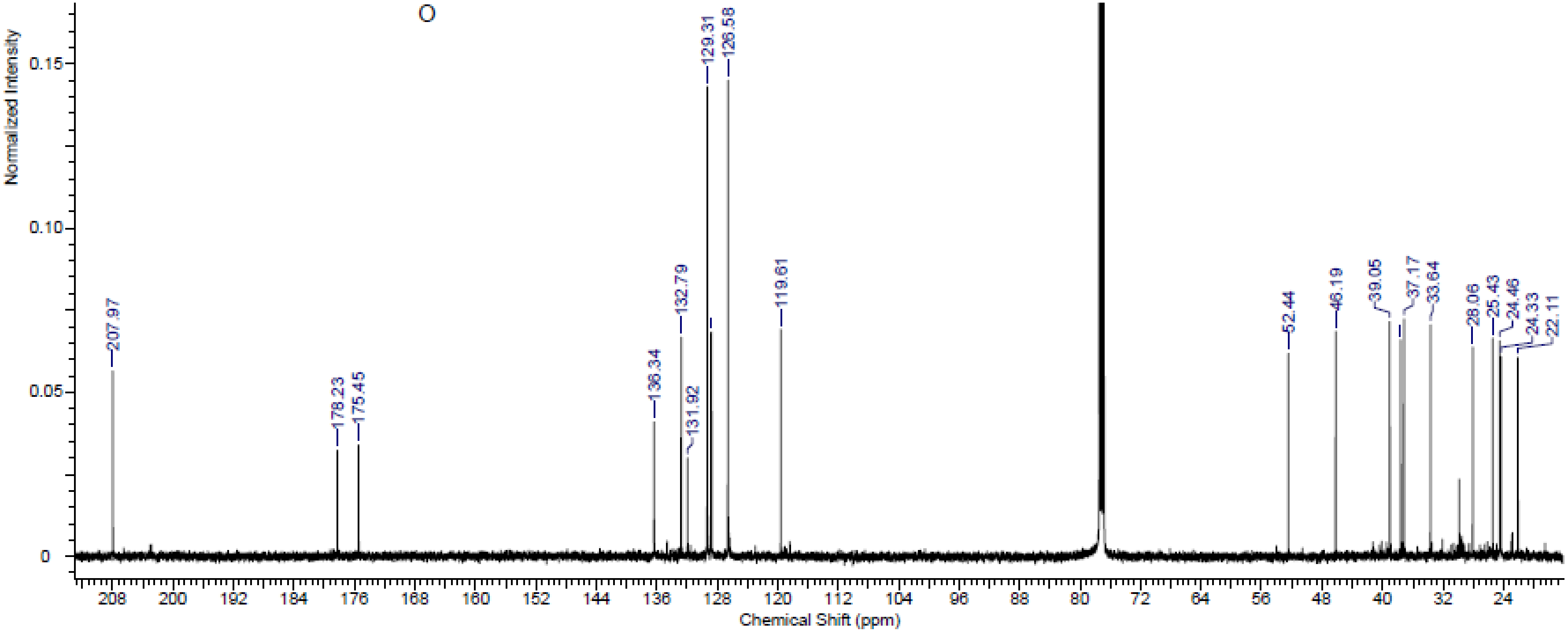


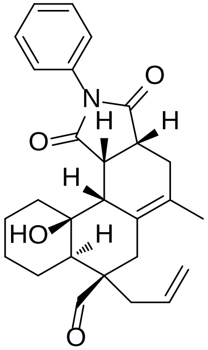
O
N
H
H
O
H
HO
H
O

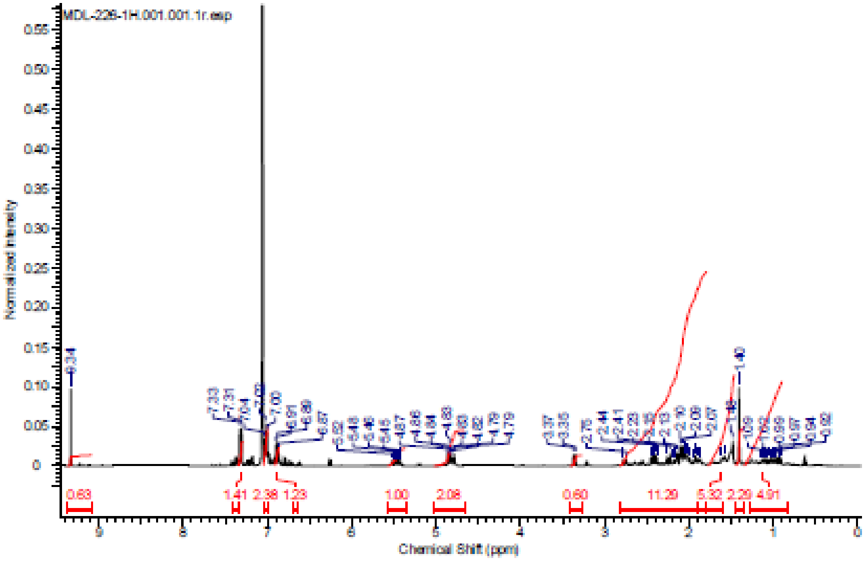


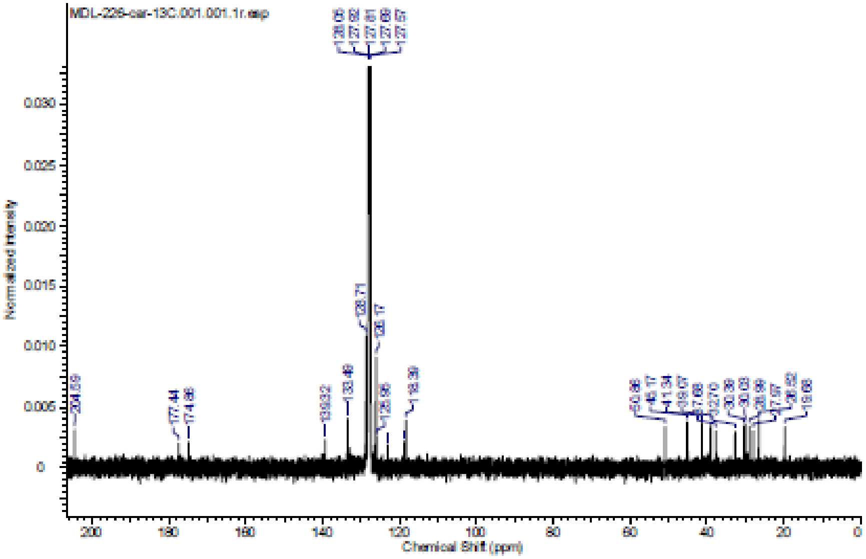
Normalized Intensity
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
0.95
4.48
1.07
0.98
2.34
1.03
2.00
2.12
3.10
9.60
1.09
2.91
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Chemical Shift (ppm)
N
O
O
H
HO
H
O

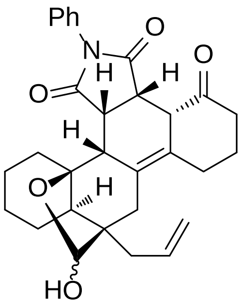

O
N
H
H
O
H
HO
H

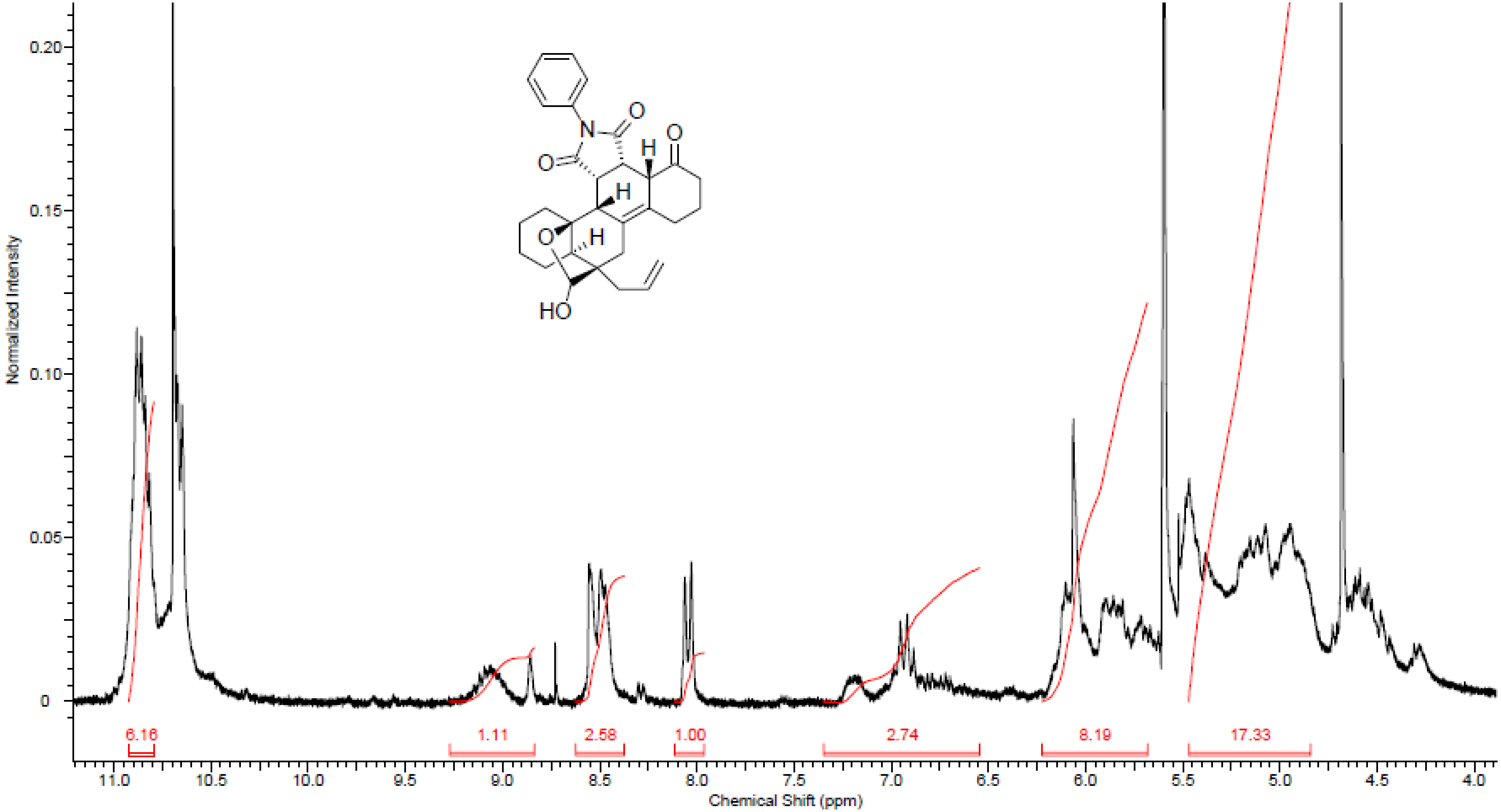

O
Normalized Intensity
0.15
0.10
0.05
0
207.97
178.23
175.45
136.34
132.79
131.92
129.31
128.58
119.61
52.44
46.19
39.05
37.17
33.64
28.06
25.43
24.46
24.33
22.11
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
Chemical Shift (ppm)

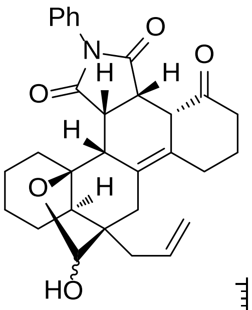

N
O
O
H
H
H
HO
H
O

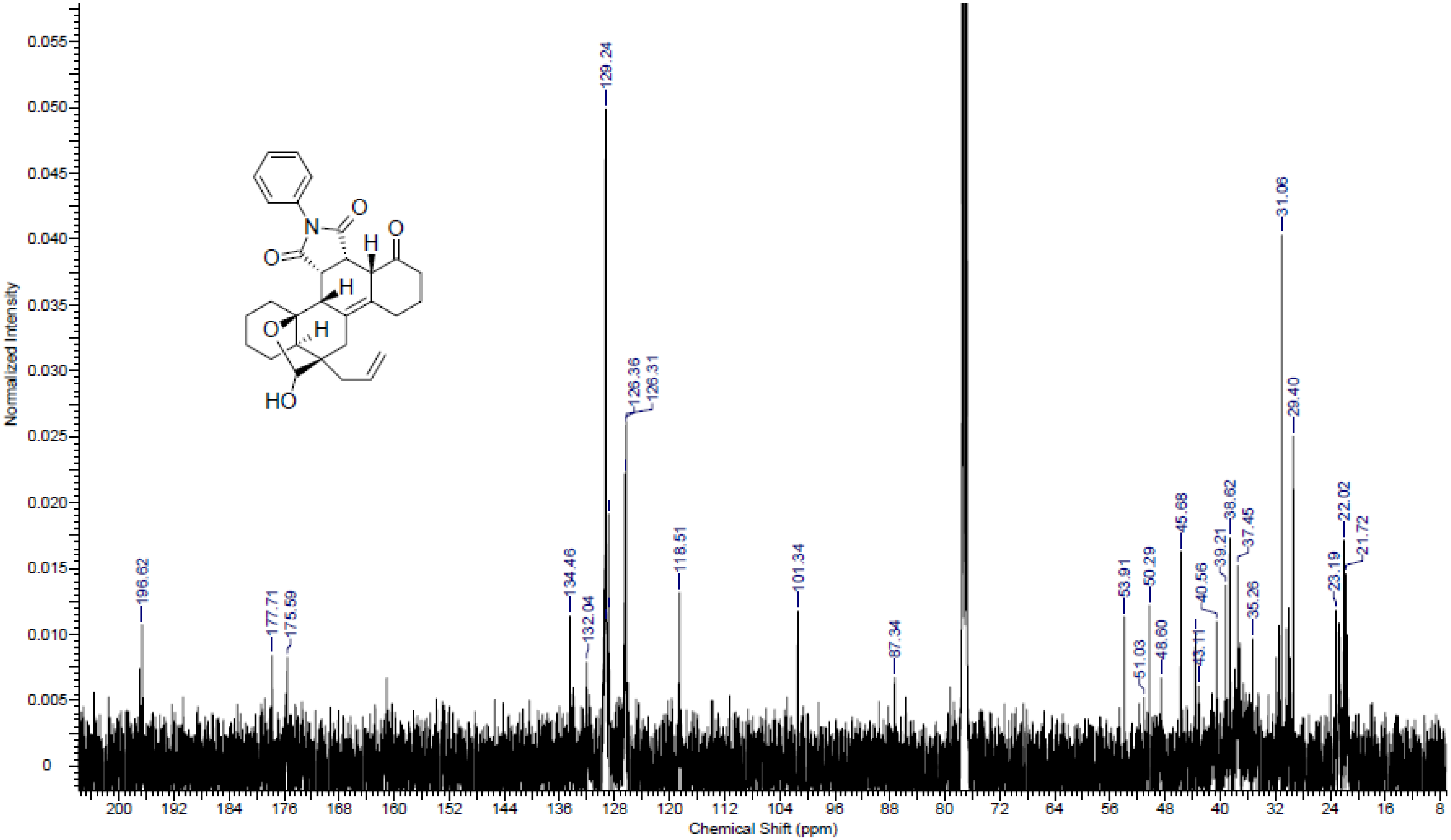

MDL-226-1H.001.001.1r.esp
Normalized Intensity
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
9.34
7.33
7.31
7.00
1.40
0.63
1.41
2.38
1.23
1.00
2.08
0.60
11.29
5.32
2.29
4.91
9
8
7
6
5
4
3
2
1
0
Chemical Shift (ppm)

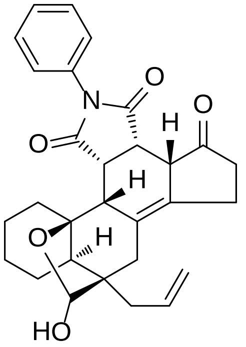

MDL-226-car-13C.001.001.1r.esp
Normalized Intensity
0.030
0.025
0.020
0.015
0.010
0.005
0
204.59
177.44
174.86
139.32
133.49
128.71
126.17
118.39
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)


Ph
N
O
O
H
H
O
H
O
H
HO

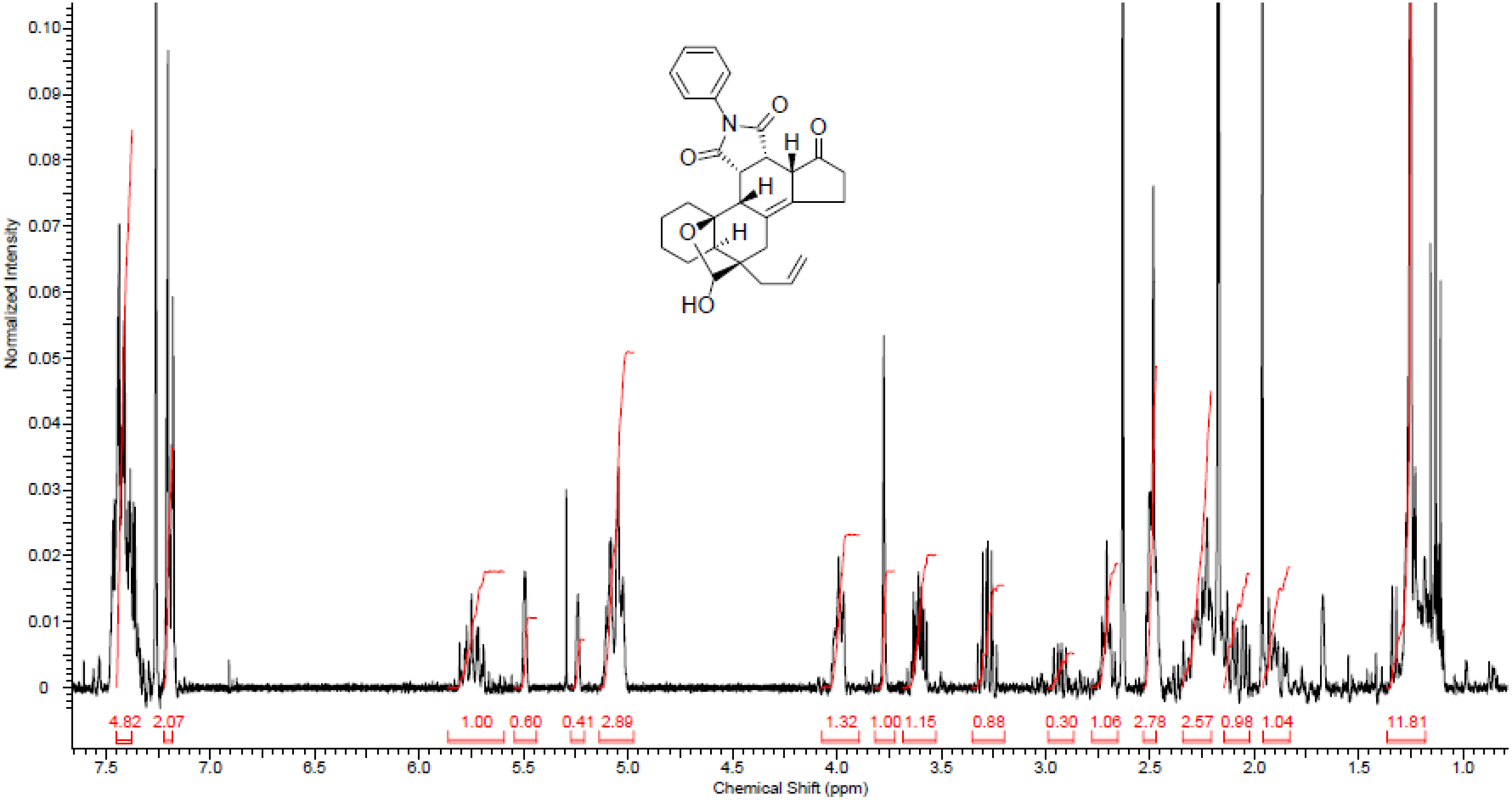

Normalized Intensity
0.20
0.15
0.10
0.05
0
6.16
1.11
2.58
1.00
2.74
8.19
17.33
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
Chemical Shift (ppm)
N
O
O
O
H
H
O
H
HO


Ph
N
O
O
O
H
H
H
O
H
HO

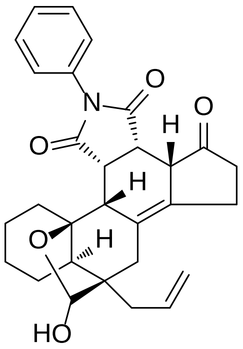

Normalized Intensity
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0
196.62
177.71
175.59
134.46
132.04
129.24
126.36
126.31
118.51
101.34
87.34
53.91
51.03
50.29
48.60
45.68
43.11
40.56
39.21
38.62
37.45
35.26
31.06
29.40
23.19
22.02
21.72
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)
N
O
O
O
H
H
O
H
HO



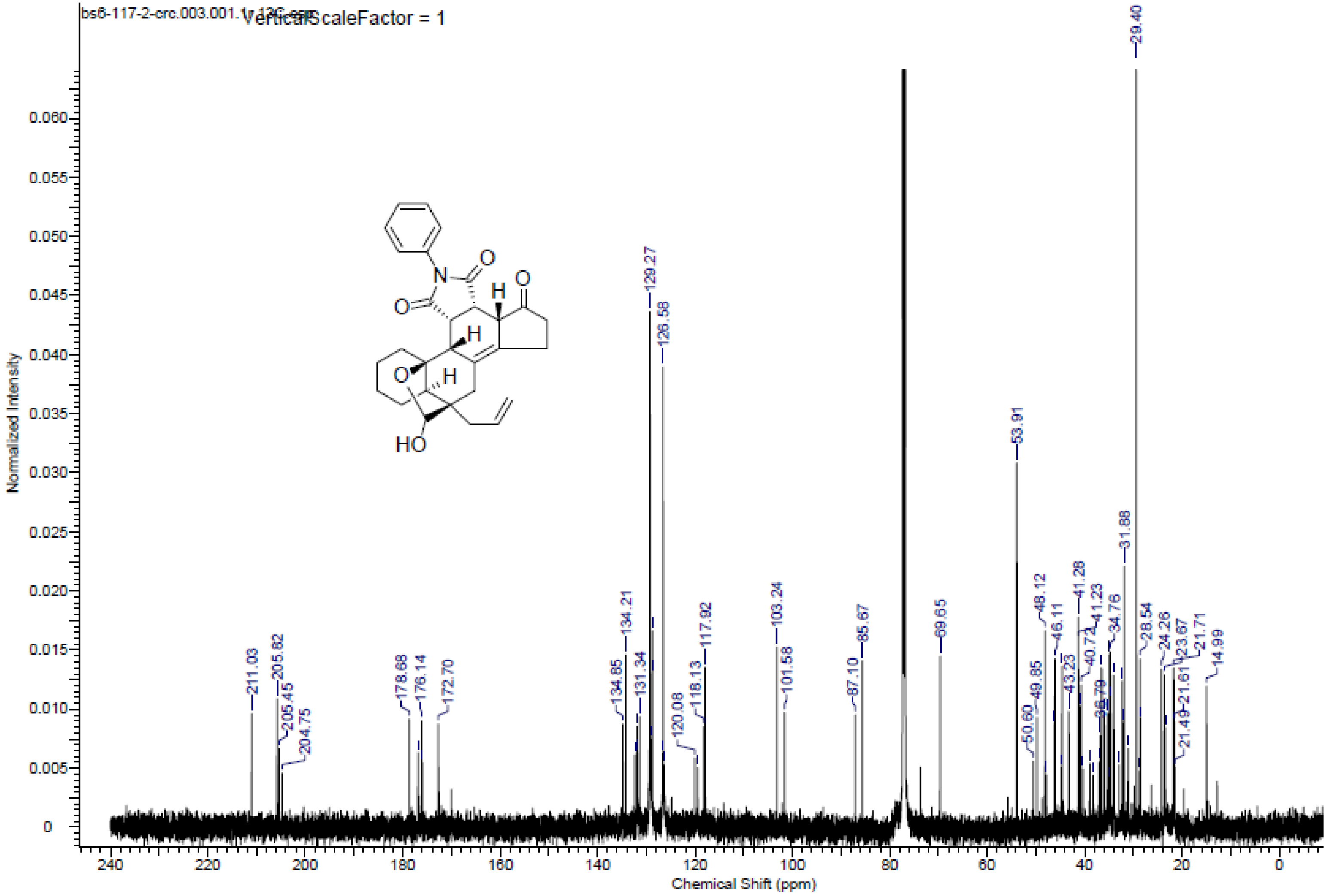
O
N
O
H
O
H
O
H
HO



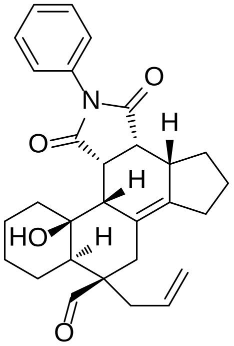
Normalized Intensity
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
4.82
2.07
1.00
0.60
0.41
2.89
1.32
1.00
1.15
0.88
0.30
1.06
2.78
2.57
0.98
1.04
11.81
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Chemical Shift (ppm)
O
N
O
H
O
H
O
H
HO

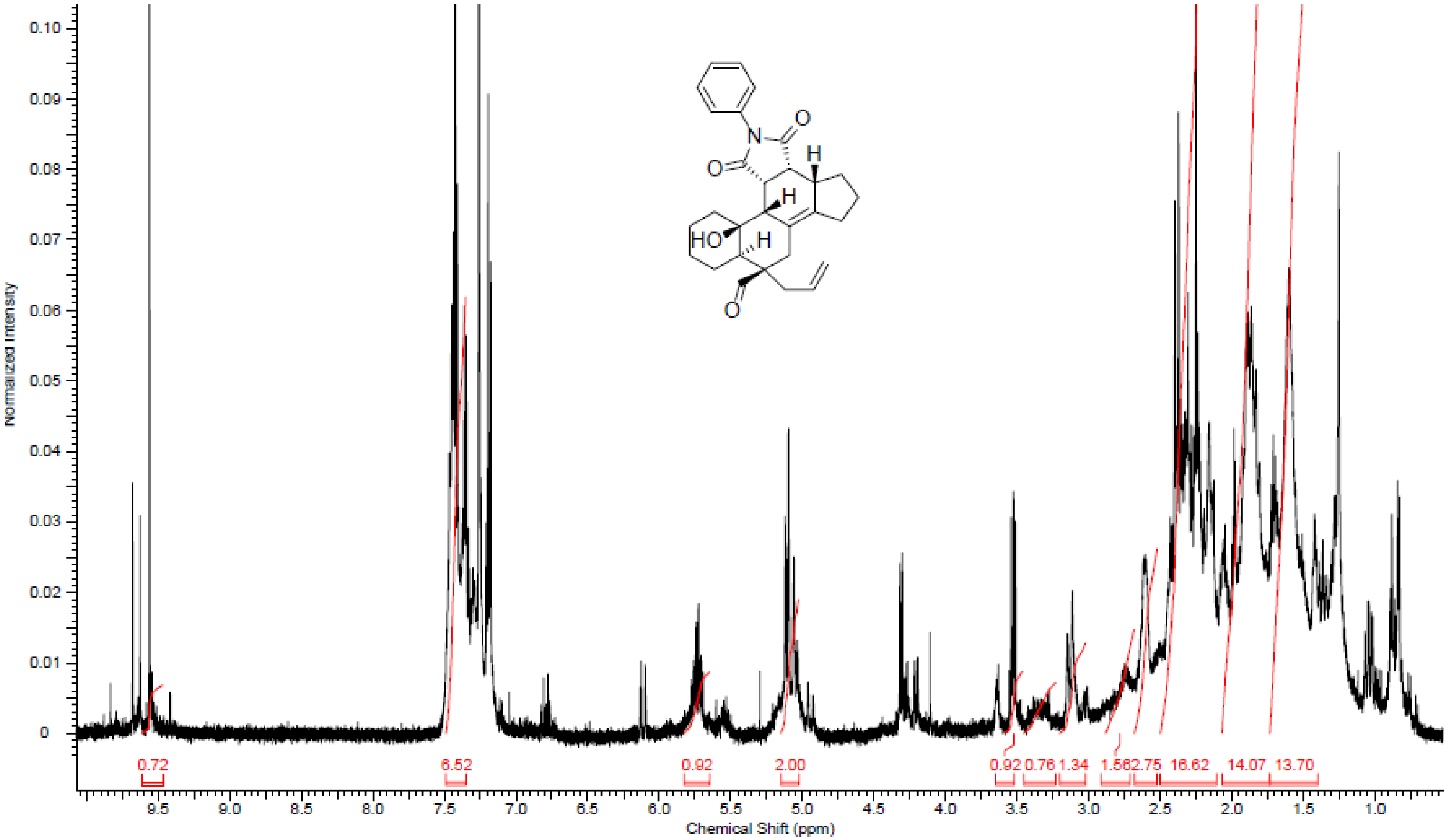


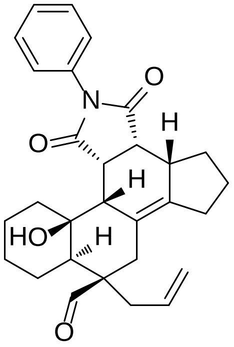
O
N
O
H
O
H
O
H
HO



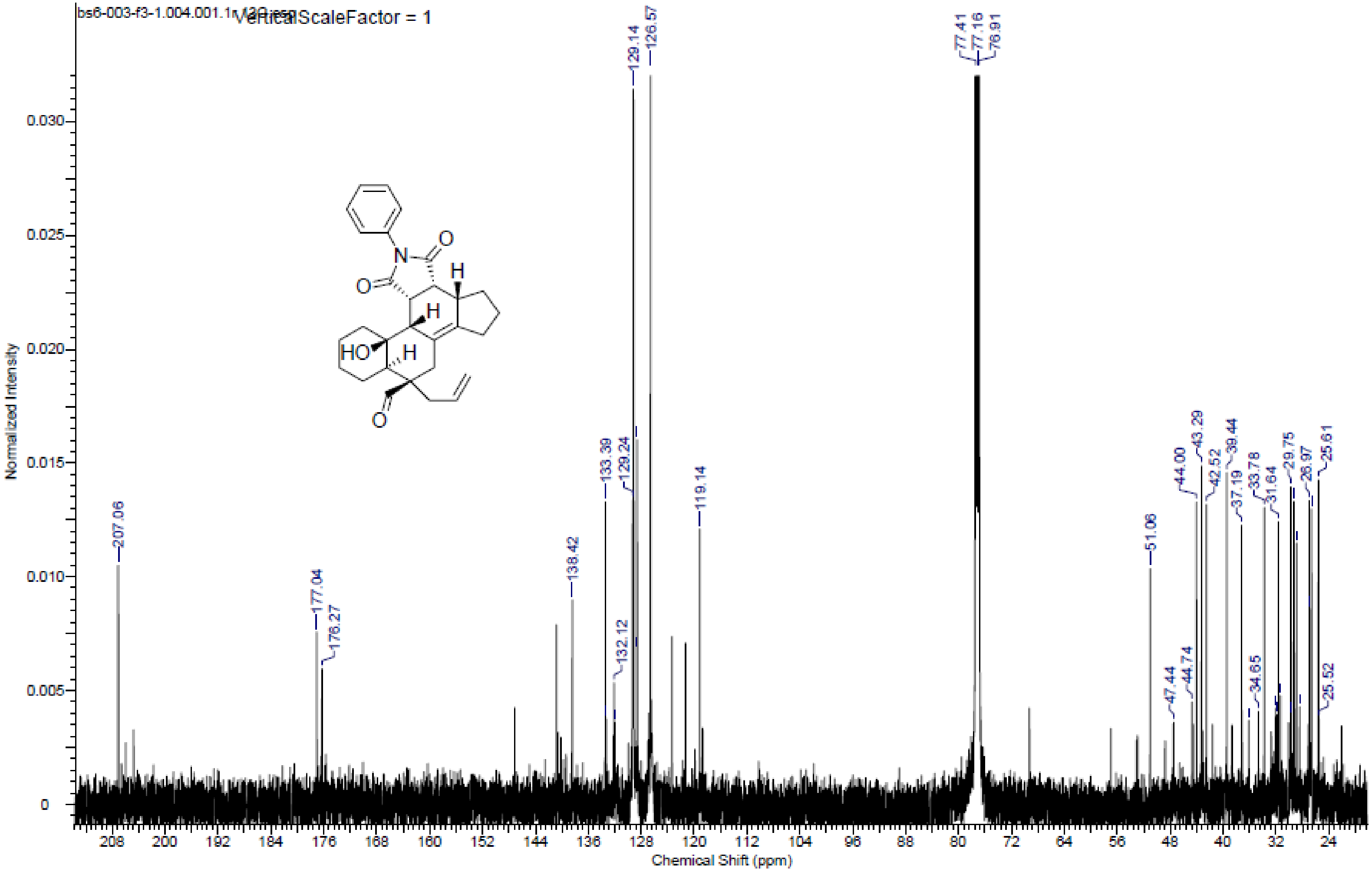
bs6-117-2-crc.003.001.1r.13C.esp
VerticalScaleFactor = 1
Normalized Intensity
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0
211.03
205.82
205.45
204.75
178.68
176.14
172.70
134.85
134.21
131.34
129.27
126.58
120.08
118.13
117.92
103.24
101.58
87.10
85.67
69.65
53.91
50.60
49.85
48.12
46.11
43.23
41.28
41.23
40.72
36.79
34.76
31.88
29.40
28.54
24.26
23.67
21.71
21.61
21.49
14.99
O
N
O
H
O
H
O
H
HO
240
220
200
180
160
140
120
100
80
60
40
20
0
Chemical Shift (ppm)


O
N
O
H
H
HO
H
O

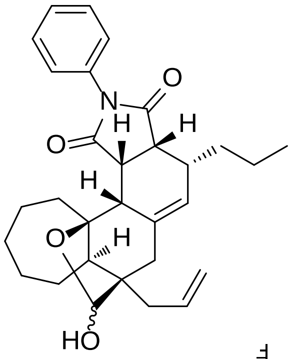

Normalized Intensity
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.72
6.52
0.92
2.00
0.92
0.76
1.34
1.56
2.75
16.62
14.07
13.70
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Chemical Shift (ppm)
O
N
O
H
H
HO
H
O

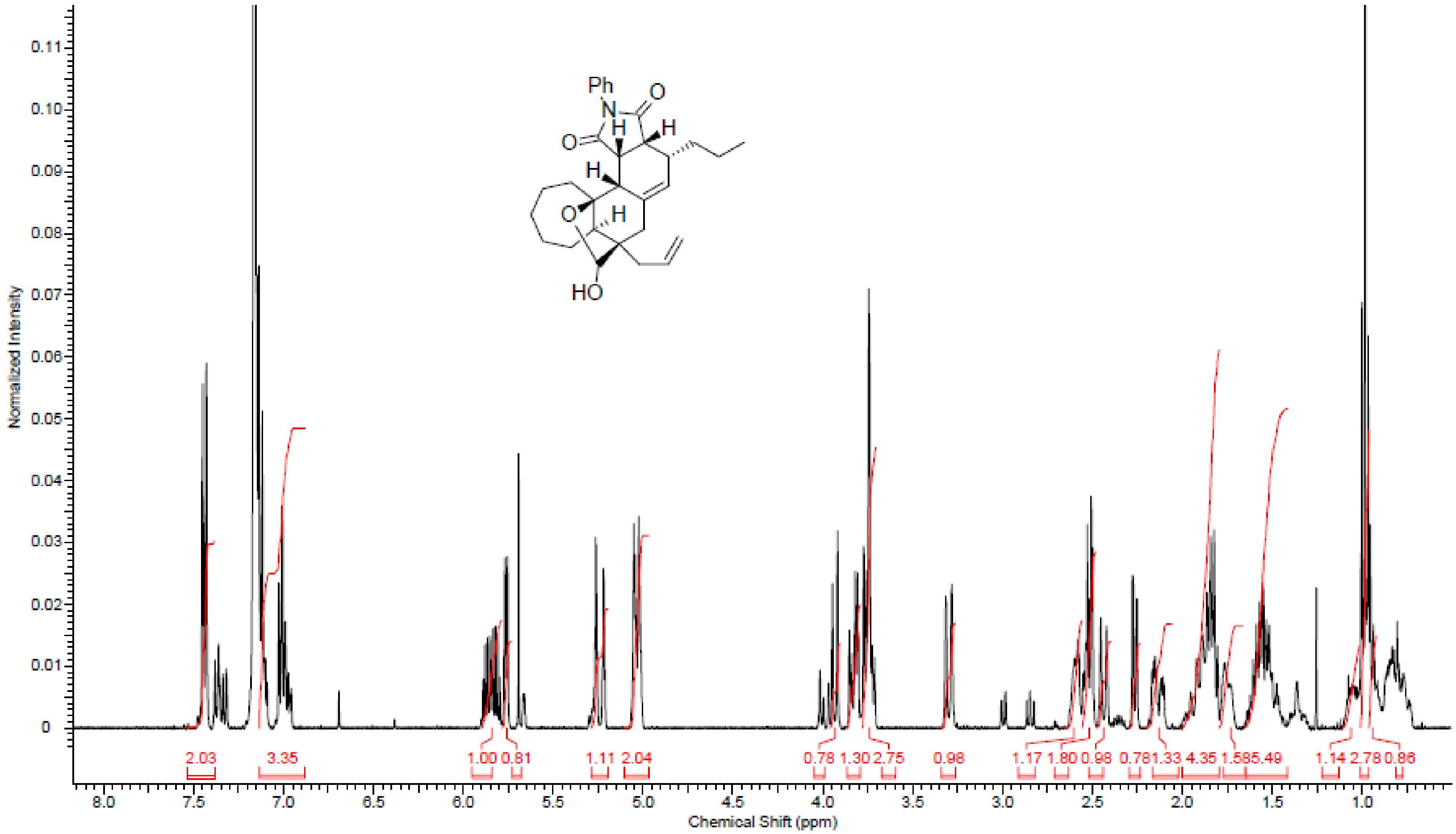


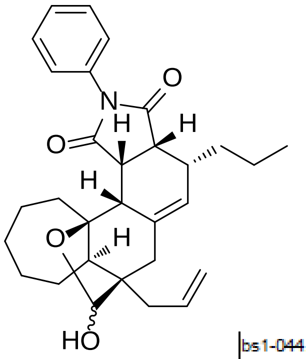
O
N
H
O
H
HO
H
O

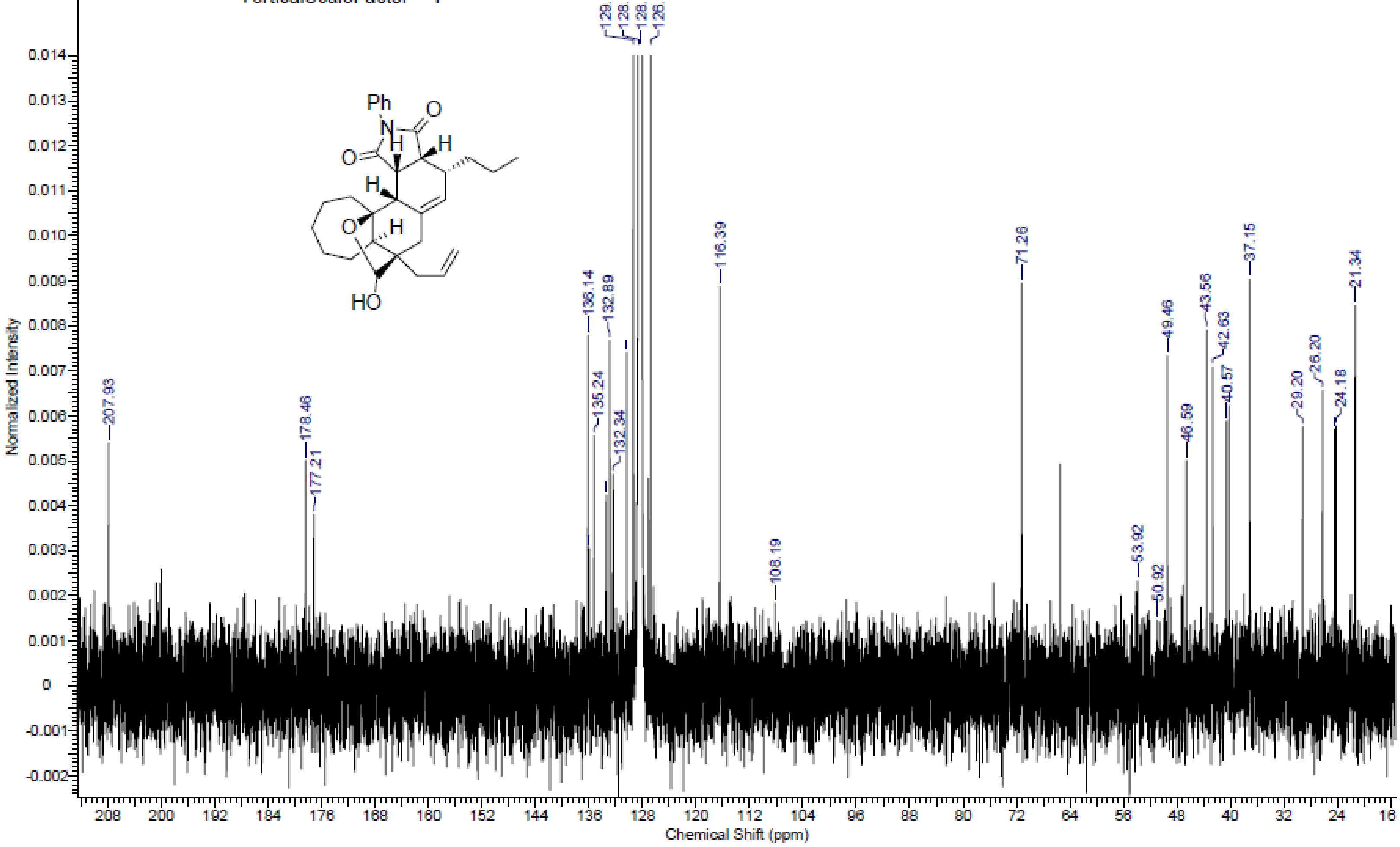


bs6-003-f3-1.004.001.1r.13C.esp
VerticalScaleFactor = 1
Normalized Intensity
0.030
0.025
0.020
0.015
0.010
0.005
0
Chemical Shift (ppm)
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
207.06
177.04
176.27
138.42
133.39
132.12
129.24
129.14
126.57
119.14
77.41
77.16
76.91
51.06
47.44
44.74
44.00
43.29
42.52
39.44
37.19
34.65
33.78
31.64
29.75
26.97
25.61
25.52
O
N
H
O
H
HO
H
O

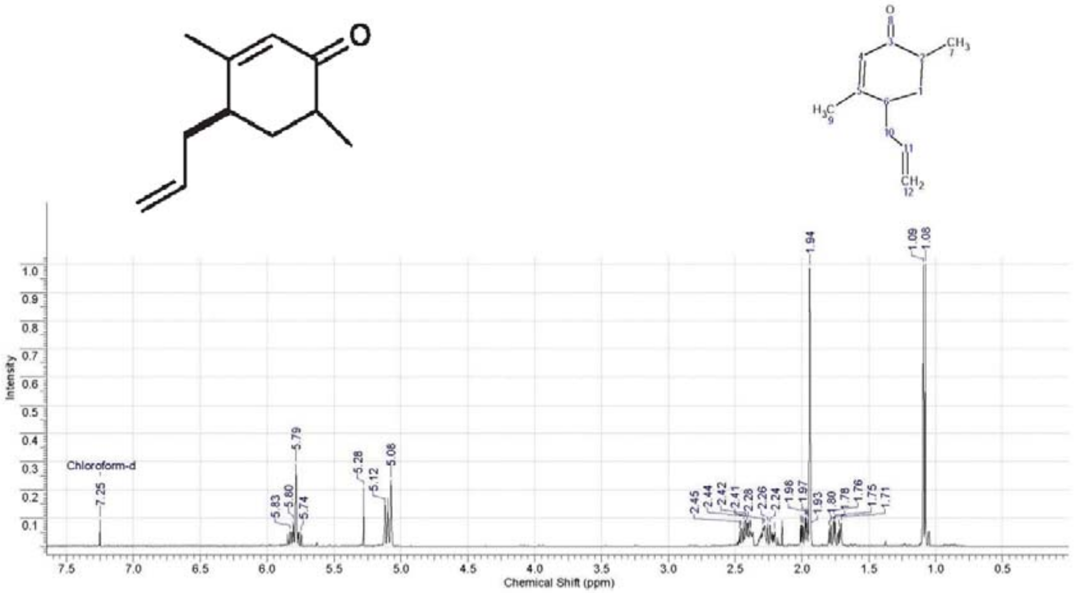

O
N
H
H
O
H
O
H
HO


Ph
N
O
H
H
O
H
O
H
HO
Normalized Intensity
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2.03
3.35
1.00
0.81
1.11
2.04
0.78
1.30
2.75
0.98
1.17
1.80
0.98
0.78
1.33
4.35
1.58
5.49
1.14
2.78
0.86
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Chemical Shift (ppm)

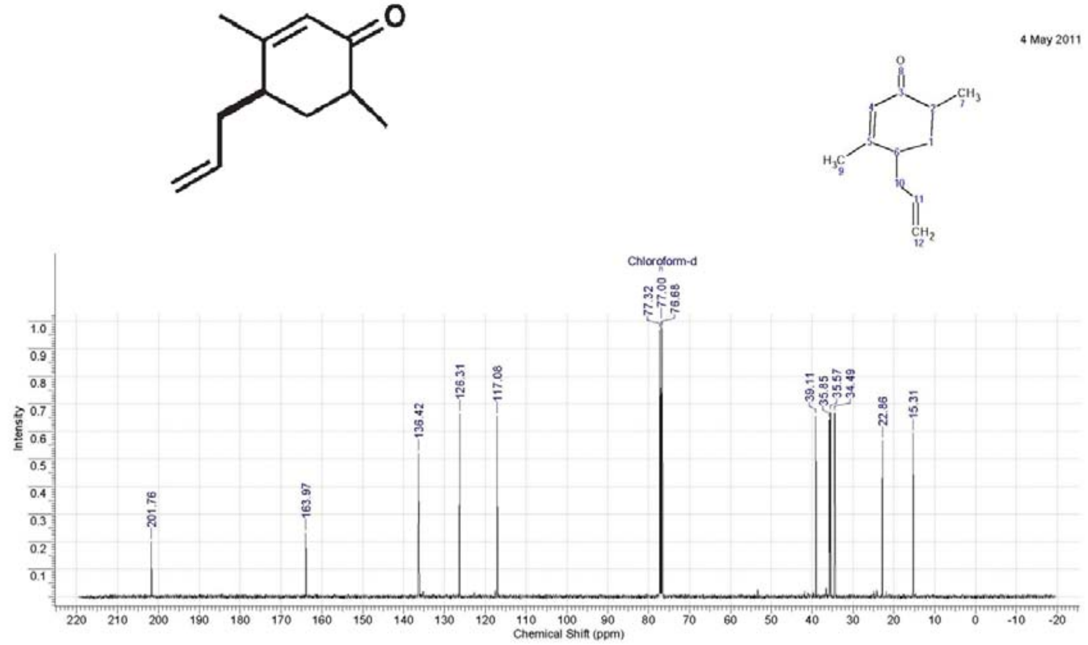



bs1-044.2_13C.001.001.1r.esp
VerticalScaleFactor = 1
Ph
N
O
H
HO
129.40
128.51
128.27
126.74
136.14
135.24
132.89
132.34
116.39
108.19
207.93
178.46
177.21
71.26
53.92
50.92
49.46
46.59
43.56
42.63
40.57
37.15
29.20
26.20
24.18
21.34
Normalized Intensity
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-0.001
-0.002
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

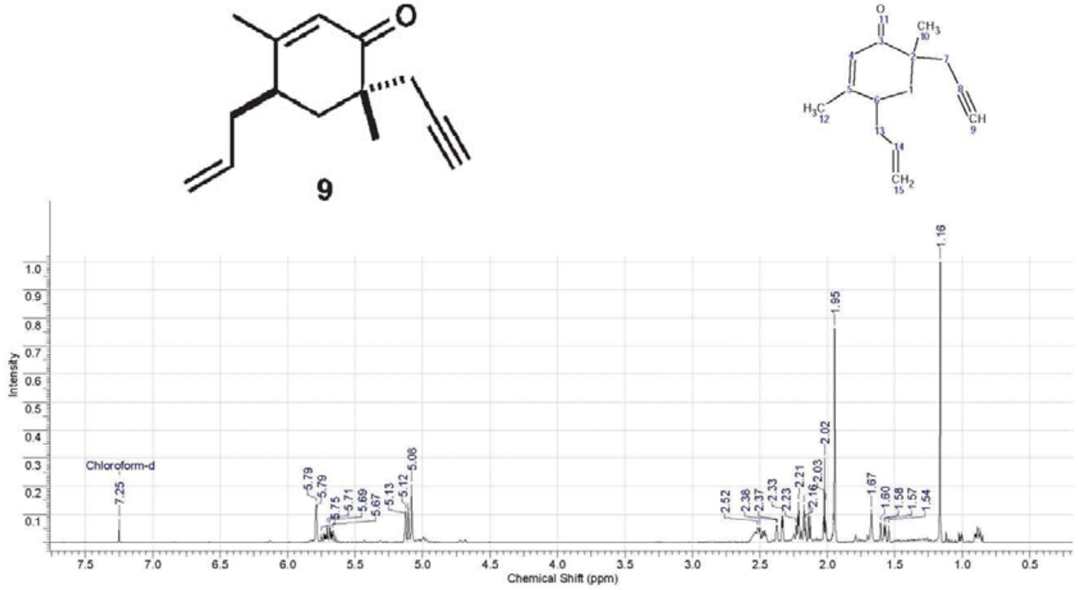
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)



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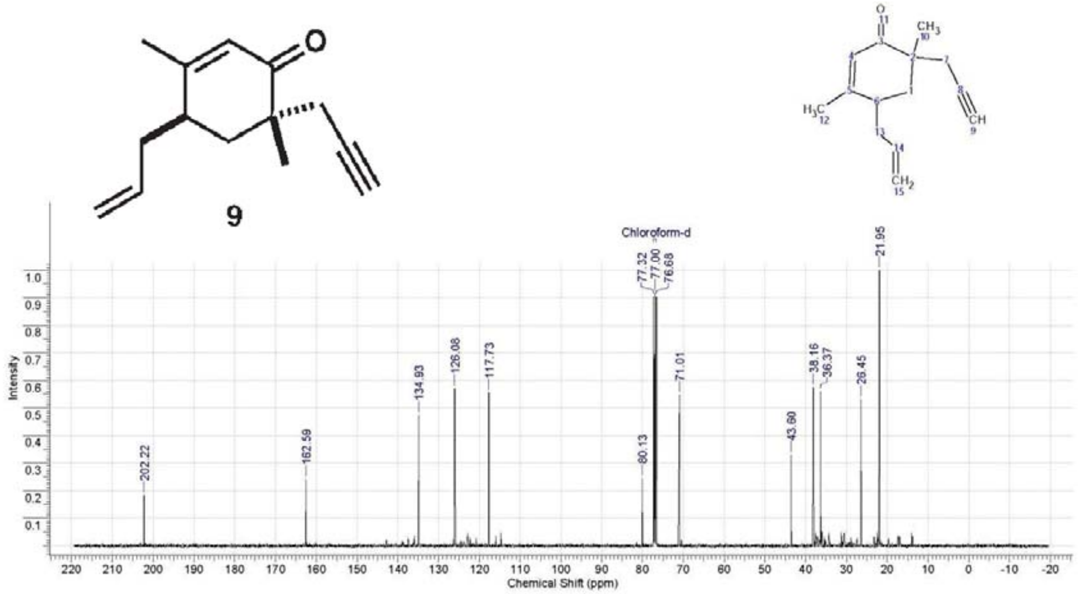
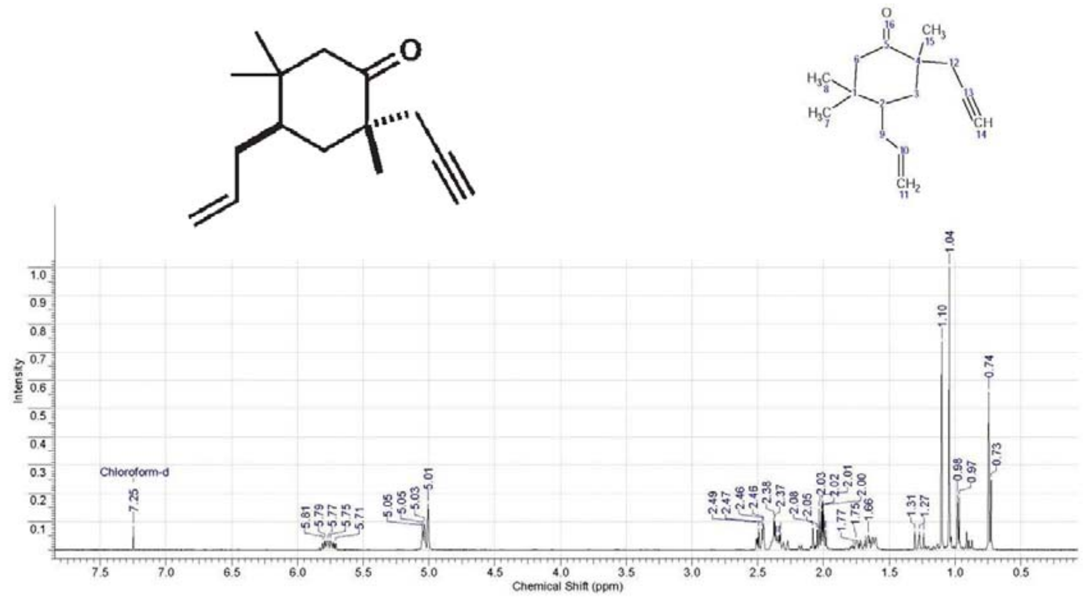
^{13}C NMR (101 MHz, $CDCl_3$)

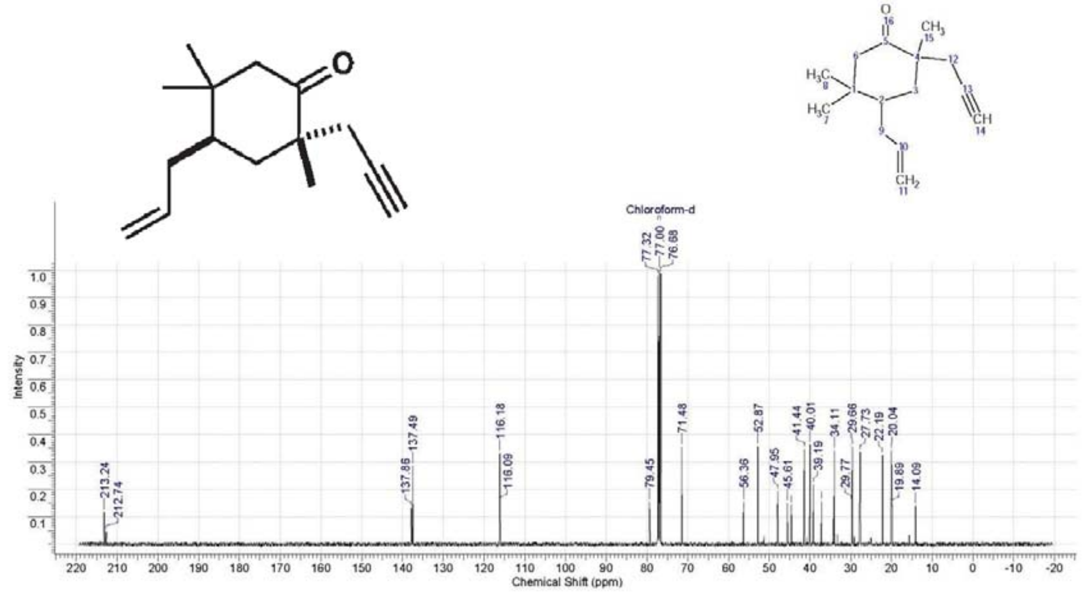


9

^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, CDCl$_3$)



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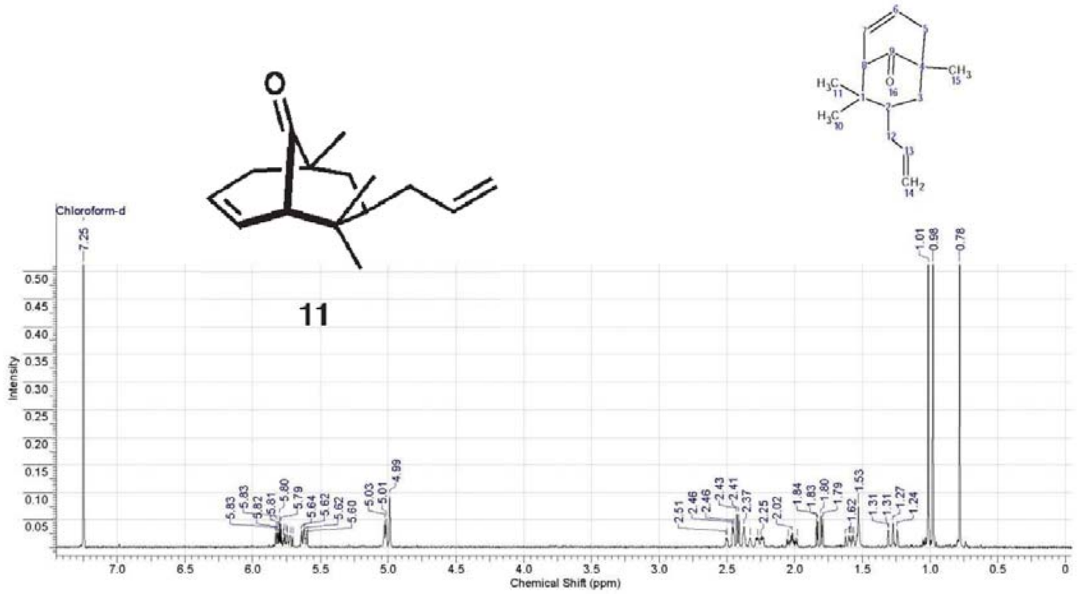

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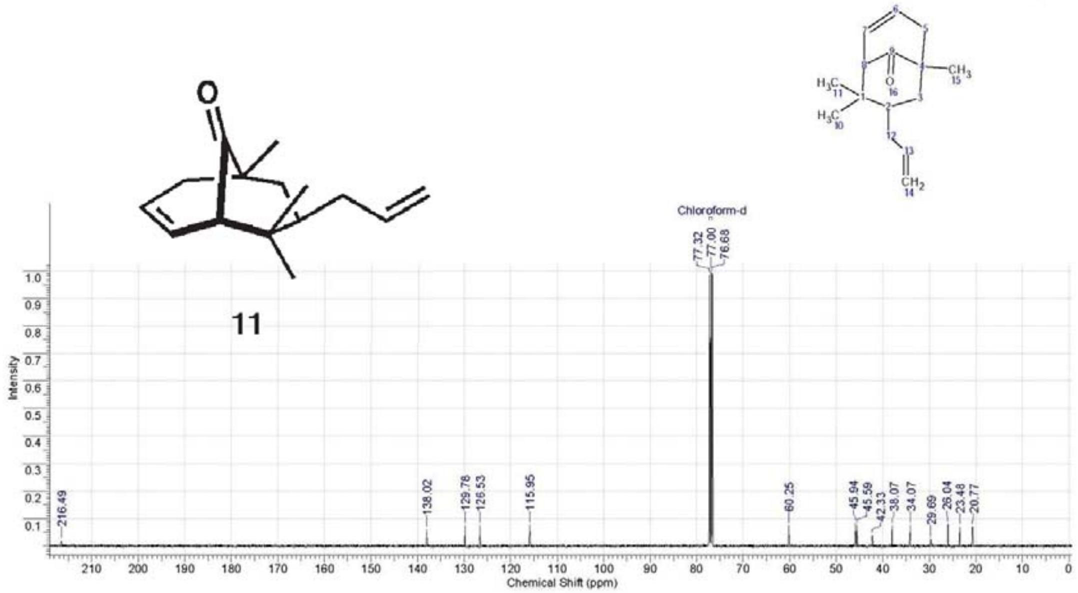

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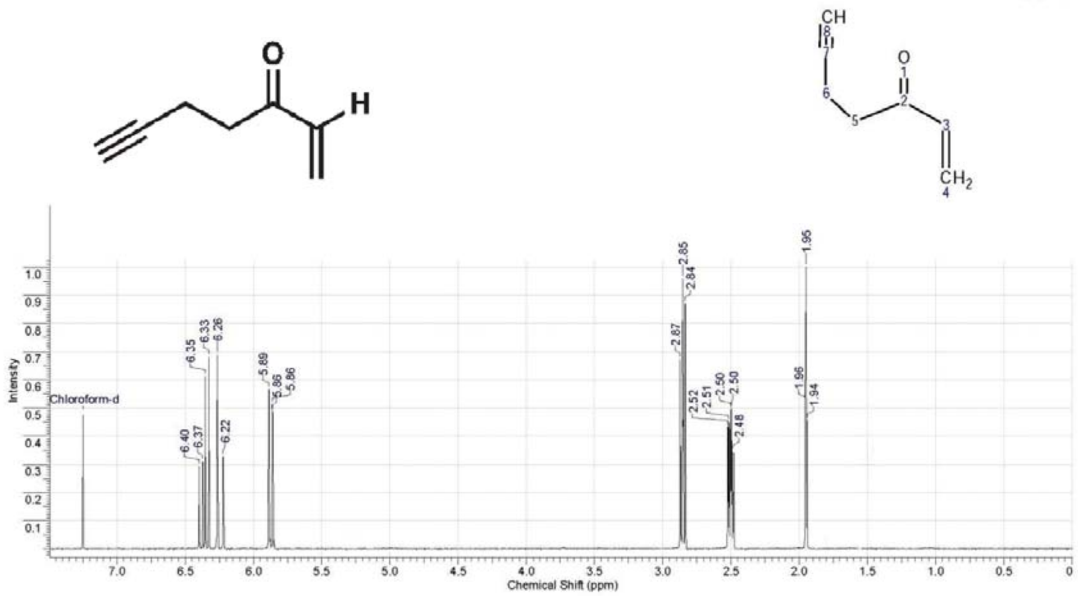

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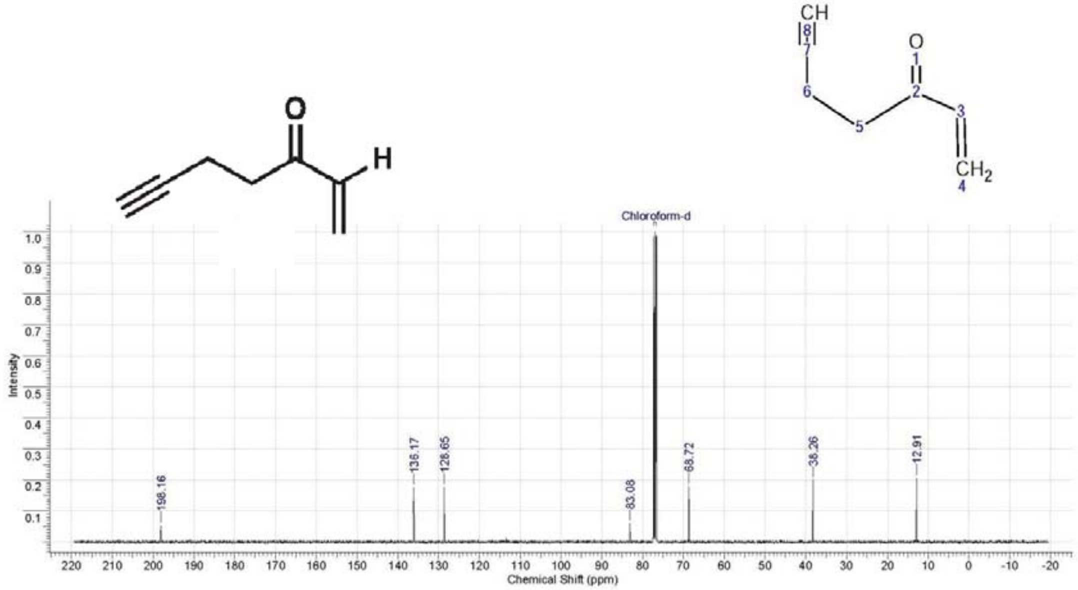

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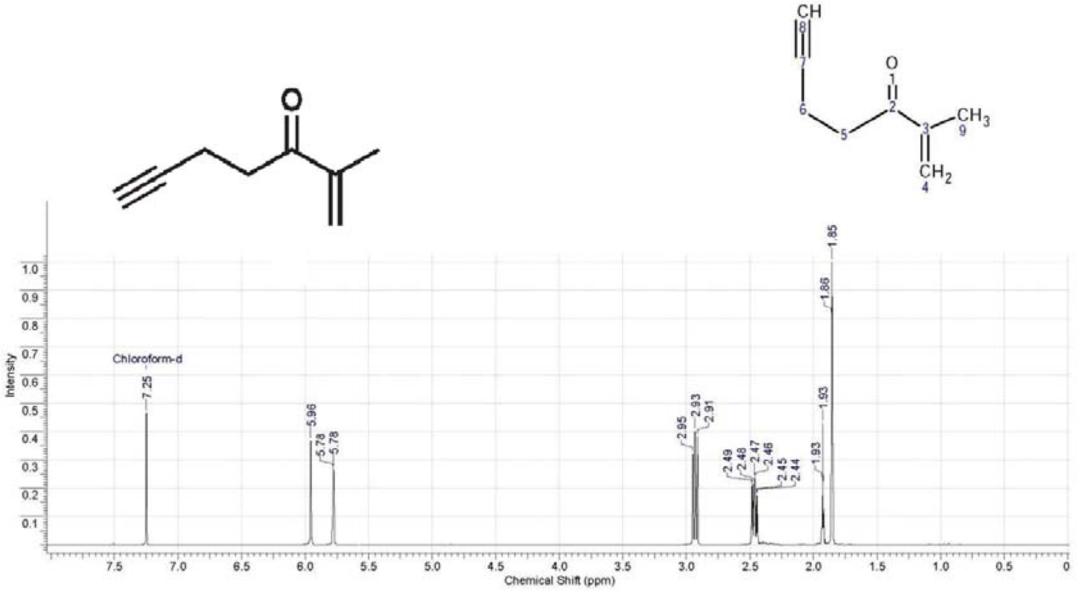

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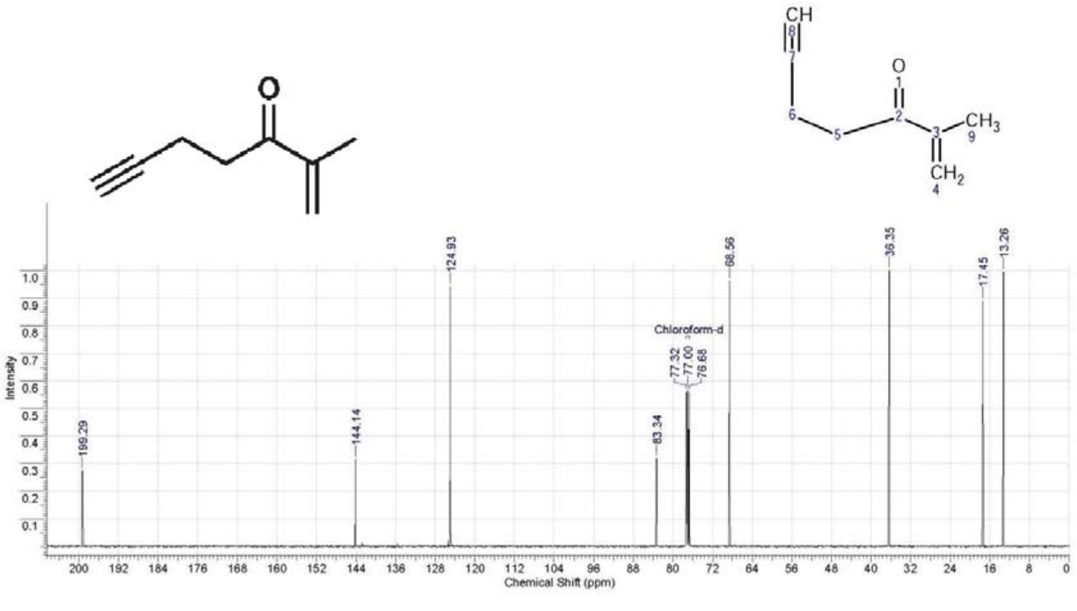

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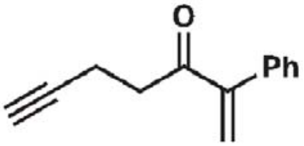

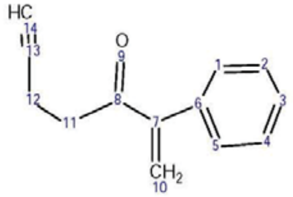

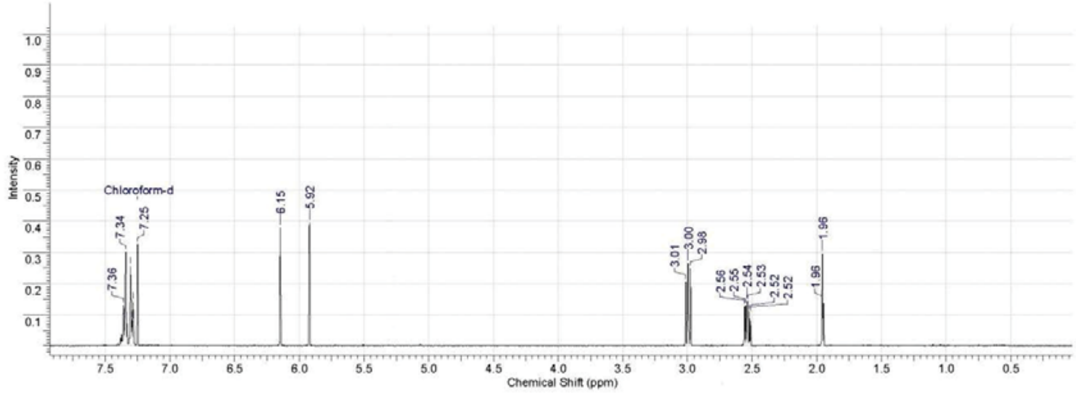

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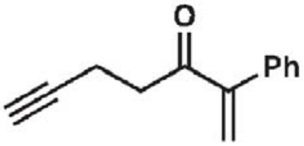

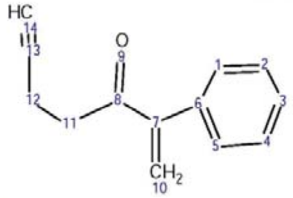

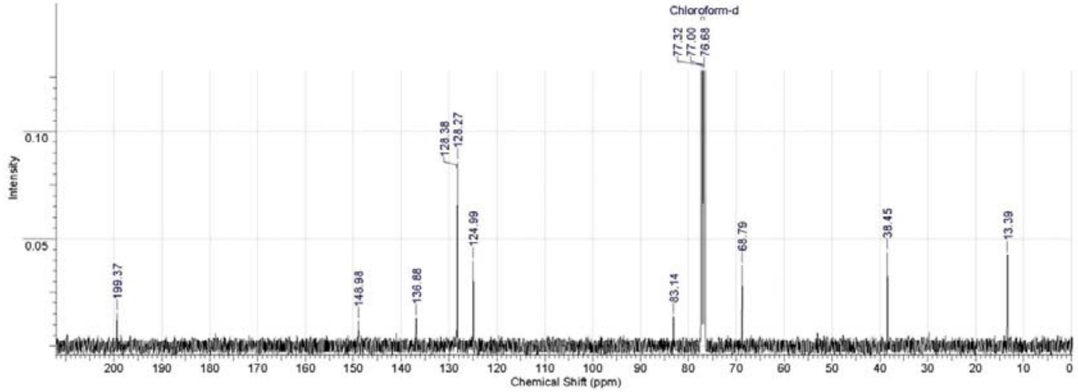

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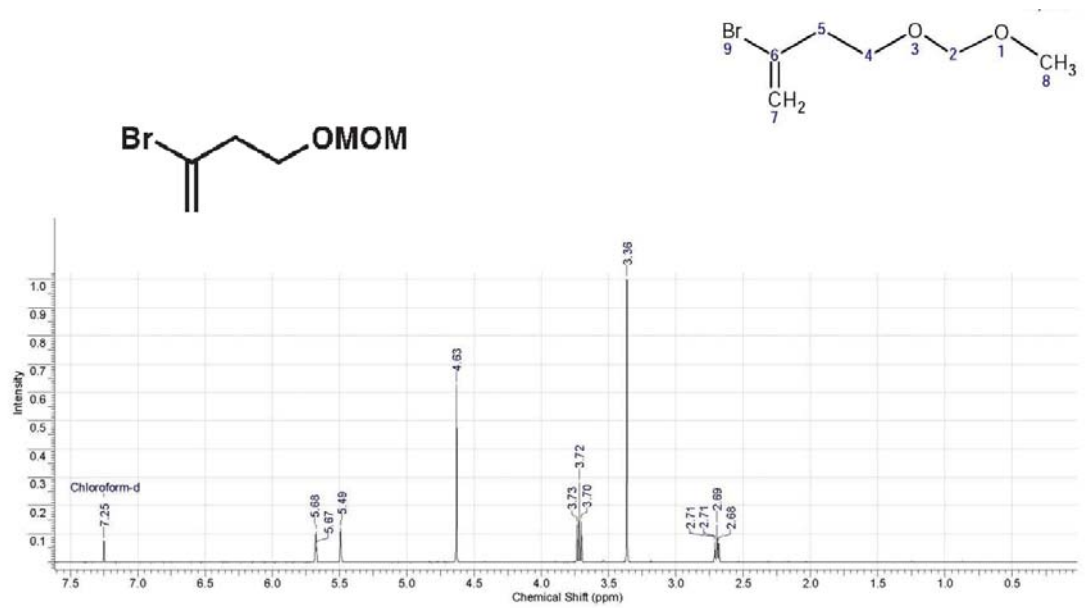

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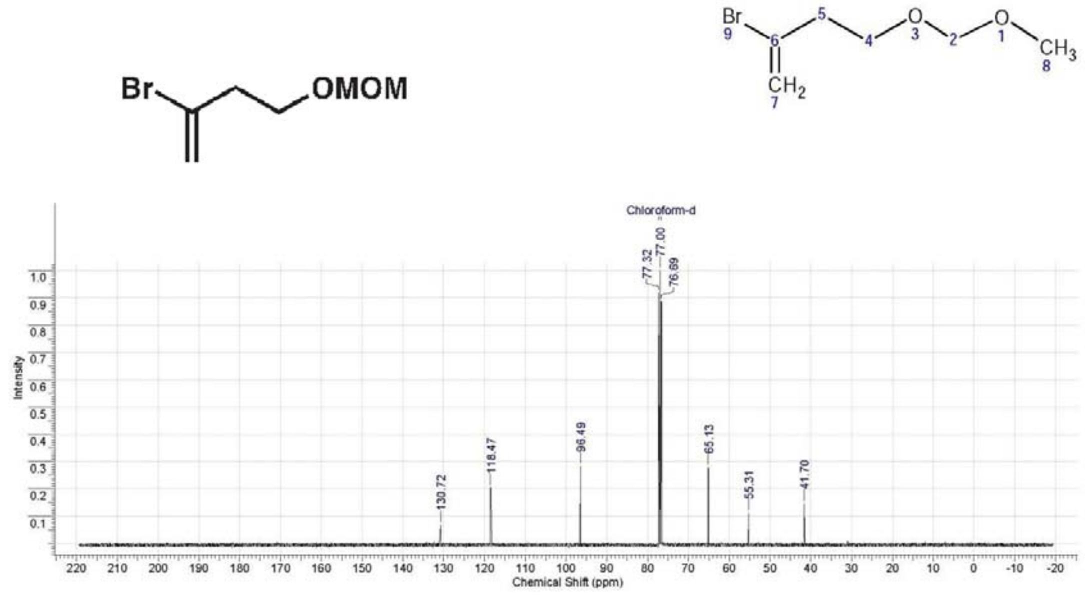

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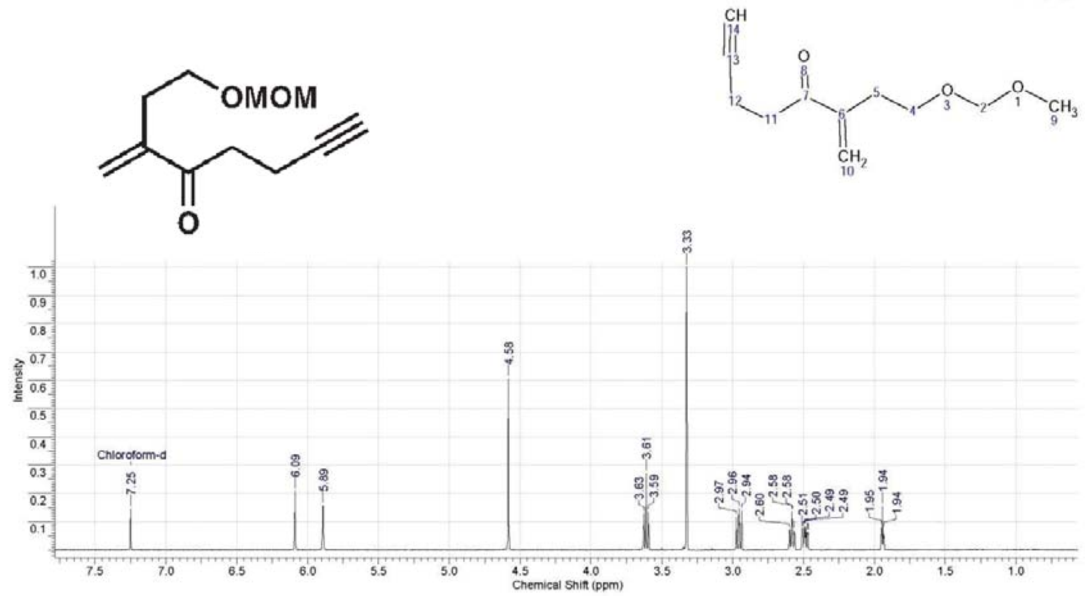

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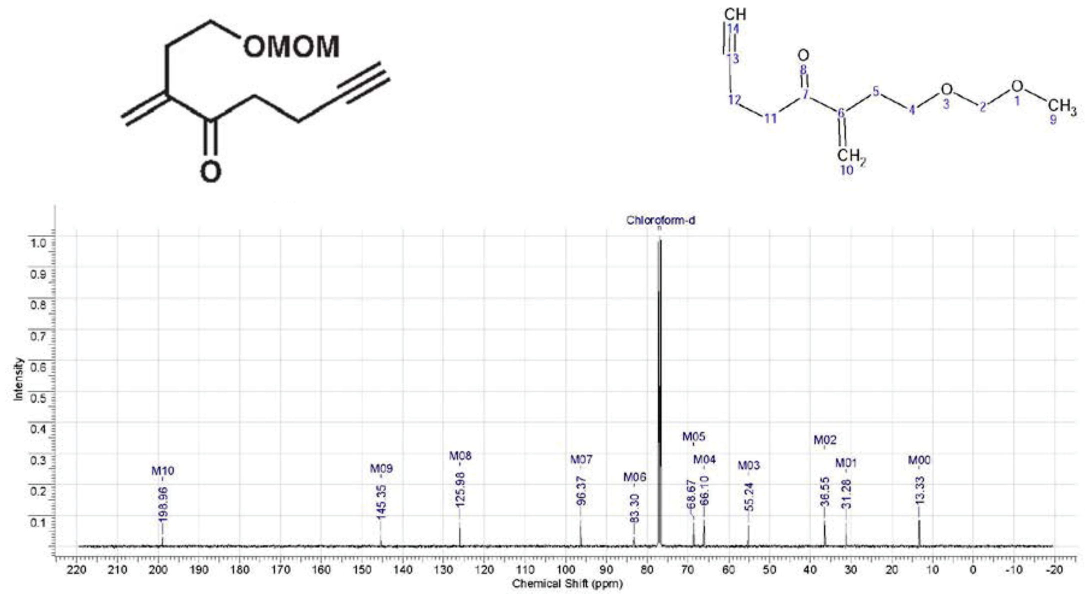

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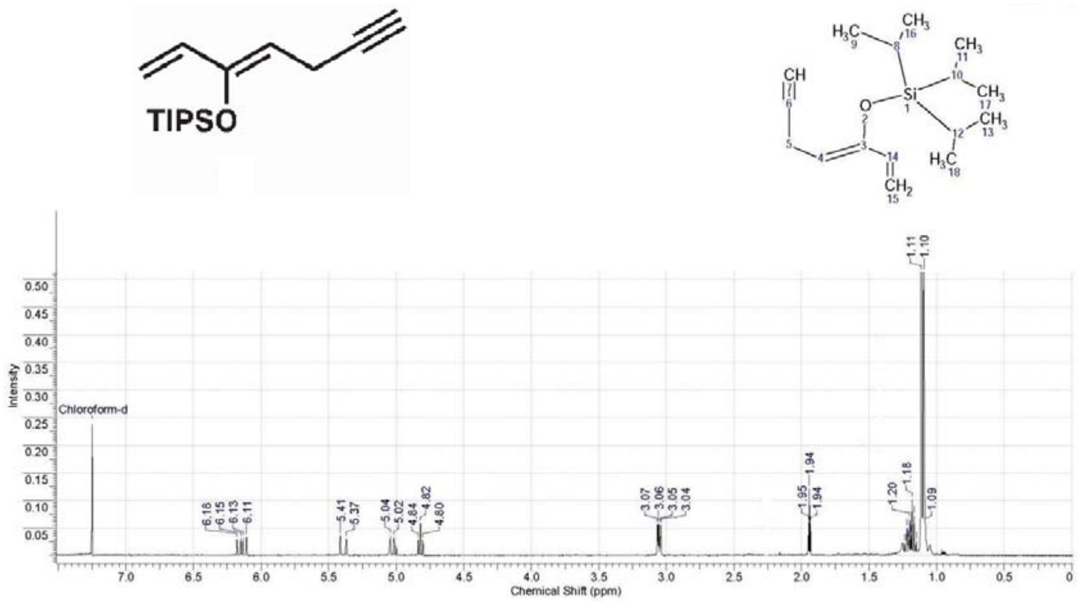

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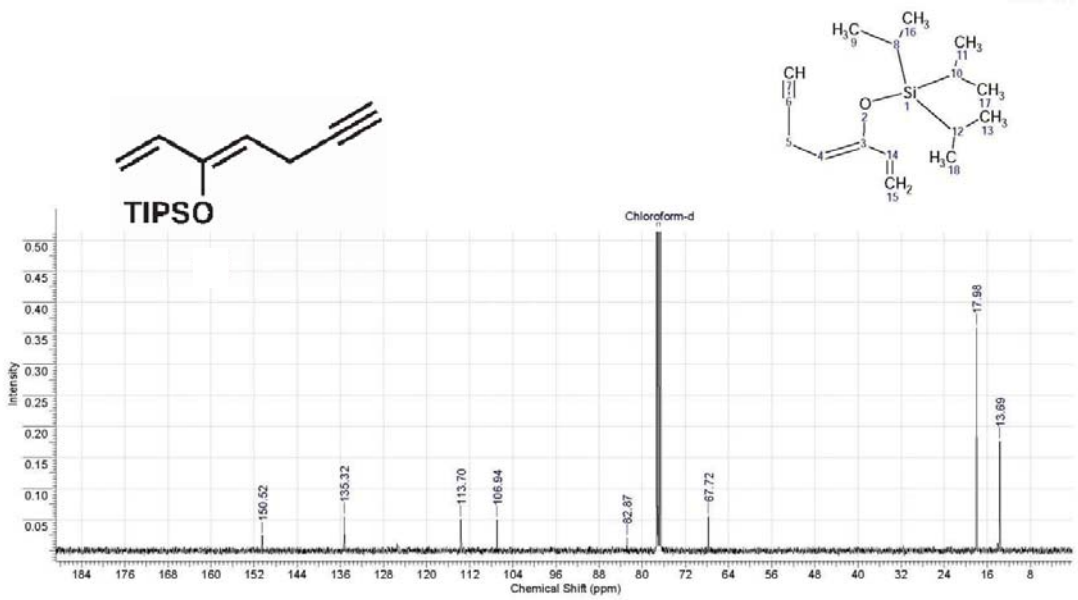

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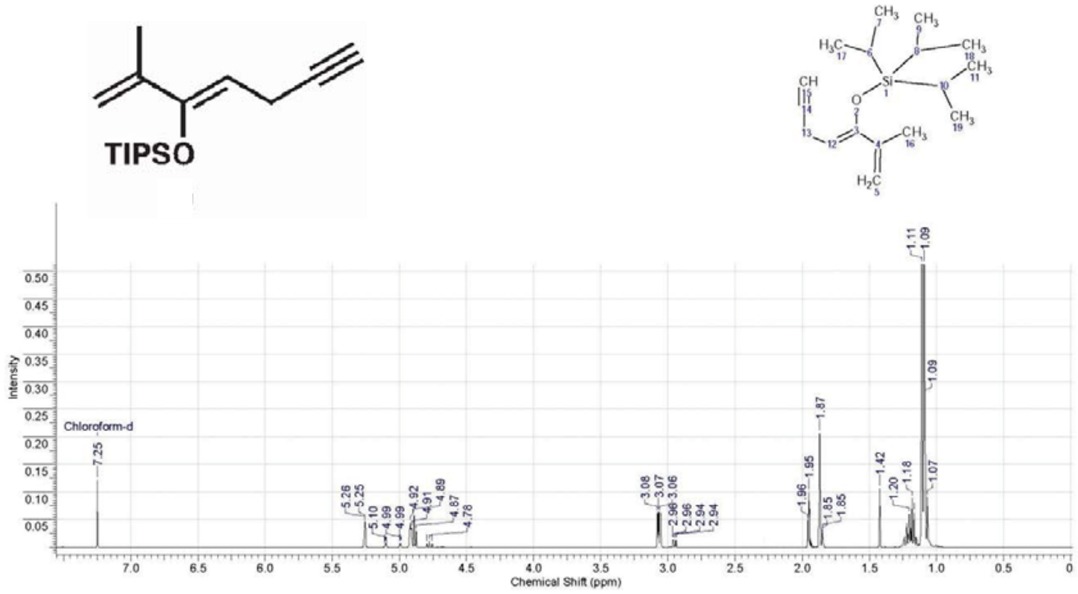

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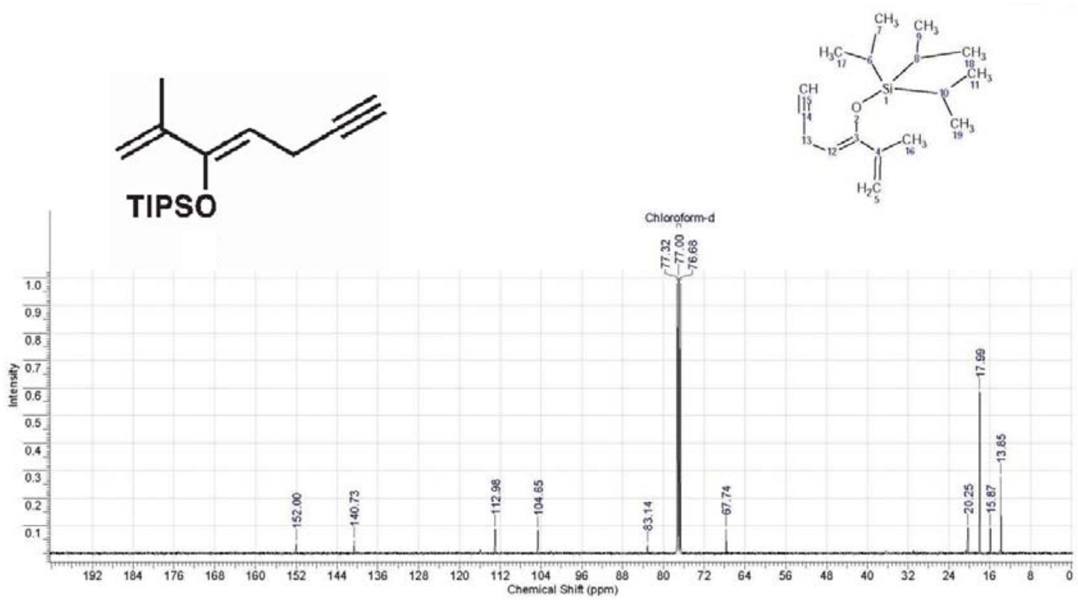

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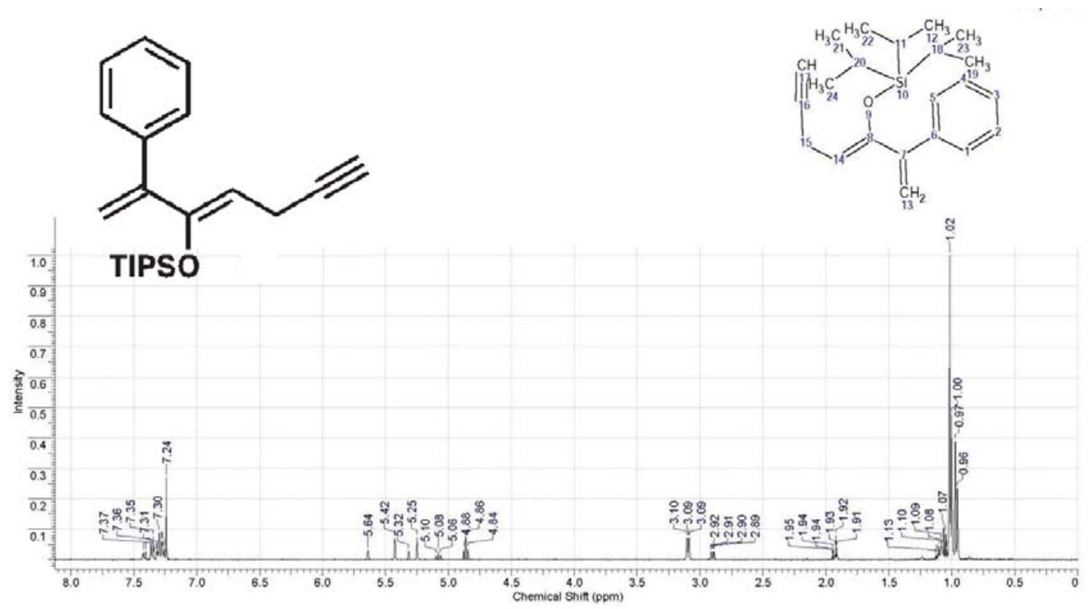

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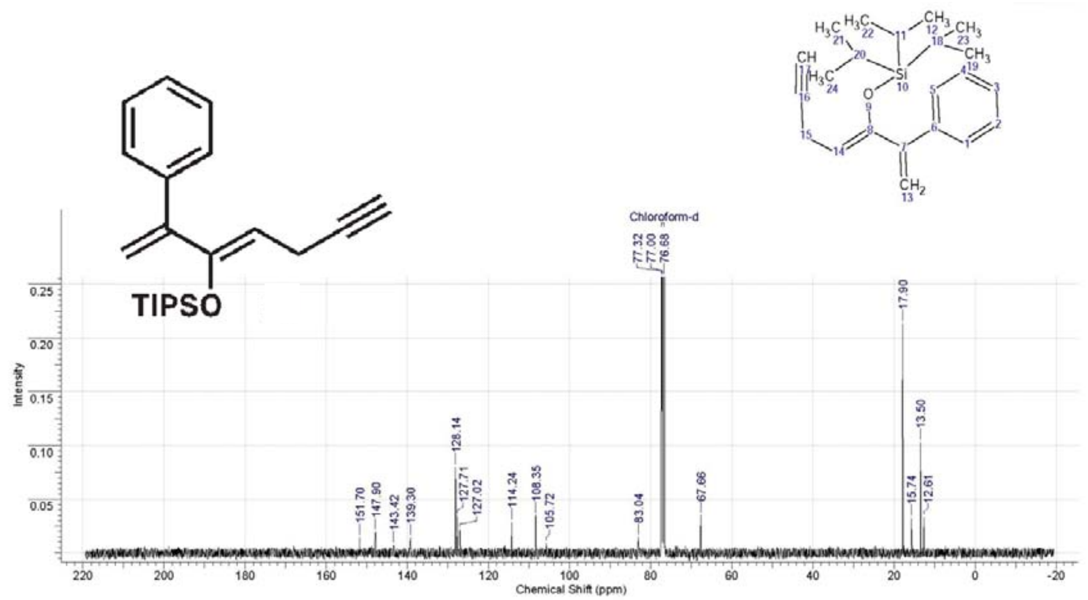

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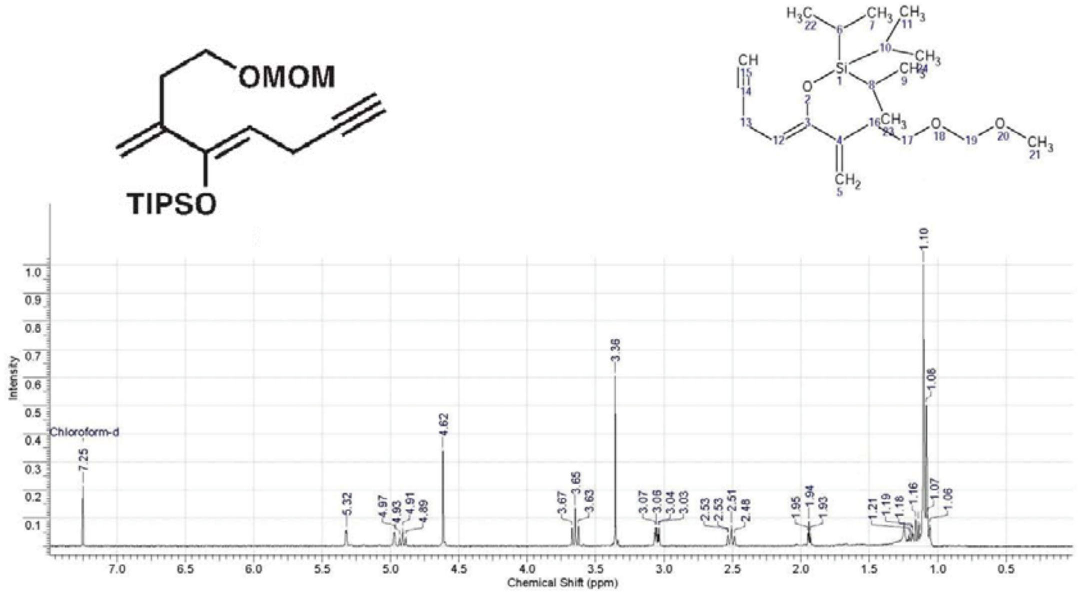

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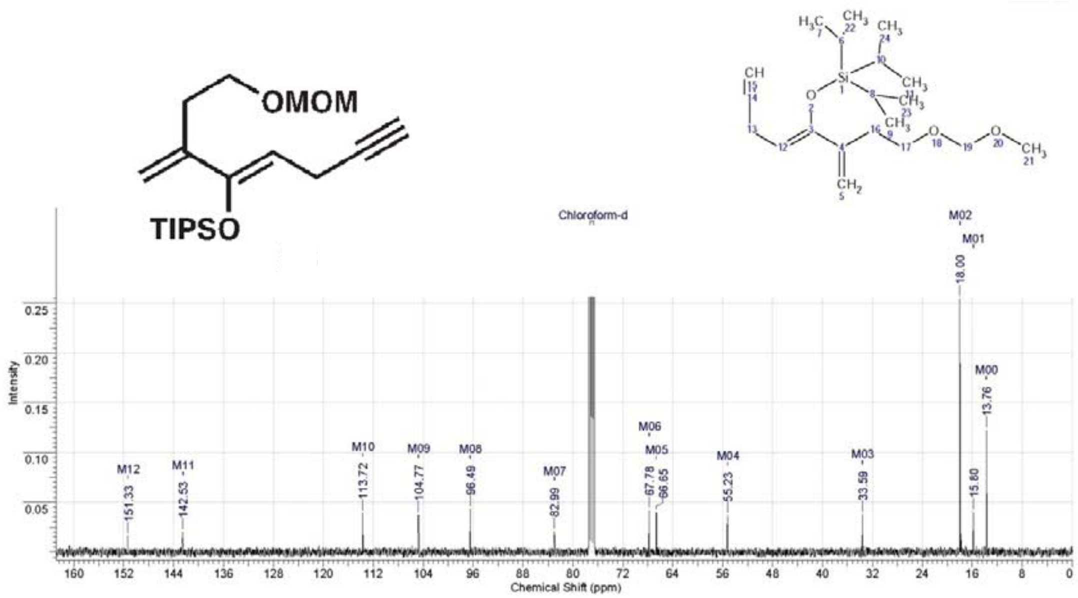

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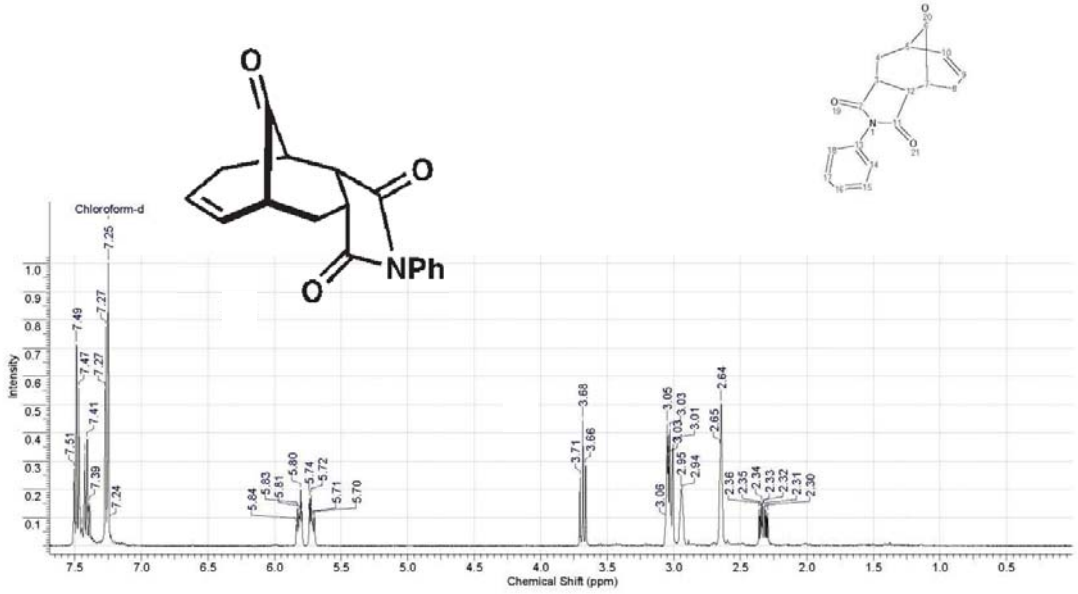

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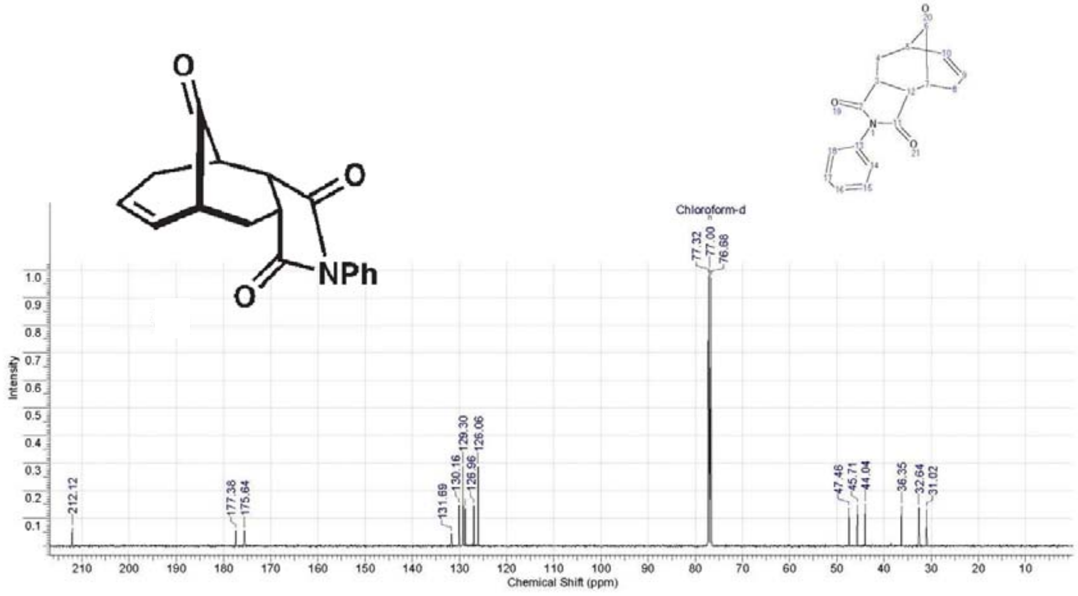

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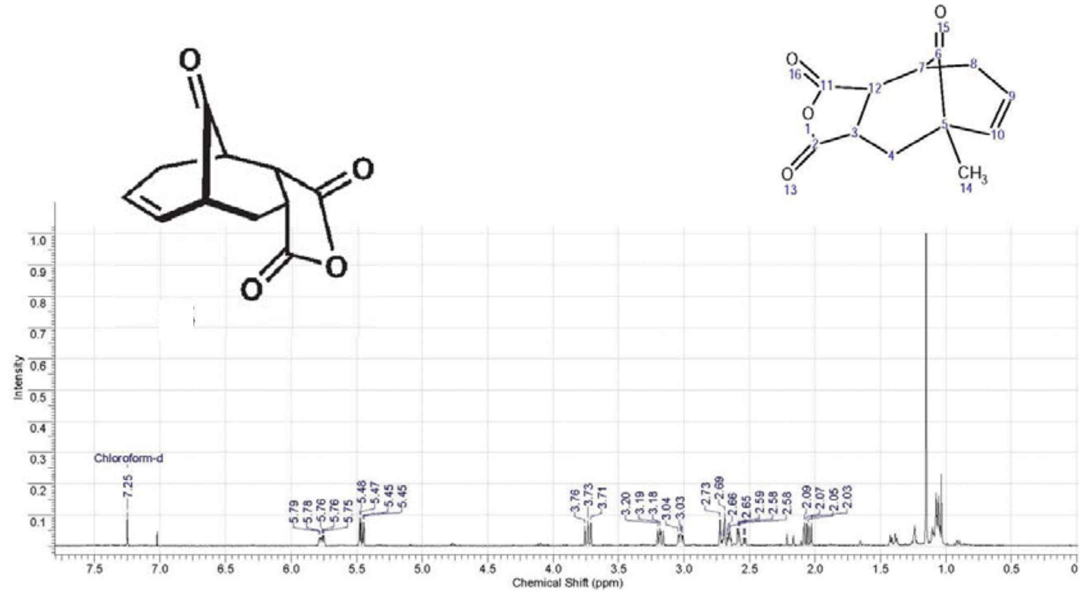

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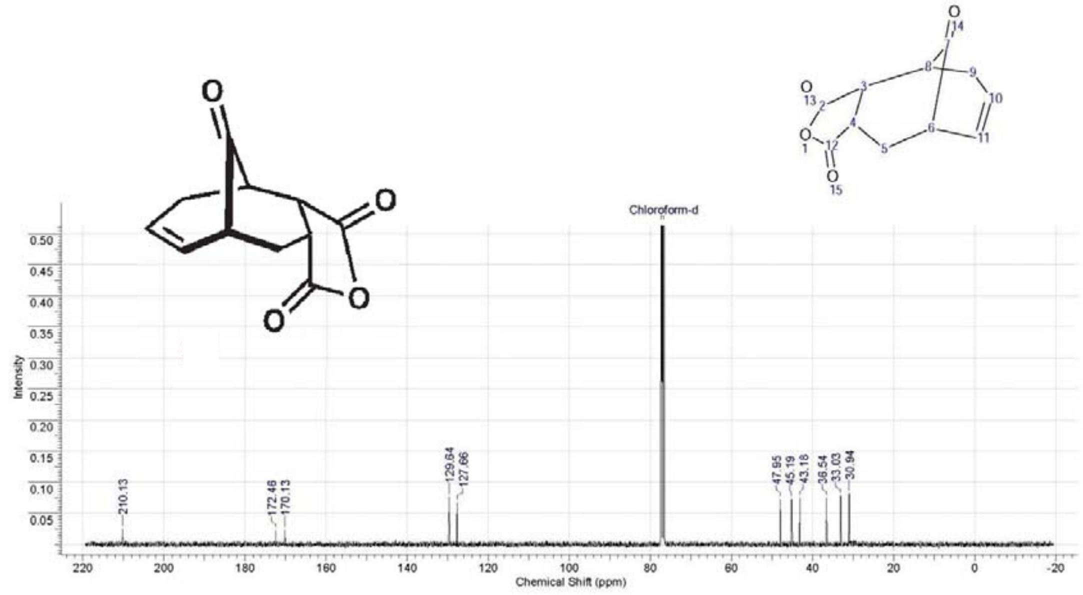

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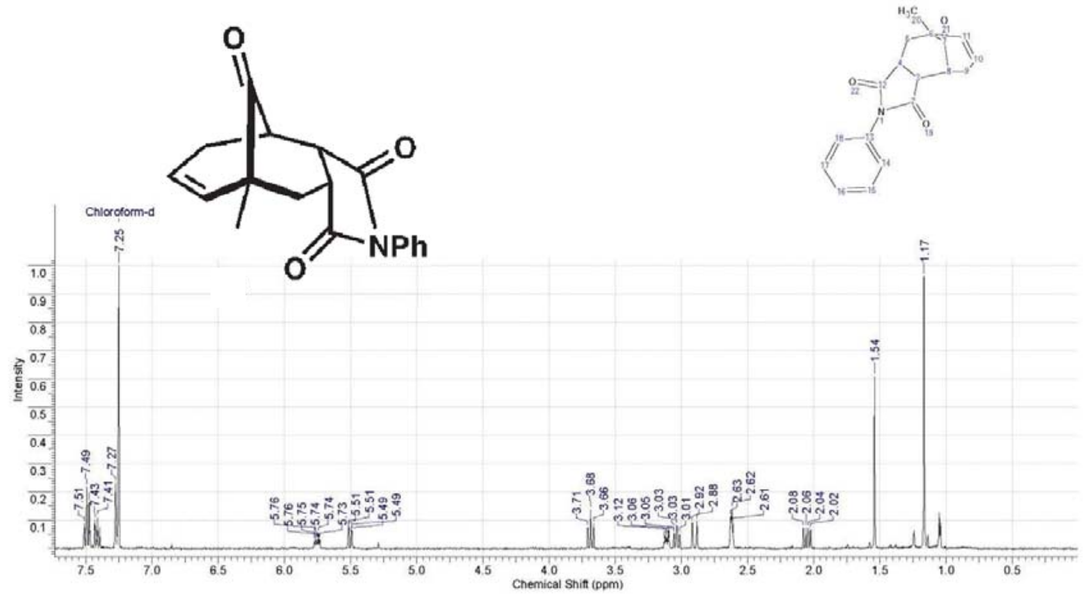

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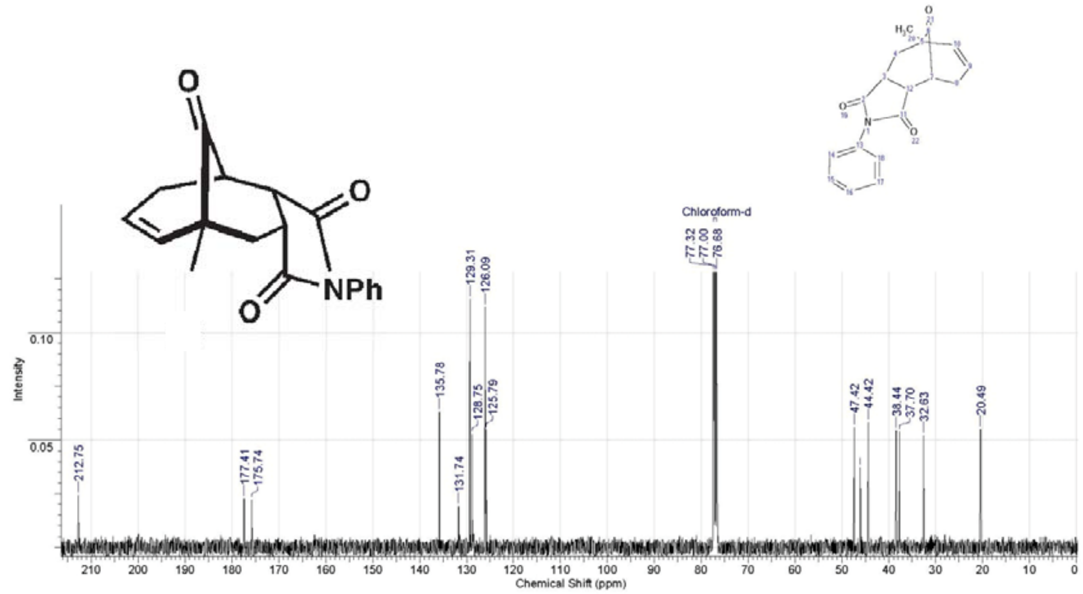

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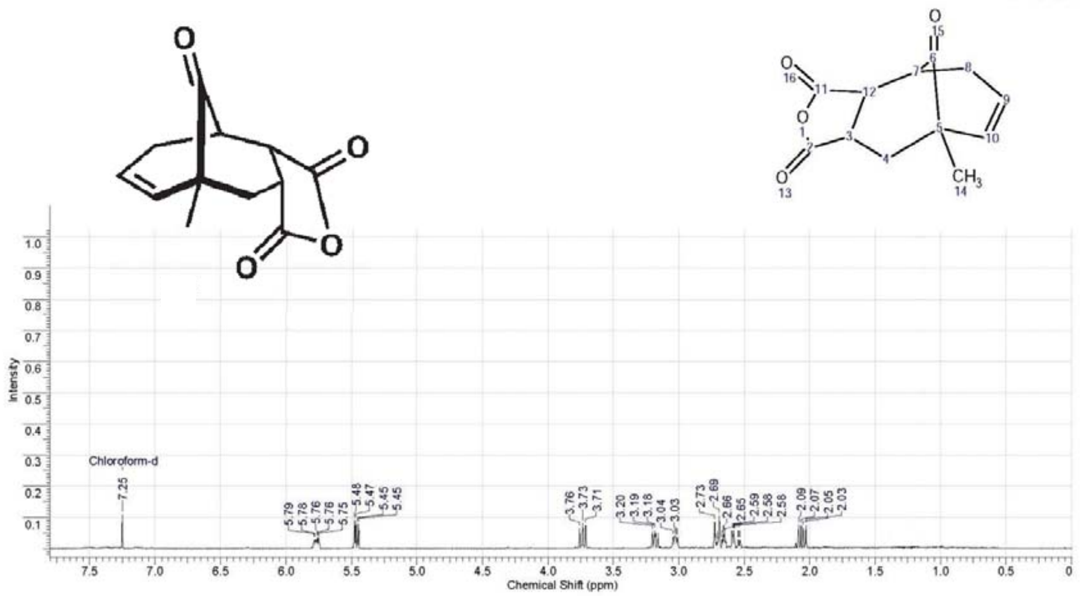

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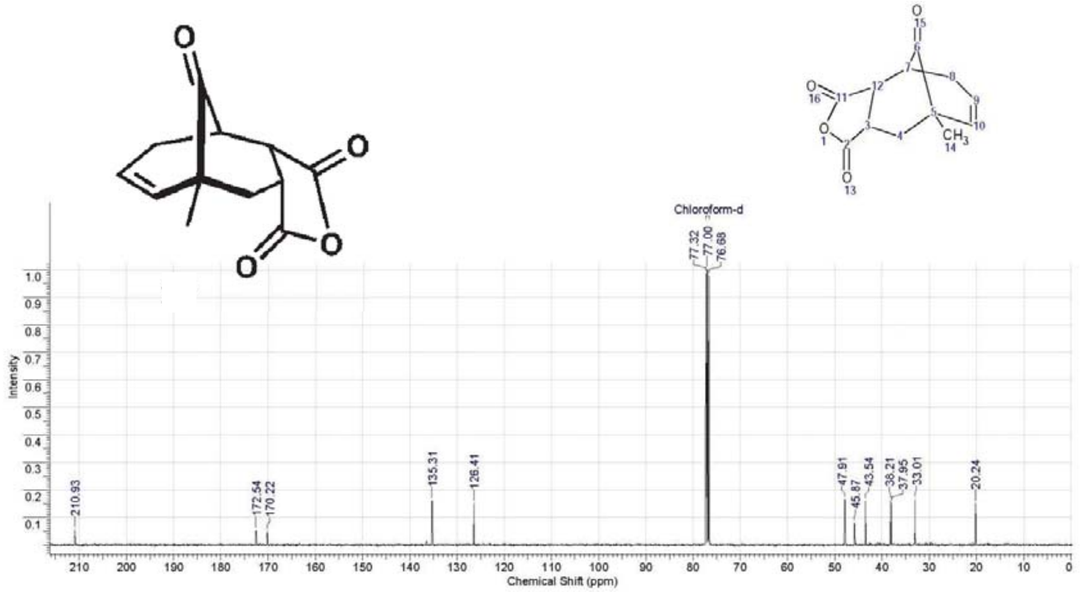

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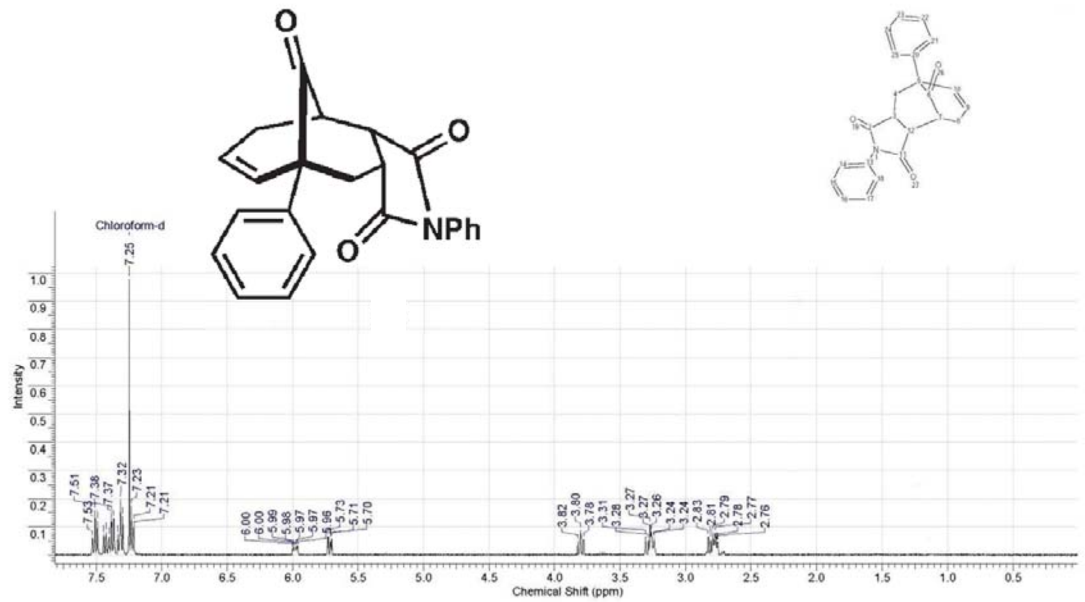

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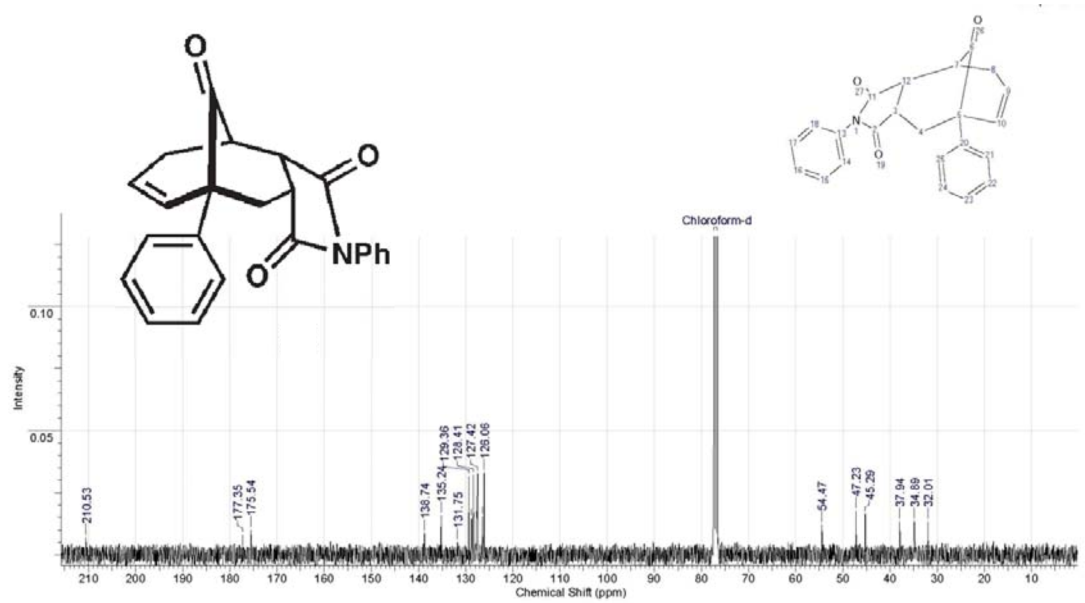

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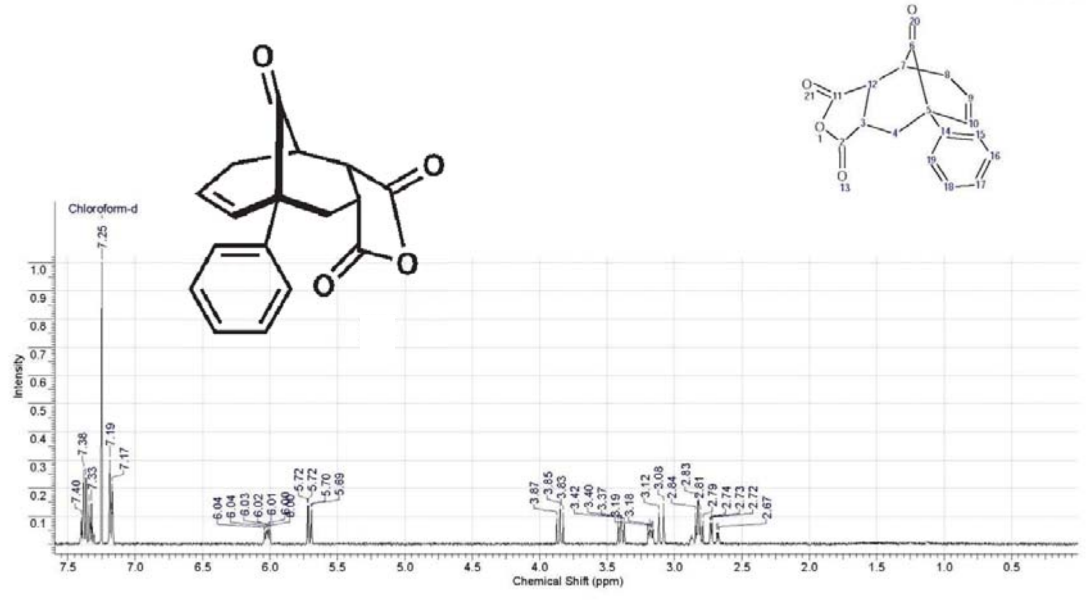

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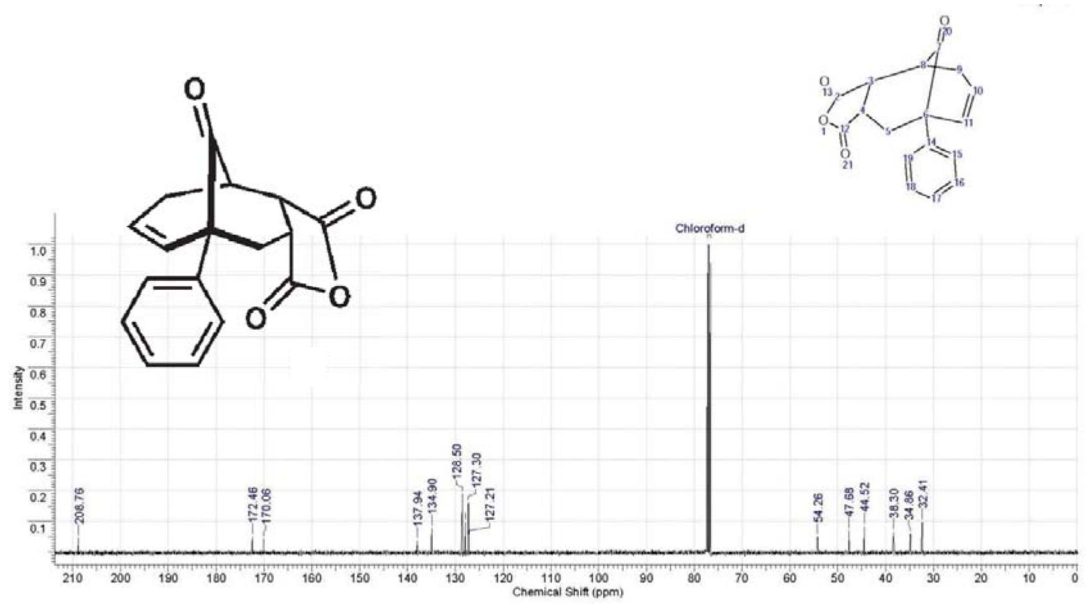

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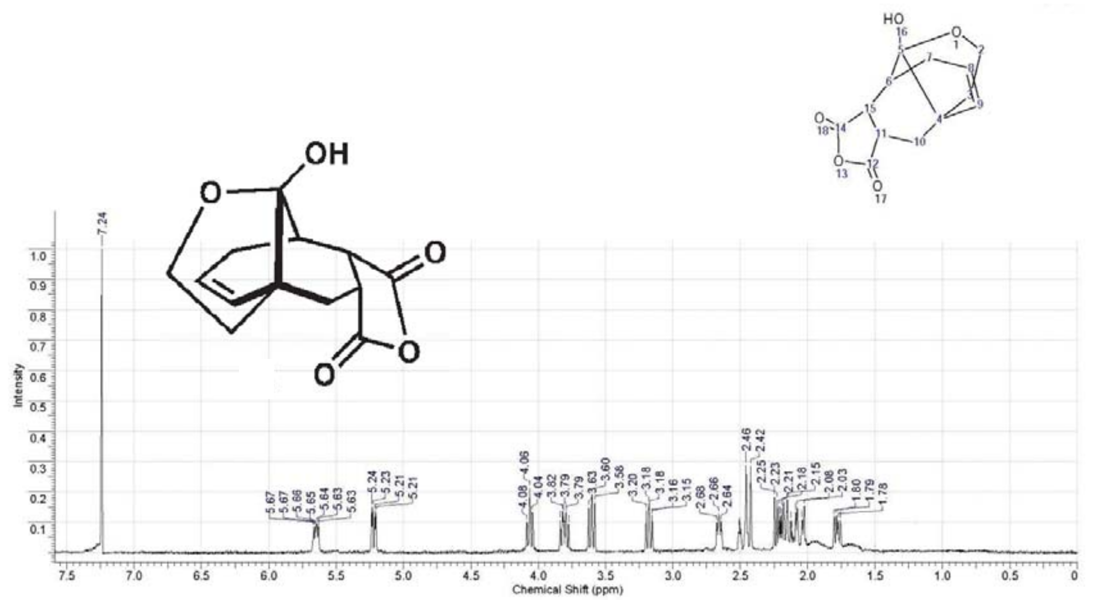

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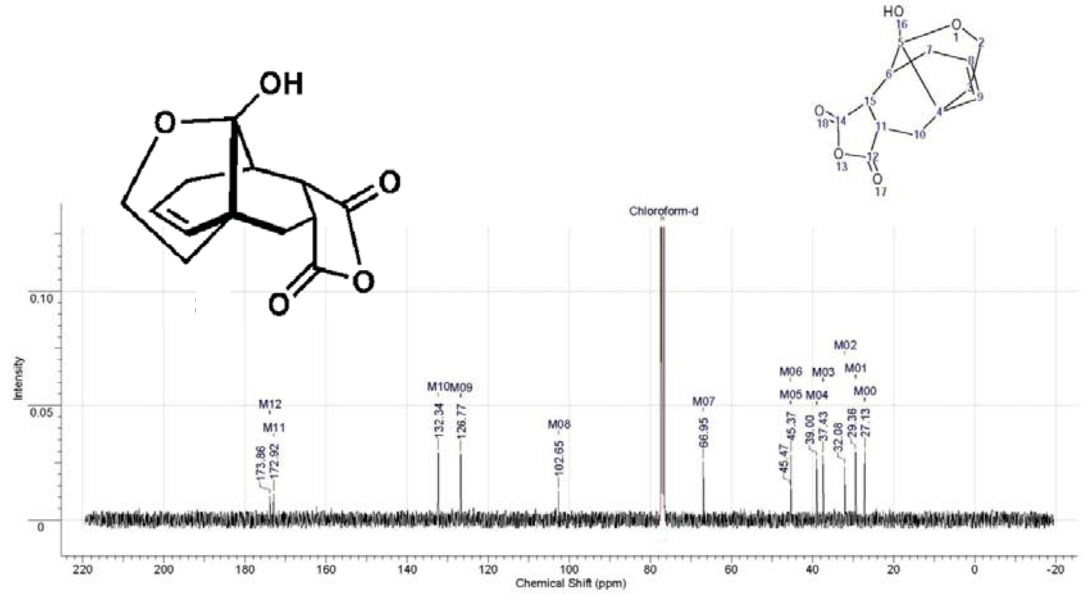

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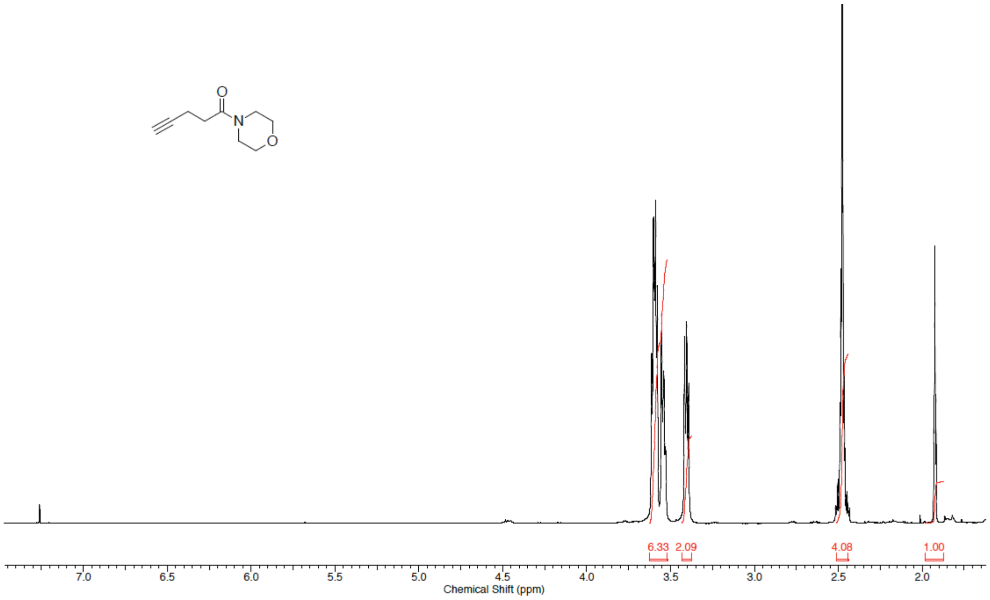

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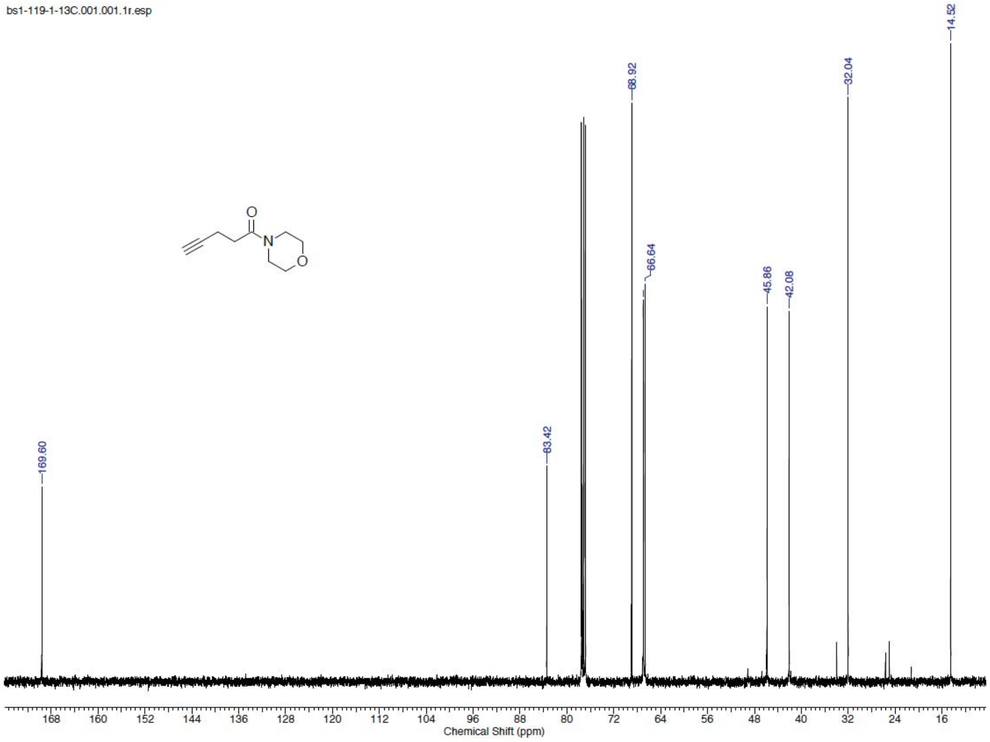

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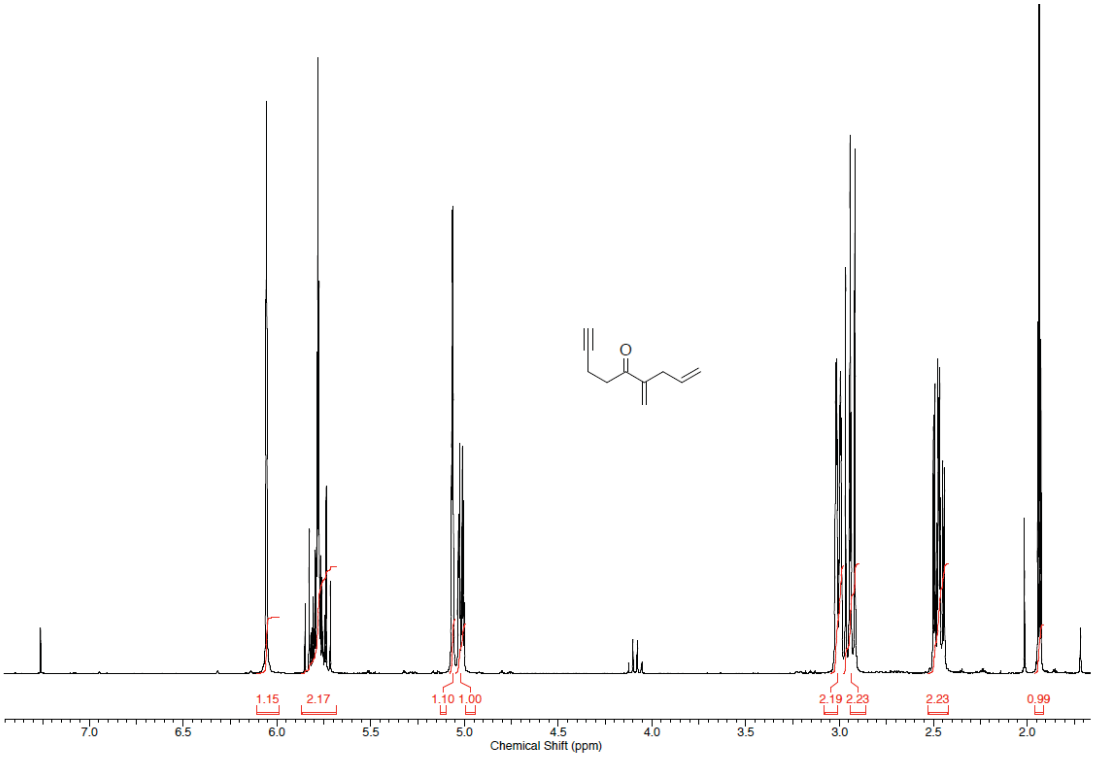

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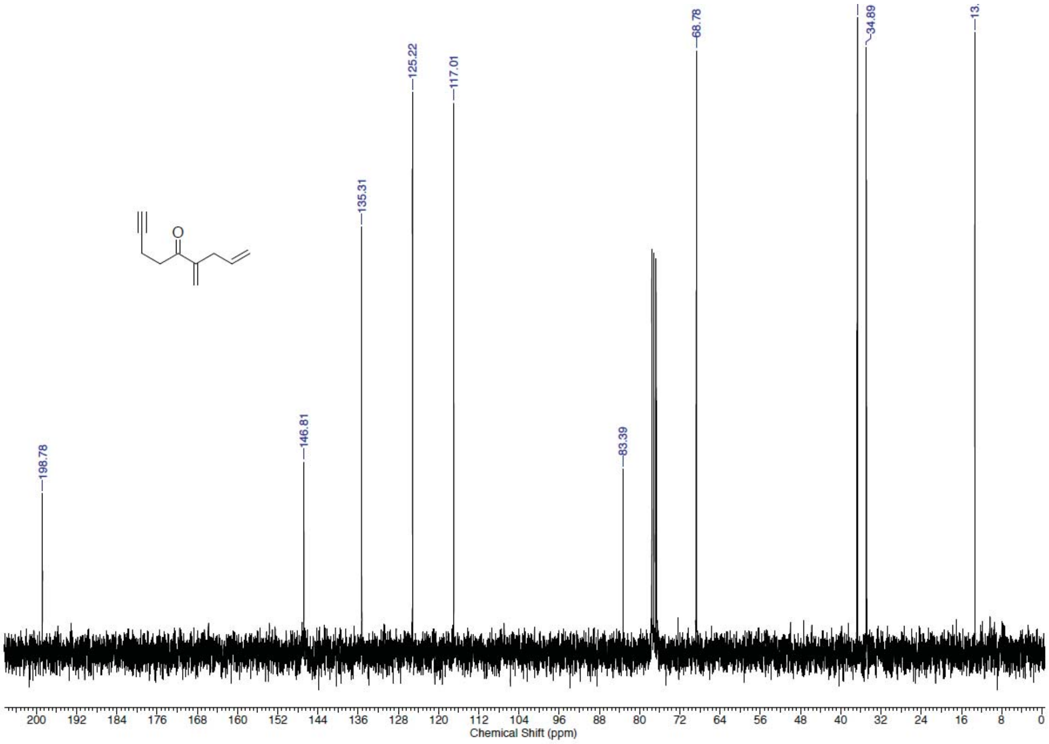

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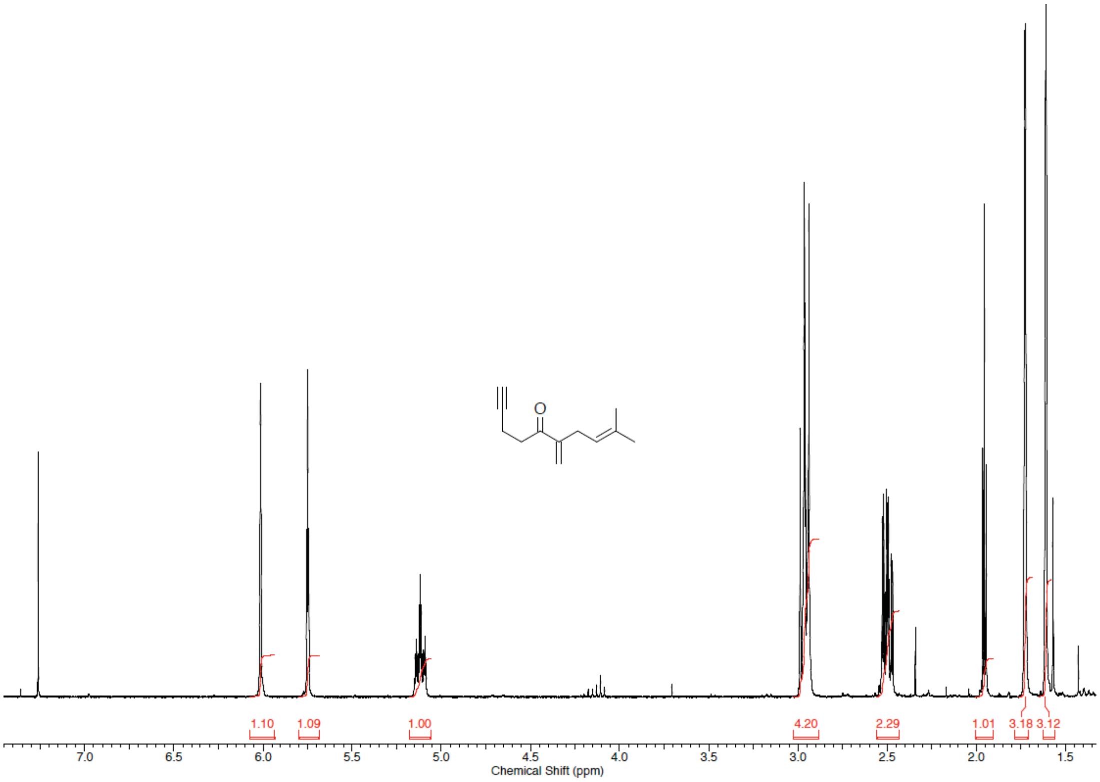

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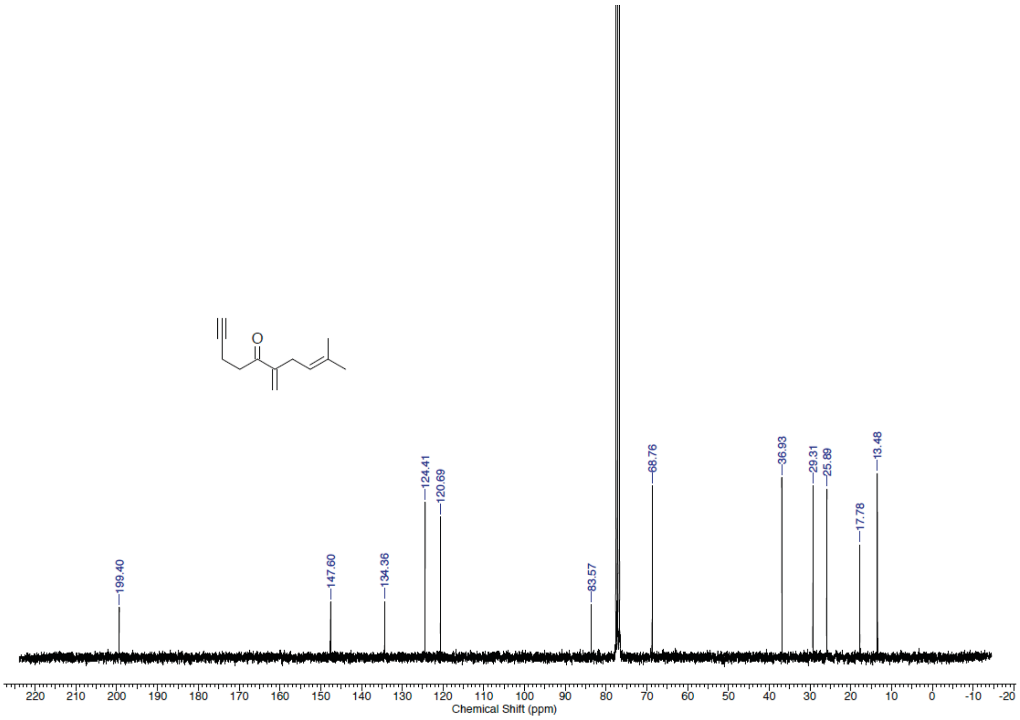

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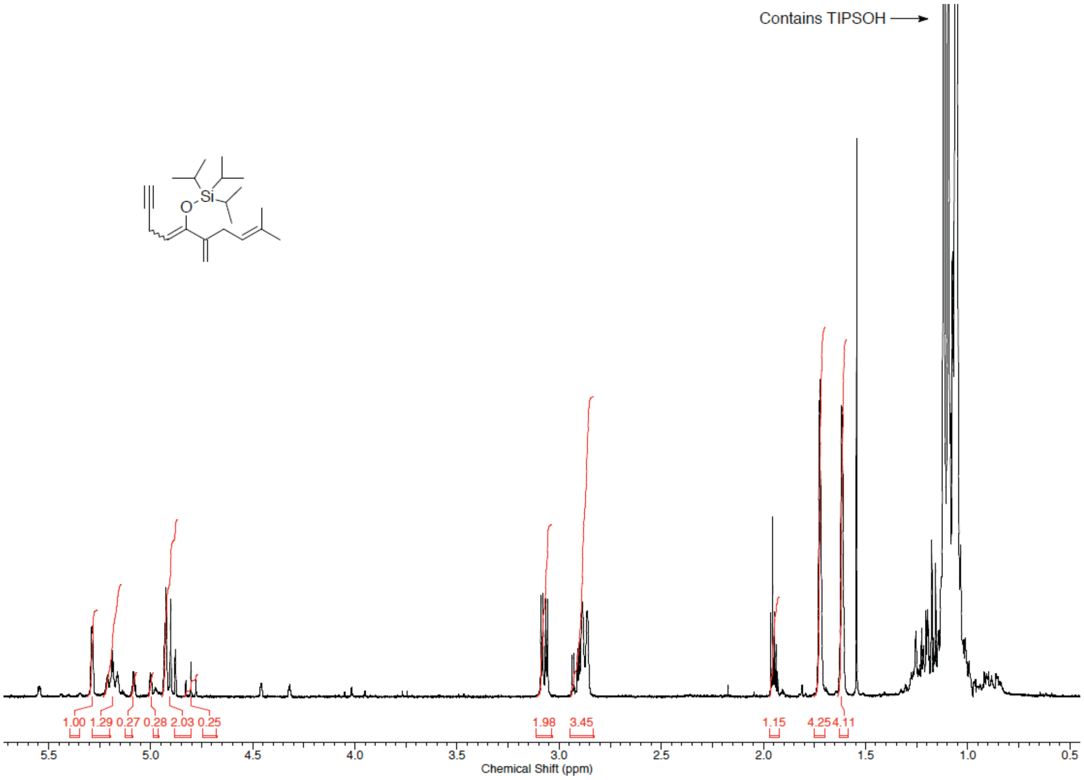

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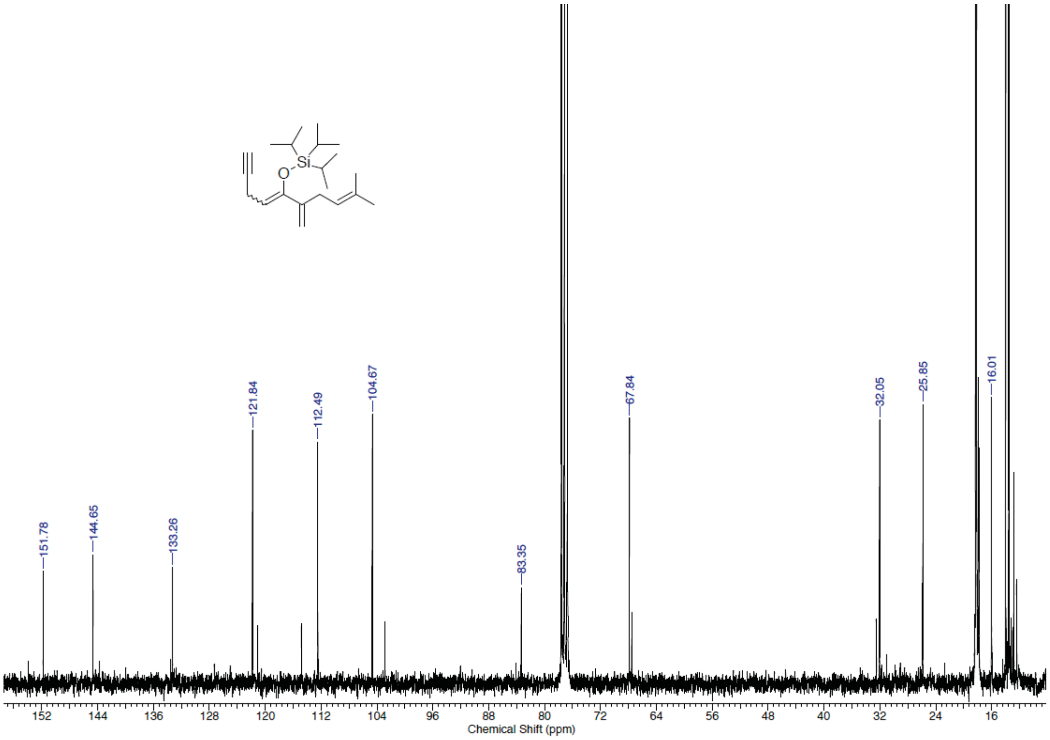

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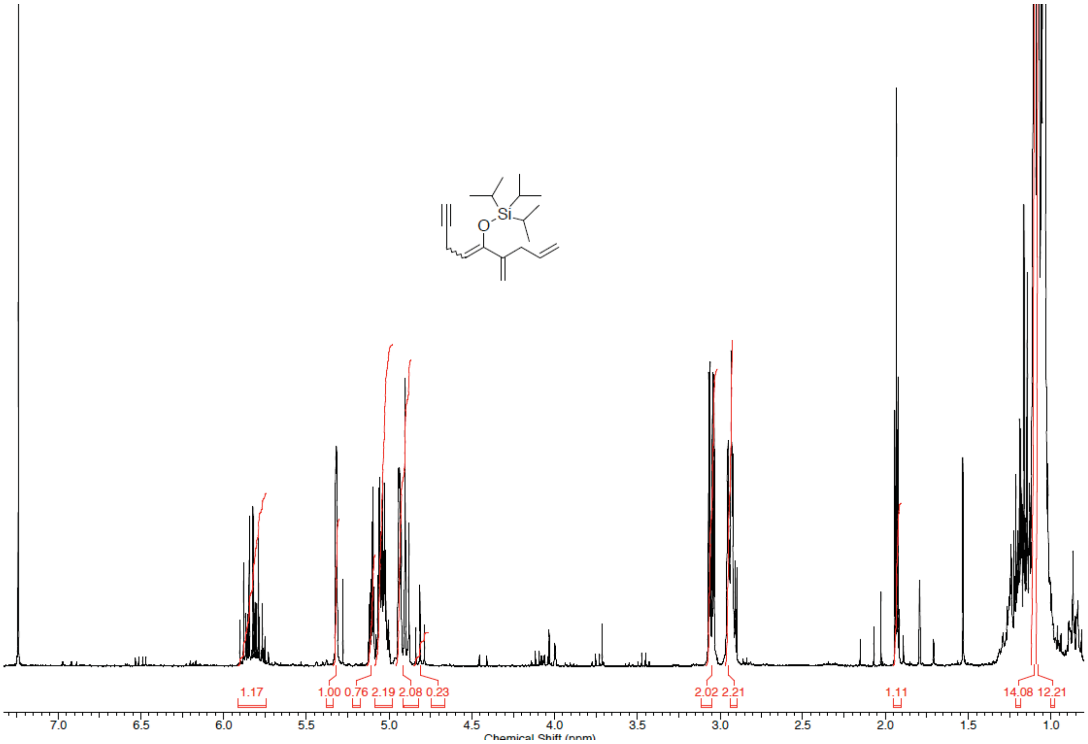

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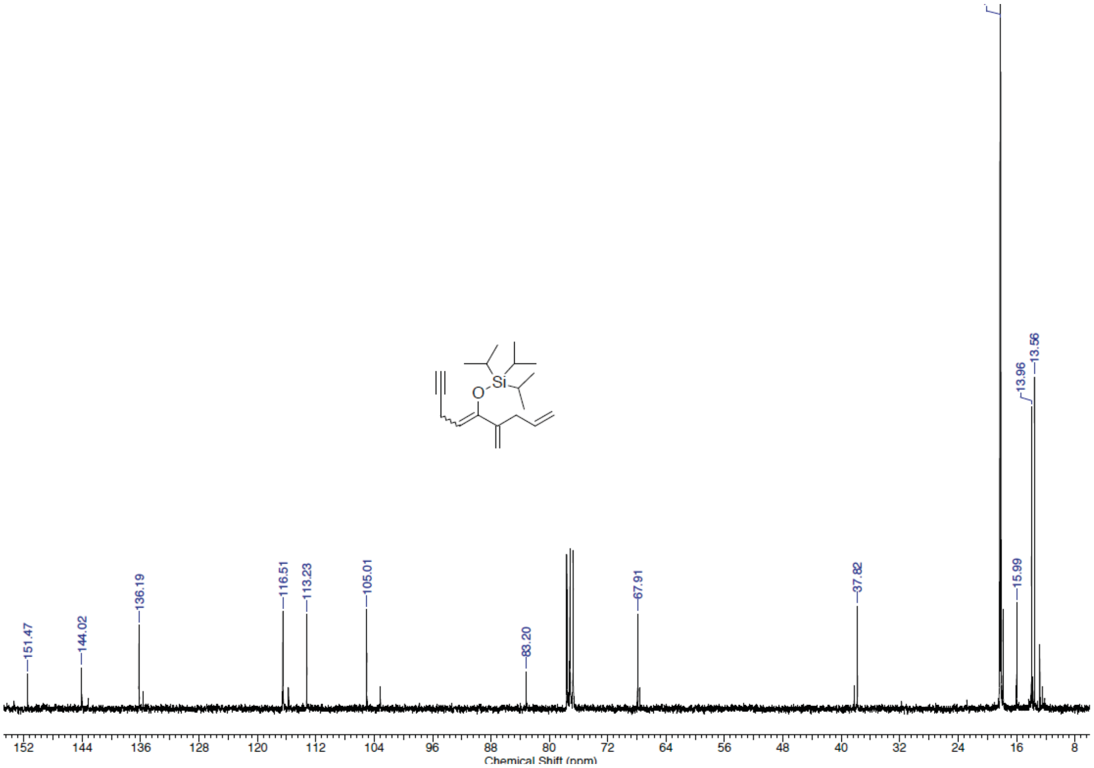

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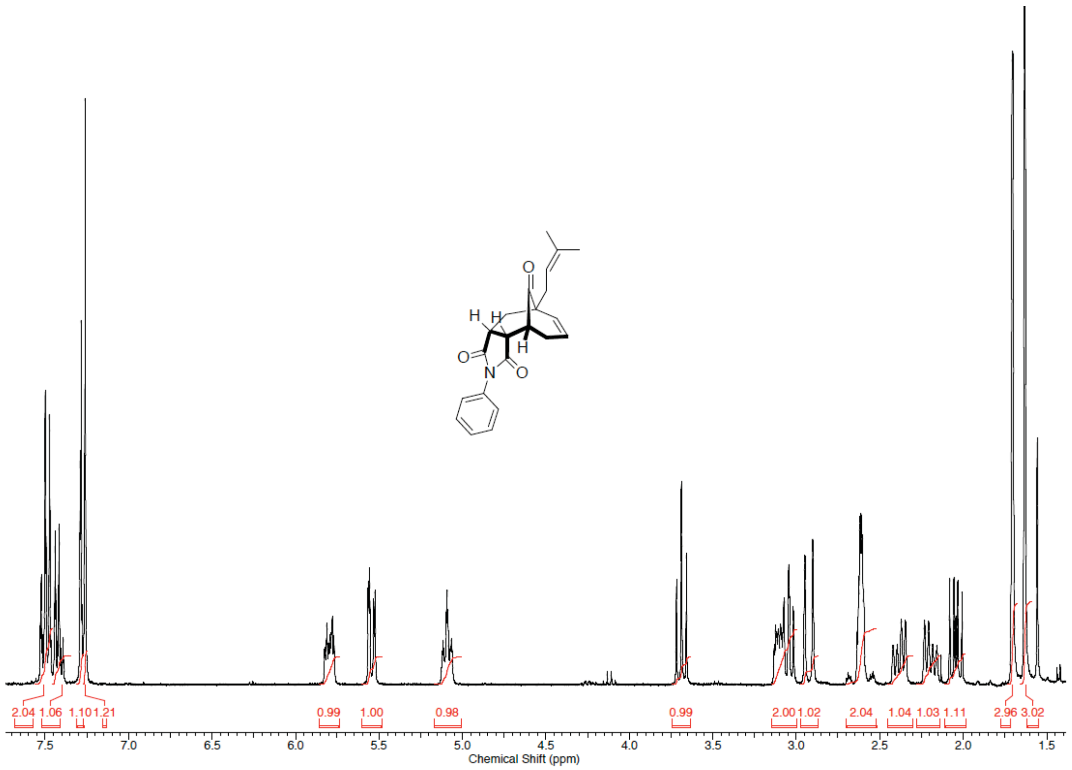

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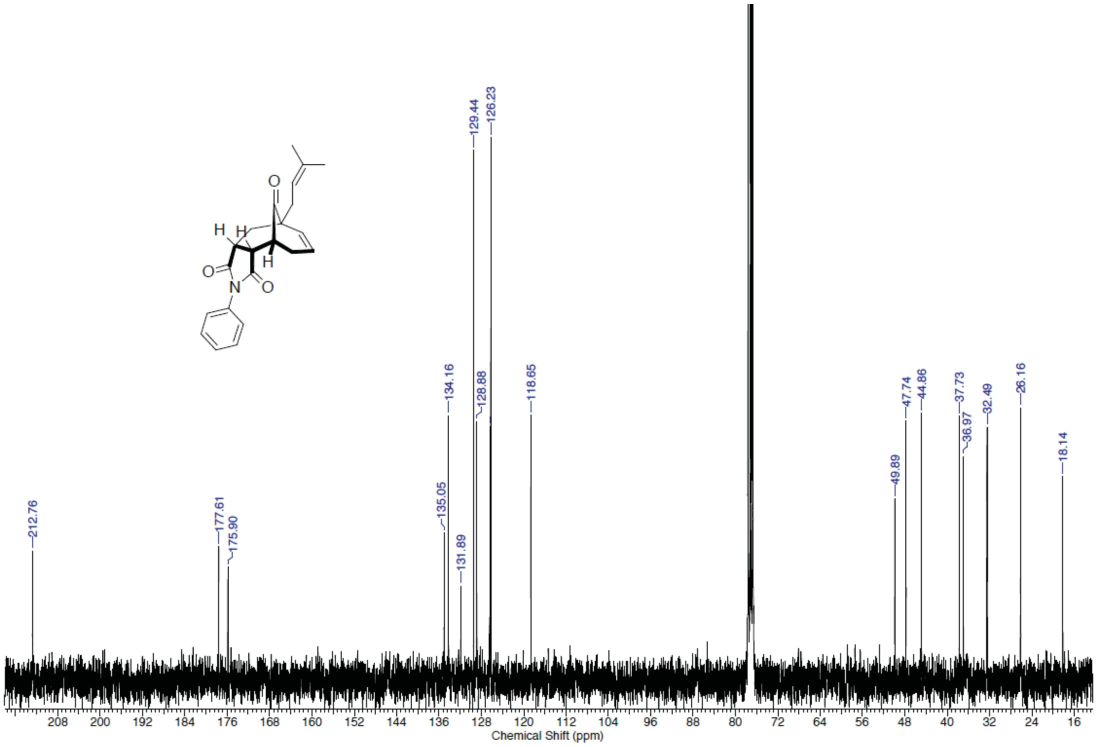

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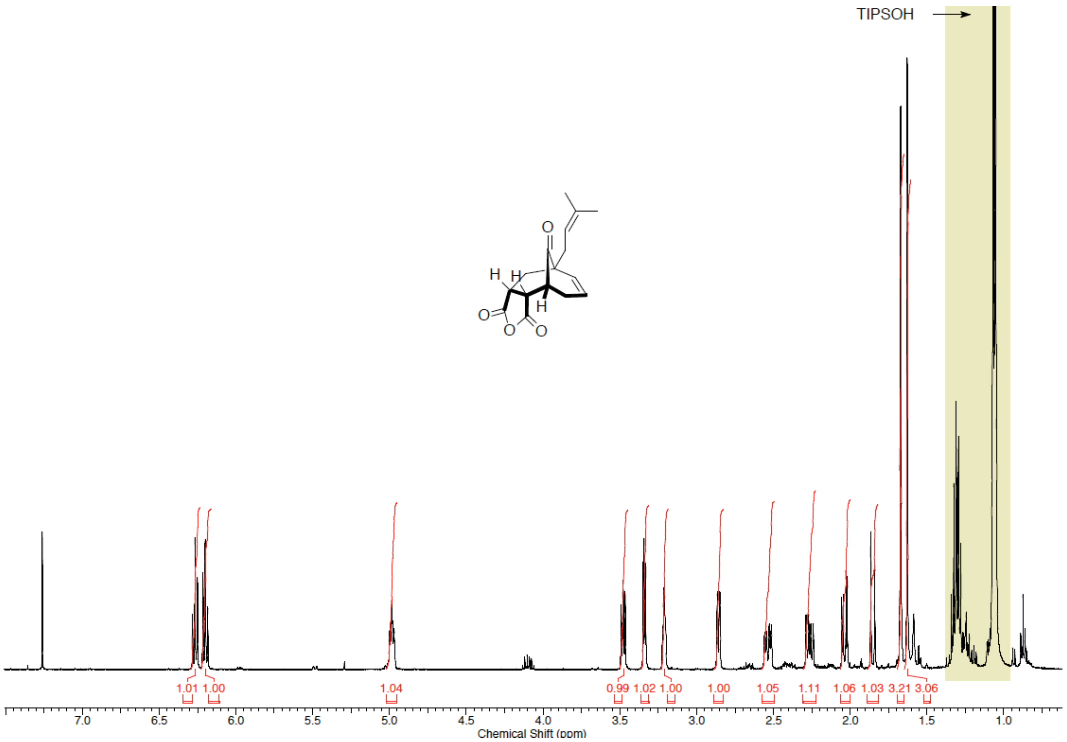

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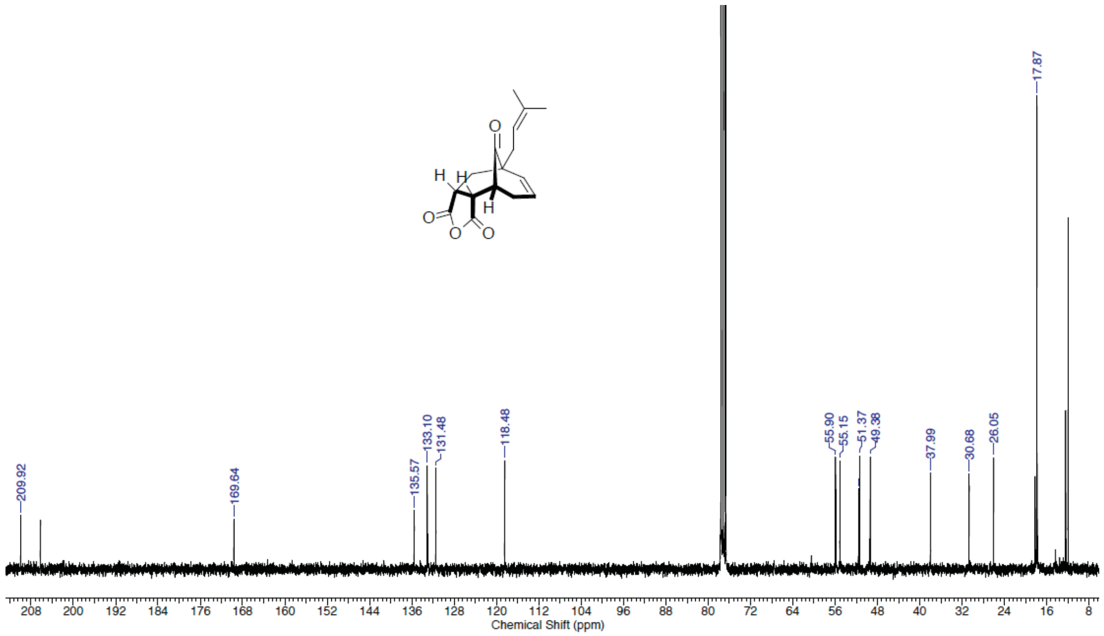

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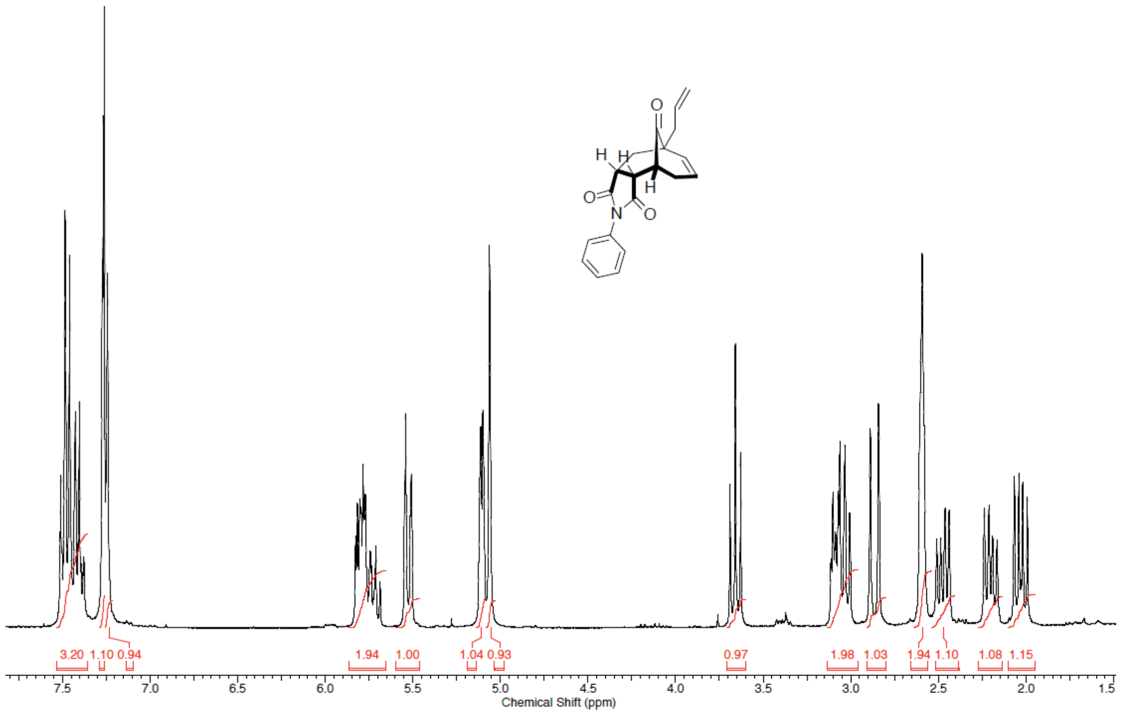

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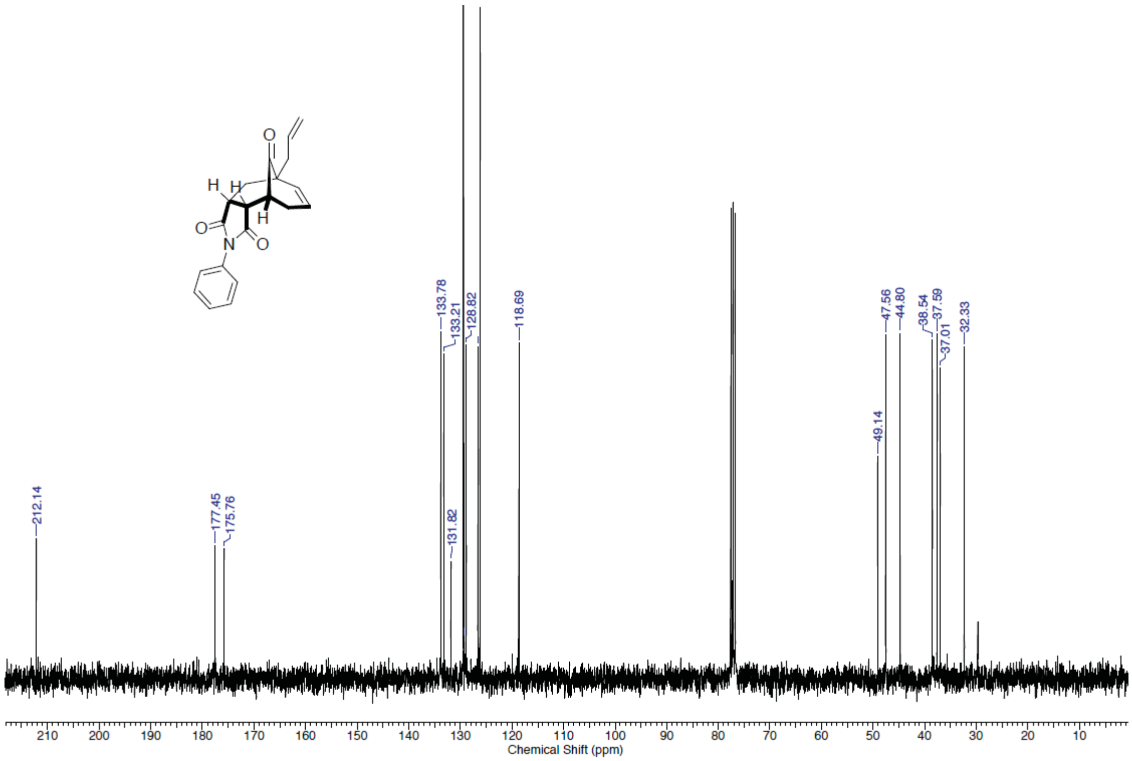

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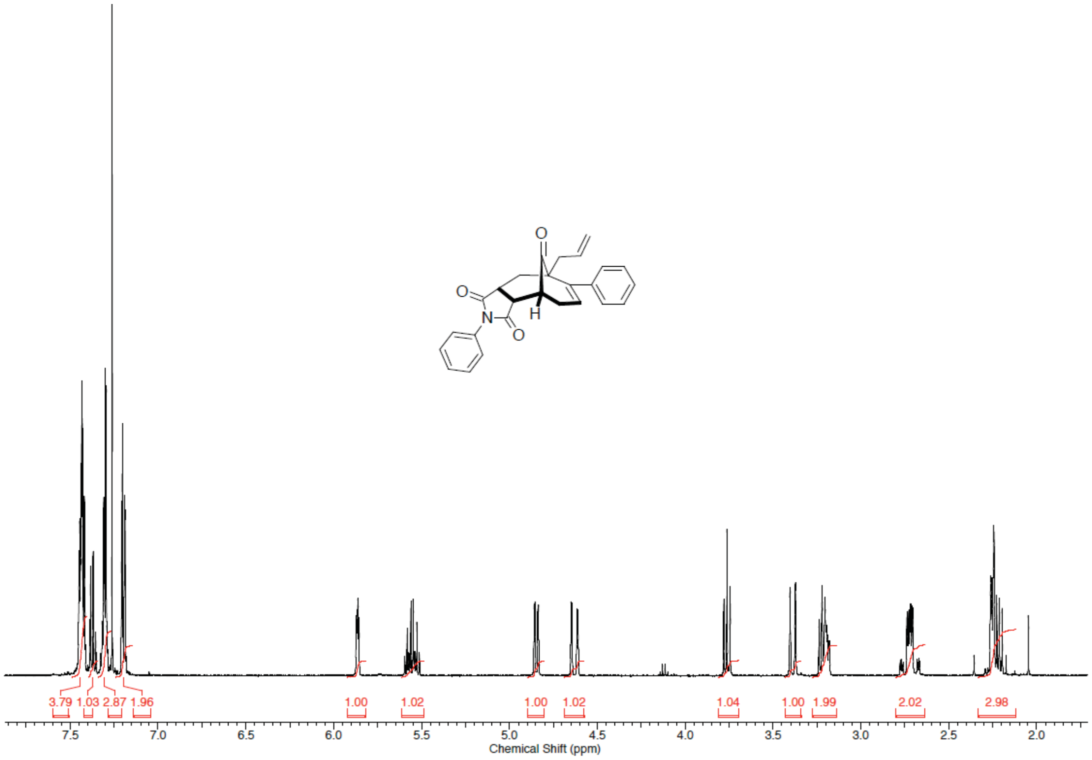

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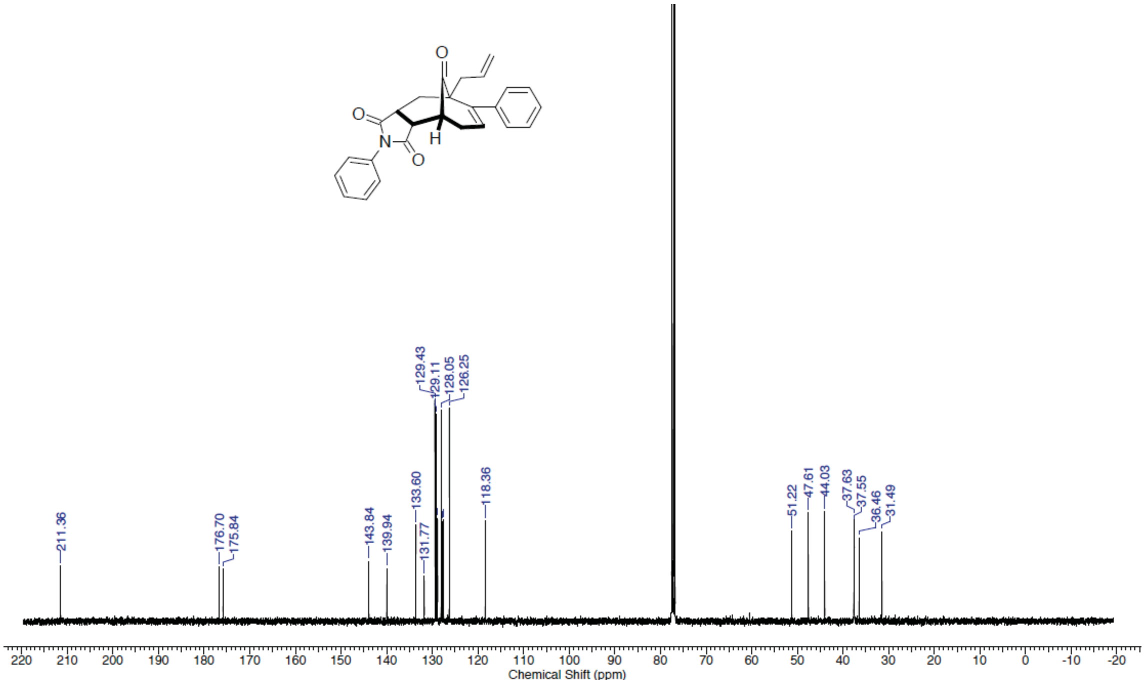

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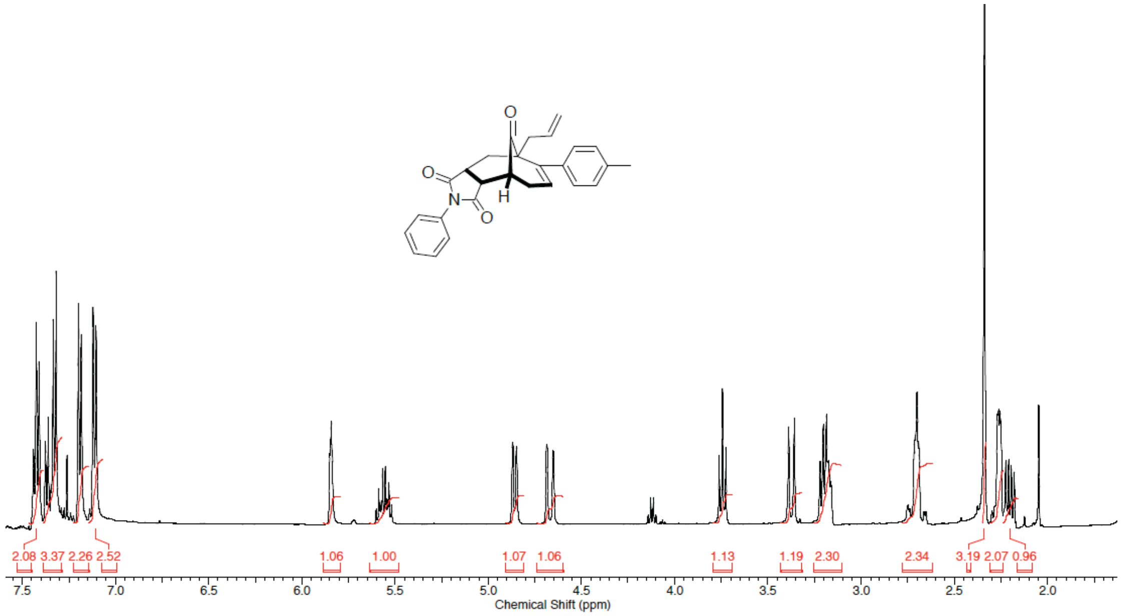

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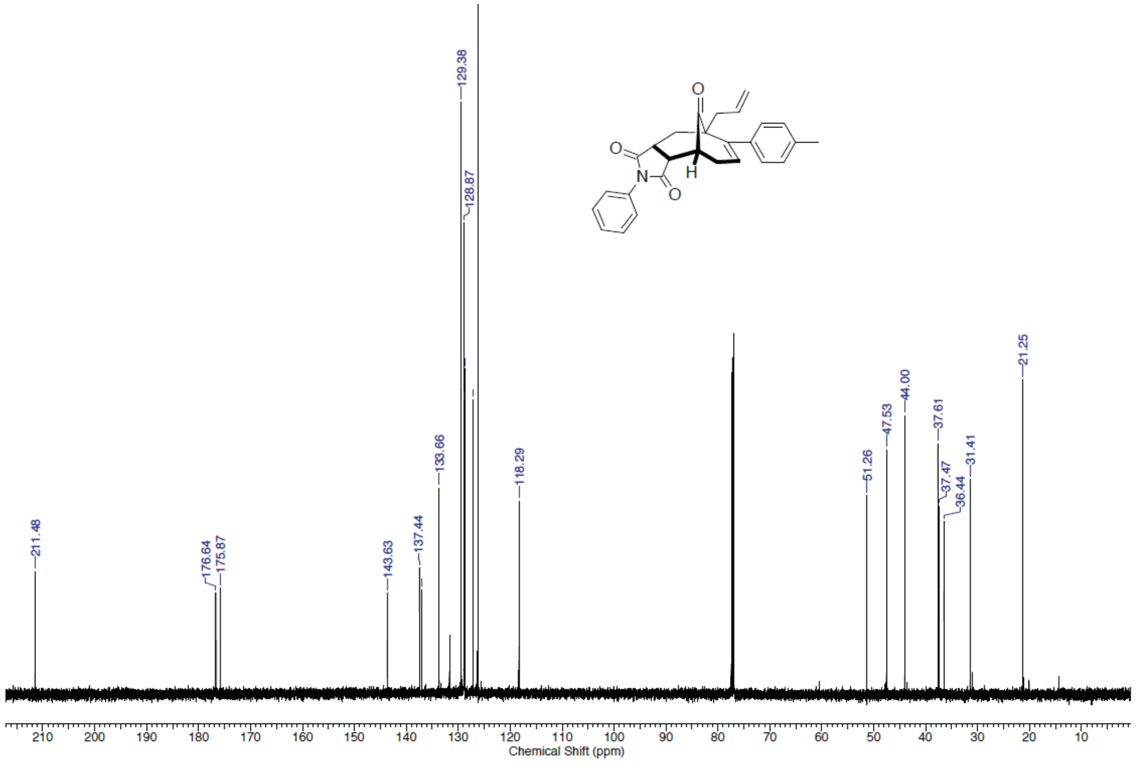

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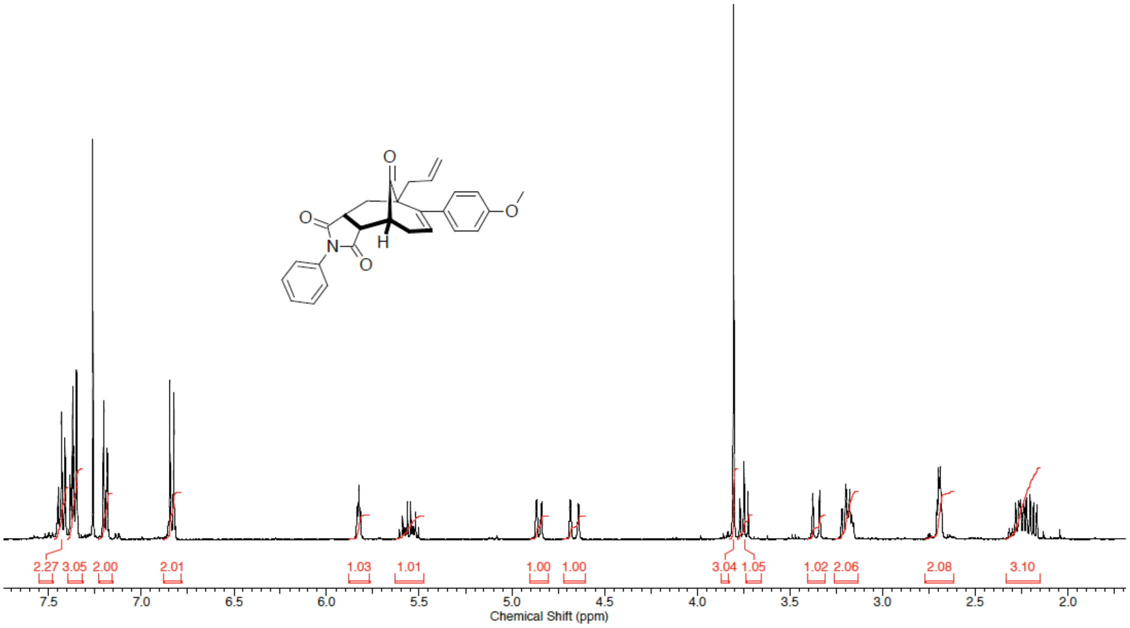

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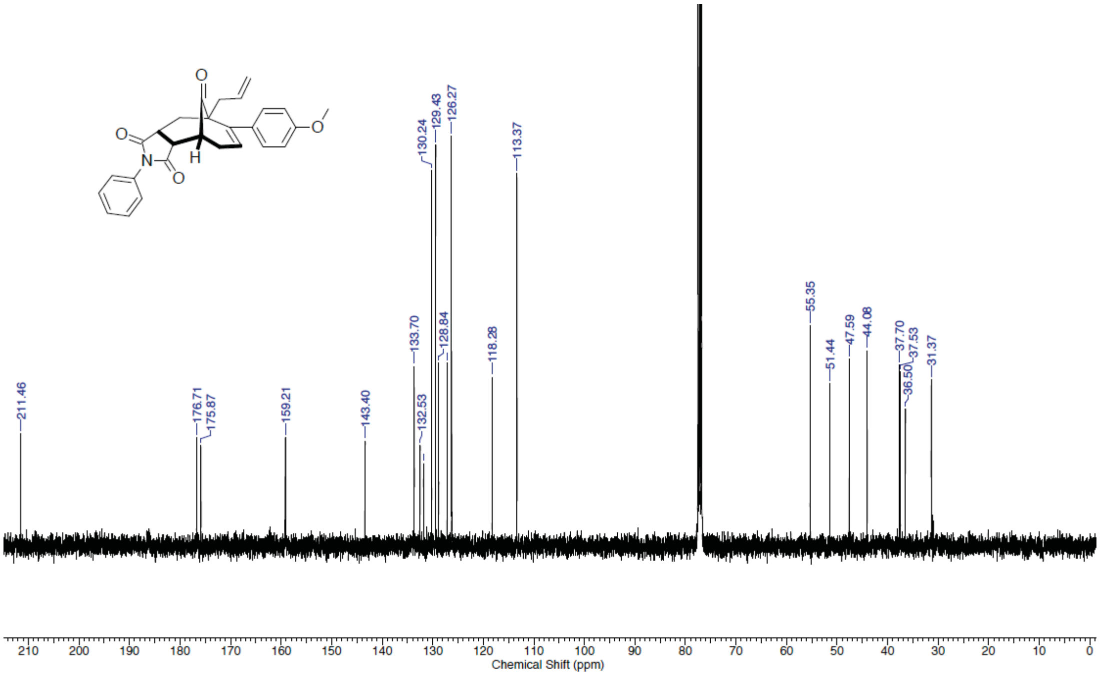

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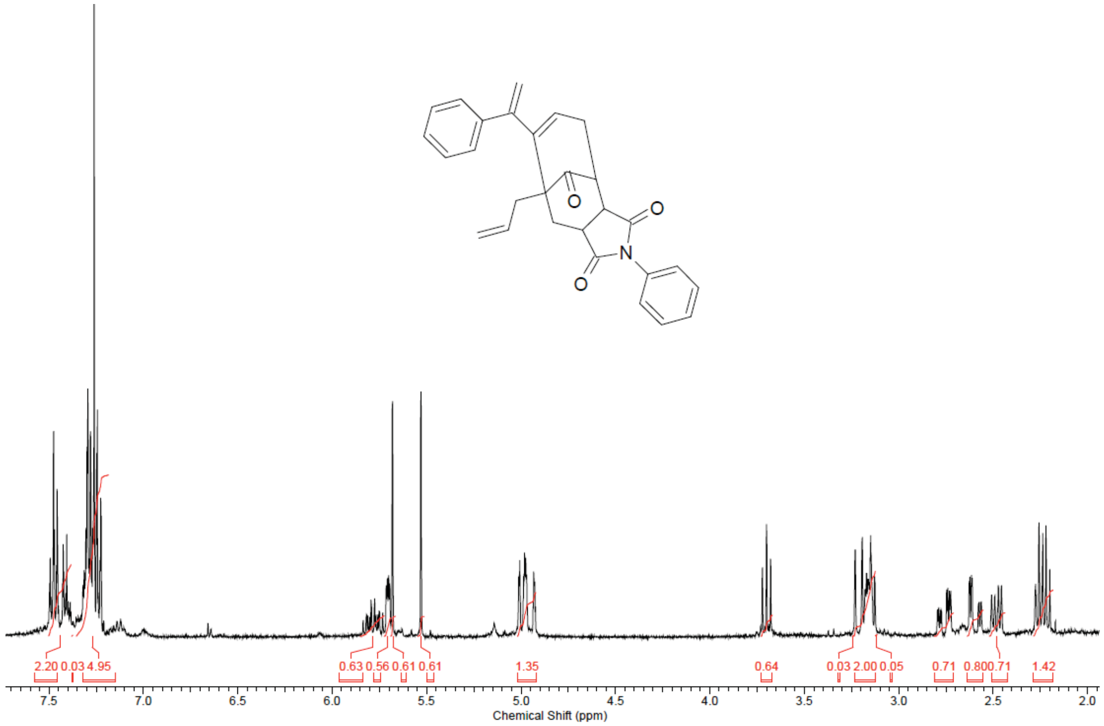

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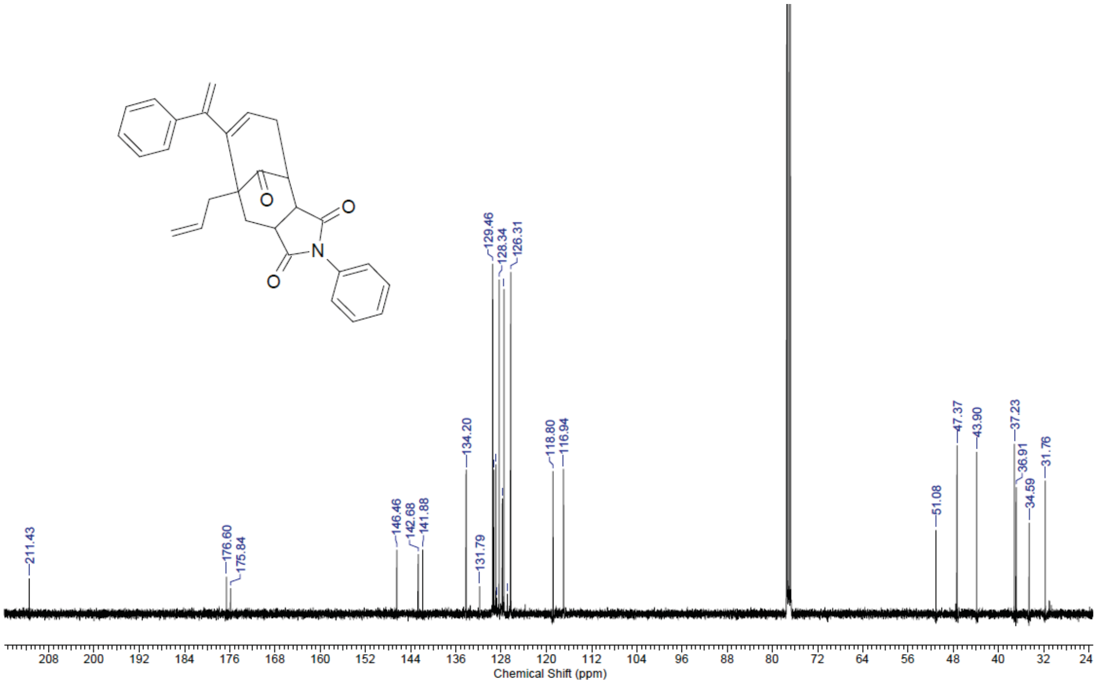

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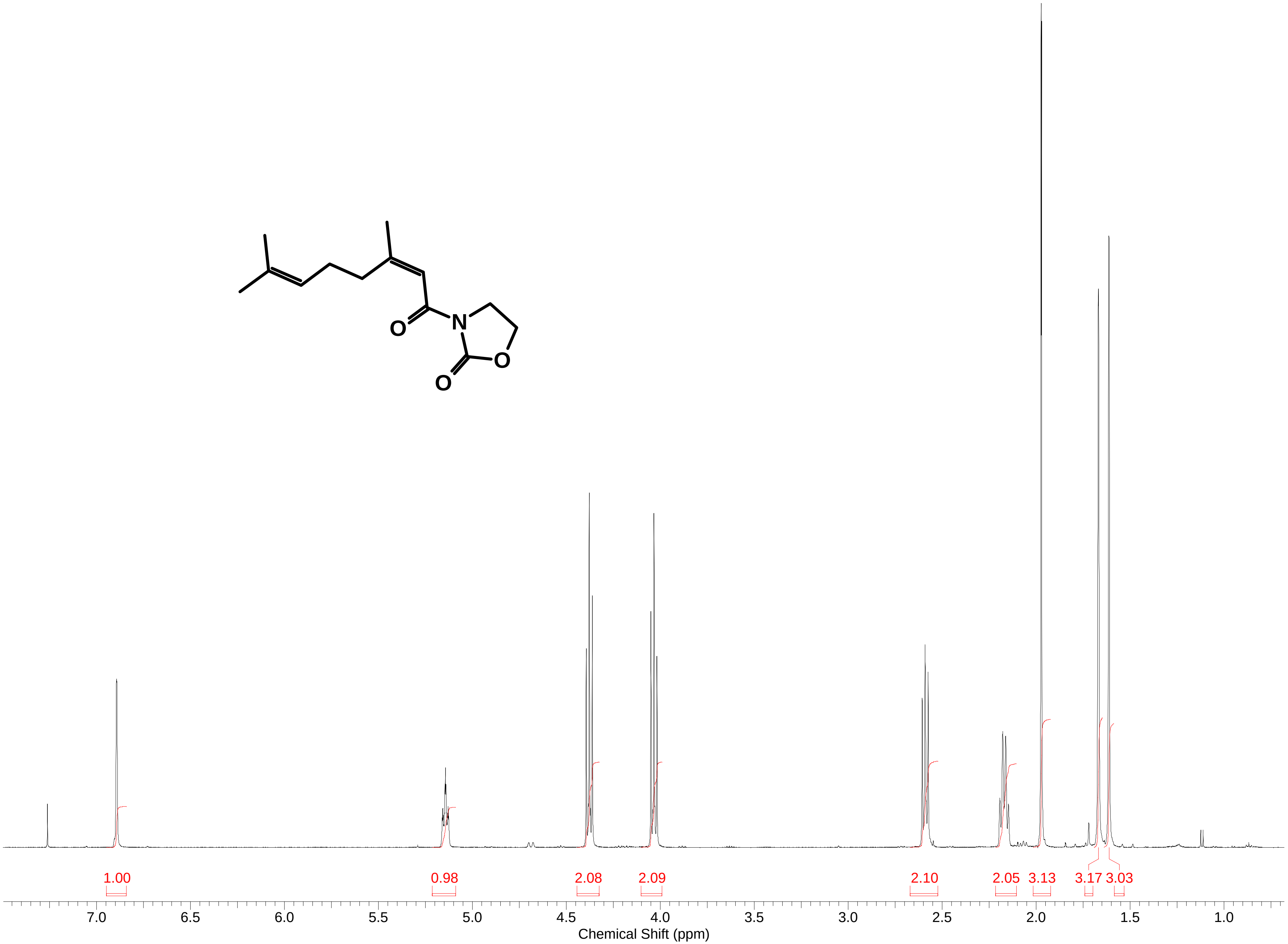

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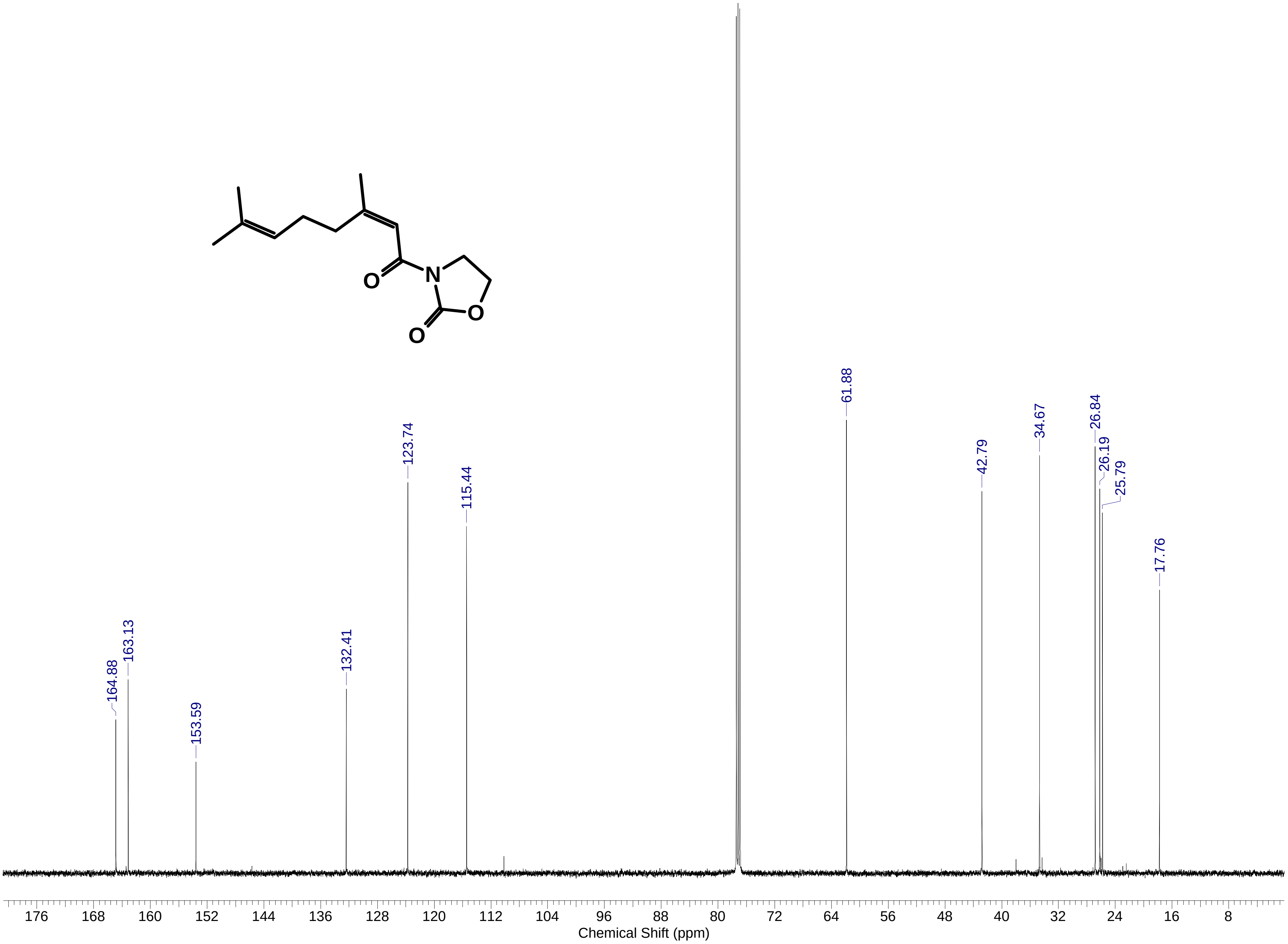

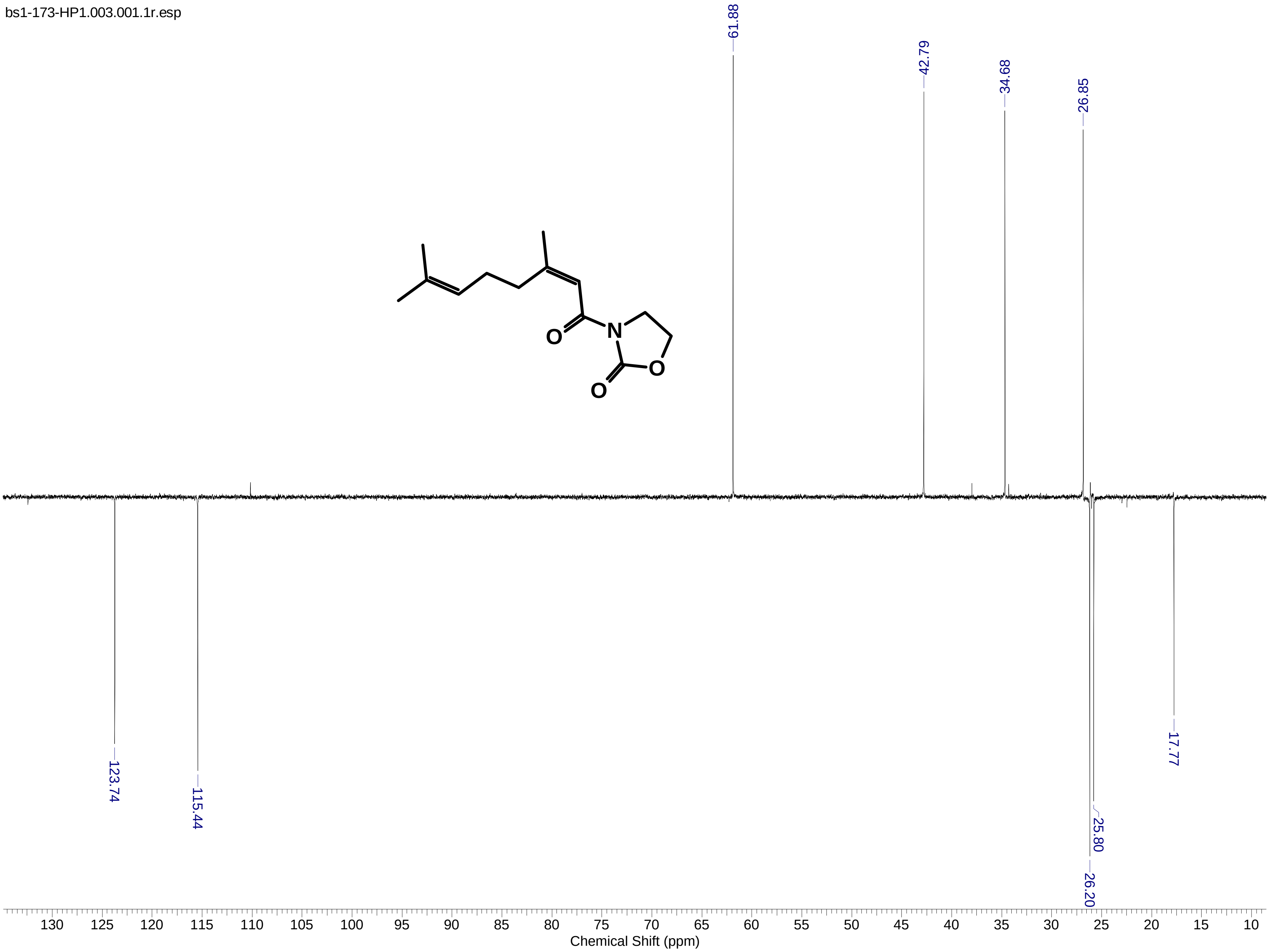
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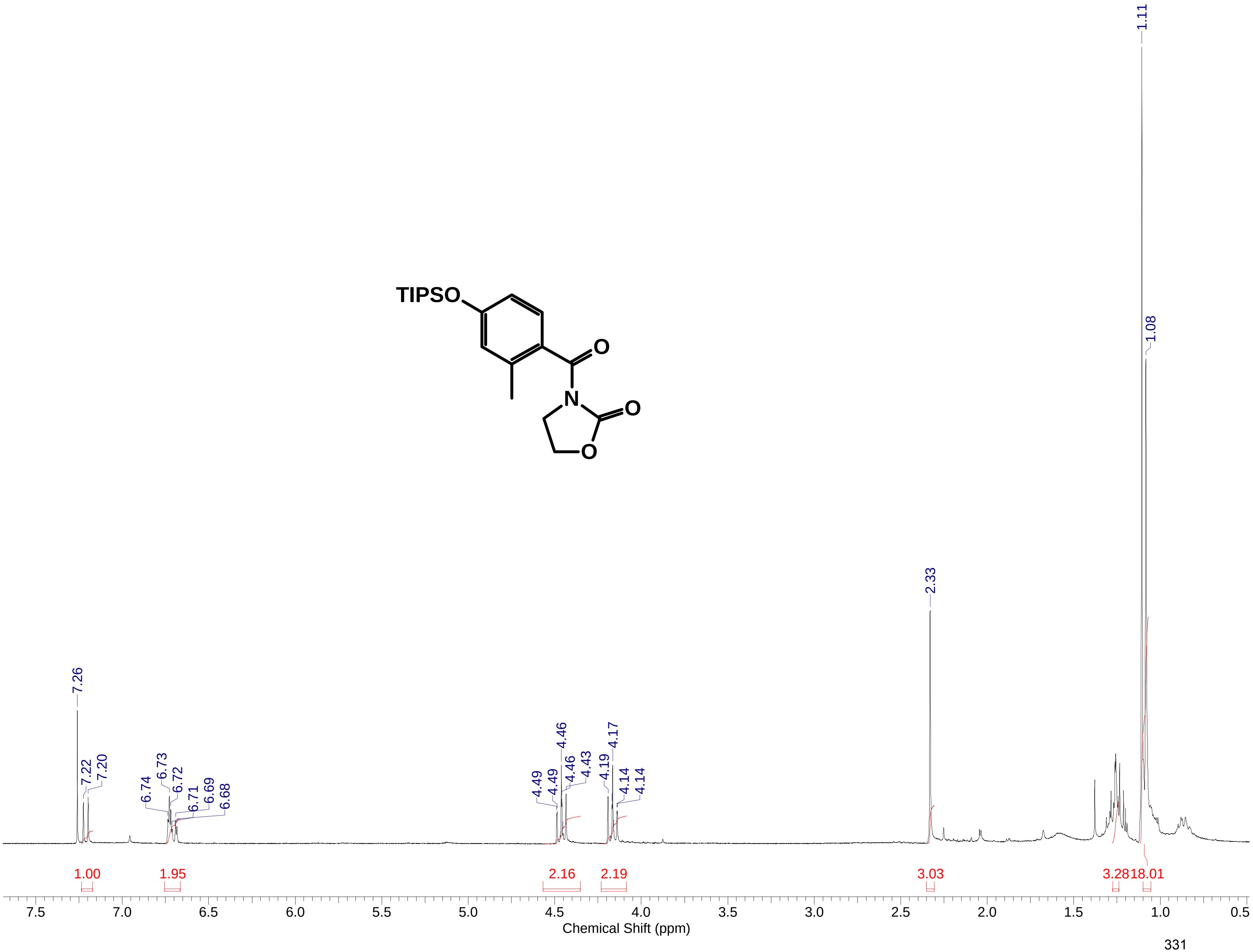
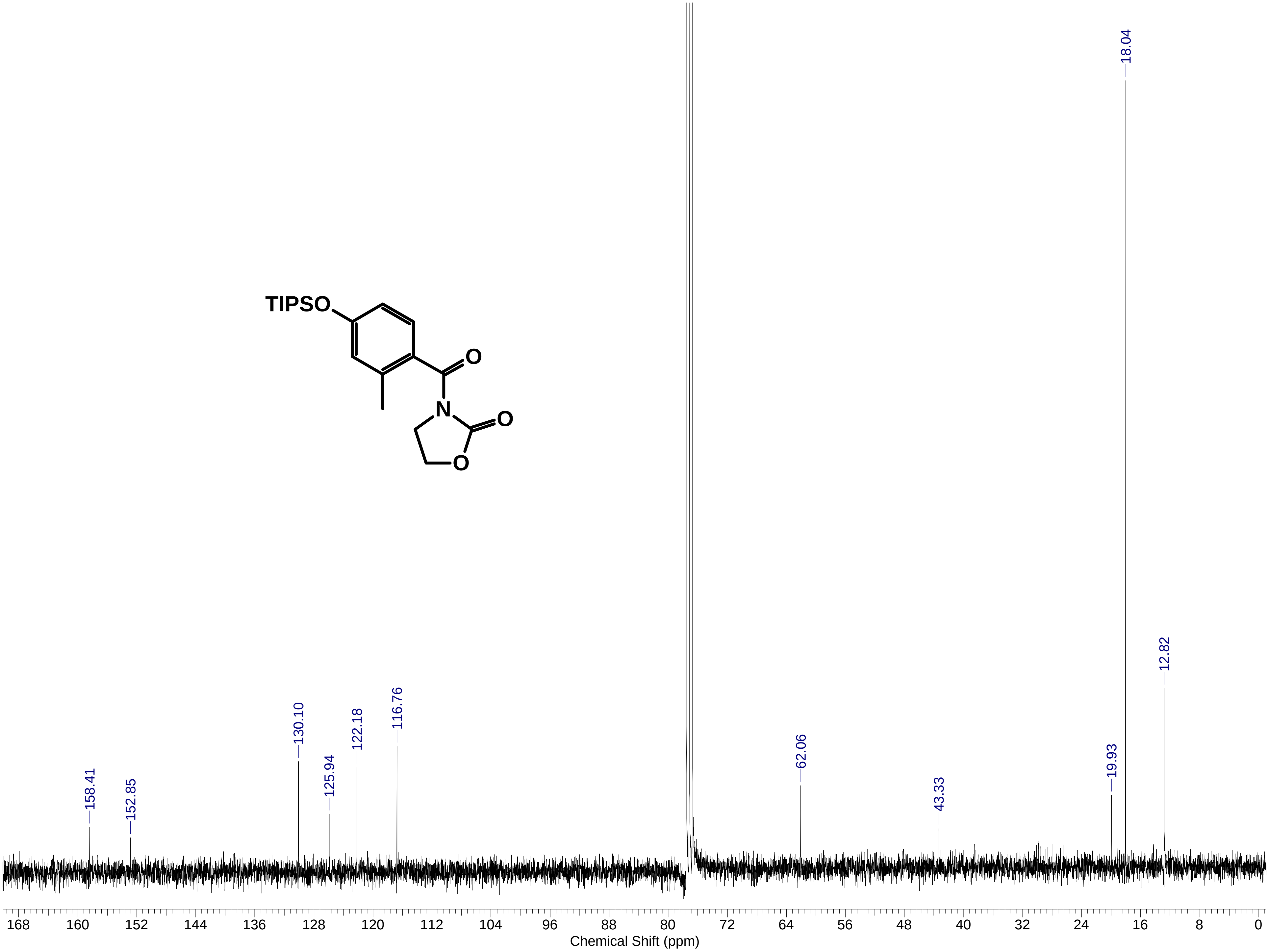
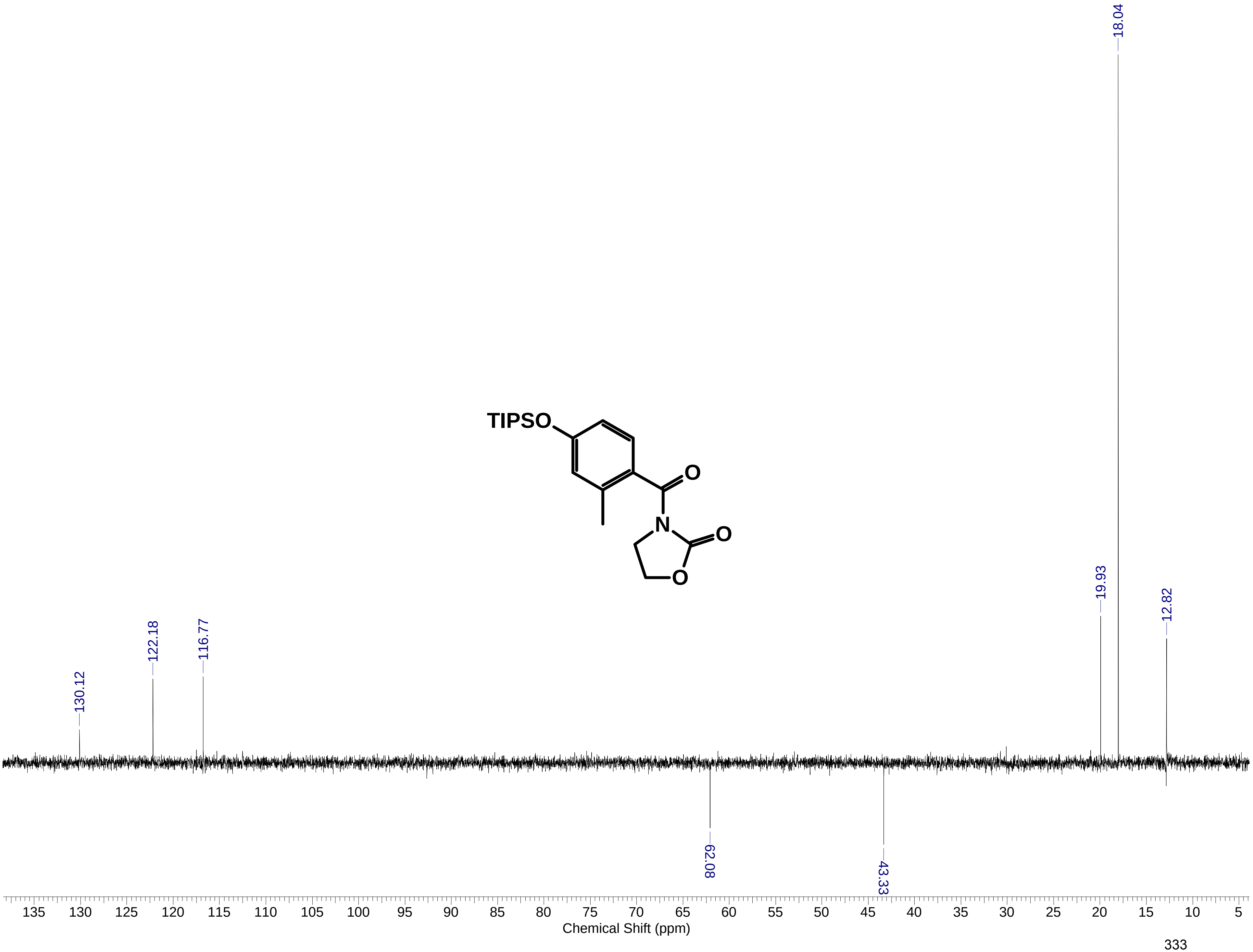
26.20
17.77
O
N
O
O
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
Chemical Shift (ppm)

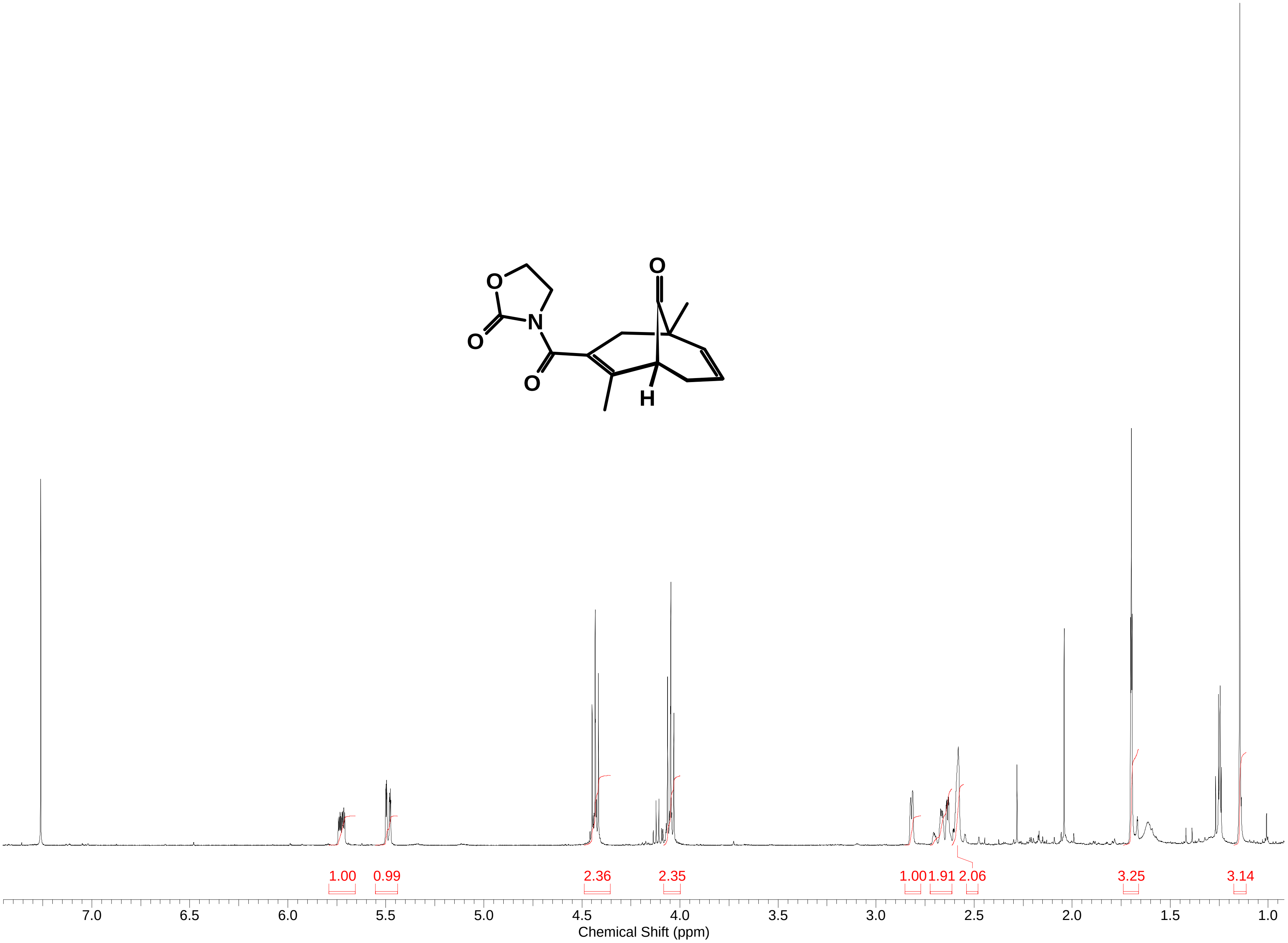

TIPSO
O
N
O
O
7.26
7.22
7.20
6.74
6.73
6.72
6.71
6.69
6.68
4.49
4.49
4.46
4.46
4.43
4.19
4.17
4.14
4.14
2.33
1.11
1.08
1.00
1.95
2.16
2.19
3.03
3.28
18.01
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

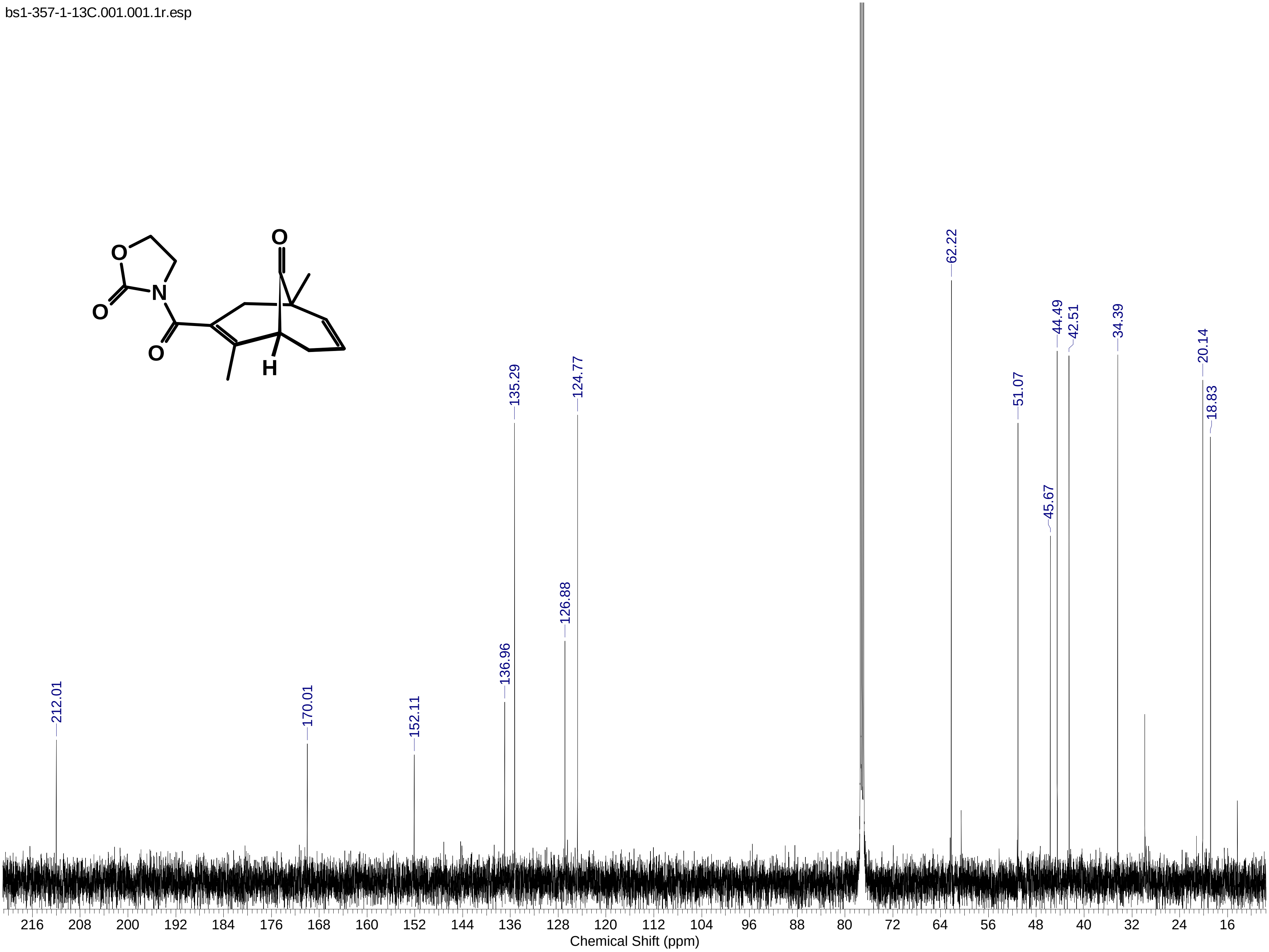

TIPSO
O
N
O
O
158.41
152.85
130.10
125.94
122.18
116.76
62.06
43.33
19.93
18.04
12.82
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
0
Chemical Shift (ppm)



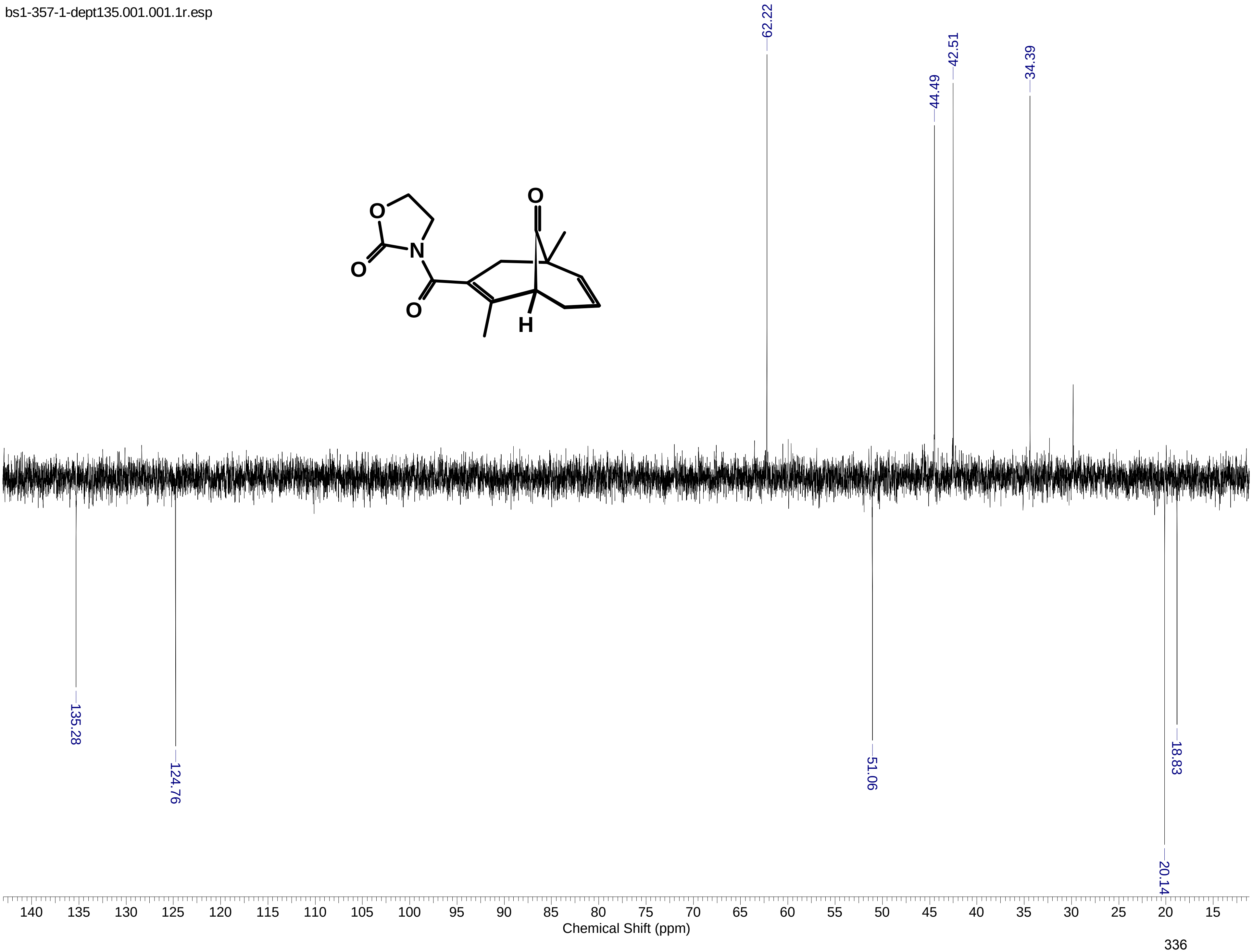
18.04
19.93
12.82
130.12
122.18
116.77
62.08
43.33
TIPSO
O
N
O
O
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Chemical Shift (ppm)

bs1-357-1-1H.001.001.1r.esp

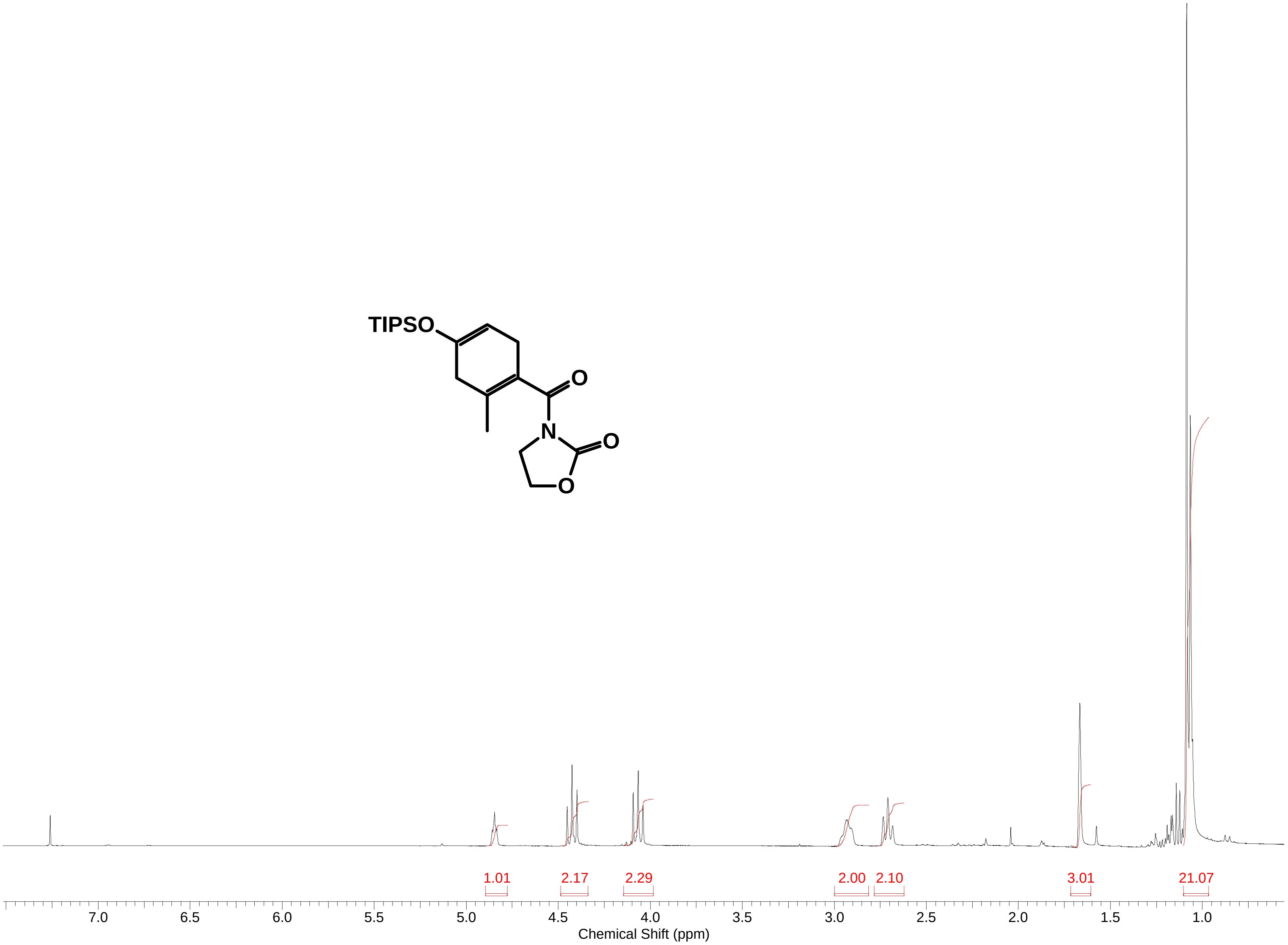


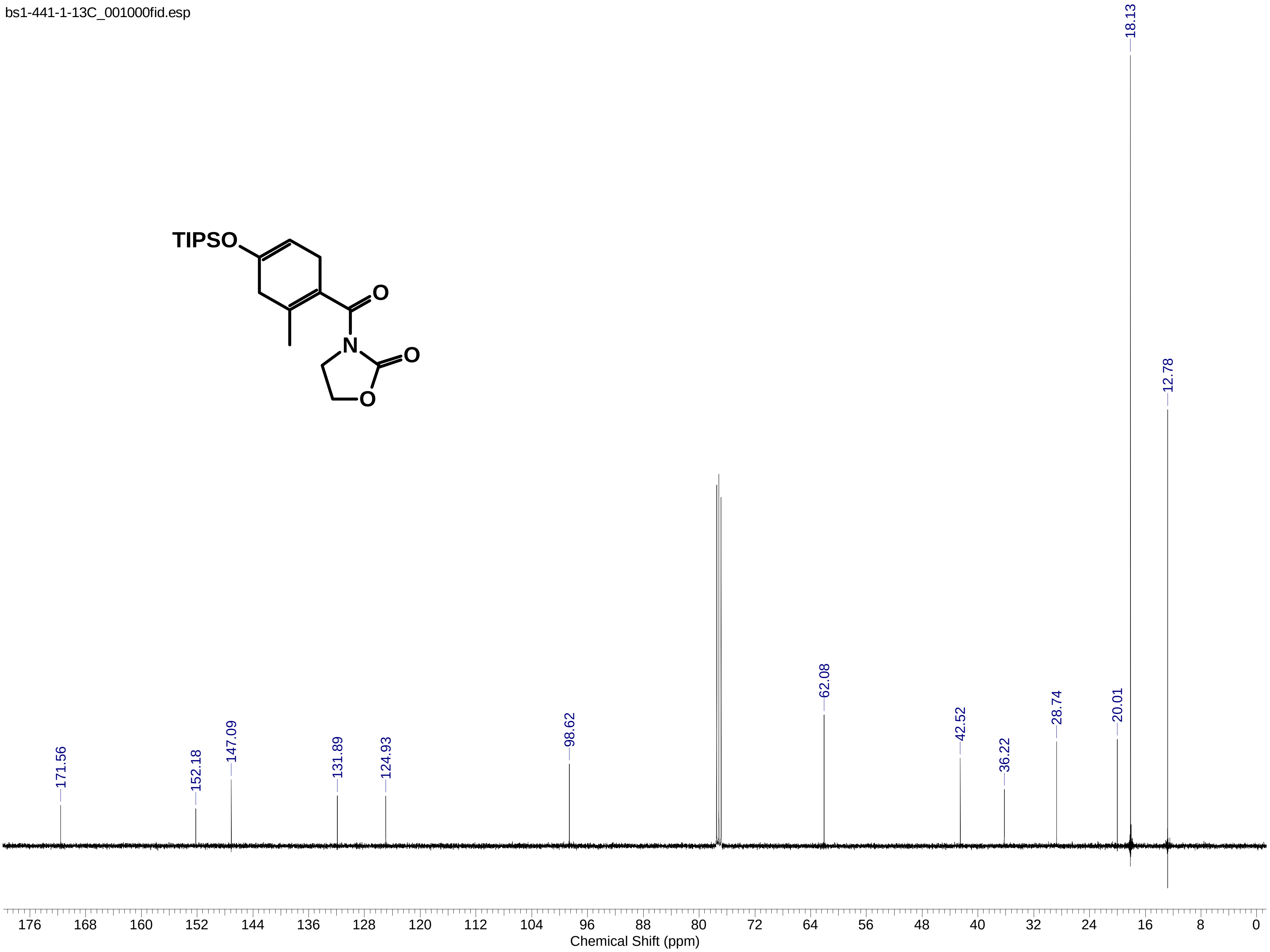

bs1-357-1-13C.001.001.1r.esp
O
O
N
O
O
O
H
212.01
170.01
152.11
136.96
135.29
126.88
124.77
62.22
51.07
45.67
44.49
42.51
34.39
20.14
18.83
216
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

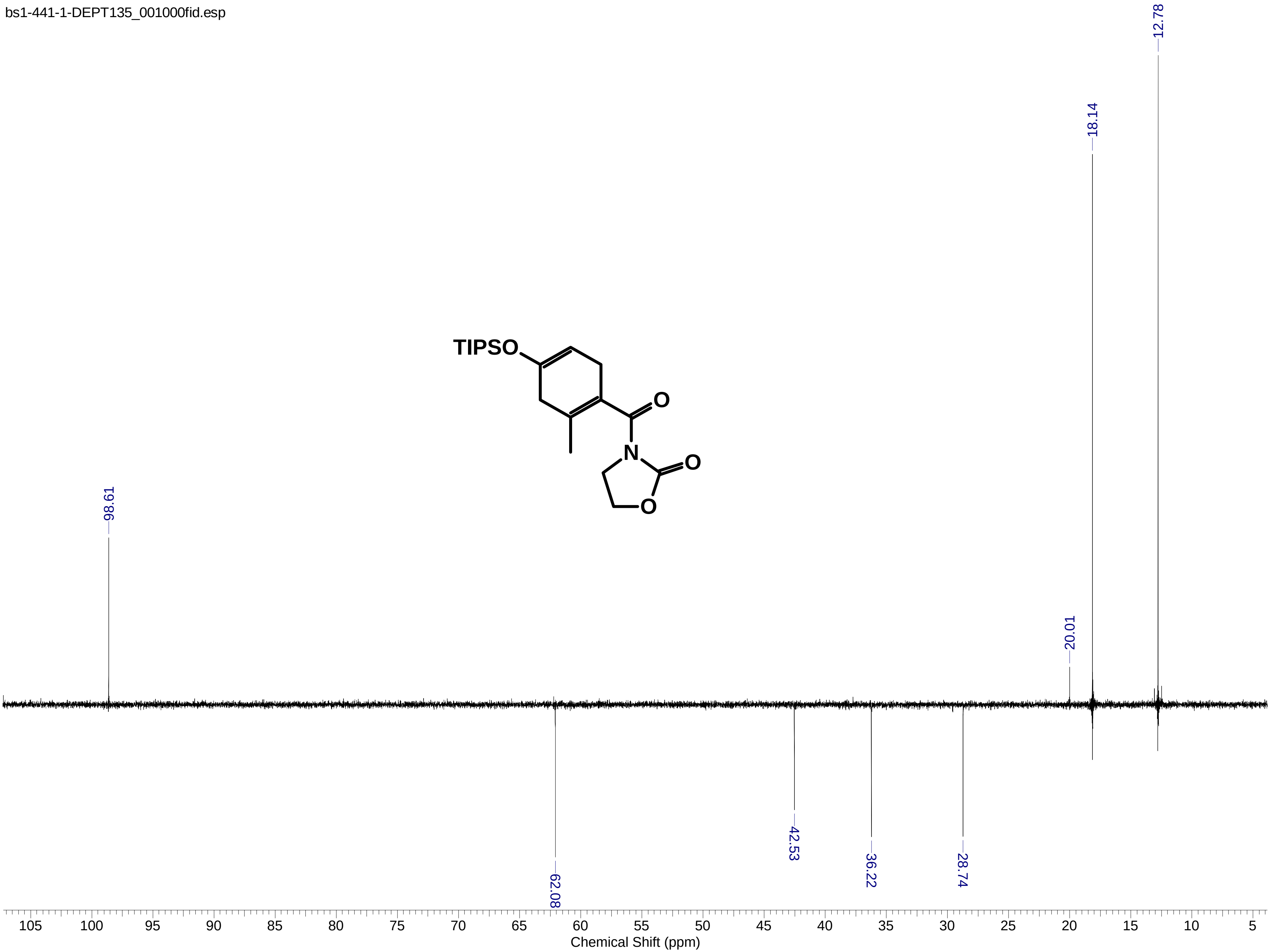
bs1-357-1-dept135.001.001.1r.esp

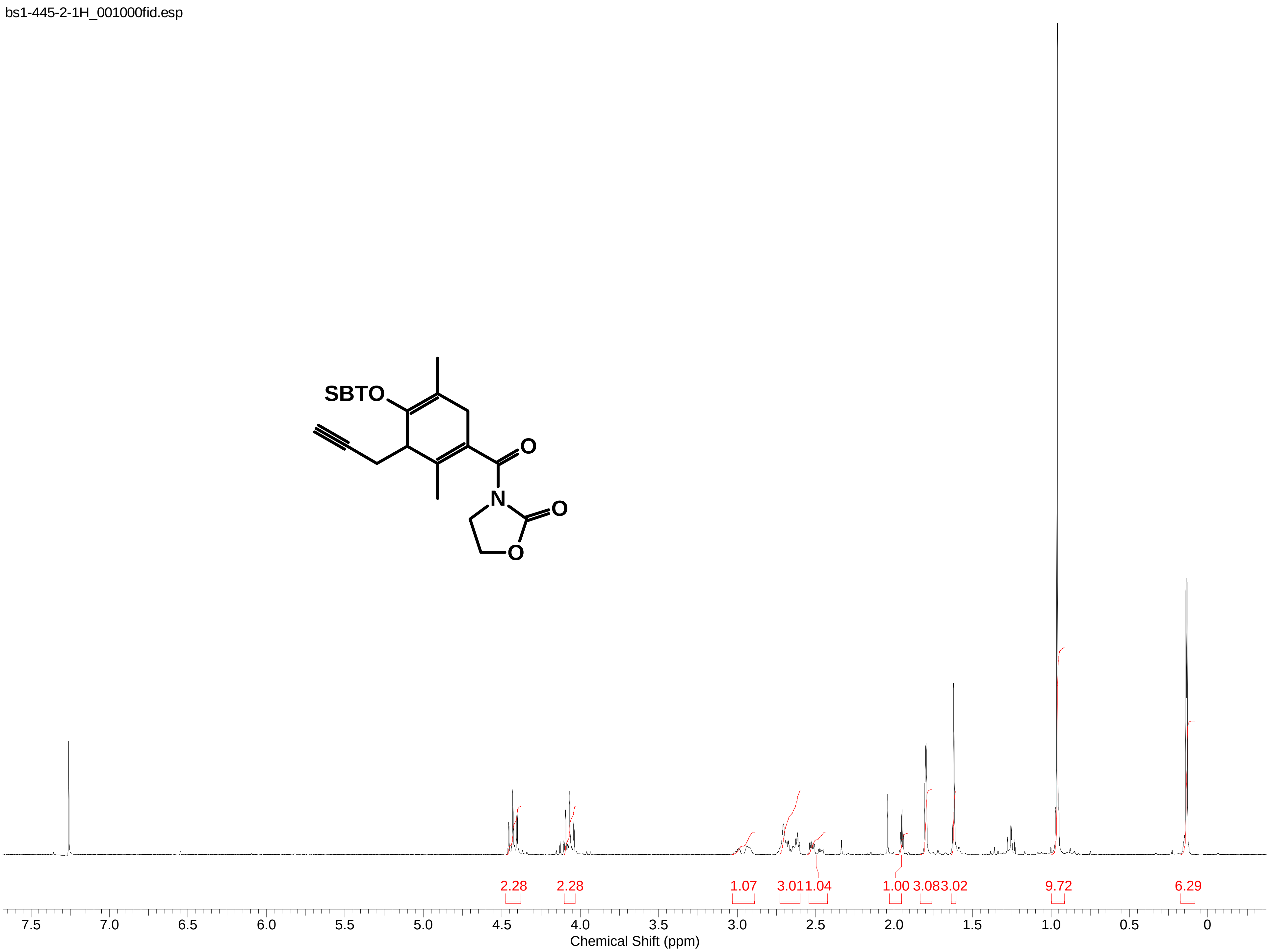


bs1-444-1-1H_001000fid.esp

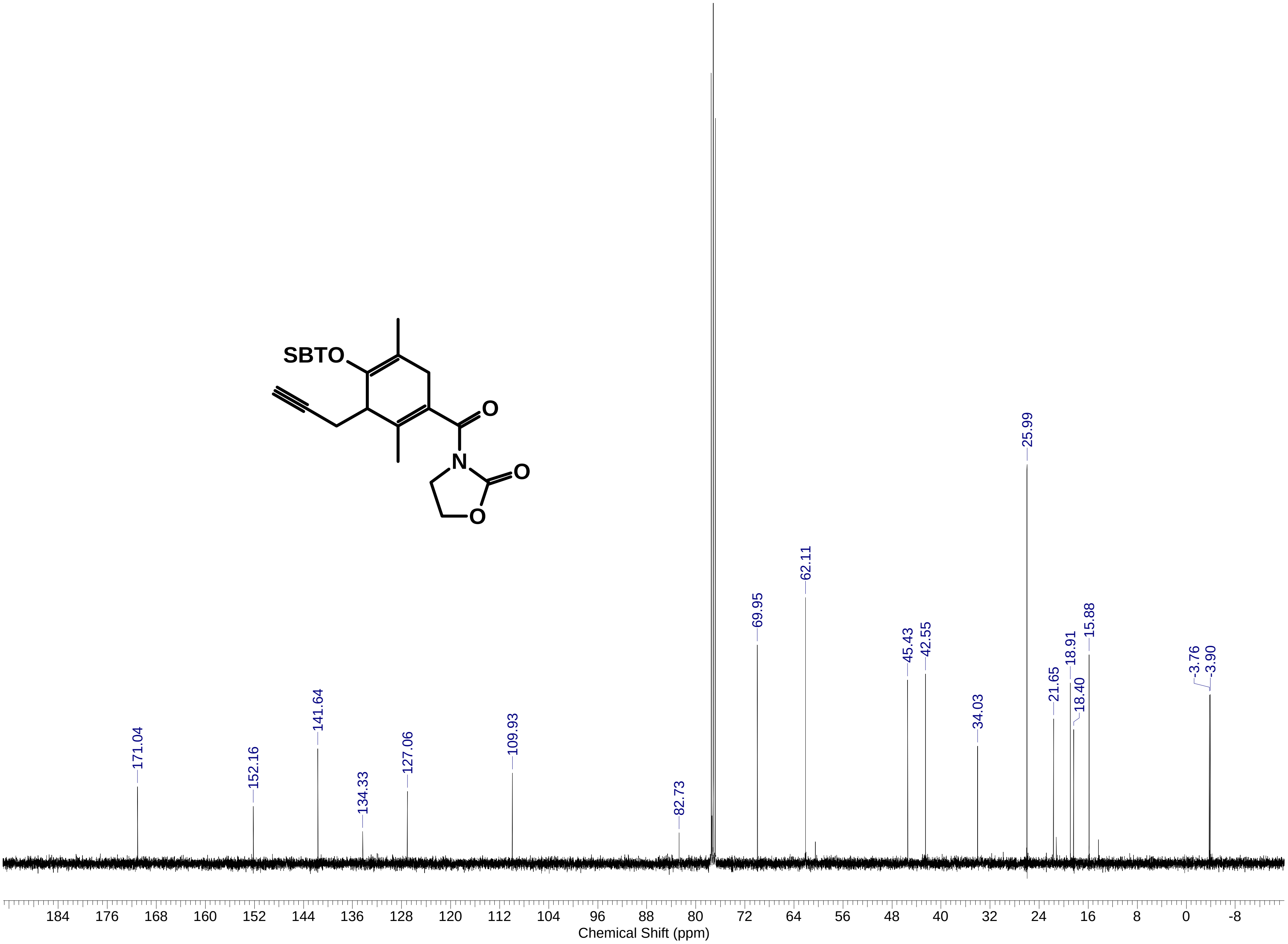



bs1-441-1-13C_001000fid.esp
TIPSO
O
N
O
O
171.56
152.18
147.09
131.89
124.93
98.62
62.08
42.52
36.22
28.74
20.01
18.13
12.78
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
0
Chemical Shift (ppm)

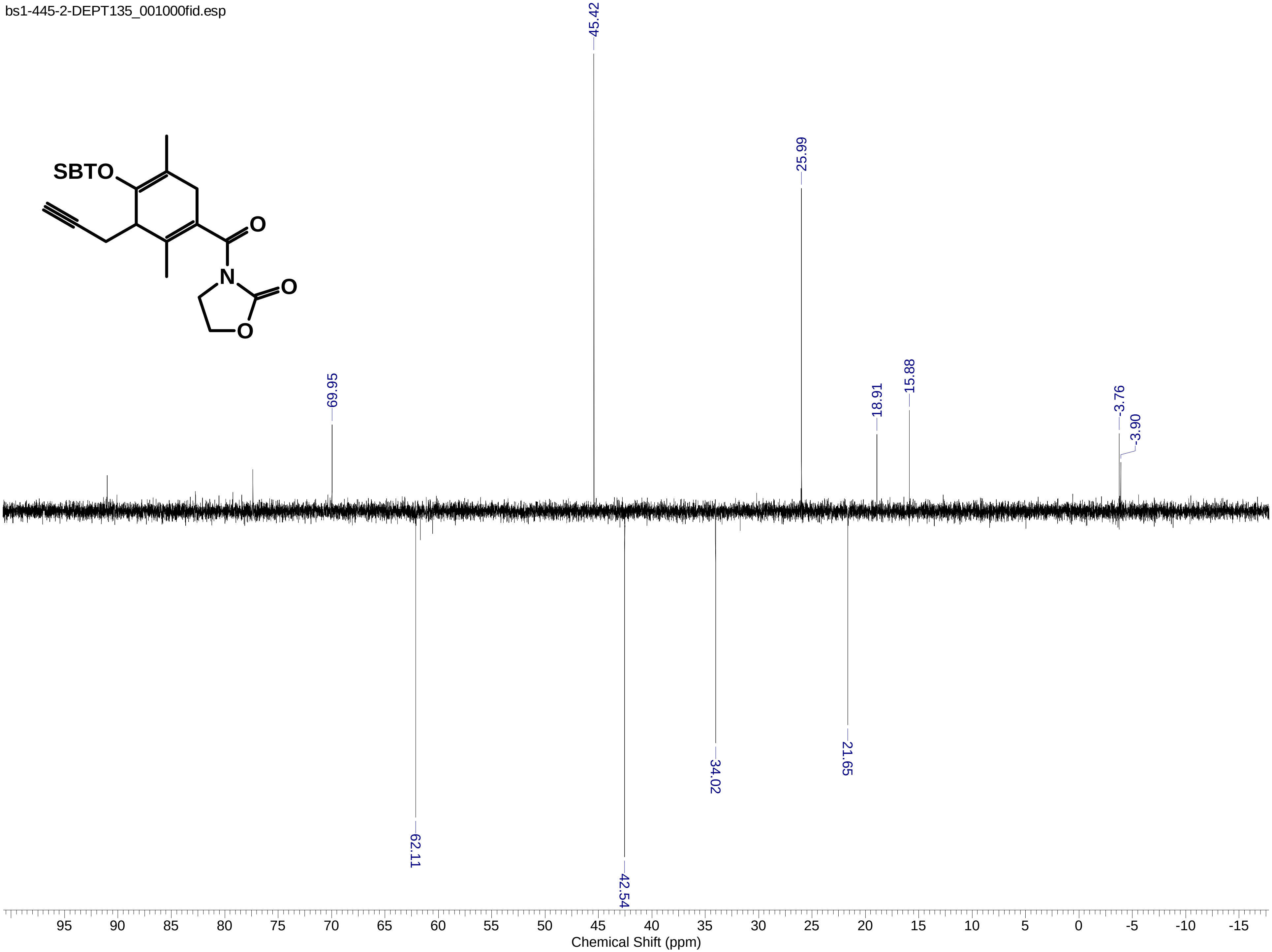

bs1-441-1-DEPT135_001000fid.esp
12.78
18.14
98.61
20.01
62.08
42.53
36.22
28.74
TIPSO
O
N
O
O
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Chemical Shift (ppm)


bs1-445-2-1H_001000fid.esp
SBTO
O
N
O
O
2.28
2.28
1.07
3.01
1.04
1.00
3.08
3.02
9.72
6.29
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Chemical Shift (ppm)

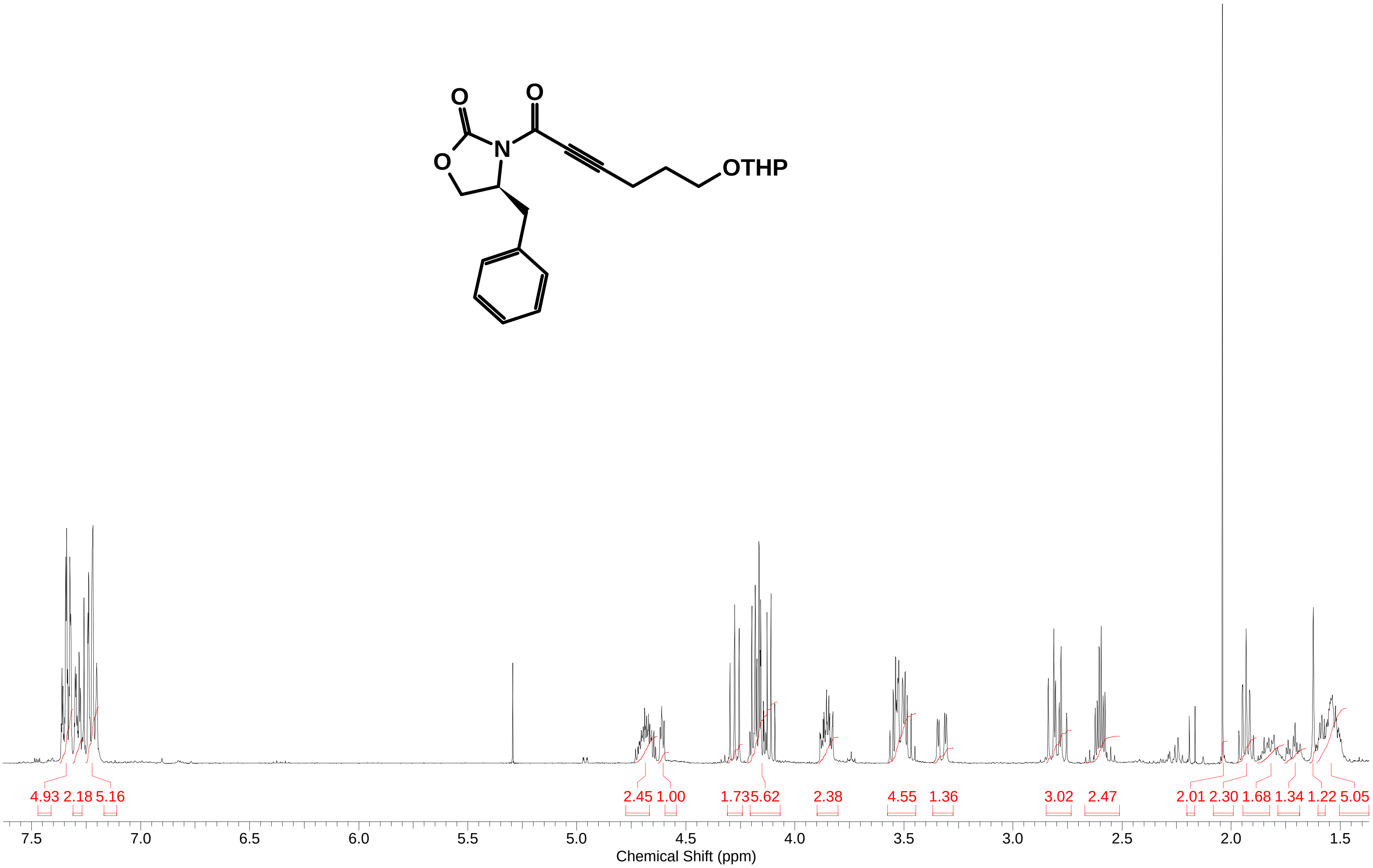
bs1-445-2-13C_001000fid.esp

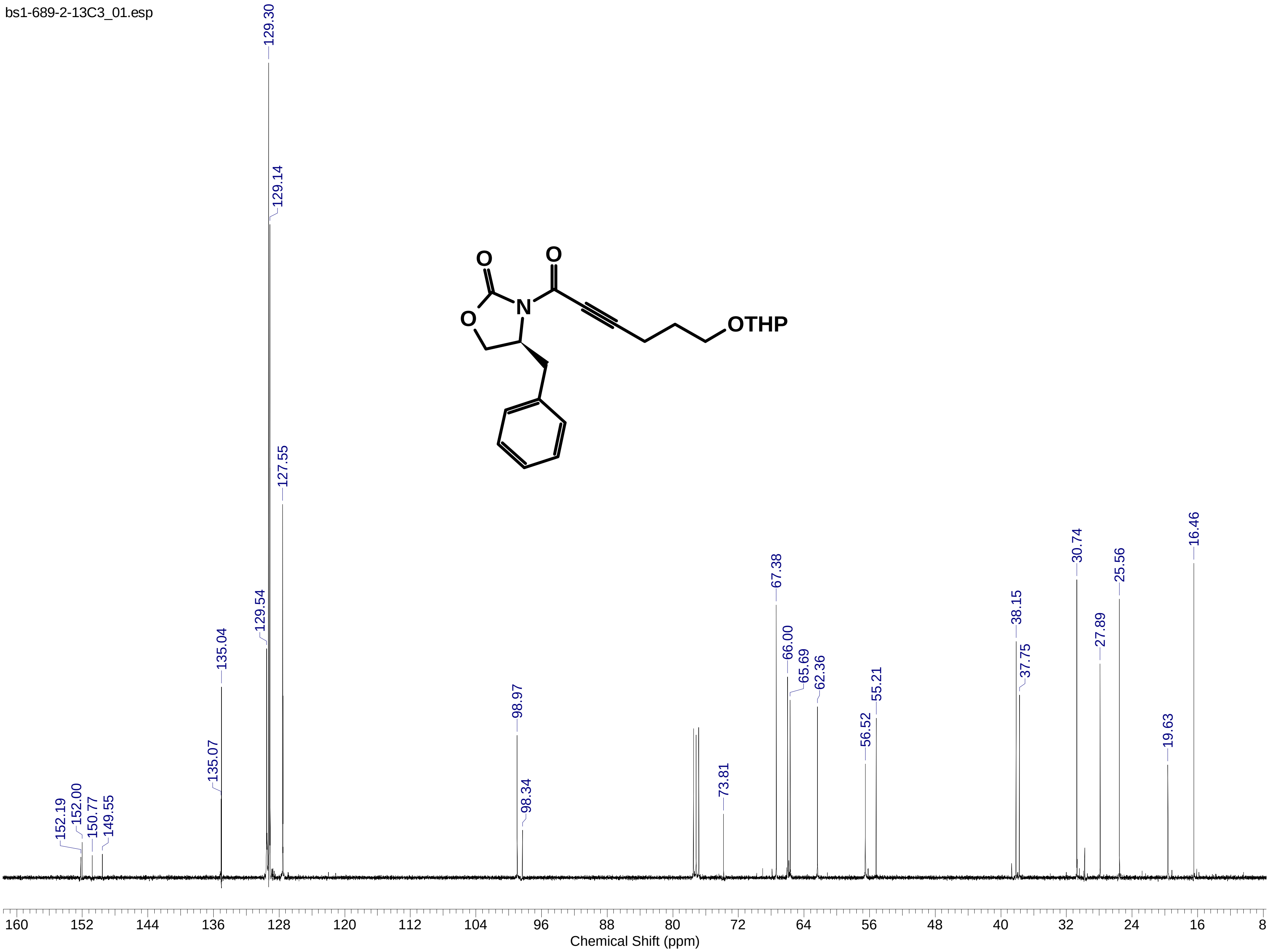


bs1-445-2-DEPT135_001000fid.esp

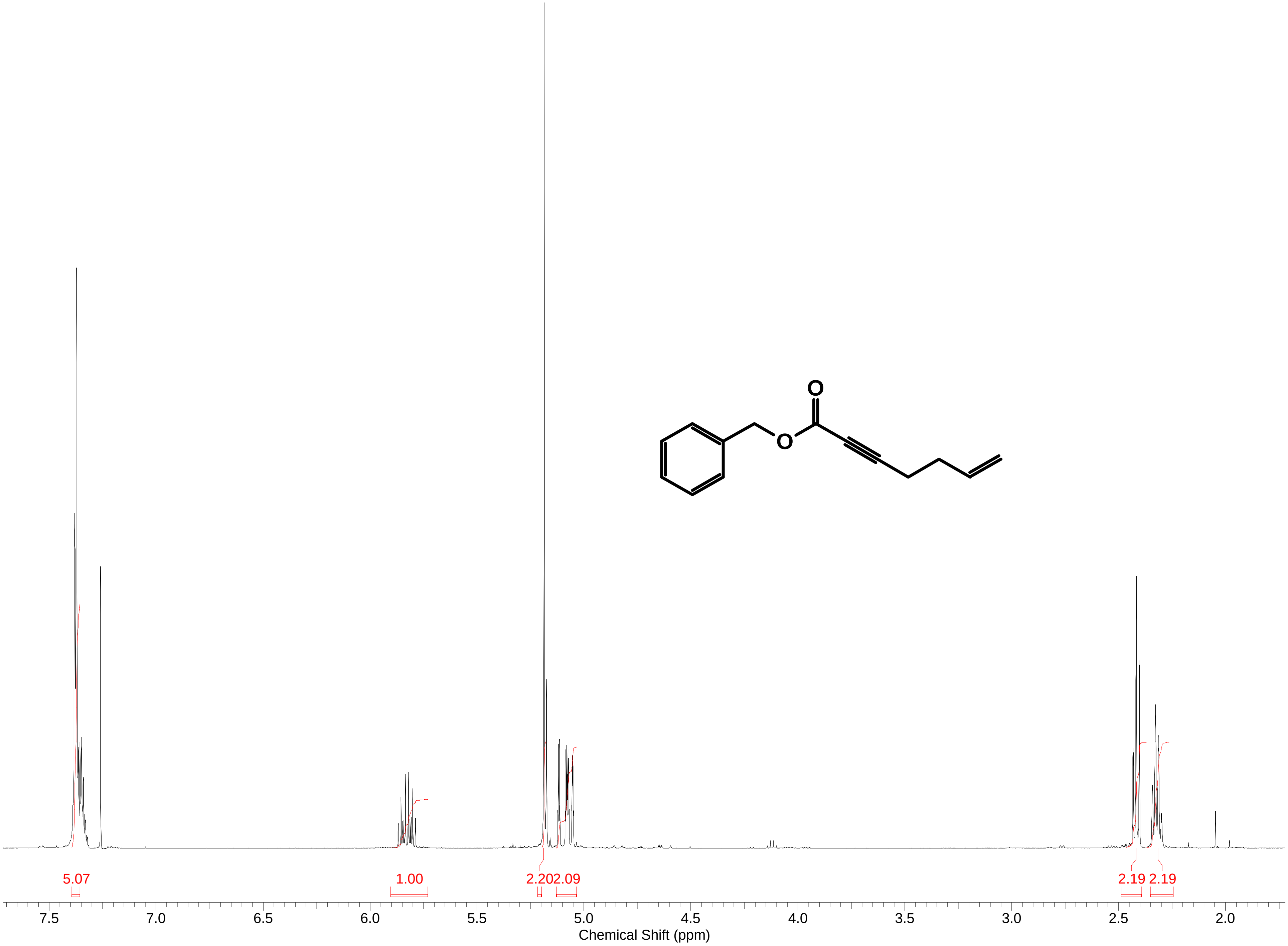


bs1-689-2-1H_01.esp

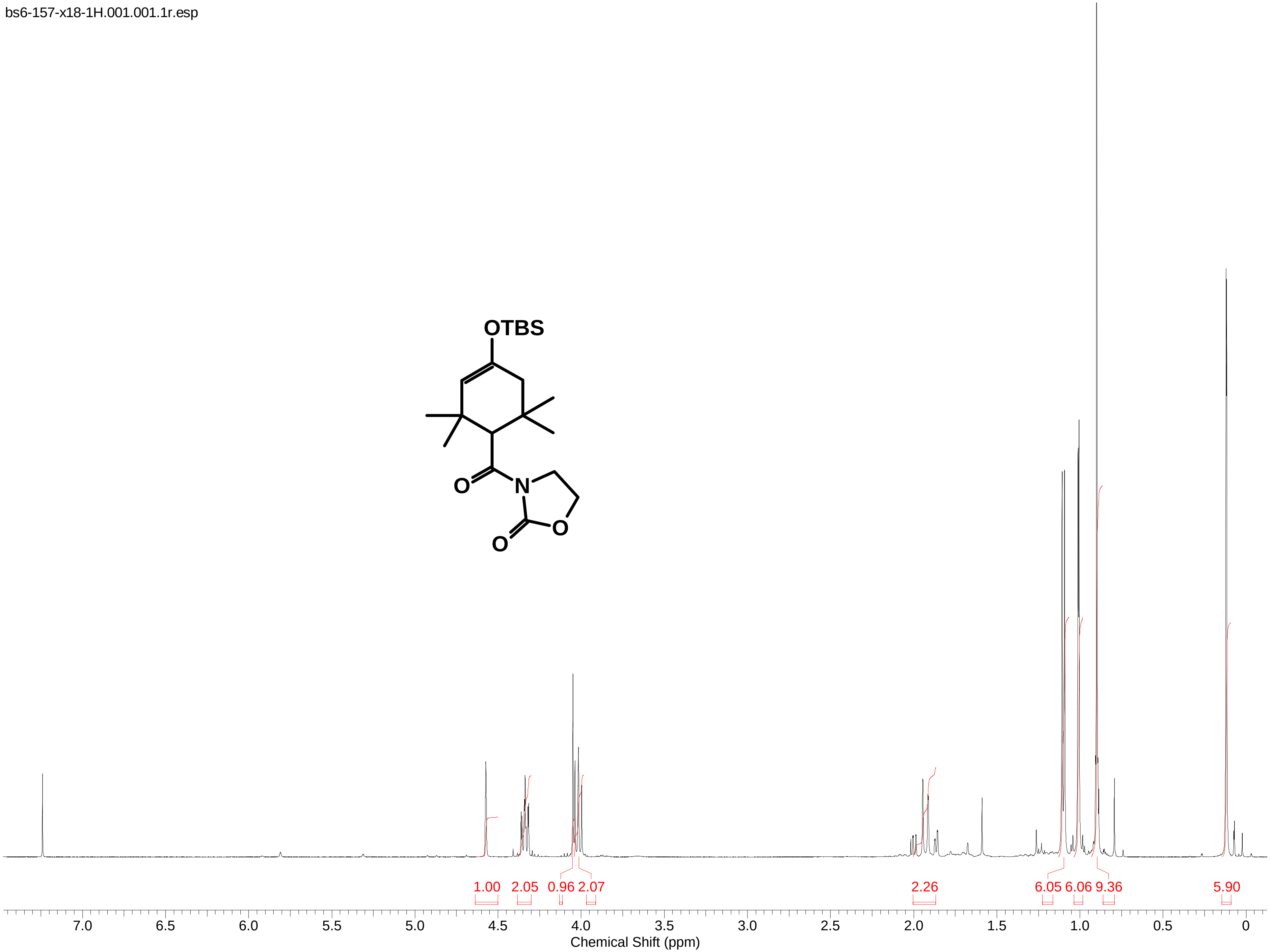


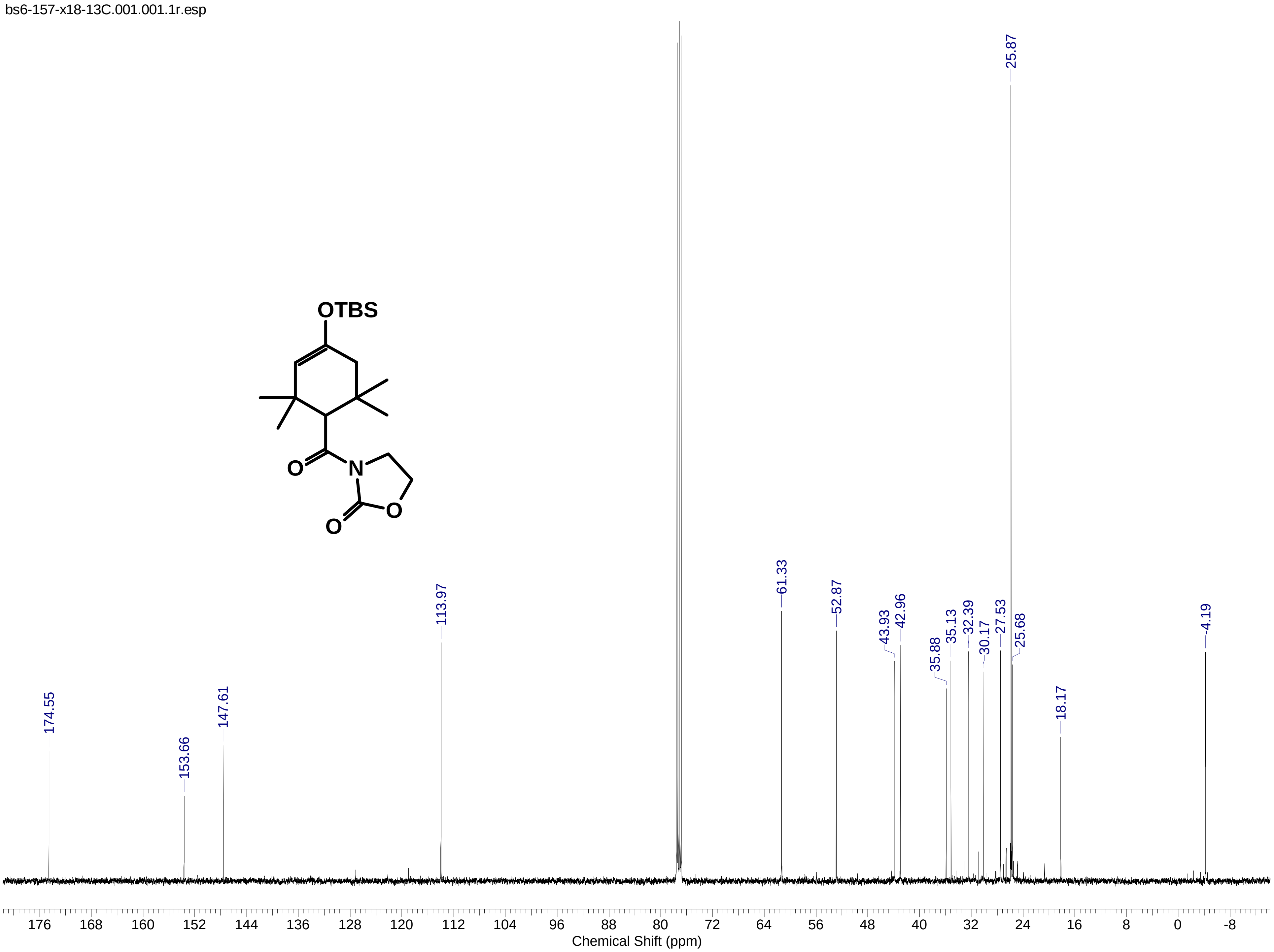

bs1-689-2-13C3_01.esp
129.30
129.14
127.55
129.54
135.04
135.07
152.19
152.00
150.77
149.55
98.97
98.34
73.81
67.38
66.00
65.69
62.36
56.52
55.21
38.15
37.75
30.74
27.89
25.56
19.63
16.46
O
O
N
O
OTHP
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

bs5-024-1-1H_H1_002.esp

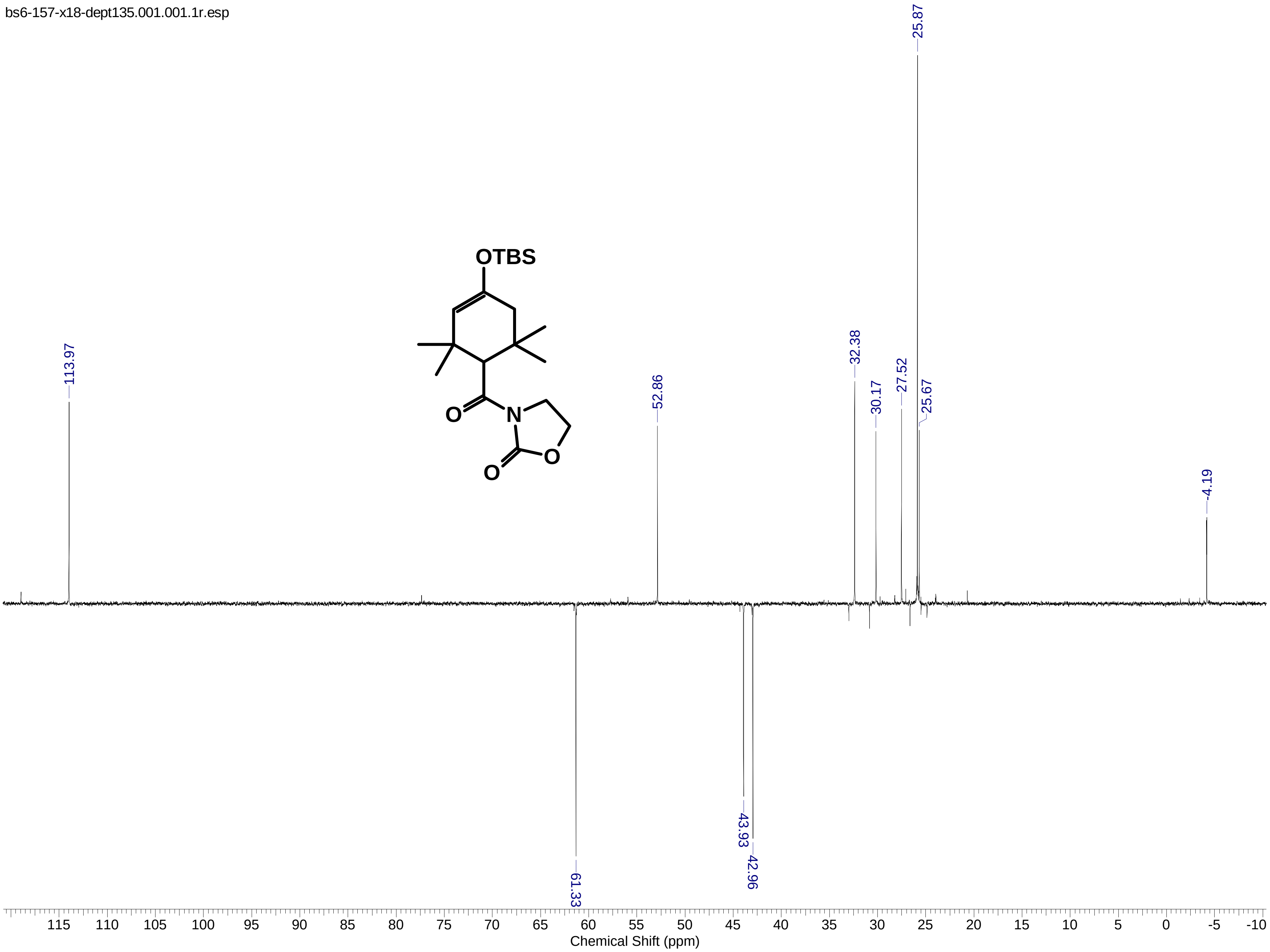


bs6-157-x18-1H.001.001.1r.esp

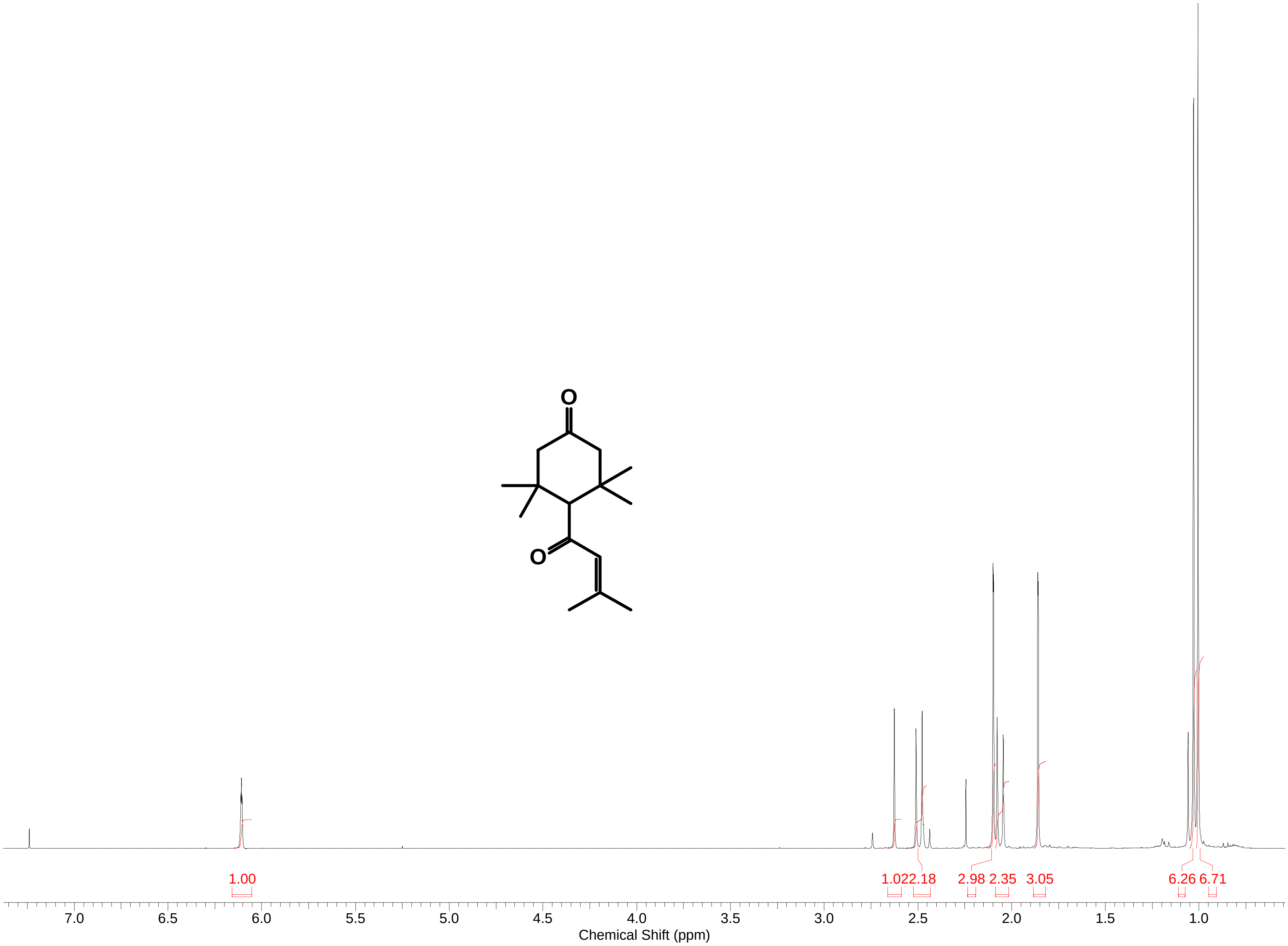



bs6-157-x18-13C.001.001.1r.esp
OTBS
O
N
O
O
174.55
153.66
147.61
113.97
61.33
52.87
43.93
42.96
35.88
35.13
32.39
30.17
27.53
25.87
25.68
18.17
-4.19
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
0
-8
Chemical Shift (ppm)

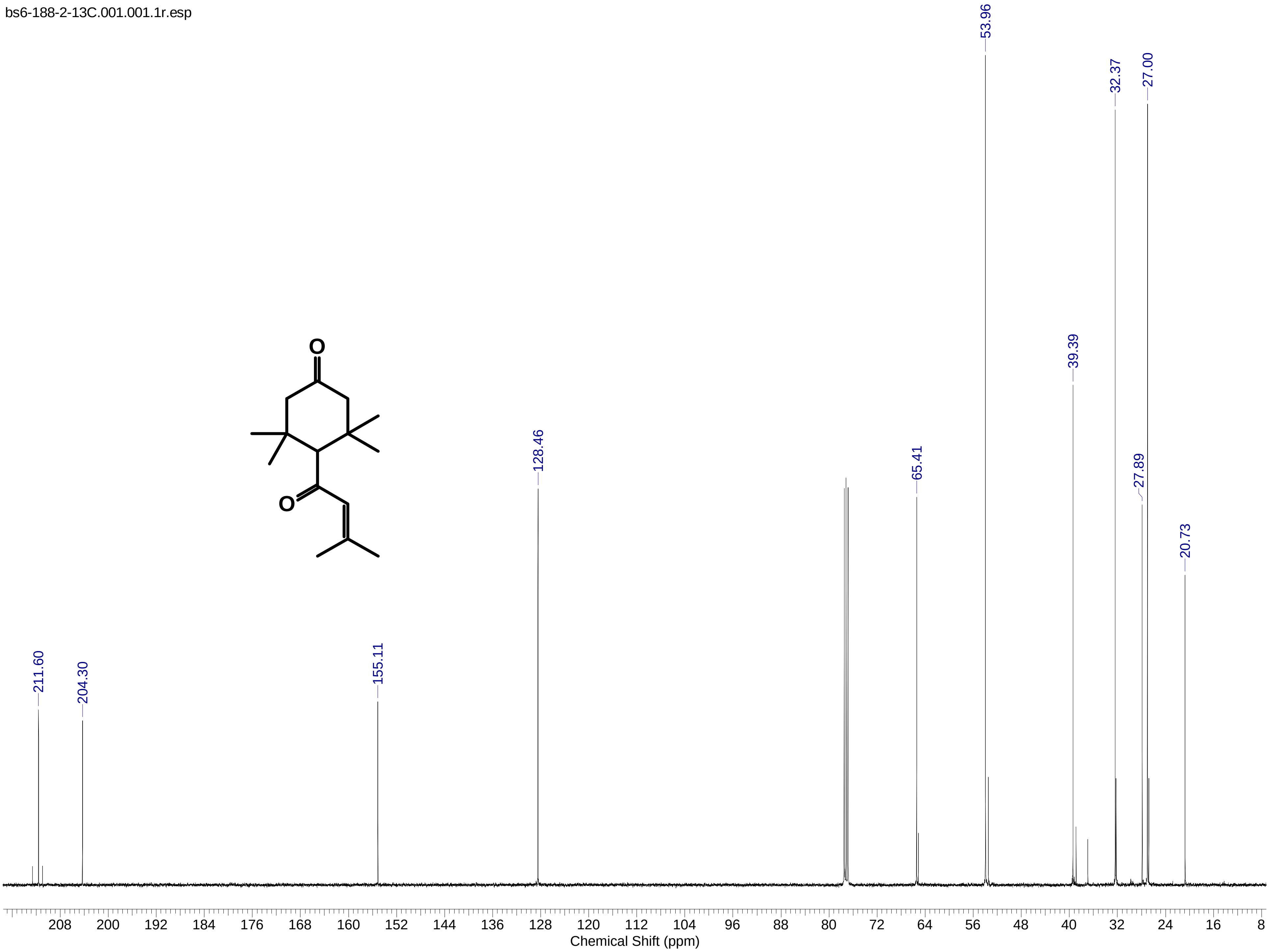
bs6-157-x18-dept135.001.001.1r.esp

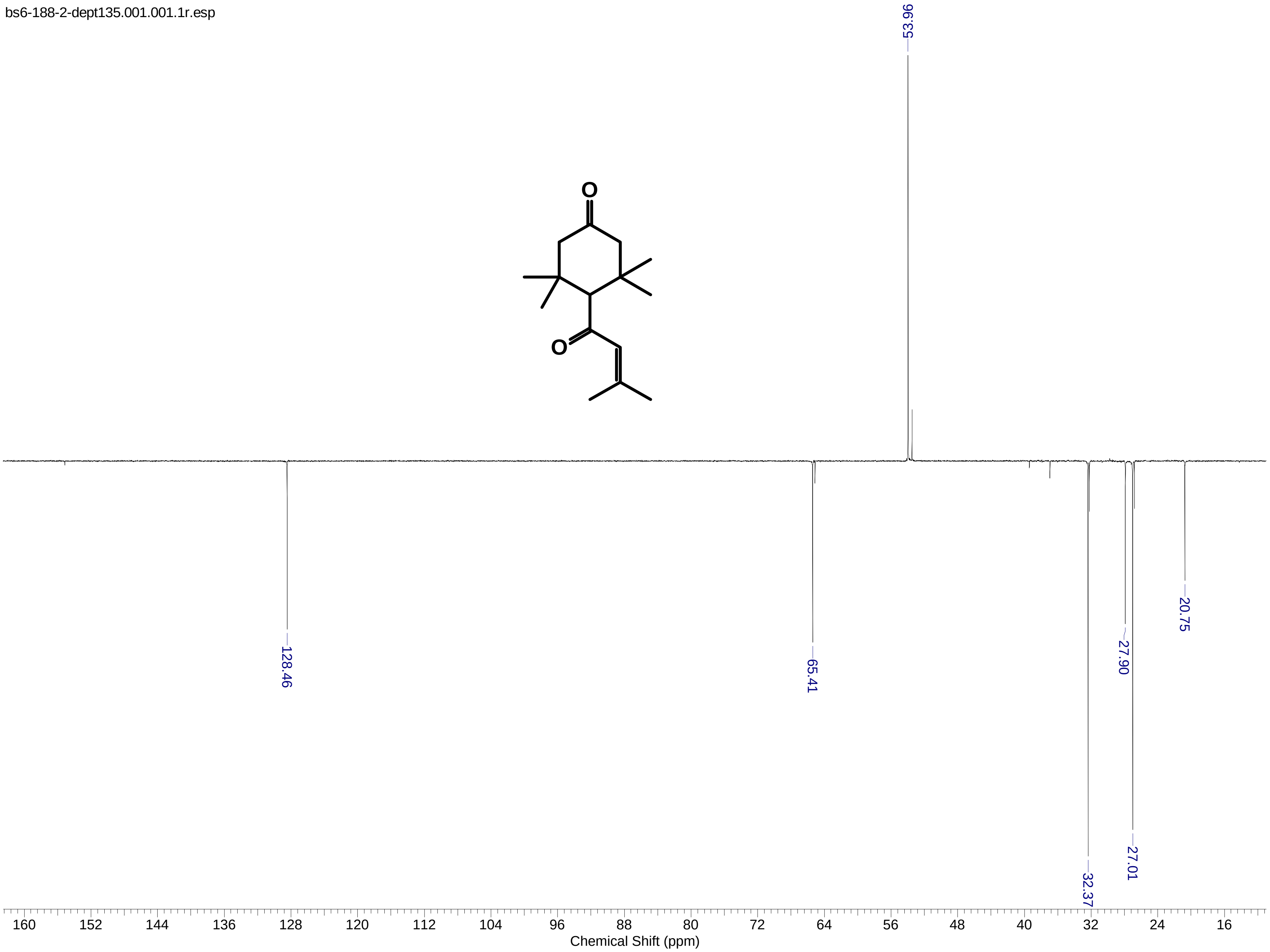


bs6-188-2-1H.001.001.1r.esp

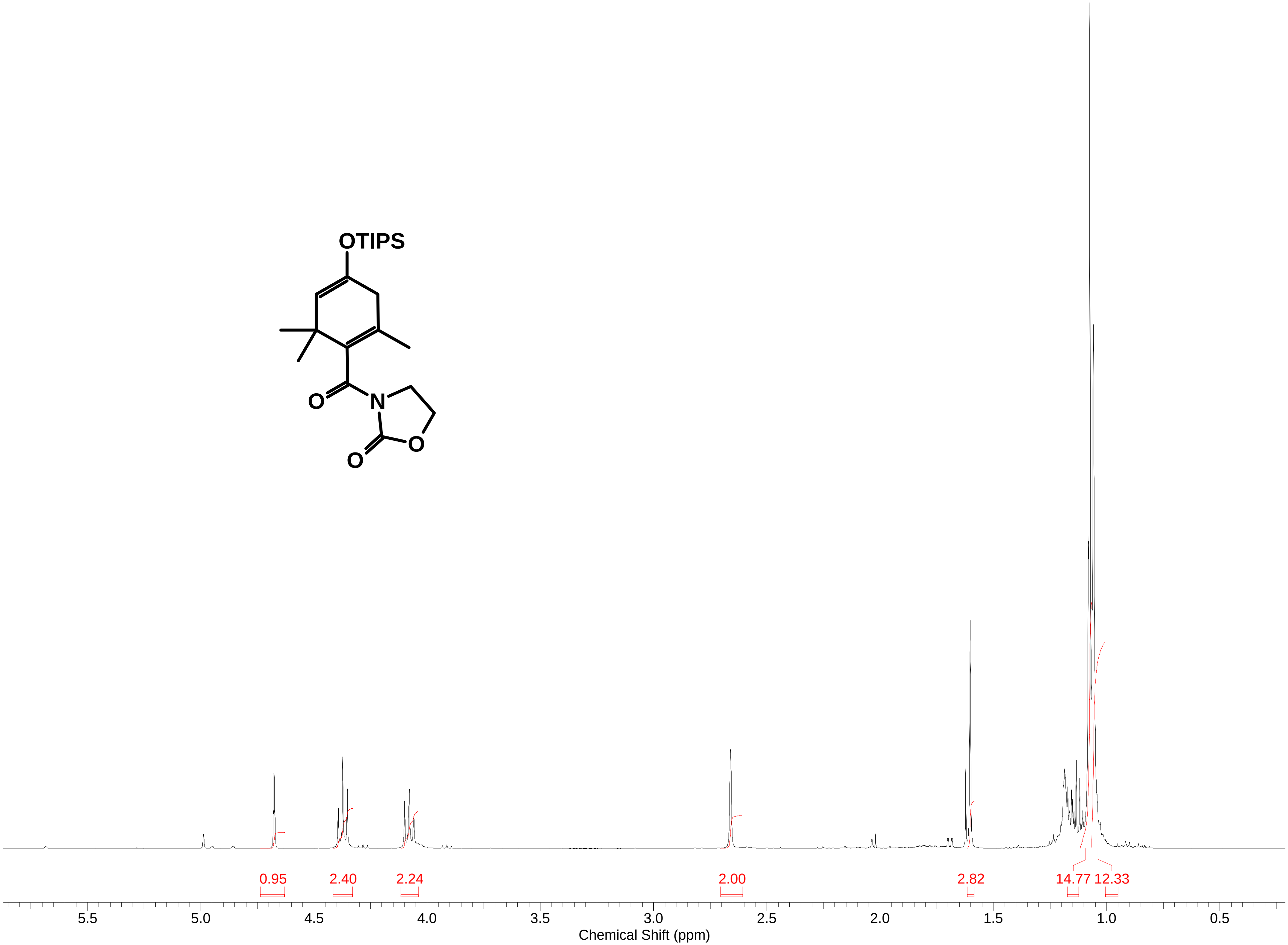


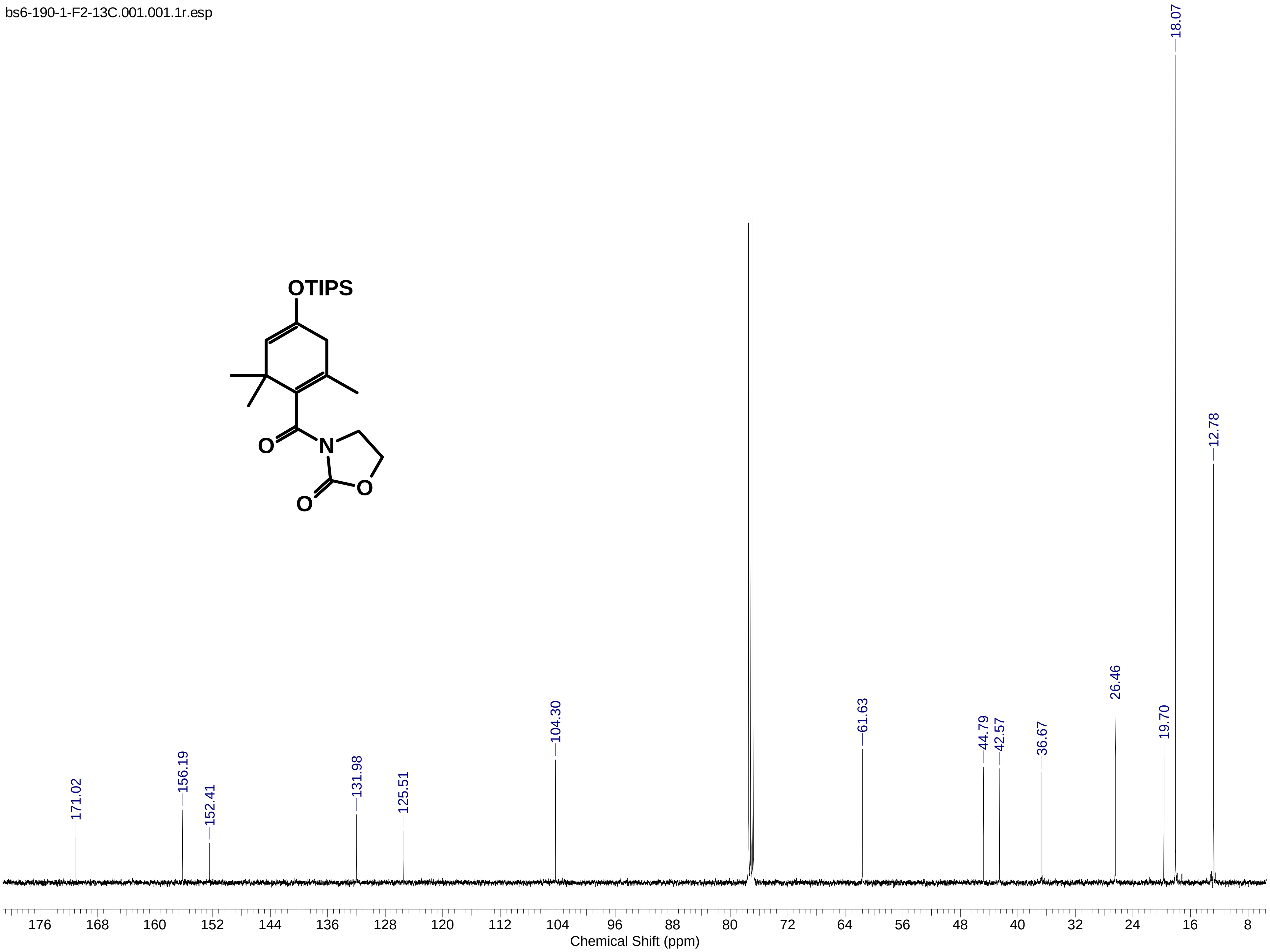
bs6-188-2-13C.001.001.1r.esp

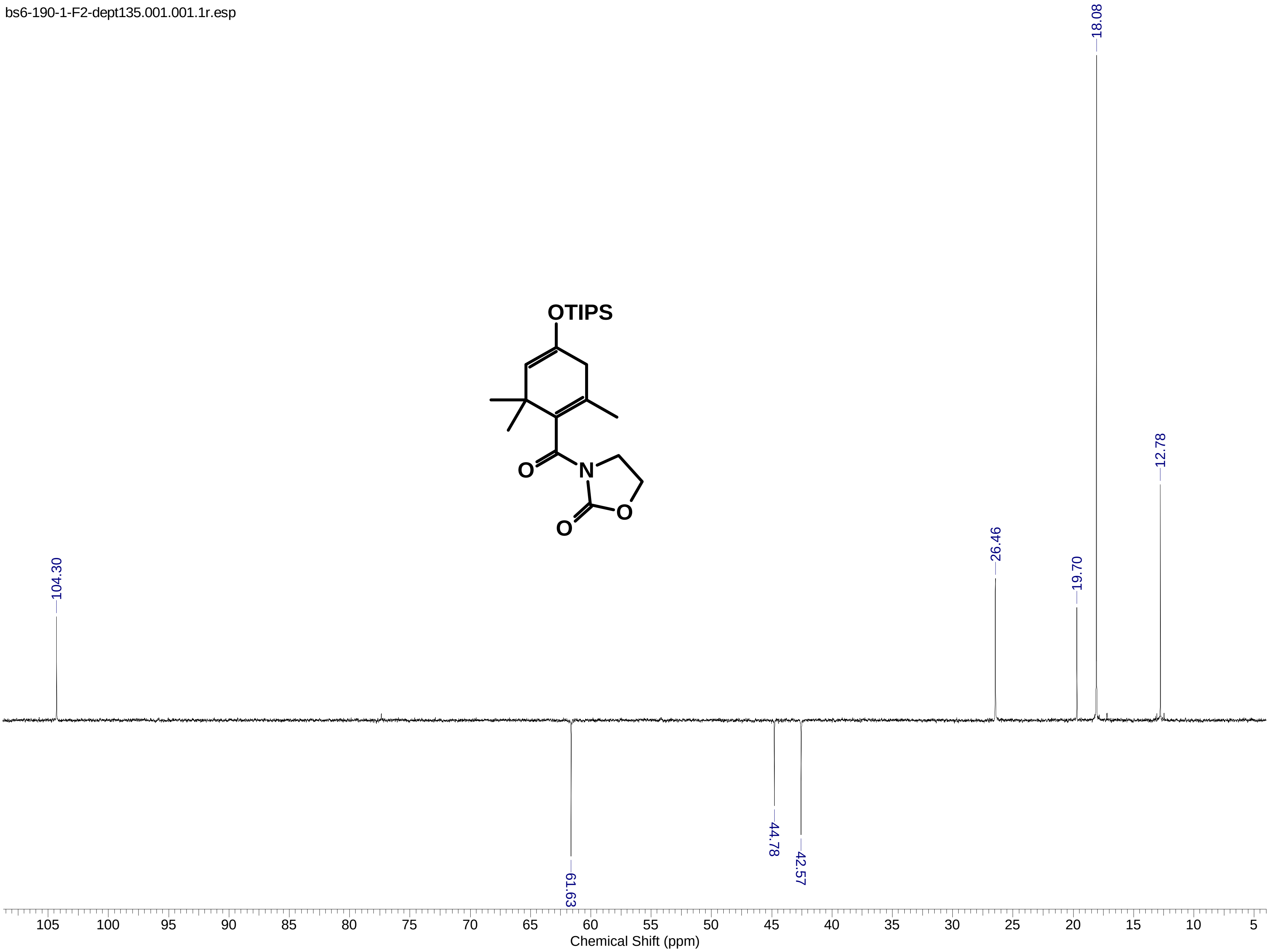



bs6-188-2-dept135.001.001.1r.esp
53.96
128.46
65.41
20.75
27.90
27.01
32.37
O
O
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

bs6-190-1-1H.001.001.1r.esp

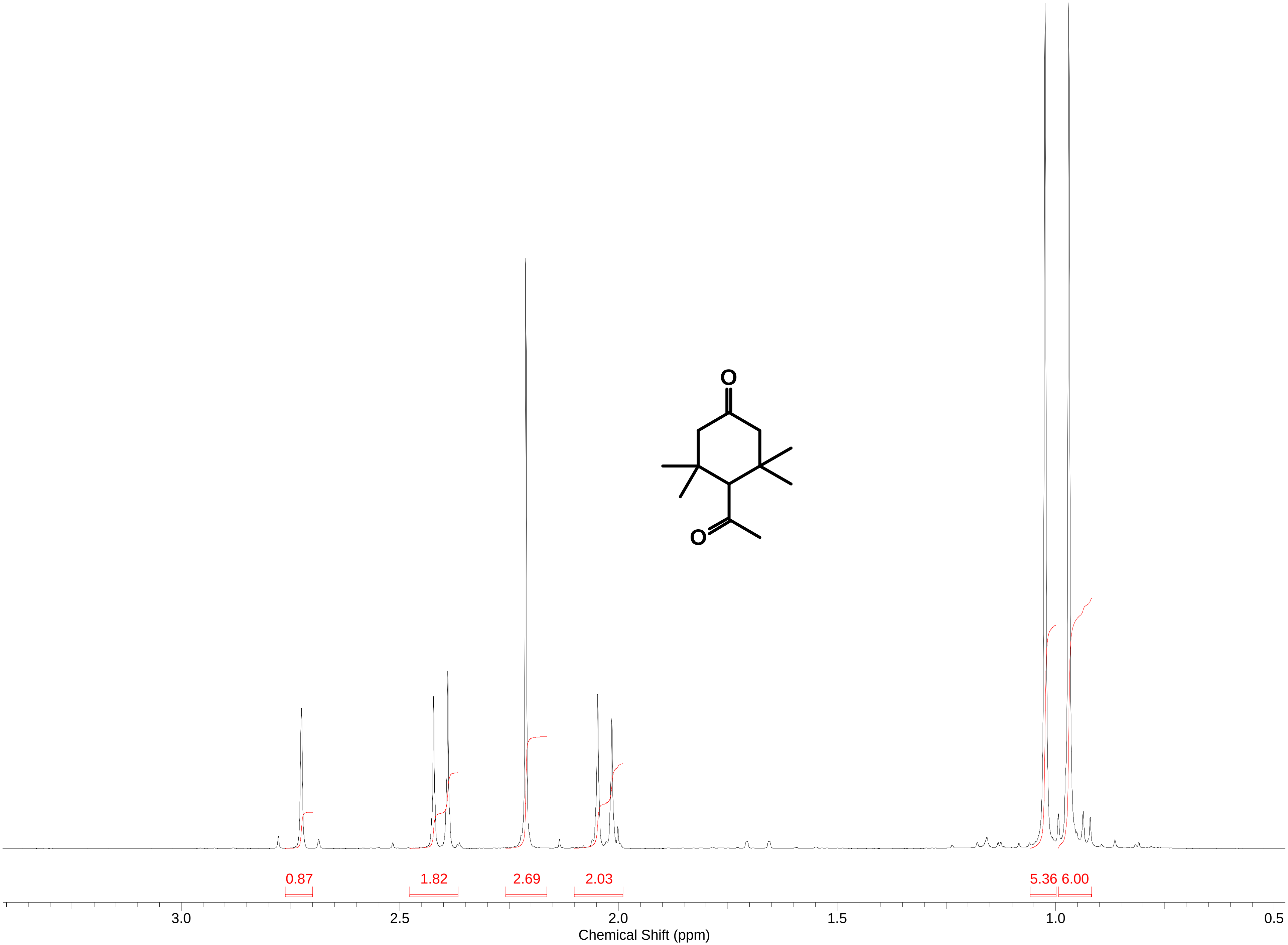


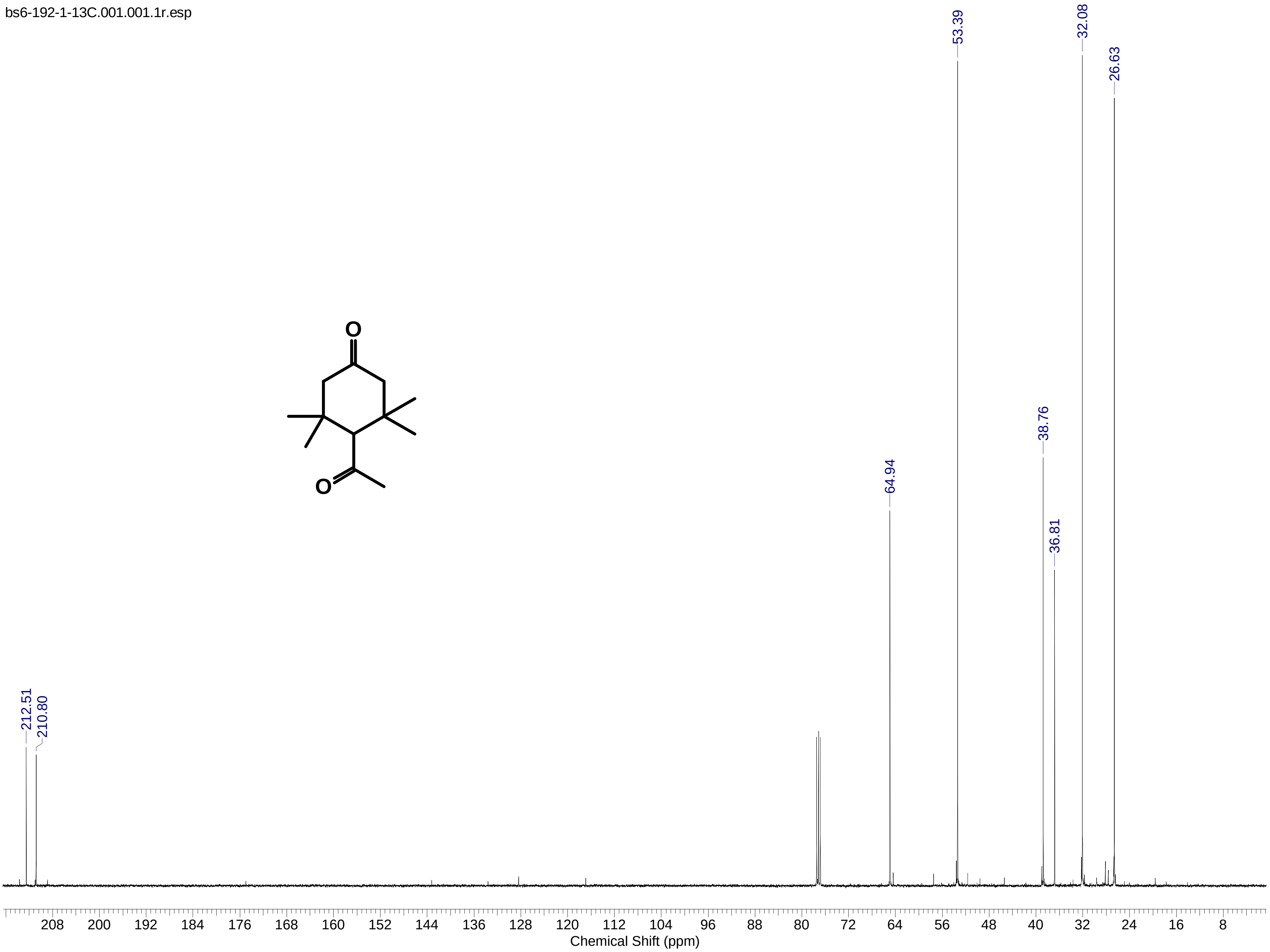

bs6-190-1-F2-13C.001.001.1r.esp
OTIPS
O
N
O
O
171.02
156.19
152.41
131.98
125.51
104.30
61.63
44.79
42.57
36.67
26.46
19.70
18.07
12.78
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)



bs6-190-1-F2-dept135.001.001.1r.esp
OTIPS
O
N
O
O
104.30
26.46
19.70
18.08
12.78
61.63
44.78
42.57
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Chemical Shift (ppm)

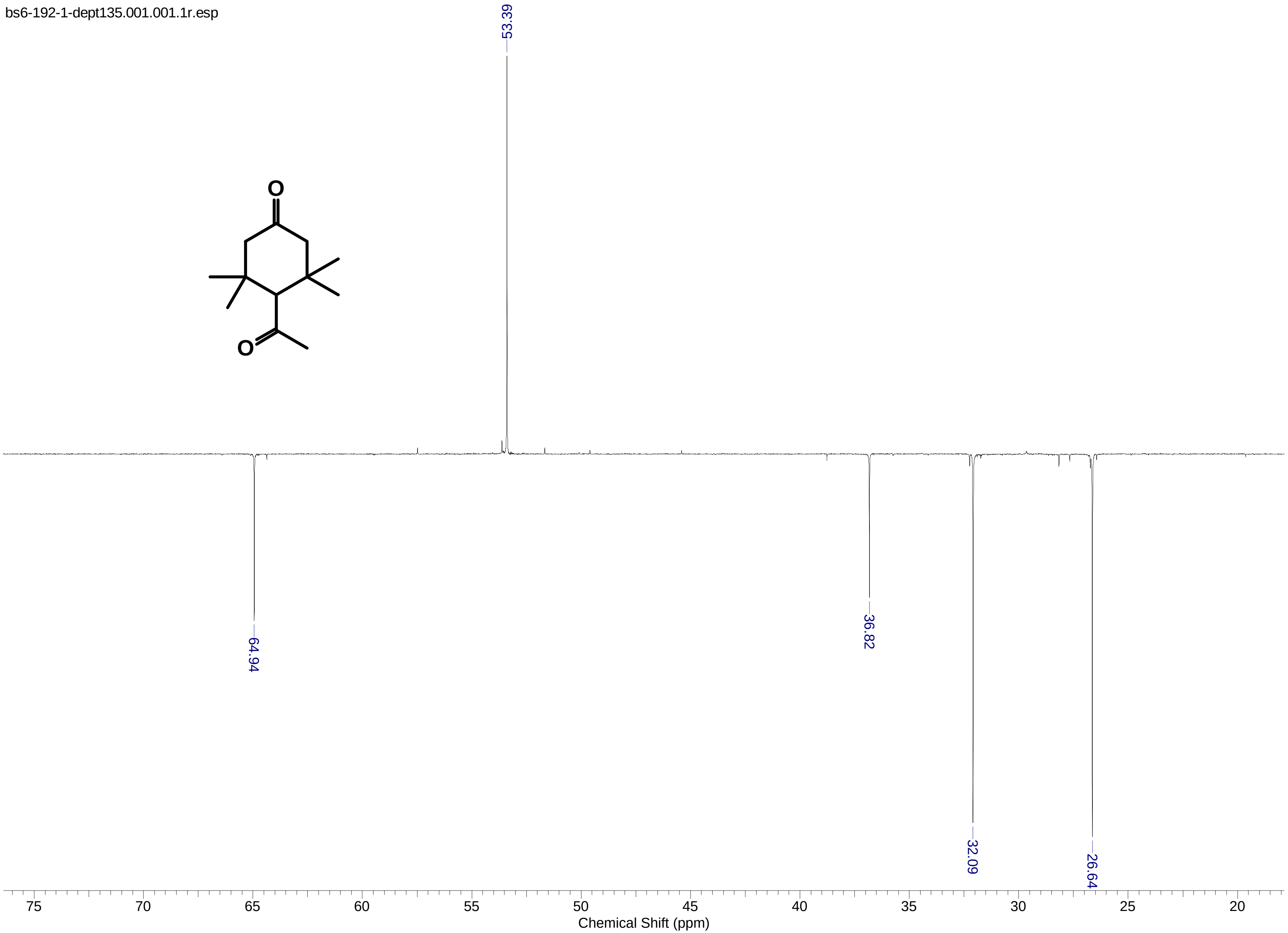
bs6-192-1-1H.001.001.1r.esp



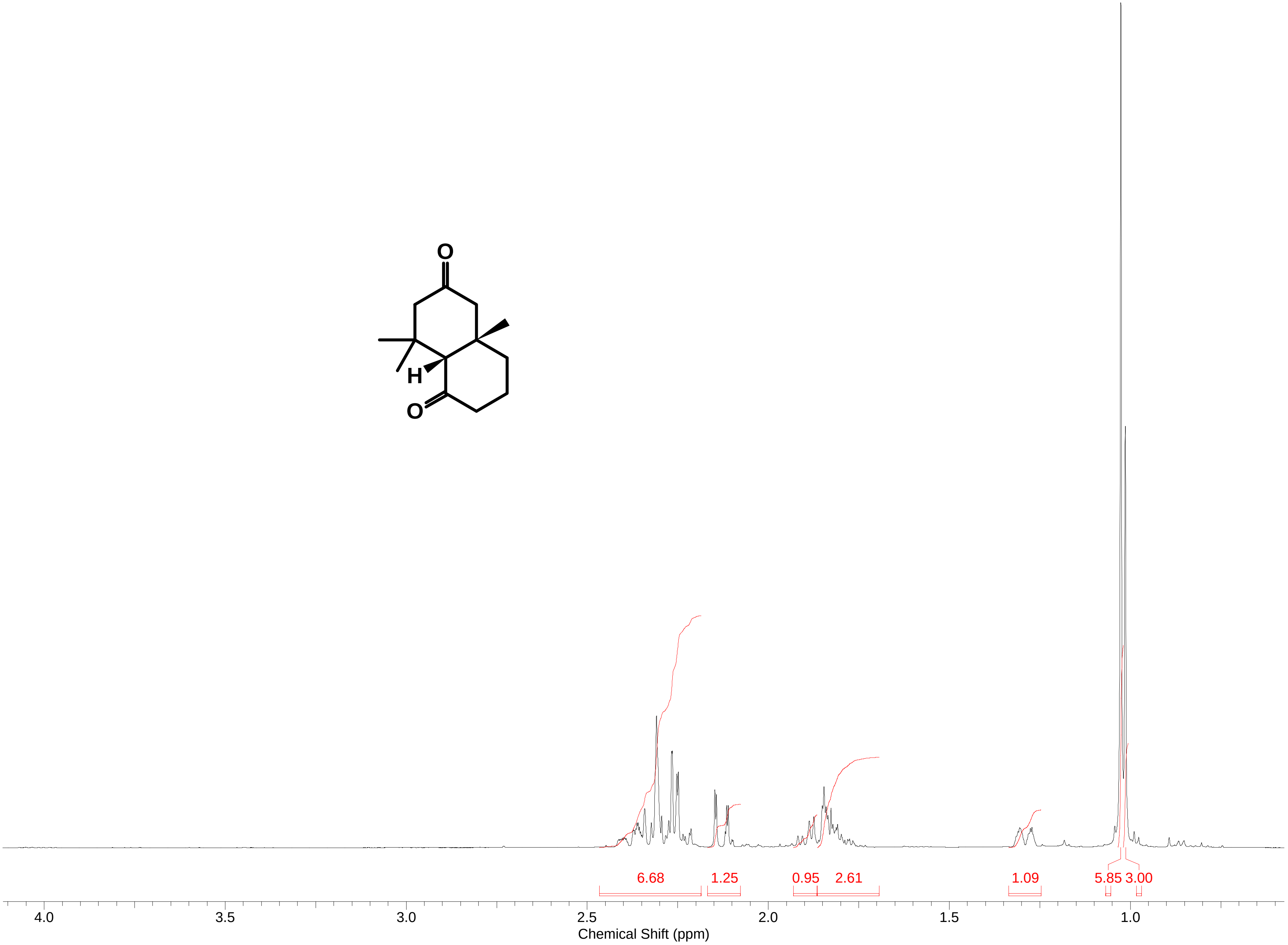

bs6-192-1-13C.001.001.1r.esp
212.51
210.80
64.94
53.39
38.76
36.81
32.08
26.63
O
O
208
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

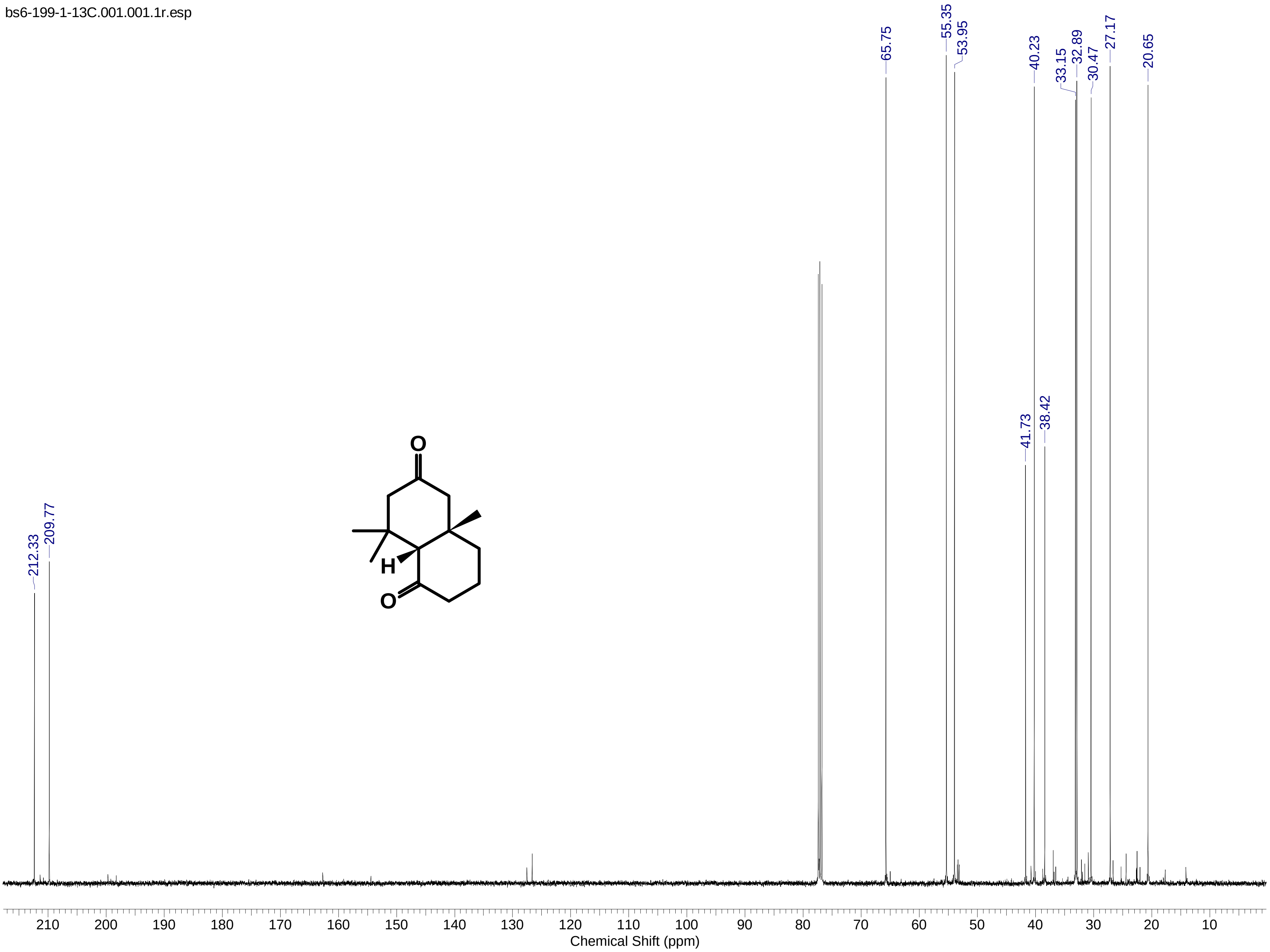
Formula $C_{12}H_{20}O_2$	*FW* 196.2860

bs6-192-1-dept135.001.001.1r.esp

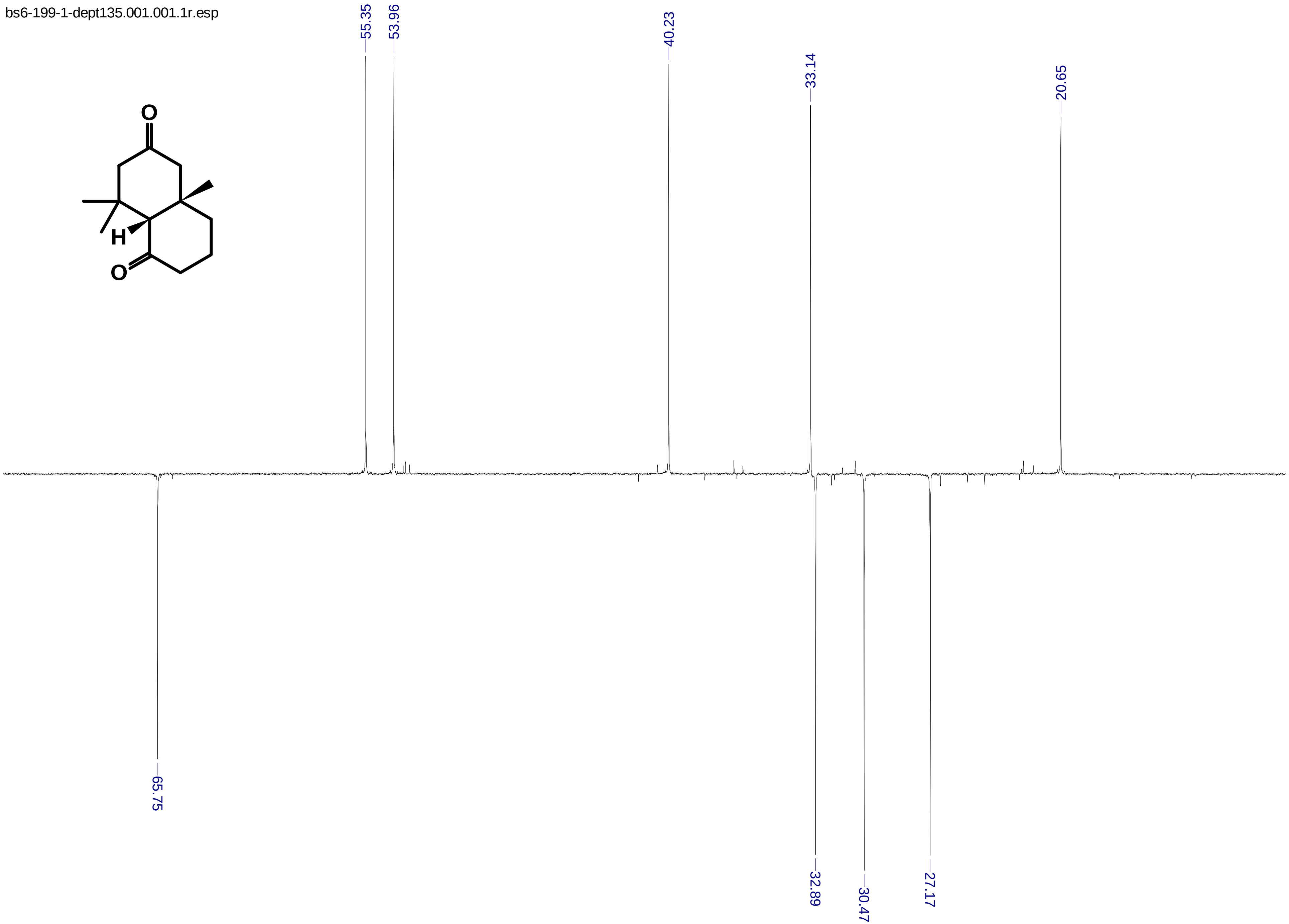


bs6-199-1-1H.001.001.1r.esp

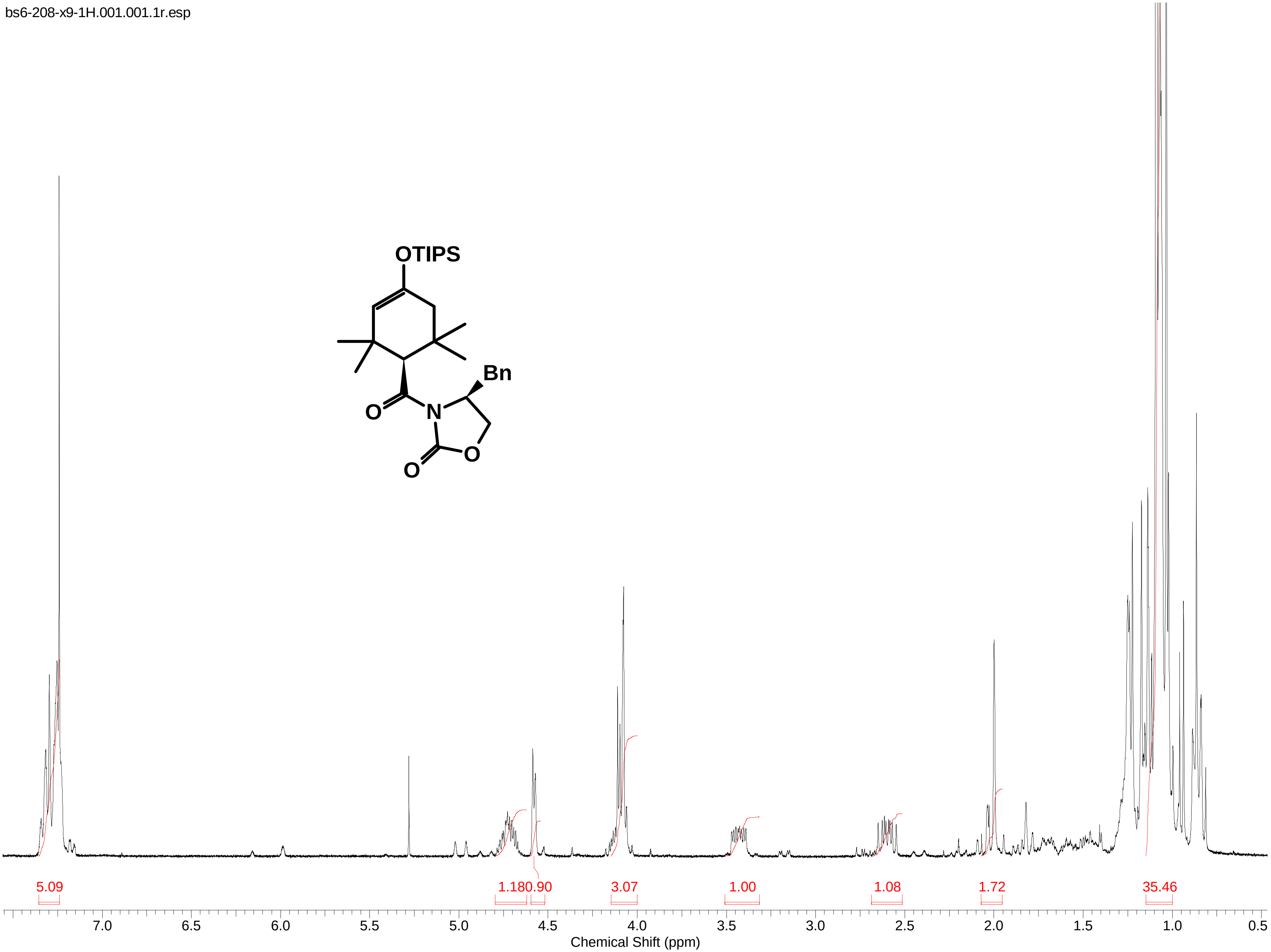



bs6-199-1-13C.001.001.1r.esp
212.33
209.77
65.75
55.35
53.95
41.73
40.23
38.42
33.15
32.89
30.47
27.17
20.65
O
H
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Chemical Shift (ppm)

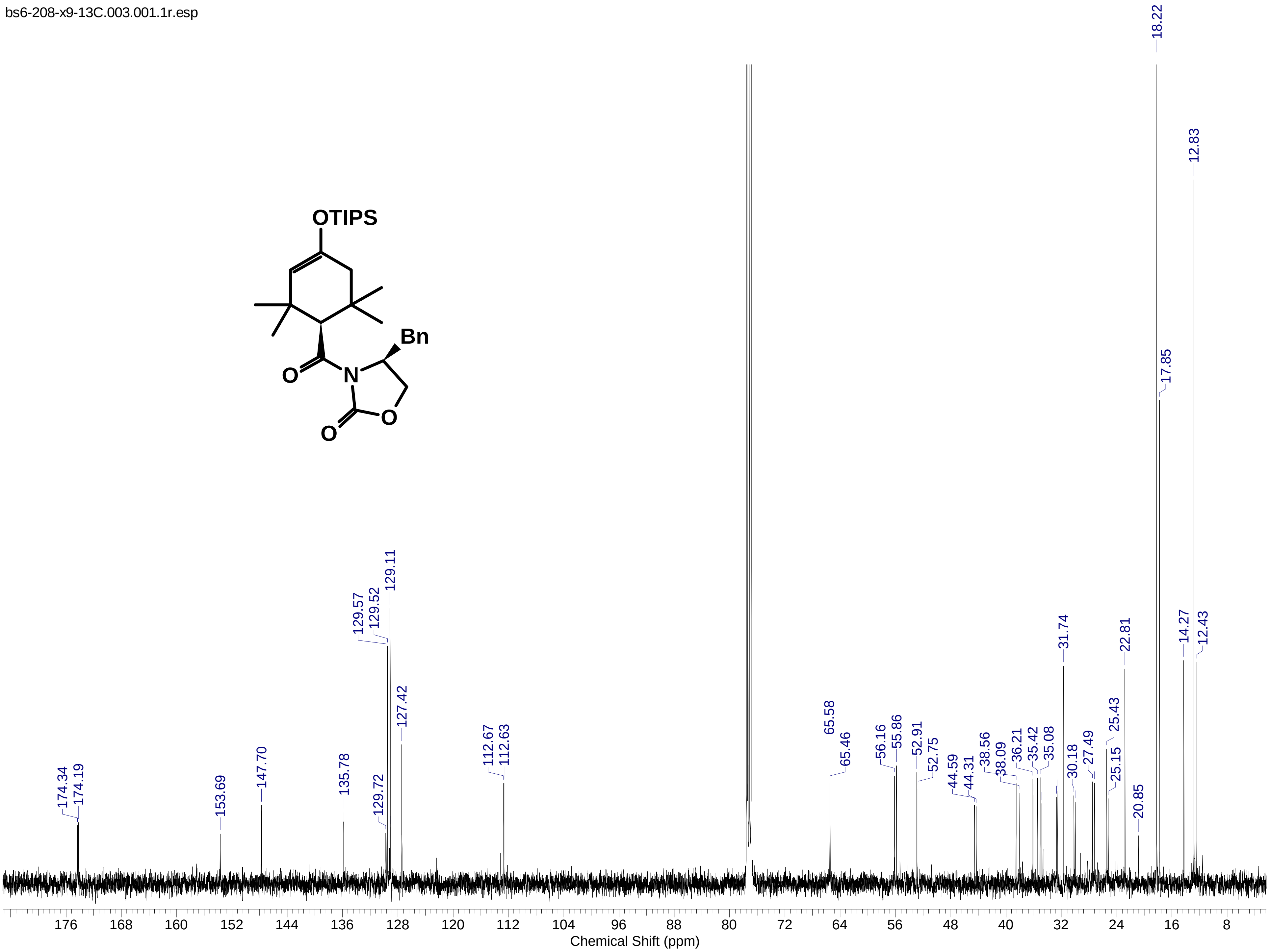
bs6-199-1-dept135.001.001.1r.esp



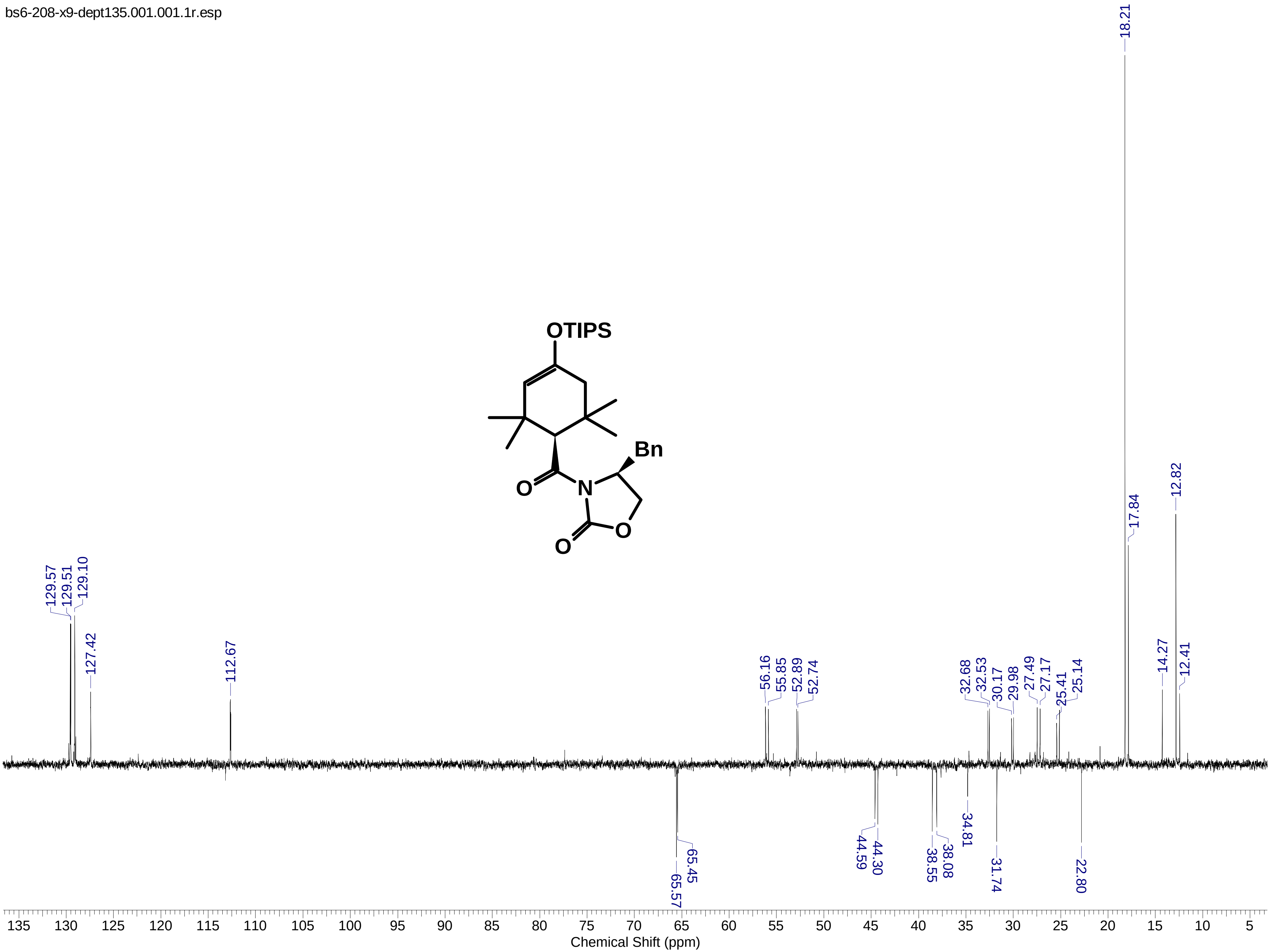
bs6-208-x9-1H.001.001.1r.esp



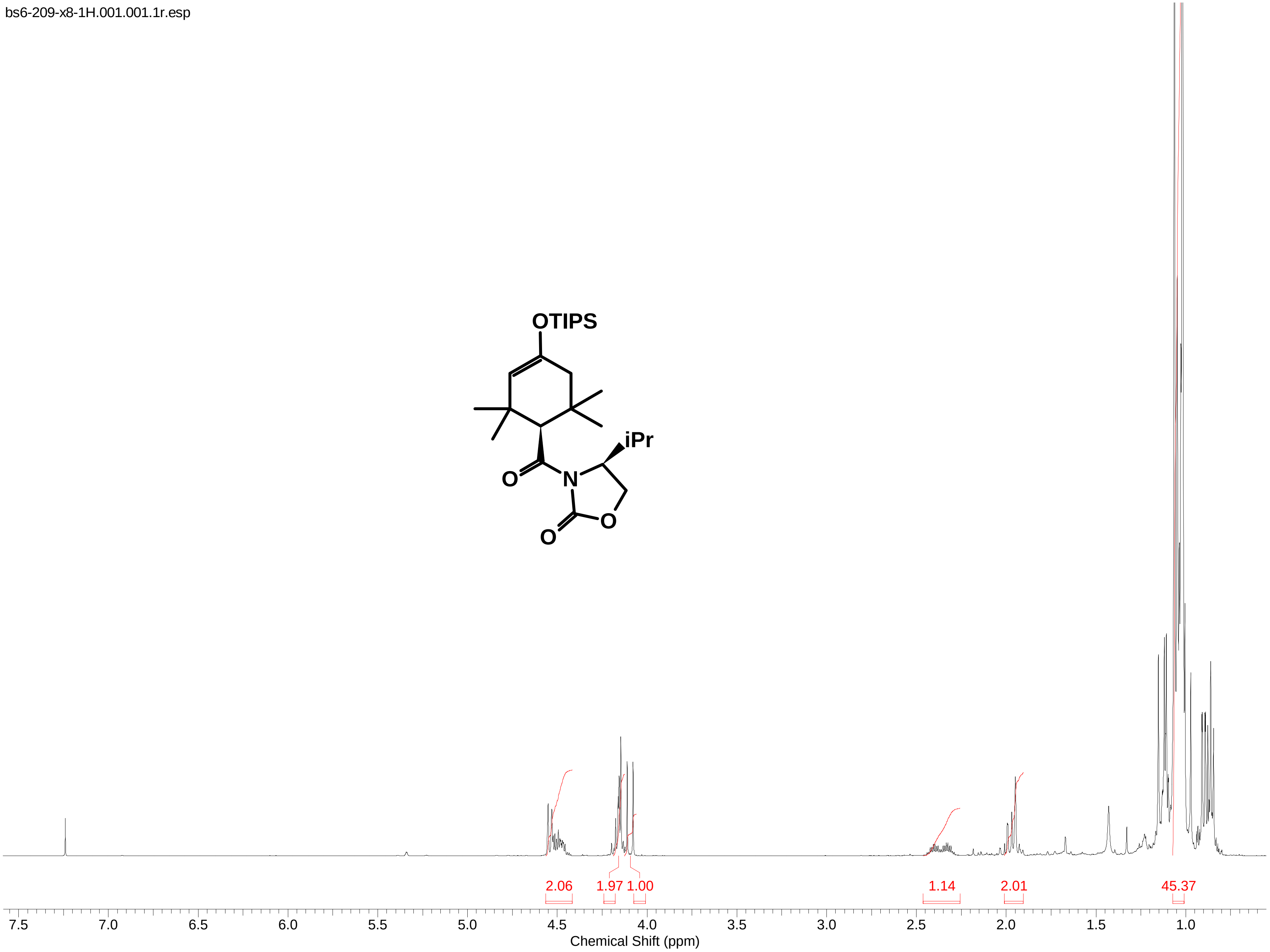
bs6-208-x9-13C.003.001.1r.esp

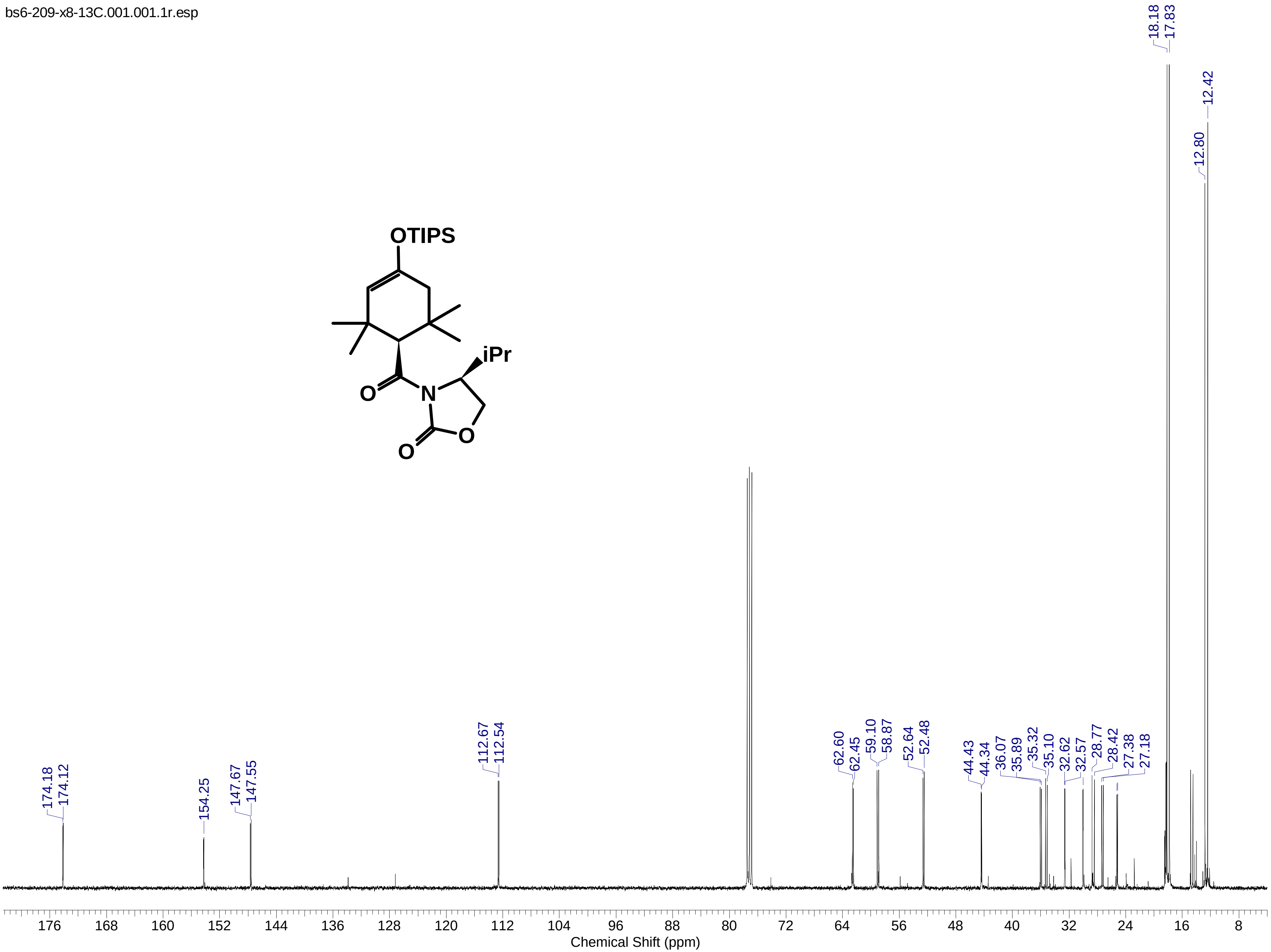


bs6-208-x9-dept135.001.001.1r.esp

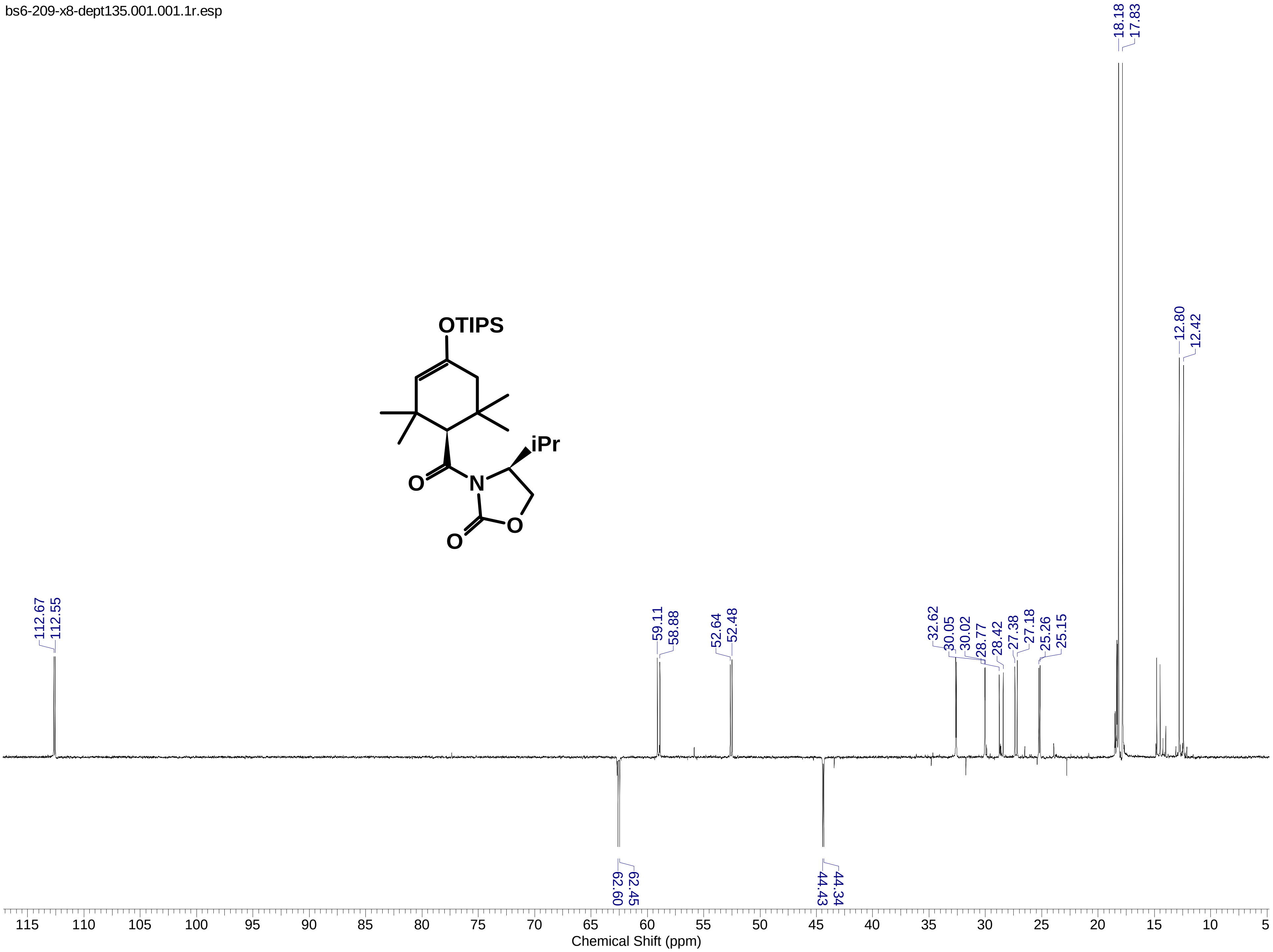


bs6-209-x8-1H.001.001.1r.esp

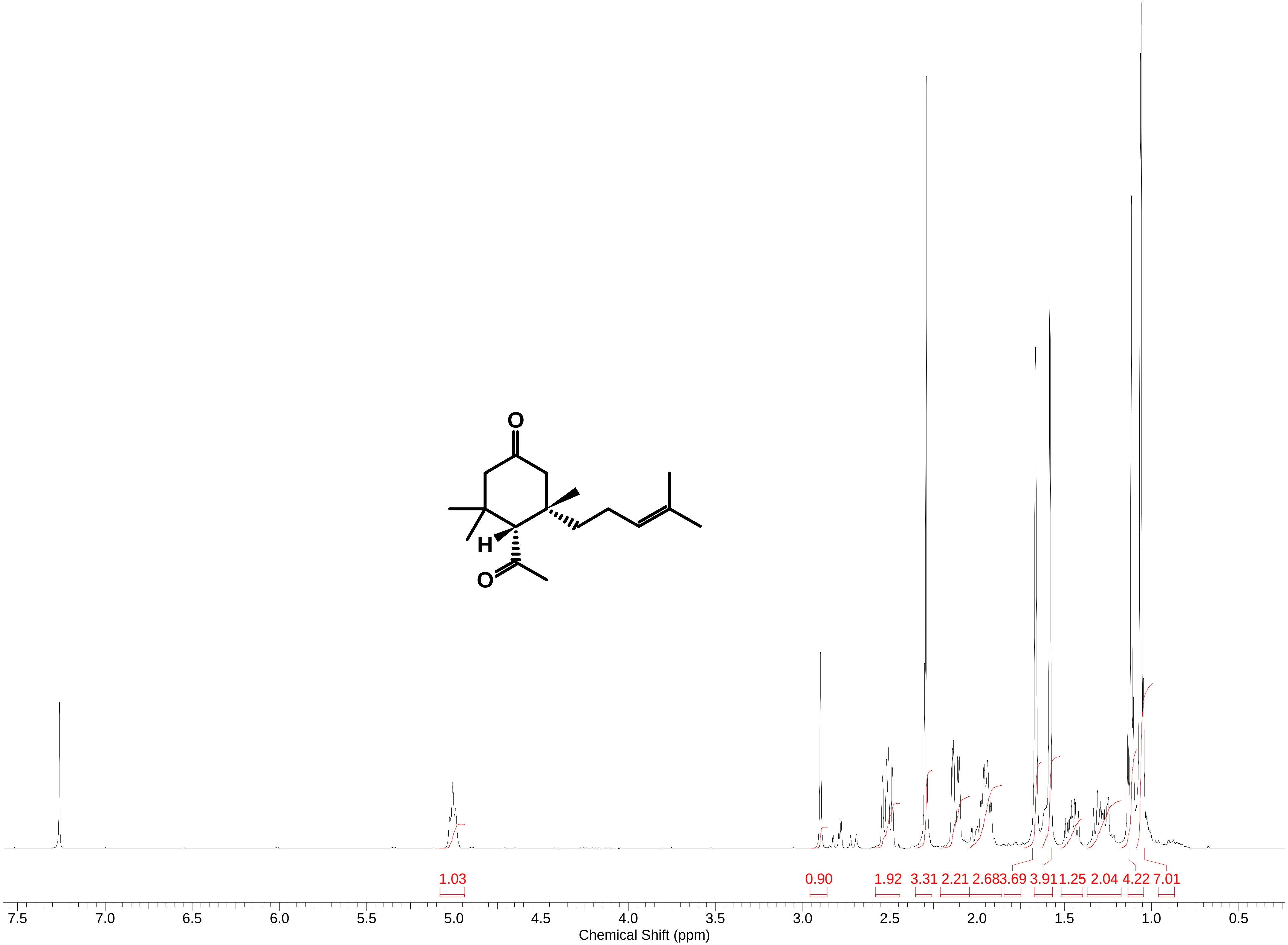



bs6-209-x8-13C.001.001.1r.esp
OTIPS
iPr
O
N
O
O
174.18
174.12
154.25
147.67
147.55
112.67
112.54
62.60
62.45
59.10
58.87
52.64
52.48
44.43
44.34
36.07
35.89
35.32
35.10
32.62
32.57
28.77
28.42
27.38
27.18
18.18
17.83
12.80
12.42
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

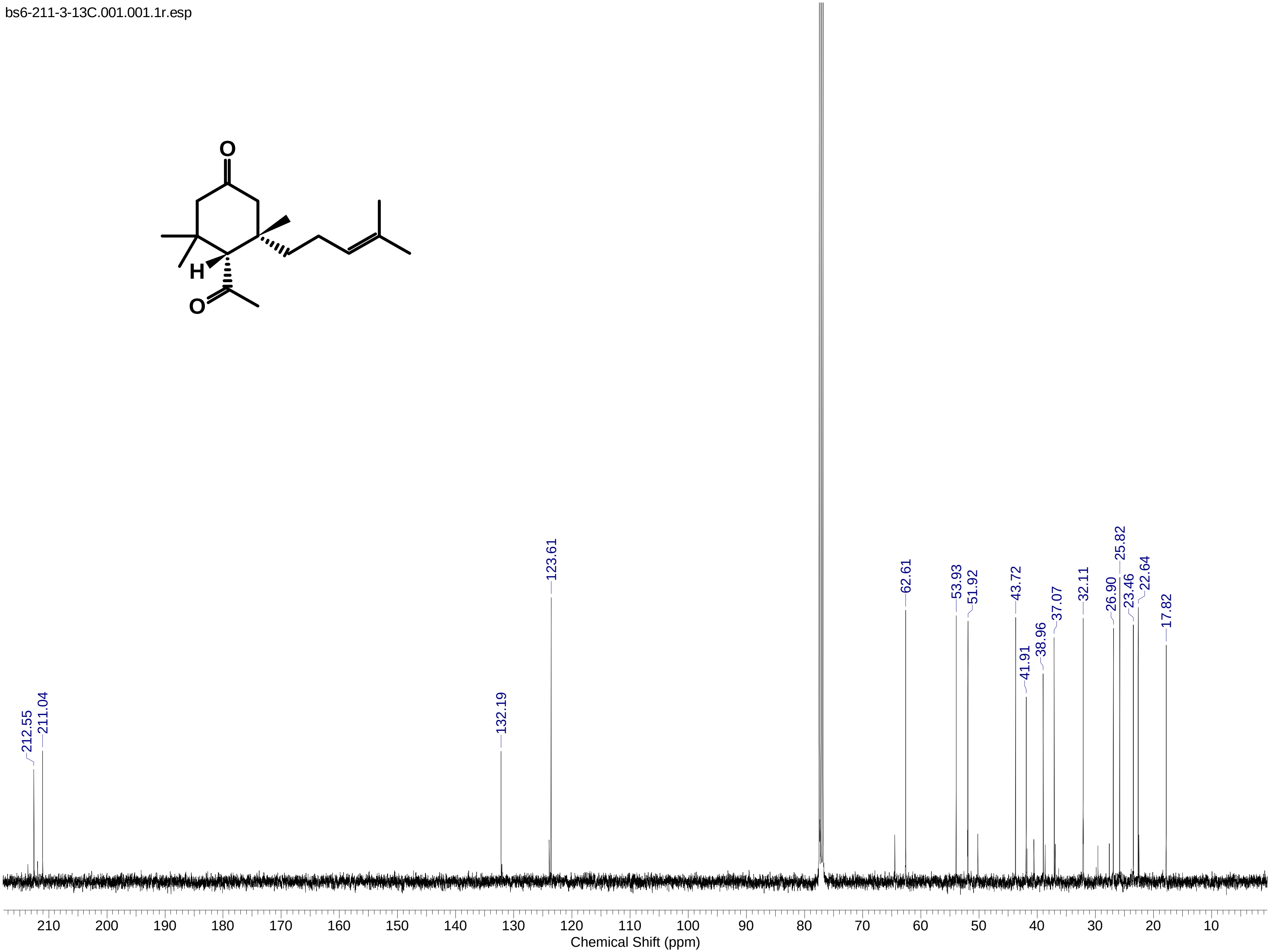
bs6-209-x8-dept135.001.001.1r.esp

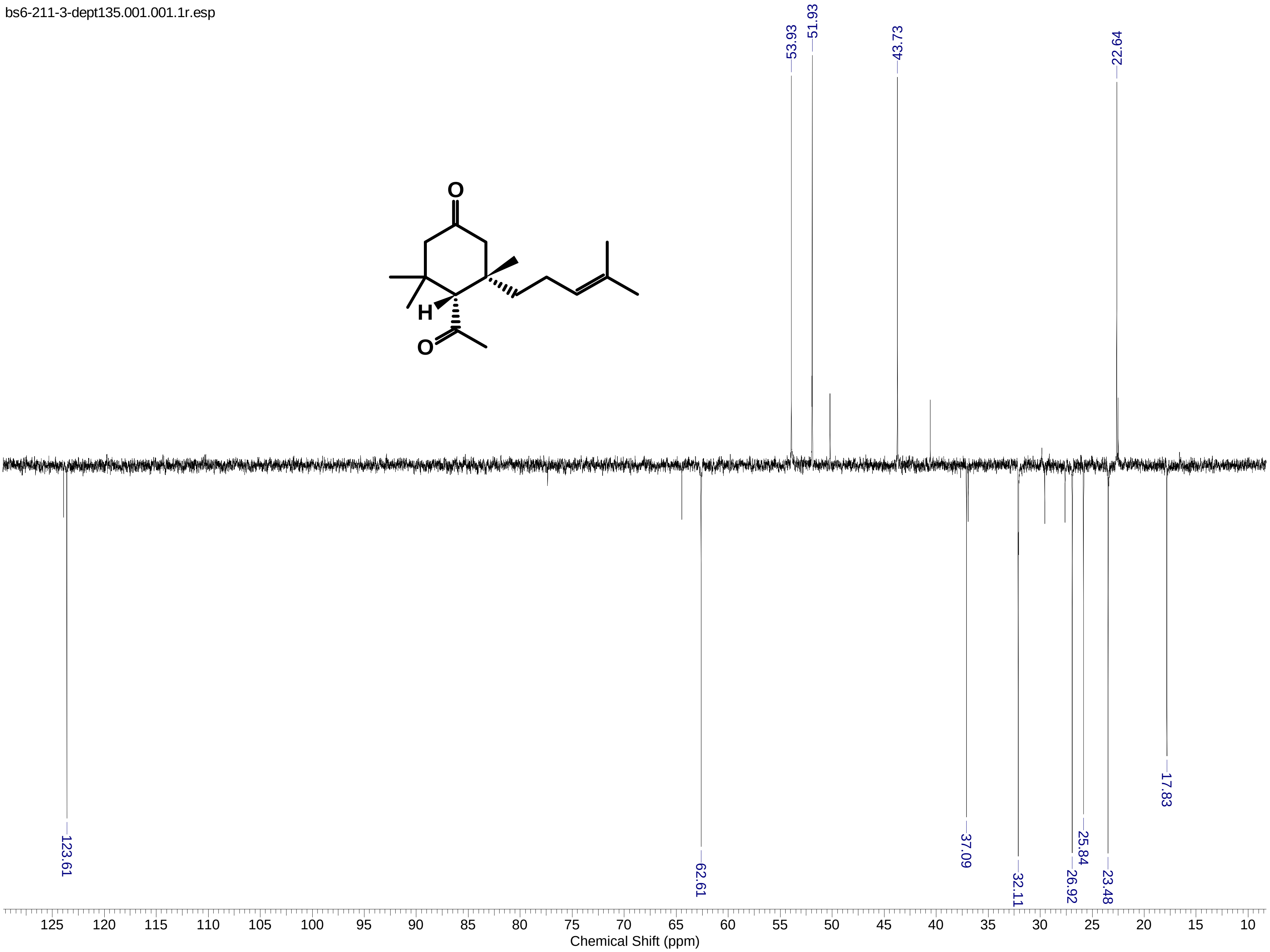


bs6-211-3-1H.001.esp



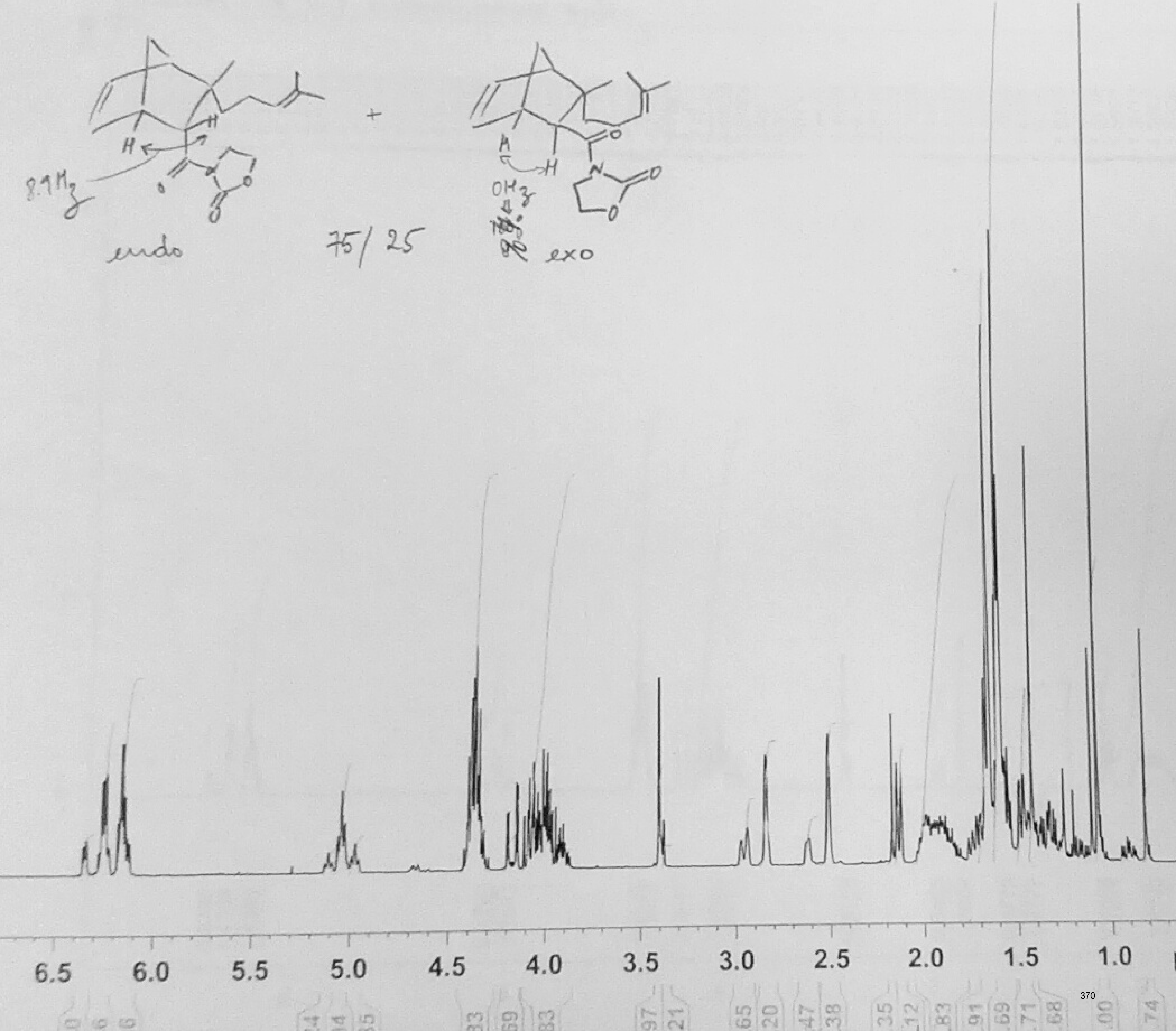
bs6-211-3-13C.001.001.1r.esp



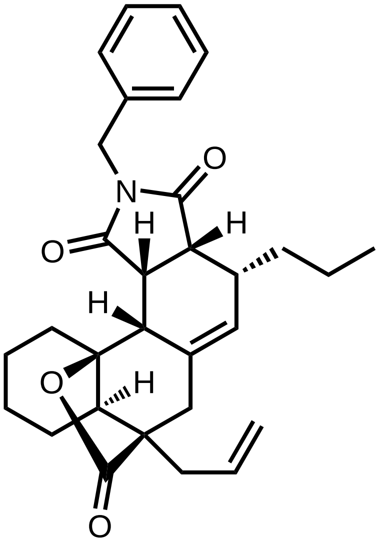

bs6-211-3-dept135.001.001.1r.esp
53.93
51.93
43.73
22.64
123.61
62.61
37.09
32.11
26.92
25.84
23.48
17.83
O
O
H
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
Chemical Shift (ppm)

mix

1d_1H_32_scans CDCl3 D:\\oBarr 26



X-ray Data


O
N
O
H
H
H
O
H
O

checkCIF/PLATON report

No syntax errors found.   CIF dictionary   Interpreting this report

Datablock: test

```
Bond precision:  C-C = 0.0034 A          Wavelength=0.71073

Cell:            a=9.033(2)    b=11.676(3)         c=24.160(6)
                 alpha=90      beta=100.344(3)     gamma=90
Temperature:     203 K

                Calculated                Reported
Volume          2506.7(11)                2506.9(10)
Space group     P 21/n                    P2(1)/n
Hall group      -P 2yn                    ?
Moiety formula  C30 H35 N O4              ?
Sum formula     C30 H35 N O4              C30 H35 N O4
Mr              473.59                    473.59
Dx,g cm-3       1.255                     1.255
Z               4                         4
Mu (mm-1)       0.082                     0.082
F000            1016.0                    1016.0
F000'           1016.46
h,k,lmax        10,13,27                  10,13,27
Nref            3851                      3840
Tmin,Tmax       0.944,0.960               0.945,0.960
Tmin'           0.944

Correction method= MULTI-SCAN

Data completeness= 0.997          Theta(max)= 23.810

R(reflections)= 0.0431( 2852)     wR2(reflections)= 0.1123( 3840)

S = 1.077                  Npar= 316
```

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level B

```
THETM01_ALERT_3_B  The value of sine(theta_max)/wavelength is less than 0.575
            Calculated sin(theta_max)/wavelength =    0.5680
```

Alert level C

```
PLAT063_ALERT_4_C Crystal Probably too Large for Beam Size .......       0.70 mm
```

Alert level G

```
HYDTR01_ALERT_1_G  Extra text has been found in the _refine_ls_hydrogen_treatment fi
            Explanatory text should be in the _publ_section_refinement field.
            Hydrogen treatment given as constrained
            Hydrogen treatment identified as  constr
PLAT066_ALERT_1_G Predicted and Reported Transmissions Identical .          ?
PLAT793_ALERT_4_G The Model has Chirality at C2      (Verify) ....          R
PLAT793_ALERT_4_G The Model has Chirality at C3      (Verify) ....          S
PLAT793_ALERT_4_G The Model has Chirality at C5      (Verify) ....          S
PLAT793_ALERT_4_G The Model has Chirality at C8      (Verify) ....          S
PLAT793_ALERT_4_G The Model has Chirality at C9      (Verify) ....          R
PLAT793_ALERT_4_G The Model has Chirality at C10     (Verify) ....          S
PLAT793_ALERT_4_G The Model has Chirality at C11     (Verify) ....          S
```

```
   0 ALERT level A = In general: serious problem
   1 ALERT level B = Potentially serious problem
   1 ALERT level C = Check and explain
   9 ALERT level G = General alerts; check

   2 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
   0 ALERT type 2 Indicator that the structure model may be wrong or deficient
   1 ALERT type 3 Indicator that the structure quality may be low
   8 ALERT type 4 Improvement, methodology, query or suggestion
   0 ALERT type 5 Informative message, check
```

Publication of your CIF in IUCr journals

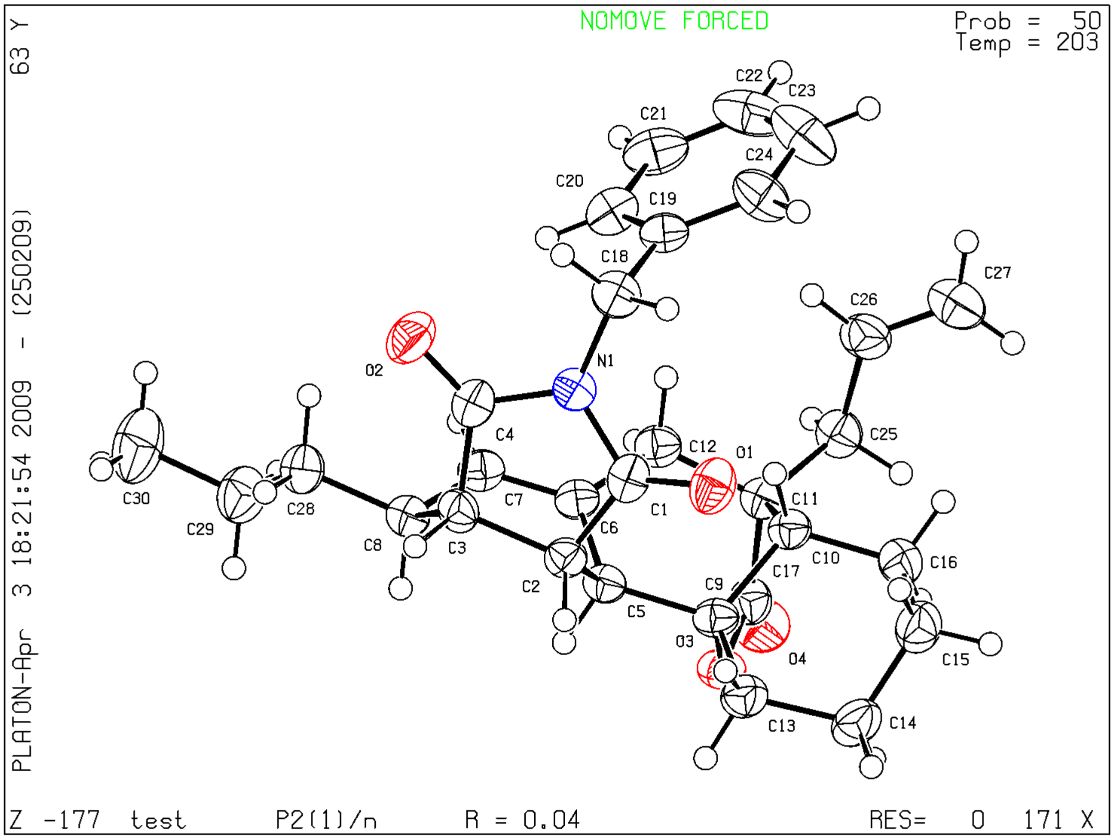
A basic structural check has been run on your CIF. These basic checks will be run on all CIFs submitted for publication in IUCr journals (*Acta Crystallographica*, *Journal of Applied Crystallography*, *Journal of Synchrotron Radiation*); however, if you intend to submit to *Acta Crystallographica Section C* or *E*, you should make sure that full publication checks are run on the final version of your CIF prior to submission.

Publication of your CIF in other journals

Please refer to the *Notes for Authors* of the relevant journal for any special instructions relating to CIF submission.

PLATON version of 25/02/2009; check.def file version of 25/02/2009

Datablock test - ellipsoid plot



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;
_chemical_name_common             ?
_chemical_melting_point           ?
_chemical_formula_moiety          ?
_chemical_formula_sum
 'C30 H35 N O4'
_chemical_formula_weight          473.59

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 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'H'  'H'   0.0000   0.0000
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'N'  'N'   0.0061   0.0033
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'O'  'O'   0.0106   0.0060
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'

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_symmetry_space_group_name_H-M    P2(1)/n

loop_
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 '-x+1/2, y+1/2, -z+1/2'
 '-x, -y, -z'
 'x-1/2, -y-1/2, z-1/2'

_cell_length_a                    9.033(2)
_cell_length_b                    11.676(3)
_cell_length_c                    24.160(6)
_cell_angle_alpha                 90.00
_cell_angle_beta                  100.344(3)
_cell_angle_gamma                 90.00
_cell_volume                      2506.9(10)
_cell_formula_units_Z             4
_cell_measurement_temperature     203(2)
_cell_measurement_reflns_used     8474
_cell_measurement_theta_min       2.29
_cell_measurement_theta_max       24.71

_exptl_crystal_description        block
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_exptl_crystal_colour             colorless
_exptl_crystal_size_max           0.70
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_exptl_crystal_density_meas       n/a
_exptl_crystal_density_diffrn     1.255
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_exptl_crystal_F_000              1016
_exptl_absorpt_coefficient_mu     0.082
_exptl_absorpt_correction_type    multi-scan
_exptl_absorpt_correction_T_min   0.9446
_exptl_absorpt_correction_T_max   0.9600
_exptl_absorpt_process_details    'SADABS, Bruker (2000)'

_exptl_special_details
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 Data collection is performed with three batch runs at phi = 0.00 deg
 (650 frames), at phi = 120.00 deg (650 frames), and at phi = 240.00 deg
 (650 frames).
 Frame width = 0.30 deg in omega.
 Data is merged, corrected for decay (if any), and treated with multi-
scan
 absorption corrections (if required). All symmetry-equivalent
reflections
 are merged for centrosymmetric data.
 Friedel pairs are not merged for noncentrosymmetric data.
;

_diffrn_ambient_temperature       203(2)
_diffrn_radiation_wavelength      0.71073
_diffrn_radiation_type            MoK\a
_diffrn_radiation_source          'fine-focus sealed tube'
_diffrn_radiation_monochromator   graphite
_diffrn_measurement_device_type   'CCD area detector'
_diffrn_measurement_method        'phi and omega scans'
_diffrn_detector_area_resol_mean  ?
_diffrn_standards_number          ?
_diffrn_standards_interval_count  ?
_diffrn_standards_interval_time   ?
_diffrn_standards_decay_%         <1
_diffrn_reflns_number             17032
_diffrn_reflns_av_R_equivalents   0.0515
_diffrn_reflns_av_sigmaI/netI     0.0434
_diffrn_reflns_limit_h_min        -10
_diffrn_reflns_limit_h_max        10
_diffrn_reflns_limit_k_min        -13
_diffrn_reflns_limit_k_max        13
_diffrn_reflns_limit_l_min        -27
_diffrn_reflns_limit_l_max        27
_diffrn_reflns_theta_min          1.71
_diffrn_reflns_theta_max          23.81
_reflns_number_total              3840
_reflns_number_gt                 2852
_reflns_threshold_expression      >2sigma(I)
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_computing_data_reduction         'Bruker SAINT'
_computing_structure_solution     'SHELXS-97 (Sheldrick, 1990)'
_computing_structure_refinement   'SHELXL-97 (Sheldrick, 1997)'
_computing_molecular_graphics     'Bruker SHELXTL'
_computing_publication_material   'Bruker SHELXTL'

_refine_special_details
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 Refinement of F^2^ against ALL reflections.  The weighted R-factor wR
and
 goodness of fit S are based on F^2^, conventional R-factors R are based
 on F, with F set to zero for negative F^2^. The threshold expression of
 F^2^ > 2sigma(F^2^) is used only for calculating R-factors(gt) etc. and
is
 not relevant to the choice of reflections for refinement.  R-factors
based
 on F^2^ are statistically about twice as large as those based on F, and
R-
 factors based on ALL data will be even larger.
;

_refine_ls_structure_factor_coef  Fsqd
_refine_ls_matrix_type            full
_refine_ls_weighting_scheme       calc
_refine_ls_weighting_details
 'calc w=1/[\s^2^(Fo^2^)+(0.0311P)^2^+1.5600P] where P=(Fo^2^+2Fc^2^)/3'
_atom_sites_solution_primary      direct
_atom_sites_solution_secondary    difmap
_atom_sites_solution_hydrogens    geom
_refine_ls_hydrogen_treatment     constrained
_refine_ls_extinction_method      none
_refine_ls_extinction_coef        ?
_refine_ls_number_reflns          3840
_refine_ls_number_parameters      316
_refine_ls_number_restraints      0
_refine_ls_R_factor_all           0.0663
_refine_ls_R_factor_gt            0.0431
_refine_ls_wR_factor_ref          0.1123
_refine_ls_wR_factor_gt           0.1007
_refine_ls_goodness_of_fit_ref    1.077
_refine_ls_restrained_S_all       1.077
_refine_ls_shift/su_max           0.001
_refine_ls_shift/su_mean          0.000

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 _atom_site_disorder_group
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O1 O 1.08224(18) 0.12319(15) 0.09212(7) 0.0455(4) Uani 1 1 d . . .
O2 O 1.3038(2) 0.32448(15) 0.24328(7) 0.0503(5) Uani 1 1 d . . .
O3 O 0.71321(17) -0.05982(13) 0.17645(6) 0.0370(4) Uani 1 1 d . . .
O4 O 0.49067(19) -0.00210(15) 0.19399(7) 0.0494(5) Uani 1 1 d . . .
C1 C 1.1168(2) 0.1432(2) 0.14217(10) 0.0327(5) Uani 1 1 d . . .
C2 C 1.1132(2) 0.06397(19) 0.19116(9) 0.0314(5) Uani 1 1 d . . .
H2A H 1.1634 -0.0091 0.1850 0.038 Uiso 1 1 calc R . .
C3 C 1.2064(2) 0.12802(19) 0.24201(9) 0.0327(5) Uani 1 1 d . . .
H3A H 1.3043 0.0886 0.2531 0.039 Uiso 1 1 calc R . .
C4 C 1.2339(2) 0.2451(2) 0.21922(10) 0.0346(6) Uani 1 1 d . . .
C5 C 0.9495(2) 0.03953(18) 0.20101(9) 0.0311(5) Uani 1 1 d . . .
H5A H 0.9603 -0.0210 0.2302 0.037 Uiso 1 1 calc R . .
C6 C 0.8888(2) 0.14310(19) 0.22781(9) 0.0302(5) Uani 1 1 d . . .
C7 C 0.9746(2) 0.18552(19) 0.27363(9) 0.0334(5) Uani 1 1 d . . .
H7A H 0.9396 0.2463 0.2933 0.040 Uiso 1 1 calc R . .
C8 C 1.1285(2) 0.1356(2) 0.29386(9) 0.0340(5) Uani 1 1 d . . .
H8A H 1.1142 0.0563 0.3064 0.041 Uiso 1 1 calc R . .
C9 C 0.8370(2) -0.00944(18) 0.15069(9) 0.0316(5) Uani 1 1 d . . .
C10 C 0.7514(2) 0.08403(19) 0.11264(9) 0.0314(5) Uani 1 1 d . . .
H10A H 0.8217 0.1443 0.1046 0.038 Uiso 1 1 calc R . .
C11 C 0.6495(2) 0.13009(19) 0.15165(9) 0.0315(5) Uani 1 1 d . . .
C12 C 0.7432(2) 0.19962(19) 0.20001(10) 0.0351(6) Uani 1 1 d . . .
H12A H 0.7670 0.2742 0.1852 0.042 Uiso 1 1 calc R . .
H12B H 0.6813 0.2135 0.2288 0.042 Uiso 1 1 calc R . .
C13 C 0.9040(3) -0.1072(2) 0.12147(10) 0.0403(6) Uani 1 1 d . . .
H13A H 0.9245 -0.1718 0.1476 0.048 Uiso 1 1 calc R . .
H13B H 1.0003 -0.0820 0.1123 0.048 Uiso 1 1 calc R . .
C14 C 0.8028(3) -0.1483(2) 0.06764(11) 0.0463(7) Uani 1 1 d . . .
H14A H 0.8571 -0.2041 0.0485 0.056 Uiso 1 1 calc R . .
H14B H 0.7135 -0.1860 0.0770 0.056 Uiso 1 1 calc R . .
C15 C 0.7554(3) -0.0472(2) 0.02915(10) 0.0462(7) Uani 1 1 d . . .
H15A H 0.6959 -0.0741 -0.0064 0.055 Uiso 1 1 calc R . .
H15B H 0.8447 -0.0079 0.0208 0.055 Uiso 1 1 calc R . .
C16 C 0.6623(3) 0.0353(2) 0.05762(10) 0.0387(6) Uani 1 1 d . . .
H16A H 0.5732 -0.0048 0.0656 0.046 Uiso 1 1 calc R . .
H16B H 0.6279 0.0985 0.0318 0.046 Uiso 1 1 calc R . .
C17 C 0.6038(3) 0.0191(2) 0.17595(10) 0.0359(6) Uani 1 1 d . . .
C18 C 1.1737(3) 0.3486(2) 0.12708(10) 0.0394(6) Uani 1 1 d . . .
H18A H 1.1885 0.3231 0.0898 0.047 Uiso 1 1 calc R . .
H18B H 1.2601 0.3961 0.1432 0.047 Uiso 1 1 calc R . .
C19 C 1.0323(3) 0.42004(19) 0.12068(10) 0.0364(6) Uani 1 1 d . . .
C20 C 0.9757(3) 0.4562(2) 0.16727(11) 0.0450(6) Uani 1 1 d . . .
H20A H 1.0233 0.4338 0.2035 0.054 Uiso 1 1 calc R . .
C21 C 0.8490(3) 0.5252(2) 0.16075(13) 0.0547(7) Uani 1 1 d . . .
H21A H 0.8113 0.5499 0.1926 0.066 Uiso 1 1 calc R . .
C22 C 0.7782(3) 0.5577(2) 0.10808(16) 0.0665(9) Uani 1 1 d . . .
```

```
H22A H 0.6926 0.6049 0.1038 0.080 Uiso 1 1 calc R . .
C23 C 0.8329(4) 0.5210(3) 0.06148(14) 0.0701(9) Uani 1 1 d . . .
H23A H 0.7847 0.5436 0.0254 0.084 Uiso 1 1 calc R . .
C24 C 0.9582(3) 0.4512(2) 0.06755(11) 0.0530(7) Uani 1 1 d . . .
H24A H 0.9934 0.4247 0.0355 0.064 Uiso 1 1 calc R . .
C25 C 0.5111(3) 0.2000(2) 0.12436(10) 0.0383(6) Uani 1 1 d . . .
H25A H 0.4437 0.1500 0.0987 0.046 Uiso 1 1 calc R . .
H25B H 0.4568 0.2249 0.1539 0.046 Uiso 1 1 calc R . .
C26 C 0.5467(3) 0.3029(2) 0.09241(11) 0.0462(7) Uani 1 1 d . . .
H26A H 0.6205 0.3533 0.1110 0.055 Uiso 1 1 calc R . .
C27 C 0.4845(3) 0.3289(2) 0.04114(12) 0.0563(8) Uani 1 1 d . . .
H27A H 0.4103 0.2809 0.0210 0.068 Uiso 1 1 calc R . .
H27B H 0.5139 0.3956 0.0242 0.068 Uiso 1 1 calc R . .
C28 C 1.2219(3) 0.1993(2) 0.34356(9) 0.0394(6) Uani 1 1 d . . .
H28A H 1.3262 0.1725 0.3484 0.047 Uiso 1 1 calc R . .
H28B H 1.2215 0.2812 0.3346 0.047 Uiso 1 1 calc R . .
C29 C 1.1662(3) 0.1840(2) 0.39887(10) 0.0504(7) Uani 1 1 d . . .
H29A H 1.0621 0.2112 0.3946 0.060 Uiso 1 1 calc R . .
H29B H 1.1674 0.1025 0.4085 0.060 Uiso 1 1 calc R . .
C30 C 1.2635(4) 0.2496(3) 0.44630(11) 0.0711(9) Uani 1 1 d . . .
H30A H 1.2252 0.2382 0.4809 0.107 Uiso 1 1 calc R . .
H30B H 1.2610 0.3306 0.4372 0.107 Uiso 1 1 calc R . .
H30C H 1.3663 0.2220 0.4511 0.107 Uiso 1 1 calc R . .

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 _atom_site_aniso_U_22
 _atom_site_aniso_U_33
 _atom_site_aniso_U_23
 _atom_site_aniso_U_13
 _atom_site_aniso_U_12
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O1 0.0458(10) 0.0571(11) 0.0349(10) -0.0075(8) 0.0108(8) -0.0091(9)
O2 0.0583(12) 0.0486(11) 0.0434(10) -0.0065(9) 0.0077(9) -0.0214(9)
O3 0.0351(9) 0.0304(9) 0.0459(10) 0.0055(7) 0.0078(7) -0.0037(7)
O4 0.0402(10) 0.0552(11) 0.0566(11) 0.0063(9) 0.0189(9) -0.0076(9)
C1 0.0233(12) 0.0416(14) 0.0344(14) -0.0070(11) 0.0087(10) 0.0020(10)
C2 0.0285(12) 0.0290(12) 0.0364(13) -0.0022(10) 0.0052(10) 0.0038(10)
C3 0.0276(12) 0.0348(13) 0.0344(13) 0.0002(10) 0.0021(10) 0.0056(10)
C4 0.0281(13) 0.0414(14) 0.0353(14) -0.0047(11) 0.0084(10) -0.0028(11)
C5 0.0311(12) 0.0277(12) 0.0346(13) 0.0022(10) 0.0062(10) 0.0019(10)
C6 0.0286(12) 0.0294(12) 0.0346(13) 0.0014(10) 0.0107(10) -0.0033(10)
C7 0.0359(13) 0.0312(13) 0.0357(13) -0.0023(11) 0.0131(11) 0.0018(10)
C8 0.0345(13) 0.0322(13) 0.0353(13) 0.0017(10) 0.0062(10) 0.0012(10)
C9 0.0293(12) 0.0279(12) 0.0389(13) 0.0014(10) 0.0095(10) -0.0021(10)
C10 0.0270(12) 0.0298(12) 0.0374(13) -0.0001(10) 0.0056(10) -0.0008(10)
C11 0.0270(12) 0.0323(12) 0.0360(13) 0.0023(10) 0.0074(10) -0.0006(10)
C12 0.0331(13) 0.0326(13) 0.0405(14) -0.0004(11) 0.0090(11) 0.0026(10)
C13 0.0402(14) 0.0327(13) 0.0464(15) -0.0039(11) 0.0032(12) 0.0030(11)
C14 0.0445(15) 0.0376(14) 0.0549(16) -0.0145(12) 0.0037(13) 0.0044(12)
C15 0.0490(16) 0.0479(16) 0.0403(15) -0.0088(12) 0.0043(12) 0.0021(13)
C16 0.0367(14) 0.0399(14) 0.0382(14) 0.0013(11) 0.0030(11) 0.0024(11)
C17 0.0306(13) 0.0409(14) 0.0359(13) 0.0007(11) 0.0053(11) -0.0036(11)
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C18 0.0397(14) 0.0425(14) 0.0386(14) 0.0039(11) 0.0138(11) -0.0031(11)
C19 0.0391(14) 0.0288(13) 0.0426(14) 0.0024(11) 0.0106(11) -0.0044(11)
C20 0.0463(16) 0.0406(15) 0.0494(16) -0.0064(12) 0.0120(13) -0.0042(12)
C21 0.0565(18) 0.0383(15) 0.074(2) -0.0091(14) 0.0259(16) 0.0017(14)
C22 0.0519(18) 0.0435(17) 0.109(3) 0.0239(18) 0.0275(19) 0.0129(14)
C23 0.062(2) 0.075(2) 0.073(2) 0.0387(18) 0.0136(17) 0.0160(17)
C24 0.0607(18) 0.0545(17) 0.0460(16) 0.0172(14) 0.0156(14) 0.0074(15)
C25 0.0298(13) 0.0425(14) 0.0427(14) -0.0005(11) 0.0069(11) 0.0027(11)
C26 0.0378(14) 0.0386(15) 0.0593(18) 0.0061(13) 0.0010(13) 0.0042(12)
C27 0.0584(18) 0.0486(17) 0.0609(19) 0.0131(14) 0.0079(15) 0.0076(14)
C28 0.0393(14) 0.0443(15) 0.0345(13) -0.0024(11) 0.0066(11) -0.0005(11)
C29 0.0550(17) 0.0589(17) 0.0386(15) -0.0055(13) 0.0117(13) -0.0076(14)
C30 0.075(2) 0.103(3) 0.0378(16) -0.0162(16) 0.0151(15) -0.0182(19)

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;
 All esds (except the esd in the dihedral angle between two l.s. planes)
 are estimated using the full covariance matrix.  The cell esds are taken
 into account individually in the estimation of esds in distances, angles
 and torsion angles; correlations between esds in cell parameters are
only
 used when they are defined by crystal symmetry.  An approximate
(isotropic)
 treatment of cell esds is used for estimating esds involving l.s.
planes.
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 _geom_bond_atom_site_label_2
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 _geom_bond_site_symmetry_2
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N1 C4 1.385(3) . ?
N1 C18 1.456(3) . ?
O1 C1 1.216(3) . ?
O2 C4 1.210(3) . ?
O3 C17 1.349(3) . ?
O3 C9 1.495(3) . ?
O4 C17 1.207(3) . ?
C1 C2 1.508(3) . ?
C2 C3 1.551(3) . ?
C2 C5 1.566(3) . ?
C3 C4 1.511(3) . ?
C3 C8 1.546(3) . ?
C5 C6 1.520(3) . ?
C5 C9 1.547(3) . ?
C6 C7 1.328(3) . ?
C6 C12 1.517(3) . ?
C7 C8 1.505(3) . ?
C8 C28 1.531(3) . ?
C9 C13 1.523(3) . ?
C9 C10 1.542(3) . ?
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C10 C11 1.529(3) . ?
C10 C16 1.535(3) . ?
C11 C17 1.511(3) . ?
C11 C25 1.539(3) . ?
C11 C12 1.544(3) . ?
C13 C14 1.527(3) . ?
C14 C15 1.516(3) . ?
C15 C16 1.522(3) . ?
C18 C19 1.510(3) . ?
C19 C20 1.383(3) . ?
C19 C24 1.385(3) . ?
C20 C21 1.386(4) . ?
C21 C22 1.371(4) . ?
C22 C23 1.376(4) . ?
C23 C24 1.382(4) . ?
C25 C26 1.495(3) . ?
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C14 C15 C16 C10 61.5(3) . . . . ?
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C12 C11 C17 O4 92.1(3) . . . . ?
C10 C11 C17 O3 28.4(2) . . . . ?
C25 C11 C17 O3 152.86(18) . . . . ?
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C1 N1 C18 C19 91.5(3) . . . . ?
C4 N1 C18 C19 -97.9(2) . . . . ?
N1 C18 C19 C20 51.4(3) . . . . ?
N1 C18 C19 C24 -129.2(2) . . . . ?
C24 C19 C20 C21 -1.8(4) . . . . ?
C18 C19 C20 C21 177.6(2) . . . . ?
C19 C20 C21 C22 0.4(4) . . . . ?
C20 C21 C22 C23 0.4(4) . . . . ?
C21 C22 C23 C24 0.3(5) . . . . ?
C22 C23 C24 C19 -1.7(4) . . . . ?
C20 C19 C24 C23 2.5(4) . . . . ?
C18 C19 C24 C23 -177.0(2) . . . . ?
C17 C11 C25 C26 -171.9(2) . . . . ?
C10 C11 C25 C26 -57.7(3) . . . . ?
C12 C11 C25 C26 68.7(3) . . . . ?
C11 C25 C26 C27 129.3(3) . . . . ?
C7 C8 C28 C29 71.0(3) . . . . ?
C3 C8 C28 C29 -166.3(2) . . . . ?
C8 C28 C29 C30 -179.8(2) . . . . ?

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_diffrn_reflns_theta_full              23.81
_diffrn_measured_fraction_theta_full   0.996
_refine_diff_density_max    0.166
_refine_diff_density_min   -0.199
_refine_diff_density_rms    0.044
```

```
TITL test in P2(1)/n
CELL 0.71073   9.0331  11.6765  24.1601   90.000 100.344   90.000
ZERR    4.00   0.0020   0.0027   0.0055   0.000   0.003   0.000
LATT 1
SYMM 0.5-X, 0.5+Y, 0.5-Z
SFAC C  H  N  O
UNIT 120 140 4 16
OMIT -5   0   5
OMIT      0   0   6
OMIT      0   6  12
OMIT      0   3   9
OMIT      3   0  15
OMIT     -4   4   4
OMIT      2   4   2
OMIT      0   7   7
OMIT      0   8   8
OMIT      0   5  10
OMIT      0   6   9
OMIT      8   0   8
OMIT      4   2   2
OMIT      2   2   6
OMIT      0   8   1
OMIT      0   0  16
L.S. 36
acta
conf
BOND
FMAP 2
PLAN 3
SIZE 0.50 0.60 0.70
TEMP -70C
WGHT    0.031100    1.560000
FVAR       0.49800
N1    3    1.168636    0.248704    0.162818    11.00000    0.03235
0.03373 =
         0.03271    0.00087    0.00781    0.00003
O1    4    1.082244    0.123190    0.092118    11.00000    0.04575
0.05708 =
         0.03488   -0.00748    0.01078   -0.00913
O2    4    1.303831    0.324480    0.243282    11.00000    0.05830
0.04862 =
         0.04343   -0.00653    0.00766   -0.02142
O3    4    0.713213   -0.059821    0.176446    11.00000    0.03508
0.03039 =
         0.04585    0.00555    0.00784   -0.00372
O4    4    0.490666   -0.002101    0.193988    11.00000    0.04022
0.05520 =
         0.05659    0.00629    0.01893   -0.00761
C1    1    1.116849    0.143222    0.142166    11.00000    0.02332
0.04156 =
         0.03440   -0.00701    0.00868    0.00198
C2    1    1.113214    0.063968    0.191165    11.00000    0.02847
0.02904 =
         0.03640   -0.00220    0.00516    0.00375
```

```
AFIX  13
H2A   2    1.163424   -0.009115    0.185025    11.00000   -1.20000
AFIX   0
C3    1    1.206375    0.128018    0.242007    11.00000    0.02759
0.03479 =
         0.03435    0.00016    0.00214    0.00563
AFIX  13
H3A   2    1.304262    0.088632    0.253104    11.00000   -1.20000
AFIX   0
C4    1    1.233871    0.245088    0.219217    11.00000    0.02808
0.04138 =
         0.03527   -0.00471    0.00839   -0.00276
C5    1    0.949462    0.039526    0.201011    11.00000    0.03111
0.02775 =
         0.03462    0.00224    0.00617    0.00191
AFIX  13
H5A   2    0.960328   -0.021001    0.230155    11.00000   -1.20000
AFIX   0
C6    1    0.888810    0.143101    0.227807    11.00000    0.02858
0.02937 =
         0.03457    0.00136    0.01070   -0.00325
C7    1    0.974643    0.185525    0.273628    11.00000    0.03591
0.03123 =
         0.03565   -0.00228    0.01311    0.00184
AFIX  43
H7A   2    0.939564    0.246300    0.293286    11.00000   -1.20000
AFIX   0
C8    1    1.128457    0.135630    0.293864    11.00000    0.03453
0.03221 =
         0.03529    0.00174    0.00621    0.00122
AFIX  13
H8A   2    1.114155    0.056330    0.306416    11.00000   -1.20000
AFIX   0
C9    1    0.837031   -0.009437    0.150688    11.00000    0.02933
0.02789 =
         0.03887    0.00138    0.00948   -0.00215
C10   1    0.751428    0.084034    0.112636    11.00000    0.02700
0.02976 =
         0.03744   -0.00010    0.00560   -0.00082
AFIX  13
H10A  2    0.821716    0.144298    0.104608    11.00000   -1.20000
AFIX   0
C11   1    0.649493    0.130093    0.151651    11.00000    0.02696
0.03235 =
         0.03597    0.00232    0.00739   -0.00056
C12   1    0.743175    0.199620    0.200013    11.00000    0.03309
0.03262 =
         0.04045   -0.00041    0.00901    0.00257
AFIX  23
H12A  2    0.767016    0.274237    0.185244    11.00000   -1.20000
H12B  2    0.681281    0.213517    0.228752    11.00000   -1.20000
AFIX   0
C13   1    0.904038   -0.107195    0.121474    11.00000    0.04022
0.03269 =
```

```
         0.04643   -0.00386    0.00324    0.00301
AFIX  23
H13A  2    0.924534   -0.171766    0.147641    11.00000   -1.20000
H13B  2    1.000306   -0.082033    0.112325    11.00000   -1.20000
AFIX   0
C14   1    0.802775   -0.148333    0.067643    11.00000    0.04453
0.03756 =
         0.05494   -0.01451    0.00371    0.00440
AFIX  23
H14A  2    0.857051   -0.204102    0.048476    11.00000   -1.20000
H14B  2    0.713478   -0.186034    0.076964    11.00000   -1.20000
AFIX   0
C15   1    0.755414   -0.047236    0.029146    11.00000    0.04904
0.04787 =
         0.04034   -0.00878    0.00433    0.00213
AFIX  23
H15A  2    0.695864   -0.074135   -0.006421    11.00000   -1.20000
H15B  2    0.844746   -0.007927    0.020832    11.00000   -1.20000
AFIX   0
C16   1    0.662320    0.035260    0.057620    11.00000    0.03672
0.03994 =
         0.03818    0.00128    0.00301    0.00239
AFIX  23
H16A  2    0.573162   -0.004762    0.065628    11.00000   -1.20000
H16B  2    0.627912    0.098519    0.031847    11.00000   -1.20000
AFIX   0
C17   1    0.603831    0.019052    0.175954    11.00000    0.03065
0.04092 =
         0.03593    0.00069    0.00534   -0.00357
C18   1    1.173698    0.348555    0.127082    11.00000    0.03974
0.04246 =
         0.03855    0.00392    0.01377   -0.00312
AFIX  23
H18A  2    1.188544    0.323116    0.089811    11.00000   -1.20000
H18B  2    1.260130    0.396131    0.143180    11.00000   -1.20000
AFIX   0
C19   1    1.032326    0.420044    0.120677    11.00000    0.03911
0.02882 =
         0.04259    0.00237    0.01065   -0.00439
C20   1    0.975684    0.456153    0.167274    11.00000    0.04628
0.04059 =
         0.04940   -0.00637    0.01201   -0.00421
AFIX  43
H20A  2    1.023316    0.433779    0.203485    11.00000   -1.20000
AFIX   0
C21   1    0.848962    0.525195    0.160745    11.00000    0.05651
0.03830 =
         0.07450   -0.00911    0.02587    0.00171
AFIX  43
H21A  2    0.811341    0.549870    0.192572    11.00000   -1.20000
AFIX   0
C22   1    0.778224    0.557669    0.108079    11.00000    0.05193
0.04347 =
         0.10888    0.02387    0.02746    0.01287
```

```
AFIX  43
H22A  2    0.692613    0.604856    0.103805    11.00000   -1.20000
AFIX   0
C23   1    0.832869    0.521010    0.061475    11.00000    0.06223
0.07513 =
         0.07347    0.03874    0.01355    0.01603
AFIX  43
H23A  2    0.784700    0.543568    0.025363    11.00000   -1.20000
AFIX   0
C24   1    0.958245    0.451183    0.067552    11.00000    0.06068
0.05454 =
         0.04603    0.01718    0.01563    0.00737
AFIX  43
H24A  2    0.993398    0.424712    0.035519    11.00000   -1.20000
AFIX   0
C25   1    0.511100    0.199979    0.124363    11.00000    0.02980
0.04251 =
         0.04266   -0.00055    0.00689    0.00273
AFIX  23
H25A  2    0.443691    0.149962    0.098711    11.00000   -1.20000
H25B  2    0.456811    0.224896    0.153908    11.00000   -1.20000
AFIX   0
C26   1    0.546721    0.302934    0.092414    11.00000    0.03776
0.03861 =
         0.05933    0.00613    0.00104    0.00425
AFIX  43
H26A  2    0.620459    0.353310    0.110983    11.00000   -1.20000
AFIX   0
C27   1    0.484526    0.328875    0.041136    11.00000    0.05837
0.04857 =
         0.06089    0.01309    0.00791    0.00760
AFIX  93
H27A  2    0.410254    0.280876    0.021005    11.00000   -1.20000
H27B  2    0.513857    0.395618    0.024214    11.00000   -1.20000
AFIX   0
C28   1    1.221866    0.199308    0.343562    11.00000    0.03934
0.04432 =
         0.03450   -0.00235    0.00664   -0.00055
AFIX  23
H28A  2    1.326189    0.172470    0.348381    11.00000   -1.20000
H28B  2    1.221540    0.281163    0.334579    11.00000   -1.20000
AFIX   0
C29   1    1.166222    0.184036    0.398866    11.00000    0.05496
0.05890 =
         0.03858   -0.00547    0.01167   -0.00757
AFIX  23
H29A  2    1.062108    0.211152    0.394550    11.00000   -1.20000
H29B  2    1.167397    0.102462    0.408477    11.00000   -1.20000
AFIX   0
C30   1    1.263476    0.249650    0.446298    11.00000    0.07456
0.10286 =
         0.03778   -0.01615    0.01509   -0.01824
AFIX  33
H30A  2    1.225193    0.238198    0.480917    11.00000   -1.50000
```

```
H30B  2    1.261042    0.330604    0.437170    11.00000   -1.50000
H30C  2    1.366256    0.222018    0.451077    11.00000   -1.50000
HKLF 4

REM  test in P2(1)/n
REM R1 =  0.0431 for   2852 Fo > 4sig(Fo)  and  0.0663 for all   3840
data
REM    316 parameters refined using      0 restraints

END

WGHT      0.0311      1.5559
REM Highest difference peak  0.166,  deepest hole -0.199,  1-sigma level
0.044
Q1    1   0.9680  0.2789  0.2827  11.00000  0.05    0.17
Q2    1   0.6918  0.2809  0.2349  11.00000  0.05    0.16
Q3    1   0.9635  0.1985  0.2299  11.00000  0.05    0.16
```

Table 1. Crystal data and structure refinement for test.

Identification code	JPS-804
Empirical formula	C30 H35 N O4
Formula weight	473.59
Temperature	203(2) K
Wavelength	0.71073 A
Crystal system, space group	Monoclinic, P2(1)/n
Unit cell dimensions	a = 9.033(2) A alpha = 90 deg. b = 11.676(3) A beta = 100.344(3) deg. c = 24.160(6) A gamma = 90 deg.
Volume	2506.9(10) A^3
Z, Calculated density	4, 1.255 Mg/m^3
Absorption coefficient	0.082 mm^-1
F(000)	1016
Crystal size	0.70 x 0.60 x 0.50 mm
Theta range for data collection	1.71 to 23.81 deg.
Limiting indices	-10<=h<=10, -13<=k<=13, -27<=l<=27
Reflections collected / unique	17032 / 3840 [R(int) = 0.0515]
Completeness to theta = 23.81	99.6 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9600 and 0.9446
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	3840 / 0 / 316
Goodness-of-fit on F^2	1.077
Final R indices [I>2sigma(I)]	R1 = 0.0431, wR2 = 0.1007
R indices (all data)	R1 = 0.0663, wR2 = 0.1123
Largest diff. peak and hole	0.166 and -0.199 e.A^-3

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for test.
U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
N(1)	11686(2)	2487(2)	1628(1)	33(1)
O(1)	10822(2)	1232(2)	921(1)	45(1)
O(2)	13038(2)	3245(2)	2433(1)	50(1)
O(3)	7132(2)	-598(1)	1765(1)	37(1)
O(4)	4907(2)	-21(2)	1940(1)	49(1)
C(1)	11168(2)	1432(2)	1422(1)	33(1)
C(2)	11132(2)	640(2)	1912(1)	31(1)
C(3)	12064(2)	1280(2)	2420(1)	33(1)
C(4)	12339(2)	2451(2)	2192(1)	35(1)
C(5)	9495(2)	395(2)	2010(1)	31(1)
C(6)	8888(2)	1431(2)	2278(1)	30(1)
C(7)	9746(2)	1855(2)	2736(1)	33(1)
C(8)	11285(2)	1356(2)	2939(1)	34(1)
C(9)	8370(2)	-94(2)	1507(1)	32(1)
C(10)	7514(2)	840(2)	1126(1)	31(1)
C(11)	6495(2)	1301(2)	1517(1)	32(1)
C(12)	7432(2)	1996(2)	2000(1)	35(1)
C(13)	9040(3)	-1072(2)	1215(1)	40(1)
C(14)	8028(3)	-1483(2)	676(1)	46(1)
C(15)	7554(3)	-472(2)	292(1)	46(1)
C(16)	6623(3)	353(2)	576(1)	39(1)
C(17)	6038(3)	191(2)	1760(1)	36(1)
C(18)	11737(3)	3486(2)	1271(1)	39(1)
C(19)	10323(3)	4200(2)	1207(1)	36(1)
C(20)	9757(3)	4562(2)	1673(1)	45(1)
C(21)	8490(3)	5252(2)	1608(1)	55(1)
C(22)	7782(3)	5577(2)	1081(2)	67(1)
C(23)	8329(4)	5210(3)	615(1)	70(1)
C(24)	9582(3)	4512(2)	676(1)	53(1)
C(25)	5111(3)	2000(2)	1244(1)	38(1)
C(26)	5467(3)	3029(2)	924(1)	46(1)
C(27)	4845(3)	3289(2)	411(1)	56(1)
C(28)	12219(3)	1993(2)	3436(1)	39(1)
C(29)	11662(3)	1840(2)	3989(1)	50(1)
C(30)	12635(4)	2496(3)	4463(1)	71(1)

Table 3. Bond lengths [A] and angles [deg] for test.

N(1)-C(1)	1.379(3)
N(1)-C(4)	1.385(3)
N(1)-C(18)	1.456(3)
O(1)-C(1)	1.216(3)
O(2)-C(4)	1.210(3)
O(3)-C(17)	1.349(3)
O(3)-C(9)	1.495(3)
O(4)-C(17)	1.207(3)
C(1)-C(2)	1.508(3)
C(2)-C(3)	1.551(3)
C(2)-C(5)	1.566(3)
C(3)-C(4)	1.511(3)
C(3)-C(8)	1.546(3)
C(5)-C(6)	1.520(3)
C(5)-C(9)	1.547(3)
C(6)-C(7)	1.328(3)
C(6)-C(12)	1.517(3)
C(7)-C(8)	1.505(3)
C(8)-C(28)	1.531(3)
C(9)-C(13)	1.523(3)
C(9)-C(10)	1.542(3)
C(10)-C(11)	1.529(3)
C(10)-C(16)	1.535(3)
C(11)-C(17)	1.511(3)
C(11)-C(25)	1.539(3)
C(11)-C(12)	1.544(3)
C(13)-C(14)	1.527(3)
C(14)-C(15)	1.516(3)
C(15)-C(16)	1.522(3)
C(18)-C(19)	1.510(3)
C(19)-C(20)	1.383(3)
C(19)-C(24)	1.385(3)
C(20)-C(21)	1.386(4)
C(21)-C(22)	1.371(4)
C(22)-C(23)	1.376(4)
C(23)-C(24)	1.382(4)
C(25)-C(26)	1.495(3)
C(26)-C(27)	1.301(4)
C(28)-C(29)	1.520(3)
C(29)-C(30)	1.520(4)
C(1)-N(1)-C(4)	112.68(19)
C(1)-N(1)-C(18)	123.05(19)
C(4)-N(1)-C(18)	123.69(19)
C(17)-O(3)-C(9)	109.22(17)
O(1)-C(1)-N(1)	122.8(2)
O(1)-C(1)-C(2)	128.7(2)
N(1)-C(1)-C(2)	108.54(19)
C(1)-C(2)-C(3)	103.93(18)
C(1)-C(2)-C(5)	112.67(17)

C(3)-C(2)-C(5)	111.14(18)
C(4)-C(3)-C(8)	111.83(18)
C(4)-C(3)-C(2)	104.42(18)
C(8)-C(3)-C(2)	114.10(18)
O(2)-C(4)-N(1)	122.9(2)
O(2)-C(4)-C(3)	128.6(2)
N(1)-C(4)-C(3)	108.51(19)
C(6)-C(5)-C(9)	113.14(18)
C(6)-C(5)-C(2)	110.02(17)
C(9)-C(5)-C(2)	116.92(18)
C(7)-C(6)-C(12)	122.5(2)
C(7)-C(6)-C(5)	116.8(2)
C(12)-C(6)-C(5)	120.54(19)
C(6)-C(7)-C(8)	119.5(2)
C(7)-C(8)-C(28)	114.43(19)
C(7)-C(8)-C(3)	106.68(18)
C(28)-C(8)-C(3)	113.37(19)
O(3)-C(9)-C(13)	106.69(17)
O(3)-C(9)-C(10)	101.19(16)
C(13)-C(9)-C(10)	116.90(19)
O(3)-C(9)-C(5)	104.65(17)
C(13)-C(9)-C(5)	112.44(18)
C(10)-C(9)-C(5)	113.27(18)
C(11)-C(10)-C(16)	112.60(18)
C(11)-C(10)-C(9)	100.04(17)
C(16)-C(10)-C(9)	112.49(18)
C(17)-C(11)-C(10)	100.04(18)
C(17)-C(11)-C(25)	111.35(18)
C(10)-C(11)-C(25)	117.09(18)
C(17)-C(11)-C(12)	107.93(18)
C(10)-C(11)-C(12)	110.03(17)
C(25)-C(11)-C(12)	109.76(18)
C(6)-C(12)-C(11)	114.84(18)
C(9)-C(13)-C(14)	113.78(19)
C(15)-C(14)-C(13)	109.7(2)
C(14)-C(15)-C(16)	109.5(2)
C(15)-C(16)-C(10)	112.33(19)
O(4)-C(17)-O(3)	121.6(2)
O(4)-C(17)-C(11)	128.6(2)
O(3)-C(17)-C(11)	109.79(19)
N(1)-C(18)-C(19)	112.78(18)
C(20)-C(19)-C(24)	119.1(2)
C(20)-C(19)-C(18)	121.0(2)
C(24)-C(19)-C(18)	119.9(2)
C(19)-C(20)-C(21)	120.2(3)
C(22)-C(21)-C(20)	120.3(3)
C(21)-C(22)-C(23)	119.8(3)
C(22)-C(23)-C(24)	120.3(3)
C(23)-C(24)-C(19)	120.2(3)
C(26)-C(25)-C(11)	114.47(19)
C(27)-C(26)-C(25)	125.7(3)
C(29)-C(28)-C(8)	114.2(2)
C(30)-C(29)-C(28)	111.5(2)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (A^2 x 10^3) for test.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
N(1)	32(1)	34(1)	33(1)	1(1)	8(1)	0(1)
O(1)	46(1)	57(1)	35(1)	-8(1)	11(1)	-9(1)
O(2)	58(1)	49(1)	43(1)	-7(1)	8(1)	-21(1)
O(3)	35(1)	30(1)	46(1)	6(1)	8(1)	-4(1)
O(4)	40(1)	55(1)	57(1)	6(1)	19(1)	-8(1)
C(1)	23(1)	42(1)	34(1)	-7(1)	9(1)	2(1)
C(2)	29(1)	29(1)	36(1)	-2(1)	5(1)	4(1)
C(3)	28(1)	35(1)	34(1)	0(1)	2(1)	6(1)
C(4)	28(1)	41(1)	35(1)	-5(1)	8(1)	-3(1)
C(5)	31(1)	28(1)	35(1)	2(1)	6(1)	2(1)
C(6)	29(1)	29(1)	35(1)	1(1)	11(1)	-3(1)
C(7)	36(1)	31(1)	36(1)	-2(1)	13(1)	2(1)
C(8)	35(1)	32(1)	35(1)	2(1)	6(1)	1(1)
C(9)	29(1)	28(1)	39(1)	1(1)	10(1)	-2(1)
C(10)	27(1)	30(1)	37(1)	0(1)	6(1)	-1(1)
C(11)	27(1)	32(1)	36(1)	2(1)	7(1)	-1(1)
C(12)	33(1)	33(1)	41(1)	0(1)	9(1)	3(1)
C(13)	40(1)	33(1)	46(2)	-4(1)	3(1)	3(1)
C(14)	45(2)	38(1)	55(2)	-14(1)	4(1)	4(1)
C(15)	49(2)	48(2)	40(2)	-9(1)	4(1)	2(1)
C(16)	37(1)	40(1)	38(1)	1(1)	3(1)	2(1)
C(17)	31(1)	41(1)	36(1)	1(1)	5(1)	-4(1)
C(18)	40(1)	43(1)	39(1)	4(1)	14(1)	-3(1)
C(19)	39(1)	29(1)	43(1)	2(1)	11(1)	-4(1)
C(20)	46(2)	41(2)	49(2)	-6(1)	12(1)	-4(1)
C(21)	57(2)	38(2)	74(2)	-9(1)	26(2)	2(1)
C(22)	52(2)	44(2)	109(3)	24(2)	28(2)	13(1)
C(23)	62(2)	75(2)	73(2)	39(2)	14(2)	16(2)
C(24)	61(2)	55(2)	46(2)	17(1)	16(1)	7(2)
C(25)	30(1)	43(1)	43(1)	-1(1)	7(1)	3(1)
C(26)	38(1)	39(2)	59(2)	6(1)	1(1)	4(1)
C(27)	58(2)	49(2)	61(2)	13(1)	8(2)	8(1)
C(28)	39(1)	44(2)	35(1)	-2(1)	7(1)	-1(1)
C(29)	55(2)	59(2)	39(2)	-6(1)	12(1)	-8(1)
C(30)	75(2)	103(3)	38(2)	-16(2)	15(2)	-18(2)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for test.

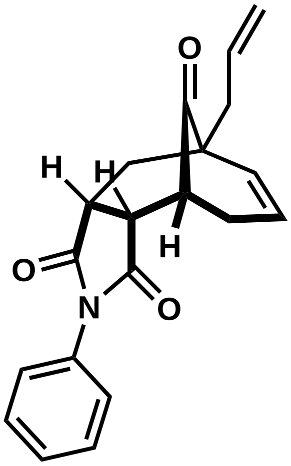
	x	y	z	U(eq)
H(2A)	11634	-91	1850	38
H(3A)	13043	886	2531	39
H(5A)	9603	-210	2302	37
H(7A)	9396	2463	2933	40
H(8A)	11142	563	3064	41
H(10A)	8217	1443	1046	38
H(12A)	7670	2742	1852	42
H(12B)	6813	2135	2288	42
H(13A)	9245	-1718	1476	48
H(13B)	10003	-820	1123	48
H(14A)	8571	-2041	485	56
H(14B)	7135	-1860	770	56
H(15A)	6959	-741	-64	55
H(15B)	8447	-79	208	55
H(16A)	5732	-48	656	46
H(16B)	6279	985	318	46
H(18A)	11885	3231	898	47
H(18B)	12601	3961	1432	47
H(20A)	10233	4338	2035	54
H(21A)	8113	5499	1926	66
H(22A)	6926	6049	1038	80
H(23A)	7847	5436	254	84
H(24A)	9934	4247	355	64
H(25A)	4437	1500	987	46
H(25B)	4568	2249	1539	46
H(26A)	6205	3533	1110	55
H(27A)	4103	2809	210	68
H(27B)	5139	3956	242	68
H(28A)	13262	1725	3484	47
H(28B)	12215	2812	3346	47
H(29A)	10621	2112	3946	60
H(29B)	11674	1025	4085	60
H(30A)	12252	2382	4809	107
H(30B)	12610	3306	4372	107
H(30C)	13663	2220	4511	107

Table 6. Torsion angles [deg] for test.

C(4)-N(1)-C(1)-O(1)	-165.7(2)
C(18)-N(1)-C(1)-O(1)	5.8(3)
C(4)-N(1)-C(1)-C(2)	14.0(2)
C(18)-N(1)-C(1)-C(2)	-174.41(18)
O(1)-C(1)-C(2)-C(3)	166.2(2)
N(1)-C(1)-C(2)-C(3)	-13.6(2)
O(1)-C(1)-C(2)-C(5)	-73.4(3)
N(1)-C(1)-C(2)-C(5)	106.9(2)
C(1)-C(2)-C(3)-C(4)	8.5(2)
C(5)-C(2)-C(3)-C(4)	-112.94(19)
C(1)-C(2)-C(3)-C(8)	130.90(19)
C(5)-C(2)-C(3)-C(8)	9.5(3)
C(1)-N(1)-C(4)-O(2)	169.8(2)
C(18)-N(1)-C(4)-O(2)	-1.7(3)
C(1)-N(1)-C(4)-C(3)	-8.1(2)
C(18)-N(1)-C(4)-C(3)	-179.63(19)
C(8)-C(3)-C(4)-O(2)	57.4(3)
C(2)-C(3)-C(4)-O(2)	-178.7(2)
C(8)-C(3)-C(4)-N(1)	-124.81(19)
C(2)-C(3)-C(4)-N(1)	-0.9(2)
C(1)-C(2)-C(5)-C(6)	-74.9(2)
C(3)-C(2)-C(5)-C(6)	41.3(2)
C(1)-C(2)-C(5)-C(9)	55.9(2)
C(3)-C(2)-C(5)-C(9)	172.10(18)
C(9)-C(5)-C(6)-C(7)	175.6(2)
C(2)-C(5)-C(6)-C(7)	-51.5(3)
C(9)-C(5)-C(6)-C(12)	-9.2(3)
C(2)-C(5)-C(6)-C(12)	123.6(2)
C(12)-C(6)-C(7)-C(8)	-170.8(2)
C(5)-C(6)-C(7)-C(8)	4.3(3)
C(6)-C(7)-C(8)-C(28)	174.4(2)
C(6)-C(7)-C(8)-C(3)	48.1(3)
C(4)-C(3)-C(8)-C(7)	65.2(2)
C(2)-C(3)-C(8)-C(7)	-53.0(2)
C(4)-C(3)-C(8)-C(28)	-61.6(2)
C(2)-C(3)-C(8)-C(28)	-179.88(19)
C(17)-O(3)-C(9)-C(13)	-147.65(18)
C(17)-O(3)-C(9)-C(10)	-24.9(2)
C(17)-O(3)-C(9)-C(5)	93.00(19)
C(6)-C(5)-C(9)-O(3)	-69.1(2)
C(2)-C(5)-C(9)-O(3)	161.53(17)
C(6)-C(5)-C(9)-C(13)	175.49(19)
C(2)-C(5)-C(9)-C(13)	46.1(3)
C(6)-C(5)-C(9)-C(10)	40.2(3)
C(2)-C(5)-C(9)-C(10)	-89.1(2)
O(3)-C(9)-C(10)-C(11)	40.85(19)
C(13)-C(9)-C(10)-C(11)	156.24(19)
C(5)-C(9)-C(10)-C(11)	-70.6(2)
O(3)-C(9)-C(10)-C(16)	-78.9(2)
C(13)-C(9)-C(10)-C(16)	36.5(3)

C(5)-C(9)-C(10)-C(16)	169.68(18)
C(16)-C(10)-C(11)-C(17)	78.2(2)
C(9)-C(10)-C(11)-C(17)	-41.46(19)
C(16)-C(10)-C(11)-C(25)	-42.2(3)
C(9)-C(10)-C(11)-C(25)	-161.85(18)
C(16)-C(10)-C(11)-C(12)	-168.41(18)
C(9)-C(10)-C(11)-C(12)	71.9(2)
C(7)-C(6)-C(12)-C(11)	-172.9(2)
C(5)-C(6)-C(12)-C(11)	12.3(3)
C(17)-C(11)-C(12)-C(6)	62.5(2)
C(10)-C(11)-C(12)-C(6)	-45.8(3)
C(25)-C(11)-C(12)-C(6)	-176.01(18)
O(3)-C(9)-C(13)-C(14)	72.5(2)
C(10)-C(9)-C(13)-C(14)	-39.8(3)
C(5)-C(9)-C(13)-C(14)	-173.3(2)
C(9)-C(13)-C(14)-C(15)	52.3(3)
C(13)-C(14)-C(15)-C(16)	-63.1(3)
C(14)-C(15)-C(16)-C(10)	61.5(3)
C(11)-C(10)-C(16)-C(15)	-159.2(2)
C(9)-C(10)-C(16)-C(15)	-47.0(3)
C(9)-O(3)-C(17)-O(4)	179.1(2)
C(9)-O(3)-C(17)-C(11)	-2.1(2)
C(10)-C(11)-C(17)-O(4)	-152.9(2)
C(25)-C(11)-C(17)-O(4)	-28.5(3)
C(12)-C(11)-C(17)-O(4)	92.1(3)
C(10)-C(11)-C(17)-O(3)	28.4(2)
C(25)-C(11)-C(17)-O(3)	152.86(18)
C(12)-C(11)-C(17)-O(3)	-86.6(2)
C(1)-N(1)-C(18)-C(19)	91.5(3)
C(4)-N(1)-C(18)-C(19)	-97.9(2)
N(1)-C(18)-C(19)-C(20)	51.4(3)
N(1)-C(18)-C(19)-C(24)	-129.2(2)
C(24)-C(19)-C(20)-C(21)	-1.8(4)
C(18)-C(19)-C(20)-C(21)	177.6(2)
C(19)-C(20)-C(21)-C(22)	0.4(4)
C(20)-C(21)-C(22)-C(23)	0.4(4)
C(21)-C(22)-C(23)-C(24)	0.3(5)
C(22)-C(23)-C(24)-C(19)	-1.7(4)
C(20)-C(19)-C(24)-C(23)	2.5(4)
C(18)-C(19)-C(24)-C(23)	-177.0(2)
C(17)-C(11)-C(25)-C(26)	-171.9(2)
C(10)-C(11)-C(25)-C(26)	-57.7(3)
C(12)-C(11)-C(25)-C(26)	68.7(3)
C(11)-C(25)-C(26)-C(27)	129.3(3)
C(7)-C(8)-C(28)-C(29)	71.0(3)
C(3)-C(8)-C(28)-C(29)	-166.3(2)
C(8)-C(28)-C(29)-C(30)	-179.8(2)

Symmetry transformations used to generate equivalent atoms:


O
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checkCIF/PLATON report

No syntax errors found. **CIF dictionary** **Interpreting this report**

Datablock: lb016

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Bond precision:  C-C = 0.0045 A          Wavelength=0.71073

Cell:            a=22.9943(4)    b=6.7284(1)         c=23.2627(4)
                 alpha=90        beta=112.879(1)     gamma=90
Temperature:     296 K

                 Calculated                 Reported
Volume           3315.94(10)                3315.94(9)
Space group      P 21/n                     P2(1)/n
Hall group       -P 2yn                     ?
Moiety formula   C20 H19 N O3               ?
Sum formula      C20 H19 N O3               C40 H38 N2 O6
Mr               321.36                     642.72
Dx,g cm-3        1.288                      1.287
Z                8                          4
Mu (mm-1)        0.087                      0.087
F000             1360.0                     1360.0
F000'            1360.64
h,k,lmax         24,7,24                    24,7,24
Nref             4067                       4012
Tmin,Tmax        0.991,0.994                0.980,0.994
Tmin'            0.980

Correction method= MULTI-SCAN

Data completeness= 0.986          Theta(max)= 22.010

R(reflections)= 0.0423( 2863)     wR2(reflections)= 0.1064( 4012)

S = 1.014                  Npar= 434
```

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

● Alert level A

```
THETM01_ALERT_3_A  The value of sine(theta_max)/wavelength is less than 0.550
            Calculated sin(theta_max)/wavelength =    0.5273
```

● Alert level B

```
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C18    --  C19     ..       8.75 su
```

```
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C19    --  C20     ..      14.40 su
```

● Alert level C

```
REFNR01_ALERT_3_C  Ratio of reflections to parameters is < 10 for a
            centrosymmetric structure
            sine(theta)/lambda                0.5273
            Proportion of unique data used    1.0000
            Ratio reflections to parameters   9.2442
PLAT045_ALERT_1_C Calculated and Reported Z Differ by ...........       2.00 Ratio
PLAT088_ALERT_3_C Poor Data / Parameter Ratio ...................       9.24
PLAT230_ALERT_2_C Hirshfeld Test Diff for    C1     --  C2      ..       7.00 su
PLAT230_ALERT_2_C Hirshfeld Test Diff for    C9     --  C10     ..       6.50 su
PLAT230_ALERT_2_C Hirshfeld Test Diff for    N2     --  C30     ..       5.50 su
PLAT230_ALERT_2_C Hirshfeld Test Diff for    C39    --  C40     ..       5.67 su
PLAT368_ALERT_2_C Short  C(sp2)-C(sp2) Bond  C19    -   C20    ...       1.18 Ang.
```

● Alert level G

```
PLAT128_ALERT_4_G Alternate Setting of Space-group P21/c   .......      P21/n
PLAT793_ALERT_4_G The Model has Chirality at C2      (Verify) ....          S
PLAT793_ALERT_4_G The Model has Chirality at C3      (Verify) ....          R
PLAT793_ALERT_4_G The Model has Chirality at C7      (Verify) ....          R
PLAT793_ALERT_4_G The Model has Chirality at C9      (Verify) ....          R
PLAT793_ALERT_4_G The Model has Chirality at C22     (Verify) ....          S
PLAT793_ALERT_4_G The Model has Chirality at C23     (Verify) ....          R
PLAT793_ALERT_4_G The Model has Chirality at C27     (Verify) ....          R
PLAT793_ALERT_4_G The Model has Chirality at C29     (Verify) ....          R
```

---

1 **ALERT level A** = Most likely a serious problem - resolve or explain
2 **ALERT level B** = A potentially serious problem, consider carefully
8 **ALERT level C** = Check. Ensure it is not caused by an omission or oversight
9 **ALERT level G** = General information/check it is not something unexpected

```
1 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
7 ALERT type 2 Indicator that the structure model may be wrong or deficient
3 ALERT type 3 Indicator that the structure quality may be low
9 ALERT type 4 Improvement, methodology, query or suggestion
0 ALERT type 5 Informative message, check
```

It is advisable to attempt to resolve as many as possible of the alerts in all categories. Often the minor alerts point to easily fixed oversights, errors and omissions in your CIF or refinement strategy, so attention to these fine details can be worthwhile. In order to resolve some of the more serious problems it may be necessary to carry out additional measurements or structure refinements. However, the purpose of your study may justify the reported deviations and the more serious of these should normally be commented upon in the discussion or experimental section of a paper or in the "special_details" fields of the CIF. checkCIF was carefully designed to identify outliers and unusual parameters, but every test has its limitations and alerts that are not important in a particular case may appear. Conversely, the absence of alerts does not guarantee there are no aspects of the results needing attention. It is up to the individual to critically assess their own results and, if necessary, seek expert advice.

Publication of your CIF in IUCr journals

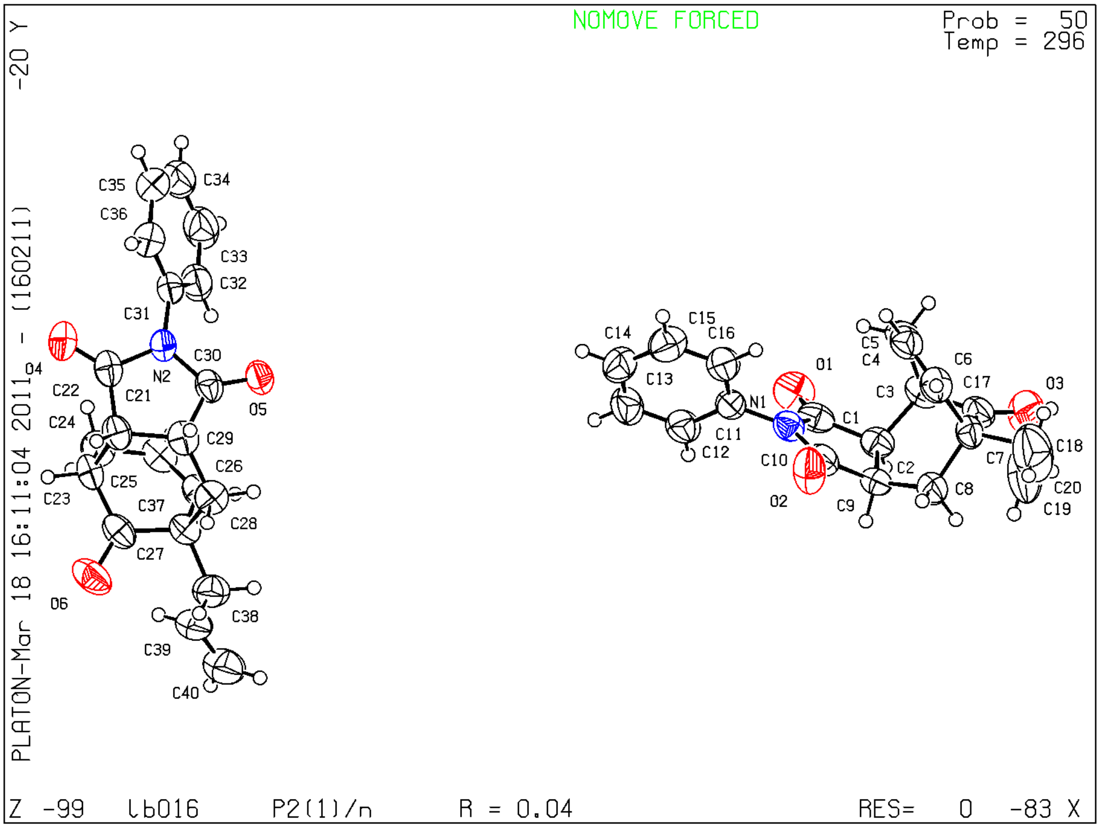
A basic structural check has been run on your CIF. These basic checks will be run on all CIFs submitted for publication in IUCr journals (*Acta Crystallographica*, *Journal of Applied Crystallography*, *Journal of Synchrotron Radiation*); however, if you intend to submit to *Acta Crystallographica Section C* or *E*, you should make sure that full publication checks are run on the final version of your CIF prior to submission.

Publication of your CIF in other journals

Please refer to the *Notes for Authors* of the relevant journal for any special instructions relating to CIF submission.

PLATON version of 16/02/2011; check.def file version of 16/02/2011

Datablock lb016 - ellipsoid plot



```
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_chemical_name_systematic
;
 ?
;
_chemical_name_common             ?
_chemical_melting_point           ?
_chemical_formula_moiety          ?
_chemical_formula_sum
 'C40 H38 N2 O6'
_chemical_formula_weight          642.72

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 _atom_type_scat_dispersion_imag
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 'C'  'C'   0.0033   0.0016
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'H'  'H'   0.0000   0.0000
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'N'  'N'   0.0061   0.0033
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'O'  'O'   0.0106   0.0060
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'

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_symmetry_space_group_name_H-M    P2(1)/n

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 _symmetry_equiv_pos_as_xyz
 'x, y, z'
 '-x+1/2, y+1/2, -z+1/2'
 '-x, -y, -z'
 'x-1/2, -y-1/2, z-1/2'

_cell_length_a                    22.9943(4)
_cell_length_b                    6.72840(10)
_cell_length_c                    23.2627(4)
_cell_angle_alpha                 90.00
_cell_angle_beta                  112.8790(10)
_cell_angle_gamma                 90.00
_cell_volume                      3315.94(9)
_cell_formula_units_Z             4
_cell_measurement_temperature     296(2)
_cell_measurement_reflns_used     3888
_cell_measurement_theta_min       2.66
_cell_measurement_theta_max       19.74

_exptl_crystal_description        needle
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_exptl_crystal_colour             colourless
_exptl_crystal_size_max           0.23
_exptl_crystal_size_mid           0.09
_exptl_crystal_size_min           0.07
_exptl_crystal_density_meas       n/a
_exptl_crystal_density_diffrn     1.287
_exptl_crystal_density_method     'not measured'
_exptl_crystal_F_000              1360
_exptl_absorpt_coefficient_mu     0.087
_exptl_absorpt_correction_type    multi-scan
_exptl_absorpt_correction_T_min   0.9804
_exptl_absorpt_correction_T_max   0.9940
_exptl_absorpt_process_details    'SADABS, Bruker (2003)'

_exptl_special_details
;
 Data collection is performed with three batch runs at phi = 0.00 deg
 (650 frames), at phi = 120.00 deg (650 frames), and at phi = 240.00 deg
 (650 frames).
 Frame width = 0.30 deg in omega.
 Data is merged, corrected for decay (if any), and treated with multi-
scan
 absorption corrections (if required). All symmetry-equivalent
reflections
 are merged for centrosymmetric data.
 Friedel pairs are not merged for noncentrosymmetric data.
;

_diffrn_ambient_temperature       296(2)
_diffrn_radiation_wavelength      0.71073
_diffrn_radiation_type            MoK\a
_diffrn_radiation_source          'fine-focus sealed tube'
_diffrn_radiation_monochromator   graphite
_diffrn_measurement_device_type   'Bruker APEX-II CCD'
_diffrn_measurement_method        '\f and \w scans'
_diffrn_detector_area_resol_mean  ?
_diffrn_reflns_number             28901
_diffrn_reflns_av_R_equivalents   0.0679
_diffrn_reflns_av_sigmaI/netI     0.0344
_diffrn_reflns_limit_h_min        -24
_diffrn_reflns_limit_h_max        24
_diffrn_reflns_limit_k_min        -7
_diffrn_reflns_limit_k_max        7
_diffrn_reflns_limit_l_min        -24
_diffrn_reflns_limit_l_max        22
_diffrn_reflns_theta_min          1.90
_diffrn_reflns_theta_max          22.01
_reflns_number_total              4012
_reflns_number_gt                 2863
_reflns_threshold_expression      >2sigma(I)

_computing_data_collection        'APEX II, Bruker (2009)'
_computing_cell_refinement        'APEX II, Bruker (2009)'
_computing_data_reduction         'XPREP, Bruker (2009)'
```

```
_computing_structure_solution     'SHELXS-97 (Sheldrick, 2008)'
_computing_structure_refinement   'SHELXL-97 (Sheldrick, 2008)'
_computing_molecular_graphics     'SHELXTL, Bruker (2004)'
_computing_publication_material   'SHELXTL, Bruker (2004)'

_refine_special_details
;
 Refinement of F^2^ against ALL reflections.  The weighted R-factor wR
and
 goodness of fit S are based on F^2^, conventional R-factors R are based
 on F, with F set to zero for negative F^2^. The threshold expression of
 F^2^ > 2sigma(F^2^) is used only for calculating R-factors(gt) etc. and
is
 not relevant to the choice of reflections for refinement.  R-factors
based
 on F^2^ are statistically about twice as large as those based on F, and
R-
 factors based on ALL data will be even larger.
;

_refine_ls_structure_factor_coef  Fsqd
_refine_ls_matrix_type            full
_refine_ls_weighting_scheme       calc
_refine_ls_weighting_details
 'calc w=1/[\s^2^(Fo^2^)+(0.0539P)^2^+0.5324P] where P=(Fo^2^+2Fc^2^)/3'
_atom_sites_solution_primary      direct
_atom_sites_solution_secondary    difmap
_atom_sites_solution_hydrogens    geom
_refine_ls_hydrogen_treatment     constr
_refine_ls_extinction_method      SHELXL
_refine_ls_extinction_coef        0.0054(5)
_refine_ls_extinction_expression
 'Fc^*^=kFc[1+0.001xFc^2^\l^3^/sin(2\q)]^-1/4^'
_refine_ls_number_reflns          4012
_refine_ls_number_parameters      434
_refine_ls_number_restraints      0
_refine_ls_R_factor_all           0.0701
_refine_ls_R_factor_gt            0.0423
_refine_ls_wR_factor_ref          0.1064
_refine_ls_wR_factor_gt           0.0946
_refine_ls_goodness_of_fit_ref    1.014
_refine_ls_restrained_S_all       1.014
_refine_ls_shift/su_max           0.000
_refine_ls_shift/su_mean          0.000

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 _atom_site_type_symbol
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 _atom_site_fract_y
 _atom_site_fract_z
 _atom_site_U_iso_or_equiv
 _atom_site_adp_type
 _atom_site_occupancy
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 _atom_site_calc_flag
 _atom_site_refinement_flags
 _atom_site_disorder_assembly
 _atom_site_disorder_group
N1 N 0.84234(9) 0.3307(3) 0.76929(10) 0.0503(6) Uani 1 1 d . . .
O1 O 0.90575(9) 0.0647(3) 0.77144(9) 0.0747(6) Uani 1 1 d . . .
O2 O 0.77725(10) 0.5504(4) 0.79103(9) 0.0822(7) Uani 1 1 d . . .
O3 O 0.92919(10) 0.0730(3) 1.01193(10) 0.0904(7) Uani 1 1 d . . .
C1 C 0.87345(12) 0.1538(4) 0.79327(13) 0.0554(7) Uani 1 1 d . . .
C2 C 0.86299(12) 0.1042(4) 0.85170(12) 0.0531(7) Uani 1 1 d . . .
H2A H 0.8503 -0.0353 0.8501 0.064 Uiso 1 1 calc R . .
C3 C 0.92522(12) 0.1360(4) 0.90946(13) 0.0579(7) Uani 1 1 d . . .
H3A H 0.9501 0.0135 0.9170 0.069 Uiso 1 1 calc R . .
C4 C 0.96655(12) 0.3094(4) 0.90486(13) 0.0646(8) Uani 1 1 d . . .
H4A H 1.0089 0.2929 0.9363 0.077 Uiso 1 1 calc R . .
H4B H 0.9692 0.3065 0.8643 0.077 Uiso 1 1 calc R . .
C5 C 0.94138(13) 0.5054(4) 0.91373(13) 0.0627(8) Uani 1 1 d . . .
H5A H 0.9565 0.6186 0.9012 0.075 Uiso 1 1 calc R . .
C6 C 0.89868(14) 0.5284(4) 0.93837(12) 0.0600(8) Uani 1 1 d . . .
H6A H 0.8861 0.6568 0.9430 0.072 Uiso 1 1 calc R . .
C7 C 0.86951(12) 0.3585(4) 0.95918(11) 0.0519(7) Uani 1 1 d . . .
C8 C 0.80476(12) 0.3082(4) 0.90831(12) 0.0602(8) Uani 1 1 d . . .
H8A H 0.7849 0.2063 0.9240 0.072 Uiso 1 1 calc R . .
H8B H 0.7783 0.4256 0.8998 0.072 Uiso 1 1 calc R . .
C9 C 0.80777(11) 0.2365(4) 0.84803(12) 0.0538(7) Uani 1 1 d . . .
H9A H 0.7697 0.1565 0.8275 0.065 Uiso 1 1 calc R . .
C10 C 0.80632(13) 0.3957(5) 0.80178(12) 0.0579(7) Uani 1 1 d . . .
C11 C 0.84521(11) 0.4294(4) 0.71569(12) 0.0498(7) Uani 1 1 d . . .
C12 C 0.82003(13) 0.3374(5) 0.65846(14) 0.0653(8) Uani 1 1 d . . .
H12A H 0.8016 0.2123 0.6545 0.078 Uiso 1 1 calc R . .
C13 C 0.82249(14) 0.4336(6) 0.60692(15) 0.0760(9) Uani 1 1 d . . .
H13A H 0.8061 0.3723 0.5680 0.091 Uiso 1 1 calc R . .
C14 C 0.84893(14) 0.6183(6) 0.61282(15) 0.0730(9) Uani 1 1 d . . .
H14A H 0.8506 0.6825 0.5781 0.088 Uiso 1 1 calc R . .
C15 C 0.87303(14) 0.7086(5) 0.67009(17) 0.0742(9) Uani 1 1 d . . .
H15A H 0.8908 0.8346 0.6742 0.089 Uiso 1 1 calc R . .
C16 C 0.87100(13) 0.6135(5) 0.72147(14) 0.0638(8) Uani 1 1 d . . .
H16A H 0.8873 0.6753 0.7603 0.077 Uiso 1 1 calc R . .
C17 C 0.91007(12) 0.1773(4) 0.96568(14) 0.0587(8) Uani 1 1 d . . .
C18 C 0.86271(15) 0.4044(5) 1.02118(13) 0.0759(9) Uani 1 1 d . . .
H18A H 0.8503 0.2836 1.0361 0.091 Uiso 1 1 calc R . .
H18B H 0.9036 0.4436 1.0518 0.091 Uiso 1 1 calc R . .
C19 C 0.8151(2) 0.5669(7) 1.01723(18) 0.1116(15) Uani 1 1 d . . .
H19A H 0.7728 0.5312 0.9979 0.134 Uiso 1 1 calc R . .
C20 C 0.8249(2) 0.7329(9) 1.03555(19) 0.1386(18) Uani 1 1 d . . .
H20A H 0.8662 0.7779 1.0553 0.166 Uiso 1 1 calc R . .
H20B H 0.7914 0.8181 1.0302 0.166 Uiso 1 1 calc R . .
N2 N 0.74238(10) 1.0089(3) 0.15070(9) 0.0493(6) Uani 1 1 d . . .
O4 O 0.71679(9) 1.1198(3) 0.05010(9) 0.0719(6) Uani 1 1 d . . .
O5 O 0.73633(8) 0.9045(3) 0.24274(8) 0.0582(5) Uani 1 1 d . . .
O6 O 0.49577(9) 0.7786(3) 0.02724(9) 0.0790(6) Uani 1 1 d . . .
C21 C 0.70046(13) 1.0670(4) 0.09114(13) 0.0542(7) Uani 1 1 d . . .
C22 C 0.63443(12) 1.0417(4) 0.08803(12) 0.0520(7) Uani 1 1 d . . .
```

```
H22A H 0.6100 1.1613 0.0695 0.062 Uiso 1 1 calc R . .
C23 C 0.60272(12) 0.8591(4) 0.04645(11) 0.0540(7) Uani 1 1 d . . .
H23A H 0.5848 0.9017 0.0027 0.065 Uiso 1 1 calc R . .
C24 C 0.64656(13) 0.6804(4) 0.05250(13) 0.0614(8) Uani 1 1 d . . .
H24A H 0.6265 0.5904 0.0178 0.074 Uiso 1 1 calc R . .
H24B H 0.6855 0.7270 0.0501 0.074 Uiso 1 1 calc R . .
C25 C 0.66158(12) 0.5709(4) 0.11211(13) 0.0538(7) Uani 1 1 d . . .
H25A H 0.6964 0.4866 0.1257 0.065 Uiso 1 1 calc R . .
C26 C 0.62808(12) 0.5876(4) 0.14636(12) 0.0513(7) Uani 1 1 d . . .
H26A H 0.6400 0.5115 0.1825 0.062 Uiso 1 1 calc R . .
C27 C 0.57189(11) 0.7210(4) 0.13120(12) 0.0492(7) Uani 1 1 d . . .
C28 C 0.59455(12) 0.9100(4) 0.17145(13) 0.0563(7) Uani 1 1 d . . .
H28A H 0.5583 0.9940 0.1654 0.068 Uiso 1 1 calc R . .
H28B H 0.6128 0.8718 0.2151 0.068 Uiso 1 1 calc R . .
C29 C 0.64305(12) 1.0294(4) 0.15645(12) 0.0496(7) Uani 1 1 d . . .
H29A H 0.6401 1.1661 0.1696 0.059 Uiso 1 1 calc R . .
C30 C 0.71097(12) 0.9676(4) 0.19041(13) 0.0485(7) Uani 1 1 d . . .
C31 C 0.80887(13) 0.9849(5) 0.16737(12) 0.0547(7) Uani 1 1 d . . .
C32 C 0.83672(14) 0.8050(5) 0.18940(12) 0.0681(8) Uani 1 1 d . . .
H32A H 0.8130 0.7007 0.1951 0.082 Uiso 1 1 calc R . .
C33 C 0.90014(17) 0.7800(6) 0.20293(14) 0.0880(11) Uani 1 1 d . . .
H33A H 0.9195 0.6591 0.2184 0.106 Uiso 1 1 calc R . .
C34 C 0.93472(17) 0.9333(8) 0.19356(16) 0.0982(13) Uani 1 1 d . . .
H34A H 0.9774 0.9153 0.2020 0.118 Uiso 1 1 calc R . .
C35 C 0.90674(17) 1.1128(7) 0.17186(15) 0.0939(12) Uani 1 1 d . . .
H35A H 0.9305 1.2165 0.1659 0.113 Uiso 1 1 calc R . .
C36 C 0.84317(15) 1.1404(5) 0.15876(13) 0.0741(9) Uani 1 1 d . . .
H36A H 0.8241 1.2625 0.1444 0.089 Uiso 1 1 calc R . .
C37 C 0.55030(13) 0.7858(4) 0.06400(13) 0.0550(7) Uani 1 1 d . . .
C38 C 0.51810(13) 0.6266(4) 0.14467(14) 0.0680(8) Uani 1 1 d . . .
H38A H 0.5319 0.6091 0.1894 0.082 Uiso 1 1 calc R . .
H38B H 0.4827 0.7180 0.1314 0.082 Uiso 1 1 calc R . .
C39 C 0.49574(13) 0.4301(5) 0.11358(14) 0.0710(9) Uani 1 1 d . . .
H39A H 0.5021 0.4038 0.0772 0.085 Uiso 1 1 calc R . .
C40 C 0.46858(14) 0.2955(5) 0.13327(16) 0.0865(10) Uani 1 1 d . . .
H40A H 0.4614 0.3163 0.1695 0.104 Uiso 1 1 calc R . .
H40B H 0.4560 0.1770 0.1113 0.104 Uiso 1 1 calc R . .

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 _atom_site_aniso_U_33
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 _atom_site_aniso_U_13
 _atom_site_aniso_U_12
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O1 0.0757(14) 0.0648(13) 0.0863(15) -0.0167(11) 0.0344(12) 0.0128(11)
O2 0.0832(15) 0.1071(18) 0.0590(13) 0.0185(12) 0.0306(11) 0.0527(14)
O3 0.0863(15) 0.0961(17) 0.0820(16) 0.0460(14) 0.0255(12) 0.0253(13)
C1 0.0453(16) 0.0498(18) 0.065(2) -0.0160(16) 0.0146(15) -0.0019(14)
C2 0.0534(16) 0.0431(16) 0.0586(18) -0.0046(14) 0.0172(14) -0.0055(13)
C3 0.0481(16) 0.0500(17) 0.065(2) 0.0049(15) 0.0102(14) 0.0113(13)
C4 0.0443(16) 0.075(2) 0.067(2) -0.0057(16) 0.0134(14) -0.0066(15)
```

```
C5 0.0655(19) 0.058(2) 0.0543(19) -0.0022(15) 0.0119(16) -0.0165(16)
C6 0.0707(19) 0.0515(18) 0.0532(18) -0.0026(14) 0.0193(16) -0.0033(15)
C7 0.0560(17) 0.0537(18) 0.0404(16) 0.0072(13) 0.0127(13) 0.0032(14)
C8 0.0504(17) 0.077(2) 0.0500(18) 0.0065(16) 0.0161(14) 0.0052(15)
C9 0.0391(15) 0.0672(19) 0.0499(17) -0.0032(15) 0.0118(13) -0.0051(13)
C10 0.0433(16) 0.077(2) 0.0475(18) -0.0062(17) 0.0109(14) 0.0079(16)
C11 0.0436(15) 0.0602(19) 0.0463(17) -0.0065(15) 0.0183(13) 0.0023(14)
C12 0.0622(18) 0.073(2) 0.059(2) -0.0171(18) 0.0220(16) -0.0117(16)
C13 0.071(2) 0.104(3) 0.051(2) -0.016(2) 0.0220(16) 0.001(2)
C14 0.065(2) 0.095(3) 0.066(2) 0.006(2) 0.0343(17) 0.0076(19)
C15 0.077(2) 0.071(2) 0.082(3) -0.006(2) 0.0392(19) -0.0082(17)
C16 0.0647(19) 0.070(2) 0.057(2) -0.0094(17) 0.0241(15) -0.0075(16)
C17 0.0484(16) 0.0584(19) 0.0551(19) 0.0120(17) 0.0045(14) -0.0022(14)
C18 0.092(2) 0.084(2) 0.0490(19) 0.0094(17) 0.0243(17) 0.0037(19)
C19 0.170(4) 0.097(3) 0.059(3) -0.009(2) 0.034(3) 0.010(3)
C20 0.155(4) 0.178(5) 0.078(3) -0.015(3) 0.039(3) 0.026(4)
N2 0.0532(14) 0.0563(14) 0.0358(13) 0.0024(11) 0.0145(11) -0.0008(11)
O4 0.0813(14) 0.0867(15) 0.0474(12) 0.0152(11) 0.0247(11) 0.0017(11)
O5 0.0631(12) 0.0657(12) 0.0386(11) -0.0008(10) 0.0119(9) -0.0088(10)
O6 0.0537(13) 0.0818(15) 0.0739(14) 0.0128(12) -0.0055(11) 0.0058(11)
C21 0.0676(19) 0.0477(17) 0.0421(18) 0.0025(14) 0.0158(16) 0.0044(14)
C22 0.0554(17) 0.0467(16) 0.0471(17) 0.0081(13) 0.0128(13) 0.0127(13)
C23 0.0592(17) 0.0573(18) 0.0356(15) 0.0021(13) 0.0076(13) 0.0046(14)
C24 0.0684(19) 0.0562(18) 0.0597(19) -0.0137(16) 0.0249(15) -0.0001(15)
C25 0.0540(17) 0.0402(16) 0.0575(19) -0.0074(14) 0.0112(15) 0.0071(13)
C26 0.0562(17) 0.0392(16) 0.0466(16) -0.0030(13) 0.0071(14) -0.0001(13)
C27 0.0472(16) 0.0467(16) 0.0488(17) -0.0034(13) 0.0132(13) 0.0017(13)
C28 0.0595(17) 0.0511(17) 0.0595(18) -0.0050(15) 0.0245(14) 0.0054(14)
C29 0.0612(17) 0.0357(15) 0.0502(17) -0.0052(13) 0.0198(14) 0.0051(13)
C30 0.0598(18) 0.0404(16) 0.0388(16) -0.0038(13) 0.0121(14) -0.0048(13)
C31 0.0511(17) 0.074(2) 0.0367(16) 0.0002(15) 0.0144(13) -0.0013(16)
C32 0.065(2) 0.084(2) 0.0520(19) 0.0057(17) 0.0189(15) 0.0092(18)
C33 0.072(2) 0.123(3) 0.065(2) 0.010(2) 0.0221(19) 0.026(2)
C34 0.058(2) 0.176(4) 0.059(2) 0.009(3) 0.0216(18) 0.011(3)
C35 0.069(2) 0.152(4) 0.062(2) 0.007(2) 0.0265(19) -0.025(3)
C36 0.068(2) 0.097(3) 0.057(2) 0.0089(18) 0.0235(16) -0.0096(19)
C37 0.0516(18) 0.0454(17) 0.0533(18) 0.0006(14) 0.0043(15) 0.0113(13)
C38 0.0604(18) 0.070(2) 0.073(2) -0.0057(17) 0.0248(16) -0.0097(16)
C39 0.0569(19) 0.082(2) 0.069(2) -0.0101(18) 0.0193(16) -0.0185(17)
C40 0.070(2) 0.088(3) 0.091(3) -0.006(2) 0.0205(19) -0.013(2)

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;
 All esds (except the esd in the dihedral angle between two l.s. planes)
 are estimated using the full covariance matrix.  The cell esds are taken
 into account individually in the estimation of esds in distances, angles
 and torsion angles; correlations between esds in cell parameters are
only
 used when they are defined by crystal symmetry.  An approximate
(isotropic)
 treatment of cell esds is used for estimating esds involving l.s.
planes.
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C3 C4 1.534(4) . ?
C4 C5 1.486(4) . ?
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C7 C17 1.506(4) . ?
C7 C8 1.537(3) . ?
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C9 C10 1.510(4) . ?
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N2 C31 1.433(3) . ?
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C31 C36 1.371(4) . ?
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C39 C40 1.282(4) . ?

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C25 C24 C23 112.2(2) . . ?
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SYMM 0.5-X, 0.5+Y, 0.5-Z
SFAC C  H  N  O
UNIT 160  152  8  24
L.S. 25
ACTA
CONF
BOND
FMAP 2
PLAN 5
SIZE 0.07 0.09 0.23
TEMP 23.0C

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O1    4    0.905754    0.064719    0.771441    11.00000    0.07569
0.06476 =
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O2    4    0.777253    0.550418    0.791026    11.00000    0.08316
0.10711 =
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C2    1    0.862990    0.104231    0.851698    11.00000    0.05336
0.04311 =
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AFIX  13
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AFIX   0
C3    1    0.925218    0.135985    0.909457    11.00000    0.04814
0.04996 =
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AFIX  13
H3A   2    0.950128    0.013460    0.916970    11.00000   -1.20000
AFIX   0
C4    1    0.966548    0.309377    0.904865    11.00000    0.04429
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         0.05319   -0.00261    0.01926   -0.00331
AFIX  43
H6A   2    0.886144    0.656798    0.942991    11.00000   -1.20000
AFIX   0
C7    1    0.869510    0.358481    0.959184    11.00000    0.05599
0.05369 =
         0.04039    0.00720    0.01273    0.00318
C8    1    0.804758    0.308181    0.908306    11.00000    0.05044
0.07715 =
         0.04996    0.00645    0.01612    0.00519
AFIX  23
H8A   2    0.784942    0.206269    0.924017    11.00000   -1.20000
H8B   2    0.778257    0.425607    0.899754    11.00000   -1.20000
AFIX   0
C9    1    0.807765    0.236462    0.848032    11.00000    0.03907
0.06721 =
         0.04994   -0.00320    0.01176   -0.00513
AFIX  13
H9A   2    0.769656    0.156486    0.827460    11.00000   -1.20000
AFIX   0
C10   1    0.806320    0.395703    0.801777    11.00000    0.04330
0.07676 =
         0.04746   -0.00622    0.01087    0.00787
C11   1    0.845209    0.429395    0.715687    11.00000    0.04358
0.06025 =
         0.04627   -0.00653    0.01826    0.00229
C12   1    0.820027    0.337379    0.658457    11.00000    0.06222
0.07320 =
         0.05908   -0.01706    0.02198   -0.01171
AFIX  43
H12A  2    0.801624    0.212347    0.654475    11.00000   -1.20000
AFIX   0
C13   1    0.822490    0.433624    0.606924    11.00000    0.07071
0.10417 =
         0.05145   -0.01551    0.02195    0.00117
AFIX  43
H13A  2    0.806068    0.372345    0.568048    11.00000   -1.20000
AFIX   0
C14   1    0.848929    0.618313    0.612824    11.00000    0.06544
0.09507 =
         0.06642    0.00616    0.03434    0.00765
AFIX  43
H14A  2    0.850553    0.682511    0.578074    11.00000   -1.20000
AFIX   0
C15   1    0.873029    0.708558    0.670089    11.00000    0.07705
0.07076 =
         0.08235   -0.00643    0.03917   -0.00817
AFIX  43
H15A  2    0.890817    0.834559    0.674155    11.00000   -1.20000
AFIX   0
```

```
C16   1    0.870997    0.613546    0.721474    11.00000    0.06469
0.07015 =
         0.05693   -0.00945    0.02413   -0.00753
AFIX  43
H16A  2    0.887292    0.675330    0.760273    11.00000   -1.20000
AFIX   0
C17   1    0.910071    0.177289    0.965685    11.00000    0.04841
0.05839 =
         0.05509    0.01201    0.00448   -0.00222
C18   1    0.862707    0.404432    1.021183    11.00000    0.09174
0.08412 =
         0.04904    0.00938    0.02426    0.00366
AFIX  23
H18A  2    0.850311    0.283564    1.036145    11.00000   -1.20000
H18B  2    0.903635    0.443648    1.051770    11.00000   -1.20000
AFIX   0
C19   1    0.815075    0.566943    1.017227    11.00000    0.17018
0.09667 =
         0.05868   -0.00896    0.03431    0.01044
AFIX  43
H19A  2    0.772804    0.531191    0.997926    11.00000   -1.20000
AFIX   0
C20   1    0.824923    0.732892    1.035553    11.00000    0.15460
0.17832 =
         0.07756   -0.01483    0.03941    0.02601
AFIX  93
H20A  2    0.866210    0.777906    1.055291    11.00000   -1.20000
H20B  2    0.791363    0.818095    1.030195    11.00000   -1.20000
AFIX   0
N2    3    0.742380    1.008872    0.150696    11.00000    0.05321
0.05633 =
         0.03582    0.00244    0.01445   -0.00083
O4    4    0.716786    1.119836    0.050104    11.00000    0.08126
0.08671 =
         0.04738    0.01518    0.02471    0.00171
O5    4    0.736329    0.904538    0.242740    11.00000    0.06313
0.06569 =
         0.03856   -0.00077    0.01187   -0.00882
O6    4    0.495774    0.778611    0.027239    11.00000    0.05367
0.08179 =
         0.07388    0.01280   -0.00552    0.00584
C21   1    0.700456    1.066952    0.091145    11.00000    0.06764
0.04769 =
         0.04207    0.00251    0.01575    0.00439
C22   1    0.634431    1.041740    0.088031    11.00000    0.05545
0.04675 =
         0.04714    0.00808    0.01276    0.01266
AFIX  13
H22A  2    0.610008    1.161283    0.069452    11.00000   -1.20000
AFIX   0
C23   1    0.602718    0.859062    0.046454    11.00000    0.05915
0.05730 =
         0.03560    0.00207    0.00757    0.00459
AFIX  13
```

```
H23A  2    0.584761    0.901677    0.002738    11.00000   -1.20000
AFIX   0
C24   1    0.646558    0.680415    0.052497    11.00000    0.06844
0.05618 =
         0.05969   -0.01366    0.02491   -0.00014
AFIX  23
H24A  2    0.626454    0.590372    0.017841    11.00000   -1.20000
H24B  2    0.685484    0.727040    0.050130    11.00000   -1.20000
AFIX   0
C25   1    0.661582    0.570856    0.112113    11.00000    0.05398
0.04020 =
         0.05754   -0.00738    0.01121    0.00714
AFIX  43
H25A  2    0.696375    0.486578    0.125717    11.00000   -1.20000
AFIX   0
C26   1    0.628081    0.587551    0.146356    11.00000    0.05625
0.03916 =
         0.04657   -0.00301    0.00710   -0.00015
AFIX  43
H26A  2    0.639988    0.511465    0.182497    11.00000   -1.20000
AFIX   0
C27   1    0.571891    0.720955    0.131203    11.00000    0.04718
0.04666 =
         0.04885   -0.00344    0.01321    0.00173
C28   1    0.594547    0.909985    0.171451    11.00000    0.05955
0.05107 =
         0.05948   -0.00498    0.02445    0.00535
AFIX  23
H28A  2    0.558336    0.993961    0.165359    11.00000   -1.20000
H28B  2    0.612766    0.871833    0.215081    11.00000   -1.20000
AFIX   0
C29   1    0.643050    1.029435    0.156446    11.00000    0.06116
0.03565 =
         0.05019   -0.00518    0.01982    0.00512
AFIX  13
H29A  2    0.640107    1.166120    0.169619    11.00000   -1.20000
AFIX   0
C30   1    0.710970    0.967630    0.190409    11.00000    0.05975
0.04042 =
         0.03880   -0.00385    0.01214   -0.00482
C31   1    0.808871    0.984949    0.167369    11.00000    0.05112
0.07373 =
         0.03666    0.00015    0.01439   -0.00134
C32   1    0.836719    0.804956    0.189401    11.00000    0.06506
0.08374 =
         0.05205    0.00573    0.01891    0.00922
AFIX  43
H32A  2    0.812962    0.700719    0.195144    11.00000   -1.20000
AFIX   0
C33   1    0.900135    0.780024    0.202930    11.00000    0.07225
0.12266 =
         0.06500    0.00984    0.02212    0.02604
AFIX  43
H33A  2    0.919494    0.659141    0.218430    11.00000   -1.20000
```

```
AFIX   0
C34   1    0.934723    0.933272    0.193561    11.00000    0.05793
0.17631 =
         0.05916    0.00910    0.02158    0.01137
AFIX  43
H34A  2    0.977359    0.915293    0.201972    11.00000   -1.20000
AFIX   0
C35   1    0.906741    1.112755    0.171864    11.00000    0.06898
0.15159 =
         0.06216    0.00653    0.02651   -0.02541
AFIX  43
H35A  2    0.930526    1.216529    0.165901    11.00000   -1.20000
AFIX   0
C36   1    0.843172    1.140426    0.158759    11.00000    0.06782
0.09661 =
         0.05712    0.00886    0.02352   -0.00956
AFIX  43
H36A  2    0.824068    1.262454    0.144357    11.00000   -1.20000
AFIX   0
C37   1    0.550304    0.785807    0.063996    11.00000    0.05155
0.04543 =
         0.05328    0.00065    0.00433    0.01130
C38   1    0.518101    0.626606    0.144668    11.00000    0.06044
0.06984 =
         0.07269   -0.00572    0.02485   -0.00967
AFIX  23
H38A  2    0.531870    0.609072    0.189402    11.00000   -1.20000
H38B  2    0.482696    0.718012    0.131431    11.00000   -1.20000
AFIX   0
C39   1    0.495745    0.430131    0.113584    11.00000    0.05691
0.08212 =
         0.06917   -0.01009    0.01926   -0.01848
AFIX  43
H39A  2    0.502071    0.403842    0.077192    11.00000   -1.20000
AFIX   0
C40   1    0.468578    0.295506    0.133275    11.00000    0.07003
0.08843 =
         0.09115   -0.00604    0.02046   -0.01321
AFIX  93
H40A  2    0.461424    0.316311    0.169507    11.00000   -1.20000
H40B  2    0.456022    0.177024    0.111328    11.00000   -1.20000
HKLF 4

REM  lb016 in P2(1)/n
REM R1 =  0.0423 for   2863 Fo > 4sig(Fo)  and  0.0701 for all   4012
data
REM    434 parameters refined using      0 restraints

END

WGHT      0.0485      0.7253
REM Highest difference peak  0.348,  deepest hole -0.163,  1-sigma level
0.030
Q1    1   0.7819  0.6164  1.0381  11.00000  0.05    0.35
```

```
Q2    1   0.8622  0.6241  1.0329  11.00000  0.05    0.26
Q3    1   0.8941  0.4562  0.7926  11.00000  0.05    0.17
Q4    1   0.8232  0.6659  0.8058  11.00000  0.05    0.15
Q5    1   0.8031  0.5146  0.9991  11.00000  0.05    0.15
```

Table 1. Crystal data and structure refinement for lb016.

Identification code	lb016
Empirical formula	C40 H38 N2 O6
Formula weight	642.72
Temperature	296(2) K
Wavelength	0.71073 A
Crystal system, space group	Monoclinic, P2(1)/n
Unit cell dimensions	a = 22.9943(4) A alpha = 90 deg. b = 6.72840(10) A beta = 112.8790(10) deg. c = 23.2627(4) A gamma = 90 deg.
Volume	3315.94(9) A^3
Z, Calculated density	4, 1.287 Mg/m^3
Absorption coefficient	0.087 mm^-1
F(000)	1360
Crystal size	0.23 x 0.09 x 0.07 mm
Theta range for data collection	1.90 to 22.01 deg.
Limiting indices	-24<=h<=24, -7<=k<=7, -24<=l<=22
Reflections collected / unique	28901 / 4012 [R(int) = 0.0679]
Completeness to theta = 22.01	98.6 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9940 and 0.9804
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4012 / 0 / 434
Goodness-of-fit on F^2	1.014
Final R indices [I>2sigma(I)]	R1 = 0.0423, wR2 = 0.0946
R indices (all data)	R1 = 0.0701, wR2 = 0.1064

Extinction coefficient	0.0054(5)
Largest diff. peak and hole	0.348 and -0.163 e.A^-3

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for lb016.
U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
N(1)	8423(1)	3307(3)	7693(1)	50(1)
O(1)	9058(1)	647(3)	7714(1)	75(1)
O(2)	7772(1)	5504(4)	7910(1)	82(1)
O(3)	9292(1)	730(3)	10119(1)	90(1)
C(1)	8734(1)	1538(4)	7933(1)	55(1)
C(2)	8630(1)	1042(4)	8517(1)	53(1)
C(3)	9252(1)	1360(4)	9095(1)	58(1)
C(4)	9666(1)	3094(4)	9049(1)	65(1)
C(5)	9414(1)	5054(4)	9137(1)	63(1)
C(6)	8987(1)	5284(4)	9384(1)	60(1)
C(7)	8695(1)	3585(4)	9592(1)	52(1)
C(8)	8048(1)	3082(4)	9083(1)	60(1)
C(9)	8078(1)	2365(4)	8480(1)	54(1)
C(10)	8063(1)	3957(5)	8018(1)	58(1)
C(11)	8452(1)	4294(4)	7157(1)	50(1)
C(12)	8200(1)	3374(5)	6585(1)	65(1)
C(13)	8225(1)	4336(6)	6069(2)	76(1)
C(14)	8489(1)	6183(6)	6128(2)	73(1)
C(15)	8730(1)	7086(5)	6701(2)	74(1)
C(16)	8710(1)	6135(5)	7215(1)	64(1)
C(17)	9101(1)	1773(4)	9657(1)	59(1)
C(18)	8627(2)	4044(5)	10212(1)	76(1)
C(19)	8151(2)	5669(7)	10172(2)	112(2)
C(20)	8249(2)	7329(9)	10356(2)	139(2)
N(2)	7424(1)	10089(3)	1507(1)	49(1)
O(4)	7168(1)	11198(3)	501(1)	72(1)
O(5)	7363(1)	9045(3)	2427(1)	58(1)
O(6)	4958(1)	7786(3)	272(1)	79(1)
C(21)	7005(1)	10670(4)	911(1)	54(1)
C(22)	6344(1)	10417(4)	880(1)	52(1)
C(23)	6027(1)	8591(4)	464(1)	54(1)
C(24)	6466(1)	6804(4)	525(1)	61(1)
C(25)	6616(1)	5709(4)	1121(1)	54(1)
C(26)	6281(1)	5876(4)	1464(1)	51(1)
C(27)	5719(1)	7210(4)	1312(1)	49(1)
C(28)	5946(1)	9100(4)	1714(1)	56(1)
C(29)	6430(1)	10294(4)	1564(1)	50(1)
C(30)	7110(1)	9676(4)	1904(1)	48(1)
C(31)	8089(1)	9849(5)	1674(1)	55(1)
C(32)	8367(1)	8050(5)	1894(1)	68(1)
C(33)	9001(2)	7800(6)	2029(1)	88(1)
C(34)	9347(2)	9333(8)	1936(2)	98(1)
C(35)	9067(2)	11128(7)	1719(2)	94(1)

C(36)	8432(2)	11404(5)	1588(1)	74(1)
C(37)	5503(1)	7858(4)	640(1)	55(1)
C(38)	5181(1)	6266(4)	1447(1)	68(1)
C(39)	4957(1)	4301(5)	1136(1)	71(1)
C(40)	4686(1)	2955(5)	1333(2)	86(1)

Table 3. Bond lengths [A] and angles [deg] for lb016.

N(1)-C(1)	1.389(3)
N(1)-C(10)	1.391(3)
N(1)-C(11)	1.437(3)
O(1)-C(1)	1.209(3)
O(2)-C(10)	1.210(3)
O(3)-C(17)	1.215(3)
C(1)-C(2)	1.507(4)
C(2)-C(9)	1.526(3)
C(2)-C(3)	1.550(3)
C(3)-C(17)	1.505(4)
C(3)-C(4)	1.534(4)
C(4)-C(5)	1.486(4)
C(5)-C(6)	1.325(4)
C(6)-C(7)	1.498(4)
C(7)-C(17)	1.506(4)
C(7)-C(8)	1.537(3)
C(7)-C(18)	1.541(4)
C(8)-C(9)	1.510(3)
C(9)-C(10)	1.510(4)
C(11)-C(16)	1.358(4)
C(11)-C(12)	1.375(4)
C(12)-C(13)	1.383(4)
C(13)-C(14)	1.367(4)
C(14)-C(15)	1.370(4)
C(15)-C(16)	1.372(4)
C(18)-C(19)	1.525(5)
C(19)-C(20)	1.185(5)
N(2)-C(21)	1.401(3)
N(2)-C(30)	1.404(3)
N(2)-C(31)	1.433(3)
O(4)-C(21)	1.207(3)
O(5)-C(30)	1.204(3)
O(6)-C(37)	1.213(3)
C(21)-C(22)	1.501(4)
C(22)-C(29)	1.528(3)
C(22)-C(23)	1.559(3)
C(23)-C(37)	1.498(4)
C(23)-C(24)	1.540(3)
C(24)-C(25)	1.488(4)
C(25)-C(26)	1.311(3)
C(26)-C(27)	1.498(3)
C(27)-C(37)	1.509(4)
C(27)-C(38)	1.527(4)
C(27)-C(28)	1.545(3)
C(28)-C(29)	1.521(3)
C(29)-C(30)	1.509(3)
C(31)-C(32)	1.373(4)
C(31)-C(36)	1.371(4)
C(32)-C(33)	1.377(4)
C(33)-C(34)	1.370(5)

C(34)-C(35)	1.369(5)
C(35)-C(36)	1.385(4)
C(38)-C(39)	1.499(4)
C(39)-C(40)	1.282(4)
C(1)-N(1)-C(10)	111.9(2)
C(1)-N(1)-C(11)	123.7(2)
C(10)-N(1)-C(11)	124.3(2)
O(1)-C(1)-N(1)	124.1(3)
O(1)-C(1)-C(2)	127.5(3)
N(1)-C(1)-C(2)	108.3(2)
C(1)-C(2)-C(9)	104.0(2)
C(1)-C(2)-C(3)	109.5(2)
C(9)-C(2)-C(3)	115.8(2)
C(17)-C(3)-C(4)	106.2(2)
C(17)-C(3)-C(2)	109.3(2)
C(4)-C(3)-C(2)	115.6(2)
C(5)-C(4)-C(3)	112.3(2)
C(6)-C(5)-C(4)	123.9(3)
C(5)-C(6)-C(7)	123.4(3)
C(6)-C(7)-C(17)	108.2(2)
C(6)-C(7)-C(8)	109.9(2)
C(17)-C(7)-C(8)	106.0(2)
C(6)-C(7)-C(18)	111.7(2)
C(17)-C(7)-C(18)	110.6(2)
C(8)-C(7)-C(18)	110.1(2)
C(9)-C(8)-C(7)	113.9(2)
C(8)-C(9)-C(10)	116.0(2)
C(8)-C(9)-C(2)	118.2(2)
C(10)-C(9)-C(2)	103.9(2)
O(2)-C(10)-N(1)	123.8(3)
O(2)-C(10)-C(9)	128.0(3)
N(1)-C(10)-C(9)	108.1(2)
C(16)-C(11)-C(12)	120.7(3)
C(16)-C(11)-N(1)	120.1(2)
C(12)-C(11)-N(1)	119.2(3)
C(11)-C(12)-C(13)	119.0(3)
C(14)-C(13)-C(12)	120.3(3)
C(13)-C(14)-C(15)	119.8(3)
C(14)-C(15)-C(16)	120.2(3)
C(11)-C(16)-C(15)	120.0(3)
O(3)-C(17)-C(3)	122.5(3)
O(3)-C(17)-C(7)	123.6(3)
C(3)-C(17)-C(7)	113.9(2)
C(19)-C(18)-C(7)	114.8(3)
C(20)-C(19)-C(18)	128.4(5)
C(21)-N(2)-C(30)	111.9(2)
C(21)-N(2)-C(31)	123.4(2)
C(30)-N(2)-C(31)	124.6(2)
O(4)-C(21)-N(2)	123.9(3)
O(4)-C(21)-C(22)	127.9(2)
N(2)-C(21)-C(22)	108.1(2)
C(21)-C(22)-C(29)	103.7(2)
C(21)-C(22)-C(23)	109.8(2)

C(29)-C(22)-C(23)	116.3(2)
C(37)-C(23)-C(24)	106.6(2)
C(37)-C(23)-C(22)	108.8(2)
C(24)-C(23)-C(22)	115.3(2)
C(25)-C(24)-C(23)	112.2(2)
C(26)-C(25)-C(24)	123.1(2)
C(25)-C(26)-C(27)	124.4(3)
C(26)-C(27)-C(37)	108.9(2)
C(26)-C(27)-C(38)	113.3(2)
C(37)-C(27)-C(38)	111.5(2)
C(26)-C(27)-C(28)	107.1(2)
C(37)-C(27)-C(28)	106.7(2)
C(38)-C(27)-C(28)	109.1(2)
C(29)-C(28)-C(27)	113.6(2)
C(30)-C(29)-C(28)	115.9(2)
C(30)-C(29)-C(22)	104.4(2)
C(28)-C(29)-C(22)	117.3(2)
O(5)-C(30)-N(2)	124.3(2)
O(5)-C(30)-C(29)	128.5(3)
N(2)-C(30)-C(29)	107.1(2)
C(32)-C(31)-C(36)	121.1(3)
C(32)-C(31)-N(2)	119.6(3)
C(36)-C(31)-N(2)	119.3(3)
C(31)-C(32)-C(33)	119.4(3)
C(34)-C(33)-C(32)	120.0(4)
C(35)-C(34)-C(33)	120.2(3)
C(34)-C(35)-C(36)	120.3(4)
C(31)-C(36)-C(35)	118.9(3)
O(6)-C(37)-C(23)	122.8(3)
O(6)-C(37)-C(27)	123.5(3)
C(23)-C(37)-C(27)	113.7(2)
C(39)-C(38)-C(27)	114.9(2)
C(40)-C(39)-C(38)	125.1(3)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (A^2 x 10^3) for lb016.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
N(1)	44(1)	57(2)	48(1)	-8(1)	15(1)	3(1)
O(1)	76(1)	65(1)	86(2)	-17(1)	34(1)	13(1)
O(2)	83(2)	107(2)	59(1)	18(1)	31(1)	53(1)
O(3)	86(2)	96(2)	82(2)	46(1)	26(1)	25(1)
C(1)	45(2)	50(2)	65(2)	-16(2)	15(2)	-2(1)
C(2)	53(2)	43(2)	59(2)	-5(1)	17(1)	-6(1)
C(3)	48(2)	50(2)	65(2)	5(2)	10(1)	11(1)
C(4)	44(2)	75(2)	67(2)	-6(2)	13(1)	-7(2)
C(5)	66(2)	58(2)	54(2)	-2(2)	12(2)	-16(2)
C(6)	71(2)	52(2)	53(2)	-3(1)	19(2)	-3(2)
C(7)	56(2)	54(2)	40(2)	7(1)	13(1)	3(1)
C(8)	50(2)	77(2)	50(2)	6(2)	16(1)	5(2)
C(9)	39(2)	67(2)	50(2)	-3(2)	12(1)	-5(1)
C(10)	43(2)	77(2)	48(2)	-6(2)	11(1)	8(2)
C(11)	44(2)	60(2)	46(2)	-6(2)	18(1)	2(1)
C(12)	62(2)	73(2)	59(2)	-17(2)	22(2)	-12(2)
C(13)	71(2)	104(3)	51(2)	-16(2)	22(2)	1(2)
C(14)	65(2)	95(3)	66(2)	6(2)	34(2)	8(2)
C(15)	77(2)	71(2)	82(3)	-6(2)	39(2)	-8(2)
C(16)	65(2)	70(2)	57(2)	-9(2)	24(2)	-8(2)
C(17)	48(2)	58(2)	55(2)	12(2)	4(1)	-2(1)
C(18)	92(2)	84(2)	49(2)	9(2)	24(2)	4(2)
C(19)	170(4)	97(3)	59(3)	-9(2)	34(3)	10(3)
C(20)	155(4)	178(5)	78(3)	-15(3)	39(3)	26(4)
N(2)	53(1)	56(1)	36(1)	2(1)	14(1)	-1(1)
O(4)	81(1)	87(2)	47(1)	15(1)	25(1)	2(1)
O(5)	63(1)	66(1)	39(1)	-1(1)	12(1)	-9(1)
O(6)	54(1)	82(2)	74(1)	13(1)	-6(1)	6(1)
C(21)	68(2)	48(2)	42(2)	2(1)	16(2)	4(1)
C(22)	55(2)	47(2)	47(2)	8(1)	13(1)	13(1)
C(23)	59(2)	57(2)	36(2)	2(1)	8(1)	5(1)
C(24)	68(2)	56(2)	60(2)	-14(2)	25(2)	0(2)
C(25)	54(2)	40(2)	58(2)	-7(1)	11(2)	7(1)
C(26)	56(2)	39(2)	47(2)	-3(1)	7(1)	0(1)
C(27)	47(2)	47(2)	49(2)	-3(1)	13(1)	2(1)
C(28)	60(2)	51(2)	60(2)	-5(2)	24(1)	5(1)
C(29)	61(2)	36(2)	50(2)	-5(1)	20(1)	5(1)
C(30)	60(2)	40(2)	39(2)	-4(1)	12(1)	-5(1)
C(31)	51(2)	74(2)	37(2)	0(2)	14(1)	-1(2)
C(32)	65(2)	84(2)	52(2)	6(2)	19(2)	9(2)
C(33)	72(2)	123(3)	65(2)	10(2)	22(2)	26(2)
C(34)	58(2)	176(4)	59(2)	9(3)	22(2)	11(3)

C(35)	69(2)	152(4)	62(2)	7(2)	26(2)	-25(3)
C(36)	68(2)	97(3)	57(2)	9(2)	24(2)	-10(2)
C(37)	52(2)	45(2)	53(2)	1(1)	4(2)	11(1)
C(38)	60(2)	70(2)	73(2)	-6(2)	25(2)	-10(2)
C(39)	57(2)	82(2)	69(2)	-10(2)	19(2)	-18(2)
C(40)	70(2)	88(3)	91(3)	-6(2)	20(2)	-13(2)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for lb016.

	x	y	z	U(eq)
H(2A)	8503	-353	8501	64
H(3A)	9501	135	9170	69
H(4A)	10089	2929	9363	77
H(4B)	9692	3065	8643	77
H(5A)	9565	6186	9012	75
H(6A)	8861	6568	9430	72
H(8A)	7849	2063	9240	72
H(8B)	7783	4256	8998	72
H(9A)	7697	1565	8275	65
H(12A)	8016	2123	6545	78
H(13A)	8061	3723	5680	91
H(14A)	8506	6825	5781	88
H(15A)	8908	8346	6742	89
H(16A)	8873	6753	7603	77
H(18A)	8503	2836	10361	91
H(18B)	9036	4436	10518	91
H(19A)	7728	5312	9979	134
H(20A)	8662	7779	10553	166
H(20B)	7914	8181	10302	166
H(22A)	6100	11613	695	62
H(23A)	5848	9017	27	65
H(24A)	6265	5904	178	74
H(24B)	6855	7270	501	74
H(25A)	6964	4866	1257	65
H(26A)	6400	5115	1825	62
H(28A)	5583	9940	1654	68
H(28B)	6128	8718	2151	68
H(29A)	6401	11661	1696	59
H(32A)	8130	7007	1951	82
H(33A)	9195	6591	2184	106
H(34A)	9774	9153	2020	118
H(35A)	9305	12165	1659	113
H(36A)	8241	12625	1444	89
H(38A)	5319	6091	1894	82
H(38B)	4827	7180	1314	82
H(39A)	5021	4038	772	85
H(40A)	4614	3163	1695	104
H(40B)	4560	1770	1113	104

Table 6. Torsion angles [deg] for lb016.

C(10)-N(1)-C(1)-O(1)	177.3(2)
C(11)-N(1)-C(1)-O(1)	-0.3(4)
C(10)-N(1)-C(1)-C(2)	-6.3(3)
C(11)-N(1)-C(1)-C(2)	176.1(2)
O(1)-C(1)-C(2)-C(9)	-167.7(3)
N(1)-C(1)-C(2)-C(9)	16.0(3)
O(1)-C(1)-C(2)-C(3)	67.9(3)
N(1)-C(1)-C(2)-C(3)	-108.4(2)
C(1)-C(2)-C(3)-C(17)	154.8(2)
C(9)-C(2)-C(3)-C(17)	37.6(3)
C(1)-C(2)-C(3)-C(4)	35.0(3)
C(9)-C(2)-C(3)-C(4)	-82.1(3)
C(17)-C(3)-C(4)-C(5)	-45.3(3)
C(2)-C(3)-C(4)-C(5)	76.2(3)
C(3)-C(4)-C(5)-C(6)	16.4(4)
C(4)-C(5)-C(6)-C(7)	-1.3(4)
C(5)-C(6)-C(7)-C(17)	17.1(4)
C(5)-C(6)-C(7)-C(8)	-98.2(3)
C(5)-C(6)-C(7)-C(18)	139.1(3)
C(6)-C(7)-C(8)-C(9)	63.6(3)
C(17)-C(7)-C(8)-C(9)	-53.1(3)
C(18)-C(7)-C(8)-C(9)	-172.9(2)
C(7)-C(8)-C(9)-C(10)	-87.3(3)
C(7)-C(8)-C(9)-C(2)	37.2(3)
C(1)-C(2)-C(9)-C(8)	-149.1(2)
C(3)-C(2)-C(9)-C(8)	-28.9(3)
C(1)-C(2)-C(9)-C(10)	-18.8(3)
C(3)-C(2)-C(9)-C(10)	101.4(3)
C(1)-N(1)-C(10)-O(2)	176.7(3)
C(11)-N(1)-C(10)-O(2)	-5.7(4)
C(1)-N(1)-C(10)-C(9)	-6.4(3)
C(11)-N(1)-C(10)-C(9)	171.2(2)
C(8)-C(9)-C(10)-O(2)	-35.8(4)
C(2)-C(9)-C(10)-O(2)	-167.3(3)
C(8)-C(9)-C(10)-N(1)	147.5(2)
C(2)-C(9)-C(10)-N(1)	16.0(3)
C(1)-N(1)-C(11)-C(16)	-117.0(3)
C(10)-N(1)-C(11)-C(16)	65.7(3)
C(1)-N(1)-C(11)-C(12)	64.7(3)
C(10)-N(1)-C(11)-C(12)	-112.6(3)
C(16)-C(11)-C(12)-C(13)	1.3(4)
N(1)-C(11)-C(12)-C(13)	179.5(2)
C(11)-C(12)-C(13)-C(14)	-0.7(4)
C(12)-C(13)-C(14)-C(15)	-0.1(4)
C(13)-C(14)-C(15)-C(16)	0.4(4)
C(12)-C(11)-C(16)-C(15)	-1.0(4)
N(1)-C(11)-C(16)-C(15)	-179.2(2)
C(14)-C(15)-C(16)-C(11)	0.2(4)
C(4)-C(3)-C(17)-O(3)	-114.1(3)
C(2)-C(3)-C(17)-O(3)	120.5(3)

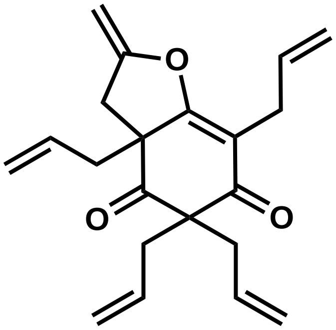
C(4)-C(3)-C(17)-C(7)	65.8(3)
C(2)-C(3)-C(17)-C(7)	-59.6(3)
C(6)-C(7)-C(17)-O(3)	129.3(3)
C(8)-C(7)-C(17)-O(3)	-112.8(3)
C(18)-C(7)-C(17)-O(3)	6.6(4)
C(6)-C(7)-C(17)-C(3)	-50.6(3)
C(8)-C(7)-C(17)-C(3)	67.3(3)
C(18)-C(7)-C(17)-C(3)	-173.3(2)
C(6)-C(7)-C(18)-C(19)	67.6(4)
C(17)-C(7)-C(18)-C(19)	-171.7(3)
C(8)-C(7)-C(18)-C(19)	-54.8(4)
C(7)-C(18)-C(19)-C(20)	-105.5(5)
C(30)-N(2)-C(21)-O(4)	176.0(3)
C(31)-N(2)-C(21)-O(4)	-7.1(4)
C(30)-N(2)-C(21)-C(22)	-6.6(3)
C(31)-N(2)-C(21)-C(22)	170.3(2)
O(4)-C(21)-C(22)-C(29)	-164.9(3)
N(2)-C(21)-C(22)-C(29)	17.8(3)
O(4)-C(21)-C(22)-C(23)	70.1(3)
N(2)-C(21)-C(22)-C(23)	-107.2(2)
C(21)-C(22)-C(23)-C(37)	157.1(2)
C(29)-C(22)-C(23)-C(37)	39.8(3)
C(21)-C(22)-C(23)-C(24)	37.4(3)
C(29)-C(22)-C(23)-C(24)	-79.9(3)
C(37)-C(23)-C(24)-C(25)	-47.0(3)
C(22)-C(23)-C(24)-C(25)	73.9(3)
C(23)-C(24)-C(25)-C(26)	18.3(4)
C(24)-C(25)-C(26)-C(27)	-1.6(4)
C(25)-C(26)-C(27)-C(37)	15.3(3)
C(25)-C(26)-C(27)-C(38)	139.9(3)
C(25)-C(26)-C(27)-C(28)	-99.7(3)
C(26)-C(27)-C(28)-C(29)	63.6(3)
C(37)-C(27)-C(28)-C(29)	-52.8(3)
C(38)-C(27)-C(28)-C(29)	-173.4(2)
C(27)-C(28)-C(29)-C(30)	-86.7(3)
C(27)-C(28)-C(29)-C(22)	37.4(3)
C(21)-C(22)-C(29)-C(30)	-21.7(3)
C(23)-C(22)-C(29)-C(30)	99.0(2)
C(21)-C(22)-C(29)-C(28)	-151.4(2)
C(23)-C(22)-C(29)-C(28)	-30.7(3)
C(21)-N(2)-C(30)-O(5)	175.7(2)
C(31)-N(2)-C(30)-O(5)	-1.2(4)
C(21)-N(2)-C(30)-C(29)	-7.8(3)
C(31)-N(2)-C(30)-C(29)	175.3(2)
C(28)-C(29)-C(30)-O(5)	-34.6(4)
C(22)-C(29)-C(30)-O(5)	-165.2(2)
C(28)-C(29)-C(30)-N(2)	149.1(2)
C(22)-C(29)-C(30)-N(2)	18.5(3)
C(21)-N(2)-C(31)-C(32)	-122.0(3)
C(30)-N(2)-C(31)-C(32)	54.5(3)
C(21)-N(2)-C(31)-C(36)	55.5(4)
C(30)-N(2)-C(31)-C(36)	-128.0(3)
C(36)-C(31)-C(32)-C(33)	-0.2(4)
N(2)-C(31)-C(32)-C(33)	177.3(2)

C(31)-C(32)-C(33)-C(34)	-0.9(5)
C(32)-C(33)-C(34)-C(35)	1.2(5)
C(33)-C(34)-C(35)-C(36)	-0.5(5)
C(32)-C(31)-C(36)-C(35)	0.9(4)
N(2)-C(31)-C(36)-C(35)	-176.6(2)
C(34)-C(35)-C(36)-C(31)	-0.6(5)
C(24)-C(23)-C(37)-O(6)	-114.9(3)
C(22)-C(23)-C(37)-O(6)	120.2(3)
C(24)-C(23)-C(37)-C(27)	64.7(3)
C(22)-C(23)-C(37)-C(27)	-60.2(3)
C(26)-C(27)-C(37)-O(6)	131.6(3)
C(38)-C(27)-C(37)-O(6)	5.9(4)
C(28)-C(27)-C(37)-O(6)	-113.1(3)
C(26)-C(27)-C(37)-C(23)	-48.0(3)
C(38)-C(27)-C(37)-C(23)	-173.7(2)
C(28)-C(27)-C(37)-C(23)	67.3(3)
C(26)-C(27)-C(38)-C(39)	-54.9(3)
C(37)-C(27)-C(38)-C(39)	68.3(3)
C(28)-C(27)-C(38)-C(39)	-174.1(2)
C(27)-C(38)-C(39)-C(40)	154.7(3)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for lb016 [A and deg.].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)


O
O
O

checkCIF/PLATON report

Structure factors have been supplied for datablock(s) lb062

No syntax errors found.   CIF dictionary   Interpreting this report

Datablock: lb062

```
Bond precision:  C-C = 0.0016 A          Wavelength=0.71073

Cell:            a=8.3690(4)     b=20.3386(9)       c=10.5092(5)
                 alpha=90        beta=94.902(2)     gamma=90
Temperature:     200 K

                Calculated                  Reported
Volume          1782.27(14)                 1782.27(14)
Space group     P 21/c                      P2(1)/c
Hall group      -P 2ybc                     ?
Moiety formula  C21 H22 O3                  ?
Sum formula     C21 H22 O3                  C21 H22 O3
Mr              322.39                      322.39
Dx,g cm-3       1.202                       1.201
Z               4                           4
Mu (mm-1)       0.079                       0.079
F000            688.0                       688.0
F000’           688.33
h,k,lmax        11,27,14                    11,27,14
Nref            4443                        4373
Tmin,Tmax       0.975,0.980                 0.975,0.980
Tmin’           0.975

Correction method= MULTI-SCAN

Data completeness= 0.984          Theta(max)= 28.350

R(reflections)= 0.0397( 3751)     wR2(reflections)= 0.1135( 4373)

S = 1.033                   Npar= 217
```

The following ALERTS were generated. Each ALERT has the format
       test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level B

```
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C10    --  C11     ..        8.3 su
```

Alert level C

```
PLAT230_ALERT_2_C Hirshfeld Test Diff for    C14    --  C15     ..        6.0 su
PLAT910_ALERT_3_C Missing # of FCF Reflections Below Th(Min) .....          1
PLAT911_ALERT_3_C Missing # FCF Refl Between THmin & STh/L=  0.600         50
PLAT912_ALERT_4_C Missing # of FCF Reflections Above STh/L=  0.600         20
```

Alert level G

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HYDTR01_ALERT_1_G  Extra text has been found in the _refine_ls_hydrogen_treatment fi
            Explanatory text should be in the _publ_section_refinement field.
            Hydrogen treatment given as constrsw
            Hydrogen treatment identified as  constr
PLAT005_ALERT_5_G No _iucr_refine_instructions_details in CIF ....          ?
PLAT710_ALERT_4_G Delete 1-2-3 or 2-3-4 Linear Torsion Angle ... #         41
            C4  -C10 -C11 -C12    91.00  5.00   1.555   1.555   1.555   1.555
PLAT793_ALERT_4_G The Model has Chirality at C6      (Verify) ....          R
```

```
   0 ALERT level A = Most likely a serious problem - resolve or explain
   1 ALERT level B = A potentially serious problem, consider carefully
   4 ALERT level C = Check. Ensure it is not caused by an omission or oversight
   4 ALERT level G = General information/check it is not something unexpected

   1 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
   2 ALERT type 2 Indicator that the structure model may be wrong or deficient
   2 ALERT type 3 Indicator that the structure quality may be low
   3 ALERT type 4 Improvement, methodology, query or suggestion
   1 ALERT type 5 Informative message, check
```

It is advisable to attempt to resolve as many as possible of the alerts in all categories. Often the minor alerts point to easily fixed oversights, errors and omissions in your CIF or refinement strategy, so attention to these fine details can be worthwhile. In order to resolve some of the more serious problems it may be necessary to carry out additional measurements or structure refinements. However, the purpose of your study may justify the reported deviations and the more serious of these should normally be commented upon in the discussion or experimental section of a paper or in the "special_details" fields of the CIF. checkCIF was carefully designed to identify outliers and unusual parameters, but every test has its limitations and alerts that are not important in a particular case may appear. Conversely, the absence of alerts does not guarantee there are no aspects of the results needing attention. It is up to the individual to critically assess their own results and, if necessary, seek expert advice.

Publication of your CIF in IUCr journals

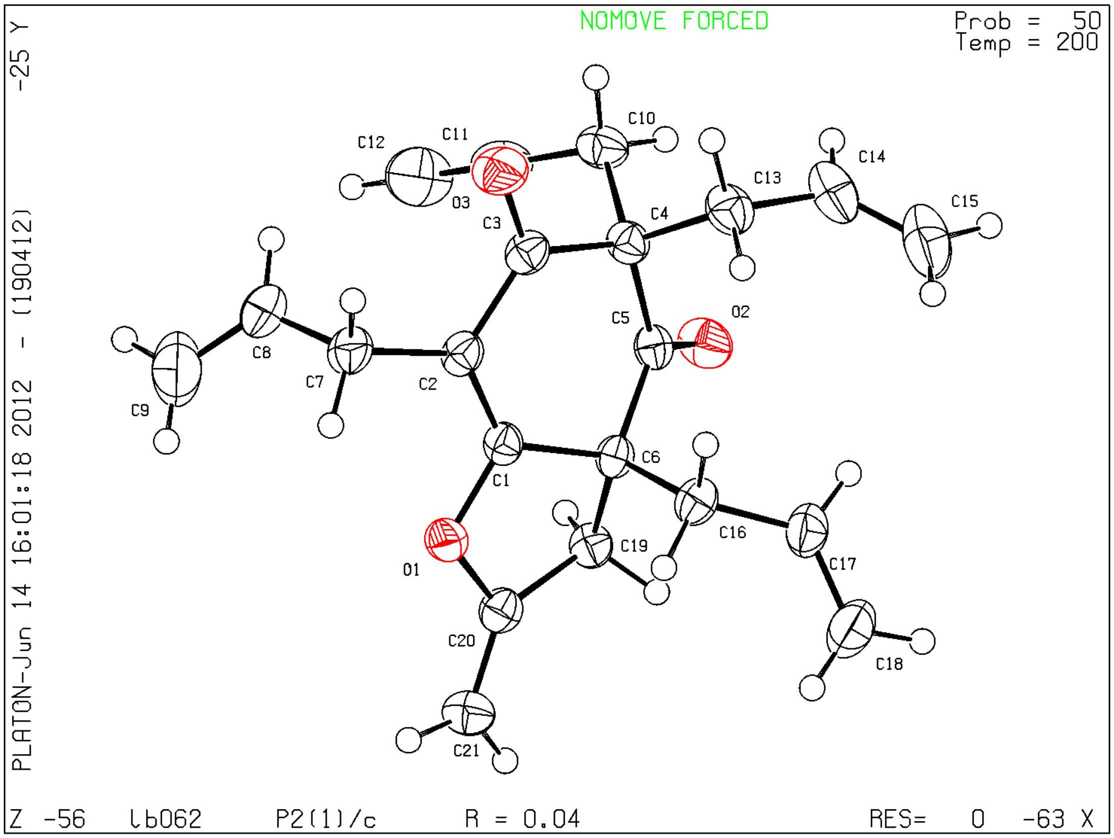
A basic structural check has been run on your CIF. These basic checks will be run on all CIFs submitted for publication in IUCr journals (*Acta Crystallographica*, *Journal of Applied Crystallography*, *Journal of Synchrotron Radiation*); however, if you intend to submit to *Acta Crystallographica Section C* or *E*, you should make sure that full publication checks are run on the final version of your CIF prior to submission.

Publication of your CIF in other journals

Please refer to the *Notes for Authors* of the relevant journal for any special instructions relating to CIF submission.

PLATON version of 19/04/2012; check.def file version of 14/04/2012

Datablock lb062 - ellipsoid plot



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data_lb062

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_chemical_melting_point           ?
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 _atom_type_scat_dispersion_real
 _atom_type_scat_dispersion_imag
 _atom_type_scat_source
 'C'  'C'   0.0033   0.0016
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'H'  'H'   0.0000   0.0000
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'O'  'O'   0.0106   0.0060
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'

_symmetry_cell_setting            Monoclinic
_symmetry_space_group_name_H-M    P2(1)/c

loop_
 _symmetry_equiv_pos_as_xyz
 'x, y, z'
 '-x, y+1/2, -z+1/2'
 '-x, -y, -z'
 'x, -y-1/2, z-1/2'

_cell_length_a                    8.3690(4)
_cell_length_b                    20.3386(9)
_cell_length_c                    10.5092(5)
_cell_angle_alpha                 90.00
_cell_angle_beta                  94.902(2)
_cell_angle_gamma                 90.00
_cell_volume                      1782.27(14)
_cell_formula_units_Z             4
_cell_measurement_temperature     200(2)
_cell_measurement_reflns_used     9872
_cell_measurement_theta_min       2.19
_cell_measurement_theta_max       28.29

_exptl_crystal_description        block
_exptl_crystal_colour             colourless
_exptl_crystal_size_max           0.32
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_exptl_crystal_size_mid           0.28
_exptl_crystal_size_min           0.25
_exptl_crystal_density_meas       n/a
_exptl_crystal_density_diffrn     1.201
_exptl_crystal_density_method     'not measured'
_exptl_crystal_F_000              688
_exptl_absorpt_coefficient_mu     0.079
_exptl_absorpt_correction_type    multi-scan
_exptl_absorpt_correction_T_min   0.9751
_exptl_absorpt_correction_T_max   0.9805
_exptl_absorpt_process_details    'SADABS, Bruker (2003)'

_exptl_special_details
;
 Data collection is performed with three batch runs at phi = 0.00 deg
 (650 frames), at phi = 120.00 deg (650 frames), and at phi = 240.00 deg
 (650 frames).
 Frame width = 0.30 deg in omega.
 Data is merged, corrected for decay (if any), and treated with multi-
scan
 absorption corrections (if required). All symmetry-equivalent
reflections
 are merged for centrosymmetric data.
 Friedel pairs are not merged for noncentrosymmetric data.
;

_diffrn_ambient_temperature       200(2)
_diffrn_radiation_wavelength      0.71073
_diffrn_radiation_type            MoK\a
_diffrn_radiation_source          'fine-focus sealed tube'
_diffrn_radiation_monochromator   graphite
_diffrn_measurement_device_type   'Bruker APEX-II CCD'
_diffrn_measurement_method        '\f and \w scans'
_diffrn_detector_area_resol_mean  ?
_diffrn_reflns_number             25223
_diffrn_reflns_av_R_equivalents   0.0238
_diffrn_reflns_av_sigmaI/netI     0.0172
_diffrn_reflns_limit_h_min        -11
_diffrn_reflns_limit_h_max        11
_diffrn_reflns_limit_k_min        -27
_diffrn_reflns_limit_k_max        27
_diffrn_reflns_limit_l_min        -13
_diffrn_reflns_limit_l_max        14
_diffrn_reflns_theta_min          2.19
_diffrn_reflns_theta_max          28.35
_reflns_number_total              4373
_reflns_number_gt                 3751
_reflns_threshold_expression      >2sigma(I)

_computing_data_collection        'APEX II, Bruker (2009)'
_computing_cell_refinement        'APEX II, Bruker (2009)'
_computing_data_reduction         'XPREP, Bruker (2009)'
_computing_structure_solution     'SHELXS-97 (Sheldrick, 2008)'
_computing_structure_refinement   'SHELXL-97 (Sheldrick, 2008)'
```

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_computing_molecular_graphics     'SHELXTL, Bruker (2004)'
_computing_publication_material   'SHELXTL, Bruker (2004)'

_refine_special_details
;
 Refinement of F^2^ against ALL reflections.  The weighted R-factor wR
and
 goodness of fit S are based on F^2^, conventional R-factors R are based
 on F, with F set to zero for negative F^2^. The threshold expression of
 F^2^ > 2sigma(F^2^) is used only for calculating R-factors(gt) etc. and
is
 not relevant to the choice of reflections for refinement.  R-factors
based
 on F^2^ are statistically about twice as large as those based on F, and
R-
 factors based on ALL data will be even larger.
;

_refine_ls_structure_factor_coef  Fsqd
_refine_ls_matrix_type            full
_refine_ls_weighting_scheme       calc
_refine_ls_weighting_details
 'calc w=1/[\s^2^(Fo^2^)+(0.0653P)^2^+0.2733P] where P=(Fo^2^+2Fc^2^)/3'
_atom_sites_solution_primary      direct
_atom_sites_solution_secondary    difmap
_atom_sites_solution_hydrogens    geom
_refine_ls_hydrogen_treatment     constrsw
_refine_ls_extinction_method      none
_refine_ls_extinction_coef        ?
_refine_ls_number_reflns          4373
_refine_ls_number_parameters      217
_refine_ls_number_restraints      0
_refine_ls_R_factor_all           0.0471
_refine_ls_R_factor_gt            0.0397
_refine_ls_wR_factor_ref          0.1135
_refine_ls_wR_factor_gt           0.1076
_refine_ls_goodness_of_fit_ref    1.033
_refine_ls_restrained_S_all       1.033
_refine_ls_shift/su_max           0.001
_refine_ls_shift/su_mean          0.000

loop_
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 _atom_site_type_symbol
 _atom_site_fract_x
 _atom_site_fract_y
 _atom_site_fract_z
 _atom_site_U_iso_or_equiv
 _atom_site_adp_type
 _atom_site_occupancy
 _atom_site_symmetry_multiplicity
 _atom_site_calc_flag
 _atom_site_refinement_flags
 _atom_site_disorder_assembly
```

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 _atom_site_disorder_group
O1 O -0.00227(8) 0.59500(4) 0.10694(7) 0.03166(18) Uani 1 1 d . . .
O2 O 0.51925(9) 0.55212(4) 0.19849(9) 0.0392(2) Uani 1 1 d . . .
O3 O 0.36844(10) 0.76546(4) 0.06134(9) 0.0430(2) Uani 1 1 d . . .
C1 C 0.14152(11) 0.62595(5) 0.12770(9) 0.0256(2) Uani 1 1 d . . .
C2 C 0.17352(12) 0.68381(5) 0.07465(9) 0.0283(2) Uani 1 1 d . . .
C3 C 0.33606(12) 0.70990(5) 0.09571(10) 0.0294(2) Uani 1 1 d . . .
C4 C 0.47464(11) 0.66631(5) 0.15369(10) 0.0282(2) Uani 1 1 d . . .
C5 C 0.42386(11) 0.59690(5) 0.19007(9) 0.0265(2) Uani 1 1 d . . .
C6 C 0.25114(11) 0.58601(5) 0.21784(9) 0.02473(19) Uani 1 1 d . . .
C7 C 0.05184(13) 0.72163(6) -0.01099(11) 0.0364(2) Uani 1 1 d . . .
H7A H -0.0573 0.7111 0.0126 0.044 Uiso 1 1 calc R . .
H7B H 0.0697 0.7694 0.0021 0.044 Uiso 1 1 calc R . .
C8 C 0.06311(16) 0.70539(7) -0.14864(12) 0.0452(3) Uani 1 1 d . . .
H8A H 0.1617 0.7139 -0.1842 0.054 Uiso 1 1 calc R . .
C9 C -0.0546(2) 0.68006(9) -0.22351(17) 0.0704(5) Uani 1 1 d . . .
H9A H -0.1546 0.6709 -0.1909 0.085 Uiso 1 1 calc R . .
H9B H -0.0397 0.6709 -0.3103 0.085 Uiso 1 1 calc R . .
C10 C 0.59825(13) 0.66119(6) 0.05178(11) 0.0353(2) Uani 1 1 d . . .
H10A H 0.6420 0.7055 0.0370 0.042 Uiso 1 1 calc R . .
H10B H 0.6884 0.6329 0.0855 0.042 Uiso 1 1 calc R . .
C11 C 0.53049(15) 0.63441(6) -0.06973(12) 0.0429(3) Uani 1 1 d . . .
C12 C 0.4749(2) 0.61429(8) -0.16892(15) 0.0589(4) Uani 1 1 d . . .
H12A H 0.4300 0.5981 -0.2489 0.071 Uiso 1 1 calc R . .
C13 C 0.55524(14) 0.70230(6) 0.27346(11) 0.0371(2) Uani 1 1 d . . .
H13A H 0.5898 0.7465 0.2473 0.045 Uiso 1 1 calc R . .
H13B H 0.4741 0.7084 0.3357 0.045 Uiso 1 1 calc R . .
C14 C 0.69681(16) 0.66748(7) 0.33865(14) 0.0486(3) Uani 1 1 d . . .
H14A H 0.7817 0.6565 0.2881 0.058 Uiso 1 1 calc R . .
C15 C 0.7137(2) 0.65104(8) 0.45807(16) 0.0620(4) Uani 1 1 d . . .
H15A H 0.6317 0.6611 0.5122 0.074 Uiso 1 1 calc R . .
H15B H 0.8081 0.6289 0.4916 0.074 Uiso 1 1 calc R . .
C16 C 0.22353(13) 0.60653(5) 0.35778(9) 0.0309(2) Uani 1 1 d . . .
H16A H 0.2579 0.6528 0.3714 0.037 Uiso 1 1 calc R . .
H16B H 0.1074 0.6042 0.3690 0.037 Uiso 1 1 calc R . .
C17 C 0.31213(15) 0.56437(6) 0.45641(10) 0.0390(3) Uani 1 1 d . . .
H17A H 0.4257 0.5630 0.4578 0.047 Uiso 1 1 calc R . .
C18 C 0.24437(19) 0.52917(7) 0.54103(12) 0.0513(3) Uani 1 1 d . . .
H18A H 0.1310 0.5293 0.5424 0.062 Uiso 1 1 calc R . .
H18B H 0.3085 0.5034 0.6011 0.062 Uiso 1 1 calc R . .
C19 C 0.18668(12) 0.51635(5) 0.18911(10) 0.0286(2) Uani 1 1 d . . .
H19A H 0.2386 0.4959 0.1177 0.034 Uiso 1 1 calc R . .
H19B H 0.2019 0.4876 0.2653 0.034 Uiso 1 1 calc R . .
C20 C 0.01225(12) 0.52983(5) 0.15314(9) 0.0293(2) Uani 1 1 d . . .
C21 C -0.11641(13) 0.49314(6) 0.15774(11) 0.0372(2) Uani 1 1 d . . .
H21C H -0.2190 0.5104 0.1300 0.045 Uiso 1 1 calc R . .
H21A H -0.1069 0.4493 0.1888 0.045 Uiso 1 1 calc R . .

loop_
 _atom_site_aniso_label
 _atom_site_aniso_U_11
 _atom_site_aniso_U_22
 _atom_site_aniso_U_33
 _atom_site_aniso_U_23
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 _atom_site_aniso_U_13
 _atom_site_aniso_U_12
O1 0.0247(3) 0.0338(4) 0.0361(4) 0.0064(3) 0.0002(3) 0.0012(3)
O2 0.0294(4) 0.0301(4) 0.0579(5) 0.0046(4) 0.0026(3) 0.0078(3)
O3 0.0405(4) 0.0305(4) 0.0578(5) 0.0125(4) 0.0035(4) 0.0008(3)
C1 0.0234(4) 0.0285(5) 0.0248(4) 0.0008(4) 0.0024(3) 0.0048(4)
C2 0.0276(5) 0.0291(5) 0.0284(5) 0.0043(4) 0.0039(4) 0.0070(4)
C3 0.0312(5) 0.0269(5) 0.0303(5) 0.0029(4) 0.0046(4) 0.0036(4)
C4 0.0258(4) 0.0265(5) 0.0322(5) 0.0004(4) 0.0010(4) 0.0013(4)
C5 0.0262(4) 0.0261(5) 0.0267(5) -0.0008(4) -0.0012(3) 0.0032(4)
C6 0.0264(4) 0.0235(4) 0.0240(4) 0.0015(3) 0.0007(3) 0.0035(4)
C7 0.0314(5) 0.0366(6) 0.0408(6) 0.0137(5) 0.0012(4) 0.0077(4)
C8 0.0488(7) 0.0462(7) 0.0396(6) 0.0171(5) -0.0022(5) 0.0010(5)
C9 0.0776(11) 0.0752(11) 0.0539(9) 0.0085(8) -0.0213(8) 0.0002(9)
C10 0.0277(5) 0.0354(6) 0.0435(6) 0.0012(5) 0.0075(4) -0.0001(4)
C11 0.0410(6) 0.0418(6) 0.0483(7) -0.0046(5) 0.0174(5) -0.0027(5)
C12 0.0654(9) 0.0631(9) 0.0501(8) -0.0176(7) 0.0152(7) -0.0126(7)
C13 0.0376(6) 0.0315(5) 0.0411(6) -0.0049(4) -0.0029(4) -0.0028(4)
C14 0.0396(6) 0.0504(7) 0.0530(7) -0.0110(6) -0.0125(5) -0.0013(5)
C15 0.0658(9) 0.0501(8) 0.0641(9) -0.0054(7) -0.0300(7) 0.0007(7)
C16 0.0374(5) 0.0306(5) 0.0248(5) -0.0006(4) 0.0036(4) 0.0022(4)
C17 0.0420(6) 0.0474(7) 0.0266(5) 0.0018(5) -0.0026(4) 0.0009(5)
C18 0.0656(9) 0.0542(8) 0.0331(6) 0.0106(5) -0.0010(5) -0.0037(7)
C19 0.0301(5) 0.0246(5) 0.0309(5) -0.0001(4) 0.0004(4) 0.0015(4)
C20 0.0312(5) 0.0302(5) 0.0269(5) -0.0005(4) 0.0039(4) 0.0017(4)
C21 0.0322(5) 0.0381(6) 0.0420(6) 0.0007(5) 0.0075(4) -0.0025(4)

_geom_special_details
;
 All esds (except the esd in the dihedral angle between two l.s. planes)
 are estimated using the full covariance matrix.  The cell esds are taken
 into account individually in the estimation of esds in distances, angles
 and torsion angles; correlations between esds in cell parameters are
only
 used when they are defined by crystal symmetry.  An approximate
(isotropic)
 treatment of cell esds is used for estimating esds involving l.s.
planes.
;

loop_
 _geom_bond_atom_site_label_1
 _geom_bond_atom_site_label_2
 _geom_bond_distance
 _geom_bond_site_symmetry_2
 _geom_bond_publ_flag
O1 C1 1.3591(12) . ?
O1 C20 1.4132(13) . ?
O2 C5 1.2093(12) . ?
O3 C3 1.2238(13) . ?
C1 C2 1.3390(14) . ?
C1 C6 1.5001(13) . ?
C2 C3 1.4593(14) . ?
C2 C7 1.5107(13) . ?
```

```
C3 C4 1.5433(14) . ?
C4 C5 1.5322(14) . ?
C4 C10 1.5548(15) . ?
C4 C13 1.5588(15) . ?
C5 C6 1.5152(13) . ?
C6 C19 1.5367(14) . ?
C6 C16 1.5647(13) . ?
C7 C8 1.4947(18) . ?
C8 C9 1.312(2) . ?
C10 C11 1.4579(17) . ?
C11 C12 1.178(2) . ?
C13 C14 1.4953(17) . ?
C14 C15 1.295(2) . ?
C16 C17 1.4927(15) . ?
C17 C18 1.3082(18) . ?
C19 C20 1.5016(14) . ?
C20 C21 1.3143(15) . ?

loop_
 _geom_angle_atom_site_label_1
 _geom_angle_atom_site_label_2
 _geom_angle_atom_site_label_3
 _geom_angle
 _geom_angle_site_symmetry_1
 _geom_angle_site_symmetry_3
 _geom_angle_publ_flag
C1 O1 C20 109.29(7) . . ?
C2 C1 O1 123.10(9) . . ?
C2 C1 C6 127.27(9) . . ?
O1 C1 C6 109.63(8) . . ?
C1 C2 C3 118.26(9) . . ?
C1 C2 C7 123.16(9) . . ?
C3 C2 C7 118.52(9) . . ?
O3 C3 C2 121.21(9) . . ?
O3 C3 C4 117.97(9) . . ?
C2 C3 C4 120.69(9) . . ?
C5 C4 C3 114.37(8) . . ?
C5 C4 C10 108.98(8) . . ?
C3 C4 C10 106.76(8) . . ?
C5 C4 C13 109.96(8) . . ?
C3 C4 C13 107.93(8) . . ?
C10 C4 C13 108.67(9) . . ?
O2 C5 C6 120.69(9) . . ?
O2 C5 C4 121.11(9) . . ?
C6 C5 C4 118.18(8) . . ?
C1 C6 C5 109.95(8) . . ?
C1 C6 C19 100.93(8) . . ?
C5 C6 C19 114.93(8) . . ?
C1 C6 C16 108.52(8) . . ?
C5 C6 C16 111.22(8) . . ?
C19 C6 C16 110.67(8) . . ?
C8 C7 C2 111.65(9) . . ?
C9 C8 C7 124.11(15) . . ?
C11 C10 C4 113.36(9) . . ?
```

```
C12 C11 C10 178.39(16) . . ?
C14 C13 C4 114.76(10) . . ?
C15 C14 C13 125.66(15) . . ?
C17 C16 C6 113.26(9) . . ?
C18 C17 C16 124.61(12) . . ?
C20 C19 C6 101.46(8) . . ?
C21 C20 O1 119.89(9) . . ?
C21 C20 C19 131.99(10) . . ?
O1 C20 C19 108.11(8) . . ?

loop_
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 _geom_torsion_atom_site_label_2
 _geom_torsion_atom_site_label_3
 _geom_torsion_atom_site_label_4
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 _geom_torsion_site_symmetry_1
 _geom_torsion_site_symmetry_2
 _geom_torsion_site_symmetry_3
 _geom_torsion_site_symmetry_4
 _geom_torsion_publ_flag
C20 O1 C1 C2 167.70(9) . . . . ?
C20 O1 C1 C6 -13.15(10) . . . . ?
O1 C1 C2 C3 -175.23(9) . . . . ?
C6 C1 C2 C3 5.77(15) . . . . ?
O1 C1 C2 C7 1.69(16) . . . . ?
C6 C1 C2 C7 -177.31(9) . . . . ?
C1 C2 C3 O3 -172.17(10) . . . . ?
C7 C2 C3 O3 10.76(16) . . . . ?
C1 C2 C3 C4 12.12(14) . . . . ?
C7 C2 C3 C4 -164.95(9) . . . . ?
O3 C3 C4 C5 -178.16(10) . . . . ?
C2 C3 C4 C5 -2.31(13) . . . . ?
O3 C3 C4 C10 -57.54(12) . . . . ?
C2 C3 C4 C10 118.30(10) . . . . ?
O3 C3 C4 C13 59.13(13) . . . . ?
C2 C3 C4 C13 -125.02(10) . . . . ?
C3 C4 C5 O2 156.92(10) . . . . ?
C10 C4 C5 O2 37.54(13) . . . . ?
C13 C4 C5 O2 -81.48(12) . . . . ?
C3 C4 C5 C6 -24.25(12) . . . . ?
C10 C4 C5 C6 -143.63(9) . . . . ?
C13 C4 C5 C6 97.35(10) . . . . ?
C2 C1 C6 C5 -30.69(13) . . . . ?
O1 C1 C6 C5 150.21(8) . . . . ?
C2 C1 C6 C19 -152.48(10) . . . . ?
O1 C1 C6 C19 28.41(10) . . . . ?
C2 C1 C6 C16 91.17(12) . . . . ?
O1 C1 C6 C16 -87.94(10) . . . . ?
O2 C5 C6 C1 -142.83(10) . . . . ?
C4 C5 C6 C1 38.34(11) . . . . ?
O2 C5 C6 C19 -29.80(13) . . . . ?
C4 C5 C6 C19 151.36(9) . . . . ?
O2 C5 C6 C16 96.94(11) . . . . ?
```

```
C4 C5 C6 C16 -81.89(10) . . . . ?
C1 C2 C7 C8 -92.83(13) . . . . ?
C3 C2 C7 C8 84.09(13) . . . . ?
C2 C7 C8 C9 119.89(15) . . . . ?
C5 C4 C10 C11 66.22(12) . . . . ?
C3 C4 C10 C11 -57.79(12) . . . . ?
C13 C4 C10 C11 -173.97(10) . . . . ?
C4 C10 C11 C12 91(5) . . . . ?
C5 C4 C13 C14 56.76(13) . . . . ?
C3 C4 C13 C14 -177.86(10) . . . . ?
C10 C4 C13 C14 -62.44(13) . . . . ?
C4 C13 C14 C15 -124.81(15) . . . . ?
C1 C6 C16 C17 173.10(9) . . . . ?
C5 C6 C16 C17 -65.83(12) . . . . ?
C19 C6 C16 C17 63.21(11) . . . . ?
C6 C16 C17 C18 -119.83(14) . . . . ?
C1 C6 C19 C20 -31.05(9) . . . . ?
C5 C6 C19 C20 -149.28(8) . . . . ?
C16 C6 C19 C20 83.70(9) . . . . ?
C1 O1 C20 C21 171.54(10) . . . . ?
C1 O1 C20 C19 -8.62(10) . . . . ?
C6 C19 C20 C21 -154.64(12) . . . . ?
C6 C19 C20 O1 25.55(10) . . . . ?

_diffrn_measured_fraction_theta_max    0.984
_diffrn_reflns_theta_full              28.35
_diffrn_measured_fraction_theta_full   0.984
_refine_diff_density_max    0.324
_refine_diff_density_min   -0.175
_refine_diff_density_rms    0.034
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```
TITL lb062 in P2(1)/c
CELL 0.71073   8.3690  20.3386  10.5092  90.000  94.902  90.000
ZERR    4.00   0.0004   0.0009   0.0005   0.000   0.002   0.000
LATT 1
SYMM -X, 0.5+Y, 0.5-Z
SFAC C  H  O
UNIT 84  88  12
L.S. 60
BOND
FMAP 2
PLAN 5
SIZE 0.25 0.28 0.32
TEMP -73.15C
ACTA
CONF
OMIT     5   5   0
OMIT    -2   9   2
OMIT    -3   3   1
OMIT     3   0   0
OMIT    -3   6   4
OMIT    -3   9   1
OMIT    -2   6   2
OMIT    -6   3   4
OMIT     4   9   0
OMIT     0   7   1
OMIT    -2   0   4
OMIT     1  10   5
OMIT    -3   5   2
OMIT    -5  11   2
OMIT     1   7   6
OMIT    -3   5   3
OMIT     4   6   4
OMIT     6   9   3
OMIT     4  10   0
OMIT     0   8   3
OMIT    -6   4   5
OMIT    -4  13   1
OMIT    -1  13   1
OMIT     1   2   5
OMIT     5   3   2
OMIT    -4   5   3
OMIT    -2  19   2
OMIT     1   7   2
OMIT    -9   2   2
OMIT     3   4   5
OMIT    -3   0   8
OMIT     3   5   1
OMIT     2   5   4
OMIT     1   7  10
OMIT     5  13   3
OMIT     0   3   6
OMIT     3   8   4
OMIT     0  12   0
OMIT     0   4   7
```

```
OMIT     5  11   5
OMIT     6   1   3
OMIT     4   7   6
OMIT     1   3   3
OMIT     4   4   1
OMIT    -3   9   8
OMIT     5  12   5
OMIT     8   3   2
OMIT     4   8   6
OMIT    -2  16   2
OMIT     1  13   2
WGHT    0.065300    0.273300
FVAR       0.23043
O1    3   -0.002271    0.594995    0.106936    11.00000    0.02473
0.03379 =
         0.03606    0.00640    0.00024    0.00123
O2    3    0.519245    0.552120    0.198494    11.00000    0.02940
0.03005 =
         0.05793    0.00458    0.00256    0.00776
O3    3    0.368444    0.765462    0.061337    11.00000    0.04046
0.03054 =
         0.05778    0.01254    0.00351    0.00080
C1    1    0.141523    0.625947    0.127697    11.00000    0.02343
0.02853 =
         0.02482    0.00077    0.00244    0.00480
C2    1    0.173521    0.683808    0.074648    11.00000    0.02759
0.02907 =
         0.02836    0.00430    0.00388    0.00696
C3    1    0.336056    0.709900    0.095711    11.00000    0.03125
0.02694 =
         0.03026    0.00288    0.00458    0.00360
C4    1    0.474644    0.666311    0.153691    11.00000    0.02578
0.02645 =
         0.03219    0.00040    0.00098    0.00125
C5    1    0.423863    0.596899    0.190068    11.00000    0.02617
0.02611 =
         0.02667   -0.00083   -0.00118    0.00322
C6    1    0.251142    0.586010    0.217844    11.00000    0.02643
0.02354 =
         0.02396    0.00152    0.00069    0.00347
C7    1    0.051836    0.721630   -0.010992    11.00000    0.03138
0.03657 =
         0.04077    0.01373    0.00117    0.00771
AFIX  23
H7A   2   -0.057308    0.711114    0.012579    11.00000   -1.20000
H7B   2    0.069660    0.769358    0.002141    11.00000   -1.20000
AFIX   0
C8    1    0.063115    0.705392   -0.148645    11.00000    0.04877
0.04620 =
         0.03964    0.01712   -0.00218    0.00104
AFIX  43
H8A   2    0.161665    0.713947   -0.184167    11.00000   -1.20000
AFIX   0
```

```
C9    1   -0.054571    0.680058   -0.223514    11.00000    0.07755
0.07518 =
         0.05393    0.00846   -0.02134    0.00025
AFIX  93
H9A   2   -0.154642    0.670926   -0.190891    11.00000   -1.20000
H9B   2   -0.039695    0.670851   -0.310335    11.00000   -1.20000
AFIX   0
C10   1    0.598252    0.661188    0.051783    11.00000    0.02772
0.03539 =
         0.04352    0.00118    0.00753   -0.00013
AFIX  23
H10A  2    0.641996    0.705498    0.036988    11.00000   -1.20000
H10B  2    0.688398    0.632899    0.085502    11.00000   -1.20000
AFIX   0
C11   1    0.530485    0.634408   -0.069735    11.00000    0.04100
0.04180 =
         0.04827   -0.00458    0.01743   -0.00271
C12   1    0.474865    0.614285   -0.168915    11.00000    0.06536
0.06313 =
         0.05009   -0.01758    0.01515   -0.01262
AFIX 163
H12A  2    0.430009    0.598057   -0.248900    11.00000   -1.20000
AFIX   0
C13   1    0.555245    0.702299    0.273459    11.00000    0.03762
0.03149 =
         0.04106   -0.00495   -0.00293   -0.00276
AFIX  23
H13A  2    0.589756    0.746486    0.247317    11.00000   -1.20000
H13B  2    0.474100    0.708441    0.335670    11.00000   -1.20000
AFIX   0
C14   1    0.696812    0.667478    0.338647    11.00000    0.03961
0.05045 =
         0.05303   -0.01101   -0.01253   -0.00135
AFIX  43
H14A  2    0.781727    0.656459    0.288057    11.00000   -1.20000
AFIX   0
C15   1    0.713699    0.651042    0.458071    11.00000    0.06585
0.05008 =
         0.06405   -0.00544   -0.03005    0.00073
AFIX  93
H15A  2    0.631726    0.661099    0.512179    11.00000   -1.20000
H15B  2    0.808061    0.628925    0.491583    11.00000   -1.20000
AFIX   0
C16   1    0.223529    0.606531    0.357778    11.00000    0.03738
0.03055 =
         0.02484   -0.00058    0.00365    0.00220
AFIX  23
H16A  2    0.257937    0.652754    0.371361    11.00000   -1.20000
H16B  2    0.107408    0.604198    0.368982    11.00000   -1.20000
AFIX   0
C17   1    0.312132    0.564367    0.456405    11.00000    0.04198
0.04740 =
         0.02660    0.00180   -0.00258    0.00091
AFIX  43
```

```
H17A  2    0.425735    0.563001    0.457820    11.00000   -1.20000
AFIX   0
C18   1    0.244366    0.529166    0.541028    11.00000    0.06564
0.05424 =
         0.03309    0.01060   -0.00103   -0.00369
AFIX  93
H18A  2    0.131017    0.529341    0.542435    11.00000   -1.20000
H18B  2    0.308503    0.503426    0.601075    11.00000   -1.20000
AFIX   0
C19   1    0.186682    0.516351    0.189108    11.00000    0.03006
0.02458 =
         0.03091   -0.00012    0.00037    0.00148
AFIX  23
H19A  2    0.238626    0.495931    0.117717    11.00000   -1.20000
H19B  2    0.201887    0.487643    0.265255    11.00000   -1.20000
AFIX   0
C20   1    0.012249    0.529825    0.153136    11.00000    0.03123
0.03019 =
         0.02688   -0.00050    0.00395    0.00169
C21   1   -0.116410    0.493141    0.157737    11.00000    0.03224
0.03807 =
         0.04201    0.00067    0.00754   -0.00255
AFIX  93
H21C  2   -0.218963    0.510442    0.130032    11.00000   -1.20000
H21A  2   -0.106857    0.449324    0.188767    11.00000   -1.20000
HKLF 4

REM  lb062 in P2(1)/c
REM R1 =  0.0397 for   3751 Fo > 4sig(Fo)  and  0.0471 for all   4373
data
REM    217 parameters refined using      0 restraints

END

WGHT      0.0577      0.3143
REM Highest difference peak  0.324,  deepest hole -0.175,  1-sigma level
0.034
Q1    1   0.2012  0.6081  0.1760  11.00000  0.05    0.32
Q2    1   0.5261  0.5966 -0.0573  11.00000  0.05    0.32
Q3    1   0.2573  0.6924  0.0766  11.00000  0.05    0.28
Q4    1   0.4007  0.6884  0.1379  11.00000  0.05    0.27
Q5    1   0.2265  0.5512  0.2081  11.00000  0.05    0.26
```

Table 1. Crystal data and structure refinement for lb062.

Identification code	lb062
Empirical formula	C21 H22 O3
Formula weight	322.39
Temperature	200(2) K
Wavelength	0.71073 A
Crystal system, space group	Monoclinic, P2(1)/c
Unit cell dimensions	a = 8.3690(4) A alpha = 90 deg. b = 20.3386(9) A beta = 94.902(2) deg. c = 10.5092(5) A gamma = 90 deg.
Volume	1782.27(14) A^3
Z, Calculated density	4, 1.201 Mg/m^3
Absorption coefficient	0.079 mm^-1
F(000)	688
Crystal size	0.32 x 0.28 x 0.25 mm
Theta range for data collection	2.19 to 28.35 deg.
Limiting indices	-11<=h<=11, -27<=k<=27, -13<=l<=14
Reflections collected / unique	25223 / 4373 [R(int) = 0.0238]
Completeness to theta = 28.35	98.4 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9805 and 0.9751
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4373 / 0 / 217
Goodness-of-fit on F^2	1.033
Final R indices [I>2sigma(I)]	R1 = 0.0397, wR2 = 0.1076
R indices (all data)	R1 = 0.0471, wR2 = 0.1135

```
Largest diff. peak and hole       0.324 and -0.175 e.A^-3
```

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for lb062.
U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
O(1)	-23(1)	5950(1)	1069(1)	32(1)
O(2)	5192(1)	5521(1)	1985(1)	39(1)
O(3)	3684(1)	7655(1)	613(1)	43(1)
C(1)	1415(1)	6260(1)	1277(1)	26(1)
C(2)	1735(1)	6838(1)	746(1)	28(1)
C(3)	3361(1)	7099(1)	957(1)	29(1)
C(4)	4746(1)	6663(1)	1537(1)	28(1)
C(5)	4239(1)	5969(1)	1901(1)	26(1)
C(6)	2511(1)	5860(1)	2178(1)	25(1)
C(7)	518(1)	7216(1)	-110(1)	36(1)
C(8)	631(2)	7054(1)	-1486(1)	45(1)
C(9)	-546(2)	6801(1)	-2235(2)	70(1)
C(10)	5982(1)	6612(1)	518(1)	35(1)
C(11)	5305(2)	6344(1)	-697(1)	43(1)
C(12)	4749(2)	6143(1)	-1689(2)	59(1)
C(13)	5552(1)	7023(1)	2735(1)	37(1)
C(14)	6968(2)	6675(1)	3386(1)	49(1)
C(15)	7137(2)	6510(1)	4581(2)	62(1)
C(16)	2235(1)	6065(1)	3578(1)	31(1)
C(17)	3121(2)	5644(1)	4564(1)	39(1)
C(18)	2444(2)	5292(1)	5410(1)	51(1)
C(19)	1867(1)	5163(1)	1891(1)	29(1)
C(20)	122(1)	5298(1)	1531(1)	29(1)
C(21)	-1164(1)	4931(1)	1577(1)	37(1)

Table 3. Bond lengths [A] and angles [deg] for lb062.

O(1)-C(1)	1.3591(12)
O(1)-C(20)	1.4132(13)
O(2)-C(5)	1.2093(12)
O(3)-C(3)	1.2238(13)
C(1)-C(2)	1.3390(14)
C(1)-C(6)	1.5001(13)
C(2)-C(3)	1.4593(14)
C(2)-C(7)	1.5107(13)
C(3)-C(4)	1.5433(14)
C(4)-C(5)	1.5322(14)
C(4)-C(10)	1.5548(15)
C(4)-C(13)	1.5588(15)
C(5)-C(6)	1.5152(13)
C(6)-C(19)	1.5367(14)
C(6)-C(16)	1.5647(13)
C(7)-C(8)	1.4947(18)
C(8)-C(9)	1.312(2)
C(10)-C(11)	1.4579(17)
C(11)-C(12)	1.178(2)
C(13)-C(14)	1.4953(17)
C(14)-C(15)	1.295(2)
C(16)-C(17)	1.4927(15)
C(17)-C(18)	1.3082(18)
C(19)-C(20)	1.5016(14)
C(20)-C(21)	1.3143(15)

C(1)-O(1)-C(20)	109.29(7)
C(2)-C(1)-O(1)	123.10(9)
C(2)-C(1)-C(6)	127.27(9)
O(1)-C(1)-C(6)	109.63(8)
C(1)-C(2)-C(3)	118.26(9)
C(1)-C(2)-C(7)	123.16(9)
C(3)-C(2)-C(7)	118.52(9)
O(3)-C(3)-C(2)	121.21(9)
O(3)-C(3)-C(4)	117.97(9)
C(2)-C(3)-C(4)	120.69(9)
C(5)-C(4)-C(3)	114.37(8)
C(5)-C(4)-C(10)	108.98(8)
C(3)-C(4)-C(10)	106.76(8)
C(5)-C(4)-C(13)	109.96(8)
C(3)-C(4)-C(13)	107.93(8)
C(10)-C(4)-C(13)	108.67(9)
O(2)-C(5)-C(6)	120.69(9)
O(2)-C(5)-C(4)	121.11(9)
C(6)-C(5)-C(4)	118.18(8)
C(1)-C(6)-C(5)	109.95(8)
C(1)-C(6)-C(19)	100.93(8)
C(5)-C(6)-C(19)	114.93(8)
C(1)-C(6)-C(16)	108.52(8)
C(5)-C(6)-C(16)	111.22(8)

C(19)-C(6)-C(16)	110.67(8)
C(8)-C(7)-C(2)	111.65(9)
C(9)-C(8)-C(7)	124.11(15)
C(11)-C(10)-C(4)	113.36(9)
C(12)-C(11)-C(10)	178.39(16)
C(14)-C(13)-C(4)	114.76(10)
C(15)-C(14)-C(13)	125.66(15)
C(17)-C(16)-C(6)	113.26(9)
C(18)-C(17)-C(16)	124.61(12)
C(20)-C(19)-C(6)	101.46(8)
C(21)-C(20)-O(1)	119.89(9)
C(21)-C(20)-C(19)	131.99(10)
O(1)-C(20)-C(19)	108.11(8)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (A^2 x 10^3) for lb062.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
O(1)	25(1)	34(1)	36(1)	6(1)	0(1)	1(1)
O(2)	29(1)	30(1)	58(1)	5(1)	3(1)	8(1)
O(3)	40(1)	30(1)	58(1)	12(1)	4(1)	1(1)
C(1)	23(1)	28(1)	25(1)	1(1)	2(1)	5(1)
C(2)	28(1)	29(1)	28(1)	4(1)	4(1)	7(1)
C(3)	31(1)	27(1)	30(1)	3(1)	5(1)	4(1)
C(4)	26(1)	26(1)	32(1)	0(1)	1(1)	1(1)
C(5)	26(1)	26(1)	27(1)	-1(1)	-1(1)	3(1)
C(6)	26(1)	24(1)	24(1)	2(1)	1(1)	4(1)
C(7)	31(1)	37(1)	41(1)	14(1)	1(1)	8(1)
C(8)	49(1)	46(1)	40(1)	17(1)	-2(1)	1(1)
C(9)	78(1)	75(1)	54(1)	8(1)	-21(1)	0(1)
C(10)	28(1)	35(1)	44(1)	1(1)	8(1)	0(1)
C(11)	41(1)	42(1)	48(1)	-5(1)	17(1)	-3(1)
C(12)	65(1)	63(1)	50(1)	-18(1)	15(1)	-13(1)
C(13)	38(1)	32(1)	41(1)	-5(1)	-3(1)	-3(1)
C(14)	40(1)	50(1)	53(1)	-11(1)	-12(1)	-1(1)
C(15)	66(1)	50(1)	64(1)	-5(1)	-30(1)	1(1)
C(16)	37(1)	31(1)	25(1)	-1(1)	4(1)	2(1)
C(17)	42(1)	47(1)	27(1)	2(1)	-3(1)	1(1)
C(18)	66(1)	54(1)	33(1)	11(1)	-1(1)	-4(1)
C(19)	30(1)	25(1)	31(1)	0(1)	0(1)	2(1)
C(20)	31(1)	30(1)	27(1)	0(1)	4(1)	2(1)
C(21)	32(1)	38(1)	42(1)	1(1)	8(1)	-2(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for lb062.

	x	y	z	U(eq)
H(7A)	-573	7111	126	44
H(7B)	697	7694	21	44
H(8A)	1617	7139	-1842	54
H(9A)	-1546	6709	-1909	85
H(9B)	-397	6709	-3103	85
H(10A)	6420	7055	370	42
H(10B)	6884	6329	855	42
H(12A)	4300	5981	-2489	71
H(13A)	5898	7465	2473	45
H(13B)	4741	7084	3357	45
H(14A)	7817	6565	2881	58
H(15A)	6317	6611	5122	74
H(15B)	8081	6289	4916	74
H(16A)	2579	6528	3714	37
H(16B)	1074	6042	3690	37
H(17A)	4257	5630	4578	47
H(18A)	1310	5293	5424	62
H(18B)	3085	5034	6011	62
H(19A)	2386	4959	1177	34
H(19B)	2019	4876	2653	34
H(21C)	-2190	5104	1300	45
H(21A)	-1069	4493	1888	45

Table 6. Torsion angles [deg] for lb062.

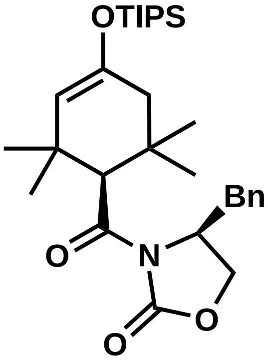
C(20)-O(1)-C(1)-C(2)	167.70(9)
C(20)-O(1)-C(1)-C(6)	-13.15(10)
O(1)-C(1)-C(2)-C(3)	-175.23(9)
C(6)-C(1)-C(2)-C(3)	5.77(15)
O(1)-C(1)-C(2)-C(7)	1.69(16)
C(6)-C(1)-C(2)-C(7)	-177.31(9)
C(1)-C(2)-C(3)-O(3)	-172.17(10)
C(7)-C(2)-C(3)-O(3)	10.76(16)
C(1)-C(2)-C(3)-C(4)	12.12(14)
C(7)-C(2)-C(3)-C(4)	-164.95(9)
O(3)-C(3)-C(4)-C(5)	-178.16(10)
C(2)-C(3)-C(4)-C(5)	-2.31(13)
O(3)-C(3)-C(4)-C(10)	-57.54(12)
C(2)-C(3)-C(4)-C(10)	118.30(10)
O(3)-C(3)-C(4)-C(13)	59.13(13)
C(2)-C(3)-C(4)-C(13)	-125.02(10)
C(3)-C(4)-C(5)-O(2)	156.92(10)
C(10)-C(4)-C(5)-O(2)	37.54(13)
C(13)-C(4)-C(5)-O(2)	-81.48(12)
C(3)-C(4)-C(5)-C(6)	-24.25(12)
C(10)-C(4)-C(5)-C(6)	-143.63(9)
C(13)-C(4)-C(5)-C(6)	97.35(10)
C(2)-C(1)-C(6)-C(5)	-30.69(13)
O(1)-C(1)-C(6)-C(5)	150.21(8)
C(2)-C(1)-C(6)-C(19)	-152.48(10)
O(1)-C(1)-C(6)-C(19)	28.41(10)
C(2)-C(1)-C(6)-C(16)	91.17(12)
O(1)-C(1)-C(6)-C(16)	-87.94(10)
O(2)-C(5)-C(6)-C(1)	-142.83(10)
C(4)-C(5)-C(6)-C(1)	38.34(11)
O(2)-C(5)-C(6)-C(19)	-29.80(13)
C(4)-C(5)-C(6)-C(19)	151.36(9)
O(2)-C(5)-C(6)-C(16)	96.94(11)
C(4)-C(5)-C(6)-C(16)	-81.89(10)
C(1)-C(2)-C(7)-C(8)	-92.83(13)
C(3)-C(2)-C(7)-C(8)	84.09(13)
C(2)-C(7)-C(8)-C(9)	119.89(15)
C(5)-C(4)-C(10)-C(11)	66.22(12)
C(3)-C(4)-C(10)-C(11)	-57.79(12)
C(13)-C(4)-C(10)-C(11)	-173.97(10)
C(4)-C(10)-C(11)-C(12)	91(5)
C(5)-C(4)-C(13)-C(14)	56.76(13)
C(3)-C(4)-C(13)-C(14)	-177.86(10)
C(10)-C(4)-C(13)-C(14)	-62.44(13)
C(4)-C(13)-C(14)-C(15)	-124.81(15)
C(1)-C(6)-C(16)-C(17)	173.10(9)
C(5)-C(6)-C(16)-C(17)	-65.83(12)
C(19)-C(6)-C(16)-C(17)	63.21(11)
C(6)-C(16)-C(17)-C(18)	-119.83(14)
C(1)-C(6)-C(19)-C(20)	-31.05(9)

C(5)-C(6)-C(19)-C(20)	-149.28(8)
C(16)-C(6)-C(19)-C(20)	83.70(9)
C(1)-O(1)-C(20)-C(21)	171.54(10)
C(1)-O(1)-C(20)-C(19)	-8.62(10)
C(6)-C(19)-C(20)-C(21)	-154.64(12)
C(6)-C(19)-C(20)-O(1)	25.55(10)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for lb062 [A and deg.].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)


OTIPS
Bn
O
N
O
O

checkCIF/PLATON report

Structure factors have been supplied for datablock(s) lb085

No syntax errors found.   CIF dictionary   Interpreting this report

Datablock: lb085

```
Bond precision:  C-C = 0.0036 A          Wavelength=0.71073

Cell:            a=8.1637(4)     b=10.6578(5)      c=17.6018(9)
                 alpha=90        beta=90.655(3)    gamma=90
Temperature:     200 K

                Calculated                 Reported
Volume          1531.38(13)                1531.38(13)
Space group     P 21                       P2(1)
Hall group      P 2yb                      ?
Moiety formula  C30 H47 N O4 Si            ?
Sum formula     C30 H47 N O4 Si            C30 H47 N O4 Si
Mr              513.78                     513.78
Dx,g cm-3       1.114                      1.114
Z               2                          2
Mu (mm-1)       0.109                      0.109
F000            560.0                      560.0
F000’           560.39
h,k,lmax        9,11,19                    9,11,19
Nref            4419[ 2350]                4308
Tmin,Tmax       0.981,0.998                0.974,0.998
Tmin’           0.974

Correction method= MULTI-SCAN

Data completeness= 1.83/0.97      Theta(max)= 23.320

R(reflections)= 0.0735( 3003)     wR2(reflections)= 0.2013( 4308)

S = 1.037                  Npar= 304
```

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.

Alert level B

```
THETM01_ALERT_3_B  The value of sine(theta_max)/wavelength is less than 0.575
            Calculated sin(theta_max)/wavelength =    0.5570
PLAT035_ALERT_1_B No _chemical_absolute_configuration info given .          ?
PLAT230_ALERT_2_B Hirshfeld Test Diff for    O4     --  C15     ..        9.0 su
```

```
PLAT230_ALERT_2_B Hirshfeld Test Diff for    N1     --  C11     ..        7.3 su
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C2     --  C3      ..        7.5 su
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C7     --  C8      ..        9.0 su
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C8     --  C9      ..        7.5 su
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C13    --  C18     ..        8.5 su
PLAT230_ALERT_2_B Hirshfeld Test Diff for    C13    --  C19     ..       10.5 su
PLAT242_ALERT_2_B Check Low       Ueq as Compared to Neighbors for        Si1
```

Alert level C

```
PLAT089_ALERT_3_C Poor Data / Parameter Ratio (Zmax  <   18) .....       7.63
PLAT230_ALERT_2_C Hirshfeld Test Diff for    O1     --  C2      ..        6.5 su
PLAT230_ALERT_2_C Hirshfeld Test Diff for    O3     --  C11     ..        5.3 su
PLAT230_ALERT_2_C Hirshfeld Test Diff for    C17    --  C20     ..        6.3 su
PLAT241_ALERT_2_C Check High      Ueq as Compared to Neighbors for         O4
PLAT241_ALERT_2_C Check High      Ueq as Compared to Neighbors for         C2
PLAT242_ALERT_2_C Check Low       Ueq as Compared to Neighbors for        C15
PLAT906_ALERT_3_C Large K value in the Analysis of Variance ......      2.480
PLAT910_ALERT_3_C Missing # of FCF Reflections Below Th(Min) .....          1
PLAT911_ALERT_3_C Missing # FCF Refl Between THmin & STh/L=  0.557         32
```

Alert level G

```
PLAT002_ALERT_2_G Number of Distance or Angle Restraints on AtSite         19
PLAT005_ALERT_5_G No _iucr_refine_instructions_details  in the CIF          ?
PLAT032_ALERT_4_G Std. Uncertainty on Flack Parameter Value High .      0.300
PLAT072_ALERT_2_G SHELXL First  Parameter in WGHT Unusually Large.       0.12
PLAT230_ALERT_2_G Hirshfeld Test Diff for    Si1    --  C22     ..       49.4 su
PLAT230_ALERT_2_G Hirshfeld Test Diff for    Si1    --  C22’    ..       51.5 su
PLAT230_ALERT_2_G Hirshfeld Test Diff for    Si1    --  C25     ..       19.3 su
PLAT230_ALERT_2_G Hirshfeld Test Diff for    Si1    --  C25’    ..       48.6 su
PLAT230_ALERT_2_G Hirshfeld Test Diff for    Si1    --  C28     ..       40.4 su
PLAT230_ALERT_2_G Hirshfeld Test Diff for    Si1    --  C28’    ..       13.4 su
PLAT301_ALERT_3_G Note: Main Residue  Disorder ..................          25 %
PLAT779_ALERT_4_G Suspect or Irrelevant (Bond) Angle in CIF .... #         10
              C22  -SI1  -C22’    1.555   1.555   1.555            11.20 Deg.
PLAT779_ALERT_4_G Suspect or Irrelevant (Bond) Angle in CIF .... #         13
              C25’ -SI1  -C25     1.555   1.555   1.555            43.90 Deg.
PLAT791_ALERT_4_G Note: The Model has Chirality at C3     (Verify)          S
PLAT791_ALERT_4_G Note: The Model has Chirality at C12    (Verify)          R
PLAT811_ALERT_5_G No ADDSYM Analysis: Too Many Excluded Atoms ....          !
PLAT860_ALERT_3_G Note: Number of Least-Squares Restraints .......         43
PLAT916_ALERT_2_G Hooft y and Flack x Parameter values differ by .       0.23
```

```
   0 ALERT level A = Most likely a serious problem - resolve or explain
  10 ALERT level B = A potentially serious problem, consider carefully
  10 ALERT level C = Check. Ensure it is not caused by an omission or oversight
  18 ALERT level G = General information/check it is not something unexpected

   1 ALERT type 1 CIF construction/syntax error, inconsistent or missing data
  23 ALERT type 2 Indicator that the structure model may be wrong or deficient
   7 ALERT type 3 Indicator that the structure quality may be low
   5 ALERT type 4 Improvement, methodology, query or suggestion
   2 ALERT type 5 Informative message, check
```

It is advisable to attempt to resolve as many as possible of the alerts in all categories. Often the minor alerts point to easily fixed oversights, errors and omissions in your CIF or refinement strategy, so attention to these fine details can be worthwhile. In order to resolve some of the more serious problems it may be necessary to carry out additional measurements or structure refinements. However, the purpose of your study may justify the reported deviations and the more serious of these should normally be commented upon in the discussion or experimental section of a paper or in the "special_details" fields of the CIF. checkCIF was carefully designed to identify outliers and unusual parameters, but every test has its limitations and alerts that are not important in a particular case may appear. Conversely, the absence of alerts does not guarantee there are no aspects of the results needing attention. It is up to the individual to critically assess their own results and, if necessary, seek expert advice.

Publication of your CIF in IUCr journals

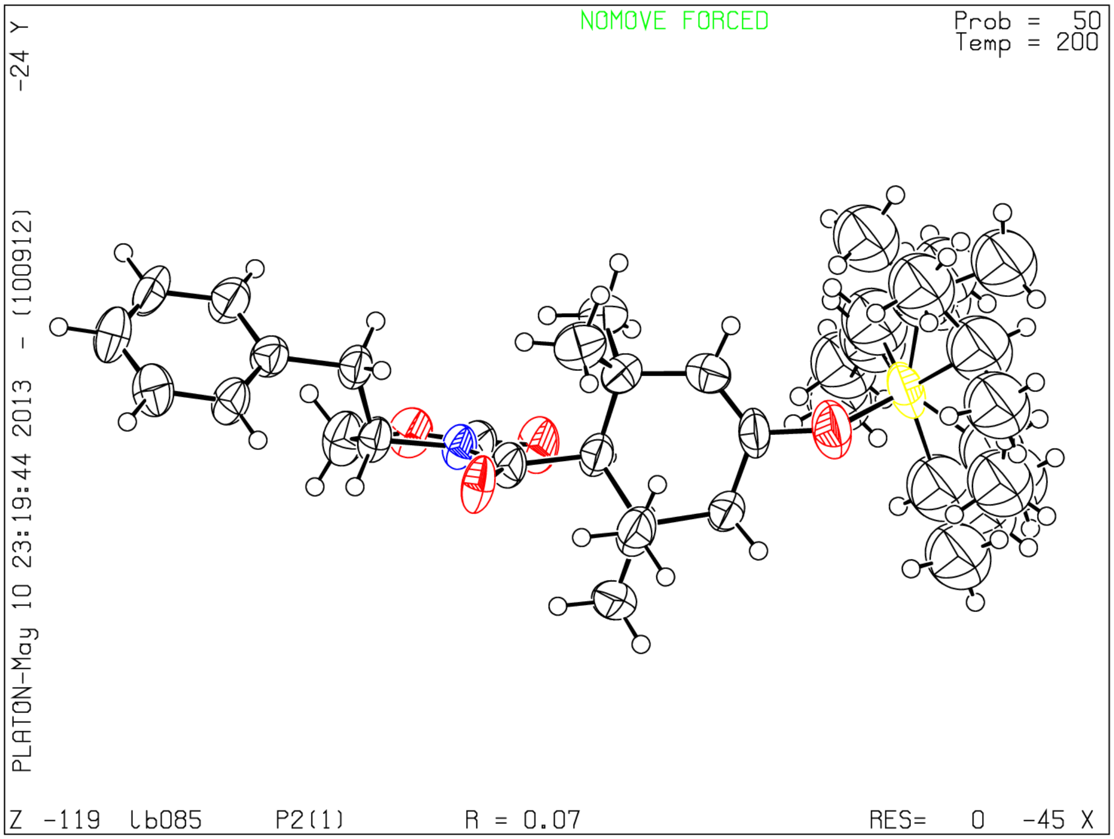
A basic structural check has been run on your CIF. These basic checks will be run on all CIFs submitted for publication in IUCr journals (*Acta Crystallographica*, *Journal of Applied Crystallography*, *Journal of Synchrotron Radiation*); however, if you intend to submit to *Acta Crystallographica Section C* or *E*, you should make sure that full publication checks are run on the final version of your CIF prior to submission.

Publication of your CIF in other journals

Please refer to the *Notes for Authors* of the relevant journal for any special instructions relating to CIF submission.

PLATON version of 24/04/2013; check.def file version of 23/04/2013

Datablock lb085 - ellipsoid plot



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_chemical_name_systematic
;
 ?
;
_chemical_name_common             ?
_chemical_melting_point           ?
_chemical_formula_moiety          ?
_chemical_formula_sum
 'C30 H47 N O4 Si'
_chemical_formula_weight          513.78

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 _atom_type_description
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 'C'  'C'   0.0033   0.0016
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'H'  'H'   0.0000   0.0000
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'N'  'N'   0.0061   0.0033
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'O'  'O'   0.0106   0.0060
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'
 'Si'  'Si'   0.0817   0.0704
 'International Tables Vol C Tables 4.2.6.8 and 6.1.1.4'

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_symmetry_space_group_name_H-M    P2(1)

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 'x, y, z'
 '-x, y+1/2, -z'

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_cell_length_b                    10.6578(5)
_cell_length_c                    17.6018(9)
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_cell_angle_beta                  90.655(3)
_cell_angle_gamma                 90.00
_cell_volume                      1531.38(13)
_cell_formula_units_Z             2
_cell_measurement_temperature     200(2)
_cell_measurement_reflns_used     4585
_cell_measurement_theta_min       2.23
_cell_measurement_theta_max       23.19

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_exptl_crystal_density_meas        n/a
_exptl_crystal_density_diffrn      1.114
_exptl_crystal_density_method      'not measured'
_exptl_crystal_F_000               560
_exptl_absorpt_coefficient_mu      0.109
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_exptl_absorpt_correction_T_min    0.9743
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;
 Data collection is performed with three batch runs at phi = 0.00 deg
 (650 frames), at phi = 120.00 deg (650 frames), and at phi = 240.00 deg
 (650 frames).
 Frame width = 0.30 deg in omega.
 Data is merged, corrected for decay (if any), and treated with multi-
scan
 absorption corrections (if required). All symmetry-equivalent
reflections
 are merged for centrosymmetric data.
 Friedel pairs are not merged for noncentrosymmetric data.
;

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_diffrn_radiation_source           'fine-focus sealed tube'
_diffrn_radiation_monochromator    graphite
_diffrn_measurement_device_type    'Bruker APEX-II CCD'
_diffrn_measurement_method         '\f and \w scans'
_diffrn_detector_area_resol_mean   ?
_diffrn_reflns_number              19571
_diffrn_reflns_av_R_equivalents    0.0553
_diffrn_reflns_av_sigmaI/netI      0.0526
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_diffrn_reflns_limit_k_max         11
_diffrn_reflns_limit_l_min         -19
_diffrn_reflns_limit_l_max         19
_diffrn_reflns_theta_min           2.23
_diffrn_reflns_theta_max           23.32
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_reflns_number_gt                  3003
_reflns_threshold_expression       >2sigma(I)

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_computing_cell_refinement         'APEX II, Bruker (2009)'
_computing_data_reduction          'XPREP, Bruker (2009)'
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_computing_structure_refinement   'SHELXL-97 (Sheldrick, 2008)'
_computing_molecular_graphics     'SHELXTL, Bruker (2004)'
_computing_publication_material   'SHELXTL, Bruker (2004)'

_refine_special_details
;
 Refinement of F^2^ against ALL reflections.  The weighted R-factor wR
and
 goodness of fit S are based on F^2^, conventional R-factors R are based
 on F, with F set to zero for negative F^2^. The threshold expression of
 F^2^ > 2sigma(F^2^) is used only for calculating R-factors(gt) etc. and
is
 not relevant to the choice of reflections for refinement.  R-factors
based
 on F^2^ are statistically about twice as large as those based on F, and
R-
 factors based on ALL data will be even larger.
;

_refine_ls_structure_factor_coef  Fsqd
_refine_ls_matrix_type            full
_refine_ls_weighting_scheme       calc
_refine_ls_weighting_details
 'calc w=1/[\s^2^(Fo^2^)+(0.1221P)^2^+0.2761P] where P=(Fo^2^+2Fc^2^)/3'
_atom_sites_solution_primary      direct
_atom_sites_solution_secondary    difmap
_atom_sites_solution_hydrogens    geom
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_refine_ls_extinction_method      none
_refine_ls_extinction_coef        ?
_refine_ls_abs_structure_details
 'Flack H D (1983), Acta Cryst. A39, 876-881'
_refine_ls_abs_structure_Flack    -0.2(3)
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_refine_ls_number_parameters      304
_refine_ls_number_restraints      43
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_refine_ls_R_factor_gt            0.0735
_refine_ls_wR_factor_ref          0.2013
_refine_ls_wR_factor_gt           0.1810
_refine_ls_goodness_of_fit_ref    1.037
_refine_ls_restrained_S_all       1.056
_refine_ls_shift/su_max           0.004
_refine_ls_shift/su_mean          0.001

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 _atom_site_fract_z
 _atom_site_U_iso_or_equiv
 _atom_site_adp_type
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 _atom_site_symmetry_multiplicity
 _atom_site_calc_flag
 _atom_site_refinement_flags
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Si1 Si 0.60901(10) 0.40933(8) 0.88839(4) 0.0775(2) Uani 1 1 d D . .
O1 O 1.1501(2) 0.83605(14) 0.51939(10) 0.0583(5) Uani 1 1 d . . .
O2 O 1.0034(2) 0.69005(14) 0.57674(11) 0.0699(6) Uani 1 1 d . . .
O3 O 0.7969(2) 1.01188(14) 0.67238(10) 0.0633(5) Uani 1 1 d . . .
O4 O 0.5761(2) 0.55123(18) 0.85752(14) 0.0973(7) Uani 1 1 d . A .
N1 N 0.9815(2) 0.90111(17) 0.60810(10) 0.0483(5) Uani 1 1 d . . .
C1 C 1.0377(3) 0.7986(2) 0.57103(14) 0.0528(7) Uani 1 1 d . . .
C2 C 1.1614(3) 0.9688(2) 0.51555(17) 0.0703(9) Uani 1 1 d . . .
H2A H 1.1163 0.9999 0.4666 0.084 Uiso 1 1 calc R . .
H2B H 1.2769 0.9961 0.5204 0.084 Uiso 1 1 calc R . .
C3 C 1.0610(3) 1.0187(2) 0.58184(14) 0.0498(7) Uani 1 1 d . . .
H3A H 0.9760 1.0787 0.5626 0.060 Uiso 1 1 calc R . .
C4 C 1.1621(3) 1.0803(2) 0.64476(14) 0.0529(7) Uani 1 1 d . . .
H4A H 1.0890 1.1017 0.6874 0.063 Uiso 1 1 calc R . .
H4B H 1.2442 1.0193 0.6639 0.063 Uiso 1 1 calc R . .
C5 C 1.2492(3) 1.1974(2) 0.61931(13) 0.0516(7) Uani 1 1 d . . .
C6 C 1.4155(3) 1.1958(3) 0.60791(16) 0.0665(8) Uani 1 1 d . . .
H6A H 1.4763 1.1207 0.6151 0.080 Uiso 1 1 calc R . .
C7 C 1.4925(3) 1.3044(3) 0.58591(17) 0.0766(9) Uani 1 1 d . . .
H7A H 1.6072 1.3028 0.5772 0.092 Uiso 1 1 calc R . .
C8 C 1.4090(3) 1.4149(3) 0.57613(14) 0.0681(8) Uani 1 1 d . . .
H8A H 1.4643 1.4896 0.5619 0.082 Uiso 1 1 calc R . .
C9 C 1.2442(3) 1.4142(2) 0.58742(14) 0.0674(8) Uani 1 1 d . . .
H9A H 1.1836 1.4894 0.5802 0.081 Uiso 1 1 calc R . .
C10 C 1.1643(3) 1.3075(2) 0.60888(14) 0.0553(7) Uani 1 1 d . . .
H10A H 1.0493 1.3095 0.6166 0.066 Uiso 1 1 calc R . .
C11 C 0.8515(3) 0.9091(2) 0.65994(13) 0.0515(7) Uani 1 1 d . . .
C12 C 0.7953(3) 0.7903(2) 0.70098(14) 0.0521(7) Uani 1 1 d . A .
H12A H 0.8312 0.7178 0.6692 0.063 Uiso 1 1 calc R . .
C13 C 0.8851(3) 0.7769(3) 0.77836(16) 0.0661(8) Uani 1 1 d . . .
C14 C 0.7926(3) 0.6862(3) 0.82809(16) 0.0692(8) Uani 1 1 d . A .
H14A H 0.8393 0.6672 0.8764 0.083 Uiso 1 1 calc R . .
C15 C 0.6542(3) 0.6317(2) 0.81038(16) 0.0638(8) Uani 1 1 d . . .
C16 C 0.5662(3) 0.6554(2) 0.73788(19) 0.0774(9) Uani 1 1 d . A .
H16A H 0.4468 0.6495 0.7466 0.093 Uiso 1 1 calc R . .
H16B H 0.5958 0.5894 0.7009 0.093 Uiso 1 1 calc R . .
C17 C 0.6047(3) 0.7839(2) 0.70369(15) 0.0618(8) Uani 1 1 d . . .
C18 C 0.9083(4) 0.9007(4) 0.82176(18) 0.0973(11) Uani 1 1 d . . .
H18A H 0.9628 0.8840 0.8706 0.146 Uiso 1 1 calc R . .
H18B H 0.8011 0.9391 0.8306 0.146 Uiso 1 1 calc R . .
H18C H 0.9757 0.9579 0.7918 0.146 Uiso 1 1 calc R . .
C19 C 1.0562(4) 0.7231(3) 0.7633(2) 0.0974(12) Uani 1 1 d . . .
H19A H 1.1159 0.7134 0.8116 0.146 Uiso 1 1 calc R . .
H19B H 1.1164 0.7804 0.7302 0.146 Uiso 1 1 calc R . .
H19C H 1.0456 0.6411 0.7385 0.146 Uiso 1 1 calc R . .
C20 C 0.5239(3) 0.8832(3) 0.7531(2) 0.0836(10) Uani 1 1 d . A .
H20A H 0.4047 0.8720 0.7514 0.125 Uiso 1 1 calc R . .
H20B H 0.5515 0.9669 0.7340 0.125 Uiso 1 1 calc R . .
```

```
H20C H 0.5634 0.8747 0.8056 0.125 Uiso 1 1 calc R . .
C21 C 0.5345(4) 0.7886(3) 0.62290(17) 0.0900(10) Uani 1 1 d . A .
H21A H 0.4146 0.7871 0.6247 0.135 Uiso 1 1 calc R . .
H21B H 0.5733 0.7158 0.5942 0.135 Uiso 1 1 calc R . .
H21C H 0.5705 0.8659 0.5979 0.135 Uiso 1 1 calc R . .
C22 C 0.8215(8) 0.3554(7) 0.8637(4) 0.1422(9) Uani 0.50 1 d PD A 1
H22A H 0.9008 0.4236 0.8771 0.171 Uiso 0.50 1 calc PR A 1
C23 C 0.8331(13) 0.3297(9) 0.7817(3) 0.1422(9) Uani 0.50 1 d PD A 1
H23A H 0.9444 0.3021 0.7699 0.213 Uiso 0.50 1 calc PR A 1
H23B H 0.8076 0.4063 0.7531 0.213 Uiso 0.50 1 calc PR A 1
H23C H 0.7549 0.2637 0.7676 0.213 Uiso 0.50 1 calc PR A 1
C24 C 0.8602(13) 0.2405(7) 0.9129(4) 0.1422(9) Uani 0.50 1 d PD A 1
H24A H 0.9702 0.2096 0.9013 0.213 Uiso 0.50 1 calc PR A 1
H24B H 0.7797 0.1744 0.9023 0.213 Uiso 0.50 1 calc PR A 1
H24C H 0.8555 0.2638 0.9667 0.213 Uiso 0.50 1 calc PR A 1
C25 C 0.7134(10) 0.4280(7) 0.9832(3) 0.1422(9) Uani 0.50 1 d PD A 1
H25B H 0.6175 0.4769 1.0020 0.171 Uiso 0.50 1 calc PR A 1
C26 C 0.8289(10) 0.5278(6) 1.0144(5) 0.1422(9) Uani 0.50 1 d PD A 1
H26A H 0.8566 0.5086 1.0675 0.213 Uiso 0.50 1 calc PR A 1
H26B H 0.7755 0.6100 1.0115 0.213 Uiso 0.50 1 calc PR A 1
H26C H 0.9292 0.5291 0.9843 0.213 Uiso 0.50 1 calc PR A 1
C27 C 0.6858(11) 0.3299(6) 1.0445(5) 0.1422(9) Uani 0.50 1 d PD A 1
H27A H 0.7497 0.3520 1.0900 0.213 Uiso 0.50 1 calc PR A 1
H27B H 0.7207 0.2476 1.0259 0.213 Uiso 0.50 1 calc PR A 1
H27C H 0.5692 0.3270 1.0570 0.213 Uiso 0.50 1 calc PR A 1
C28 C 0.4184(8) 0.3230(7) 0.8985(4) 0.1422(9) Uani 0.50 1 d PD A 1
H28A H 0.4391 0.2484 0.9317 0.171 Uiso 0.50 1 calc PR A 1
C29 C 0.3755(12) 0.2765(8) 0.8174(3) 0.1422(9) Uani 0.50 1 d PD A 1
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H29C H 0.3590 0.3489 0.7838 0.213 Uiso 0.50 1 calc PR A 1
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H30A H 0.1910 0.3486 0.9357 0.213 Uiso 0.50 1 calc PR A 1
H30B H 0.2710 0.4721 0.9002 0.213 Uiso 0.50 1 calc PR A 1
H30C H 0.3267 0.4251 0.9829 0.213 Uiso 0.50 1 calc PR A 1
C22' C 0.8045(9) 0.3473(7) 0.8447(4) 0.1422(9) Uani 0.50 1 d PD A 2
H22B H 0.8962 0.4065 0.8568 0.171 Uiso 0.50 1 calc PR A 2
C23' C 0.7830(13) 0.3388(8) 0.7581(3) 0.1422(9) Uani 0.50 1 d PD A 2
H23D H 0.8828 0.3042 0.7358 0.213 Uiso 0.50 1 calc PR A 2
H23E H 0.7625 0.4227 0.7373 0.213 Uiso 0.50 1 calc PR A 2
H23F H 0.6900 0.2839 0.7458 0.213 Uiso 0.50 1 calc PR A 2
C24' C 0.8516(13) 0.2156(7) 0.8725(4) 0.1422(9) Uani 0.50 1 d PD A 2
H24D H 0.9515 0.1882 0.8469 0.213 Uiso 0.50 1 calc PR A 2
H24E H 0.7624 0.1570 0.8607 0.213 Uiso 0.50 1 calc PR A 2
H24F H 0.8712 0.2175 0.9275 0.213 Uiso 0.50 1 calc PR A 2
C25' C 0.5543(8) 0.3829(8) 0.9884(4) 0.1422(9) Uani 0.50 1 d PD A 2
H25A H 0.5700 0.2948 1.0067 0.171 Uiso 0.50 1 calc PR A 2
C26' C 0.6858(8) 0.4797(8) 1.0192(5) 0.1422(9) Uani 0.50 1 d PD A 2
H26D H 0.6775 0.4864 1.0745 0.213 Uiso 0.50 1 calc PR A 2
H26E H 0.6656 0.5621 0.9961 0.213 Uiso 0.50 1 calc PR A 2
H26F H 0.7957 0.4508 1.0059 0.213 Uiso 0.50 1 calc PR A 2
C27' C 0.3881(7) 0.4386(9) 1.0052(5) 0.1422(9) Uani 0.50 1 d PD A 2
H27D H 0.3618 0.4244 1.0586 0.213 Uiso 0.50 1 calc PR A 2
H27E H 0.3048 0.3986 0.9727 0.213 Uiso 0.50 1 calc PR A 2
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H27F H 0.3901 0.5290 0.9949 0.213 Uiso 0.50 1 calc PR A 2
C28' C 0.4503(8) 0.3366(6) 0.8184(5) 0.1422(9) Uani 0.50 1 d PD A 2
H28B H 0.4884 0.3522 0.7655 0.171 Uiso 0.50 1 calc PR A 2
C29' C 0.4363(10) 0.1956(6) 0.8298(5) 0.1422(9) Uani 0.50 1 d PD A 2
H29D H 0.3535 0.1617 0.7947 0.213 Uiso 0.50 1 calc PR A 2
H29E H 0.4041 0.1782 0.8823 0.213 Uiso 0.50 1 calc PR A 2
H29F H 0.5423 0.1561 0.8199 0.213 Uiso 0.50 1 calc PR A 2
C30' C 0.2674(8) 0.3867(7) 0.8248(5) 0.1422(9) Uani 0.50 1 d PD A 2
H30D H 0.1973 0.3427 0.7879 0.213 Uiso 0.50 1 calc PR A 2
H30E H 0.2649 0.4769 0.8142 0.213 Uiso 0.50 1 calc PR A 2
H30F H 0.2272 0.3713 0.8762 0.213 Uiso 0.50 1 calc PR A 2

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O3 0.0617(9) 0.0337(8) 0.0951(11) -0.0010(8) 0.0319(9) -0.0071(7)
O4 0.0675(12) 0.0784(11) 0.1464(16) 0.0598(11) 0.0219(12) 0.0121(10)
N1 0.0462(10) 0.0251(8) 0.0738(11) 0.0029(9) 0.0087(9) 0.0019(9)
C1 0.0510(13) 0.0283(11) 0.0788(16) 0.0020(11) -0.0028(13) 0.0035(11)
C2 0.0662(17) 0.0489(15) 0.0964(19) 0.0000(14) 0.0187(16) 0.0018(13)
C3 0.0442(13) 0.0352(12) 0.0703(15) 0.0032(11) 0.0123(12) -0.0037(10)
C4 0.0467(13) 0.0395(13) 0.0727(15) 0.0087(11) 0.0047(12) -0.0073(11)
C5 0.0482(12) 0.0417(12) 0.0649(15) 0.0015(11) -0.0008(12) -0.0036(11)
C6 0.0492(14) 0.0508(13) 0.0995(19) 0.0078(14) -0.0014(14) -0.0050(13)
C7 0.0490(14) 0.0754(17) 0.106(2) 0.0155(16) 0.0065(15) -0.0290(14)
C8 0.0763(16) 0.0438(13) 0.0847(16) -0.0065(14) 0.0160(14) -0.0208(15)
C9 0.0866(18) 0.0315(11) 0.0840(16) 0.0003(13) 0.0022(15) -0.0012(14)
C10 0.0555(14) 0.0329(12) 0.0776(16) -0.0058(11) 0.0054(13) -0.0064(11)
C11 0.0563(13) 0.0247(10) 0.0735(14) 0.0008(12) 0.0030(12) -0.0017(11)
C12 0.0440(12) 0.0412(12) 0.0712(15) 0.0080(12) 0.0043(12) -0.0086(11)
C13 0.0459(13) 0.0650(15) 0.0871(17) 0.0165(14) -0.0110(13) -0.0117(13)
C14 0.0542(14) 0.0834(17) 0.0697(16) 0.0222(14) -0.0086(13) 0.0009(15)
C15 0.0579(16) 0.0465(13) 0.0874(17) 0.0295(12) 0.0136(14) -0.0024(12)
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C20 0.0439(14) 0.0625(18) 0.144(3) 0.0371(15) 0.0023(16) -0.0022(13)
C21 0.0831(18) 0.0735(17) 0.112(2) 0.0378(16) -0.0463(16) -0.0203(16)
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C26 0.1533(17) 0.1311(15) 0.1419(16) 0.0133(15) -0.0074(16) 0.0026(14)
C27 0.1533(17) 0.1311(15) 0.1419(16) 0.0133(15) -0.0074(16) 0.0026(14)
C28 0.1533(17) 0.1311(15) 0.1419(16) 0.0133(15) -0.0074(16) 0.0026(14)
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C29 0.1533(17) 0.1311(15) 0.1419(16) 0.0133(15) -0.0074(16) 0.0026(14)
C30 0.1533(17) 0.1311(15) 0.1419(16) 0.0133(15) -0.0074(16) 0.0026(14)
C22' 0.1533(17) 0.1311(15) 0.1419(16) 0.0133(15) -0.0074(16) 0.0026(14)
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 All esds (except the esd in the dihedral angle between two l.s. planes)
 are estimated using the full covariance matrix.  The cell esds are taken
 into account individually in the estimation of esds in distances, angles
 and torsion angles; correlations between esds in cell parameters are
only
 used when they are defined by crystal symmetry.  An approximate
(isotropic)
 treatment of cell esds is used for estimating esds involving l.s.
planes.
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Si1 C22' 1.898(7) . ?
Si1 C25 1.876(6) . ?
Si1 C28' 1.940(7) . ?
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O1 C2 1.420(3) . ?
O2 C1 1.195(3) . ?
O3 C11 1.204(3) . ?
O4 C15 1.357(3) . ?
N1 C1 1.356(3) . ?
N1 C11 1.410(3) . ?
N1 C3 1.488(3) . ?
C2 C3 1.529(4) . ?
C3 C4 1.522(3) . ?
C4 C5 1.507(3) . ?
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C5 C10 1.375(3) . ?
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C7 C8 1.370(4) . ?
C8 C9 1.363(4) . ?
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C25 C26 1.520(9) . ?
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C28 C29 1.548(9) . ?
C22' C24' 1.534(9) . ?
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C25' Si1 C22 114.1(3) . . ?
O4 Si1 C22' 108.9(2) . . ?
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C25' Si1 C22' 123.2(3) . . ?
C22 Si1 C22' 11.2(3) . . ?
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C25' Si1 C25 43.9(3) . . ?
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C22' Si1 C28' 99.3(3) . . ?
C25 Si1 C28' 154.3(3) . . ?
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C1 N1 C3 112.21(18) . . ?
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O2 C1 O1 120.1(2) . . ?
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O1 C2 C3 106.0(2) . . ?
N1 C3 C2 100.58(18) . . ?
N1 C3 C4 111.83(19) . . ?
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C7 C8 C9 117.9(2) . . ?
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C9 C10 C5 120.4(2) . . ?
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O3 C11 C12 123.6(2) . . ?
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C11 C12 C17 110.82(19) . . ?
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C14 C13 C12 109.5(2) . . ?
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C24' C22' C23' 106.7(6) . . ?
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C5 C6 C7 C8 1.0(4) . . . . ?
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C4 C5 C10 C9 178.6(2) . . . . ?
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C22' Si1 C25 C26 78.7(8) . . . . ?
C28' Si1 C25 C26 -166.5(7) . . . . ?
O4 Si1 C25 C27 148.7(6) . . . . ?
C28 Si1 C25 C27 28.2(7) . . . . ?
C25' Si1 C25 C27 39.0(6) . . . . ?
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C22' Si1 C25 C27 -101.2(7) . . . . ?
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C22' Si1 C28 C29 -54.6(6) . . . . ?
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C28' Si1 C28 C29 9.2(5) . . . . ?
O4 Si1 C22' C24' 177.6(5) . . . . ?
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C25 Si1 C22' C24' 70.6(6) . . . . ?
C28' Si1 C22' C24' -85.9(6) . . . . ?
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C25' Si1 C22' C23' 157.8(5) . . . . ?
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C25 Si1 C22' C23' -170.2(6) . . . . ?
C28' Si1 C22' C23' 33.3(6) . . . . ?
O4 Si1 C25' C27' 45.7(6) . . . . ?
C28 Si1 C25' C27' -58.3(6) . . . . ?
C22 Si1 C25' C27' 175.1(5) . . . . ?
C22' Si1 C25' C27' -177.4(5) . . . . ?
C25 Si1 C25' C27' 132.7(8) . . . . ?
C28' Si1 C25' C27' -58.9(6) . . . . ?
O4 Si1 C25' C26' -63.3(5) . . . . ?
C28 Si1 C25' C26' -167.3(6) . . . . ?
C22 Si1 C25' C26' 66.2(5) . . . . ?
C22' Si1 C25' C26' 73.6(6) . . . . ?
C25 Si1 C25' C26' 23.7(5) . . . . ?
C28' Si1 C25' C26' -167.9(4) . . . . ?
O4 Si1 C28' C29' -178.2(5) . . . . ?
C28 Si1 C28' C29' -60.7(6) . . . . ?
C25' Si1 C28' C29' -59.8(6) . . . . ?
C22 Si1 C28' C29' 68.3(6) . . . . ?
C22' Si1 C28' C29' 72.0(6) . . . . ?
C25 Si1 C28' C29' -41.1(10) . . . . ?
O4 Si1 C28' C30' -58.9(6) . . . . ?
C28 Si1 C28' C30' 58.7(6) . . . . ?
C25' Si1 C28' C30' 59.5(6) . . . . ?
C22 Si1 C28' C30' -172.3(5) . . . . ?
C22' Si1 C28' C30' -168.7(6) . . . . ?
C25 Si1 C28' C30' 78.3(9) . . . . ?

_diffrn_measured_fraction_theta_max    0.986
_diffrn_reflns_theta_full              23.32
_diffrn_measured_fraction_theta_full   0.986
_refine_diff_density_max    0.436
_refine_diff_density_min   -0.267
_refine_diff_density_rms    0.051
```

```
TITL lb085 in P2(1)
CELL 0.71073   8.1637  10.6578  17.6018  90.000  90.655  90.000
ZERR    2.00   0.0004   0.0005   0.0009   0.000   0.003   0.000
LATT -1
SYMM -X, 0.5+Y, -Z
SFAC C H N O Si
UNIT 60 94 2 8 2
TEMP -73.15C
SIZE 0.02 0.15 0.24

L.S. 190
BOND
FMAP 2
PLAN 5
ACTA
CONF
DAMP 3000

SADI C22 Si1 C25 Si1 C28 Si1 C22' Si1 C25' Si1 C28' Si1
DFIX 1.52 0.02 C22 C23 C22 C24 C25 C26 C25 C27 C28 C29 C28 C30
DFIX 1.52 0.02 C22' C23' C22' C24' C25' C26' C25' C27' C28' C29' C28'
C30'
EADP C22 C23 C24 C25 C26 C27 C28 C29 C30 =
 C22' C23' C24' C25' C26' C27' C28' C29' C30'
SADI C23 C24 C23' C24' C26 C27 C26' C27' C29 C30 C29' C30'
OMIT     2   0   4
OMIT    -3   2  10
OMIT     3   0   3
OMIT     0   0   3
OMIT    -5  -1   4
OMIT    -3  -2  10
OMIT    -5   1   4
OMIT    -2   0   4
OMIT     3   0   2
OMIT    -3   0  10
OMIT    -2  -1   4
OMIT    -3   2  11
OMIT     6  -1   0
OMIT     0  -4   6
OMIT    -4  -3   6
OMIT    -3   1   7
OMIT    -1  -4   5
OMIT    -2   1   4
OMIT     3   0   8
OMIT     0   4   6
OMIT    -3   0   4
OMIT    -3  -1  10
OMIT    -2  -2   5
OMIT    -3  -5   6
OMIT    -1  -3   6
OMIT    -2   2   5
OMIT    -4  -6   3
OMIT     4   0   0
OMIT    -6   6   2
```

```
OMIT    -2   1  11
OMIT    -3   4  12
OMIT    -3   5   6
OMIT     0  -4   0
OMIT     1   0   0
OMIT    -3  -1   7
OMIT     6   1   0
OMIT    -4  -5  11
OMIT    -2   1   3
OMIT    -4  -5  15
OMIT    -3   7   1
OMIT    -3  -2  11
OMIT    -3   0   7
OMIT    -4   0   9

WGHT    0.122100    0.276100
FVAR       0.25512
SI1   5    0.609012    0.409327    0.888394    11.00000    0.08351
0.06838 =
         0.08120    0.03717    0.02287    0.01141
O1    4    1.150080    0.836046    0.519386    11.00000    0.05848
0.03433 =
         0.08242   -0.01112    0.01292    0.01106
O2    4    1.003433    0.690053    0.576743    11.00000    0.08112
0.02180 =
         0.10704   -0.00557    0.01220    0.00147
O3    4    0.796896    1.011885    0.672375    11.00000    0.06173
0.03372 =
         0.09514   -0.00097    0.03187   -0.00714
O4    4    0.576077    0.551226    0.857521    11.00000    0.06754
0.07838 =
         0.14642    0.05980    0.02189    0.01212
N1    3    0.981474    0.901109    0.608101    11.00000    0.04623
0.02513 =
         0.07380    0.00289    0.00871    0.00186
C1    1    1.037723    0.798587    0.571028    11.00000    0.05102
0.02835 =
         0.07882    0.00201   -0.00278    0.00355
C2    1    1.161366    0.968801    0.515547    11.00000    0.06618
0.04890 =
         0.09636    0.00000    0.01867    0.00175
AFIX  23
H2A   2    1.116293    0.999851    0.466594    11.00000   -1.20000
H2B   2    1.276942    0.996078    0.520356    11.00000   -1.20000
AFIX   0
C3    1    1.061041    1.018721    0.581837    11.00000    0.04416
0.03519 =
         0.07035    0.00322    0.01233   -0.00366
AFIX  13
H3A   2    0.975979    1.078675    0.562581    11.00000   -1.20000
AFIX   0
C4    1    1.162071    1.080269    0.644759    11.00000    0.04668
0.03947 =
         0.07269    0.00874    0.00469   -0.00733
```

```
AFIX  23
H4A   2    1.089023    1.101708    0.687351    11.00000   -1.20000
H4B   2    1.244195    1.019320    0.663925    11.00000   -1.20000
AFIX   0
C5    1    1.249237    1.197383    0.619307    11.00000    0.04816
0.04165 =
         0.06489    0.00147   -0.00082   -0.00355
C6    1    1.415458    1.195787    0.607906    11.00000    0.04924
0.05081 =
         0.09948    0.00784   -0.00138   -0.00501
AFIX  43
H6A   2    1.476315    1.120667    0.615121    11.00000   -1.20000
AFIX   0
C7    1    1.492549    1.304415    0.585908    11.00000    0.04896
0.07538 =
         0.10566    0.01551    0.00648   -0.02896
AFIX  43
H7A   2    1.607172    1.302820    0.577233    11.00000   -1.20000
AFIX   0
C8    1    1.409012    1.414863    0.576127    11.00000    0.07626
0.04376 =
         0.08469   -0.00645    0.01597   -0.02077
AFIX  43
H8A   2    1.464290    1.489555    0.561916    11.00000   -1.20000
AFIX   0
C9    1    1.244164    1.414195    0.587424    11.00000    0.08663
0.03154 =
         0.08400    0.00028    0.00219   -0.00118
AFIX  43
H9A   2    1.183570    1.489446    0.580235    11.00000   -1.20000
AFIX   0
C10   1    1.164254    1.307536    0.608875    11.00000    0.05550
0.03286 =
         0.07759   -0.00584    0.00538   -0.00641
AFIX  43
H10A  2    1.049311    1.309480    0.616629    11.00000   -1.20000
AFIX   0
C11   1    0.851503    0.909072    0.659936    11.00000    0.05625
0.02466 =
         0.07355    0.00079    0.00304   -0.00167
C12   1    0.795263    0.790264    0.700979    11.00000    0.04404
0.04115 =
         0.07116    0.00803    0.00433   -0.00863
AFIX  13
H12A  2    0.831210    0.717803    0.669158    11.00000   -1.20000
AFIX   0
C13   1    0.885054    0.776870    0.778360    11.00000    0.04590
0.06501 =
         0.08714    0.01652   -0.01100   -0.01174
C14   1    0.792598    0.686161    0.828090    11.00000    0.05415
0.08339 =
         0.06974    0.02221   -0.00859    0.00093
AFIX  43
H14A  2    0.839301    0.667189    0.876420    11.00000   -1.20000
```

```
AFIX   0
C15   1    0.654187    0.631660    0.810382    11.00000    0.05792
0.04652 =
         0.08737    0.02955    0.01360   -0.00237
C16   1    0.566155    0.655403    0.737880    11.00000    0.04815
0.06197 =
         0.12160    0.04087   -0.02237   -0.01597
AFIX  23
H16A  2    0.446810    0.649504    0.746585    11.00000   -1.20000
H16B  2    0.595821    0.589381    0.700943    11.00000   -1.20000
AFIX   0
C17   1    0.604694    0.783889    0.703691    11.00000    0.04217
0.04947 =
         0.09366    0.02843   -0.00536   -0.01370
C18   1    0.908269    0.900672    0.821764    11.00000    0.09976
0.10402 =
         0.08729    0.00882   -0.02911   -0.03196
AFIX  33
H18A  2    0.962756    0.884022    0.870630    11.00000   -1.50000
H18B  2    0.801138    0.939150    0.830606    11.00000   -1.50000
H18C  2    0.975731    0.957866    0.791763    11.00000   -1.50000
AFIX   0
C19   1    1.056236    0.723054    0.763279    11.00000    0.05522
0.10820 =
         0.12830    0.04679   -0.02519   -0.00726
AFIX  33
H19A  2    1.115885    0.713390    0.811557    11.00000   -1.50000
H19B  2    1.116436    0.780358    0.730185    11.00000   -1.50000
H19C  2    1.045569    0.641090    0.738477    11.00000   -1.50000
AFIX   0
C20   1    0.523861    0.883240    0.753094    11.00000    0.04389
0.06251 =
         0.14435    0.03714    0.00231   -0.00216
AFIX  33
H20A  2    0.404739    0.871954    0.751421    11.00000   -1.50000
H20B  2    0.551463    0.966893    0.733994    11.00000   -1.50000
H20C  2    0.563440    0.874714    0.805614    11.00000   -1.50000
AFIX   0
C21   1    0.534488    0.788599    0.622902    11.00000    0.08310
0.07352 =
         0.11231    0.03778   -0.04625   -0.02028
AFIX  33
H21A  2    0.414569    0.787127    0.624719    11.00000   -1.50000
H21B  2    0.573325    0.715839    0.594220    11.00000   -1.50000
H21C  2    0.570541    0.865852    0.597949    11.00000   -1.50000
AFIX   0
PART   1
C22   1    0.821536    0.355416    0.863653    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  13
H22A  2    0.900808    0.423635    0.877105    10.50000   -1.20000
AFIX   0
```

```
C23   1    0.833053    0.329724    0.781710    10.50000    0.15332
0.13112 =
          0.14189    0.01328   -0.00744    0.00255
AFIX  33
H23A  2    0.944385    0.302065    0.769912    10.50000   -1.50000
H23B  2    0.807580    0.406277    0.753084    10.50000   -1.50000
H23C  2    0.754860    0.263727    0.767586    10.50000   -1.50000
AFIX   0
C24   1    0.860237    0.240465    0.912900    10.50000    0.15332
0.13112 =
          0.14189    0.01328   -0.00744    0.00255
AFIX  33
H24A  2    0.970227    0.209642    0.901256    10.50000   -1.50000
H24B  2    0.779718    0.174374    0.902274    10.50000   -1.50000
H24C  2    0.855528    0.263827    0.966680    10.50000   -1.50000
AFIX   0
C25   1    0.713381    0.427981    0.983216    10.50000    0.15332
0.13112 =
          0.14189    0.01328   -0.00744    0.00255
AFIX  13
H25B  2    0.617494    0.476890    1.002024    10.50000   -1.20000
AFIX   0
C26   1    0.828929    0.527803    1.014406    10.50000    0.15332
0.13112 =
          0.14189    0.01328   -0.00744    0.00255
AFIX  33
H26A  2    0.856573    0.508615    1.067472    10.50000   -1.50000
H26B  2    0.775513    0.610040    1.011531    10.50000   -1.50000
H26C  2    0.929184    0.529103    0.984320    10.50000   -1.50000
AFIX   0
C27   1    0.685787    0.329948    1.044488    10.50000    0.15332
0.13112 =
          0.14189    0.01328   -0.00744    0.00255
AFIX  33
H27A  2    0.749687    0.352035    1.090024    10.50000   -1.50000
H27B  2    0.720708    0.247587    1.025948    10.50000   -1.50000
H27C  2    0.569179    0.327027    1.056990    10.50000   -1.50000
AFIX   0
C28   1    0.418385    0.322951    0.898481    10.50000    0.15332
0.13112 =
          0.14189    0.01328   -0.00744    0.00255
AFIX  13
H28A  2    0.439082    0.248374    0.931703    10.50000   -1.20000
AFIX   0
C29   1    0.375533    0.276527    0.817350    10.50000    0.15332
0.13112 =
          0.14189    0.01328   -0.00744    0.00255
AFIX  33
H29A  2    0.274949    0.226420    0.818648    10.50000   -1.50000
H29B  2    0.465482    0.224897    0.798272    10.50000   -1.50000
H29C  2    0.359032    0.348866    0.783755    10.50000   -1.50000
AFIX   0
C30   1    0.291630    0.398213    0.931997    10.50000    0.15332
0.13112 =
```

```
         0.14189    0.01328   -0.00744    0.00255
AFIX  33
H30A  2    0.190990    0.348575    0.935709    10.50000   -1.50000
H30B  2    0.270992    0.472145    0.900197    10.50000   -1.50000
H30C  2    0.326699    0.425107    0.982879    10.50000   -1.50000
AFIX   0
PART   2
C22'  1    0.804452    0.347319    0.844742    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  13
H22B  2    0.896156    0.406510    0.856821    10.50000   -1.20000
AFIX   0
C23'  1    0.783008    0.338762    0.758053    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  33
H23D  2    0.882829    0.304208    0.735803    10.50000   -1.50000
H23E  2    0.762480    0.422688    0.737283    10.50000   -1.50000
H23F  2    0.690036    0.283934    0.745786    10.50000   -1.50000
AFIX   0
C24'  1    0.851631    0.215600    0.872458    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  33
H24D  2    0.951460    0.188236    0.846875    10.50000   -1.50000
H24E  2    0.762410    0.156957    0.860723    10.50000   -1.50000
H24F  2    0.871168    0.217454    0.927485    10.50000   -1.50000
AFIX   0
C25'  1    0.554257    0.382884    0.988416    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  13
H25A  2    0.570047    0.294808    1.006664    10.50000   -1.20000
AFIX   0
C26'  1    0.685768    0.479741    1.019159    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  33
H26D  2    0.677523    0.486361    1.074516    10.50000   -1.50000
H26E  2    0.665598    0.562115    0.996147    10.50000   -1.50000
H26F  2    0.795731    0.450808    1.005879    10.50000   -1.50000
AFIX   0
C27'  1    0.388103    0.438613    1.005152    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  33
H27D  2    0.361756    0.424359    1.058641    10.50000   -1.50000
H27E  2    0.304837    0.398603    0.972746    10.50000   -1.50000
H27F  2    0.390081    0.528980    0.994910    10.50000   -1.50000
AFIX   0
C28'  1    0.450273    0.336560    0.818407    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
```

```
AFIX  13
H28B  2    0.488414    0.352176    0.765456    10.50000   -1.20000
AFIX   0
C29'  1    0.436273    0.195592    0.829841    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  33
H29D  2    0.353457    0.161679    0.794717    10.50000   -1.50000
H29E  2    0.404054    0.178163    0.882255    10.50000   -1.50000
H29F  2    0.542285    0.156067    0.819920    10.50000   -1.50000
AFIX   0
C30'  1    0.267370    0.386672    0.824800    10.50000    0.15332
0.13112 =
         0.14189    0.01328   -0.00744    0.00255
AFIX  33
H30D  2    0.197337    0.342666    0.787892    10.50000   -1.50000
H30E  2    0.264906    0.476935    0.814226    10.50000   -1.50000
H30F  2    0.227204    0.371284    0.876221    10.50000   -1.50000
PART   0

HKLF 4

REM  lb085 in P2(1)
REM R1 =  0.0735 for   3003 Fo > 4sig(Fo)  and  0.1068 for all   4308
data
REM    304 parameters refined using     43 restraints

END

WGHT      0.1242      0.2498
REM Highest difference peak  0.436,  deepest hole -0.267,  1-sigma level
0.051
Q1    1   0.6264  0.3204  0.8047  11.00000  0.05    0.44
Q2    1   0.6552  0.4074  1.0623  11.00000  0.05    0.30
Q3    1   0.8273  0.3581  0.7621  11.00000  0.05    0.24
Q4    1   0.8699  0.2981  0.9784  11.00000  0.05    0.22
Q5    1   0.6281  0.1980  0.8008  11.00000  0.05    0.22
```

Table 1. Crystal data and structure refinement for lb085.

Identification code	lb085
Empirical formula	C30 H47 N O4 Si
Formula weight	513.78
Temperature	200(2) K
Wavelength	0.71073 A
Crystal system, space group	Monoclinic, P2(1)
Unit cell dimensions	a = 8.1637(4) A alpha = 90 deg. b = 10.6578(5) A beta = 90.655(3) deg. c = 17.6018(9) A gamma = 90 deg.
Volume	1531.38(13) A^3
Z, Calculated density	2, 1.114 Mg/m^3
Absorption coefficient	0.109 mm^-1
F(000)	560
Crystal size	0.24 x 0.15 x 0.02 mm
Theta range for data collection	2.23 to 23.32 deg.
Limiting indices	-9<=h<=8, -11<=k<=11, -19<=l<=19
Reflections collected / unique	19571 / 4308 [R(int) = 0.0553]
Completeness to theta = 23.32	98.6 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9978 and 0.9743
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4308 / 43 / 304
Goodness-of-fit on F^2	1.037
Final R indices [I>2sigma(I)]	R1 = 0.0735, wR2 = 0.1810
R indices (all data)	R1 = 0.1068, wR2 = 0.2013
Absolute structure parameter	-0.2(3)

```
Largest diff. peak and hole       0.436 and -0.267 e.A^-3
```

Table 2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for lb085.
U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
Si(1)	6090(1)	4093(1)	8884(1)	78(1)
O(1)	11501(2)	8360(1)	5194(1)	58(1)
O(2)	10034(2)	6900(1)	5767(1)	70(1)
O(3)	7969(2)	10119(1)	6724(1)	63(1)
O(4)	5761(2)	5512(2)	8575(1)	97(1)
N(1)	9815(2)	9011(2)	6081(1)	48(1)
C(1)	10377(3)	7986(2)	5710(1)	53(1)
C(2)	11614(3)	9688(2)	5156(2)	70(1)
C(3)	10610(3)	10187(2)	5818(1)	50(1)
C(4)	11621(3)	10803(2)	6448(1)	53(1)
C(5)	12492(3)	11974(2)	6193(1)	52(1)
C(6)	14155(3)	11958(3)	6079(2)	66(1)
C(7)	14925(3)	13044(3)	5859(2)	77(1)
C(8)	14090(3)	14149(3)	5761(1)	68(1)
C(9)	12442(3)	14142(2)	5874(1)	67(1)
C(10)	11643(3)	13075(2)	6089(1)	55(1)
C(11)	8515(3)	9091(2)	6599(1)	52(1)
C(12)	7953(3)	7903(2)	7010(1)	52(1)
C(13)	8851(3)	7769(3)	7784(2)	66(1)
C(14)	7926(3)	6862(3)	8281(2)	69(1)
C(15)	6542(3)	6317(2)	8104(2)	64(1)
C(16)	5662(3)	6554(2)	7379(2)	77(1)
C(17)	6047(3)	7839(2)	7037(2)	62(1)
C(18)	9083(4)	9007(4)	8218(2)	97(1)
C(19)	10562(4)	7231(3)	7633(2)	97(1)
C(20)	5239(3)	8832(3)	7531(2)	84(1)
C(21)	5345(4)	7886(3)	6229(2)	90(1)
C(22)	8215(8)	3554(7)	8637(4)	142(1)
C(23)	8331(13)	3297(9)	7817(3)	142(1)
C(24)	8602(13)	2405(7)	9129(4)	142(1)
C(25)	7134(10)	4280(7)	9832(3)	142(1)
C(26)	8289(10)	5278(6)	10144(5)	142(1)
C(27)	6858(11)	3299(6)	10445(5)	142(1)
C(28)	4184(8)	3230(7)	8985(4)	142(1)
C(29)	3755(12)	2765(8)	8174(3)	142(1)
C(30)	2916(10)	3982(8)	9320(4)	142(1)
C(22')	8045(9)	3473(7)	8447(4)	142(1)
C(23')	7830(13)	3388(8)	7581(3)	142(1)
C(24')	8516(13)	2156(7)	8725(4)	142(1)
C(25')	5543(8)	3829(8)	9884(4)	142(1)
C(26')	6858(8)	4797(8)	10192(5)	142(1)
C(27')	3881(7)	4386(9)	10052(5)	142(1)
C(28')	4503(8)	3366(6)	8184(5)	142(1)

C(29')	4363(10)	1956(6)	8298(5)	142(1)
C(30')	2674(8)	3867(7)	8248(5)	142(1)

Table 3. Bond lengths [A] and angles [deg] for lb085.

Si(1)-O(4)	1.628(2)
Si(1)-C(28)	1.819(7)
Si(1)-C(25')	1.843(6)
Si(1)-C(22)	1.883(7)
Si(1)-C(22')	1.898(7)
Si(1)-C(25)	1.876(6)
Si(1)-C(28')	1.940(7)
O(1)-C(1)	1.359(3)
O(1)-C(2)	1.420(3)
O(2)-C(1)	1.195(3)
O(3)-C(11)	1.204(3)
O(4)-C(15)	1.357(3)
N(1)-C(1)	1.356(3)
N(1)-C(11)	1.410(3)
N(1)-C(3)	1.488(3)
C(2)-C(3)	1.529(4)
C(3)-C(4)	1.522(3)
C(4)-C(5)	1.507(3)
C(5)-C(6)	1.374(3)
C(5)-C(10)	1.375(3)
C(6)-C(7)	1.375(4)
C(7)-C(8)	1.370(4)
C(8)-C(9)	1.363(4)
C(9)-C(10)	1.366(4)
C(11)-C(12)	1.531(3)
C(12)-C(13)	1.546(4)
C(12)-C(17)	1.559(3)
C(13)-C(14)	1.512(4)
C(13)-C(18)	1.535(5)
C(13)-C(19)	1.537(4)
C(14)-C(15)	1.305(4)
C(15)-C(16)	1.479(4)
C(16)-C(17)	1.530(4)
C(17)-C(20)	1.525(4)
C(17)-C(21)	1.528(4)
C(22)-C(23)	1.472(9)
C(22)-C(24)	1.532(9)
C(25)-C(26)	1.520(9)
C(25)-C(27)	1.520(9)
C(28)-C(30)	1.441(9)
C(28)-C(29)	1.548(9)
C(22')-C(24')	1.534(9)
C(22')-C(23')	1.537(9)
C(25')-C(27')	1.513(9)
C(25')-C(26')	1.580(10)
C(28')-C(29')	1.520(9)
C(28')-C(30')	1.591(9)
O(4)-Si(1)-C(28)	111.4(3)
O(4)-Si(1)-C(25')	114.8(3)

C(28)-Si(1)-C(25')	67.2(3)
O(4)-Si(1)-C(22)	110.8(2)
C(28)-Si(1)-C(22)	131.3(3)
C(25')-Si(1)-C(22)	114.1(3)
O(4)-Si(1)-C(22')	108.9(2)
C(28)-Si(1)-C(22')	126.0(3)
C(25')-Si(1)-C(22')	123.2(3)
C(22)-Si(1)-C(22')	11.2(3)
O(4)-Si(1)-C(25)	105.7(3)
C(28)-Si(1)-C(25)	110.3(3)
C(25')-Si(1)-C(25)	43.9(3)
C(22)-Si(1)-C(25)	80.1(3)
C(22')-Si(1)-C(25)	91.2(3)
O(4)-Si(1)-C(28')	93.0(2)
C(28)-Si(1)-C(28')	45.0(3)
C(25')-Si(1)-C(28')	112.2(3)
C(22)-Si(1)-C(28')	110.0(3)
C(22')-Si(1)-C(28')	99.3(3)
C(25)-Si(1)-C(28')	154.3(3)
C(1)-O(1)-C(2)	111.68(18)
C(15)-O(4)-Si(1)	135.54(18)
C(1)-N(1)-C(11)	128.44(19)
C(1)-N(1)-C(3)	112.21(18)
C(11)-N(1)-C(3)	119.00(18)
O(2)-C(1)-N(1)	131.2(2)
O(2)-C(1)-O(1)	120.1(2)
N(1)-C(1)-O(1)	108.68(18)
O(1)-C(2)-C(3)	106.0(2)
N(1)-C(3)-C(2)	100.58(18)
N(1)-C(3)-C(4)	111.83(19)
C(2)-C(3)-C(4)	114.5(2)
C(5)-C(4)-C(3)	113.2(2)
C(6)-C(5)-C(10)	119.3(2)
C(6)-C(5)-C(4)	120.2(2)
C(10)-C(5)-C(4)	120.5(2)
C(5)-C(6)-C(7)	119.1(2)
C(8)-C(7)-C(6)	122.0(2)
C(7)-C(8)-C(9)	117.9(2)
C(10)-C(9)-C(8)	121.3(3)
C(9)-C(10)-C(5)	120.4(2)
O(3)-C(11)-N(1)	117.1(2)
O(3)-C(11)-C(12)	123.6(2)
N(1)-C(11)-C(12)	119.2(2)
C(11)-C(12)-C(13)	110.51(19)
C(11)-C(12)-C(17)	110.82(19)
C(13)-C(12)-C(17)	115.6(2)
C(14)-C(13)-C(18)	108.7(2)
C(14)-C(13)-C(12)	109.5(2)
C(18)-C(13)-C(12)	114.4(2)
C(14)-C(13)-C(19)	108.8(2)
C(18)-C(13)-C(19)	107.4(2)
C(12)-C(13)-C(19)	107.8(2)
C(15)-C(14)-C(13)	125.7(3)
C(14)-C(15)-O(4)	123.1(3)

C(14)-C(15)-C(16)	122.7(2)
O(4)-C(15)-C(16)	114.1(2)
C(15)-C(16)-C(17)	113.1(2)
C(20)-C(17)-C(21)	110.3(2)
C(20)-C(17)-C(16)	107.8(2)
C(21)-C(17)-C(16)	108.6(2)
C(20)-C(17)-C(12)	115.2(2)
C(21)-C(17)-C(12)	109.5(2)
C(16)-C(17)-C(12)	105.12(19)
C(23)-C(22)-C(24)	113.0(6)
C(23)-C(22)-Si(1)	110.6(6)
C(24)-C(22)-Si(1)	107.3(5)
C(26)-C(25)-C(27)	108.7(6)
C(26)-C(25)-Si(1)	132.0(5)
C(27)-C(25)-Si(1)	119.3(5)
C(30)-C(28)-C(29)	113.6(6)
C(30)-C(28)-Si(1)	112.2(6)
C(29)-C(28)-Si(1)	104.9(5)
C(24')-C(22')-C(23')	106.7(6)
C(24')-C(22')-Si(1)	113.5(6)
C(23')-C(22')-Si(1)	109.6(5)
C(27')-C(25')-C(26')	106.5(6)
C(27')-C(25')-Si(1)	110.7(5)
C(26')-C(25')-Si(1)	93.2(5)
C(29')-C(28')-C(30')	104.5(6)
C(29')-C(28')-Si(1)	111.2(5)
C(30')-C(28')-Si(1)	116.2(5)

Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters (A^2 x 10^3) for lb085.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
Si(1)	84(1)	68(1)	81(1)	37(1)	23(1)	11(1)
O(1)	58(1)	34(1)	82(1)	-11(1)	13(1)	11(1)
O(2)	81(1)	22(1)	107(1)	-6(1)	12(1)	2(1)
O(3)	62(1)	34(1)	95(1)	-1(1)	32(1)	-7(1)
O(4)	68(1)	78(1)	146(2)	60(1)	22(1)	12(1)
N(1)	46(1)	25(1)	74(1)	3(1)	9(1)	2(1)
C(1)	51(1)	28(1)	79(2)	2(1)	-3(1)	4(1)
C(2)	66(2)	49(2)	96(2)	0(1)	19(2)	2(1)
C(3)	44(1)	35(1)	70(2)	3(1)	12(1)	-4(1)
C(4)	47(1)	40(1)	73(2)	9(1)	5(1)	-7(1)
C(5)	48(1)	42(1)	65(2)	2(1)	-1(1)	-4(1)
C(6)	49(1)	51(1)	100(2)	8(1)	-1(1)	-5(1)
C(7)	49(1)	75(2)	106(2)	16(2)	6(2)	-29(1)
C(8)	76(2)	44(1)	85(2)	-6(1)	16(1)	-21(2)
C(9)	87(2)	32(1)	84(2)	0(1)	2(2)	-1(1)
C(10)	56(1)	33(1)	78(2)	-6(1)	5(1)	-6(1)
C(11)	56(1)	25(1)	74(1)	1(1)	3(1)	-2(1)
C(12)	44(1)	41(1)	71(2)	8(1)	4(1)	-9(1)
C(13)	46(1)	65(2)	87(2)	16(1)	-11(1)	-12(1)
C(14)	54(1)	83(2)	70(2)	22(1)	-9(1)	1(2)
C(15)	58(2)	46(1)	87(2)	30(1)	14(1)	-2(1)
C(16)	48(1)	62(2)	122(2)	41(1)	-22(1)	-16(1)
C(17)	42(1)	50(1)	94(2)	28(1)	-5(1)	-14(1)
C(18)	100(2)	104(2)	87(2)	9(2)	-29(2)	-32(2)
C(19)	55(2)	108(2)	128(2)	47(2)	-25(2)	-7(2)
C(20)	44(1)	62(2)	144(3)	37(2)	2(2)	-2(1)
C(21)	83(2)	74(2)	112(2)	38(2)	-46(2)	-20(2)
C(22)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(23)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(24)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(25)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(26)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(27)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(28)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(29)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(30)	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(22')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(23')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(24')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(25')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(26')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(27')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)

C(28')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(29')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)
C(30')	153(2)	131(2)	142(2)	13(2)	-7(2)	3(1)

Table 5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for lb085.

	x	y	z	U(eq)
H(2A)	11163	9999	4666	84
H(2B)	12769	9961	5204	84
H(3A)	9760	10787	5626	60
H(4A)	10890	11017	6874	63
H(4B)	12442	10193	6639	63
H(6A)	14763	11207	6151	80
H(7A)	16072	13028	5772	92
H(8A)	14643	14896	5619	82
H(9A)	11836	14894	5802	81
H(10A)	10493	13095	6166	66
H(12A)	8312	7178	6692	63
H(14A)	8393	6672	8764	83
H(16A)	4468	6495	7466	93
H(16B)	5958	5894	7009	93
H(18A)	9628	8840	8706	146
H(18B)	8011	9391	8306	146
H(18C)	9757	9579	7918	146
H(19A)	11159	7134	8116	146
H(19B)	11164	7804	7302	146
H(19C)	10456	6411	7385	146
H(20A)	4047	8720	7514	125
H(20B)	5515	9669	7340	125
H(20C)	5634	8747	8056	125
H(21A)	4146	7871	6247	135
H(21B)	5733	7158	5942	135
H(21C)	5705	8659	5979	135
H(22A)	9008	4236	8771	171
H(23A)	9444	3021	7699	213
H(23B)	8076	4063	7531	213
H(23C)	7549	2637	7676	213
H(24A)	9702	2096	9013	213
H(24B)	7797	1744	9023	213
H(24C)	8555	2638	9667	213
H(25B)	6175	4769	10020	171
H(26A)	8566	5086	10675	213
H(26B)	7755	6100	10115	213
H(26C)	9292	5291	9843	213
H(27A)	7497	3520	10900	213
H(27B)	7207	2476	10259	213
H(27C)	5692	3270	10570	213
H(28A)	4391	2484	9317	171
H(29A)	2749	2264	8186	213
H(29B)	4655	2249	7983	213
H(29C)	3590	3489	7838	213
H(30A)	1910	3486	9357	213

H(30B)	2710	4721	9002	213
H(30C)	3267	4251	9829	213
H(22B)	8962	4065	8568	171
H(23D)	8828	3042	7358	213
H(23E)	7625	4227	7373	213
H(23F)	6900	2839	7458	213
H(24D)	9515	1882	8469	213
H(24E)	7624	1570	8607	213
H(24F)	8712	2175	9275	213
H(25A)	5700	2948	10067	171
H(26D)	6775	4864	10745	213
H(26E)	6656	5621	9961	213
H(26F)	7957	4508	10059	213
H(27D)	3618	4244	10586	213
H(27E)	3048	3986	9727	213
H(27F)	3901	5290	9949	213
H(28B)	4884	3522	7655	171
H(29D)	3535	1617	7947	213
H(29E)	4041	1782	8823	213
H(29F)	5423	1561	8199	213
H(30D)	1973	3427	7879	213
H(30E)	2649	4769	8142	213
H(30F)	2272	3713	8762	213

Table 6. Torsion angles [deg] for lb085.

C(28)-Si(1)-O(4)-C(15)	-144.0(3)
C(25')-Si(1)-O(4)-C(15)	142.1(3)
C(22)-Si(1)-O(4)-C(15)	11.0(4)
C(22')-Si(1)-O(4)-C(15)	-0.7(4)
C(25)-Si(1)-O(4)-C(15)	96.2(4)
C(28')-Si(1)-O(4)-C(15)	-101.7(4)
C(11)-N(1)-C(1)-O(2)	-7.1(4)
C(3)-N(1)-C(1)-O(2)	179.9(3)
C(11)-N(1)-C(1)-O(1)	172.1(2)
C(3)-N(1)-C(1)-O(1)	-0.9(3)
C(2)-O(1)-C(1)-O(2)	173.8(2)
C(2)-O(1)-C(1)-N(1)	-5.5(3)
C(1)-O(1)-C(2)-C(3)	9.4(3)
C(1)-N(1)-C(3)-C(2)	6.2(2)
C(11)-N(1)-C(3)-C(2)	-167.6(2)
C(1)-N(1)-C(3)-C(4)	-115.8(2)
C(11)-N(1)-C(3)-C(4)	70.5(2)
O(1)-C(2)-C(3)-N(1)	-8.9(2)
O(1)-C(2)-C(3)-C(4)	111.2(2)
N(1)-C(3)-C(4)-C(5)	177.99(18)
C(2)-C(3)-C(4)-C(5)	64.4(3)
C(3)-C(4)-C(5)-C(6)	-105.9(3)
C(3)-C(4)-C(5)-C(10)	75.5(3)
C(10)-C(5)-C(6)-C(7)	-0.4(4)
C(4)-C(5)-C(6)-C(7)	-178.9(2)
C(5)-C(6)-C(7)-C(8)	1.0(4)
C(6)-C(7)-C(8)-C(9)	-1.3(4)
C(7)-C(8)-C(9)-C(10)	0.9(4)
C(8)-C(9)-C(10)-C(5)	-0.3(4)
C(6)-C(5)-C(10)-C(9)	0.0(4)
C(4)-C(5)-C(10)-C(9)	178.6(2)
C(1)-N(1)-C(11)-O(3)	-162.8(2)
C(3)-N(1)-C(11)-O(3)	9.8(3)
C(1)-N(1)-C(11)-C(12)	21.2(3)
C(3)-N(1)-C(11)-C(12)	-166.15(19)
O(3)-C(11)-C(12)-C(13)	-82.8(3)
N(1)-C(11)-C(12)-C(13)	92.9(2)
O(3)-C(11)-C(12)-C(17)	46.7(3)
N(1)-C(11)-C(12)-C(17)	-137.6(2)
C(11)-C(12)-C(13)-C(14)	162.0(2)
C(17)-C(12)-C(13)-C(14)	35.1(3)
C(11)-C(12)-C(13)-C(18)	39.6(3)
C(17)-C(12)-C(13)-C(18)	-87.3(3)
C(11)-C(12)-C(13)-C(19)	-79.8(3)
C(17)-C(12)-C(13)-C(19)	153.3(2)
C(18)-C(13)-C(14)-C(15)	122.7(3)
C(12)-C(13)-C(14)-C(15)	-3.0(4)
C(19)-C(13)-C(14)-C(15)	-120.6(3)
C(13)-C(14)-C(15)-O(4)	-179.7(3)
C(13)-C(14)-C(15)-C(16)	-1.6(4)

Si(1)-O(4)-C(15)-C(14)	-70.5(4)
Si(1)-O(4)-C(15)-C(16)	111.3(3)
C(14)-C(15)-C(16)-C(17)	-25.6(4)
O(4)-C(15)-C(16)-C(17)	152.6(2)
C(15)-C(16)-C(17)-C(20)	-71.1(3)
C(15)-C(16)-C(17)-C(21)	169.4(2)
C(15)-C(16)-C(17)-C(12)	52.2(3)
C(11)-C(12)-C(17)-C(20)	-67.6(3)
C(13)-C(12)-C(17)-C(20)	59.1(3)
C(11)-C(12)-C(17)-C(21)	57.5(3)
C(13)-C(12)-C(17)-C(21)	-175.8(2)
C(11)-C(12)-C(17)-C(16)	174.0(2)
C(13)-C(12)-C(17)-C(16)	-59.3(3)
O(4)-Si(1)-C(22)-C(23)	-72.2(6)
C(28)-Si(1)-C(22)-C(23)	76.3(7)
C(25')-Si(1)-C(22)-C(23)	156.3(6)
C(22')-Si(1)-C(22)-C(23)	10.3(15)
C(25)-Si(1)-C(22)-C(23)	-175.3(6)
C(28')-Si(1)-C(22)-C(23)	29.2(7)
O(4)-Si(1)-C(22)-C(24)	164.1(4)
C(28)-Si(1)-C(22)-C(24)	-47.4(7)
C(25')-Si(1)-C(22)-C(24)	32.6(6)
C(22')-Si(1)-C(22)-C(24)	-113(2)
C(25)-Si(1)-C(22)-C(24)	61.0(5)
C(28')-Si(1)-C(22)-C(24)	-94.5(5)
O(4)-Si(1)-C(25)-C(26)	-31.4(8)
C(28)-Si(1)-C(25)-C(26)	-151.9(7)
C(25')-Si(1)-C(25)-C(26)	-141.1(10)
C(22)-Si(1)-C(25)-C(26)	77.6(8)
C(22')-Si(1)-C(25)-C(26)	78.7(8)
C(28')-Si(1)-C(25)-C(26)	-166.5(7)
O(4)-Si(1)-C(25)-C(27)	148.7(6)
C(28)-Si(1)-C(25)-C(27)	28.2(7)
C(25')-Si(1)-C(25)-C(27)	39.0(6)
C(22)-Si(1)-C(25)-C(27)	-102.3(7)
C(22')-Si(1)-C(25)-C(27)	-101.2(7)
C(28')-Si(1)-C(25)-C(27)	13.6(12)
O(4)-Si(1)-C(28)-C(30)	-42.6(6)
C(25')-Si(1)-C(28)-C(30)	66.3(6)
C(22)-Si(1)-C(28)-C(30)	169.0(5)
C(22')-Si(1)-C(28)-C(30)	-178.3(5)
C(25)-Si(1)-C(28)-C(30)	74.4(6)
C(28')-Si(1)-C(28)-C(30)	-114.5(7)
O(4)-Si(1)-C(28)-C(29)	81.1(5)
C(25')-Si(1)-C(28)-C(29)	-170.0(6)
C(22)-Si(1)-C(28)-C(29)	-67.2(6)
C(22')-Si(1)-C(28)-C(29)	-54.6(6)
C(25)-Si(1)-C(28)-C(29)	-161.9(5)
C(28')-Si(1)-C(28)-C(29)	9.2(5)
O(4)-Si(1)-C(22')-C(24')	177.6(5)
C(28)-Si(1)-C(22')-C(24')	-45.8(7)
C(25')-Si(1)-C(22')-C(24')	38.6(7)
C(22)-Si(1)-C(22')-C(24')	76.1(17)
C(25)-Si(1)-C(22')-C(24')	70.6(6)

C(28')-Si(1)-C(22')-C(24')	-85.9(6)
O(4)-Si(1)-C(22')-C(23')	-63.2(6)
C(28)-Si(1)-C(22')-C(23')	73.3(6)
C(25')-Si(1)-C(22')-C(23')	157.8(5)
C(22)-Si(1)-C(22')-C(23')	-165(2)
C(25)-Si(1)-C(22')-C(23')	-170.2(6)
C(28')-Si(1)-C(22')-C(23')	33.3(6)
O(4)-Si(1)-C(25')-C(27')	45.7(6)
C(28)-Si(1)-C(25')-C(27')	-58.3(6)
C(22)-Si(1)-C(25')-C(27')	175.1(5)
C(22')-Si(1)-C(25')-C(27')	-177.4(5)
C(25)-Si(1)-C(25')-C(27')	132.7(8)
C(28')-Si(1)-C(25')-C(27')	-58.9(6)
O(4)-Si(1)-C(25')-C(26')	-63.3(5)
C(28)-Si(1)-C(25')-C(26')	-167.3(6)
C(22)-Si(1)-C(25')-C(26')	66.2(5)
C(22')-Si(1)-C(25')-C(26')	73.6(6)
C(25)-Si(1)-C(25')-C(26')	23.7(5)
C(28')-Si(1)-C(25')-C(26')	-167.9(4)
O(4)-Si(1)-C(28')-C(29')	-178.2(5)
C(28)-Si(1)-C(28')-C(29')	-60.7(6)
C(25')-Si(1)-C(28')-C(29')	-59.8(6)
C(22)-Si(1)-C(28')-C(29')	68.3(6)
C(22')-Si(1)-C(28')-C(29')	72.0(6)
C(25)-Si(1)-C(28')-C(29')	-41.1(10)
O(4)-Si(1)-C(28')-C(30')	-58.9(6)
C(28)-Si(1)-C(28')-C(30')	58.7(6)
C(25')-Si(1)-C(28')-C(30')	59.5(6)
C(22)-Si(1)-C(28')-C(30')	-172.3(5)
C(22')-Si(1)-C(28')-C(30')	-168.7(6)
C(25)-Si(1)-C(28')-C(30')	78.3(9)

Symmetry transformations used to generate equivalent atoms:

Table 7. Hydrogen bonds for lb085 [A and deg.].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)

Glossary of Abbreviations

Ac	acetate
acac	acetoacetonate
Bn	benzyl
Bu	butyl
BuLi	n-butyllithium
cat.	catalyst or catalytic
DBU	1,8-diazabicyclo[5.4.0]undec-7-ene
DCM	dichloromethane
DIBAL-H	diisobutylaluminumhydride
DMF	N,N-dimethylformamide
DMSO	dimethylsulfoxide
dr	diastereomeric ratio
equiv	equivalents
Et	ethyl
GC	gas chromatography
GC/MS	gas chromatography coupled to mass spectrometry
HMPA	hexamethylphosphoramide
HMQC	heteronuclear multiple quantum coherence
HRMS	high resolution mass spectrum
Im	imidazole
KHMDS	potassium bis(trimethylsilyl)amide
LDA	lithiumdiisopropylamide
m-CPBA	3-chloroperoxybenzoic acid
Me	methyl

mp	melting point
ms	molecular sieves
NMO	N-methylmorpholine oxide
NOE	nuclear Overhauser effect
NOESY	nuclear Overhauser effect spectroscopy
OTf	trifluoromethylsulfonate
OTs	toluenesulfonate
ox.	oxidation
PCC	pyridiniumchlorochromate
Ph	phenyl
ppm	parts per million
quant.	quantitative yield (i.e. >98%)
rF	“to-Front” ratio = analyte elution distance / solvent elution distance
TBAF	tetrabutylammonium fluoride
TBHP	*tert*-butyl hydroperoxide
TBS	*tert*-butyldimethyl silyl
t-BuLi	*tert* butyllithium
TFA	trifluoroacetic acid
TFAA	trifluoro acetic anhydride
THF	tetrahydrofuran
TMS	trimethylsilyl
tol	toluene
TPAP	tetrapropylammonium perruthenate
xs	excess

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