World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:18, No:11, 2024

Sustainable Manufacturing and Performance of Ceramic Membranes

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Abstract : The large-scale application of microbial fuel cell (MFC) technology is significantly hindered by the high cost of the commonly used proton exchange membrane, Nafion. This has led to the recent development of ceramic membranes using various clay minerals. This study evaluates the characteristics and potential use of a new ceramic membrane made from potter's clay © mixed with different proportions (0, 5, 10 wt%) of fly ash (FA), labeled as CFA0, CFA5, CFA10, for cost-effective and sustainable MFC use. Among these, the CFA10 membrane demonstrated superior quality with a fine pore size distribution (average 0.41 μm), which supports higher water uptake and reduced oxygen diffusion. Its oxygen mass transfer coefficient was $4.13 \pm 0.13 \times 10^{-4}$ cm/s, about 40% lower than the control. X-ray diffraction analysis revealed that the CFA membrane is rich in quartz, which enhances proton conductance and water retention. Electrochemical kinetics studies, including cyclic voltammetry and electrochemical impedance spectroscopy (EIS), also confirmed the effectiveness of the CFA10 membrane in MFC, showing a peak current output of 15.35 mA and low ohmic resistance (78.2 Ω). The novel CFA10 ceramic membrane, incorporating coal fly ash, a waste material, shows promise for high MFC performance at a significantly reduced cost (96%), making it suitable for sustainable scaling up of the technology.

Keywords : ceramic membrane, Coulombic efficiency, electro-chemical kinetics, fly ash, proton conductivity, microbial fuel cell
Conference Title : ICMSE 2024 : International Conference on Materials Science and Engineering
Conference Location : Toronto, Canada
Conference Dates : November 25-26, 2024