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ELECTROCHEMICAL REDUCTION OF OXYGEN ON PLATINUM-FREE CATHODE CATALYSTS FOR ALKALINE MEMBRANE FUEL CELLS

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The aim of this work was to study multi-walled carbon nanotube (MWCNT) supported cobalt phthalocyanine (CoPc) and iron phthalocyanine (FePc) electrocatalysts as alternative cathode materials to Pt/C in alkaline membrane fuel cell. We have also explored the electrocatalytic activity of FePc/MWCNT and CoPc/MWCNT modified glassy carbon (GC) electrodes toward oxygen reduction using the rotating disk electrode (RDE) method.

The electroreduction of oxygen has been studied on FePc/MWCNT and CoPc/MWCNT modified GC electrodes in 0.1 M KOH using the RDE method. Phthalocyanine/MWCNT catalysts have been prepared in the ratio of 50/50 in isopropanol and pyrolyzed at 800 ºC for 2 h in flowing argon atmosphere. Surface composition of the synthesized FePc/MWCNT and CoPc/MWCNT materials was analyzed using X-ray photoelectron spectroscopy (XPS). The fuel cell performance of Co and Fe phthalocyanines modified MWCNTs was investigated by fabricating membrane-electrode assemblies (MEAs) using Tokuyama membrane (# A201) and compared with unmodified MWCNT and commercial Pt/C catalysts.

The XPS results showed the decomposition of the phthalocyanine ring because of the pyrolysis and the formation of different electrocatalytically active metallic and nitrogen surface groups. The results of electrochemical measurements indicated excellent electrocatalytic properties of phthalocyanine modified MWCNTs toward O_2 reduction in alkaline media. A significant enhancement of the oxygen reduction activity was observed for FePc/MWCNT and CoPc/MWCNT catalysts as compared to acid-treated MWCNTs [1]. The number of electrons transferred per O_2 molecule (n) at different potentials for the CoPc/MWCNT modified GC electrode was calculated from the Koutecky-Levich equation. The value of n for the CoPc/MWCNT material was close to 3 at -0.4 V, but at more negative potentials the n value gradually increases and approaches almost four, which indicates that the peroxide formed reduces further to water in this potential range. For the FePc/MWCNT material the value of n was close to 3 over the whole range of potentials studied. Comparative fuel cell performance experiments have been also performed. The fuel cell performance of the MEAs with MWCNT supported Co and Fe phthalocyanines and Tanaka Kikinzoku Kogyo Pt/C cathode catalysts were 100, 60 and 120 mW cm^{-2} using H_2 and O_2 gases [2].

The results obained in this work show that MWCNT supported CoPc and FePc catalysts possess excellent electrocatalytic activity toward oxygen reduction in alkaline solution and could be used as alternative cathode catalysts in alkaline membrane fuel cells. The fuel cell performance of the MEAs with Co phthalocyanine/MWCNT cathode was found to be almost similar to the commercial 20 wt.% Pt/C catalyst using H_2 and O_2 gases [2].

References

1. I. Kruusenberg, N. Alexeyeva, K. Tammeveski, *Carbon*, **47**, (2009) 651-658.
2. I. Kruusenberg, L. Matisen, Q. Shah, A.M. Kannan, K. Tammeveski, *Int. J. Hydrogen Energy*, **37**, (2012) 4406-4412.