PRINCIPLES OF DYE REMOVAL FROM TEXTILE EFFLUENT

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Abstract. The initial rate of Disperse Blue 7 dye removal from textile effluent depends on the surface mass transfer coefficient. The effects of certain variables namely, agitation, initial dye concentration, particle size and solution temperature, on the dimensionless mass transfer term, $Sh/Sc^{0.33}$, have been studied.

1. Introduction

The disposal of dye wastewaters poses one of industry's major problems, because such effluents contain a number of contaminants including acid or caustic, dissolved solids, toxic compounds and color. Of all these, color is the first contaminant to be recognized because it is visible to the human eye. Industry and government are becoming increasingly aware of the need to clean up industrial effluents and reduce river pollution.

Many dyes used in the textile industry are particularly difficult to remove by conventional waste treatment methods since they are stable to light and oxidizing agents, and are resistant to aerobic digestion. The removal of dyes in an economic fashion remains a major problem although recently a number of successful systems have been designed using adsorption techniques (ICI America Inc., 1971; Davies et al., 1973; Hutchins, 1973). Carbon has been used generally for the treatment of industrial effluents (Fornwalt et al., 1963; Fornwalt and Hutchins, 1966; Joyce and Valentine, 1962) but there is very little data on the mechanism of dye removal from effluent using activated C.

The aim of this paper is to study the ability of activated C to remove Disperse Blue 7 Dye (Cibacet Turquoise Blue G) from solution. The results of varying several parameters are reported, including agitation, C particle size range, initial dye concentration and temperature. Equilibrium isotherms were undertaken and the results together with the rate data were used to determine surface mass transfer coefficients.

2. Experimental

2.1. Rate experiments

The time dependent experiments to investigate the transport of dyes onto the surfaces of the C were studied using a 2000 ml cylindrical glass vessel, 0.13 m diameter, containing eight baffles evenly spaced around the circumference. Different degrees of agitation were obtained by driving the six-bladed impeller with a variable speed motor, 20 to 800 r.p.m. In preparation for each run, a 1700 ml volume of dye solution,
of known initial concentration, was placed in the vessel and a known mass of adsor- 
bent added. Samples of 2 ml were withdrawn from the vessel, using a syringe, at known 
time intervals for analysis.

2.2. ANALYSIS

The dye used in the experiments, namely, Disperse Blue 7 (Cibacet Turquoise Blue G) 
was supplied by Ciba-Geigy. The concentration of coloring matter in each solution 
was determined spectrophotometrically. All measurements were made at the wave-
length corresponding to maximum adsorption, for Disperse Blue 7, \( \lambda_{\text{max}} = 585 \, \text{nm} \).

3. Theory

The color removal process is considered as a three-step model:

(i) mass transfer of dye from the bulk solution to the particle surface;

(ii) intraparticle diffusion; and

(iii) adsorption at an interior site.

It is assumed that step (iii) is rapid with respect to the first two steps. Furthermore, 
the experimental results and the effect of intraparticle diffusion have been reported 
in a previous paper (McKay et al., 1980). It was concluded that intraparticle diffusion 
was rate determining for most of the adsorption process but surface adsorption was 
important in the early stages. In a well agitated slurry adsorber mixing in the liquid 
phase is rapid, hence the concentration \( C_t \) of adsorbate and concentration \( m_s \) of C 
particles in the liquid are nearly uniform throughout the vessel. Then the change in \( C_t \) 
with respect to time is related to the fluid-particle mass transfer coefficient, \( \beta \), by the 
equation

\[
\frac{dC_t}{dt} = -\beta S(C_t - C_s) \tag{1}
\]

\[
C_t = C_0 \quad \text{at} \quad t = 0 \tag{2}
\]

where \( C_s \) is the concentration in the liquid at the outer surface of the particle.

The differential mass balance of dye within the particle is assuming a constant total, 
effective intraparticle diffusivity, \( D_t \),

\[
D_t \left( \frac{\partial C_r^2}{\partial r^2} + \frac{2}{r} \frac{\partial C_r}{\partial r} \right) - \rho_p \frac{\partial n_r}{\partial t} = \varepsilon_p \frac{\partial C_r}{\partial t} \tag{3}
\]

where \( C_r \) is the concentration in the liquid-filled pores at radius \( r \), \( n_r \) is the concentra-
tion of adsorbed dye at a radius \( r \) of the particle, \( \rho_p \) is the density of C particles and \( \varepsilon_p \) 
is the porosity of the C particles.

Boundary and initial conditions are

\[
D_t \left( \frac{\partial C_r}{\partial r} \right)_{r=R} = \beta (C_t - C_s) \tag{4}
\]