Synthesis of nanostructured platinum and platinum-based electrocatalyst for DAFC

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Abstract

Among various types of fuel cells, direct alcohol fuel cells (DAFCs) are anion-exchange systems in which alcohol is used as the fuel for anode. DAFCs promised to be commercialized for portable electronic devices and vehicles due to alcohol usage, hence overcome the hydrogen specific restrictions. Moreover, it is significant that glycerol, a byproduct of biodiesel production by trans-esterification of vegetable oils or animal fats, can be used as fuel for DAFCs due to its high mass energy density about 5.0 kWh.kg^{-1}.

Using nano-scale metallic or bimetallic electrocatalytic materials will facilitate the cost-reducing of DAFCs. In this work, catalytic Pt and alloyed PtX (X: Ru, Ni) nanoparticles are synthesized on carbon Vulcan XC-72 support by polyol method, with ethylene glycol (EG) as reduction agent, and under microwave or ultrasonic irradiation. The structure and particle size of synthesized materials were analyzed by transmission electron microscopy (TEM), nitrogen adsorption (BET), X-Ray fluorescence (XRF) and X-Ray diffraction (XRD). The electrocatalytic activity of Pt/C, PtRu/C, PtNi/C and commercial Pt/C electrodes (Aldrich Sigma, 10%wt Pt/activated carbon) for alcohol oxidation in alkaline media was investigated by cyclic voltammetry (CV) and chronoamperometry (CA).

3.0 nm sized nanoparticles with face-centered cubic crystal lattice were synthesized by sonochemical method, which are relatively smaller than nanoparticles synthesized with microwave oven.

The CVs in $HClO_4$ solution were used to determine electrochemically active surface area (ECA) of electrode coated with nanocatalysts. The alcohol oxidation in the studied conditions is a multi-step process with the primary oxidation peak at -0.10 ÷ -0.20 V (Ag/AgCl electrode) and the secondary oxidation peak of intermediates at more negative potentials. Compared to commercial ones, the synthesized electrodes have higher electrochemical active surface area and perform better catalytic activity. The presence of Ru and Ni in Pt alloy nanomaterials improves the catalytic behavior for alcohol oxidation (methanol, ethanol, ethylene glycol and glycerol).

Keywords: alcohol oxidation, biodiesel, electrocatalyst, glycerol, nanoparticle, platinum alloy

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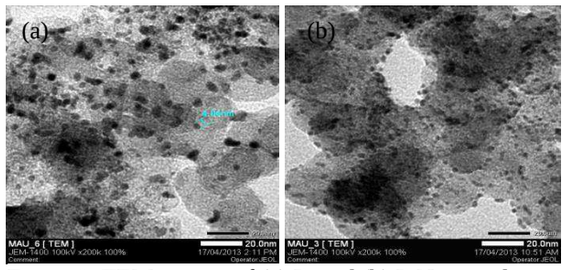

Figure 1. TEM images of (a) Pt and (b) PtNi particles on carbon support

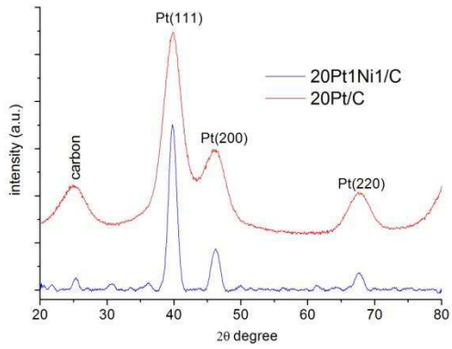

Figure 2. XRD pattern of carbon supported Pt and PtNi pacticles

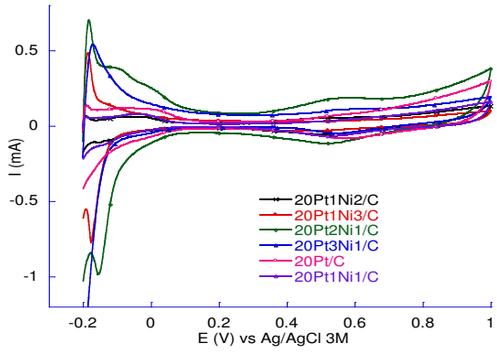

Figure 3. CVs of Pt/C and PtNi/C electrodes in 0.5 M $HClO_4$, at potential scan rate 50 mV/s, 25^{o}C

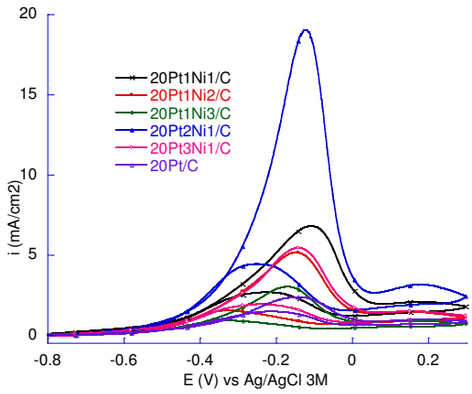

Figure 4. CVs of Pt and PtNi catalysts in 1.0 M KOH +1.0 M glycerol at 25^{o}C, scan rate 50 mV/s.