

Synthesis and evaluation of silica sodalite/PSF/PVA membrane for removal of phenol from industrial wastewater

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Abstract

Human activities such as industrial developments are polluting and compromising the safety and quality of water resources available for human consumption and domestic purposes. Phenol is one of the major pollutants produced by industrial processes and it has high toxicity levels even at low. United States Environmental Protection Agency (EPA) and the National Pollutant Release Inventory (NPRI) of Canada have designated phenol as one of the priority pollutants. Recently researchers have focused attention towards the utilization of membrane technology for removal of phenol from industrial wastewater due to its cost effectiveness as compared to other technologies. In this study, a novel mixed matrix composite membrane was developed for removal of phenol from a synthetic wastewater consisting of phenol. Organic-free silica sodalite (SSOD) nano-particles were synthesized via topotactic conversion and embedded in polysulfone (PSF) matrix for enhancement of mechanical strength and separation performance of the polymer membrane. As comparison, a similar membrane was prepared using hydroxy sodalite (HSOD) nano-particles obtained via hydrothermal synthesis method. The composite membranes were synthesized via phase inversion and coated with polyvinyl alcohol (PVA) for improving anti-fouling property. Different characterization techniques such as; Scanning Electron Microscope (SEM) to examine the surface morphology, Brunauer Emmett–Teller (BET) for evaluating textural properties of the nanoparticles. Contact angle measurements to check the surface hydrophilicity; nanotensile tests to measure the mechanical properties; and Atomic Force Microscopy (AFM) to study the surface roughness of the membrane. The results obtained show that pure PSF has highest contact angle of 83.81° while composite membrane coated with PVA showed significantly lower contact angle of 57.47° , indicating enhanced hydrophilicity of the PSF membranes. The composite membrane displayed 56.14% increase in young's modulus and 81.53% increase in ultimate tensile strength when compared to that of the pure PSF, indicating an enhancement in the mechanical strength of the PSF. AFM results showed that surface roughness reduces with increasing nano-particles loading and PVA coating of PSF membranes. Separation performance of the fabricated membranes was carried out using a dead-end filtration cell at varied feed pressure with a synthetic phenol-containing wastewater

of 20 mg/L of phenol. Results showed that, 10 wt.% SSOD/PSF/PVA displayed the highest flux; $0.835 \text{ Lm}^{-2}\text{h}^{-1}$ for pure water and $0.625 \text{ Lm}^{-2}\text{h}^{-1}$ phenol-containing water, attributable to the enhanced hydrophilicity as seen by lower contact angle. Furthermore, results showed that phenol rejection decreased with increasing pressure. Pure PSF membrane performed well rejecting 93.55% phenol at 4 Bar. However, the 10 wt.% SSOD/PSF/PVA, 0 wt.% SSOD/PSF/PVA, and 10 wt.% HSOD/PSF/PVA all coated with PVA displayed lower rejection of 27.9%, 40.65% and 35.6%, respectively. Nonetheless, 10 wt.% SSOD/PSF membrane performed relatively well with 64.75% rejection compared to 27.9% achieved with 10 wt.% SSOD/PSF/PVA. Therefore, a novel mixed matrix membrane with enhanced mechanical properties and selectivity was successfully developed for removal of phenol from industrial wastewater.

Key Words: Phenol; Fouling; Composite membrane; Silica sodalite