International Journal of Hydrogen Energy 85 (2024) 489–499

Contents lists available at ScienceDirect

International Journal of Hydrogen Energy

journal homepage: www.elsevier.com/locate/he

Ni–Co–Cu composite supported by graphene oxide doped with nitrogen as an anode catalyst in a high-performance glucose electrooxidation

Ramin Kamali, Ali Reza Rezvani [*], Sania Saheli

Department of Chemistry, University of Sistan and Baluchestan, P. O. Box 98135-674, Zahedan, Iran

ARTICLE INFO

Handling Editor: Ramazan Solmaz

Keywords:
Electrocatalyst
Electrochemical performance
Glucose fuel cells
Nitrogen-doped reduced graphene oxide

ABSTRACT

In this research, two electrocatalysts (Ni–Co–Cu/NG-1 and Ni–Co–Cu/NG-2) were synthesized by combined use of nitrogen-doped graphene (NG) and cobalt, copper and nickel with different metallic content. The synthesis procedure was optimized such that nickel and cobalt are composed in hydroxide form and the copper is formed as copper oxide. The electrocatalytic performance of the electrocatalysts studied by cyclic voltammetry for glucose oxidation and the eletrocatalyst with higher metal content displayed a larger current density (30.22 mA/cm^2) in comparison to the other electrocatalyst (22.72 mA/cm^2). This enhancement stems from the synergistic effects of the composite materials in the electrocatalysts. Moreover, graphene oxide plays a key role in improving the movement of electrons on the electrocatalysts surface, which leads to improving the catalytic performance of the catalyst. The durability of the catalysts was evaluated and the results showed that the current decline of the Ni–Co–Cu/NG-1 catalyst was larger than the Ni–Co–Cu/NG-2 electrocatalyst.

1. Introduction

Driven by the substantial impact that millions of vehicles have on air pollution, researchers are diligently exploring sustainable substitutes for traditional power plants [1]. Fuel cells are emerging as an up-and-coming candidate for widespread commercial use. These units transform chemical energy into direct current (DC) electricity via an electrochemical reaction, providing benefits such as low environmental footprint, decreased noise pollution, and adaptability. Fuel cells are becoming crucial alternatives to traditional fossil fuel-based systems in various sectors. There are several types of fuel cells, each distinguished by its own set of characteristics such as operating temperatures, efficiency levels, potential uses, and cost bracket [2–4]. Fuel cells are at the cutting edge of eco-friendly energy solutions, which offer a renewable way to produce electricity from biological fuels like glucose, fructose, and alcohol. These cells can transform chemical energy into electrical energy while driving electrochemical reactions. Highlighting its critical importance in the progress of biofuel cell technology, glucose, in particular, is essential for operating numerous implanted medical devices, including pacemakers, defibrillators, and insulin pumps [5]. Due to its compact molecular structure and high energy density, it is an excellent biofuel for generating electricity through the conversion of chemical energy. In glucose biofuel cells, glucose is oxidized to gluconolactone at the anode, while oxygen is reduced to water at the cathode. Electrocatalysts are pivotal in these reactions, as they help to reduce the water requirement and lower the overpotential, thereby boosting the efficiency of glucose oxidation. The efficiency of the oxidation procedure and the properties of the resulting oxidation byproducts are significantly impacted by the selection of electrocatalyst utilized at the anode [5,6]. Studies have shown that the advancement of glucose fuel cells faces challenges due to the efficiency of charge transfer in electrodes and the expensive nature of electrocatalysts [7,8]. Researchers have explored materials like graphite, carbon nanotubes, non-precious metals, and other sized substances to tackle these obstacles to enhance performance and lower expenses [9]. Graphene isolated in 2004 boasts a surface area of 2630 m^2/g and qualities such as mechanical strength, thermal conductivity, and elasticity. These characteristics position it as a material for this purpose [10–13]. Graphene in a suspended single-layer form can achieve charge carrier mobility exceeding 200 000 $cm^2\ V^{-1}\ s^{-1}$. This showcases conductivity with electrons reaching speeds of 10^{-6} m/s at the Fermi level [14,15].

Furthermore, nitrogen-doped graphene displays heightened activity compared to its doped counterparts, potentially boosting electrochemical performance [16]. Carbon-based electrocatalysts like graphene with transition metals and nitrogen are favored over platinum-based options due to their eco nature, wider availability, and

* Corresponding author.
E-mail address: ali@hamoon.usb.ac.ir (A.R. Rezvani).

https://doi.org/10.1016/j.ijhydene.2024.08.351
Received 14 June 2024; Received in revised form 30 July 2024; Accepted 21 August 2024