DEVELOPMENT OF ION EXCHANGE MEMBRANES FOR CAPACITIVE DEIONIZATION

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ABSTRACT

Capacitive deionization (CDI) has attracted rapidly growing research interest as a novel and energy-efficient technology that has the potential to compete with conventional desalination technologies such as reverse osmosis (RO) and electrodialysis (ED) among others. [1, 2] CDI is an electrochemical-based desalination technology driven by a low voltage applied under ambient conditions between two electrodes made of conductive materials. [3] In membrane capacitive deionization (MCDI), ion-exchange membranes (IEMs) are placed in front of the electrodes to further enhance desalination efficiency by increasing selectivity and preventing co-ion expulsion from the electrodes into the salt solution. [4]

In the present study, novel two-layer composite electrode(s) were developed by coating the top surface of an activated carbon (AC)-based modified graphite electrode, which serves simultaneously as a support material and a current collector, with a poly(vinyl alcohol) (PVA)-based composite ion exchange membrane. Specifically, AC was dispersed in a solution of PVA mixed with either polyacrylic acid (PAA) or poly dimethyl diallyl ammonium chloride (PDMDAAC), and then cast onto the top surface of an AC-based modified graphite electrode prepared by phase inversion to form a thin composite layer that was cross-linked in the presence of glutaraldehyde (GA) for further stabilization. The chemical structure of the PVA-based membranes was determined by Fourier-Transform Infrared (FTIR) spectroscopy and their morphology was analyzed by Scanning Electron Microscopy (SEM). Cyclic Voltammetry (CV) was performed to examine the electrochemical properties of the composite electrodes. Desalination experiments were subsequently conducted in batch mode using a MCDI unit cell with the novel two-layer composite electrodes to experimentally investigate the effect of cross-linking on the desalination efficiency of the system. Comparative studies were realized with commercially available membranes proving that the developed two-layer composite electrodes can be further applied in water desalination and increase the efficiency of the process. The enhanced desalination performance is attributed to the optimized properties of the selected polymers and the improved adhesion of IEMs to the electrodes.

KEYWORDS: ion exchange membranes, composite electrodes, capacitive deionization, water desalination, water treatment

REFERENCES

[1] Liu Y, Nie C, Liu X, Xu X, Suna Z, Pan L. (2015). Rsc Advances, 5(20), 15205-15225.
[2] Liu P, Yan T, Shi L, Park H S, Chen X, Zhao Z, Zhang D. (2017). Journal of Materials Chemistry A, 5(27), 13907-13943.
[3] Suss M E, Porada S, Sun X, Biesheuvel P M, Yoon J, Presser V. (2015). Energy & Environmental Science, 8(8), 2296-2319.
[4] McNair R, Szekely G, Dryfe R A. (2020). ACS ES&T Water, 1(2), 217-239.