Abstract

Fuel cells (FCs) emerge as a promising class of energy conversion system in recent times. The power generation in FC mainly controlled by its electrode performance. Thus, the electrode material plays a key role in energy conversion in FC. Most commonly, Platinum is used as the cathode catalyst for different FCs as well as anode catalysts for alcohol FC. But, high cost, scarcity, and stability associated with Pt prompt the scientific community to develop inexpensive electrocatalyst. In the present thesis metal oxides nanostructures and their composites with nanocarbon/conducting polymers have been synthesized and tested as oxygen reduction reaction catalyst for microbial FC (MFC) and hydrazine electro-oxidation catalyst for direct hydrazine FC. Moreover, developed biocompatible metal oxide was used for anode modification in MFC. The metal oxides were hydrothermally synthesized, and their electrocatalytic activities explored. Significant improvement of electrocatalytic performance was achieved with the composite catalyst as compared to their pristine individual components. In particular, MnO_2 nanotubes (MnO_2-NTs) coupled with different conducting supports such as Vulcan XC, MWCNTs, and graphene (GR) composites were studied as ORR catalyst for air cathode in single chambered MFC. The electrochemical investigation and sMFC results corroborate the superiority of MnO_2-NTs/GR composite over the other two composites. Moreover, similar ORR catalytic activity and sMFC performance were tested for $MnCo_2O_4$ nanorods/polypyrrole composite and $MnFe_2O_4$ nanoparticles/polyaniline ($MnFe_2O_4$NPs/PANI) composites. The sMFC performance achieved with composite catalysts was comparable to the state-of-the-art Pt/C cathode catalyst. The promising electrocatalytic activity of metal oxides and their composites attributed to the excellent electrochemical behavior of the metal oxides. In the present work $MnFe_2O_4$NPs/PANI composite was used to modify the anode surface of sMFC. A notable improvement of anode performance was noticed with the modified anode which attributed to the faster extracellular electron transfer kinetics on the modified bioanode. The electrocatalytic hydrazine oxidation was studied with $MnFe_2O_4$NPs/N-doped GR composite. N-doping on the GR was found to be a vital factor for improvement of electrocatalytic behavior of the composite.

Key words: Fuel cell, metal oxide, catalysis, oxygen reduction reaction, nanostructure.