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Effect of pore size of electrospun membrane on quality and ion separation of nanofiltration membrane

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In this research, the effect of the pore size of the electrospun membrane in the preparation of a three-layer thin film nanofiber composite membrane (TFNC) was investigated. Due to its special properties, such as high porosity and the ability to produce pore sizes ranging from tens of nanometers to several micrometers, along with different mechanical properties, it finds wide applications in various fields, including medicine and health (i.e., tissue engineering, drug delivery, protective clothing, and biosensors), environment (air and water filtration membranes), energy (solar cell, battery fuel) and makes the use of electrospun membranes highly promising in separation technology.

The three-layer membrane comprised a first layer of mesh-shaped polyester and a middle layer of a substrate consisting of hydrophobic polysulfone with a concentration of 20% by weight. The middle layer was produced by electrospinning with varying pore sizes. The third layer was a polyamide layer formed through interfacial polymerization between piperazine monomers (2wt.%) and trimesoyl chloride monomers (0.2wt.%). The polyamide layer and polysulfone fibers were characterized using infrared spectroscopy (FTIR), scanning electron microscope (SEM), bubble point, and MgSO4 divalent ion separation.

Based on the FTIR test, peaks of 1618 and 2990 were observed, indicating the presence of the polyamide layer and polysulfone substrate, respectively. The electrospinning was conducted under constant conditions, including a voltage of 17 kV, a needle-to-collector distance of 120 mm, and a variable polymer injection rate set at 2, 1.2, 0.8, and 0.5 ml/h. The diameter of the fibers was measured using SEM images (0.11 ± 1.25, 0.45 ± 0.9, 0.37 ± 0.58, and 0.12 ± 0.3 micrometers), and the pore sizes of each substrate were measured as 9.3, 7.1, 3.5, and 1.1 microns by bubble point. The MgSO4 salt separation test was conducted on membranes with various pore sizes and fiber diameters after the coating process. In this experiment, the separation percentage for MgSO4 divalent salt was measured as 0%, 23%, 51%, and 83%, respectively. The separation of MgSO4 ions increased with the reduction of the pore size.

Nanofiltration is a relatively recent separation process that has found widespread applications in the chemical and environmental industries due to its lower energy consumption and higher flux. In this study, we investigated the effect of the pore size of the electrospun layer. It was observed that the average diameter of the electrospun membrane fibers has a direct relationship with the pore size. As the diameter of the fibers decreases, the pore space also becomes smaller. Subsequently, the layer uniformity of polyamide is enhanced on the electrospun membrane, leading to a higher separation rate of bivalent ions.

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Primary authors: KHEZRI, zahra (Separation Processes and Nanotechnology Lab, Faculty of Caspian, College of Engineering, University of Tehran, Tehran, Iran); RIAZI, Masoud (School of Mining and Geosciences, Nazarbayev University, Kabanbay Batyr 53, Astana, Kazakhstan, 010000); MOUSAVI, Seyed Hamed (Separation Processes and Nanotechnology Lab, Faculty of Caspian, College of Engineering, University of Tehran, Tehran, Iran)

Presenter: RIAZI, Masoud (School of Mining and Geosciences, Nazarbayev University, Kabanbay Batyr 53, Astana, Kazakhstan, 010000)

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