분말활성탄 흡착공정을 결합한 침지형 정밀여과막을 이용한 Orange 16 과 Black 5 제거

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Removal of Orange 16 and Black 5 by Submerged Microfiltration Membrane Coupled with Powdered Activated Carbon Adsorption

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1. Introduction

Synthetic reactive dyes causing considerable environmental pollution, are toxic to some aquatic organisms and are of serious health risk to human beings. They lead to greater public concern and present legislation problems. However, these reactive dyes are the most problematic compared to other forms of dyes and removal of these dyes from wastewater is a major environmental challenge [1,2]. The objective of this study is to evaluate the performance of adsorption, coagulation and membrane processes individually for the removal of binary reactive dyes (Orange 16 and Black 5) and then study the performance of the combined coagulation-adsorption-membrane process.

2. Experimental

The experiments were carried out using two commercially available reactive dyes (Black 5 and Orange 16) purchased from Aldrich Co. (USA) PAC namely coal based(CB) was obtained from James Cumming & Sons PTY Ltd.(Australia).
The schematic of the combined coagulation-adsorption-membrane hybrid system is shown in Fig. 1. The membrane used in the study is a submerged-type hollow fiber MF membrane (Mitsubishi, Japan). The membrane hybrid system was operated as a continuous stirred tank reactor (CSTR). Coagulation and sedimentation pretreatment was carried out prior to adsorption-membrane operation. Coagulation studies were conducted using Jar-Test apparatus. Coagulant was added to the dye solution and was rapidly mixed (100 rpm) for 2 min followed by slow mixing (40 rpm) for 30 min and then allowed to settle for 1 h. The pH was adjusted by adding HCl or NaOH. The supernatant after the treatment was examined for residual dye concentration. Adsorption and membrane separation were carried out in a single tank. Specific amount of PAC dose was added once at the beginning of the experimental run.

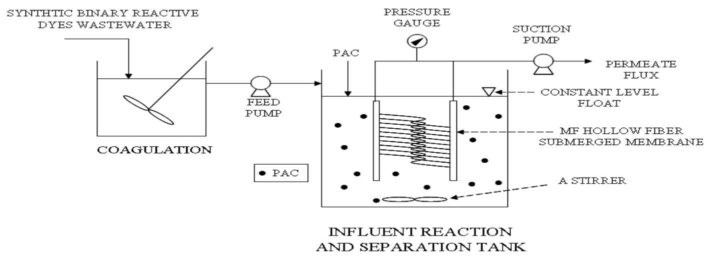

Fig. 1. Schematic diagram of submerged hollow fiber MF membrane.

3. Results and discussion

3.1. Coagulation study

Figs. 2 and 3 show the removal efficiencies of binary reactive dyes at different coagulant doses and pH. It was found that the optimal coagulation conditions for bianary dyes mixture were 0.5 g/L of alum coagulant dose at pH 6. Aluminium chloride ($AlCl_3$ $6H_2O$) (Junsei Co., Japan), having a gram molecular weight of 241.45, was used as a coagulant. Maximum removal efficiency for 100 mg/L of binary dyes concentration was about 84%.

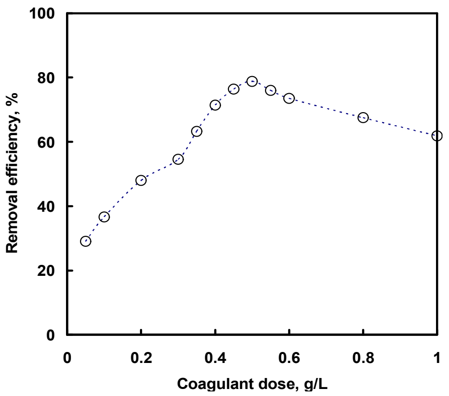

Fig. 2. Removal efficiency of reactive dyes mixture in terms of coagulant dose(dye concentration: Black 5 -100 mg/L, Orange 16 -100 mg/L pH 6).

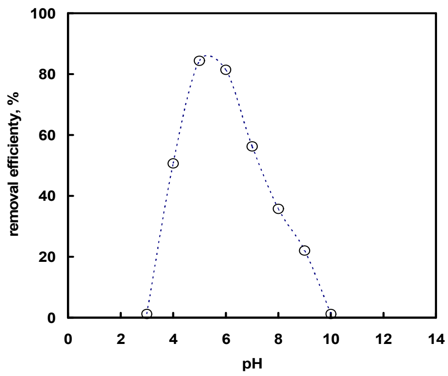

Fig. 3. Removal efficiency of reactive dyes at various solution pH.

3.2. Coagulation-adsorption-membrane hybrid study

In this study, a submerged MF membrane was applied as the final polishing step for the separation of micro flocs and PAC after the adsorption of reactive dyes from aqueous solution. Membrane alone was not effective in the retention of dyes and also the fouling was severe. When dye wastewater alone was fed into the system without coagulation or adsorption pretreatment, it was evident that the fouling of the membrane was significant as almost 50% of the initial permeate flux within 5h of operation. Continuous flux decline may come from membrane fouling mainly due to the deposition of reactive dyes on membrane surface. This includes adsorption, pore blocking, precipitation and cake formation. In addition, there was almost negligible amount of dye removal efficiency about 2-3%. On the other hand, with the coagulation and adsorption pretreatment membrane performance was very high as there was very little decline in permeate flux, for the entire 5h of experimental run (Fig. 4). Fig. 5 shows the effect of pH on the flux decline in membrane separation after coagulation and adsorption. The fluxes remained nearly constant at an initial level of approximately 310 L/.m^2h for binary reactive dyes. In this study, coagulation was carried out separately and then the supernatant was treated in a tank containing the submerged membrane into which PAC is also added. So PAC adsorption and membrane separation takes place simultaneously. In such a case it is generally believed that the reason for reduced fouling is due to the activated carbon adsorption of reactive dyes causing membrane fouling.

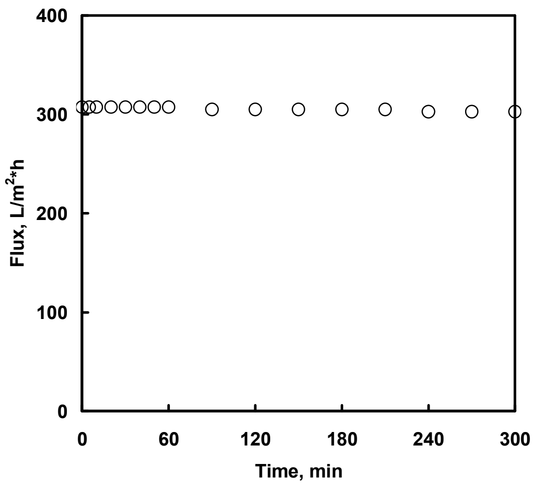

Fig. 4. Effect of binary reactive dye concentration on the flux decline(membrane separation after coagulation and adsorption).

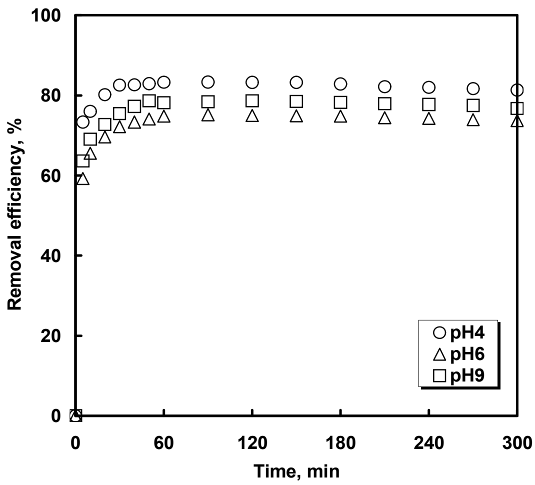

Fig. 5. Effect of pH on the flux decline (membrane separation after coagulation and adsorption).

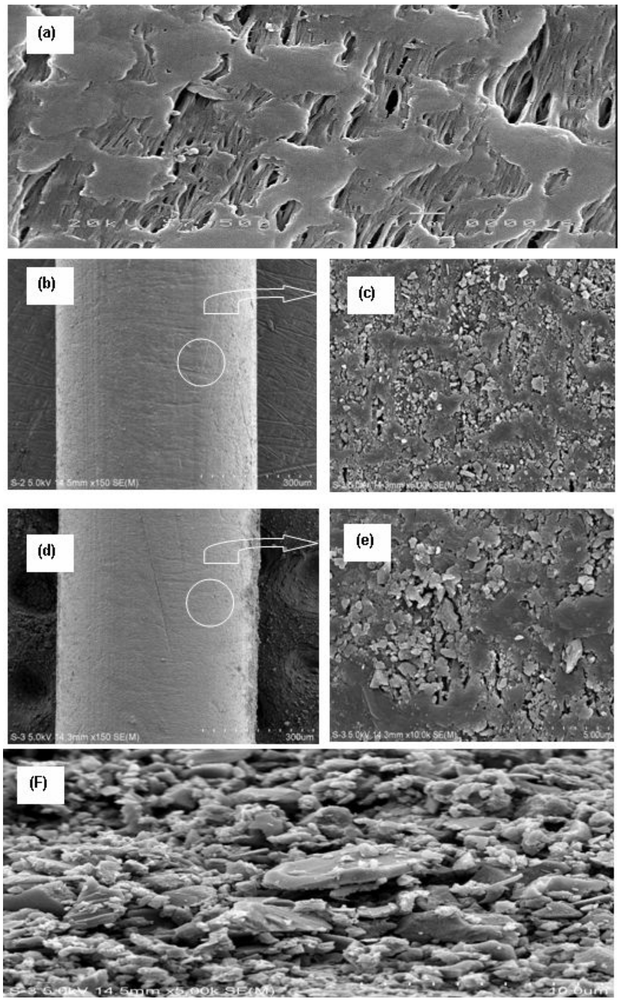

Fig. 6. SEM micrographs of fouled membrane surface in hybrid system with and without PAC-CB adsorption for Black 5 and Orange 16 after 5 hr experimental run (a) clean membrane, (b) fouled membrane after coagulation for dyes, (c) fouled membrane coagulation for dyes, (d) fouled membrane after coagulation and PAC adsorption for dyes, (e) fouled membrane after coagulation and PAC adsorption for dyes, (F) PAC Adsorption for dyes.

References

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(2) J.W. Lee, S.P. Choi, R. Thiruvenkatachari, W.G. Shim, H. Moon, Water Research, 40 (2006) 435.