



Development and characterization of catalytic membrane (FeL/PVDF) for degradation of organic compounds

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Abstract

Catalytic membranes combining catalytic activity with conventional filtration membranes have shown promise, as they can simultaneously perform physical separation and chemical oxidation in an integrated system. Therefore, this study aimed to develop catalytic membranes for removal of organic pollutants. Commercial membranes were successfully loaded with FeL catalyst resulting in an increase in water permeance and hydrophilicity. Removals up to 78% were obtained for the model molecule used.

Introduction

A membrane can be defined as a barrier that separates two phases and restricts the transport of chemical species in a specific manner, either totally or partially^[1]. Membrane separation processes (MSP) have several advantages, such as energy savings, simplicity of operation, ease of scaling, and selectivity in separation. However, these processes still face the challenge of reduced flow and useful life of the membrane owing to fouling problems, which imposes excessive costs on the process.

Alternatives to mitigate this problem have been studied, including the possibility of combining MSP with advanced oxidative processes (AOPs) through catalytic membranes. This hybrid process combines catalytic activities with conventional filtration membranes. It can simultaneously perform physical separation and chemical oxidation in an integrated system, thus providing several attractive benefits for membrane filtration processes.^[4]

Thus, this study aims to develop catalytic membranes by coating commercial PVDF membranes with the inorganic catalyst FeL^[2] and evaluate their performance of degrading organic compounds such as dyes and drugs.

Material and Methods

The complex (FeL) was synthesized under magnetic stirring for 2 h, by adding a methanolic solution of iron (III) chloride hexahydrate (1:2) to the ligand (L) obtained by the condensation of salicylaldehyde with ethanolamine (1:1)^[2]. FeL was then precipitated and filtered through a qualitative filter paper.

The membranes were loaded with FeL using a methodology described in the literature^[3] with some modifications. Commercial PVDF membranes were immersed in ethanol for 1 h to remove surface impurities, and then washed with distilled water for further use. A Tris-HCl buffer solution (40 mmol/L, pH 8.5) was prepared and then 0.2 g of dopamine (PDA) was added and dissolved in 40 mL of this solution in falcon tubes. PDA was cross-linked at 160 rpm for 1 h. The membrane was then immersed in cross-linked PDA for 3 h. Finally, the catalyst mass was added to the cross-linked PDA and filtered under vacuum by suction on the membrane. The functionalized membranes were characterized by contact angle, water permeance, X-ray Diffraction (XRD), and Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS).

Finally, removal tests were performed on a shaking table in Erlenmeyer flasks with 250 mL of 20 mg/L Drimaren Red (VDX) solution. The tests were carried out in duplicate, for one hour, at room temperature (25°C), 160 rpm, pH 6.5, 11.70 mmol/L of hydrogen peroxide (H₂O₂) and catalyst equal to: M0 = 0 mg/L; M1 = 0.28g/L; M2 = 0.56g/L; M3 = 0.84 g/L.

Results and Discussion

The water permeance increased almost five times for the M3 membrane (5120 L/m².h.bar) in comparison to the commercial membrane (922,4 L/m².h.bar), probably due to the increase of hydrophilicity as observed in the contact angle. A decrease in the angle from 56.02° to 27.28° was observed in the functionalized membrane in comparison with the commercial PVDF membrane, demonstrating an increase in the hydrophilicity of the membrane.



The SEM image in Fig. 1 shows agglomerated FeL on the surface of the membrane, and EDS confirmed the presence of Fe in the membrane loaded with catalyst FeL.

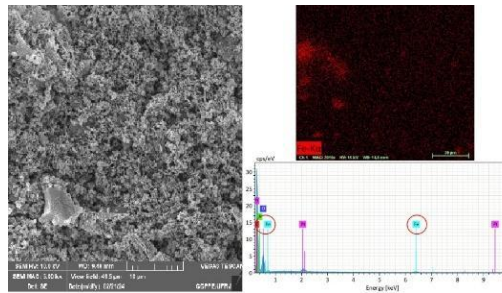


Figure 1. SEM and EDS of the M1 membrane

Regarding the removal rate, it is possible to observe that at the end of 60 min, the removal was greater in the membranes with the two highest concentrations of FeL, with removals of 71 and 78% for M2 and M3 membranes, respectively (Fig.2). Such results suggest that membranes loaded with FeL are promising for the degradation of the pollutant used in the present study.

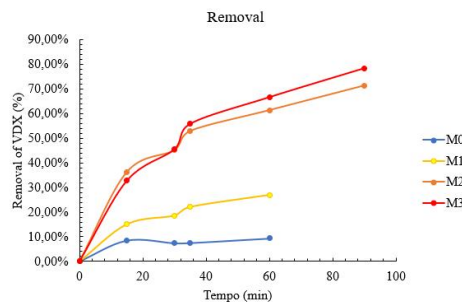


Figure 2. VDX removal (%) over time. Conditions: pH 6.5 and H₂O₂ concentration = 11.7 mmol/L.

Conclusions

Based on the characterization results, it can be inferred that the impregnation technique was successful. Furthermore, the membranes loaded with FeL achieved better performance and were promising for the degradation of the pollutant used in the present study.

References

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