**Petroleum Research**

Petroleum Research 2018 (February-March), Vol. 28, No. 102. 17-21

**DOI: 10.22078/pr.2018.3022.2402**

# Fabrication and Characterization of blending Nanofiltration Membranes Based on PES / PVDF for Wastewater Treatment

**Fahime Parvizian*, Mahdieh Sadat Mosavi Motahar, Sayed Mohsen Hosseini, Ehsan Bagheripor**

Department of Chemical Engineering, Faculty of Engineering, Arak University, Arak, Iran

**F-Parvizian@araku.ac.ir**

**DOI: 10.22078/pr.2018.3022.2402**

Received: December/04/2017 Accepted: November/24/2017

## INTRODUCTION

The membrane process is a memorable separation technology because it is the fast and energy efficient process without any phase change. The application of membranes is growing in pharmaceutical, chemical, paper, semiconductor, textile, water and wastewater processes. The controlling of the membrane structure is the main aim in preparation of membranes. It effects on the membrane performance [1]. Nanofiltration membrane is one type of membrane which is characterized by its surface charge and pore sizes [2]. PES has been extremely used as a membrane fabrication material because of its appropriate properties. PES is a hydrophobic polymer and is easily susceptible for fouling. PES and PES-based membranes show thermal and hydrolytic stability as well as good mechanical property and chemical resistance [3].

Poly (vinylidene fluoride) (PVDF) is a prevalent membrane material in microfiltration (MF), ultrafiltration (UF) and nanofiltration (NF) membrane preparation because of its excellent chemical resistance, high mechanical strength and thermal stability. Also, Poly (vinylidene fluoride) (PVDF) is a partially crystalline polymer known for its excellent resistance to solvent, thermos oxidative degradation, and exceptional hydrolytic stability. Moreover, it has high chemical resistance with many acids and alkalis, and also with good biology. All these properties make PVDF as an attractive membrane material [4,5].

In this work, PES/PVDF blend membranes based on nanofiltration have been prepared for waste water treatment. It has been investigated the effect of various blend ratio of PES/PVDF on the NF membrane performance/properties.

In addition, resulting blend membranes have been characterized by scanning electron microscopy (SEM), mechanical strength, contact angel, water content, pure water flux, permeate water flux and salt rejection.

## EXPERIMENTAL PROCEDURE

### MATERIALS

Polyethersulfone (PES Ultrason E6020P with Mw=58,000 g/mol) and poly (vinylidene fluoride) (PVDF) from Alfa-Aesar as membrane polymers have been used; moreover, polyvinylpyrrolidone (PVP, with Mw=25,000 g/mol) from Merck has been applied as pore former and dimethylacetamide (DMAC) from Merck has been utilized as solvent. In addition, the distillated water has been used as non-solvent (coagulation bath) during all experiments.

### MEMBRANE PREPARATION

Blended membranes of PES/PVDF have been prepared by the phase inversion method. In the PVDF/PES blend casting solution, PVDF concentrations have been set as 0%, 0.5%, 1%, 1.5% and 2%. The prepared PVDF/PES membranes have been termed M1, M2, M3, M4 and M5 Respectively. The homogenous solutions of PES/PVDF have dissolved in DMAC in the presence of 4 wt.% PVP as pore former. The homogeneous polymer solutions have been kept for the removal of bubbles. The solutions have been sprinkled and have been casted on a glass plates by a homemade casting knife with 150 µm thickness. The glass plates have been immediately moved to the non-solvent bath and have been immersed in deionized water bath at room temperature. Then the exchange between the solvent (DMAC) and the nonsolvent (water) has happened.

## RESULTS AND DISCUSSION

The FTIR-ATR spectra of neat PVDF/PES membranes are shown in Fig. 1. As shown in Fig. 1, the peak of 1404 $cm^{-1}$ has been associated with the deformation vibration of $–CH_2$, and the vibration bonds at 1296 cm-1 and 1155 $cm^{-1}$ corresponded to the symmetrical and asymmetrical stretching of –CF2, respectively [6]. Moreover, the peak of between 615 $cm^{-1}$ and 719 $cm^{-1}$ has been considered as one of the characteristic peaks of PVDF. In addition, the results demonstrate the presence of PVDF in blend membranes.

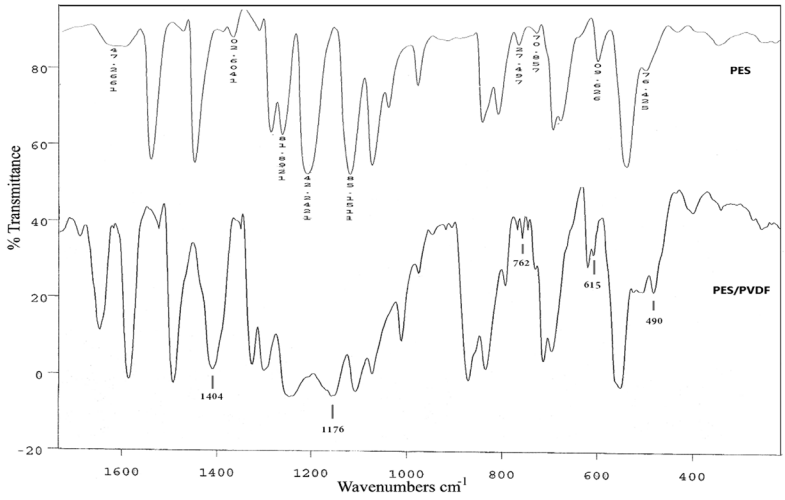


**Figure 1:** FTIR spectra of PES and PES/PVDF nanofiltration membranes.

SEM images (Fig. 2) have been carried out to evaluate changes in morphology of prepared membranes.

Due to the incompatibility of PES and PVDF, a structure with more porosity has been obtained by adding PVDF.

The effect of PVDF concentrations on membrane water content and porosity has been shown in Fig. 3. In addition, the results have shown that membrane water content has been generally increased by adding PVDF polymers with various concentrations.

The effect of PVDF concentration on flux and salt rejection is shown in Fig. 4. Moreover, the obtained results have shown that the flux has been improved by adding PVDF up to 0.5 wt.%.

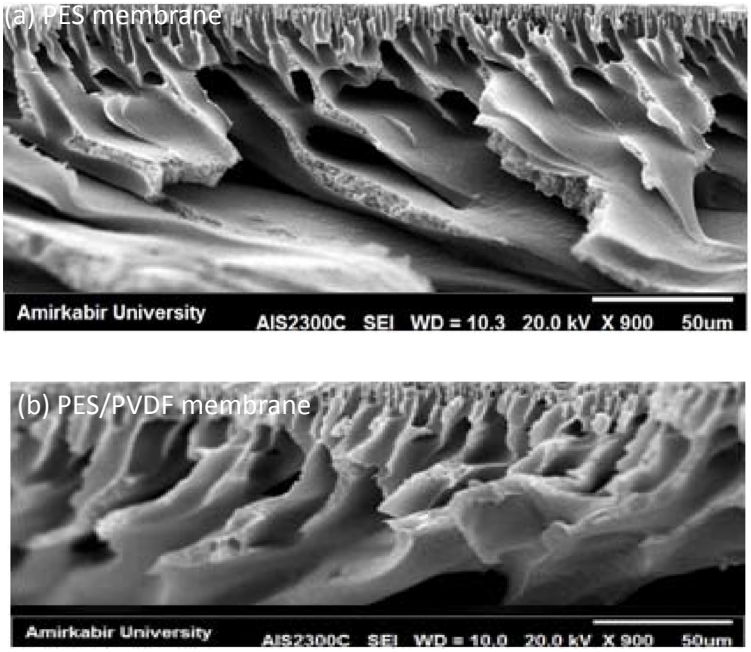


**Figure 2:** The SEM images of cross-sectional of fabricated membranes.

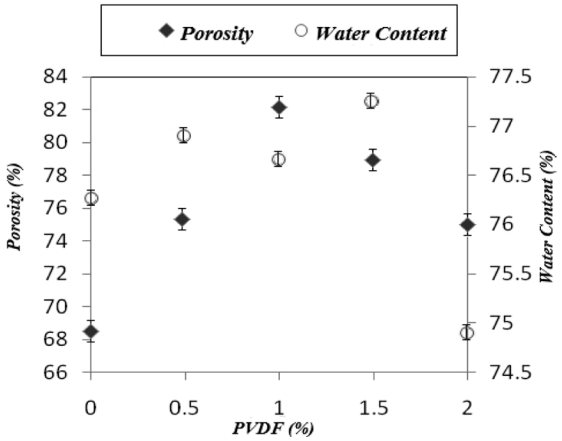


**Figure 3**: Water content and porosity of prepared membranes.

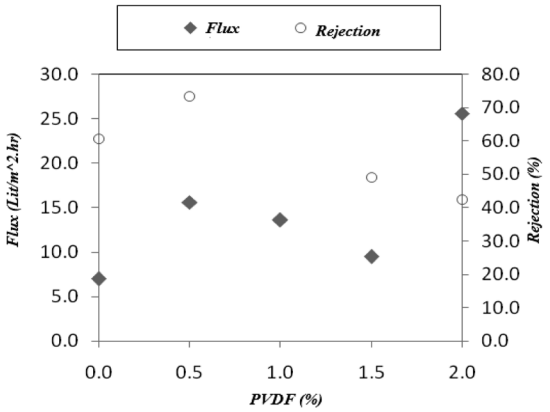


**Figure 4:** Flux and Rejection of prepared membranes.

Also, the obtained results have shown that the flux has been improved by adding PVDF up to 0.5 wt.%. This behavior can be explained by water content improvement and porosity increment (Fig. 3). By more adding PVDF, the flux has been decreased up to 1.5 wt.%. This may be due to the accumulation of PVDF in the some surface pores. The incompatibility between PVDF and PES has caused more porous surface formed. An increase in PVDF from 0 wt.% to 0.5 wt.% has improved the sodium sulfate rejection from 61% to 76%.

## CONCLUSION

In this work, a blending nanofiltration membrane based on PES and PVDF has been prepared and characterized. Also, the results of FTIR spectra demonstrate the presence of PVDF in blend membranes. In addition, it has been found that the membrane water content has been generally increased by adding PVDF up to 0.5 wt.%. The SEM images have shown that porosity in sub-layer has increased by adding PVDF because of its incompatibility with PES. The obtained results have revealed that the membrane water content, porosity and permeation flux have improved by increasing PVDF content at 0-0.5 wt.% loading range and again, they have deducted by the application of higher PVDF into the casting solution. Finally, the results have indicated the better performance of blending membrane at both permeability and rejection for 0.5 wt.% PVDF content.

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