ABSTRACT

Removal of Toxic Dyes from Industrial Effluent using a Combination of Adsorption and Nanofiltration

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A combination method comprising of adsorption and nanofiltration (NF) is adopted for removal of dyes from textile effluent. A typical dye concentration in an industrial effluent is usually in the range of 150-200 mg/l. If this solution is treated directly in a membrane-based separation process e.g., nanofiltration, the permeate flux declines rapidly due to the increasing concentration polarization. The permeate quality also deteriorates. Hence, in the present study, adsorption is used as the first step to reduce the bulk dye concentration of the effluent released from the textile industries. An adsorbent prepared from sawdust is used for this purpose. The effluent from the adsorption unit is treated by nanofiltration where the remaining dye is separated. Separation of the dyes, as well as, recovery and reuse of the associated chemicals (mainly salt) and minimization of the process wastewater are the prime objectives of this study. Enhancing the process output (in terms of the permeate flux) is another major goal of this combination process.

Two typical dyes: crystal violet and methylene blue are chosen and the aqueous synthetic solutions of these dyes are adopted for the primary study. Later on, the process scheme is applied to the treatment of an industrial effluent containing a mixture of two reactive dyes, collected from a textile dye house. Equilibrium and kinetic studies are carried out with each system to observe the effect of various process parameters, such as, particle size of the adsorbent, initial dye concentration, temperature, pH of solution, agitation and adsorbent loading. Adsorption equilibrium data are fitted to a number of isotherms. A two-resistance mass transfer model, which includes a film mass transfer coefficient and an internal effective diffusivity, is used to interpret the adsorption kinetic data for both the single component as well as the two-component systems. The model parameters are estimated by fitting the experimental data to the model. The evaluated

parameters are used to predict the concentration profiles at various other operating conditions.

Nanofiltration is carried out in two different process configurations: unstirred batch and cross flow system. The effects of various process parameters, such as operating pressure, initial dye concentration and the cross flow velocities on the permeate concentration and flux profiles are evaluated. An unsteady state mass transfer model is developed to predict the permeate flux and permeate concentration in the batch cell for the single component as well as the two-component systems. Using the experimental results, the model parameters i.e. the diffusivity of the solute and real retention of the membrane are evaluated by optimizing the experimental flux and permeate concentration profiles. Film theory is used to explain the experimental data for the steady state cross flow system. Using a suitable molecular weight cut-off membrane, a fractionation study is carried out with the mixture of crystal violet and methylene blue.

Finally, the application of the proposed treatment scheme (adsorption followed by nanofiltration) is successfully employed in the treatment of a textile effluent containing a mixture of the two reactive dyes. Both dye removal and the reduction in COD (chemical oxygen demand) are more than 99% in all the operating conditions and salt recovery is higher than 88%. The performance of the proposed method is compared with that of the direct nanofiltration of the effluent. Although the salt recovery and the COD reduction are comparable in these two methods, the dye concentrations in the permeate stream is above the permissible limit in the direct nanofiltration method. The major drawback of the direct nanofiltration i.e. a substantial reduction in the permeate flux, is largely overcome in the combination method.