ID 1013

Development and Characterization of Composite Electrodes as New Cathode Materials for Water Electrolysis

Benredouane Soumia*, Ifres Madjid , Naama Sabrina , Hadjersi Toufik

Centre de Recherche en Technologie des Semi-conducteurs pour l'Energétique (C.R.T.S.E)
*Corresponding author's email: benredouane_sl@hotmail.fr

ABSTRACT

Herein, we present a novel, efficient and economical composite electrode for hydrogen production. The electrode has been formed by a direct electrophoretic deposition (EPD) of the commercial Ni foam . The obtained active coatings have been tested for their efficiency and performance as electrode surfaces for hydrogen evolution reaction (HER) in 1M KOH by scanning electron microscopy (SEM) and X-ray diffractometry (XRD). The electrochemical characterization for hydrogen evolution reaction (HER) was investigated by cyclic voltammetry (CV) curves, linear sweep voltammetry (LSV) curves and electrochemical impedance spectroscopy (EIS) techniques.

Keywords: Hydrogen evolution reaction, electrophoretic deposition, Electrodes material, electrocatalysis.

1. Introduction

Hydrogen is a promising alternative solution for energy production from both an environmental and economic perspective. Currently, 95% of hydrogen is produced from natural gas, which is a polluting fossil source with a limited lifespan [1]. The search for alternative sources of production is another challenge that humanity must respond to guarantee a secure and sustainable energy supply. Water electrolysis is one of the most important techniques to meet these challenges, particularly due to its economic cost, the simplicity of its implementation and the high purity of the product [2]. In this paper, a simple, rapid, scalable and eco-friendly electrophoretic deposition (EPD) approach was developed for the fabrication of NiCoP_Gn on the surface of Ni foam, and then used it as a robust integrated three-dimensional electrode, the NiCoP-Gr/NF is highly active for the HER with a very low overpotential of 30 mV to drive current densities of 10 mA cm^{-2} in alkaline media

2. Experimental

Electrode preparation.

Firstly, a sheet of nickel foam with the size of 1*1 cm^2 was cleaned in hydrochloric acid (37%), alcohol and water for 15 minutes under ultrasonic, respectively. EPD was developed for to prepare Ni Co P Gr films on the Nickel foam substrate, by using 20 volt/cm^2 anodic current for 30 min.

Electrochemical measurements

The whole electrochemical test was carried out at room temperature in the Autolab electrochemical workstation (PGSTAT 302 N, Metrohm, Switzerland), through a three electrode system, the Ni foam covered with products served as the working electrode, a Pt wire as the counter electrode, and Ag/AgCl electrode served as the reference electrode, 1 M KOH (pH 13.6) was used as the electrolyte. All potentials measured were calibrated to reversible hydrogen electrode (RHE) using the following Equations: E (RHE) = E (Ag/AgCl) + 0.098 + 0.059 pH (in 1.0 M KOH).

3. Results and Discussion

Electrochemical measurements

The cyclic voltammetry curve (Figure 1) shows obvious oxidation peaks and reduction peaks, indicating

DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)

that the material has good redox properties.

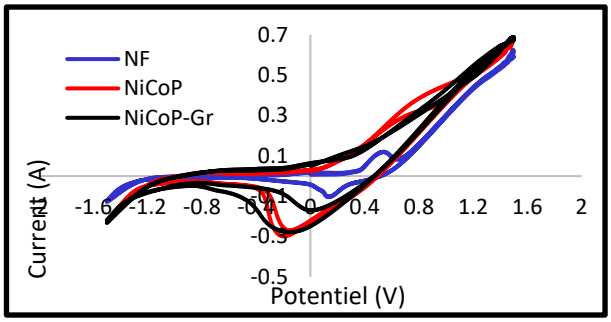

Figure 1: CV curves of NF, NiCoP, and NiCoP-Gr

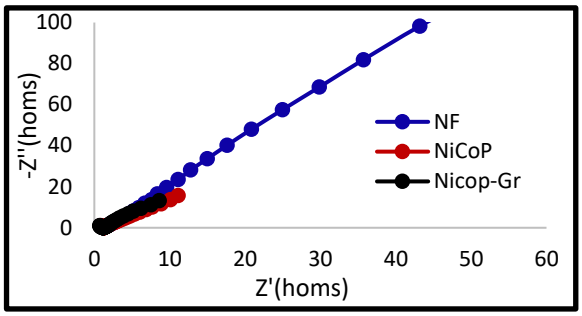

Figure 2: EIS spectrum of NF, NiCoP, and NiCoP-Gr

After being compounded with graphene, the current density and curve area of the composite are much larger than that of Nickel foam alone at the same sweep speed. Figure 2 shows a comparison of Nyquist plots of NF, NiCoP/NF, and NiCoP-Gr/NF. It can be seen that the addition of graphene greatly reduces the resistance, representing that NiCoP-Gr/NF catalyst has exceptional conductivity and electron-transport kinetics toward HER.

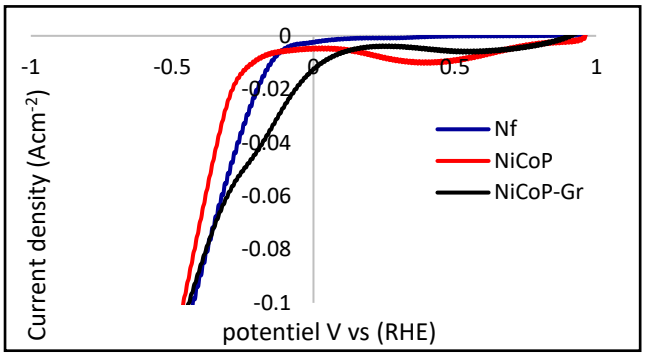

Figure 3: Comparative LSV curves with iR corrected

The analogous test for bare Ni foam is also performed for comparison purposes. Figure 3 show the LSV curves catalysts at a fixed scanning rate of 10 mV s^{-1}. bare Ni foam exhibits very poor HER performance with an initial over potential of 150 mV. On the contrary, the NiCoP-Gr/NF electrode exhibits remarkably high activity for HER with a low onset overpotential of ~30 mV, at current densities of 10 mA cm^{-2}. which is also comparable to those of many HER catalysts non-noble metals reported in alkaline environments.

4. Conclusions

In this study, NiCoP-Gr alloy coating were electrophoretically deposited on a Nickel foam and characterized by different techniques in view of their possible applications as an electrocatalytic material for the HER in alkaline solution. Parameters affecting the electrocatalytic activity for the HER are systematically investigated. Results show the introduction of Gr into NiCoP coating has a significant effect on the HER activity. Hence, this study would open up exciting new avenue to explore the design of self-supported three-dimensional electrodes, ranging from water splitting catalysts to other applications.

5. Acknowledgements

The authors are grateful for financial support by the FNR/CRTSE/DGRSDT/MESRS of Algeria.

References

[1] Zhang.B , Zhang.S-X , Yao.R , Wu.Y-H , Qiu.J-S ,Progress and prospects of hydrogen production: Opportunities and challenges, ournal of Electronic Science and Technology 19 (2021) 1000

[2] Jones.A, Hamann.J, Lund.A, Schuh.C, Nanocrystalline Ni-W alloy coating for engineering applications, Plat. Surf. Finish. 97 (2010) 52.

ISBN: 978-81-970666-4-1

Series: AIJR Abstracts

DOI: 10.21467/abstracts.169