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Investigation and comparative analysis of materials, efficiency, and design in microbial electrolysis cells for biomethane production

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Abstract

The escalating global demand for energy and the imperative to address greenhouse gas emissions have spurred the exploration of alternative energy sources. Microbial Electrolysis Cells (MECs) have emerged as a promising technology, converting organic compounds into electrical energy and hydrogen gas. A recent breakthrough, namely a hybrid (H-MEC) system, integrates electromethanogenesis to convert CO_2 to methane, offering a novel avenue for efficiently harnessing renewable energy and mitigating emissions. This paper underscores the significance of optimizing the design, materials, and operational strategies to enhance the scalability and efficiency of MEC-based electromethanogenesis. Traditional anaerobic digestion processes, converting biomass residues and food waste into hydrocarbon bioenergy, are being redefined through the integration of H-MECs. This integration presents opportunities for improved effluent treatment, heightened methane production, and the generation of valuable compounds. Recent studies reveal the remarkable ability of ionic conductivity and electrochemical reactions within bacteria to synthesize hydrocarbons, emphasizing factors such as microbes, biofilm development, substrates, and electrode surfaces for amplified methane yields. H-MECs demonstrate exceptional versatility in consuming diverse substances, notably untreated food waste, positioning them as potent microbial biocatalysts. The diligent exploration of this domain has given rise to various H-MEC technologies for hydrogen generation and carbon dioxide reduction. This review delves into the mechanisms and methodologies of H-MECs for electromethanogenesis through varied biochemical reactions, shedding light on single or double-chambered MECs and reactor materials. Furthermore, it elucidates the production of methane and hydrogen via the hydrogen and organic water evolution process coupled with catalyst support systems. By comprehensively exploring H-MECs, this review contributes to a nuanced understanding of their potential and implications in advancing sustainable energy solutions and achieving emissions reduction goals. The integration of electromethanogenesis into MEFCs holds promise for ushering in a new era of cleaner energy production and environmental sustainability.

Author keywords

BioM; CO_2 Capture; Electromethanogenesis; Electron Transfer Mechanism; MECs

Sustainable Development Goals

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