Abstract

Depleting fossil fuels, increasing environmental concerned and looming energy crisis motivates researcher around the globe to explore some of the possible eco-friendly energy alternative resources. Among various available selections, electrochemical energy conversion and storage devices have the potential to serve the portable electronics to automobile sectors. In this regard, direct alkaline methanol fuel cell (DAMFC) is very promising. The efficiency of DAMFC mainly depends upon methanol oxidation reaction (MOR) and oxygen reduction reaction (ORR) that take place at anode and cathode of the device, respectively. However, both the reactions are complex and sluggish in nature due to multiple electron transfer involvement and various intermediate species formation during the course of reactions and require catalysts to drive these reactions at desire rates. Pt is known as the best mono metallic catalysts for both MOR and ORR, however, it suffers from catalytic poising and various degradation pathways like dissolution, leaching, agglomeration, Ostwald ripening, etc. Therefore, it is of enormous importance to enhance the operational stability of Pt based electro catalysts by alloying it with other available system or to design Pt-free electrocatalysts without trading off between the activity and stability. Metal-air battery is an energy storage device, relies on ORR and oxygen evolution reaction (OER) which requires efficient and robust electrocatalysts. The literature survey suggests that the combined over-potentials of ORR and OER cause a loss of ~ 70 % in the efficiency of metal-air batteries. Moreover, the commercially available state-of-the-art electro catalysts like Pt-C (for ORR) and RuO_2/IrO_2 (for OER), in addition to their high cost, are known for their mono-functionality only, and so metal-air battery system requires two kind of electrocatalysts to perform ORR/OER during discharging/charging. Therefore, it is of immense importance to develop commercially viable, robust and bifunctional electrocatalysts to serve the metal-air battery system. The present thesis presents the rational designing of bifunctional, robust and commercially viable electrocatalysts for electrochemical energy conversion and storage devices like DAMFC, metal-air batteries, water electrolyser and their practical realizations.