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Toward the Electrochemical Valorization of Glycerol: Tunning Activity & Selectivity of Nickel-rich Nanostructures

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Abstract

Glycerol partial electro-oxidation to produce various chemicals has attracted a great amount of attention in the decade . Glycerol is the main by-product of biodiesel production and could be converted into high value-added chemicals. The control of catalyst selectivity and activity could be achieved through formulation of novel, nano-structured electrocatalysts. Nickel (Ni) is an attractive material for glycerol electro-oxidation (GEOR) in alkaline media , due to its natural abundance, anti-poising and good stability in alkaline media . We cared out extensive research to determine the effect of size, morphology, shape, support, experimental conditions and catalyst preparation methods on the catalytic performance of Ni. While the effect of noble metal promoters has been relatively well studied for Pt group catalysts, the same cannot be said for Ni based catalysts. Thus, the research work aims to demonstrate how the selectivity of unsupported Ni nanoparticles for GEOR can be improved via interaction of Ni with low noble and transition metals content. Enhanced selectivity towards C3 and C2 products such as glycerate, lactate, oxalate and tartronate, was achieved by simply adding less than 20 atomic percent of any of bismuth (Bi), Pd or Au onto Ni nanoparticles. Furthermore, the composition effect of carbon supported NixM1-x (M = Bi, Pd and Au) nanomaterials were combined with Pt/C and commercial silver nanoparticles for cathodic hydrogen production and CO2 electro-reduction, respectively. These rich-phase of Ni(OH)2 catalysts were highly active and selective towards C-C bond breaking product leading to 100% selectivity of formate after 1 hr electrolysis and 100% conversion of glycerol after 24 hr at +1.55 V. Lastly, the First-Principles calculations based on the Density Functional Theory (DFT) insights provided an explanation to understand the electronic structure, magnetism and reactivity of our catalysts. Core@shell (Mm@Nin) nanoparticles of 13-, 54- and 55-atoms with different elements concentrations, and the α-Ni(OH)2 and β-NiOOH systems as well as its different cleavage planes with different possible terminations were set up as simplified model in the sake of clarity..

Biography:

Mohamed S. E. Houache has a Post-doctoral researcher leading a joint project between Gbatteries and University of Ottawa funded by Elevate Mitacs to develop safe, dendrite-free and long cycle-life of Li-metal batteries.6+ years of research experience in electrochemical energy storage and electrocatalysis with application to glycerol electrooxidation, CO2 electro-reduction and water splitting on metallic oxide nano-catalysts.Proficient in materials synthesis, surface/interface characterization techniques (i.e., electrochemical testing methods, XRD, TDA-TGA, SEM, TEM, XPS, SAED, EDS, FTIR, PM-IRRAS, HPLC, NMR and GC-MS).Strong analytical, verbal and written communication skills demonstrated by 31 conference and poster presentations, 10 journal publications and 10 teaching positions.Energetic and self-motivated with the ability to work independently as well as multi-disciplinary teams with successful experience in leading and supervising 10 research students.

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