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*Abstract*

# Development of Composite Electrodes for Efficient Generation of Green Hydrogen through Photovoltaic Energy †

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Hybrid systems for hydrogen production via photovoltaic electrolysis (PVEL) are recognized as environmentally clean but economically impractical. Consequently, a critical need has emerged for novel materials in both photovoltaic panels and electrolysis cell electrodes. This project aimed to develop carbon-based composite electrodes integrating iron oxide anchored on graphene and multi-walled carbon nanotubes (MWCNTs) for hydrogen generation via aqueous electrolysis under neutral pH conditions utilizing photovoltaic energy. Synthesis of iron oxide nanoparticles ($Fe_3O_4$) occurred through ammonia solution precipitation, followed by their combination with graphene oxide (GO) and MWCNTs. Subsequently, electrodes were crafted through drop-casting with varying $Fe_3O_4$ nanoparticle, GO, and MWCNT proportions on copper substrates.

SEM and Energy-Dispersive Spectroscopy (EDS) analyses were conducted to investigate the nanocomposites' morphology and composition. High-resolution environmental scanning electron microscopy (SEM) and an EDS module were employed. Morphological tests revealed homogeneous $Fe_3O_4$ nanoparticles with a nanoscale diameter, showing the presence of carbon, oxygen, silicon, and iron, consistent with the substrate elements. The results indicate successful $Fe_3O_4$ nanoparticle synthesis. Utilizing carbon-based composites with anchored iron oxide nanoparticles sought to enhance the hydrogen evolution efficiency and stability under neutral pH, fostering the development of efficient and eco-friendly hydrogen production systems driven by photovoltaic energy. Controlled potential electrolysis (CPE) experiments evaluated the water reduction capacity using the $Fe_3O_4$/FMWCNT/OG-modified electrode in a 0.1 M phosphate buffer at pH 7.0. Monitoring charge accumulation revealed its reliance on the applied potentials. Notably, at −1.1 V, charge accumulation was initiated and increased steadily, with a higher negativity yielding greater accumulations. Remarkably, at −1.4 V, the maximum charge accumulation reached 488 mC, highlighting the modified electrode's catalytic efficacy in hydrogen production. These findings underscored the electrode's effectiveness in facilitating hydrogen evolution under neutral pH, emphasizing its potential in practical clean hydrogen generation systems powered by photovoltaic energy.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/proceedings2024105132/s1, Conference Poster: Development of Composite Electrodes for Efficient Generation of Green Hydrogen Through Photovoltaic Energy.



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