

EFFICIENCY EVALUATION OF TEXTILE BASIC DYE REMOVAL FROM WATER BY NANOFILTRATION

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ABSTRACT

Nanofiltration, widely developed over the past decade, is a promising technology for the treatment of organic and inorganic pollutants in surface and groundwater resources. The aim of the present research was to study the efficiency of textile dyes removal by a commercial nanofilter NF90 (Dow-Film Tec). Dye rejection was studied using basic dye (Basic Chrysoidine Cryst Yellow Gold 0.4%) with its relevant additive. Experiments were continued until the fouling time of the membrane. Each experiment was repeated after washing to evaluate the efficiency of the washing process. Results showed that the values of color removal were 97.98 % for the simulated textile wastewater containing basic dye. The membrane was sensitive to fouling since most of dyes were used for polyamide textile dyeing. Washing the membrane with a solution including NaOH (pH=12) and HCl (pH=2) showed its efficiency to solve the fouling problem. The filtration process was efficient and promising for reusing wastewater in this industry.

Key words: Textile industry, basic dye, dye removal, nanofiltration, water quality

INTRODUCTION

Industrialization and urbanization have resulted in rapid deterioration of water quality. The scientific evidences prove that the effluents released from different industries e.g. textile, leather, paint etc. comprise of different hazardous and toxic compounds, some of which are known carcinogens and others probable carcinogens. The emergence of industrial centers without a corresponding growth in civic amenities and pollution control mechanisms results in a gradual decay of water quality.

Textile industries, particularly those involved in finishing processes are major water consumers and the source of considerable pollution. The environmental challenge for the textile industry is associated with liquid waste, which tends to dominate over air emissions and solid wastes in terms of the severity of environmental impacts. A typical textile unit generates various types of wastewater differing in magnitude and quality. The wastewater from printing and dyeing units in a textile plant are often rich in color, containing residual of reactive dyes and chemicals, and needs

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proper treatment before releasing into the environment. The membrane process that can meet the necessary standards is nanofiltration, because nanofiltration membranes can retain ions as well as relatively small organic molecules from an aqueous solution (Rautenbach and Gröschl, 1990; Van der Bruggen *et al.*, 1999). However, it is not well understood what mechanisms of retention and flux decline are involved in this process and it is generally accepted that membrane technology offers solutions for the wastewater problem in the textile industry, with the possibility of water recycling (Ciardelli *et al.*, 2001; Vedavyasan, 2000). Nanofiltration (NF), in particular, is often suggested as a good candidate (Sungpet *et al.*, 2004; Marcucci *et al.*, 2001) and has been tested in a pilot scale (Marcucci *et al.*, 2002; Koyuncu *et al.*, 2001).

A membrane filtration unit can be placed at the very end of the wastewater treatment line, treating wastewater from various sources after traditional pretreatment and biological degradation (Yazhen *et al.*, 1999) had used NF for the treatment of textile dye plant effluent. Experimental runs with

pure dye solutions as well as an industrial dye solution confirmed the potential of the process. Schrig and Widmer undertook NF of a mixture of dye salt and sodium chloride in a spiral-wound module (Schrig and Widmer, 1992). Similarly, Yu applied NF membrane technology for the desalting and concentrating of aqueous dye at a dye producing plant (Yu *et al.*, 2001). The newly developed process using NF was continuous in operation, was not labor intensive and produced a high purity product of consistent quality.

The objective of this research was to study the effect of dye concentration from a solution of simulated wastewater containing Basic Chrysoidine Cryst Yellow Gold 0.4% dye and acetic acid 99.6% using a polyamide thin film composite NF membrane.

MATERIALS AND METHODS

The schematic layout of the NF process used in this work is shown in Fig. 1. In this research the efficiency of the textile dye removal by nanofiltration for basic dye with its relevant additives for a long time until the fouling time of the membrane was evaluated. Each experiment was repeated after washing the membrane to evaluate the efficiency of the washing process. In order to simulate textile wastewater, basic dye (Basic Chrysoidine Cryst Yellow Gold 0.4%) from textile industry has been used with its relevant additive acetic acid. Nanofiltration pilot is schematically shown in Fig. 1. Required equipments for experiments and specifications of the membrane in the pilot scale system are described in Table 1.

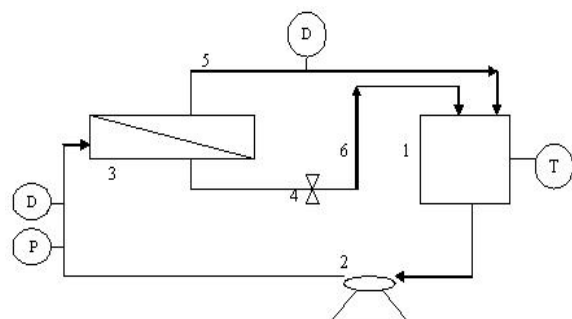


Fig. 1: Schematic demonstration of the nanofiltration pilot

D: Pressure indicator, P: High pressure pump, T: Feed water tank,
1: Concentrate and permeate water, 2: Pump, 3: Module, 4: Valve,
5: Permeate water, 6: Concentrate water

Required Materials were Basic dye (Basic Chrysoidine Cryst yellow gold 0.4%), acetic acid 99.6%, HCl 99% and NaOH. According to NF90 manufacturer's recommendation, after a 15% decrease in permeate water discharge, the membrane should be washed. Therefore in order to evaluate the probability of reusing this membrane after fouling, washing process is recommended using a solution of HCl at pH=2 and NaOH at pH=12.

Table1: Specifications of NF 90-2540 membrane

Membrane Type	Polyamide thin film composite
Maximum operating temperature	113 F (45 °C)
Maximum operating pressure	600 psig (31 bar)
Continuous operating pH range	3-10
pH range in cleaning (30 min)	1-12
Maximum influent discharge	70 gpm (15.9 m ³ /h)
Membrane area	2.6 m ²

Two experiments were done: experiments number 1 and 2 evaluated dye removal efficiency of NF90 membrane before and after washing process, respectively. All experiments were done at ambient temperature (25°C) and 8 bar pressure. In order to simulate textile wastewater including basic dye, *Basic Chrysoidine Cryst Yellow Gold 0.4%* dye made in Youhao company of China was used. Acetic acid was also used as an additive. 25 mg/L of dye and 0.6 mL/L of acetic acid have been resolved in water in ambient temperature. During mixing of the dye, additives and water in the tank, the mixture has been reached to appropriate volume by adding enough water. In all stages of the experiments before and after washing process, clean water was fed into the membrane to measure the permeate water discharge. After washing process, the mixture of mentioned dye was fed into the membrane to compare the permeate water discharge and also dye removal efficiency. The simulated dye and its additives were fed in to the membrane to measure dye units in the effluent. This was continued until fouling of the membrane. In all experiments input water discharge was 12.5 L/min (750 L/h) and experiments were carried out by Standard Methods (AWWA and WPCF, 2002). Dye measurement was carried out by 2120-Platinum-Cobalt Standard Method using HACH

DR/2000 Spectrophotometer at 455 nanometer wave length. Measurement range was between zero and 500 units of PtCo. Dye percent removal was calculated by following formula:

$$R(\%) = (1 - (C_p - C_o)) * 100 \quad (1)$$

Where R is dye percent removal, C_p and C_o are dye concentration in permeate and input water, respectively. pH measurement was carried out by HACH digital pH meter. Temperature was measured by a digital thermometer (AWWA, 2002).

RESULTS

Fig. 2 shows the efficiency of NF90 in dye removal from a simulated wastewater containing basic dye with its additives. Fig. 3 shows the efficiency after washing the membrane. Fig. 4 shows the permeate water discharge before and after washing process.

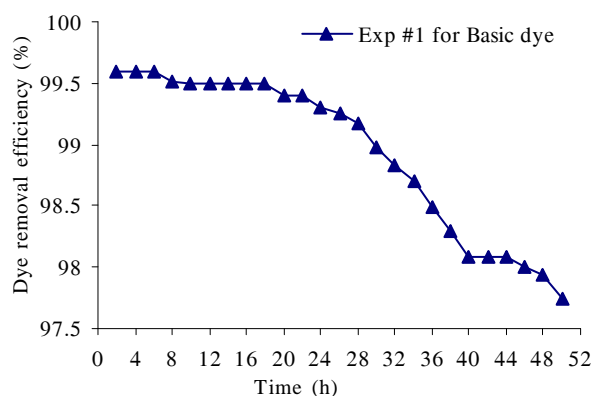


Fig. 2: Percentage of dye removal efficiency before washing NF90

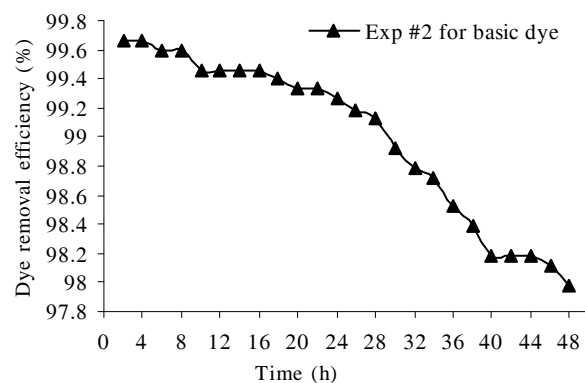


Fig. 3: Percentage of dye removal efficiency after washing NF90

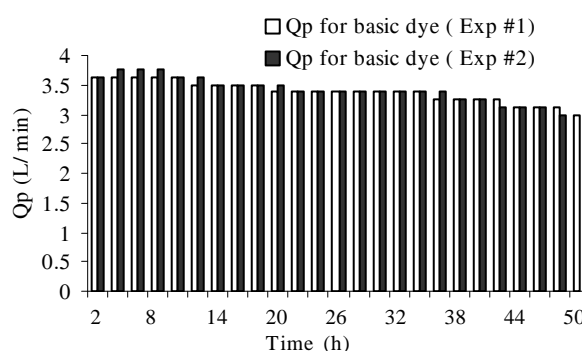


Fig. 4: Permeate water discharge during experiments before and after washing of the membrane

DISCUSSION

The efficiency dye removal at the beginning of the experiment was 99.59%. After 48 hours from the beginning of the experiment the membrane removed dye at 97.98% which was still significant. 97.98% removal equals the presence of 10 units of dye in permeate water. After 50 hours of the beginning of the experiment it is recommended to wash the membrane to evaluate washing process efficiency. As in Fig. 3 after washing process membrane started removing dye at 99.66%, but after 48 hours removal efficiency reached 97.98%. Fig. 4 shows permeate water discharge. In the first experiment (before washing process) permeate water discharge reduced from 3.125 L/s at the beginning of the experiment to 3 L/s after 50 hours. After washing process in the second experiment, permeate water discharge again reaches to 3.625 L/s which shows the revival of the membrane by washing process. In the second experiment permeate water discharge reduced from 3.625 L/s to 3 L/s after 48 hours. Increasing of the operating time of the membrane in the second experiment also shows the positive effect of washing process. Razmkhah *et al.*, also evaluated the dye removal efficiency from textile wastewater using coagulants. Results showed final COD and dye rejection coefficients of 29% and 2.5% for sulfuric dyes using lime (Nabi, 2006). Torabian investigated textile industry wastewater decolorization by magnesium carbonate (Torabian, 1996). He reported magnesium carbonate is appropriate for some dyes such as Khomi dyes and showed by adding 40 mg/L magnesium carbonate; decolorization effectiveness of 250 mg/

Lime could increase from 57% to 86.9%. Gholami *et al.*, evaluated the effectiveness of two methods for dyestuff removal from a textile waste stream. Results showed final chemical oxygen demand and dye rejection coefficients of 73%, 76% for basic dye (Gholami and *et al.*, 2003).

The results of this research showed a high dye removal efficiency using nanofilter membrane compared with previous methods. It is obvious from the figures that nanofilter membrane can successfully remove basic dye and its additives. This high removal efficiency is related to the pH of the solution, high molecular weight of this dye and also electric charge of the membrane.

Fouling of the NF membrane is also a serious problem in dye removal process and the membrane can be revived after fouling by washing. It shows the same high removal efficiency after washing process, which is done after a 15% decrease in permeate water discharge according to its manufacturer's recommendation.

It is highly recommended to use nanofiltration as a complementary treatment system after preliminary treatment in textile industries due to its high dye removal efficiency and low efficiency of conventional treatment methods, so that the treated water can be reused in other parts of textile or other industries.

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