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Adsorptive removal of Megenta MB cold brand reactive dye by modified activated carbons derived from agricultural waste

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Abstract
The activated carbon produced from agricultural waste, Tapioca Peel, was used for the adsorption of reactive dye Megenta MB from its aqueous solutions. The preparation of activated carbon from agricultural waste could increase economic return and reduce pollution. In our project, adsorption studies were performed by varying parameters such as dye concentration, pH of the dye solution and contact time. The study investigates the removal of Megenta MB dye from its aqueous solution. The equilibrium adsorption data obtained were used to calculate the Freundlich and Langmuir isotherm parameters. Higher adsorption percentages were observed at lower concentrations of Megenta MB. Optimum pH value for dye adsorption was determined as 7. Maximum dye was removed within 120 min after the beginning for every experiment.

Keywords: Tapioca peel; Megenta MB; effluent treatment, textile dye, water pollution, environment, industry, India

Introduction
Dyes are highly coloured polymers and low biodegradable in nature. Colour/dye being one of the important recalcitrant, persist for long distances in flowing water, retards photosynthetic activity, inhibit the growth of aquatic biota by blocking out the sunlight and utilizing dissolved oxygen and also decrease the recreation value of stream (Filipkowska *et al.,* 2002; Filipkowska *et al.,* 2004).

Textile industries consume the large volumes of water and chemicals for wet processing of textiles. Worldwide annual textile production is currently 30 million tons with expected growth of 3% per annum (Yasin *et al.,* 2007). Water consumption in the textile industry is on average 100 m^3 (per ton of product). Currently, the world's production is over 40,000 structural dye units (Reddy *et al.,* 2006). Reactive dye use equals 26% approximately. Dye plants use great amounts of water- 225 m^3/ton of dye. The losses of reactive dyes are about 2% in the production processes and about 9% through dying and finishing operations in the textile industry. As a result, from 40,000 to 50,000 tons of dye are discharged to surface water every year (Albanis *et al.,* 2000).

Due to inefficiency of dyeing process results in 10-25% of all dyestuffs being lost directly to the waste water (Ncibi *et al.,* 2007). Although the textile dyes contribute only a small portion of the total volume of discharged waste water after the dyeing process, yet they make it deeply coloured (Balakrishnan *et al*., 2008).

Due to the advantages of colouring and dyed fabric durability, reactive dyes have increasingly been used for dying and printing on both natural and regenerated cellulose fibers (Suteu & Bilba, 2005), The textile industry is in the forefront in the use of dyes in its operations with more than 9,000 types of dyes incorporated in the colour index. Similarly, more than 70000 tons of approx. 10000 different types of dyes and pigments are produced annually world wide, of which 20-30% are wasted in industrial effluents during dyeing and finishing processes in the textiles industries. Wastewaters from the textile finishing industry commonly contain moderate concentrations (10-200 mg/L) of dye stuffs (Jusoh *et al.,* 2004), contributing significantly to the pollution of aquatic ecosystems. Textile effluents are highly coloured, and their discharge into rivers makes water unfit for domestic, agricultural and industrial purposes (Abdullah *et al.,* 2005; Tumin *et al.,* 2008; Gopalakrishnan *et al*., 2009; Sukanchan Palit, 2009; Praveen Kumar *et al*., 2010).

The main advantages of using the tapioca peel are economically viable, ease of availability, ease of operation and environment friendly (Parvathi *et al*., 2010).

Materials and methods
Preparation of adsorbent
Tapioca root is washed in the cold, distilled water, which does not have any chemical constituents. After that the outer layer of the tapioca root was removed manually. The outermost layer of the tapioca root was gently rubbed and removed. After removing the outermost layer, which is in dark brownish in colour, the tapioca peel will be in a light pink or whitish in colour. This layer is gently removed from the tapioca. This process is repeated again and again to collect the tapioca peel as a whole.

Tapioca peel was rinsed in the cold water two or three times and then it was dried under the direct sun light for about 48h in order to dry it completely without leaving any moisture content present in it. If moisture content presents in it, then the formation of fungus may happen, unavoidably. So it is very much essential to completely dry the tapioca peel under the natural, direct sunlight for a plenty of time. After 48h the tapioca peel is taken out and again cleaned manually so as to remove the soils and dust deposited over the surface of the tapioca peel. Then this purified tapioca peel only taken to the further processes such as treating with chemicals or direct activation.

Batch adsorption studies

The present investigation employs the adsorption experiments of megenta MB dye on tapioca peel adsorbents under different experimental conditions. The different experimental conditions under study are initial concentration of megenta MB dye, contact time and pH.

A stock solution of 1000 ppm concentration dye was prepared by dissolving 1 g of megenta MB dye in 1 l of solvent (double distilled water) and used for experimental work. 50 ml of dye solution of different initial concentrations from 0 -10 ppm in the increment of 2 ppm solution were prepared in standard measuring flasks separately, from the stock solution of megenta MB (1000 PPM) with required volume of DD water.

The optical density (OD) of dye solution was measured by using Systronics UV visible Spectrophotometer 169 model from the standard curve, λ_{max} for megenta MB dye is found in 600-640 nm (Fig.1).

Results and discussions

Effect of concentration (Fig.2,3)

In all the batch adsorption experiments, the extent of removal of dye, in terms of the values of percentage removal of dye and amount adsorbed (q in mg g^{-1}) have been calculated using the following relationships.

$$\text{Percentage removal} = \frac{100\,(C_i - C_e)}{C_i}$$

$$\text{Amount adsorbed (q)} = \frac{x\,(C_i - C_e)}{m}$$

Where,

C_i = initial concentration of dye (in ppm)

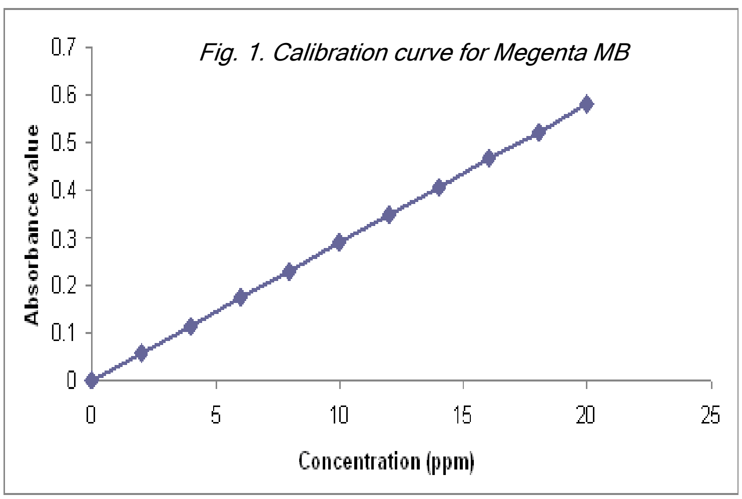
C_e = equilibrium concentration of dye (in ppm)

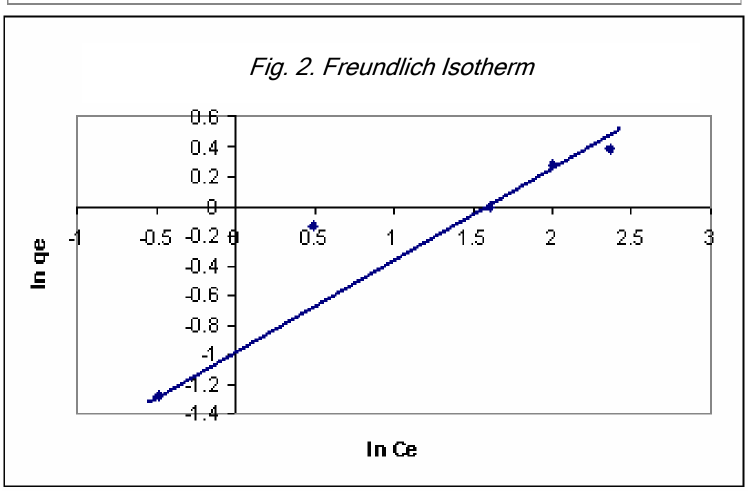
x = amount of dye adsorbed (mg/l)

m = mass of adsorbent (g/l)

Effect of contact time (Fig.4)

In order to identify the time required to attaining the equilibrium, time variation of dye-adsorbent, 50 ml of dye (10 ppm for megenta MB) and 100 mg of SATC, CSTC, TAC and DAC. The investigation carried at different time intervals viz., 30, 60, 90, 120, 150, 180, 210 minutes. Then the mixture was centrifuged at REMI centrifuge pump for 30 min. The unabsorbed dye molecules present in the solution were determined by the OD measurements of the supernatant liquid by Systronics UV visible spectrophotometer 169 models. The experimental results clearly indicate that the optimum time to attain the equilibrium for this reaction is 40 min.





Effect of pH (Fig.5)

In order to study the effect of pH (3, 5, 7, 9 & 11) on the extent of removal (% 7 q) of megenta MB, the adsorption experiments were carried out at constant dose of adsorbents 100 mg l^{-1} of SATC, CSTC, TAC and DAC, and optimum initial concentration of dye (C_i = Megenta MB = 10 ppm). The percentage removal of megenta MB increases exponentially with the increase in contact time and reaches a maximum value to attain a pH of 10.

Conclusions

The present study deals with the removal of dye megenta MB on SATC, TAC, CSTC, and DAC for the effect of initial concentration (C_i), contact time, dose of adsorbent and pH. The percentage removal of dye on these adsorbents was found to decrease with the increase in initial concentration of dye, which is due to the lack of available active sites. The percentage removal of dye increased exponentially with the increase in contact time. Optimum contact time was found to be 150 min for the dye-adsorbent system. From this experimental result of the present study, it is concluded that TAC, SATC and $AgNO_3$ are the effective low cost adsorbents for the removal of dyes/colour from water and wastewater/textile industrial effluents.

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Fig. 3. Langmuir Isotherm

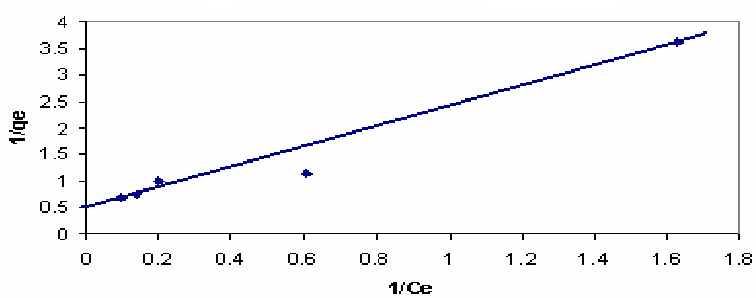


Fig. 4. Effect of contact time

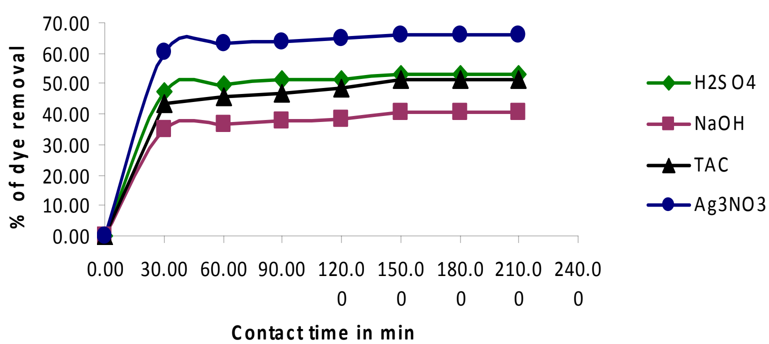
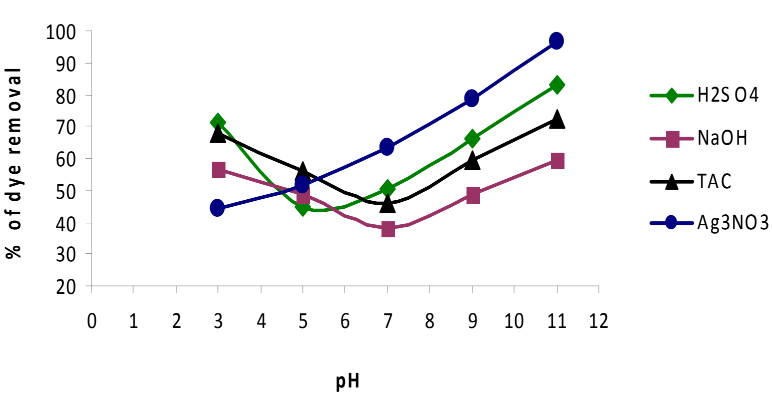


Fig. 5. Effect of pH



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