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Cucumis sativus used as adsorbent for the removal of dyes from aqueous solution

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Abstract In this article, the agricultural solid waste, *Cucumis sativus* (RCS) was activated by sulfuric acid (CCS) for removing typical basic dyes, crystal violet (CV) and rhodamine B (RHB) from aqueous solution. The different parameters like effect of concentration, sorbent dosage, contact time and pH were studied. Isotherm data showed that the Langmuir isotherm provided the best correlation for the adsorption of CV and RHB onto RCS and CCS. The kinetic experimental data were well fitted by the pseudo-second-order kinetic model with intraparticle diffusion being one of the rate limiting steps. It can be concluded that *C. sativus*, the eco friendly adsorbent, is expected to be environmentally and economically feasible for the removal of CV and RHB from aqueous solution.

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1. Introduction

Waste water from dyeing and finishing operations associated with the textile industry is highly contaminated in both color and organic content. Color removal from textile effluents has been the target of great attention in the last few years, not only because of its potential toxicity, but also due to visibility problems (Voundrias et al., 2002). To protect humans and the receiving ecosystem from contamination, the dyes must be eliminated from the dye containing wastewaters before being released into the environment. Various physicochemical and

biological techniques have been employed to remove dyes from waste water. They include membrane filtration, coagulation/flocculation (Mecay et al., 1984), adsorption (Meshko et al., 1998), ion-exchange (Wong et al., 2004), advanced oxidation (Forgacs et al., 2004), and biological treatment (bacterial and fungal biosorption, biodegradation in aerobic or anaerobic conditions) (Kaur et al., 1998). The technical and economical feasibility of each technique is determined by several factors such as dye type, waste water composition, operation costs and generated water products. Also the use of one individual technique is not sufficient to achieve complete discoloration. Therefore dye removal strategies consist of a combination of different techniques.

Amongst various techniques, adsorption is superior in simplicity of design, initial cost, ease of operation and insensitivity to toxic substance. A large number of suitable adsorbents such as activated carbon, polymeric resins or various low cost adsorbents (non modified or modified cellulose biomass, chitin, bacterial biomass, etc.) have been studied. Identification of a potential dye adsorbent must be in good agreement with

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its dye binding capacity, its regeneration properties, its requirements and limitations with respect to environmental condition. The valorization of agricultural wastes into valuable materials without generating pollutants is a big challenge and recommended for an industrial sustainable development in order to preserve the environment (Santhi et al., 2010).

Cucumis sativus is a leading commercial crop and a popular home garden vegetable. Commercial cucumber production includes processing types for pickling and fresh market types for slicing. At one season or another, cucumbers may be grown in all regions of India. The peel of *C. sativus* is a segregated waste product, hence it is available free of cost. The aim of the paper is to find out the more suitability and applicability of carbon prepared from *C. sativus* for the uptake of cationic dyes from simulated waste water (Santhi and Manonmani, 2010, 2011). To evaluate the adsorption potential of *C. sativus* leaves for removing dyes from wastewater, crystal violet (CV) and rhodamine B (RH B) were selected as the model cationic dyes. Discharge of CV into the hydrosphere can cause environmental degradation, because CV is readily absorbed into the fish tissue by water exposure and is reduced metabolically by fish to the leuco moiety, leucocrystal violet (LCV). Several studies by the National Toxicology Program reported the carcinogenic and mutagenic effects of crystal violet in rodents. It has also been linked to increased risk of human bladder cancer. The leuco form induces renal, hepatic and lung tumor in mice. In California, rhodamine B is suspected to be carcinogenic and thus products containing it must contain a warning on its label.

2. Materials and methods

2.1. Materials

The commercial grade CV and RH B, models of the cationic dye with molecular formula of $C_{25}H_{30}ClN_3$ and $C_{28}H_{31}ClN_2O_3$ were used in the present study. Crystal violet (color index No. 42555) with molecular weight 407.99 and λ_{max} 584 nm are obtained from Thomas baker (chemicals) Ltd., Mumbai, India and rhodamine B (color index No. 45170) with molecular weight 479.02 and λ_{max} 554 nm are obtained from Qualigens fine chemicals Mumbai, India. The molecular structures are illustrated in Fig. 1. All the chemicals used throughout this study were of analytical-grade reagents and

the adsorption experiments were carried out at room temperature ($27 \pm 2^\circ\text{C}$).

2.2. Adsorbent preparation

The fruit peel of *C. Sativus* used for the present study was collected from Palamudhir Nilyam, Coimbatore. The fruit peel was crushed and dried in an oven and used as a raw adsorbent (RCS). The oven dried peel of the adsorbent was treated with conc. H_2SO_4 for 12 h and was washed thoroughly with distilled water till it attained neutral pH and soaked in 2% $NaHCO_3$, for overnight in order to remove any excess of acid present. Then the material was washed with distilled water and dried. The material thus obtained was designated into activated carbon (CCS). The materials were sieved to get different geometrical sizes such as 75–125, 125–250 and 250–500 μm .

2.3. Characterization of prepared adsorbents

Determination of zero point charge (pH_{zpc}) was done to investigate the surface charge of both chemically and microwave activated adsorbents at different solution pH.

2.4. Dye uptake experiments

The adsorption experiments were carried out in a batch process to evaluate the effect of pH, contact time, adsorbent dose, adsorption kinetics, adsorption isotherm of CV and RH B onto RCS and CCS. For each experiment, a series of flasks were prepared with 50 mL of dye solution (25–200 mg/L, respectively) and the pH was adjusted from 2 to 8 using a pH meter (Deluxe pH meter, model-101 E). About 0.2 g of the sorbent was added, and the flasks were agitated at 160 rpm. The sorbent was removed by centrifugation and the supernatant was analyzed using a Systronic Spectrophotometer-104 at wavelength of 584 nm.

The amount of dye adsorbed at equilibrium onto carbon, q_e (mg g^{-1}) was calculated by the following mass balance relationship.

$$q_e = (C_0 - C_e)V/W \quad (1)$$

where C_0 and C_e are the concentrations (mg L^{-1}) of CV at initial and equilibrium respectively. V is the volume (L) of the solution and W is the weight (g) of the adsorbent used.

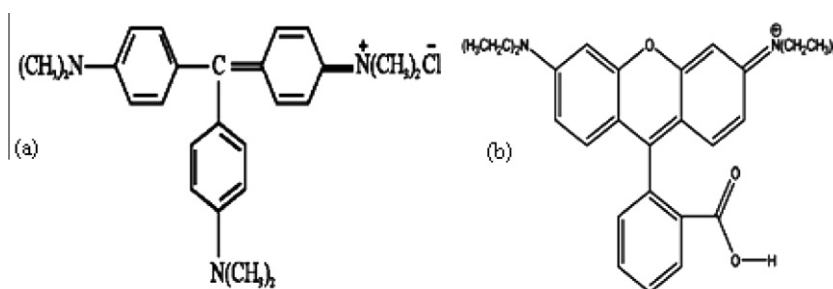


Figure 1 Structure of (a) Crystal violet dye (b) Rhodamine B.

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