EXTENDED ABSTRACT

STUDIES ON THE DEVELOPMENT OF SALT RESISTANT ACTIVE ELECTRODES FOR SEAWATER SPLITTING

Name of Student: Arpan Tewary

Roll No.: 20BS0012

Degree for which submitted: Ph. D.

Name of Department: Sciences & Humanities

Name of the Supervisor

Prof. Umaprasana Ojha

&

Prof. A. S. K. Sinha

Introduction

The unabated rise in average global temperature attributed to the large-scale exploitation of fossil fuels and their unbridled use over the years has brought mankind to a juncture of self-destruction. The deteriorating climate conditions, global warming, loss of species and imbalanced ecosystems are all good examples to further support the claim. Population explosion worldwide which is considered to be one of the main reasons behind the rise in energy consumption has been identified as an unfamiliar problem that can only be resolved by developing abundant energy resources that are both sustainable and renewable. Green hydrogen (GH_2) in view of the present context is the future fuel which has the possible capacity to solve multiple problems being faced by mankind. Therefore, electrochemical water splitting is being explored as a viable procedure for the generation of green hydrogen. This technique is eco-friendly with the least chance of CO_2 emissions and a limited scope of intermittency.

Water splitting seems to be an interesting and easy concept however, its practical realization is quite challenging. The synthesis of electrochemically active materials with higher activity and stability under harsh electrocatalytic conditions requires extensive research and development, especially concerning the current scenario of energy production. The process requires meticulous consideration at both the macro and micro levels or even possibly beyond the nanoscale, to develop sustainable electrocatalysts and use them further in the fabrication of electrodes. The accomplishment in this initiative will indeed help us with a step forward towards sustainability.

Chapter 1: Transition metal-based materials like metal oxides, hydroxides, oxyhydroxides, nitrides, carbides, phosphides, sulphides and selenides are all emerging class of materials for electrocatalysis. They hold a lot of promise owing to their unique electronic structure, and material properties that are capable to address the concerns of electrocatalysis. Reportedly several state-of-the-art electrocatalysts have been developed for the purpose of water splitting in both acidic and basic mediums. Concurrently, heterostructures also offer great promise as viable options for further investigation as electrocatalysts and commercialization in the realm of green hydrogen generation.

Chapter 2: In this research work, we have utilized a NC-layered FeOOH heterostructures with Ni_3N encapsulation for performing bifunctional electrocatalysis and durable seawater splitting at feasibly high current density (*j*) values. Regulating the metal content and magnitude of metal-nitride nanoparticles in the heterostructure is also made easier by this method. This method provides for sustainable synthesis of diverse composite heterostructure with controllable catalytic efficacy. This generic process can be expanded to additional metal-nitride systems intended for diverse uses. It may also be appropriate for further commercial application because it is less expensive and doesn't require ammonia or other harsh reducing chemicals like those employed in standard synthetic techniques.

Chapter 3: In this research work we have utilized an in-situ grown Iron-Nickel heterostructures on the nickel foam surface for active hydrogen evolution. This system with nanospike shape and narrow breadth, offers the required large surface area, which is highly appropriate and desirable for HER activity. In alkaline seawater electrolyte, the system displayed adequate electrochemical activity having low overpotential and longer durability. Overall, the study reveals a straightforward process for the in-situ synthesis of heterostructures based active electrodes for seawater electrolysis.

Chapter 4: In this research work, we have used a Nickel-Zinc bimetallic nitride heterostructure based nanocatalyst for electrochemical green hydrogen generation. Electrochemical activity results are promising under both alkaline and alkaline seawater environment. The observed values of HER/OER overpotential are low and the magnitude of current density (*j*) is ultrahigh which is strongly desirable. The work promotes the concept of synergistic effect of transition and non-transition metals for water electrolysis application.

Chapter 5: In this chapter, we put forward conclusive remarks on the findings that have emerged from our research work. We also discuss the opportunities to work in this area along with the future perspectives that lies ahead. This will not only expedite the process of rolling out a greener economy swiftly but also help in achieving the "**Net Zero**" at the earliest.