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Abstract

Reverse Electrodialysis Stack with New Grafted Ion-Exchange Membranes Show Net Power Density up to 2 W/m² †

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Abstract: Introduction. In recent years, the search for alternative renewable energy sources has been actively carried out. Considerable attention of scientists is attracted by energy generation methods based on the mixing of electrolyte solutions of different concentrations – Blue Battery systems. Among these methods, a promising system is reverse electrodialysis, the principle of which is the generation of electrical potential over a stack of ion-selective membranes when a concentrated and diluted electrolyte is passed at different sides of the membranes in the RED stack. The development and testing of membranes are among the main trends for RED optimization. Due to the outstanding transport properties, it was suggested that grafted membranes could be potentially effective in the RED process. In this study, synthesized grafted cation and anion exchange membranes based on functionalized polystyrene grafted onto UV-oxidized polymethylpentene films was tested in lab-scale reverse electrodialysis stacks.

Results and Discussion. The synthesized grafted membranes provided the highest power density of lab-scale stacks with a total active membrane area of 72 cm² with the use of 0.1 M/1 M NaCl (0.67 W/m²) and 0.1 M/5 M NaCl (2.1 W/m²) solutions. The use of grafted membranes with a low resistance ~0.5 Ω cm² (0.5 M NaCl, 25 °C) did not benefit the stack resistance; the low selectivity of such membranes resulted in a lower open-circuit voltage of stacks and high non-selective diffusion losses. Higher power densities and current efficiencies in model systems were observed for grafted membranes with moderate conductivity and high permselectivity. A strong correlation between the calculated and experimental stack resistances was found for the 0.1 M/1 M NaCl electrolyte system. In the case of a 0.1 M/5 M NaCl stack, this correlation is markedly poorer, which may be attributable, first, to a considerable change in the concentration of dilute electrolyte in the dilute feed channel caused by the high diffusive flux of the electrolyte and the high osmotic flux of water and, second, to the effect of concentration polarization. The correlations between the measured membrane potential and the open circuit voltage for the stacks in both electrolyte systems are very strong. The results of the study were published in the following article [1].

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Reference. 1. Golubenko D.V., Van der Bruggen B., Yaroslavtsev A.B. Ion exchange membranes based on radiation-induced grafted functionalized polystyrene for high-performance reverse electrodialysis // J. Power Sources. 2021. Vol. 511, № March. P. 230460.

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