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Adsorption behaviour of direct yellow 50 onto cotton fiber: equilibrium, kinetic and thermodynamic profile

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Abstract

This study investigated the adsorption of direct yellow 50 onto cotton fiber from aqueous solution by using parameters, such as pH, temperature, contact time, initial dye concentration and the effect of sodium sulphate, tetrasodium edate and trisodium citrate. The extent of dye adsorption increased with increasing contact time, temperature and solution concentration. The experimental data were analysed by the Langmuir and Freundlich models of adsorption. It was found that the Langmuir equation fit better than the Freundlich equation. The results show that the presence of SE and SC significantly enhance the dye adsorption onto cotton fiber. In addition, the adsorption data obtained at different temperatures of DY50 onto cotton fiber were applied to pseudo first-order, pseudo second-order and intraparticle diffusion models. The rates of adsorption were found to conform to pseudo second-order kinetics with good correlation. Also, free energy of adsorption ($\Delta G^{\#}$), enthalpy ($\Delta H^{\#}$), and entropy ($\Delta S^{\#}$) changes were determined to predict the nature of adsorption. The positive value of the enthalpy change indicated that the adsorption is endothermic process. The activation energy, E_a, is ranged between 1.9- 3.9 kJ mol^{-1} indicated that the adsorption process is a physisorption. This low value of E_a generally indicates diffusion controlled process.

Keywords: Cotton fiber, Adsorption, Isotherm, Kinetics, Thermodynamics.

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1. Introduction

Direct dyes are one of the most popular types of colorant used for the dyeing and printing of cellulosic fibres and their blends. Because of the ease of their application and the wide gamut of products available at a modest cost, direct dyes are still a popular dye class [1, 2]. The name □ direct dye□ alludes to the fact that these dyes do not require any form of □ fixing□ . They are almost always azo dyes, with some similarities to acid dyes. Most direct dyes have disazo and trisazo structures, with each hue dominated by unmetallized structures [3, 4]. They also have sulphonate functionality, but in this case, it is only to improve solubility, as the negative charges on dye and fibre will repel each other. Their flat shape and their length enable them to lay along-side cellulose fibres and maximise the Van-der-Waals, dipole and hydrogen bonds.

Moreover, the dyeing is a heterogeneous process which takes place at the interphase between the dyeing solution and the fiber. Its proceeding includes (i) diffusion of the dye in the bulk liquid phase; (ii) adsorption of the dye on the fibers outer surface; (iii) diffusion in the bulk of the fibers; (iv) adsorption on the inner surface of the fibers [5]. Depending on the dyeing conditions each one of these steps can become limiting and hence determining the overall rate and the kinetic relations

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