Development and Optimization of Anion Exchange Membranes for Salinity Gradient Energy Harvesting

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Abstract

Reverse electrodialysis (RED) is an emerging renewable energy technology that harnesses the salinity gradient between high-concentration saline water sources (e.g., seawater, ocean water, or brine) and low-concentration sources (e.g., river water, lakes, or treated wastewater) [1]. By mixing these streams across a membrane stack composed of alternately arranged cation and anion exchange membranes connected to an external load, RED can generate electrical energy with a theoretical yield of 0.44 to 0.75 kWh/m³ [2]. However, the practical feasibility of RED is constrained by cell efficiency, which is largely dependent on membrane selectivity, ionic conductivity, fouling resistance, and cost [3].

This research focuses on the development and optimization of anion exchange membranes (AEMs) based on polyether sulfone, modified with a cationic surfactant to enhance ion transport and electrochemical performance. The synthesis route offers a relatively safer alternative to traditional, more hazardous AEM fabrication methods. A systematic design of experiments (DOE) approach was employed to study the effects of membrane composition and structural parameters on key performance indicators. Electrochemical characterization demonstrated promising improvements, with membrane selectivity reaching 82.4% and power density achieving 0.63 mW/m² under a five-fold salinity gradient.

References

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Figures

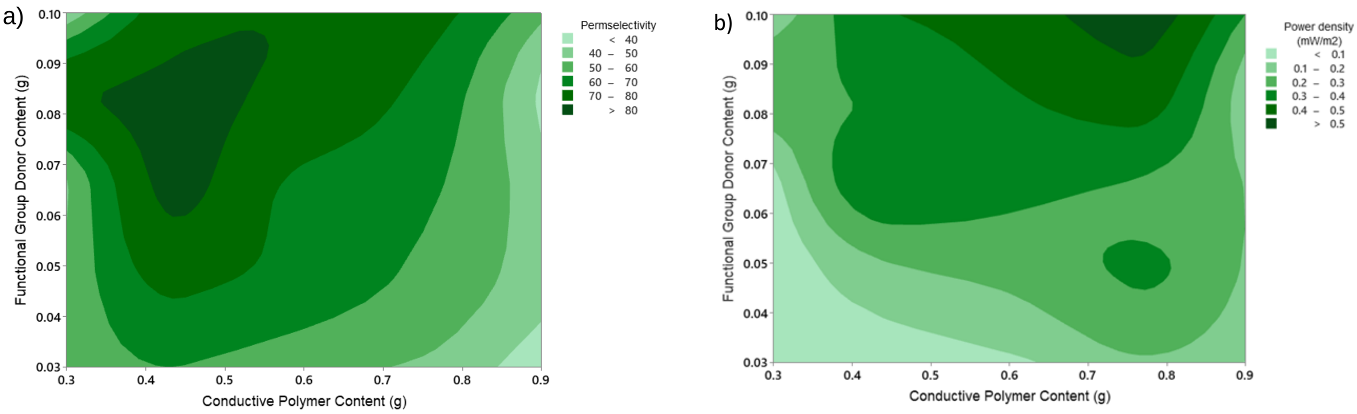

Figure 1: Influence of composition variables on membrane performance: (a) permselectivity and (b) power density (mW/m^2).