Seminar

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Institute for Plasma Research

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Title: Tailoring Bifunctional Electrocatalysts Through Plasma-Mediated Surface Activation for Enhanced Water Electrolysis

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Date: 14th July 2024 (Monday)

Time: 03:00 PM

Venue: Seminar Hall, IPR

Abstract

The development of efficient, durable and cost-effective bifunctional electrocatalysts is critical for advancing overall water splitting technologies. In this research, $NiCo_2O_4$ catalysts were synthesized via a hydrothermal method and subsequently doped with iron (Fe) at various concentrations. The resulting Fe-doped $NiCo_2O_4$ catalysts were characterized using XRD, SEM, BET, and Raman spectroscopy to investigate their structural, morphological and electrochemical properties. XRD and Raman analyses confirmed the formation of a spinel structure, while SEM revealed a uniform distribution of Fe nanostructures. Among the different compositions, $NiCo_2O_4$-Fe1 (1 wt% Fe) exhibited the highest BET surface area (41.82 $m^2\ g^{-1}$) and the smallest pore size (7.795 nm), facilitating enhanced ion transport and greater exposure of active sites. Electrochemical analysis showed that $NiCo_2O_4$-Fe1 delivered excellent bifunctional performance, with low overpotentials of 228 mV for the hydrogen evolution reaction (HER) and 274 mV for the oxygen evolution reaction (OER) at a current density of 10 mA cm^{-2}. The corresponding Tafel slopes were 151 mV dec^{-1} (HER) and 52.54 mV dec^{-1} (OER), indicating favorable reaction kinetics. Additionally, the catalyst achieved an overall water-splitting voltage of 1.72 V at 10 mA cm^{-2} and demonstrated excellent stability in a 12 h chronopotentiometry test. The enhanced electrocatalytic performance is attributed to the synergistic effects of Fe-induced modifications in the Ni/Co matrix, which improved electrical conductivity, increased active site density and accelerated catalytic kinetics. These findings identify $NiCo_2O_4$-Fe1 as a promising trimetallic spinel catalyst for bifunctional water splitting applications. Furthermore, $NiCo_2O_4$-Fe1 was composited with reduced graphene oxide (RGO) in a 10:1 ratio and subjected to N_2 plasma treatment for 10, 20 and 30 minutes. The plasma treated composites exhibited further improvements in catalytic activity attributed to the combined effects of Fe doping and plasma-induced surface modifications.

Keywords: Fe-doped $NiCo_2O_4$, Bifunctional electrocatalyst, N_2 plasma treatment.

Reference:

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