Carbon-Supported AgCo Catalysts for Oxygen Reduction Reaction in Anion Exchange Membrane Fuel Cells

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In recent years, it has seen a growing interest in oxygen reduction reactions (ORRs) in alkaline media due to the development of anion exchange membrane fuel cells (AEMFCs) [1]. Compared to proton exchange membrane fuel cells (PEMFCs), one of the key advantages of the AEMFCs is the potential use of non-Pt electrocatalysts for the ORR on the cathode. Non-Pt catalysts, including Ag, Au, Pd, cobalt and manganese oxide, prophyrins, and phthalocyanines, have been tested for the ORRs in the alkaline media. Among them Ag is often considered a top candidate not only because of its relative abundance and low cost but also relative high activity for the ORR through an approximated 4-electron pathway.

Although the activity of Ag/C is relative high compared to some other non-precious metal catalysts, it is still more than 100 mV lower than that of the Pt/C catalyst. The lower activity of Ag/C is usually attributed to the weak bonding of O_2 molecules on the silver atoms. Therefore, bimetallic catalysts formed between silver and one other oxyphilic elements such as AgCo, AgPt. AgW, AgMn, AgMg, and AgPd have been studied to improve Ag-based catalyst activity toward the ORR.

In this work, carbon supported bimetallic silver/cobalt (AgCo/C) catalysts with three different atomic ratios of Ag:Co were prepared by using a salt impregnation method followed by heat treatments in H_2.The structure, morphology and electrochemical properties of the catalysts were characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM), cyclic voltammetry (CV), rotating ring disk electrode (RRDE), single cell AEMFC tests and electrochemistry impedance spectroscopy (EIS).The influence of atomic ratios of Ag:Co on ORR activity was studied and discussed.

AEMFC performances with various catalysts are shown in Figure 1. From the test results, the peak power density of AEMFC with Ag_5Co_1/C is 325 mW cm^{-2}, which is much higher than those with Ag/C (215 mW cm^{-2}) and Co/C (208 mW cm^{-2}) catalysts. The tested fuel cells show a performance decreasing trend with the increase of cobalt content in the Ag_3Co_3/C or Ag_1Co_5/C catalysts. Based on the analysis of electrochemical impedance spectra recorded at 0.8 and 0.4 V in Figure 2. It can be concluded that cobalt in the bimetallic AgCo/C catalysts tends to reduce adsorption of OH- on silver surfaces: the stronger affinity between cobalt and OH- sets more silver sites free for ORR catalytic reactions. However, too high a ratio of cobalt to silver in the AgCo/C catalysts is found to increase the overall mass transportation resistance of OH^- in the AEMFCs.

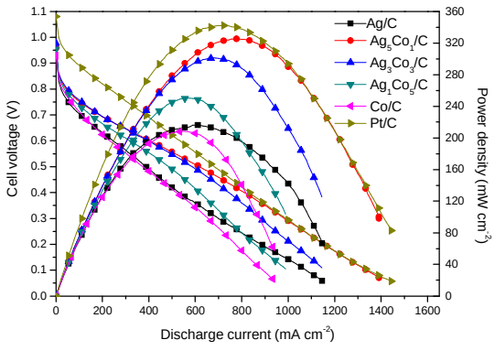
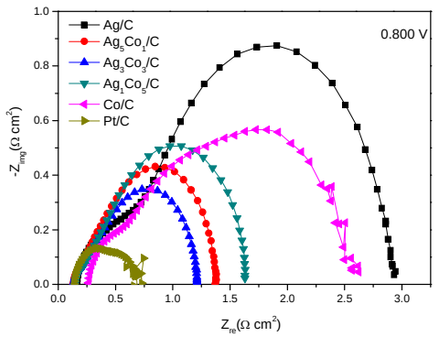
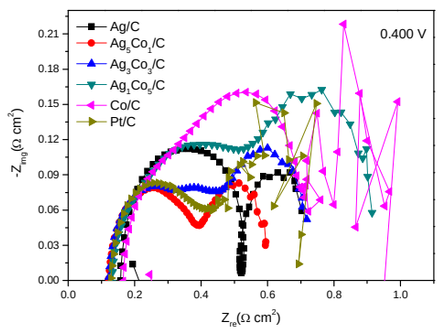


Fig. 1 Polarization and power density curves of anion exchange membrane fuel cells using 30 wt.% Ag/C, 30 wt.% Ag5Co1/C, 30 wt.% Ag3Co3/C, 30 wt.% Ag1Co5/C, 30 wt.% Co/C and 50 wt.% Pt/C catalysts as cathode catalysts respectively; Anode: 50 wt.% Pt/C, flow rate 200 sccm H_2, 100% humidity. Cathode: 2.0 mg catalyst/cm2, flow rate: 200 sccm O2, 100% humidity. Test temperature: 50oC; back pressure: 20 psi.



(a)



(b)

Fig.2 Electrochemical impedance spectra of fuel cells with different cathode catalysts at 08 (a) and 0.4 V (b). Test temperature: 50°C; back pressure: 20 psi.

References

[1] Varcoe, J.; Slade, R. Prospects for Alkaline Anion-Exchange Membranes in Low Temperature Fuel Cell. Fuel Cells 2005, 5, 87-200.