ADVANCED SKIN LAYER MODIFICATION OF SUBMERGED POLYETHER SULFONE HOLLOW FIBER MEMBRANE FOR USING IN MBR

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In this work, optimal and critical characteristics evaluation of hollow fiber membranes used in a bioreactor system for wastewater treatment were investigated. As a result, the polyether sulfone (PES) hollow fiber (HF) membrane was selected as the initial membrane sample for further modification and analysis. Skin layer modification of the PES HF membrane was conducted using two methods: a) polydopamine, and b) polydopamine + zinc oxide nanoparticles. The surface-modified membranes, along with the PES HF as the control sample, were tested with water and activated sludge collected from the real wastewater treatment plant to assess the fouling rate and critical flux using the flux step method.

Keywords: polyether sulfone, hollow fiber membrane, polydopamine, critical flux

INTRODUCTION

The industry's growing energy and water supply needs have driven the development of advanced wastewater technologies. Among various water purification methods, systems using hollow fiber (HF) membranes have gained significant attention. These systems offer advantages such as low capital investment, efficient space utilization, selective separation, and high-quality effluent [1].

Submerged hollow fiber membranes integrated into bioreactors combine biological treatment with membrane filtration. This integration has propelled the growing popularity of membrane bioreactors (MBRs) in wastewater treatment. MBRs are favored for their capacity to recycle wastewater, as well as the cost benefits in terms of setup and operation. They have gained widespread acceptance for urban wastewater treatment. MBRs surpass traditional activated sludge processes in several ways. They enable operation at high biomass concentrations, curbing excessive sludge production, eradicating pathogens and viruses, and yielding superior-quality effluent. These advantages, coupled with the potential for water reuse, position MBRs as a more attractive option compared to conventional wastewater treatment systems.

While organic HF membranes within MBR exhibit remarkable properties, a hindrance exists that limits their widespread adoption. The accumulation of foulants and organic pollutants on the membrane surface results in pore blockage and reduced membrane efficiency [2]. Consequently, a new trend in membrane science has emerged, emphasizing direct skin layer modification of HF membranes to reduce the need for frequent backwashing, chemical cleaning, and transmembrane pressure (TMP) requirements [3].

Accordingly, this investigation aims to create a hydrophilic and nanometric skin layer on the surface of the PES HF membrane by in-situ oxide-activated polymerization of dopamine hydrochloride along with incorporation of ZnO NPs to reduce the tendency of absorption of hydrophobic foulants and combat biofilm formation.

METHODOLOGY

A ZnO seed solution was prepared by dissolving zinc acetate in DI water to achieve a concentration of 0.02 M. The in-situ synthesis and immobilization of ZnO NPs began by vigorously stirring the solution at 70°C and slowly adding 2 M Tris(hydroxymethyl)aminomethane (Tris) buffer until the pH reached 9. Subsequently, dopamine hydrochloride (99% purity, Alfa Aesar) at a concentration of 2mg/mL was introduced to the reactive solution while continuously shaking on a stirrer. PES membranes were then immersed in this reactive solution and left for 2 hours. The resulting PDA-coated PET fabric with incorporated immobilized ZnO NPs was later extracted, washed to remove unattached particles, and prepared for further use.

The flux-step experiments will be conducted at 10 minute intervals, increasing the flux in steps of 2 LMH. Each flux step will be duplicated, resulting in a total permeate extraction time of 20 minutes for each step. In this approach, the critical flux will be defined as the flux at which the fouling rate, represented by the change in transmembrane pressure (dTMP/dT), exceeds a threshold of 0.5 $mbar.min^{-1}$.

RESULTS AND DISCUSSION

The permeabilities of the hollow fiber membrane modules were measured. This was done by gradually increasing the flux and collecting the permeate while recording the transmembrane pressure (TMP) at regular time intervals. This procedure enabled the assessment of the membrane's permeability characteristics and provided valuable data for further analysis and evaluation.

By performing these tests and measurements, the integrity and performance of the membrane modules could be thoroughly examined, ensuring their reliability and suitability for the intended application. Fig. 1 shows the permeability measurement of three different samples. As it is clear, the blank PES sample shows higher permeability to be around 140 (l.m^{-2}.h^{-1}.bar^{-1}).

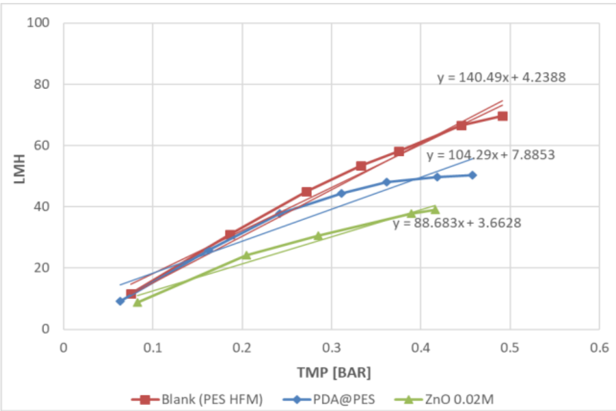


Figure 1: Permeability results of: blank, PDA treated, and ZnO contain modified samples.

a

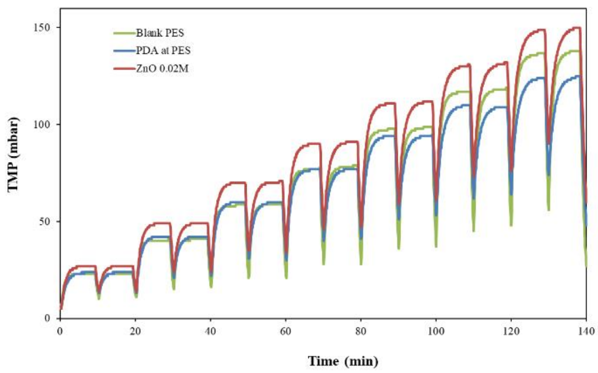
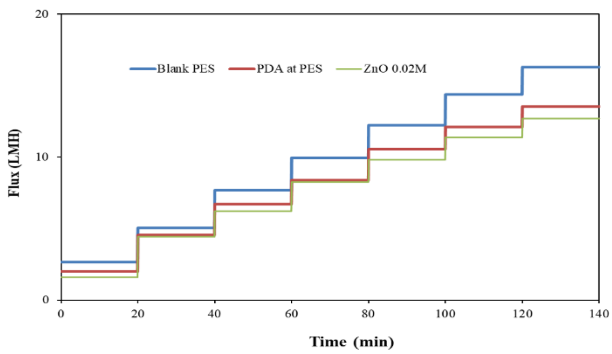


Figure 2: Results of the sludge filtration experiment, including diagrams of the fouling rate and critical flux.

b



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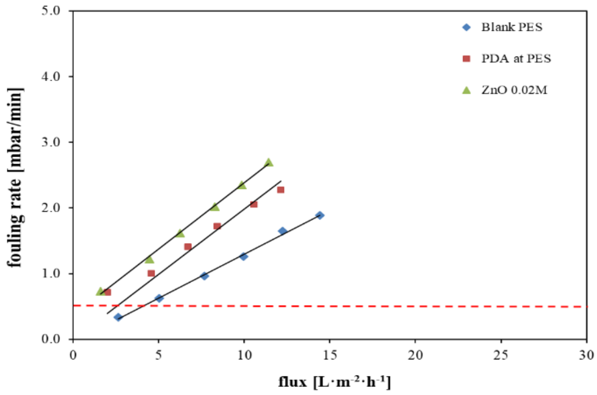

CONCLUSION

The experimental analysis indicates a successful modification of the skin layer of the PES HF membrane. Despite the fact that the PDA coating along with the in situ immobilization of ZnO NPs on the PES HF membranes led to decreased permeability and increased critical flux, it is reasonable to assume that over prolonged operation within an MBR system, the reduction in biofilm formation could contribute to lowered transmembrane pressure (TMP) and improved system performance. Consequently, it can be inferred that the proposed modification technique holds potential for utilization within a bioreactor system, which could be explored in future studies.

ACKNOWLEDGMENT

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