



# Constancy and Kinetics of Direct Yellow 27 from Aqueous Solution using *Balsamodendron caudatum* Wood Squander Activated Nano Springy Carbon Material

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## ABSTRACT

The sorption competence of *Balsamodendron caudatum* wood waste comparative to Direct Yellow 27 was analyzed to check its significance in textile wastewater association. *Balsamodendron caudatum* wood squanders activated nano springy carbon material (BANCM) was treated by means of sulphuric acid to make a choice up sorption ability for the exclusion of Direct Yellow 27 (C.I. No 13950) from aqueous solution. The treated (BANCM) using sulphuric acid was determined through SEM, XRD and FT-IR. The use of BANCM squander as an adsorbent for the elimination of Direct Yellow 27 dye from its aqueous solutions is a topic of present research. In the current analysis, the initial dye concentration, dye solution pH, and sorption temperature were investigated to see whether sorption is perfunctory. Kinetic force of dye followed the pseudo-first-order, pseudo second order and Elovich models respectively. Consequences show that the pseudo first order kinetic model was established to compare the investigational description excellent.

**Keywords:** Aqueous solution; Direct Yellow 27; Kinetics; Low-priced adsorbents; Sorption.

## 1. INTRODUCTION

Nowadays, the textile industry plays a key role in the economy of countries around the world (Amin, 2009). Among the textile operation, dyeing is a fundamental process which produces a large volume of colored wastewater that can affect environmental ecosystems, especially aqueous ambient. Direct Yellow 27 is an azo dye group with three azo bonds. The potential toxicity and carcinogenicity of azo dyes have been reported (El-Bahy *et al.* 2009). In addition to aesthetically displeasing, some dyes (as azo group dye) are toxic to some microorganisms and may cause direct destruction or inhibition of their catalytic activities (Armagan *et al.* 2004). According to reports, Direct dyes constitute about 17% of all dyes employed for dyeing textiles and about 30% of dyes used for dyeing cellulose fiber. Oxidation, precipitation, ion exchange bio-sorption, electrochemical treatment, and adsorption are the traditional methods for decolorizing dyes from aqueous solutions (Bulut *et al.* 2007; Shirmardi *et al.* 2013). Such types of adsorbents include pine tree leaves (Deniz *et al.* 2011), bagasse fly ash (Mane *et al.* 2007), rice husk ash (Mane *et al.* 2007), (Arundo donax), reeds (Arwa Abdelhay *et al.* 2017), red mud (Zhong-Pan Hu *et al.* 2017), TiO<sub>2</sub> (Dayeon ChoiSooHo HamDu-Jeon Jang *et al.* 2018), nanocomposites

agricultural waste and timber industry waste carbons for the removal of various dyes from wastewaters (Bansa *et al.* 2009). A critical review of low-cost adsorbents for wastewater treatment has been presented by earlier researchers (Demirbas *et al.* 2009).

## 2. EXPERIMENTAL METHODS

### 2.1 Adsorbent

*Balsamodendron caudatum* wood waste was collected from various locations in Tamil Nadu and India, including the districts of Coimbatore and Tirupur. Wood waste from the *Balsamodendron caudatum* is considered to be low-cost, ecologically friendly, and useful as a sorbent. The product was pulverised, rinsed with purified water, and dried to form sorbent. The dried material was treated with hydrogen peroxide (40 percent W/V) at room temperature for around 24 hours to oxidise the adhering organic components. The resultant product was extensively rinsed with twice filtered water before being dried at 120 °C to eliminate moisture. For a total of 24 hours, one part of the aforesaid substance was fully soaked in H<sub>2</sub>SO<sub>4</sub> solution. The surplus H<sub>2</sub>SO<sub>4</sub> solution was decanted and dried in the air after 24 hours. A muffle furnace was used to carbonise the compounds at 120-130 °C. The dried

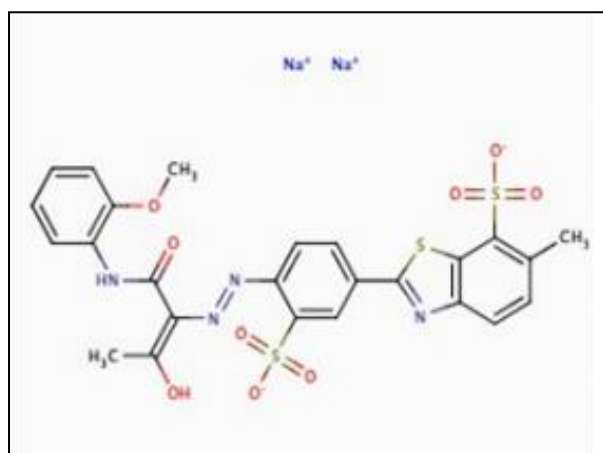
materials were powdered and activated for 60 minutes in a muffle furnace set to 800 °C. The sample was then cleaned with enough of water to eliminate any residual acid before being dried to the desired particle size. The resulting carbon was given the name BANCM.

## 2.2 Preparation of aqueous dye solution

The dye stockpile solutions (1000 ppm) is made by dissolving 1 g of dye in one litre of water and storing it in dark-colored glass bottles with no further care. An aqueous solution of this dye was prepared from stock solutions in deionized water for the batch analysis. For pH tests, NaOH and HCl solutions were used as buffers.

**Table 1. The individuality of the dye used**

Class	Sample	General name	C.I. No.	Mw
Direct	DI 27	Direct Yellow 27	13950	662.63



**Fig. 1: Structure of Direct Yellow 27**

## The pseudo-first-order equation

The pseudo-first-order equation ( Lagergren *et al.* 1898 ) is generally expressed as follows:

$$\frac{dq_t}{dt} = k_1(q_e - q_t) \quad (1)$$

where  $q_e$  and  $q_t$  are the adsorption capacity at equilibrium and at time  $t$ , respectively ( $\text{mg g}^{-1}$ ),  $k_1$  is the rate constant of pseudo-first-order adsorption ( $\text{l min}^{-1}$ ).

## The Pseudo Second – Order Equation

The pseudo-second-order adsorption kinetic rate equation is expressed as (Mckay *et al.* 2000)

$$\frac{dq_t}{dt} = k_2(q_e - q_t)^2 \quad (2)$$

Where  $k_2$  is the rate constant of pseudo-second-order adsorption ( $\text{g. mg}^{-1}. \text{min}^{-1}$ ). Where  $k_2$  is the rate constant of pseudo-second-order adsorption ( $\text{g. mg}^{-1}. \text{min}^{-1}$ ). If the initial adsorption rate  $h$  ( $\text{mg g}^{-1} \text{min}^{-1}$ ) is

$$h = k_2 q_e^2 \quad (3)$$

## The Elovich Equation

The Elovich model equation is normally expressed (Chien *et al.* 1980) as

$$\frac{dq_t}{d_t} = \alpha \exp(-\beta q_t) \quad (4)$$

where,  $\alpha$  is the initial adsorption rate ( $\text{mg.g}^{-1} \text{min}^{-1}$ ),  $\beta$  is the adsorption constant ( $\text{g. mg}^{-1}$ ) during any one experiment.

## 3. RESULTS AND DISCUSSION

### 3.1 Characterization of adsorbent

Using a NOVA1000 from Quanta chrome, the surface area of the BANCM was measured using N2 adsorption at 77K. A PHS-3C pH metre was used to determine the pH of BANCM. The pH of the samples' zero point charges (pHpzc) was determined using the pH drift equation (Fariaa *et al.* 2004). The N2 equilibrium adsorption isotherms revealed that the BANCM has a surface area of 760 m<sup>2</sup>/g. The findings of a "pH drift" survey, which revealed that the pHpzc of the BANCM studied in this test was 4. At a pH of 6, the dye Direct Yellow 2 was found to remove the colour more effectively.

### 3.2 Effect of pH

pH affects BANCM surface dye-binding sites and dye chemistry in water, according to a series of experiments performed to determine the effect of pH on the sorption phenomenon. At the initial pH value, Fig. 2 shows the amount of dye extracted using acid-activated sorbent. The initial dye concentration was set to 20 ppm in this experiment. At pH 6, improved colour elimination of the pigment, Direct Yellow 27, was observed in shake flask experiments. Direct Yellow 27 uptake was found to be optimum at pH 6, with a maximum dye uptake of 89 percent. The electrostatic repulsion between the positively charged dye and the surfaces of the sorbent is decreased as the surface charge intensity decreases with an increase in the solvent pH, resulting in further sorption (Krupadam *et al.* 2003). As the pH rises past pH<sub>zpc</sub>, the adsorbent's

surface takes on a negative charge, resulting in increased cationic dye adsorption due to electrostatic attraction.

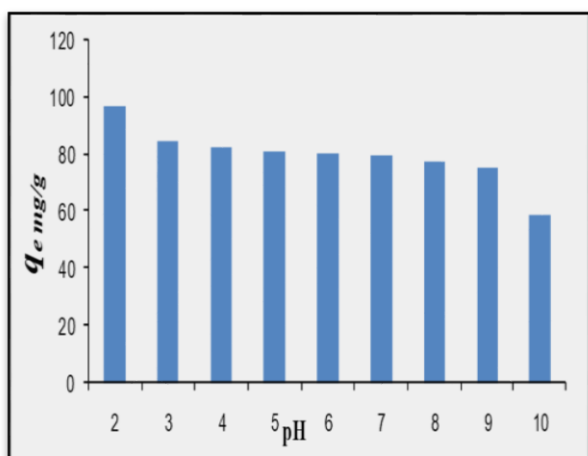


Fig. 2: Effect of pH on % of removal of Direct Yellow 27 by BANCM

### 3.3 Effect of concentration

At pH 6, batch adsorption tests were carried out with three separate dye concentrations: 20 mg/L, 40 mg/L, and 60 mg/L. The adsorbent was chosen at a reaction temperature of 30 °C. The agitation speed was kept steady at 200 rpm. The adsorbent BANCM measurements were used to construct the colour fall profiles.

### 3.4 SEM analysis

The morphological analysis of the adsorbent by SEM revealed that it is highly porous in nature, as seen in Fig. 3. According to the SEM findings, there are similar gaps and cave-like openings on the surface of the sample, which will have a larger surface area than before (Khattri *et al.* 2000).

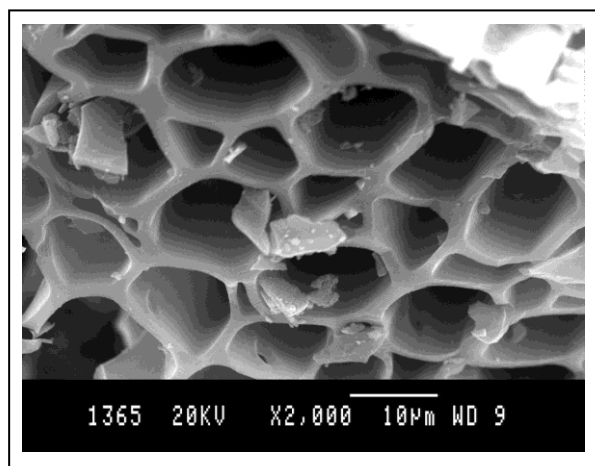


Fig. 3: SEM analysis for BANCM

### 3.5 XRD analysis

Fig. 4 shows the wide-angle XRD pattern for nanoporous carbon sample. The XRD analysis of nanoporous carbon proved that the carbon prepared by acid treatment shows the X-ray diffraction angle  $2\theta = 23$  it is similar to the reported graphitization wood waste (Syed, 2003).

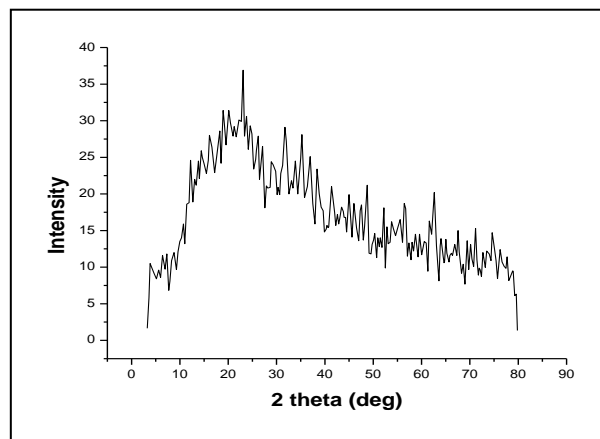


Fig. 4: XRD pattern for BANCM

### 3.6 FT-IR analysis

The FT-IR spectrum of the *Balsamodendron caudatum* wood waste activated nanoporous carbon prepared by a range of treatment processes shown in Fig. 6 revealed that the carbon evaluated contain four classes of surface groups: carboxyls, lactones, phenols and carbonyls. The task of the exact wavenumber to a given functional group was not possible because the sorption bands of different functional groups overlap and shift depending on their molecular structure and environment. Shifts in absorption position may be caused by factors such as intramolecular and intermolecular hydrogen bonding, steric effect and degree of conjugation.

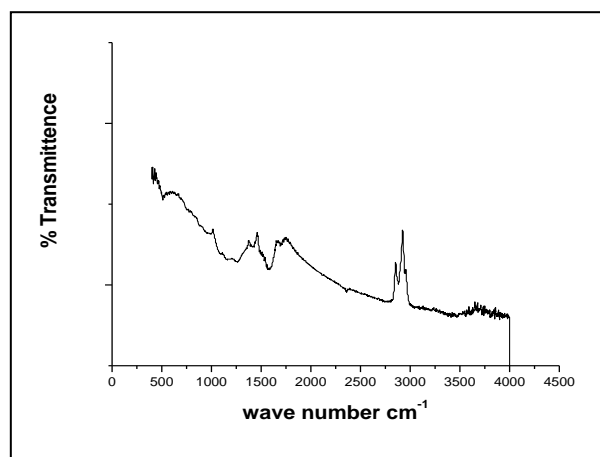


Fig. 5: FTIR Spectra for BANCM

### 3.7 TGA-DTA Analysis

The Thermal stability of the carbon materials prepared by sulphuric acid was analyzed by the TG&DTA are shown in Fig. 6. The curve clearly illustrates that the carbon samples begin to lose weight at about 60 °C due to the volatilization of small molecules, and it started to lose weight intensively above 600 °C may be due to the decomposition of polymeric (or) aromatic molecules formed during the carbonization process.

### 3.8 Effect of Temperature on Kinetic Rate Constant and Rate Parameters

The sorption experiment was carried out at 30 °C, 45 °C and 60 °C with a set initial dye concentration (20mg/L) at pH 6 and at different temperatures of 30 °C, 45 °C and 60 °C. The pseudo-second-order rate constants have very little effect on dye temperature, according to the data in (Table 2). Table 2 also shows that dye temperature has no significant or minor effect on Elovich and pseudo-first-order rate

constants. It is self-evident that a first-order rate equation with a regression coefficient greater than 0.98 better describes dye sorption on BANCM waste activated carbon.

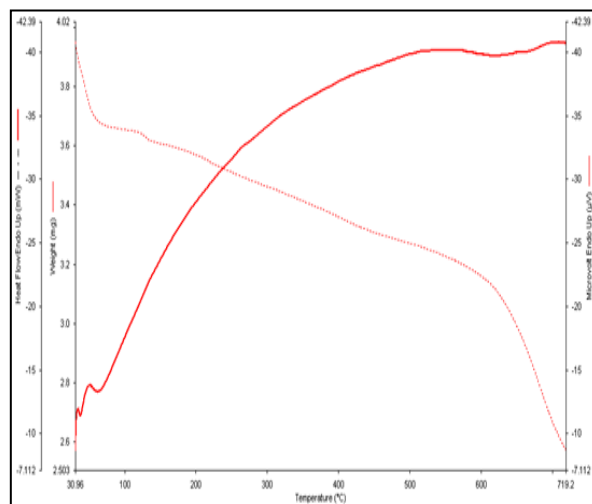


Fig. 6: TGA Curve for BANCM

Table 2: The sorption kinetic model rate constants for BANCM various temperature

Adsorbent	Initial Temp.	Pseudo first order		Pseudo Second-order			Elorich Model		
		$k_1$ $\text{l min}^{-1}$	$r^2$	$k_2$ $\text{g mg}^{-1} \text{min}^{-1}$	$h$ $\text{mg g}^{-1} \text{min}^{-1}$	$r^2$	$\beta$ $\text{g min}^{-1}$	$\alpha$ $\text{mg g}^{-1} \text{min}^{-1}$	$r^2$
	30 °C	0.0527	0.9967	0.00887	0.6287	0.8238	0.1678	0.4548	0.9899
BANCM	45 °C	0.0099	0.8855	0.0688	6.4489	0.6567	0.1928	0.82466	0.9389
	60 °C	0.09014	0.7787	0.0646	0.2158	0.4369	0.4956	0.6357	0.9798

## 4. CONCLUSION

The BANCM adsorption of Direct Yellow 27 dye was found to be dependent on pH (the optimum pH of Direct Yellow 27 was 6), temperature, and sorbent concentration. The Direct Yellow 27 dye used in this test achieved saturation equilibrium after 220 minutes of contact time. In the case of the BANCM, the percentage saturation was observed to be nearly 99 percent. A pseudo-first-order rate equation was discovered to govern the kinetics of Direct Yellow 27 adsorption on adsorbent. The adsorbent was employed to adsorb Direct Yellow 27 from an aqueous solution openly and showed high removal competence at suitable conditions, indicating that the secondary adsorption was an efficient and inexpensive way for reuse of the used sorbents. The Freundlich and Langmuir isotherm equations were used

to analyse an equilibrium isotherm for the sorption of Direct Yellow 27 on BANCM. The final result showed that the Freundlich isotherm best-fit the Direct Yellow 27 absorption.

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