Nickel based electro-catalyst: toward the electrochemical valorization of glycerol in alkaline medium

Kara A. Hughes, Mohamed S. E. Houache, Elena A. Baranova
Department of Chemical and Biological Engineering, University of Ottawa, 161 Louis-Pasteur Ottawa ON K1N 6N5 Canada

Introduction

Produced 600 million litres in 2017

Trans-esterification reaction

By-product glycerol – 10 wt%

Biodiesel production

Electrochemical transformation of glycerol into value-added chemicals

Objectives

- Synthesising efficient nano-structures of nickel;
- Determining the effect different amounts of a capping agent – polyvinyl pyrrolidone (PVP) has on nanoparticles;
- Investigating electrocatalytic activity for (GOR) in an alkaline medium.

Methodology

I. Synthesis of Ni nanoparticles (NiNPs)

Reaction: \( \text{NiCl}_2 + 2	ext{PVP} \rightarrow \text{NiNPs} + 2	ext{PVP} \)

Hydrazine

NaOH (6G)

NiNPs

0.33±3.2%

0.25g PVP

0.48±4.7%

0.5g PVP

0.75±1.4%

0.75g PVP

0.41±7.2%

Steps involved in transition of NiO to fcc-Ni

II. Ink Preparation

- 6 mg NiNPs
- 1 μl H₂O
- 200 μl Isopropanol
- 100 μl Nanion

Deposited 10 μl on glassy carbon electrode surface

III. Electrochemistry Tests

Working Electrode: NiNPs + PVP
Reference Electrode: Mercury /Mercury Oxide (Hg/HgO)
Counter Electrode: Platinum Mesh
Electrolyte: 1 M KOH

Results and Discussion

I. Interaction mechanism between PVP & NiNPs

PVP coated Ni

17.4 nm

17.7 nm

18.6 nm

19.1 nm

The corresponding XRD spectrum for NiNPs on PVP shows

The catalytic activity of NiNPs on PVP

Determination of Electrochemical Surface Area

Formation of α-Ni(OH)₂ on GC electrode in 1 M KOH was 50 mV/s

\[ A_{\text{catalyst}} = \frac{q}{514 \mu C/cm²} \]

No PVP: 0.33±3.2%

0.25g PVP: 0.48±4.7%

0.5g PVP: 0.75±1.4%

0.75g PVP: 0.41±7.2%

CVs of as-prepared electro-catalysts in Ni₂-saturated 1 M KOH solution with 0.1 M glycerol solution vs 1 mV/s

Tafel plots of as-prepared catalysts in 1 M KOH + 0.1 M glycerol solution vs 1 mV/s

Conclusion

- The resultant NiNPs by the hydrazine reduction were characterized by XRD and found to be pure crystalline nickel with face-centered cubic (fcc) structure.
- Increasing the amount of PVP added increased the time taken for the nanoparticles to form, for the synthesis. However, increasing the concentration of NaOH used reduced the reaction time dramatically.
- The nanoparticles with higher amounts of PVP had lower current densities and slightly smaller crystallinity.

Recommendations for Further Work

- Coupling CA with in-situ PM-IRRAS to identify glycerol electro-oxidation products on the catalyst surface.
- The effect of different molecular weights of PVP can be investigated to determine which one is the best for the this synthesis.
- Bimetallic nanoparticles such as NiPd₃ could be synthesised and electrochemically examined for use in glycerol oxidation.

References


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