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ORIGINAL ARTICLE

A comparative study of microwave and chemically treated *Acacia nilotica* leaf as an eco friendly adsorbent for the removal of rhodamine B dye from aqueous solution

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Abstract The use of cheap and eco friendly adsorbents prepared from freely and abundantly available *Acacia nilotica* leaves have been investigated by batch methods. Microwave treated *A. nilotica* leaves (MVM) are more effective than chemically treated *A. nilotica* leaves (CVM) for the removal of rhodamine B (RH B) from aqueous solution. The effect of initial pH, contact time and initial dye concentration of RH B onto CVM and MVM has been investigated. The applicability of the linear form of Langmuir model to CVM and MVM was proved by the high correlation coefficients R^2 = 0.9413 and 0.9681 for RH B adsorption. The R^2 values were greater than 0.994 for all RH B concentrations, which indicates the applicability of the pseudo-second-order kinetic model. The recycling ability of MVM is greater than CVM. The preparation of MVM does not require an additional chemical treatment step and it attains rapid equilibrium. Hence it is agreeing with the principles of green chemistry and less time is required to possess high adsorption of RH B. Therefore, the eco friendly adsorbent MVM is expected to be environmentally and economically feasible for the removal of RH B from aqueous solutions.

1. Introduction

Dyes used in textile industry may be toxic to aquatic organisms and can be resistant to natural biological degradation. Hence, the removal of colour synthetic organic dyestuff from waste effluents becomes environmentally important (Hameed, 2009). The valorization of agricultural wastes into valuable materials without generating pollutants is a big challenge

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and is recommended for an industrial sustainable development in order to preserve the environment (Reffas et al., 2010). Adsorption onto activated carbon is proven to be very effective in treating textile wastes. However, in view of the high cost and associated problems of regeneration, there is a constant search for alternate low-cost adsorbents. Such alternatives include coffee ground (Reffas et al., 2010), spent tea leaves (Hameed, 2009), palm ash (Ahmad et al., 2007; Hameed et al., 2007a,b), pomelo (*Citrus grandis*) peel (Hameed et al., 2008), pine-cone (Mahdi et al., 2010), pumpkin seed hull (Hameed and El-Khaiary, 2008), ginger waste (Ahmad and Kumar, 2010), rice husk (Verma and Mishra, 2010).

Rhodamine B, a synthetically prepared carcinogenic xanthine dye is widely used for paper printing, textile dyeing, leather and paint industries. Discharge of RH B into the hydrosphere can cause environmental degradation. In California, rhodamine B is suspected to be carcinogenic and thus products containing it must contain a warning on its label. *Acacia nilotica* is a species of *Acacia*, native to Africa and the Indian subcontinent. In Haryana, *A. nilotica* based agro forestry systems reduced the yield of wheat (Puri et al., 1995).

The aim of the paper is to prepare an eco friendly microwave treated *A. nilotica* leaves as an agricultural waste for the depollution of water effluents contaminated by dyes from textile industry. And to find out the suitability and applicability of carbon prepared by different treatments (microwave and chemical) of *A. nilotica* to uptake cationic dye (rhodamine B) from simulated waste water. The preparation of microwave treated *A. nilotica* leaves was based on green chemistry. Green chemistry is an approach to the design, manufacture and use of chemical products to intentionally reduce or eliminate chemical hazards. The goal of green chemistry is to create better, safer chemicals while choosing the safest, most efficient ways to synthesize them and to reduce wastes. Desorption was used to elucidate the nature of adsorption and recycling of the spent adsorbent.

2. Materials and methods

2.1. Preparation of chemically treated adsorbent (CVM)

The leaves of *A. nilotica* used in this work were collected locally. It was dried in an oven and treated with conc. H_2SO_4 for 12 h and was washed thoroughly with distilled water till it attained neutral pH and was soaked in 2% $NaHCO_3$ overnight in order to remove any excess of acid present. Then the material was washed with distilled water and dried.

2.2. Preparation of microwave treated eco friendly adsorbent (MVM)

The collected *A. nilotica* leaves were shade-dried and powdered in a grinder. The raw sample is placed in a microwave oven (Samsung; Triple Distribution System) at 800 °C for 2 min. The carbonated sample was preserved in an air tight container for further experiments. No other chemical or physical treatments were used prior to adsorption experiments.

2.3. Adsorbate

The commercial grade rhodamine B was used in this work. Rhodamine B (colour index No. 45170) with molecular formula $C_{28}H_{31}ClN_2O_3$, molecular weight 479.02 and λ_{max} 554 nm is obtained from Qualigens fine chemicals Mumbai, India. The molecular structure is illustrated in Fig. 1. The dye stock solution (500 mg L^{-1}) was prepared and the serial dilutions were made by diluting the dye stock solution in accurate proportions to the desired initial concentrations. The initial pH was adjusted with 0.1 M HCl or 0.1 M NaOH. All the chemicals used throughout these studies were of analytical-grade reagents. All the adsorption experiments were carried out at room temperature (27 ± 2 °C).

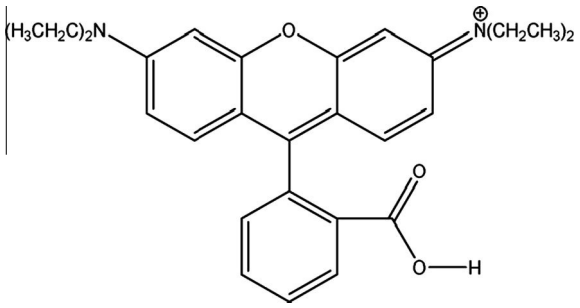

Figure 1 Structure of rhodamine B.

2.4. Characterization of CVM and MVM

The functional groups available on the surface of CVM and MVM were detected using Fourier Transform Infrared (FTIR) analysis. The spectrum was recorded from the range of 4000 to 500 cm^{-1}. Determination of zero point charge (pH_{zpc}) was done to investigate the surface charge of both adsorbents. For the determination of pH_{zpc}, 1 g of the sample suspension was prepared in 50 mL of $NaNO_3$ electrolyte of concentration approximately 10^{-2} M. Aliquots of suspension were adjusted to various pH values with dil. NaOH and HNO_3. After 60 min for equilibrium, the initial pH was measured. Then 0.1 g of $NaNO_3$ was added to each aliquot to bring the final electrolyte concentration to about 0.45 M. After an additional 60 min of agitation, final pH was measured. The results were plotted with initial pH (final pH − initial pH) against final pH. The pH at which pH is equal to zero is zero point charge (pH_{zpc}).

2.5. Batch adsorption experiments

The batch adsorption experiments were carried out in order to evaluate the effect of pH, adsorption kinetics, adsorption isotherm and desorption of RH B on CVM and MVM.

2.5.1. Effect of pH on RH B onto CVM and MVM

The effect of pH on the equilibrium uptake of dye was investigated by 50 mL of RH B with initial concentration 100 mg L^{-1} was taken in 250 mL shaking flask. The initial pH values adjusted from 2 to 8 were measured using a pH meter (Deluxe pH meter, model-101 E). The initial dye concentration was measured by a double beam UV–vis spectrophotometer (Digital photo colorimeter, model-313) by adjusting the λ_{max} of the dye. The dye solutions were agitated with about 0.2 g of CVM and MVM in a mechanical shaker at room temperature. Agitation was made for 120 min (RH B onto CVM)