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$Ni_xMo_{1-x}O_3$ ($x \leq 0.4$) as Electrocatalysts for Electrochemical Hydrogen Production from Acid Water

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ABSTRACT

Solar electricity powered water splitting is an important scheme for solar energy conversion and storage. For this, electrochemical production of hydrogen from water electrolyzers seems to be one of the promising and sustainable solutions. This hydrogen can be converted back to electricity as in hydrogen driven fuel cell and it can also be used directly in several other applications. Conventional noble metal based electrocatalysts used in the electrolysis of water in devices like proton exchange membrane water electrolyzer (PEMWE) have very limited use due to their high cost and scarcity. Identification of an apt non noble electrocatalyst will be a breakthrough in this field. In this work, we have tried to dope Ni in cheaper MoO_3 nano belt materials and examined the resulting materials as electrocatalysts for the cathodic hydrogen evolution reaction (HER). X- ray diffraction analysis of our synthesized materials indicated that Ni enters into the orthorhombic structure of $\alpha - MoO_3$ up to x = 0.2. Nanobelt morphologies have been observed in TEM analysis and with the increase in the Ni concentration, presence of broken belts has been observed along with few spherical particles. The HER catalytic studies have been performed on these particles using 2.5 M H_2SO_4 solution as the electrolyte in a three electrodes cell assembly. The HER evolving rates as inferred from the linear sweep voltammograms recorded at the 500th cycle for $Ni_{0.1}Mo_{0.9}O_3$, $Ni_{0.2}Mo_{0.8}O_3$, $Ni_{0.3}Mo_{0.7}O_3$ and $Ni0.4Mo_{0.6}O_3$ are compared. The data suggest that the HER current densities increase several times on **$Ni_{0.2}Mo_{0.8}O_3$** and with further increase in the doping concentration beyond x = 0.2, the HER activities decrease. A Tafel slope value of 126 mV/dec has been noticed for $Ni_{0.2}Mo_{0.8}O_3$ from the recorded Tafel curves.
It appears that the adsorption of hydrogen (Volmer reaction) $Mo^{6+}\ OH^- + H_{aq}^+ + e^- \longrightarrow Mo^{5+}OH_2$ is the slow rate determining step during the occurrence of the cathodic HER on this oxide material.

Keywords: Hydrogen evolution reaction, Ni doped MoO_3, Catalytic studies.