

Efficient and inexpensive bio adsorbent for the removal of Safranin: Kinetic and Isotherm study

ABSTRACT

Alstonia Scholaris leaves after treatment with 0.01 M NaOH was used for the adsorptive removal of safranin. As the initial safranin concentration increases from 20 mg/L to 80 mg/L the dye removal increases up to 91 % in 60 min contact time at optimum pH of 8. Pseudo second order model and Freundlich isotherm was followed by the adsorption experimental data.

Key Words: Adsorption, Cotton red, saptaparni, basic red

• INTRODUCTION

India is a developing country and with the development in the industrial sector like paper, pulp, leather and textile, the consumption of synthetic dyes were also increases, though at most care were taken by these industries, some of the dyes and pigments residues likely to be present in the effluents. The presence of synthetic dyes in trace amount can affect the aquatic and human life [1]. Most of the synthetic dyes have carcinogenic and mutagenic effects [2]. Various chemical, physical and biological methods were used to remove hazardous material from water. Due to the non-biodegradable nature of some of the dyes, the microbial degradation methods have limitation [3]. The various chemical and physical methods used for the removal of hazardous material from industrial effluents, some of them are adsorption [4], oxidation, ozonolysis, chemical and photochemical destruction [5], coagulation, filtration. From the above methods adsorption method is mostly applied due its cost effective and simplicity [6]. Activated charcoal is the best adsorbent but it is not cost effective so researcher preferably uses low cost adsorbent form the waste material like Gmelina Aborea [7], pomegranate peel [8] mango leaf powder [9].

Alstonia Scholaris is commonly called as saptaparni or devil plants grown in different parts of India and easily available. Safranin is cationic dye used to stain natural fibers like wool, cotton, silk etc.[10]. Safranin can cause some serious health hazard like abdominal discomfort, eye and skin irritation, mouth and throat discomfort. [10,11]. Various adsorbent were reported for the removal of safranin such as Snail Shell [12], soybean hull [13], zeolites [14], red mud [15], Citrus reticulata peels[16] etc. Safranin is a cationic dye also known as cotton red, the specification are given in table1

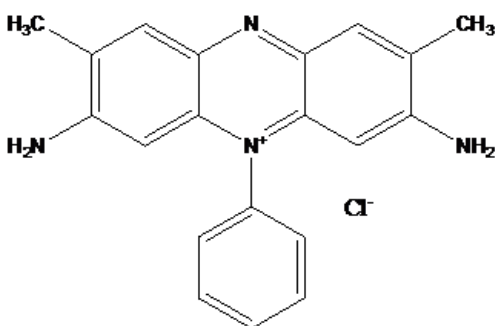


Fig. 1 Chemical structure of Safranin

Table1 Specification of Safranin

Molecular Formula	C ₂₀ H ₁₉ N ₄ Cl
Molecular Weight	350.85
λ max (nm)	521

So in the present adsorption study, the effectiveness of leaves powder after treatment with NaOH was investigated. The data was analyzed for kinetic and isotherm model

• **MATERIALS AND METHODS**

All chemicals were purchased from Loba Chemie Pvt Ltd. India and were used without further purification. Elico double beam spectrophotometer SL-210 was used to determine the absorbance. Equiptronics pH meter and Remi stirrer was used. 0.1 M NaOH and 0.1M HCl were used to adjust the pH. The dried leaves of *Alstonia Scholaris* were collected from the institute, grinded and washed with water. The powder was treated with 0.01 M NaOH solution and washed with water till the pH is neutral. The residue was dried in a hot air oven overnight and used for as an adsorbent. By measuring absorption at 521 nm and with the help of standard curve the concentration of Safranin was determined.

The milligram of Safranin dye on adsorbent (q_e) was determined using the following equation

$$qt = \frac{(C_i - C_t)v}{W}$$

Where C_i and C_t were concentration of Safranin, v is volume of dye solution and w is weight of adsorbent

To determine the optimum condition of adsorption, the adsorption study was performed

using batch adsorption method. In this 25 mL dye solution was taken in 100 mL flask and stirred with 0.05 g of adsorbent powder for specific time.

- **Result and Discussion**

- Effect of Initial amount of Adsorbent

The effect of adsorbent dose was assessed by altering the adsorbent dose from 0.02 to 0.15 g. The result shows that the percentage removal of Safranin increases with increase in the initial amount of adsorbent (77 to 89 %) (as shown in Fig 2). The increase in the initial adsorbent dose increases the site for adsorption thus increases the percentage removal.

Fig. 2 Effect of amount of adsorbent

- Effect of Initial pH

The initial H^+ ion concentration (pH) mostly affect the dye adsorption process [17]. It has been observed from experimental result that the increase in pH increases the dye adsorption, this trend is observed up to pH 8, and further increase in pH decreases the removal. (Fig. 3)

Fig.3. effect of initial pH

- Effect of initial dye concentration and contact time

Batch adsorption study was performed by altering initial dye concentration (20 mg/L, 40 mg/L, 60 mg/L and 80 mg/L) and contact time at optimum pH with 0.1 g of adsorbent

With increase in initial dye concentration and contact time the percentage removal increases up to 91% this may be due to mono layer formation [18]

Fig4. Effect of initial dye concentration and contact time

- Kinetics Studies

The experimental data was studied by applying three kinetic model viz. pseudo first order model, pseudo second order model and Elovich model

The following equation were used

$$\log(q_e - q_t) = \log q_e - \frac{k_1 t}{2.303} \quad \text{pseudo first order equation) [18]}$$

Where k_1 is the pseudo first order rate constant and the value is determine from a plot of $\log(q_e - q_t)$ versus t .

$$q_t = \frac{1}{\beta} \ln(\alpha, \beta) + \frac{1}{\beta} \ln t \quad \text{(Elovich model) [19]}$$

The Elovich parameters were determined from the plot of q_t versus $\ln t$

$$\frac{t}{q_t} = \frac{1}{q_e^2 k_2} + \frac{t}{q_t} \quad \text{(pseudo second order equation) [20]}$$

K_2 is pseudo second order rate constant, the values were determined from a plot of t/q_t versus t

Fig.5 pseudo second order plot

The above parameters were represented in table 2

Table 2. Parameters for pseudo first-order , pseudo second-order adsorption and Elovich model

Dye Conc	First order				Second order				Elovich model		
(mg L ⁻¹)	K ₁	q _e (exp)	q _e (cal)	R ²	K ₂	q _e (exp)	q _e (cal)	R ²	β	α	R ²
	(min ⁻¹)	(mg g ⁻¹)	(mg g ⁻¹)		(min ⁻¹)	(mg g ⁻¹)	(mg g ⁻¹)		(mg g ⁻¹)	(mg g ⁻¹ min ⁻¹)	
20	0.0859	8.158 9	2.6224	0.956 5	0.067 5	8.158 9	8.389 2	0.999 7	1.516 9	4.677 5	0.967 2
40	0.0773	17.30 6	5.6636	0.895	0.026 8	17.30 6	17.85 7	0.999 3	0.721 2	9.767 6	0.942 5
60	0.0660	26.40 9	4.8350 3	0.860 1	0.028 8	26.40 9	26.88 1	0.999 6	0.796 5	61.84 1	0.911
80	0.0700 1	36.77 8	8.1583	0.961 7	0.018 0	36.77 8	37.59 3	0.999 7	0.452 3	40.19 6	0.974 3

It has been observed from the R² values that the most suitable kinetic model for

present study is the pseudo second order kinetic model. Similar trend was observed in the literature [19-21]

- Adsorption isotherm

The three isotherm model viz. Temkin isotherm, Langmuir isotherm and Freundlich isotherm were applied for the present study.

The following equations were used

$$q_e = B \ln A + B \ln C_e \quad \text{Temkin isotherm [12]}$$

The Temkin parameters A and B were determined from the plot of q_e versus $\ln C_e$

$$\frac{C_e}{q_e} = \frac{C_e}{q_m} + \frac{1}{b q_m} \quad \text{Langmuir isotherm [22]}$$

The Langmuir constant q_m and b were determined from a plot of C_e/q_e versus C_e

$$\log q_e = \frac{1}{n} \log C_e + \log k_f \quad \text{Freundlich isotherm [23]}$$

The values of n and k_f were determined from plot of $\log q_e$ versus $\log C_e$

Table 3 Adsorption isotherm parameters

Langmuir Isotherm			Freundlich Isotherm			Temkin Isotherm		
b (L mg ⁻¹)	q _m (mg g ⁻¹)	R ²	n	K _f (mg g ⁻¹)	R ²	A (L mg ⁻¹)	B (J mole ⁻¹)	R ²
-11.952	4.9504	0.8926	-2.9403	4.6387	0.9938	4.2975	-35.366	0.9711

As the value of n is less than one (-2.9403) it shows desired correlation of n with Freundlich isotherm [24], thus from the values of R^2 and n , it has been observed that the present study follows Freundlich isotherm model [24].

- **Conclusion**

The 91% removal of Safranin was observed at optimum pH 8, 80 min contact time with 80 mg/L dye concentration. The present experimental data follows pseudo second order kinetic model and Freundlich isotherm model. Alstonia Scholaris leaves powder after alkali treatment can be used as cheap and efficient adsorbent for the removal of safranin.

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