

Modification of a Commercial Ultrafiltration Membrane by Electrospray Deposition for Performance Adjustment

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Abstract : Filtration with nanoporous ultrafiltration membranes is an attractive option to remove ionic pollutants from contaminated effluents. Unfortunately, commercial membranes are not necessarily suitable for specific applications, and their modification by polymer deposition is a fruitful way to adapt their performances accordingly. Many methods are usually used for surface modification, but a novel technique based on electrospray is proposed here. Various quantities of polymers were deposited on a commercial membrane, and the impact of the deposit is investigated on filtration performances and discussed in terms of charge and hydrophobicity. The electrospray deposition is a technique which has not been used for membrane modification up to now. It consists of spraying small drops of polymer solution under a high voltage between the needle containing the solution and the metallic support on which membrane is stuck. The advantage of this process lies in the small quantities of polymer that can be coated on the membrane surface compared with immersion technique. In this study, various quantities (from 2 to 40 $\mu\text{L}/\text{cm}^2$) of solutions containing two charged polymers (13 mmol/L of monomer unit), namely polyethyleneimine (PEI) and polystyrene sulfonate (PSS), were sprayed on a negatively charged polyethersulfone membrane (PLEIADE, Orelis Environment). The efficacy of the polymer deposition was then investigated by estimating ion rejection, permeation flux, zeta-potential and contact angle before and after the polymer deposition. Firstly, contact angle (θ) measurements show that the surface hydrophilicity is notably improved by coating both PEI and PSS. Moreover, it was highlighted that the contact angle decreases monotonously with the amount of sprayed solution. Additionally, hydrophilicity enhancement was proved to be better with PSS (from 62 to 35°) than PEI (from 62 to 53°). Values of zeta-potential (ζ) were estimated by measuring the streaming current generated by a pressure difference on both sides of a channel made by clamping two membranes. The ζ -values demonstrate that the deposits of PSS (negative at pH=5.5) allow an increase of the negative membrane charge, whereas the deposits of PEI (positive) lead to a positive surface charge. Zeta-potentials measurements also emphasize that the sprayed quantity has little impact on the membrane charge, except for very low quantities (2 $\mu\text{L}/\text{m}^2$). The cross-flow filtration of salt solutions containing mono and divalent ions demonstrate that polymer deposition allows a strong enhancement of ion rejection. For instance, it is shown that rejection of a salt containing a divalent cation can be increased from 1 to 20 % and even to 35% by depositing 2 and 4 $\mu\text{L}/\text{cm}^2$ of PEI solution, respectively. This observation is coherent with the reversal of the membrane charge induced by PEI deposition. Similarly, the increase of negative charge induced by PSS deposition leads to an increase of NaCl rejection from 5 to 45 % due to electrostatic repulsion of the Cl⁻ ion by the negative surface charge. Finally, a notable fall in the permeation flux due to the polymer layer coated at the surface was observed and the best polymer concentration in the sprayed solution remains to be determined to optimize performances.

Keywords : ultrafiltration, electrospray deposition, ion rejection, permeation flux, zeta-potential, hydrophobicity

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