High performance of Corrole Derivatives as a Potential Non-precious Catalyst for Proton Exchange Membrane Fuel Cell

Hsin-Chih Huang[1], Chen-Hao Wang[1*],Sun-Tang Chang[1], Hsin-Cheng Hsu[1], Li-Chyong Chen[3], Kuei-Hsien Chen[2,3]

[1]Department of Materials Science and Engineering,

National Taiwan University of Science and Technology,

Taipei, 10607, Taiwan

[2] Institute of Atomic and Molecular Science, Academia

Sinica, Taipei, 10617, Taiwan

[3] Center for Condensed Matter Sciences, National Taiwan

University, Taipei, 10617, Taiwan

*E-mail: chwang@mail.ntust.edu.tw

This study attempts to synthesize corrole derivatives as non-precious catalyst to replace the platinum catalysts for proton exchange membrane fuel cell. It demonstrates the carbon black-supported pyrolyzed M-corrole (py-Fe-corrole/C and py-Co-corrole/C) catalyst of the oxygen reduction reaction (ORR) in a PEMFC cathode, with high catalytic performance.

Figure 1 shows that py-Fe-corrole/C and py-Co-corrole/C exhibit the optimized ORR activity after the pyrolysis, which the electron transfer numbers are above 3.90, nearly a direct four-electron reduction pathway for the reduction of O_2 to H_2O. This preference for direct four-electron transfer pathway over indirect two-electron pathway is clearly demonstrated by the plot of k_1/k_2 in Figure 2. The k_1/k_2 ratio for py–Co-corrole/C ranges between 13.5 to 21, and py-Fe-corrole/C can reach 35 to 60 even more, which is highest value among the other non-precious catalysts reported in the literature (1-4). Figure 3 shows the H_2-O_2 PEMFC test of py-M-corrole/C in the cathode, which reveals a maximum power density of 330 mW cm^{-2}. This study indicates that py-Fe-corrole/C and py-Co-corrole/C have the higher performances than previous studies of non-precious catalysts for PEMFCs. The effects of corrole structures with central metals and surrounding ligands on the ORR activity are investigated furthermore.

Reference

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Figures

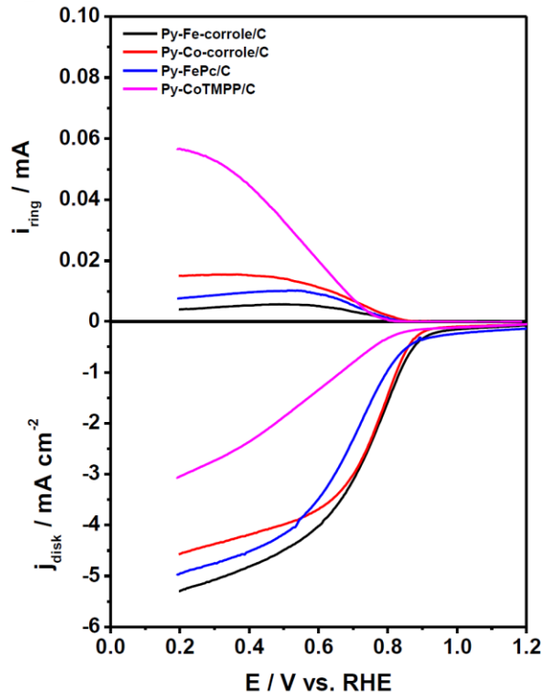

Figure 1 The ORR curves of py-Fe-corrole/C, py-Co-corrole/C, py-FePc/C and py-CoTMPP/C in saturated oxygen, 0.1 M $HClO_4$. Scan rate: 10 mV/s; rotation speed: 1600 rpm.

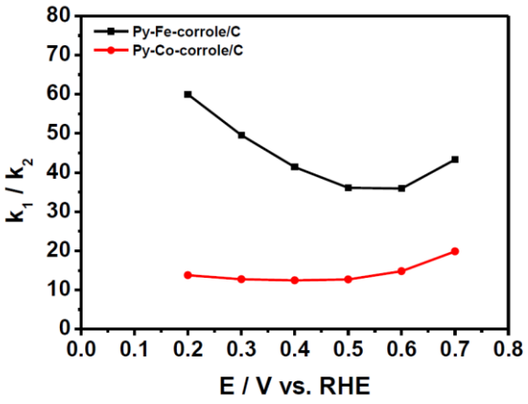

Figure 2 The k_1/k_2 ratios of py-Fe-corrole/C and py-Co-corrole/C as a function of applied potential.

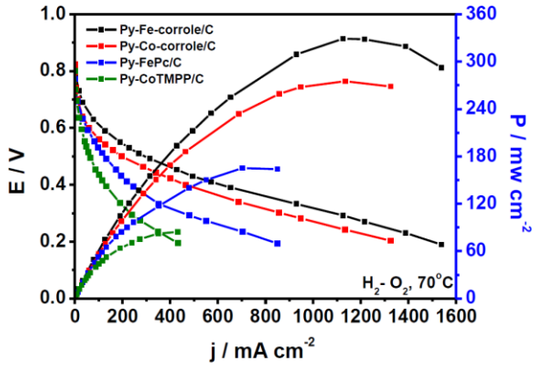

Figure 3 Polarization curves of the H_2-O_2 PEMFCs using py-Fe-corrole/C, py-Co-corrole/C, py-FePc/C and py-CoTMPP/C as cathodes. Operation temperature: 70 °C; back pressure of H_2 and O_2: 1 atm; anode catalysts: 30 wt.% Pt/C with the metal loading of 0.25 mg cm^{-2} (E-TEK); cathode catalysts: 2.0 mg cm^{-2} of 60 wt.% py-M-corrole/C; electrolyte: Nafion® 212 (H^+, DuPont).