Editorial

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The Nano-Electrocatalysts for Rechargeable Zinc Air Batteries

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Editorial

Electrochemical devices such as fuel cell, battery and supercapacitors are potential alternatives for energy conversion and storage apart from the burning of fossil fuels. Among the different energy storage systems, the rechargeable zinc-air battery displays great promise due to many attractive features, such as high energy density, cost-effective and environmentally friendly design, as well as low operating risks [1]. However, rechargeable zinc-air batteries suffer from the slow kinetics of oxygen reduction reaction (ORR) and the oxygen evolution reaction (OER), resulting in the large overpotentials which is one of major challenges in commercialization [2]. Thereby it is important to develop more highly efficient, novel bifunctional nano-electrocatalysts to efficiently promote both ORR and OER processes. Currently, significant progress has been made in bifunctional-catalyst development including transition-metal-based materials (oxides, chalcogenides, nitrides, and carbides), heteroatom-doped carbon nanomaterials and hybrid materials that consist of the former two [3]. The hybrid materials have been demonstrated synergistically enhanced ORR and OER activities, utilizing the nanostructured carbon with high surface area to be helpful with the dispersion of electrolyte and fasten charge transport of metal oxides. The carbon materials can act as an oxygen electrocatalyst to improve the activity of ORR, while the metal oxide facilitates OER [4]. Such synergetic effects observed with hybrid catalysts are attributed to two factors: (i) the electronic interaction between carbon and metal species creates rapid electron transfer pathways; (ii) the active carbon species initially facilitate the reduction of O_2 to HO_{2-}, and then the metal species subsequently catalyze HO_{2-} to OH, resulting in the overall four-electron reduction process [5,6].

As previous reported, the basically hybrid type catalysts are single metal oxide, spinel-type metal oxide and perovskite-type metal oxide hybridized with carbon materials. During these types of hybrid materials, spinel and carbon hybrids materials, such as CoMnO, MnCoO FeCoO, NiCoO, and MnFeO hybridized with carbon materials, have gained more attention from researchers due to the high OER activity of spinel complemented by the high ORR activity of carbon materials [7]. As the example, spinel $NiCo_2O_4$ crystals coupled with graphene sheets ($NiCo_2O_{4-}G$) for both ORR and OER were reported by Lee and co-workers [8]. The $NiCo_2O_{4-}G$ materials have been demonstrated the incorporation of Ni atoms into the spinel lattice is found to significantly improve both ORR and OER performances of $Co_3O_{4-}G$. This is ascribed to the increased electrical conductivity and the creation of new active sites by Ni incorporation into the octahedral sites of the spinel crystal structure. However, the composition of spinel oxides is tuned with different cations depending on the specific activity required, and materials cost restrictions. Similarity, Prabu et al. [9] reported the fabrication of $CoMn_2O_4$/rGO and $CoMn_2O_4$/N-rGO via a simple one-step hydrothermal method. Under ambient air condition, $CoMn_2O_4$/rGO and $CoMn_2O_4$/N-rGO hybrid bifunctional materials respectively show the small potential gap of 1.25 V and 1.65 V; these values are remarkable when compared with that of Pt/C: 1.94 V at 75 mA cm^{-2}. Therefore, the unique structure, morphology, and electrocatalytic property of the CoM_2O_4/N-rGO hybrid is a promising candidate for zinc-air battery applications.

In summary, the synergistic activity of hybrids materials is ascribed to the unique coupling between the metal oxide and carbon species, which also improves electrochemical durability due to lowered overpotentials. However, the mechanism of synergistic bi-functional activity of hybrids materials is not clear and definite. Thereby, the next research direction should be concentrated on mechanism of hybrids materials reaction to further optimize the design of the hybrid catalysts and facilitate commercialization of the rechargeable zinc-air batteries.

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