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NiCo-doped C-N nano-composites for cathodic catalysts of Zn-air batteries in neutral media

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Abstract: One of the major challenges towards the development of the conventional alkaline Zn-air battery is its spontaneous discharge caused by the unstability of the anode Zn in concentrated alkaline electrolyte. Utilization of a neutral electrolyte as the alternative to alkaline electrolyte is likely to be a promising strategy to overcome this issue because of much high stability of anode Zn in neutral solution. To realize the normal operation of the neutral Zn-air battery however, a crucial issue is how to ensure that the cathodic catalyst can efficiently electro-catalyze oxygen reduction reaction (ORR) in neutral solution. Herein, we report a facile preparation of Ni/Co-doped C-N nano-composite catalysts (NiCo/C-N) from direct pyrolysis of Ni/Co salt, polyaniline (PANI), carbon nanotube (CNT) and dicyandiamide. Among the as-synthesized catalysts, Ni_1Co_3/CN-3 presents high and stable ORR current density of 5.27 mA cm^{-2} in 0.5 mol L^{-1} KNO_3 solution at 2000 rpm. Electron transfer number of ORR on Ni_1Co_3/CN-3 catalyst is 3.78, showing a nearly completed reduction of O_2 to H_2O. A neutral Zn-air battery with the prepared NiCo/C-N composite coated on carbon paper as the air electrode catalyst and metal Zn as the anode was constructed in 0.5 mol L^{-1} KNO_3 solution. For the catalyst Ni_1Co_3/CN-3, the open circuit voltage of the neutral Zn-air battery is 1.16 V, and the maximum power density is 38.5 mW cm^{-2}. The galvanostatic discharge time is 345.7, 160.6, 18.1 and 1.3 h as the discharge current density keeps 10, 50, 100 and 150 mA cm^{-2} respectively. A stable voltage plateau arises at various discharge current densities. The neutral Zn-air battery can repeatedly discharge after the zinc anode has been replaced, indicating that the synthesized ORR catalyst is an excellent cathode material for the neutral Zn-air battery. This kind of neutral Zn-air battery has a wide application prospect as mobile power supply.

Keywords: Zn-air battery; Oxygen reduction reaction; Non-precious metal catalyst; Neutral electrolyte; Carbon paper