

Ni(OH)₂-SUPPORTED Pd ELECTROCATALYSTS FOR METHANOL OXIDATION IN ALKALINE MEDIA

Muhammad Adeel Tariq¹, Hafiz Muhammad Naeem¹, Loreta Tamašauskaitė-Tamašiūnaitė¹, Eugenijus Norkus¹, Ramūnas Levinas¹

¹Center for Physical Sciences and Technology (FTMC), Department of Catalysis, Vilnius, Lithuania.
adeel.tariq@ftmc.lt

Direct methanol fuel cells (DMFCs) have gained characteristics attraction due to low operating temperature, high energy density and easy fuel storage and handling. However, comprehensive commercialization of DMFC technology is limited due to slow methanol oxidation reaction kinetics and severe poisoning of catalytic active sites resulting from adsorbed carbonaceous intermediates. Therefore, in order to overcome these challenges Ni(OH)₂ support material was hydrothermally synthesized followed by Pd nanoparticles decoration using chemical reduction treatment. The phase structure, crystallinity, morphological analysis with elemental composition and chemical composition of Pd/Ni(OH)₂ catalysts were analyzed using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS) and X-ray photoelectron spectroscopy (XPS). XRD patterns demonstrate that all the characteristics peaks of Ni(OH)₂ along metallic Pd peaks in Pd/Ni(OH)₂ catalysts. Highly irregular and agglomerated surface morphologies consisting of interlinked hydroxide aggregates revealed by SEM analysis, while EDS elemental mapping shows the presence of all constituent's elements with well dispersion. Also, XPS technique was used to evaluate the oxidation states of elements in Pd/Ni(OH)₂, indicating the presence of metallic Pd at binding energies of 335.00 eV and 340.22 eV. All these physiochemical characterizations confirmed the successful synthesis of Pd/Ni(OH)₂ along uniform distribution of Pd on Ni(OH)₂ substrate. Cyclic voltammetry (CV), chronoamperometry (CA), and electrochemical impedance spectroscopy (EIS) were used to evaluate the electrocatalytic performance of composite with different composition. Pd/Ni(OH)₂ electrodes exhibited good catalytic activity for methanol oxidation relatively to Ni(OH)₂ without Pd incorporation, due to synergistic interaction between Pd active sites and Ni(OH)₂/NiOOH support. Among the investigated catalyst Pd/Ni(OH)₂ (1:0.5) showed highest forward anodic peak current density (30 mA cm⁻²) and mass activity normalized by Pd mass (450 mA mg⁻¹ Pd), significant I_f/I_b ratios indicating good poisoning intermediates resistance along efficient long term stability. While, increasing Ni(OH)₂ contents in Pd-decorated Ni(OH)₂ catalyst leads to decrease the catalytic activity because of masking and dilution of Pd active sites. Kinetic studies suggest that methanol activation through initial C–H bond cleavage governs the overall reaction rate. Overall, the obtained Pd-decorated Ni(OH)₂ material presents a cost effective, promising, durable anode catalyst.

Keywords: Direct methanol fuel cells, methanol oxidation, Pd-decorated Ni(OH)₂, Synergistic effect, catalytic activity