ABSTRACT

Development of efficient energy storage and conversion technologies become vital to address the energy crisis and environmental issues associated with fossil fuels. Hence, designing efficient electrocatalysts that are useful in the energy conversion and storage devices is a major concern towards global sustainability. This work is based on the development of low-cost efficient electrocatalysts and their practical application in the various energy storage and conversion devices. Particularly I have focused on the synthesis of CeO_2 and its composites such as CeO_2/NiO, CeO_2/CuO, gC_3N_4-CeO_2 for various important electrochemical reactions. Diverse CeO_2 nanostructures were synthesized by solvothermal method without using any harsh or corrosive chemicals and explored as low-cost electrocatalysts in oxygen reduction reaction (ORR). The morphology was found to have a significant impact on the surface property and in turn, on the activity of the electrocatalyst. The CeO_2 hollow spheres with the highest BET surface area and high oxygen vacancy defects revealed itself as the best performing ORR catalyst, that even surpass the commercial Pt/C in terms of stability and methanol tolerance. The bifunctional ORR and OER (oxygen evolution reaction) activity was explored with CeO_2 nanospheres embedded NiO nanoflakes composites. The best bifunctional composite with the highest number of oxygen vacancy defects was further utilized as air-cathode in Zn-air battery (ZAB), that shows remarkable performance. The CeO_2/CuO composites were also synthesized and tested for bifunctional OER and HER (hydrogen evolution reaction) activity. The optimized CeO_2/CuO core-shell-like microspheres show the best result due to internal charge-transportation and highest oxygen vacancy defects. The overall water splitting in a practical two-electrode system was performed using the CeO_2/CuO core-shell catalyst, which ensures better performance than that of Pt/C//IrO_2. In the final work, CeO_2-gC_3N_4 nanospheres were prepared as an ORR active catalyst to utilize as cathode catalysts in the microbial fuel cells (MFCs). The chemical synergy between CeO_2 and gC_3N_4 at the interface of the composite helps in the formation of abundant ORR active sites. The highly ORR active CeO_2-gC_3N_4 composite becomes an excellent cathode catalyst in MFCs. In summary, this thesis focused on the development of the CeO_2 and CeO_2-based composite electrocatalysts that has been used in various electrochemical process related to several energy storage and conversion devices.

Keywords: *CeO_2, CeO_2/NiO, CeO_2/CuO, gC_3N_4-CeO_2, oxygen vacancy defects, ORR, HER, OER, Zn-air battery, microbial fuel cell.*