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Turning Agricultural Waste into Functional Membranes: Banana Peel-Based Materials for Hydrogen Production via Alkaline Water Electrolysis

ABSTRACT

This study presents the development of a sustainable, low-cost composite membrane for hydrogen production via alkaline water electrolysis using banana peel (BP) as a biomass-derived additive. The membranes were synthesized using polysulfone and polyvinylpyrrolidone (PVP) in N,N-dimethylacetamide, incorporating ground BP particles ($<112\mu\text{m}$) at varying loadings to evaluate their influence on membrane structure, transport properties, and electrochemical performance. A systematic investigation was conducted by varying BP content (0.1-0.4 g and up to 40 wt.% relative to PVP), while maintaining constant polymer composition. Structural and morphological characteristics were analyzed using FTIR and SEM, confirming successful incorporation of BP and its role in modifying pore structure. Electrochemical performance was assessed through electrolysis testing by measuring cell voltage and current and electrochemical impedance spectroscopy (EIS). The results demonstrated that BP incorporation does not prohibit ionic transport and membrane performance. Optimized membranes exhibited charge transfer resistance as low as 0.27-0.28 Ω , compared to 1.05-1.10 Ω for the commercial Zirfon® membrane, corresponding to a 70-75% improvement in ionic conductivity. Additionally, membranes with lower BP loading achieved electrolysis performance comparable to commercial membranes under identical conditions. Overall, this work highlights the potential of agricultural waste-derived materials as functional membrane additives, offering a sustainable pathway for enhancing alkaline water electrolysis systems and advancing green hydrogen production technologies.

Keywords: Hydrogen, Alkaline Water Electrolysis, Membrane, Sustainability

BIOGRAPHY

Şehnaz GENÇ is a PhD candidate and research assistant in Chemical Engineering at Eskişehir Technical University. She holds a B.Sc. degree from Middle East Technical University. Her research focuses on hydrogen production via alkaline water electrolysis, membrane development, and adsorption-based gas separation. Her work combines experimental studies with process modeling for sustainable energy applications.