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FABRICATION AND OPTIMIZATION OF NANOPOROUS MEMBRANES FOR ZINC-BROMINE FLOW BATTERY

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Zinc-bromine flow batteries are crucial for large-scale energy storage. A key challenge is to develop a membrane that selectively allows bromide ions (Br^-) to pass through while preventing bromine (Br_2) without compromising efficiency. Commercial membranes, while effective, tend to be expensive. This study focused on enhancing nanoporous membranes made from poly(methyl methacrylate) (PMMA) Perspex for application in zinc-bromine redox flow batteries. The method involved initially dissolving PMMA in dichloro methane (DCM) by varying both PMMA (from 1.000 ± 0.001 g to 3.000 ± 0.001 g) and DCM (from 20 to 35 cm^3). After determining the optimal formulation for PMMA, silica (particle size range of 40-120 nm confirmed by a particle size analyser, with 99% purity determined by XRF analysis) synthesised from rice husks was added (1% to 10%). The solution was cast into an iron glass mould, and the pore size was measured. The data analysis revealed that the pore size is significantly decreased when silica concentration is increased. The optimal membrane formulation, consisting of 1.000 ± 0.001 g of PMMA and 25 cm^3 of DCM, produced an average pore size of 30.84 µm. Upon incorporating 6% rice husk silica into this formulation, the average pore size was further reduced to 6.68 µm (confirmed by SEM), making this combination the most effective for achieving the smallest pore size. However, the commercial polyethylene membranes have pore sizes ranging from 0.17 to 0.85 µm. Further, a bromine diffusion test conducted over three hours showed that approximately 45% of the bromine diffused through the membrane, whereas the commercial polyethylene showed 5% bromine diffusion. Although the pores were in the micrometre range from SEM data, the overlapping layers of PMMA created a distinct nanostructure and would be the reason for moderate bromine diffusion. The findings of this research provide valuable insights into the factors influencing the optimization of nanoporous membranes and highlight the positive impact of incorporating silica nanoparticles on membrane performance in zinc-bromine redox flow batteries.

Keywords: Nanoporous membranes, Poly(methyl methacrylate) (PMMA), Silica nanoparticles, Zinc-bromine redox flow batteries