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WASTEWATER TREATMENT WITH POLYMERIC MEMBRANES

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Abstract

Membrane processes for industrial wastewater treatment are used for large types of pollutants in the pharmaceutical industry, textile industry, food industry, agronomy, but it also has the disadvantage of fouling which has an influence on the water flow. To minimize these problems, it is necessary to obtain membranes with a reduced roughness, so we will also obtain an increase in water flow. By increasing the polymer concentration, the membrane has lower porosity and the water flow decreases. The roughness increases at a lower concentration of polymer because the pours are connected with the surface and the top layer disappears. Research in the field has shown the improvement of membrane properties by adding additives, but these represent additional costs of the process. In this paper, results of the properties of membranes obtained at different concentrations and thicknesses of the polymer are presented. 1-Methyl-2-pirrolidinone (NMP) solvent and polyethersulfone (PES) polymer were used to make the membranes. Polyethersulfone membranes were fabricated using phase inversion. The results show that the polymer concentration has an important influence on the water flux. In this study, there are presented four types of membranes with concentrations ranging from 15 wt.% – 30 wt.% and two different types of thicknesses, 200 μm and 300 μm. The thickness has a negative impact on the water flux. After the preparation of the membranes at different concentrations and thicknesses of the polymer, the flow of the membranes was determined, and after its establishment, the permeability of the membranes was determined. It has been observed that the permeability decreases when high concentrations of the pouring solution are used.

Keywords: Polymer, membrane, wastewater treatment

1 INTRODUCTION

The extensive field of use of membranes, including water treatment and wastewater treatment has led over time to an improvement of the whole process, from the use of different types of polymers to the improvement of their properties.

Membrane technology is a complex process starting from the manufacture of membranes, to the process of filtration through membranes in order to obtain a high flow of permeate with considerable retention [1].

There are many studies in the field regarding the membranes properties by using additives like nanoparticles in the membranes structures or on the surface [2], [3], [4], [5], [6]. The advantages of the additives are the reducing of the surface roughness and increase of the porosity but the cost is increasing.

Polyethersulfone has been used in a wide range of applications in the preparation of membranes such as the medical field [7], liquid separation processes (liquid-gas separations; wastewater treatment) [8], with good thermal properties, chemical stability, mechanical properties [7].

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Barth et al. [9] investigated the effects of pouring solution, substrate and membrane thickness on the structural and permeability properties of PES membranes.

Wood et al. [10] examined the effect of polyethersulfone concentration (PES) on the performance of membranes and showed that their performance was influenced by the concentration of PES.

To have an economic process, more studies are necessary to determine the optimal concentration of polymer to obtain membranes for every type of wastewater treatment process.

2 MATERIALS AND METHODS

2.1 MATERIALS

In this experimental study, to obtain membranes for water filtration, the solvent 1-Methyl-2-pyrrolidinone and the polymer polyethersulfone (PES) were used, purchased from Sigma-Aldrich. The support layer was NOVATEXX 2471 received from Freudenberg, Germany.

2.2 METHODS

We obtained different concentrations of the polymer solution (with 4 concentrations and two different thicknesses of the polymer) by mixing PES with NMP. The membranes were fabricated by the phase inversion method, and subsequently, the formed membranes were tested to obtain values of flow through the membrane and their permeability.

3 RESULTS AND DISCUSSION

In this paper, we studied membrane flow and permeability of PES membranes. The materials for the manufacture of membranes were used in the form received from the manufacturers. The polymer solution was prepared by mixing the NMP solvent with the PES polymer for at least 24 hours for each concentration.

The latter was poured onto the backing layer and spread on it using a thin film applicator and a pouring knife. The formed film was immersed in distilled water for 15 minutes. The membranes were cut and tested.

Polymer concentrations and their thickness (Table 1) have an influence on flow and permeability.

Table 1 Polymer concentration and thickness in the manufacture of composite polymeric membranes.

Membrane	Type of polymer	Concentration of polymer [wt.%]	Thickness [μm]
1	Polyethersulfone (PES)	15 wt.%	200 μm and 300 μm
2		20 wt.%	
3		25 wt.%	
4		30 wt.%	

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3.1 Membrane flow parameters and membrane permeability

We used mixtures with different concentrations of PES polymer (15 wt.%; 20 wt.%; 25 wt.%; 30 wt.%), as well as its different thicknesses (200μm; 300μm).

3.1.1 Flow

Pure water flow was measured for every type of membrane to study compaction time and the pure water flux. In Fig. 1, it is shown the water flux for membranes at 15, 20, 25 and 30 wt.% polymer at two different membranes thickness, 200 and 300 micrometers.

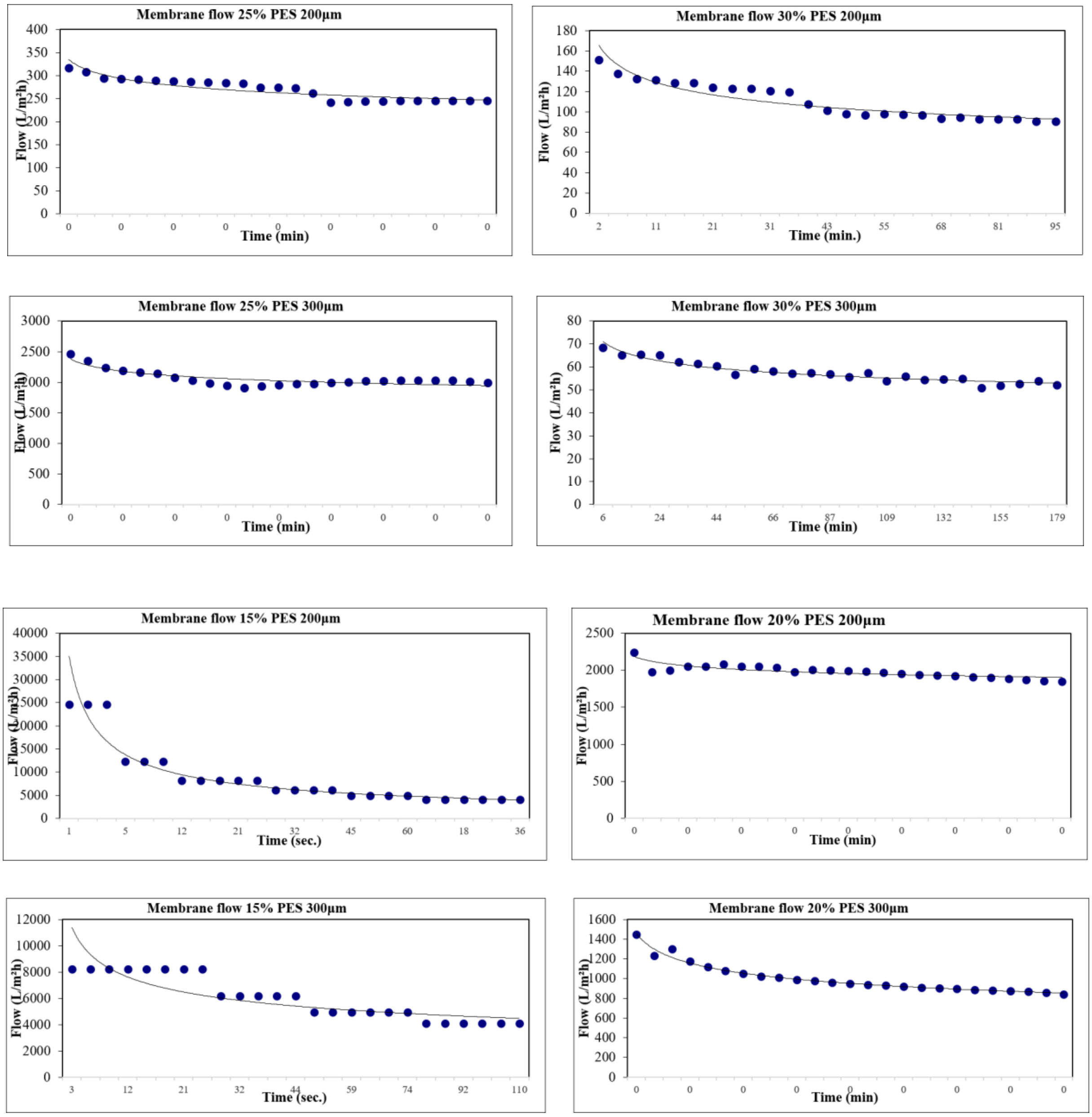

Figure 1. Pure water flux.

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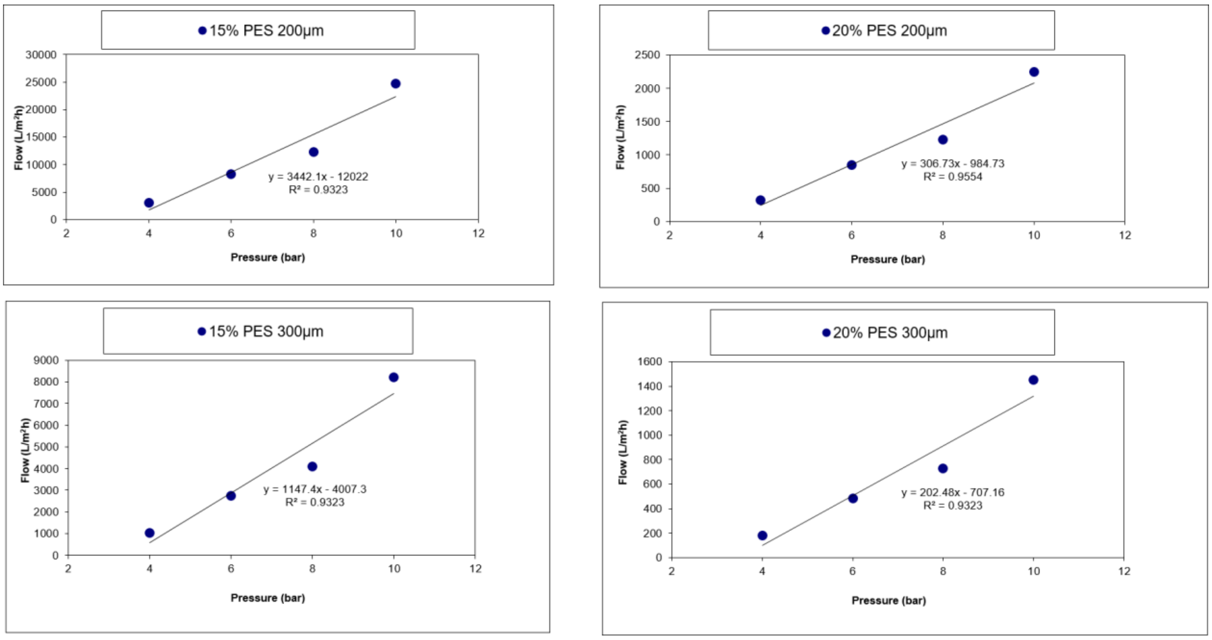
The results show that the polymer concentration has an important effect on the water flux. Increasing the polymer concentration, the flux is decreasing. The same effect can be observed if the membrane thickness is increasing.

3.1.2 Permeability

Permeability was measured for every type of membrane to study compaction time and the pure water flux. In Fig. 2, it is shown the permeability for membranes at 15, 20, 25 and 30 wt.% polymer at two different membranes thickness, 200 and 300 micrometers.



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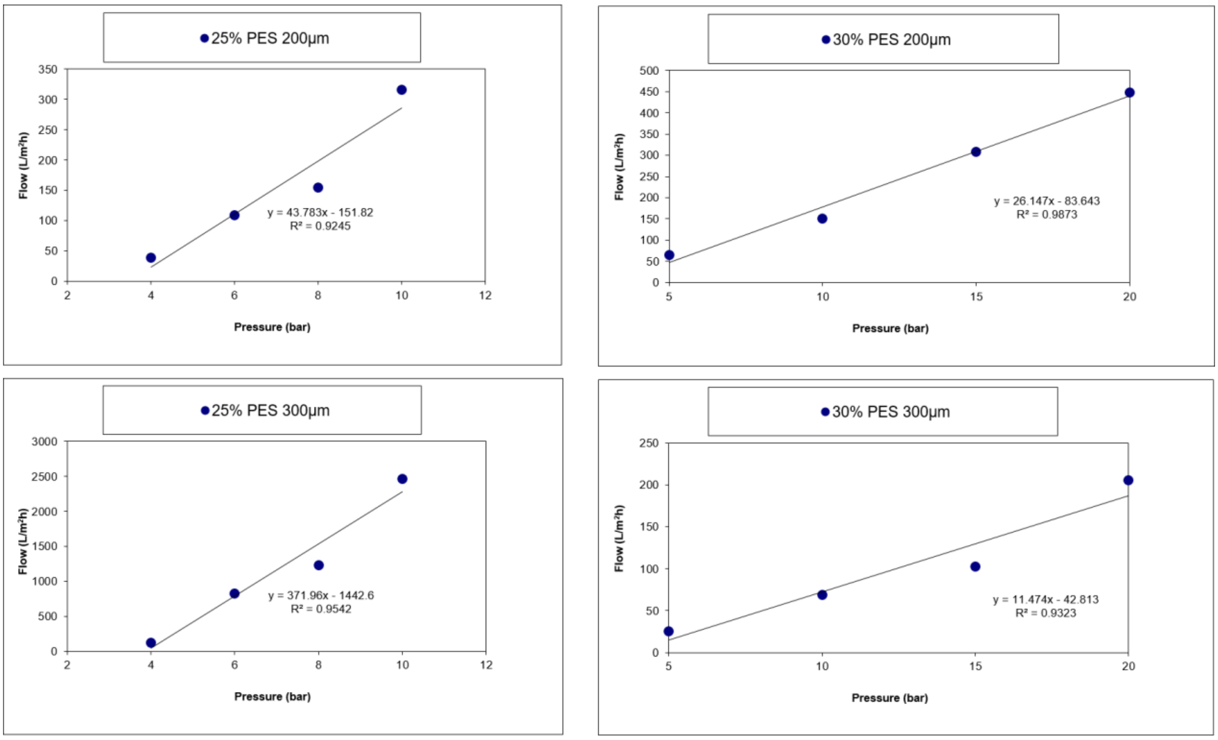

Figure 2. Pure water permeability.

The results show that the increasing of polymer concentration and thickness have a negative impact on the water permeability because the porosity is decreasing.

3.1.3 Membrane flow at different concentrations and thicknesses of the polymer

In Fig. 3, a comparison of water flux between membranes with different thickness can be observed.

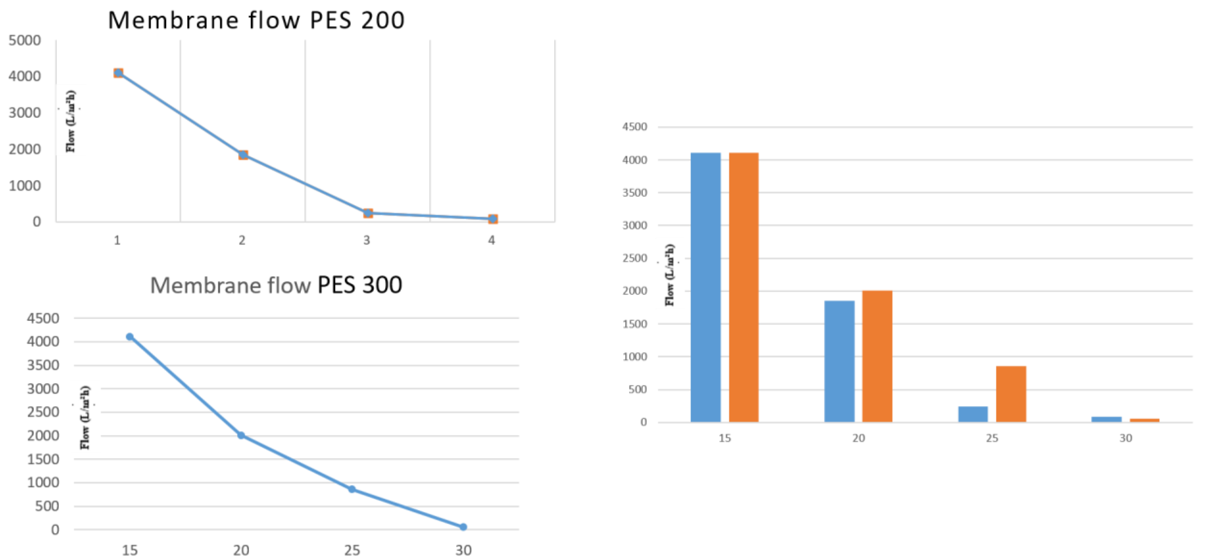

Figure 3. Influence of the membrane thickness on the water flux.

The results shows that the membranes with a small thickness can be used only for microfiltration process because of the pore size which is larger than membranes with a big thickness.

4. CONCLUSIONS

These filtration and permeability tests of PES membranes at different concentrations and thicknesses of the polymer, which are initial, were done to allow me to determine the optimal membrane type in terms of these parameters and then to choose a concentration, with the best results on the tests performed, which can be improved by adding nanoparticles.

It can be seen how the increase of the polymer concentration leads to the decrease of the porosity of the membranes and implicitly to the decrease of their permeability.

The membrane with a concentration of 20 wt.% and a thickness of PES 200 μm shows a good flow and permeability.

To have good conclusions is necessary to continue this study with a SEM analysis to see the distribution and size of the pores.

For advanced filtration processes, membranes with a high polymer concentration, more than 25 wt.% are necessary.

REFERENCES

[1] V. Vatanpour, S.S. Madaeni, R. Moradian, S. Zinadini, and B. Astinchap, “Fabrication and characterization of novel antifouling nanofiltration membrane prepared from oxidized multiwalled carbon nanotube/polyethersulfone nanocomposite,” *Journal of Membrane Science*, vol. 375, no. 1–2, pp. 284–294, 2011. DOI:10.1016/j.memsci.2011.03.055.

[2] S. Balta, A. Sotto, L. Patricia, L. Benea, B.V. der Bruggen, and K. Jeonghwan, ”A new outlook on membrane enhancement with nanoparticles: The alternative of ZnO,” *Journal of Membrane Science*, vol. 389, pp. 155–161, 2012. DOI:10.1016/j.memsci.2011.10.025.

[3] L. Jiuyang, Y. Wenyuan, M.C. Baltaru, Y.P. Tang, N.J. Bernstein, P. Gao, S. Balta, M. Vlad, A. Volodin, A. Sotto, L. Patricia, A.L. Zydney, and B.V. der Bruggen, ”Tight ultrafiltration membranes for enhanced separation of dyes and Na2SO4 during textile wastewater treatment,” *Journal of Membrane Science*, vol. 514, pp. 217–228, 2016, DOI:10.1016/j.memsci.2016.04.057.

[4] L. Jiuyang, Y. Wenyuan, H. Jie, R. Borrego, M.C. Baltaru, B. Greydanus, S. Balta, S. Jiangnan, M. Vlad, A. Sotto, L. Patricia, and B.V. der Bruggen, ”Toward Resource Recovery from Textile Wastewater: Dye Extraction, Water and Base/Acid Regeneration Using a Hybrid NF-BMED Process,” *ACS Sustainable Chemistry & Engineering*, vol. 3, no. 9, pp. 1993–2001, 2015, DOI:10.1021/acssuschemeng.5b00234.

[5] A. Sotto, A. Boromand, S. Balta, K. Jeonghwan, and B.V. der Bruggen, ”Doping of polyethersulfone nanofiltration membranes: antifouling effect observed at ultralow

concentrations of TiO2 nanoparticles," *Journal of Materials Chemistry*, vol. 21, no. 28, pp. 10311-10320, 2011, DOI:10.1039/c1jm11040c.

[6] Q.F. Alsalhy, J.M. Ali, A.A. Abbas, A. Rashed, B.V. der Bruggen, and S. Balta, "Enhancement of poly(phenyl sulfone) membranes with ZnO nanoparticles," *Desalination and Water Treatment*, vol. 51, no. 31-33, pp. 6070–6081, 2013. DOI:10.1080/19443994.2013.764487.

[7] C. He, C.X. Nie, W.F. Zhao, L. Ma, T. Xiang, C.S. Cheng, S.D. Sun, and C.S. Zhao, "Modification of polyethersulfone membranes using terpolymers engineered and integratedantifouling and anticoagulant properties," *Polymers for Advanced Technologies*, vol. 24, no. 12, pp. 1040–1050, 2013. DOI:10.1002/pat.3179.

[8] A. Ameri, M. Gholami, N. Nasseri, and T. Matsuura, "Modification of Polyether Sulfone (PES) Hollow Fiber Membranes Characteristics for More Efficient Water Treatment Process," *Iranian Journal of Public Health*, vol. 33, no. 2, pp. 49–55, 2004. Retrieved from https://www.researchgate.net/publication/268346834_Modification_of_Polyether_Sulfone_PES_Hollow_Fiber_Membranes_Characteristics_for_More_Efficient_Water_Treatment_Process.

[9] C. Barth, M.C. Goncalves, A.T.N. Pires, J. Roeder, and B.A. Wolf, "Asymmetric polysulfone and polyethersulfone membranes: effects of thermodynamic conditions during formation on their performance," *Journal of Membrane Science*, vol. 169, no. 2, pp. 287–299, 2000. DOI:10.1016/S0376-7388(99)00344-0.

[10] H. Wood, J. Wang, and S. Sourirajan, "The Effect of Polyethersulfone Concentration on Flat and Hollow Fiber Membrane Performance," *Separation Science and Technology*, vol. 28, no. 15-16, pp. 2297-2317, 1993. DOI:10.1080/01496399308019740.