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An experimental and computational investigation of poly(piperazine-amide) thin-film composite membrane for salts separation from water using artificial neural network

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ABSTRACT

From ever-evolving techniques for desalination to wastewater treatment, membranes have been established themselves as front runners. Recent advances in the development of thin-film composite (TFC), membranes have enabled efficient contaminant separation in terms of ions as well as organics to improvise water treatment. In this study, poly(piperazine-amide) based three-layer membrane was developed through interfacial polymerization of piperazine (aq.) and 1,3,5-trimesoyl chloride (hexane) on a base polysulfone layer supported on non-woven polyester fabric. Membrane efficiency, in terms of permeate flux and salt rejection, was evaluated experimentally by separating $NaCl/Na_2SO_4$ from solutions having different salt concentrations (500-20,000 mg/L). The experimental results have been further modeled and simulated using artificial neural network (ANN) trained using efficient algorithms: Levenberg-Marquardt backpropagation (LM-BP), scaled conjugate gradient backpropagation (SCG-BP), and particle swarm optimization (PSO). Modeling performance has been compared using regression coefficient and mean square error. Optimal search of acceleration factors (c_1 = 1.75/1.5, c_2 = 1.75/2.5), weight of inertia (ω = 0.4), swarm size (10), and nodes (10) exhibited superior performance for PSO-ANN model than LM-BP-ANN and SCG-BP-ANN models to enable efficient modeling of output–input correlations. This combined experimental and computational study paves the way for study and development of next-generation TFC membrane materials for desalination and inherent process optimization.

Keywords: Poly(piperazine-amide) thin-film composite membrane; Separation of salts; Artificial neural network; Modeling and simulation; Particle swarm optimization

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