Water Reuse from the Reactive Dye Manufacturing Process by NF and RO Membrane Integrated Process

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1. Introduction

In the dye manufacturing process, dyes are generally synthesized in a reactor, filtered, dried, and blended with other additives to produce the final product. The dye is then separated from the mixture and purified. A large amount of wastewater that is highly colored with high loading of inorganic salt was produced at each step and liquid effluents can contain toxic organic residues. Effluent treatment of dye manufacturing process normally includes neutralization, flocculation, coagulation, carbon adsorption, advanced chemical oxidation, and biological treatment. Due to the variable contents of the wastewater, such methods encounter serious difficulties in meeting environmental discharge requirements. Water insoluble dyes (e.g. disperse and vat dyes) generally have been reported to be removed by physical means such as coagulation and adsorption. However, water soluble dyes such as reactive dyes, which are used extensively by the industry, are no longer able to achieve adequate color removal by conventional biological treatment processes[1]. Although these dyes and color materials in wastewater can be effectively destroyed by wet oxidation and advanced chemical oxidation such as H_2O_2/UV, O_3, the costs of these methods are relatively high[2].

The membrane process that can meet the necessary standards is nanofiltration (NF) and reverse osmosis (RO) membranes can retain ions as well as relatively small organic molecules from an aqueous solution. Removal of dye compounds from dye manufacturing wastewater is a possible application of RO filtration. However, RO membrane filtration has problems with fouling, which resulted in low fluxes and poor separation[3]. NF membranes are used to separate reactive dye residuals from spent dye solution while allowing sodium and chlorine ions to pass through the membrane at the permeate stream[1].

2. Materials and Methods

The dye wastewater samples used in this study were obtained from a dye manufacturing company in Gyeonggi, Korea. In this study, crossflow NF and RO filtration using thin film composite polysulfone membrane was used to recover the water and reject the color and the salt. Different NF membrane (DK, OSMONICS Co.) and RO membranes (AG, SE, OSMONICS Co.) were used. For the filtration experiments, a commercial NF and RO filtration unit on laboratory scale was used. Flat sheet membranes were used with and active surface of 0.03 m^2. The feed solution is pumped to the membrane by a membrane pump. The pressure over the membrane can be varied from 0 to 6 MPa with manual valves. The temperature of feed solution is set with a refrigerated bath circulator (JEIO TECH, Co., Korea). The system was operated in total recycle mode for performance evaluation. Permeate flux was measured by measuring the discharged volume in specific time, while retentate was measured with the help of a precalibrated rotameter. Retention of two reactive dyes (reactive black 5 and reactive yellow 145) was studied. The water flux in each of the experiments was monitored.

The UV-Vis spectra of the samples were recorded for color using UV-Vis spectrophotometer (UNVIKON XS, BIO-TEK Ins., Italy). The COD was analyzed using a colorimetric method after digestion of the samples in a COD reactor (Model 45600, HACH Co., USA). The concentration of salt was measured using salt analyzer (SAT-210, TOA Co., Japan).

3. Results and conclusion

Using reactive dye manufacturing wastewater, the study focused on the flux and rejection by varying four main parameters; types of dye, feed pressure, kinds of membrane, and a number of cycles. Results show that the flux was dominated by the feed pressure and kinds of membrane. Water flux increased by an increase in pressure. Working at pressure of 3 MPa, the permeate flux observed for the actual dye bath samples were 0.72-0.90 $m^3m^{-2}h^{-1}$ and 0.36-0.42 $m^3m^{-2}h^{-1}$ as against that for pure water, 1.50 $m^3m^{-2}h^{-1}$ and 1.02 $m^3m^{-2}h^{-1}$, which is about 48-60% and 35-41% of pure water for NF and RO filtration, respectively.

By the only NF membrane, the rejection of COD and color was more than 96% while the salt rejection were about 21.2% and 51.7% for reactive black 5 and reactive yellow 145, respectively. However, an integrated process, NF and RO, has been demonstrated to treat the reactive dye manufacturing process wastewater effectively. This integrated membrane process showed >98.4% COD, >99.6% color and 53.2% (reactive black 5), 96.6% (reactive yellow 145) salt rejection of dye compound. Thus, a high quality of reuse water could be recovered. Even after a number of cycles, the membrane did not foul irreversibly, with an overall mean waterflux recovery of 95%.

The NF and RO integrated membrane process was found to be suitable for the removal of residual color and reuse of water from waste stream arising from reactive dye manufacturing process. The permeate can be recycled back into the process, thus offering economical benefits by reducing the water consumption, waste treatment cost and effluent discharge.

4. References

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