

Enhancing the optical activity of chiral molecules

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1. INTRODUCTION

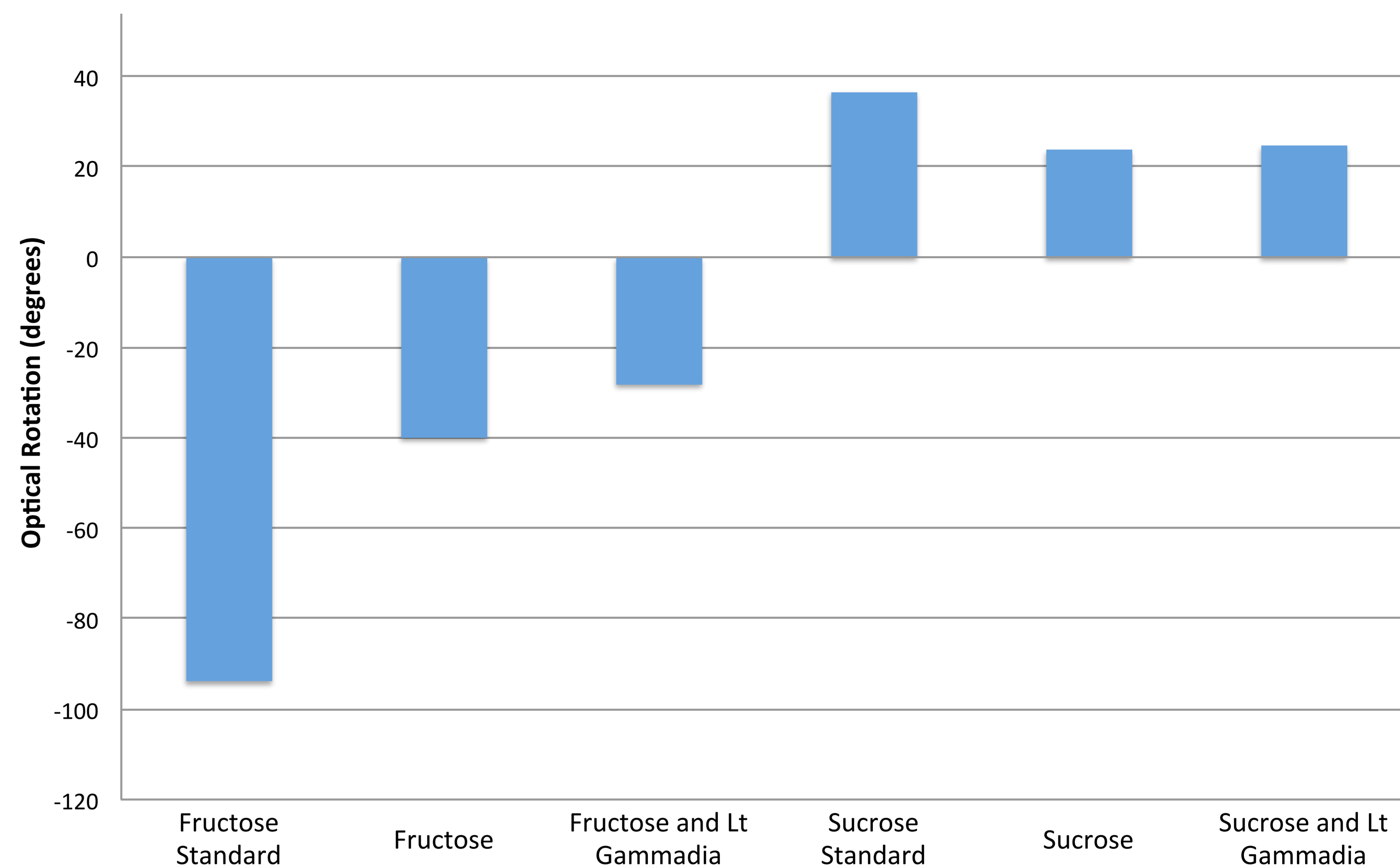
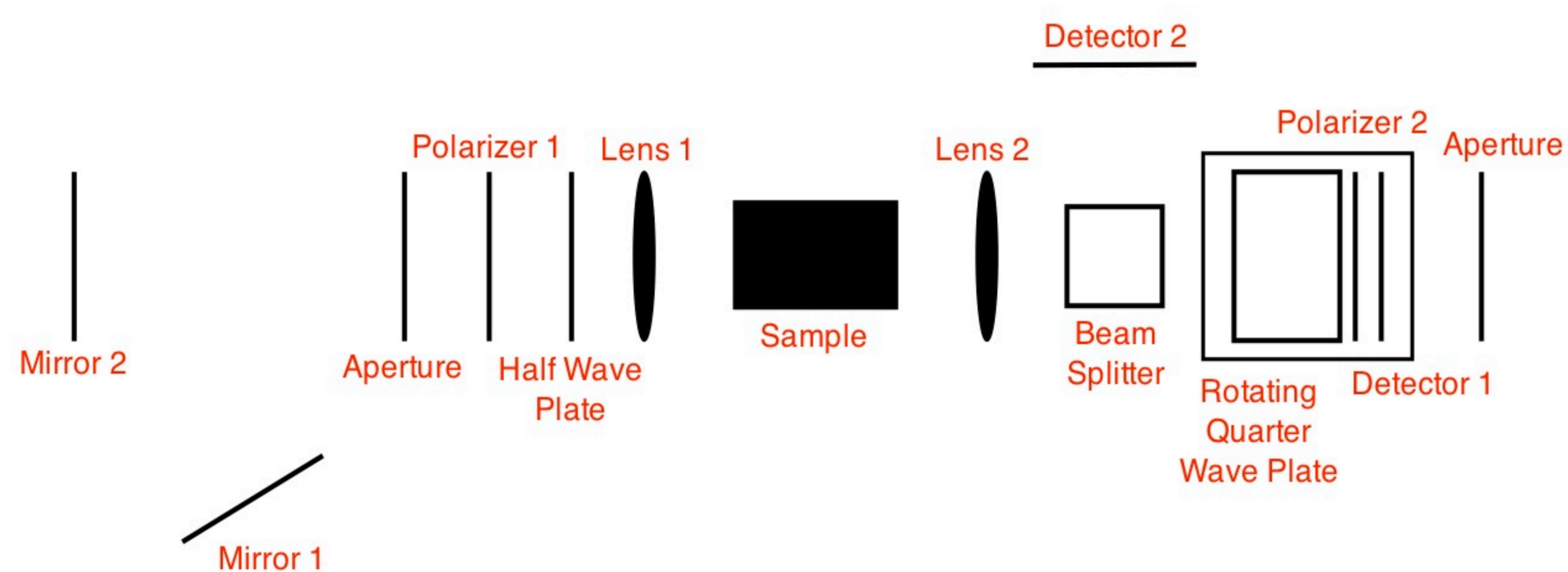
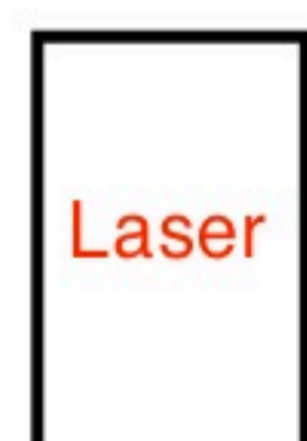
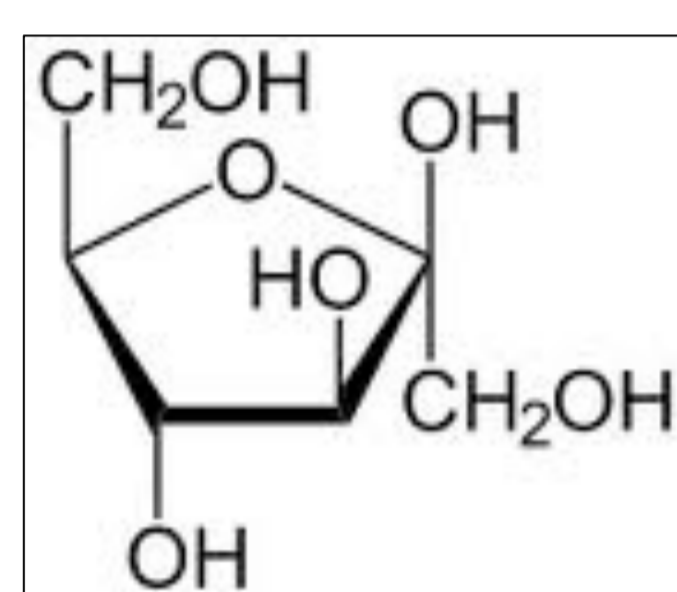
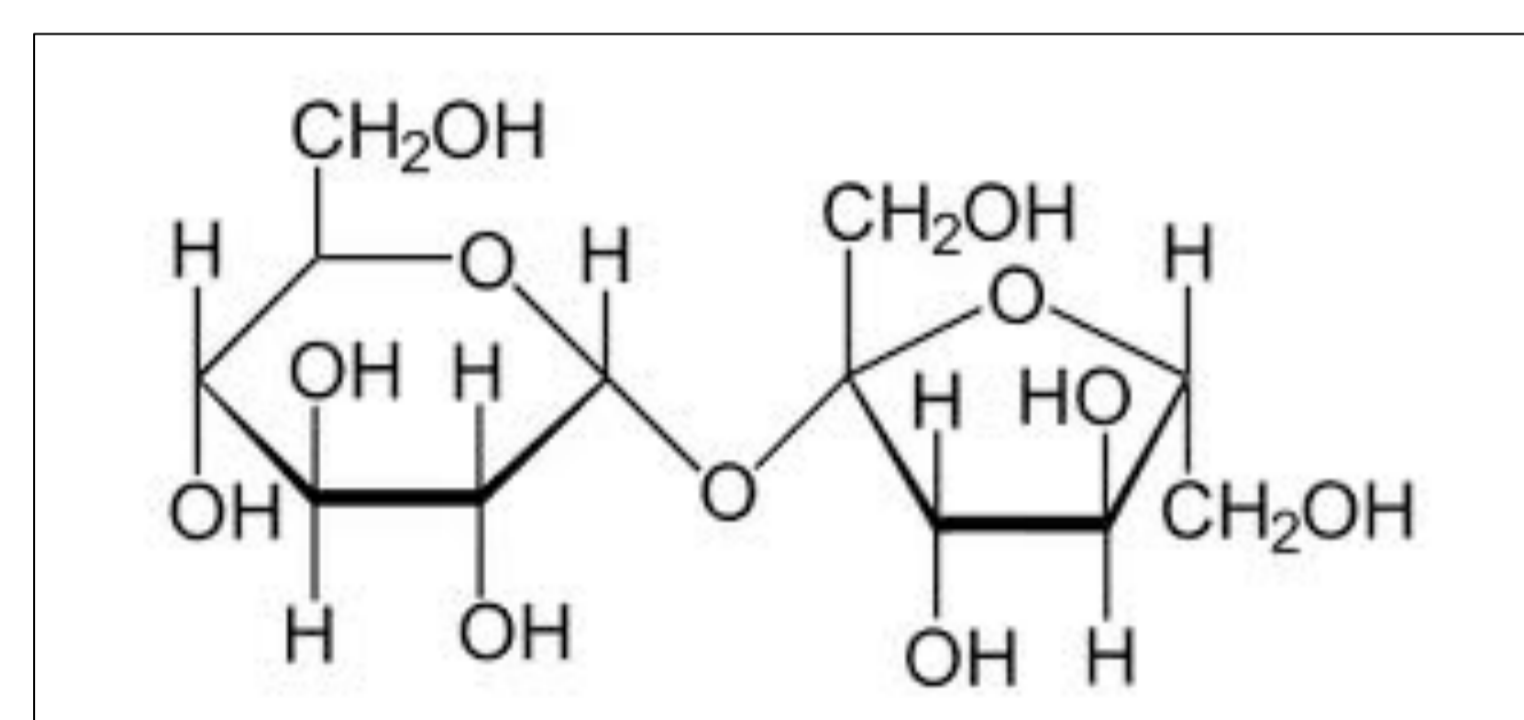
This study investigates a potential way to enhance the optical activity of chiral molecules through the use of chiral plasmonic structures. Chiral molecules exist in the form of pairs of enantiomers, which are non superimposable mirror images of one another. Each enantiomer is optically active, rotating the polarization direction of linearly polarized light either to the right or the left, creating a measurable optical rotation. The goal of this project was to investigate whether the optical activity of the chiral molecules, sucrose and fructose, absorbed on the chiral plasmonic/ gold nanostructures is increased. These findings could provide another effective way to test the purity of pharmaceuticals in order to ensure the medicinal drug contains the desired enantiomer by measuring and comparing the optical activity to a standard value.

2. METHODOLOGY

A home-built near-IR rotating quarter wave plate polarimeter operating with collimated light at 780 nm was calibrated and aligned using apertures located at the beginning (before the first polarizer) and end of the setup space (after the last detector). Additionally, a back reflection technique was used when placing the lenses and quarter wave plate to ensure the incoming and reflected rays were aligned.

The final detector records the power transmission with respect to the relative angular position. From this the Stoke's parameters can be calculated. The polarimeter calibration was tested by matching the Stoke's parameter standards for horizontal, vertical, +45°, and -45° linearly polarized light. These states of polarized light were achieved by adjusting the first polarizer to the respective angle.

The home-built polarimeter measured the optical rotation of sucrose and fructose. This was compared to the measured optical rotation of sucrose and fructose coated on a glass substrate (chip) containing arrays of gold plasmonic nanostructures in the shape of left-handed gammadia. The optical activity of the chiral plasmonic nanostructures alone was also measured.



$$\Psi = \frac{1}{2} \sin^{-1} \left(\frac{S_3}{S_0} \right)$$

3. RESULTS

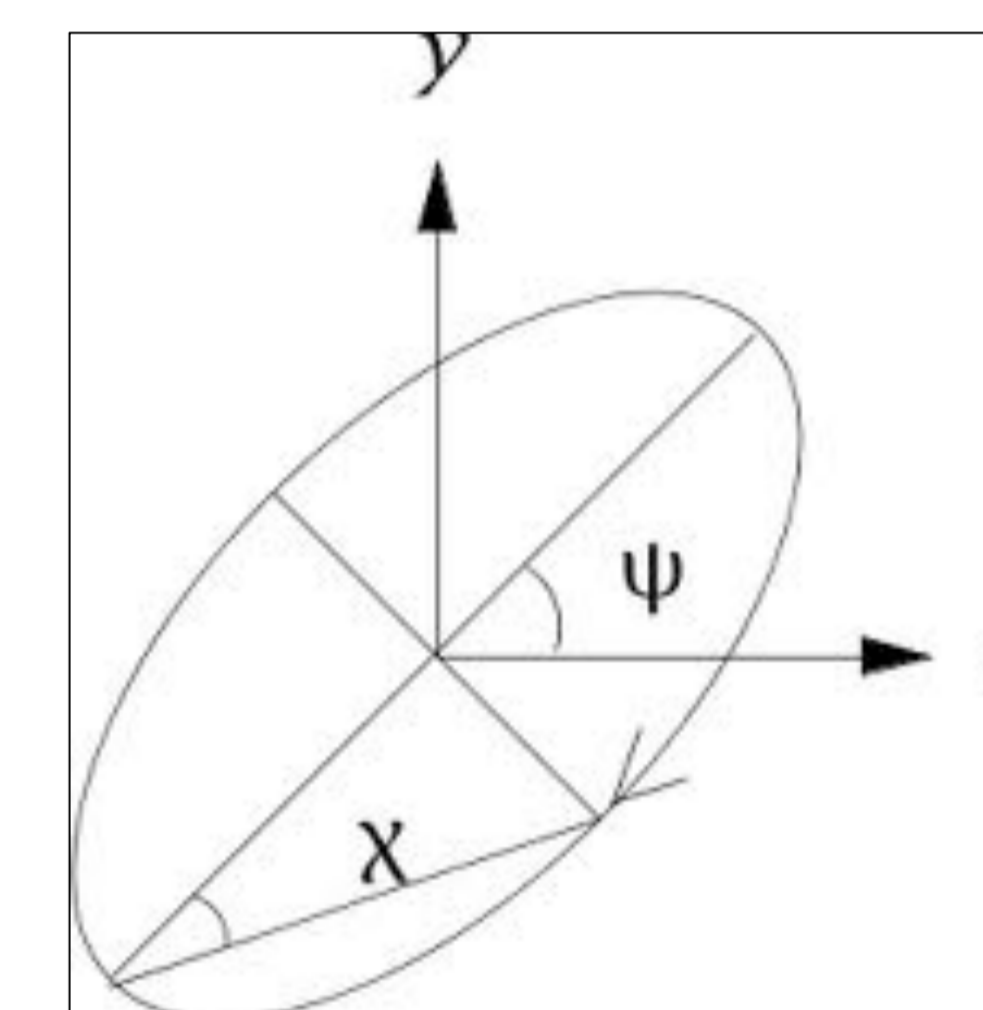
The home-built polarimeter can produce detectable measurement to two degrees. Sucrose is a right handed sugar and rotates light in the clockwise direction (dextrorotatory) whereas fructose is a left handed sugar and rotates light in the counter-clockwise direction (levorotatory).

Sucrose and fructose both rotated light in their respective directions. The standard rotation for sucrose is +36.7° at a wave length of 780nm, the home-built polarimeter measured +23.8° at a wave length of 780nm. The standard rotation for fructose is -93.78° at a wave length of 590nm, the home-built polarimeter measured -39.9° at a wave length of 780nm.

There was no detectable optical rotation of the chiral plasmonic/ gold nanostructures in water, nor with the chiral molecules adsorbed on the chiral plasmonic/ gold nanostructures. The collimated light may not have been providing enough intensity on the individual gammadia structures to elicit an optical rotation.

Two lenses were added into the system to increase the light intensity on the respective gammadia structures. Lens 1 functioned as a converging lens to decrease the spot size, thus increasing the intensity of the light rays on the sample. After the smallest spot size the rays start to diverge, increasing the spot size. Lens 2 functioned as a collector lens which made the light rays collimated again.

The smaller spot size had no affect on the chiral plasmonic/ gold nanostructures in water; they had no optical rotation. However on the left handed chiral plasmonic/ gold nanostructures sucrose had an optical rotation of 23.8° and fructose had an optical rotation of -28.1°.



4. CONCLUSION

The home-built near-IR rotating quarter wave plate polarimeter operating with collimated light at 780 nm was able to detect the optical rotation of sucrose and fructose as +23.8° and -39.9° respectively. However it was unable to detect an optical rotation of the chiral plasmonic/ gold nanostructures with water, sucrose or fructose absorbed on them. With an increased intensity of light, a smaller spot size, the left handed chiral plasmonic/ gold nanostructures had no affect on the optical rotation of sucrose but suppressed the rotation of fructose to -28.1°.

Next steps include further increasing the intensity of the system to see if any further effects occur to the optical rotation of fructose and sucrose, as well to test biological molecules on the right handed chiral plasmonic/ gold nanostructures to see if a similar patterns of suppression of optical rotation occurs.

REFERENCES, ACKNOWLEDGEMENTS

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$$\text{Stokes} = \begin{pmatrix} S_0 \\ S_1 \\ S_2 \\ S_3 \end{pmatrix} \quad \text{Horizontal} = \begin{pmatrix} 1 \\ 1 \\ 0 \\ 0 \end{pmatrix} \quad \text{Vertical} = \begin{pmatrix} 1 \\ -1 \\ 0 \\ 0 \end{pmatrix} \quad +45^\circ = \begin{pmatrix} 1 \\ 0 \\ 1 \\ 0 \end{pmatrix} \quad -45^\circ = \begin{pmatrix} 1 \\ 0 \\ -1 \\ 0 \end{pmatrix}$$