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Influence of controlled functionalization of mesoporous silica nanoparticles as tailored fillers for thin-film nanocomposite membranes on desalination performance

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Abstract

Thin film nanocomposite (TFN) membranes comprising of controlled functionalized mesoporous silica nanoparticles (MSN) blended in the polyamide (PA) barrier layer were prepared via interfacial polymerization of m-phenylenediamine (MPD) and trimesoyl chloride (TMC) on a porous polyethersulfone (PES) support membrane. MSN were synthesized by sol-gel process and then functionalized with octadecyltrichlorosilane (OTS) using post-grafting method. The nitrogen adsorption measurements demonstrated that the hydrophobic alkyl chains of OTS can be grafted onto the internal pores of MSN or just be located on the external particle surface, depending on the functionalization procedure and the OTS concentration. The functionalized nanoparticles with a diameter of about 80 nm were thereafter easily dispersed in the organic phase during the interfacial polymerization. Evaluation of membranes' performance was based on water and ethanol permeability measurements, in addition to salt rejection from aqueous solutions. The results indicated that the functionalization of the external surface of MSN only, without extension to the interior pores surface, significantly increased both water and ethanol permeabilities. Contrarily, the surface modification of the MSN internal pores, only increased the permeability of ethanol and reduced the water permeability, mainly due to the hydrophobicity of OTS. The influence of nanoparticles loading, as well as the concentration of OTS and thus the extent of MSN functionalization on the separation performance of TFN membranes were also investigated. TFN membranes prepared using the optimized MSN functionalization and loading yielded up to 63 % higher water permeability compared to the reference TFC membrane without sacrificing the membrane selectivity. This work clearly emphasizes the direct relationship between the internal pores of MSN as functional nanofiller