**Thesis Title:** “Development of Nanostructured Materials for Photoelectrochemical Cell and Fuel Cell Application”

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**ABSTRACT**

Renewable energy sources are currently fastest growing energy solution to compensate the ever increasing energy consumption demands. The utilization of solar energy as an alternative to conventional energy source has drawn much attention since last few decades. Storing of solar energy in the form of chemical bond like hydrogen has been given much importance recently. Additionally, fuel cell is also an area of immense importance to meet future energy demands. The thesis is aimed to synthesize and characterize various nanostructured materials by simple method such as electrodeposition or chemical route for application in photoelectrochemical (PEC) water splitting and oxygen reduction reaction catalyst for alkaline fuel cell. These two areas have immense potential to meet the future energy demands. Primarily, it is important to design an efficient electrocatalyst which will work effectively to meet the criteria for the applications in commercial purpose and which will be stable for long duration at the same time. In this direction, the thesis reports synthesis of semiconductor materials such as hematite (\(\alpha\)-Fe\(_2\)O\(_3\)) and graphitic carbon nitride (g-C\(_3\)N\(_4\)) by simple electrodeposition and solid state heat treatment procedures. The surface passivation of hematite (\(\alpha\)-Fe\(_2\)O\(_3\)) photoanodes by an oxygen evolution reaction (OER) co-catalyst NiMnO\(_x\) results in enhanced photocurrent density. Solar photo conversion efficiency (STH) is achieved upto 0.85% for modified hematite photoanode with 200s NiMnO\(_x\) layer. Next, in-situ solid state synthesis of bimetallic AgNi incorporated graphitic carbon nitride by simple heat treatment in N\(_2\) atmosphere is reported for PEC water splitting and Rhodamine B dye degradation. These metal nanoparticles incorporated photoelectrodes demonstrate improved photoactivity due to faster charge transport. The photocurrent density increases upto 1.2
mA/cm² and the maximum dye degradation efficiency achieved is upto 95%. Further work is carried out on electrochemical modification of hematite dendrites/carbon nitride composite by CoFeOx co-catalyst for application in PEC water splitting. The said heterojunction leads to improved PEC activity with 0.60 mA/cm² photocurrent density at 1.23 V vs. RHE. The work on development of electrocatalyst for oxygen reduction reaction (ORR) in alkaline medium is carried out in search of better cathode catalyst in alkaline fuel cell. Here one step electrodeposition of AgCd electrocatalyst on carbon paper for ORR application is reported. The ORR is found to follow four electron pathways. Next, ORR study of Ag incorporated g-C₃N₄ material supported on graphene oxide synthesized by solid state heat treatment route is also investigated in alkaline medium. The ORR study reveals that it follows most favourable four electrons pathway. Following the chapters in details, the thesis present conclusion and future scope where a device fabrication combining PEC and fuel cell is suggested for application in commercial purpose with synthesized the catalysts.