# THESIS INFORMATION

Thesis title: **Fabrication and investigation of electrochemical properties of PtM/C catalyst (M = Ni, Cu, Co) used for proton exchange membrane fuel cell.**

Speciality: Theoretical and Physical Chemistry
Code: 62440119
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Academic year: 2013
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## 1. SUMMARY

The proton exchange membrane fuel cell (PEMFC) is a promising power source for electric vehicles and residential application. However, current PEMFCs have several problems that need to be solved, including high cost, in sufficient power density and limted performace durability.

Research and development of $Pt_xM_y/C$ metal nanocatalysts (M = Ni, Cu, Co) on different support materials (Vulcan carbon and carbon nanotube) with high activity and low cost base on Pt metal for Proton exchange membrane fuel cell (PEMFC). Chemical reduction method with the help of ultrasound and microwave was performed to synthesize the catalyst with a Pt:M molar ratio of 1:0; 3:1; 2:1; 1:1; 1:2; 1:3. The $Pt_xM_y/C$ (M = Ni, Cu, Co) catalysts were characterized by X-ray diffraction (XRD), transmission electron spectroscopy (TEM), BET surface area and coupled plasma atomic mass spectroscopy (ICP-MS). The electrochemical surface area of the synthesized catalysts were detemined by cyclic voltammetry (CV) in 0.5 M $HClO_4$ acid with a scan rate 50 mV/s. The fuel oxidation of catalysts at the anode electrode with methanol, ethanol, ethylenen glycol, glycerol were evaluated by CV in 0.1 M KOH solution with a scan rate of 50 MV/s in the potential range from -0.8 V to + 1.2 V. The oxygen reduction reaction (ORR) at cathode was determined by linear sweep voltammetry (LSV) in a saturated 0.5 M $O_2/H_2SO_4$ acid. Evaluating the Koutecky Levich liner coefficient and calculating the numer of exchange electrons of the oxygen reduction reaction at the cathode. The stability and durability of different catalysts is characterized by chronoamperometric (CA) curves in 1.0 M MeOH and 1.0 M KOH under -0.3 V for 3600 s.

Comparing and selecting suitable catalysts to fabricate membrane electrode assemblies (MEA) on available materials in Vietnam. Researching and manufacturing other parts of fuel cells such as: outer shell plate, collector electrode plate, air gasket, bipolar plate... Conduct initial battery assembly and briefly survey electrical leakage, open circuit potential.

## 2. NEW CONCLUSIONS

The reduction efficiency of the catalytic synthesis is over 90%. The size of the $Pt_xM_y/C$ nanocatalyst (M = Ni, Cu, Co) on the Vulcan and CNT carbon carriers is in the range of 1-5 nm. Analysis of the XRD pattern and TEM images showed that the $Pt_xM_y$ nanoparticles were uniformly dispersed on the carbon surface. The diffraction peaks of Pt in $Pt_xM_y/C$ catalyst appear to have higher angles than that in Pt/C catalyst. This may be caused by the lattice contraction due to the introducing of M (M = Ni, Cu, Co) into Pt fcc structure. The electrochemical surface area (ESCA) of all composites are larger than those of commercial Pt. The ESCA of nanocatalyst are 16.18 $m^2/g$; 40.85 $m^2/g$; 17.07 $m^2/g$; 24.39 $m^2/g$; 18.21 $m^2/g$ for $PtNi_2/C$; $Pt_2Ni/t\text{-}CNT_1$; PtCu/C; $PtCu_2/CNT$; $PtCo_3/C$, respectively. The electrochemical properties of catalysts such as fuel oxidation at the anode, and the oxygen reduction reaction (ORR) at the cathode are higher than those of commercial Pt/C. The highest Eop of ORR of $Pt_xM_y/C$ (M = Ni, Cu, Co) catalysts were 0.636 V with $Pt_3Ni/C$; 0.663 V with PtCu/C; 0.61 V with PtCo/C. The highest mass activity of catalyts were 1.00 A/mg; 1.12 A/mg; 0.56 A/mg for $PtNi_2/C$; PtCu/C; PtCo/C catalysts at E = 0.1 V, respectively. The linear coefficient of the Koutecky Levich liner was above 99%. The number of exchange electrons for the oxygen reduction reaction is in the range of 3 to 4, that was still exist intermediate compounds, such as $H_2O_2$. The CA curves is observed that all $Pt_xM_y/C$ catalysts show the decline of current density which caused by immediate poisoning product of methanol oxidation (about 500 seconds) and from 1200-3600 seconds they were relatively stable. From the current-time curves, the onset current density and the steady current after stability test of $Pt_xM_y/C$ are higher than those of pure Pt, which indicates that $Pt_xM_y/C$ has excellent durability and stability. The CA test demonstrates the long-term catalytic activity and excellent stability for $Pt_xM_y$ electrocatalyst. The best catalyst which have appropriate electrochemical parameters and cost reduction are PtNi/C; PtCu/C; PtCo/C.

Assembling the PEMFC with a synthetic catalyst resulted that the open-circuit potential of PtNi/C, PtCu/C, and PtCo/C systems are 0.85 V; 1.01 V; 0.94 V which are higher than commercial batteries of Horizon fuel cell techonologies (7.8 V) with a stack of 13 single batteries.

**3. APPLICATIONS/ APPLICABILITY/ PERSPECTIVE**

The results of this study could be used as a premise for bimetallic Pt-based catalysts used in proton exchange membrane fuel cells.

Studying more about different metal molar ratios as well as investigating more conditions to optimize the catalytic synthesis process. Further investigation of the affect on shape, structure as well as electrochemical properties of the nano catalyst.

Researching more on the method of manufacturing MEA film, other parts of the battery, investigating the amperage, capacity, operating temperature... of the designed battery.

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