

# Fast Removal of Malachite Green by Adsorption on Rice Husk Activated Carbon

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**Abstract:** Application of activated carbon developed from rice husk, an agricultural waste product has been investigated for the removal of malachite green from aqueous solutions and wastewaters. Batch adsorption experiments were carried out for the removal of malachite green from aqueous solutions onto rice husk activated carbon. Effect of important parameters namely initial concentration of dye and contact time, and temperature was studied on removal of the dye. The removal increased from 93.75 to 94.91% by decreasing the initial concentration from 100 to 60 mg/l. Equilibrium data were fitted to Freundlich and Langmuir isotherm equations and the isotherm constants were determined. The monolayer adsorption capacity of rice husk activated carbon for adsorption of the dye was found to be 63.85 mg/g at room temperature.

**Keywords:** Activated carbon, adsorption, aqueous solution, malachite green.

## 1. INTRODUCTION

Dyes and colours are frequently used in industries and textile and pulp and paper industries are reported to utilize large quantities of a number of dyes. According to an estimate more than 1,00,000 commercially available dyes with over  $7 \times 10^5$  tonnes of dyestuff are produced and used annually. The discharge of effluents from these applications is one of the potential sources of their contamination and pollution [1-3]. These industrial discharges are highly colored with high Biochemical Oxygen Demand (BOD) as well as Chemical Oxygen Demand (COD) [4]. Malachite green (MG) is a popular dye and is used extensively. It also finds applications in medical sciences. MG is highly toxic to flora and fauna. It induces risk of cancer, acts as a liver tumor-enhancing agent and many other diseases. The dyes check the biological activity in aquatic lives. They also pose in human. It has mutagenic and carcinogenic characteristics [5,6]. It can cause severe effects on nervous system, reproductive system, liver, brain and kidney. Precipitation, coagulation, flocculation, ion exchange, biosorption, and adsorption are the conventional methods used for removal of dyes. Activated carbons are widely used as industrial adsorbents for separation, purification of solid and liquid phase, and as recovery processes due to their texture being highly porous and they have large capacity to adsorb pollutants but their large scale application is cost intensive [7,8]. The use of activated carbon for removal of malachite green has also been reported [9]. Commercial activated carbons are expensive and therefore, there is a need to search for effective adsorbents for economical wastewater treatment. Utilizing wastes and bio-wastes of environment as adsorbents for the removal of dyes from wastewater is of interest. Number of materials such as coconut coir, bagasse

pith, rice husk, neem tree leaves, and orange peel have been used to prepare carbon from agricultural wastes as low-cost adsorbent materials for the removal of dyes from wastewater [10-14].

In the present studies, rice husk, a non conventional agricultural-waste material, has been indirectly used to prepare activated carbon for the removal of MG from its aqueous solutions.

## 2. MATERIALS AND METHODS

### 2.1. Adsorbent

The rice husk used in the present investigation was procured locally. It was washed and dried in hot air oven at  $110^\circ\text{C}$ . Carbonization was carried out in a quartz tube reactor placed in a tubular muffle furnace at  $450^\circ\text{C}$  for 1 hr in an indigenous experimental set up. A constant nitrogen (99.99%) flow of 150 ml/min was maintained throughout the process. Activation of primary carbon was carried out at  $650^\circ\text{C}$  for 2 hrs under conditions. The carbon was then cooled in inert atmosphere in the presence of nitrogen at room temperature and washed with hot deionized water and 0.5N hydrochloric acid until the pH of sample reached 7.0. The carbon was then again dried in hot air oven at  $110^\circ\text{C}$ , ground and sieved to obtain desired particle size ( $150\ \mu\text{m}$ ) and stored in desiccators for further use.

#### 2.1.1. Adsorbate

All reagents used in the experiments were analytical grade chemicals and were obtained from Merck, Mumbai, India. Stock solutions of the test reagents were made by dissolving the dye in distilled water. The dye, malachite green oxalate, C.I. Basic Green 4, C.I. Classification Number 42,000, chemical formula =  $\text{C}_{52}\text{H}_{54}\text{N}_4\text{O}_{12}$ , MW = 927.00,  $\lambda_{\text{max}} = 618\ \text{nm}$  (measured value) was supplied by Merck. The chemical structure of malachite green oxalate is shown in Fig. (1).

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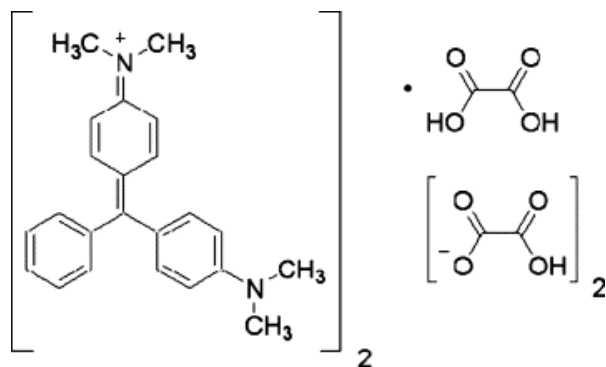


Fig. (1). Chemical structure of malachite green.

## 2.2. METHODS

### 2.2.1. Adsorption Studies

Adsorption experiments were carried out by agitating 0.25 g of rice husk activated carbon (RHAC) to 50 ml of dye solution of the desired dye concentrations in 250 ml stoppered conical flasks, at 150 rpm, 30°C in a thermo stated water bath shaker to reach equilibrium. The dye solution was separated from the adsorbent by centrifugation at 10,000 rpm for 10 min. Residual concentration of dye in supernatant was estimated spectrophotometrically by monitoring the absorbance at 618 nm  $\lambda_{max}$  using a UV-vis spectrophotometer (Spectronic 20, Bausch & Lomb, USA). Amount of adsorbed dye molecules per g of solid was determined as follows:

$$q_e = (C_o - C_e)V/w \quad (1)$$

where,  $C_o$  is the initial concentration of malachite green (mg/l),  $C_e$  is the equilibrium concentration of dye (mg/l),  $V$  is the volume of the solution (l) and  $w$  is the mass of the rice husk activated carbon (g). The kinetic data were fitted to pseudo first order reaction for the removal of malachite green onto rice husk activated carbon.

## 3. RESULTS AND DISCUSSION

### 3.1. Effect of Contact Time and Initial Concentration

Effect of contact time and initial concentration for removal of malachite green from aqueous solutions is quite

important. The adsorption data for 'uptake of dye vs. contact time at different concentrations' are presented in Fig. (2). The removal increased from 93.75 to 94.91 % by decreasing the initial concentration of MG from 100 to 60 mg/l (Fig. 2).

It is clear from Fig. (2) that the graphs are single and smooth, indicating monolayer coverage of the surface adsorbent by MG. Further, the removal is rapid in initial stages, decreases slowly, and acquired a maxima at 40 min., and maximum removal was found to be 94.91% at 60 mg/l malachite green concentration. The removal increased from 93.75 to 94.91% by decreasing the initial concentration from 100 to 60 mg/l at 30°C, 150 rpm, and 150  $\mu$ m adsorbent particle size.

#### 3.1.1. Kinetic Studies

The kinetic modeling of the removal of dye malachite green by rice husk activated carbon was carried out and data were treated with pseudo first order kinetic model [15].

$$\log (q_e - q) = \log q_e - (K_{ad}/2.303).t \quad (2)$$

where  $q$  and  $q_e$  (both in mg/g) are amounts of dye adsorbed at any time and at equilibrium respectively, and  $K_{ad}$  ( $\text{min}^{-1}$ ) is the rate constant of adsorption. The straight line plots of ' $\log (q_e - q)$  vs  $t$ ' (Fig. 3) confirm that the process of removal is governed by first-order kinetics. The linear plots also demonstrate the applicability of pseudo first order nature of the process of removal. The values of  $K_{ad}$  were determined by the slopes of the graphs of Fig. (3) and the value of  $K_{ad}$  was found to be  $2.38 \times 10^{-2} \text{ min}^{-1}$  at 60 mg/l concentration of malachite green and 30°C. The values of  $K_{ad}$  show that rice husk activated carbon is a good adsorbent for removal of MG from aqueous solutions.

#### 3.1.2. Equilibrium Modeling

Equilibrium modeling shows how does the adsorption the process acquire equilibrium state. The Langmuir model assumes that uptake of MG molecules occurs on a homogeneous surface by monolayer adsorption. Selection of an isotherm equation depends on the nature and type of the system. Linear form of langmuir equation is as under [16,17]:

$$(C_e/q_e) = 1/Q^0b + C_e/Q^0 \quad (3)$$

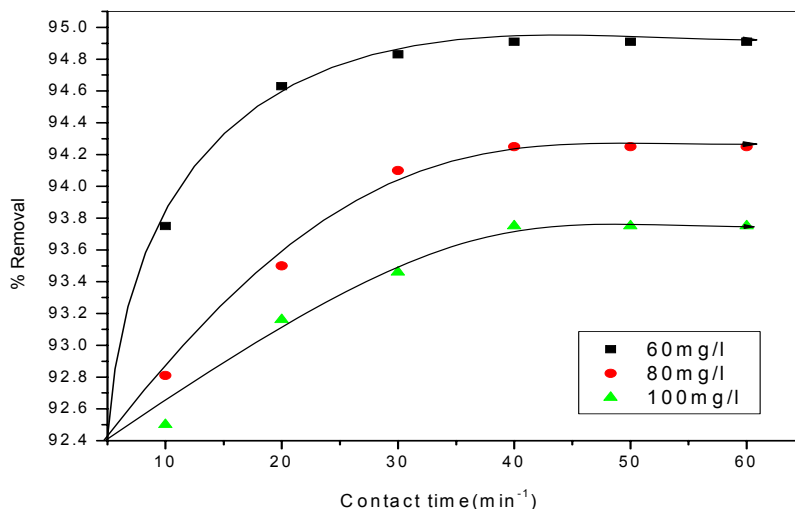


Fig. (2). Effect of initial concentration on percent removal of malachite green on RHAC.





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