ABSTRACT

Due to the ever-growing demand in textiles, synthetic organic dyes are widely used in textile fibers such as cotton, silk and polyester. More than 10,000 different types of dyes and pigments, with an annual production of more than 0.7 million tons are commercially available and 5 to 10% of the dye-stuff is lost as industrial effluents. Untreated disposal of this coloured water into the natural water bodies not only cause damage to aquatic life, but also to human beings by mutagenic and/or carcinogenic effect. Thus, the removal of dyes from coloured effluents, particularly those from textile industries, is one of the major environmental concerns nowadays. To minimize the impact of effluents, various techniques such as electro flotation, membrane filtration, reverse osmosis, oxidation techniques and ion-exchange have been employed. However, these processes are expensive and cannot be used to treat a wide range of industrial effluents.

Among the advanced chemical or physical treatments, adsorption is considered more effective and less expensive than other techniques. Activated carbon is widely used as an adsorbent because of its high adsorption capacity to several organic compounds in wastewater treatments. However, the cost of activated carbons is relatively high, thus limiting its usage. As a result, many novel materials have been tested as adsorbents with two objectives: to replace activated carbon with inexpensive alternatives and to use various waste products as adsorbents. These include mango seed kernel, peanut hull, hazelnut shells and jute fibre. The main disadvantage of these low-cost adsorbent is their low adsorption capacity and requirement of high dose of
adsorbent for complete colour removal. So, coloured wastewater treatment needs new adsorbents that are economical, easily available and effective.

In the present study, three activated carbons (SH1, SH2 and SH3) prepared from sunflower seed hull (SH) have been used as adsorbent for the removal of colour from aqueous solution. Three acid dyes (Acid Blue 15, Acid Red 114 and Acid Violet 17) and one acid dye mixture (Acid Blue 15 and Acid red 114) were selected for the adsorption studies. The activated carbon surface has been analysed by BET, FT-IR and SEM analyses. To study the effect of parameters such as adsorbent dosage, pH and initial concentration for the removal of colour, batch experiments were carried out in a thermostatic orbital shaker. Kinetic studies were carried out for activated sunflower seed hull in a 1000 mL beaker using a mechanical stirrer. The concentration of dye solution was measured using UV-Vis spectrophotometer.

The effect of adsorbent mass on the percentage colour removal and adsorption capacity for the three activated adsorbents were studied. An increase in the percentage of adsorption with increasing adsorbent dosage was observed in all the three adsorbents. This was due to the availability of more surface functional groups at higher mass of the adsorbent. But the amount of dye adsorbed per unit weight of the adsorbent decreases with increase in dosage, as observed in all the cases. This may be attributed to the aggregation of adsorbent particles at high dosage, which reduces the total surface area of the adsorbent. Acidic pH favours maximum colour removal of all selected dyes. In acidic medium, more protons will be available which increases electrostatic attraction between negatively charged dye anion and positively charged adsorption sites causing an increase in dye adsorption. When pH of the dye solution increases, positive charge on the oxide or solution interface decreases and the adsorption surface becomes negatively charged thereby decreasing the colour removal.
The experimental isotherm data at different dye concentrations were compared with Freundlich, Langmuir and Temkin isotherms. Langmuir isotherm best describes the isotherm data for all the three adsorbents and the dyes studied. The adsorption capacity of SH2 is higher for Acid Blue 15, Acid Violet 17 and mixture of dyes. SH3 shows high adsorption capacity for AR 114 dye. The experimental kinetic values were compared with pseudo-first order, pseudo-second order, Elovich and intra-particle diffusion model in order to evaluate the adsorption mechanism for the adsorption process. The pseudo-second order kinetic model is the best fit among the four kinetic models studied. It explains the adsorption behaviour for the whole process. Intra-particle diffusion model could be explained by three stages of adsorption. The thermodynamic constants of adsorption were also evaluated. The negative value of $\Delta G^\circ$ confirms the spontaneous nature of adsorption process. The positive value of $\Delta S^\circ$ showed the increased randomness at the solid-solution interface during adsorption and the positive value of $\Delta H^\circ$ indicated the adsorption process was endothermic.

Desorption studies were carried out for the adsorbed dye molecules onto the adsorbents with distilled water at various pH. The amount of dye molecule desorbed was less which indicates there is strong attraction between the adsorbent and dye molecule and thus chemisorption is operating in the adsorption process. In order to verify the adsorption capability of the prepared activated carbon, adsorption studies were carried out with the textile effluent and the results were compared with the commercially available activated carbon. When compared to commercial activated carbon, the prepared activated carbons show better adsorption behaviour for the two textile effluents studied.