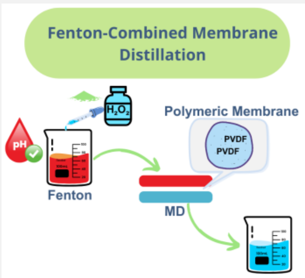
POSTER
Ph.D. Student: N
Journal: NONE

Comparative Degradation of Reactive and Acid of Dyes in Textile Wastewater using Fenton-Combined Membrane Distillation

M. Schmidt[1], C. Cassettari¹, A. Paulazzi[1], A. Silva[1], R. S. Silva¹, R. A. F. Machado¹, R. F. P. M. Moreira¹, C. Marangoni[1](1) Federal University of Santa Catarina, Campus Universitário Reitor João David Ferreira Lima, Florianópolis-SC, Brazil, cintia.marangoni@ufsc.br



Treating textile effluents poses a complex challenge due to the diversity of chemicals involved, requiring the use of combined processes including biological, chemical, and/or physicochemical treatments. In that way, Membrane Distillation (MD) offers a solution, yet membrane fouling remains a persistent issue. This study aims to address this challenge by using the MD process and comparing its efficacy with the integration of the Fenton process into MD. The effectiveness of PVDF membrane separation and degradation in treating simulated textile wastewater containing reactive and acid dyes and anionic surfactants was examined. The results indicated the use of Fenton-MD result in higher permeate fluxes for both dye classes with high dye rejection rate.The color removal was also improved by using Fenton-MD, leading to the conclusion that the combined process offerings enhanced water quality, making this proposal a particularly attractive option for textile industrial wastewater treatment applications.

Introduction

The textile industry represents an intensive consumer of water resources, with specific stages of its production processes introducing contaminants such as dyes, surfactants, and other pollutants into wastewater, requiring rigorous treatment to comply with environmental regulations [1]. Among the available technologies, Advanced Oxidation Processes (AOPs) are prominent solutions, as the Fenton process, which effectively degrades organic pollutants even generating substantial sludge by products [2]. An alternative method, Membrane Distillation (MD), offers selective pollutant rejection capabilities, although challenges related to membrane wetting hinder its widespread application [3]. Integration of Fenton process with MD presents a compelling approach for wastewater treatment, facilitating the efficient conversion of complex pollutants into biodegradable compounds while mitigating sludge production [4]. This proposal has been already studied with different applications like pharmaceutical wastewater, treatment of bio-treated landfill leachate and also textile wastewater. However, a comparative analysis about different dye classes has not yet been explored.This strategy not only enhances the quality of reclaimed water resources, but also underscores its accessibility and practicality for clean water sources. Furthermore, reactive and acid dyes, widely used in the textile industry, need to be properly treated for reuse. Therefore, the main objective of the present work is to evaluate the combined process with Fenton for treating wastewater containing reactive oracid dyes class and anionic surfactants, aiming to assess its efficiency in treating textile wastewater while minimizing environmental impact and reducing operational costs.

Material and Methods

The study utilized synthetic solutions containing Acid Black (AB) dye, or Reactive Black (RB) dye with an anionic surfactant (Colorswet DTU-M) as a dispersant. Experiments were carried outusing a PVDF membrane prepared by the phase inversion technique, utilizing PVDF (15 wt%) and polyethylene glycol (PEG-400) (1 wt%) dissolved in dimethylformamide (DMF) solvent. The resulting membrane had a thickness of 85 ± 3.65 µm and a contact angle of 101.25° ± 0.01.
The Fenton process used a 500 mL wastewater solution with H_2O_2 and $FeSO_4.7H_2O$ in the proportions ([750 $mg.L^{-1}$]:[37.5 $mg.L^{-1}$]), and was conducted for 1 h and maintaining the pH ~ 3. Direct Contact Membrane Distillation (DMCD) was carried out with feed flow rate of 1.5 $L.min^{-1}$, a permeate flow rate of 0.7 $L.min^{-1}$, and feed and permeate temperatures of 60 °C and 20 °C, respectively. These experiments were conducted for 4 h.
The permeate flux, dye rejection and degradation rate, were calculated by Equations 1 - 4:

$$J = \frac{M_f - M_i}{A\ x\ t} \quad (1)$$

$$Dye\ rejection\ (\%) = \frac{C_a - C_i}{C_a} \quad (2)$$

$$Degradation\ rate\ (\%) = 1 - \frac{c}{c_0} \quad (3)$$

$$C_p = \frac{C_f\ x\ M_f - C_i\ x\ M_i}{M_f - M_i} \quad (4)$$

where, J is the permeated flux ($kg.h^{-1}.m^{-2}$), M_i and M_f is the permeated initial and final mass (kg), A is the membrane area (m^2) and t is the time (h). C_f and C_p are the concentration of feed and permeated respectively and lastly C and C_0 are the initial and final dye concentration.

Results and Discussion

Figure 1 presents the comparison of permeate flux values of each solution with dye and anionic surfactant treated with only membrane distillation (DCMD) and with the combined process. As can be observed, the Fenton-DCMD processes showed a higher permeate flux compared to the single process. This is due to the degradation of organic material and consequent decrease of its concentration in the wastewater (Table 1). This behaviour agrees with previous studies [3] have already shown that the solution concentration has an inverse relationship with permeate flux. But is important to notice that for permeate flux it was not highlighted differences in the behavior concerning the dye class.

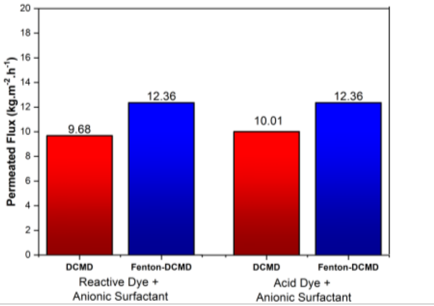


Figure 1. Permeate flux results of DCMD and Fenton-DCMD.

Table 1. Dye degradation of Fenton process (initial concentration of 30 mg.L^{-1}).

Wastewater	Dye concentration (mg.L^{-1})
Reactive dye	7.64
Acid Dye	15.77

As a means of assessing the quality of the permeate, analyses of dye rejection (%) in the permeate were conducted (Table 2). It is possible to observe that all processes presented high rejection rates, but there was a reduction when using the reactive dye and an increase in the acid dye with the Fenton-DCMD processes. These results may be related to the molecular weight of 991.82 g/mol and greater stability amoung the chemical bonds of the reative dye, compared to the acid dye, which has a molecular weight of 461.38 g/mol and makes it easier to remove color.

Table 2. Dye Rejection (%) on the DCMD and combinedFenton-DCMD process

Wastewater	DCMD (%)	Fenton-DCMD (%)
Reactive Dye+ Anionic Surfactant	100	95.3
Acid Dye+ Anionic Surfactant	97.4	100

Figure 2 illustrates the surfactant concentration in permeate after the combined process. These results highlight that there was no influence of the surfactant interaction with different dye classes, as the values of concentration were similar, when compared to the initial concentration of the anionic surfactant of 41.7 mg/L.

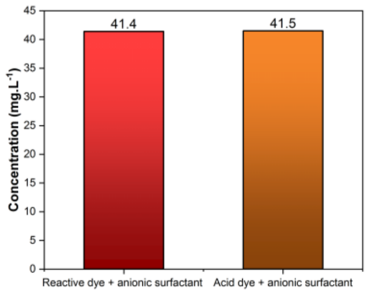


Figure 2. Surfactant concentration in the permeate samples from the Fenton-DCMD process.

Conclusions

The textile industry's significant water consumption and the introduction of contaminants into wastewater necessitate robust treatment methods. Advanced Oxidation Processes (AOPs), notably the Fenton process, effectively degrade organic pollutants but generate substantial sludge. Membrane Distillation (MD) offers comprehensive pollutant rejection but faces challenges like membrane wetting. Integrating the Fenton process with MD provides a compelling approach, efficiently converting pollutants into biodegradable compounds while minimizing sludge. The study successfully evaluated this combined process using Fenton-DCMD, demonstrating enhanced permeate flux and complete dye rejection. This innovative strategy promises efficient textile wastewater treatment, emphasizing environmental sustainability and operational cost reduction.

Acknowledgments

This study was supported by Federal University of Santa Catarina (UFSC), Higher Educational Personnel Improvement Coordination (CAPES) and National Council for Scientific and Technological Development (CNPQ).

References

[1]S. Samsami, M. Mohamadizaniani, M-H. Sarrafzadeh, E.R. Rene, M. Firoozbahr. Recent advances in the treatment of dye-containing wastewater from textile industries: Overview and perspectives,*Proc. Safe and Env. Prot.*, 143 (2020).
[2]S.Palit, C.M.Hussain, Advanced oxidation processes as nonconventional environmental engineering techniques for water treatment and groundwater remediation , R.O.A. Rahman, C.M.Hussainm, Elsevier., 33 (2021)
[3]C.M.T Filho, H.B. Madalosso, C.D.K. Cavalcanti, M.A. Granato, R.A.F Machado, C. Marangoni. Influence of multi-component composition of dyeing bath in the membrane distillation performance, *Proc. Safe and Env. Prot.*, 156 (2021).
[4]K. Nadeem, G.T. Guyer, B. Keskinler, N. Dizge. Investigation of segregated wastewater streams reusability with membrane process for textile industry, *J. Of Clean. Prod.,* 228 (2019)