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Adsorptive Removal of Amido Black From Aqueous Solution Using Economical Adsorbent: Kinetic and Isotherm Study

A. S. SALUNKE[1]. N. N. GUND[1].B. M. MARMAT[1]. J. P. SONAR [1]. S. A. DOKHE[1]. A. M. ZINE [1]. S. N. THORE[2]. S. D. PARDESHI[1*].

[1] Department of Chemistry, Vinayakrao Patil Mahavidyalaya, Vaijapur, Maharashtra 423 701, India.
[2] Department of Chemistry, Deogiri College, Aurangabad, Maharashtra, India
* Orcid ID orcid.org/0000-0001-8794-5629
***Corresponding Author E-Mail:** sandeeppardeshi007@gmail.com

Abstract

In the current study, the removal of Amido black 10B from solution by means of adsorption on economical adsorbent prepared from vilaytitulsi is studied. The effect of pH, contact time, dye concentration, adsorbent dose and temperature was observed. The isotherm study shows, Langmuir isotherm was best fitted for present work. The adsorption follows pseudo-second order kinetic. An enhance in temperature decreases the dye removal.

Keywords: Amido black dye, Adsorption, Hyptissuaveolens, Vilayti Tulsi.

Introduction:

Water is one of the essential parts of human life; due industrialisation and urbanization water pollution becomes a major issue. Large amount of synthetic pollutant such as dyes, phenols etc. are present in industrial effluents and cause contamination of water. Dyes are one the important organic pollutant present in industrial effluents [1]. Dyes are widely used in textile and leather industries, the effluent of these industries always contain some amount of dyes. Azo dyes are, widely used in textile industries, characterised by –N=N- bond [2].Amido black 10B is a azo dye used to colour cotton, wool, nylon, rayon etc.[3], it may cause skin and eye irritation, serious damage to respiratory system [4]. Many methods are utilized to remove contamination of synthetic pollutant from water such as photo catalytic decolourisation [5], microbial degradation [6], precipitation [7, 8] etc. out these technique adsorption is most commonly used technique for contaminant removal from solution [9].Activated carbon is the far and wide used adsorbent [10] but cellulose based adsorbent, due to cheap cost and wide availability, attracted the researcher for their study in dye removal [11]. Various low cost bio adsorbents are reported such as Palm Shell Powder [9], jute fibre[11], rice husk [12], neem saw dust [13] etc. the literature reveals the use of various adsorbents [14,15]. In this work, the adsorptive capacity of adsorbent prepared Hyptissuaveolens was investigated for the Amido black 10B. The adsorption effectiveness was calculated by applying various parameters like temperature, dye concentration, contact time and adsorbent dose.

Experimental:

Preparation of Adsorbent

Fully grown plants of Vilayti Tulsi were collected from places nearby vaijapur city and cut, washed and dried under shed. The adsorbent was prepared as per the literature procedure [16].

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Preparation of dye solution

Amido black10 B (AB), was purchased from LobaChemPvt. Ltd. Indiawas used for current study. The molecular formula is $C_{22}H_{14}N_6Na_2O_9S_2$, and the utmost absorbance observed at wavelength 618 nm. A stock solution of 500 mg L^{-1}, dissolving accurately weigh dye quantity in double distilled water. Dilution with double distilled was carry out to get desired experimental concentration.

Adsorption Studies

50mL sorbet solution of predetermined pH and dye concentration be taken in 250 mL conical flask, 100mG adsorbent was added, and the solution stirred mechanically. Requisite amount of solution was removed at preset time and centrifuge at 3,000 rpm to separate adsorbent from dye solution. 0.1 M HCl and 0.1 M NaOh was utilized to adjust the initial pH. The sorbet amount remain unadsorbed was determine by measuring absorption of solution using Elico double beam SL-210 spectrophotometer. The adsorption capacity was determined using the Langmuir and Freundlich isotherm.

Equation 1 was applied to find solid phase dye concentration

$$q_t = \frac{(C_o - C_t)V}{W} \quad (1)$$

Where C_o is dye concentration at initial time and C_t is dye concentration at time t in mg L^{-1}, V is volume of solution in L q_t is adsorption amount at time t, and W is weight of adsorbent in g.

Results and Discussion:

Effect of pH

The adsorption of ionized dyes over the surface of adsorbent is mainly depends on initial pH rather than final [17]. 0.1 g adsorbent was shaken for 30 min with 50 mL solution of 50mg L^{-1} dye concentration. It has been seen that the adsorption is not much affected if the pH is varied from 2-4, further increase in pH decreases the dye elimination. Lower pH favours the adsorption may be attributable to higher electrostatic attraction between adsorbent surface and dye [17]. As shown in the Fig.1, pH 4 is applied in further studies.

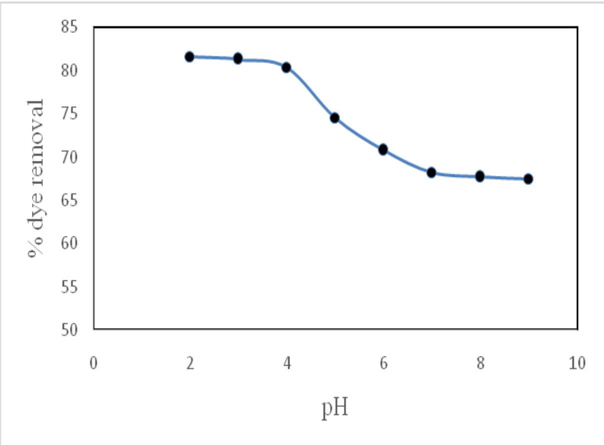


Fig. 1: Effect of pH on dye removal

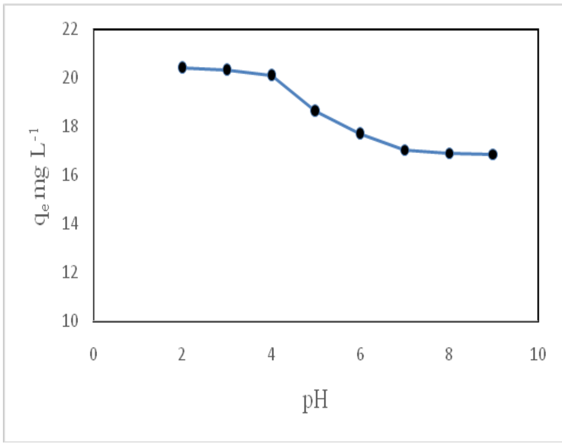
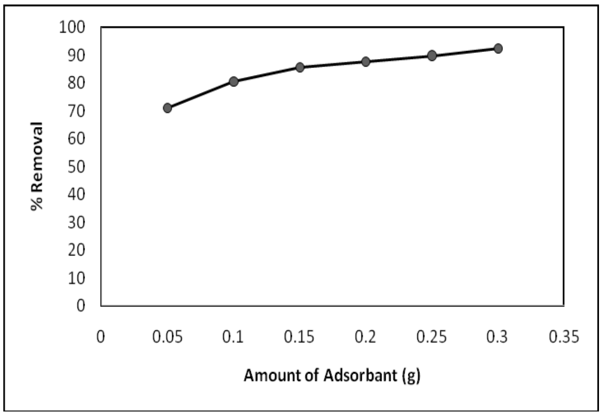


Fig. 2: q_e versus pH

Effect of Adsorbent dose

Quantity of adsorbent is one of the main parameter which affects the process of adsorption; 50mL dye solution with 0.05 g/L dye concentration was stirred with predetermined quantity of adsorbent (0.05 to 0.3 g). The percentage of dye removal increases with increase in quantity of adsorbent from 70.94 to 92.50 % but the adsorption was decline from 35.47 mg/g to 7.70 mg/g with increase in adsorbent dose amount as shown in Fig 3 and Fig 4 this may be because of enhance in the amount of vacant adsorption site with increase adsorbent dose [18].



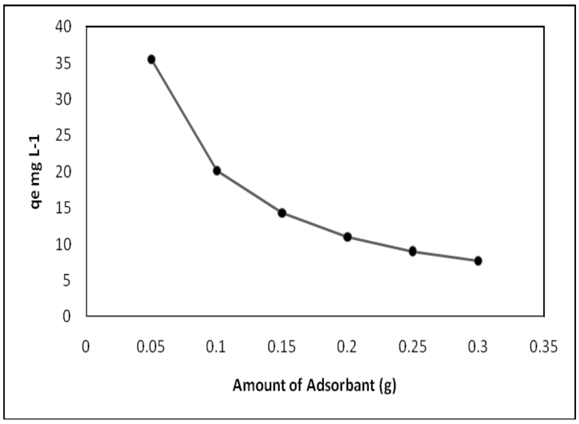
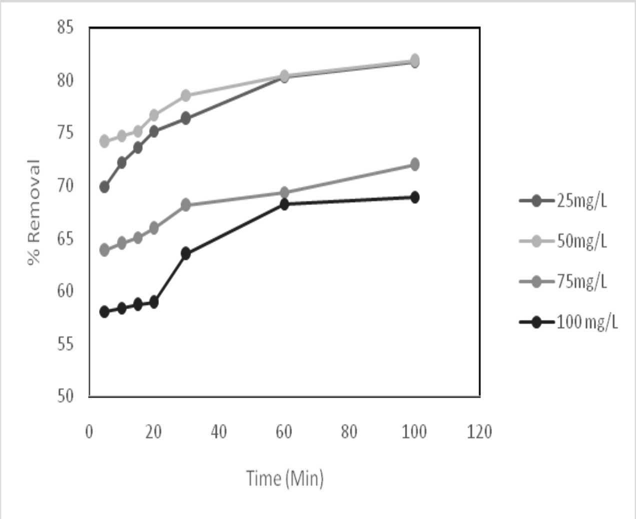


Fig. 3: %removal versus dose

Fig. 4: q_e versus Adsorbent dose

Effect of dye concentration:

50 mL solution of optimum pH and predetermined concentration (25 mg/L to 100 mg/L) was stirred with 100 mg adsorbent; the results are represented in Fig. 5. Initially there was large number of adsorption site are available due which the initial rate of adsorption was fast [19]. The % removal of AB decreases with increase in solution concentration.



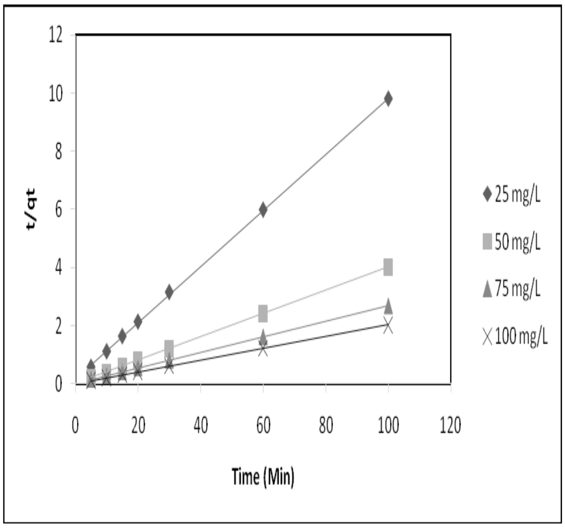


Fig. 5: Effect of initial dye concentration on % adsorption

Fig. 6: t/qt vs t

Adsorption dynamics:

The pseudo first order kinetic model:

The pseudo first order kinetic model expression is [20] as follows

$$\log(q_e - q_t) = \log q_e - \frac{k_1 t}{2.303} \quad (2)$$

Where q_t and q_e are quantity of dye removed at time t and equilibrium, respectively and k_1 is known as rate constant.

The pseudo second order kinetic model:

The Lagergren pseudo second order equation is represented as [21]

$$\frac{t}{q_t} = \frac{1}{q_e^2 k_2} + \frac{t}{q_t} \quad (3)$$

The Fig.6 shows Plot of t/q_tvs t. Values of equilibrium adsorption capacity (q_e) and pseudo second order rate constant (k_2) were represented in table 1. From the table number 1 it has been seen that the adsorption process was depend on both adsorbent and dye concentration, thus pseudo second order kinetic model is best suited.

The intra particle diffusion model:

The intra particle diffusion model is expresses as [22]

$$q_{t=t^{\frac{1}{2}}k_p} \quad (4)$$

Where qt is adsorption capacity and kp is intra particle diffusion constant, plot of qt versus t1/2 give the value of kp, as from the R2 value for intra particle diffusion model, the current study does not fits in it

Table 1: Rate constants; for pseudo first-order; pseudo second-order adsorption and intra particle diffusion model

Conc.	**pseudo first-order**			**pseudo second-order**			**Intra particle diffusion**	
C_0 (mg/L)	**q_e (mg/g)**	**K_1 (1/min)**	**R^2**	**q_e (mg/g)**	**K_2 (1/min)**	**R^2**	**Kp (mg/(g $min^{1/2}$)**	**R^2**
50	2.1832	0.04767	0.9244	10.5374	0.04722	0.999	0.1904	0.961
75	1.7290	0.05365	0.968	24.3902	0.2425	1.00	0.0083	0.9591
100	5.2107	0.03915	0.9612	36.3636	0.5817	1.00	0.0125	0.9771
125	13.7499	0.0244	0.9124	48.7804	1.4009	1.00	0.0261	0.9125

Adsorption equilibrium study:

Langmuir isotherm and Freundlich isotherm were used for current study.

Langmuir isotherm:

Langmuir isotherm in equation form is as follows [23]

$$\frac{C_e}{q_e} = \frac{C_e}{q_m} + \frac{1}{bq_m} \qquad (5)$$

Where Ce is the equilibrium concentration (mg/L),q_m is Langmuir constant (mg/g), b is Langmuir constant (L/mg)and q_e is the equilibrium adsorbed amount (mg/g).

Freundlich isotherm:

Freundlich isotherm is represented as follows [23]

$$\log q_e = (1/n) \log C_e + \log k_f \qquad (6)$$

Where n represent adsorption intensity, k_f shows adsorption capacity, q_e represent equilibrium concentration in solid and C_e represent equilibrium concentration in solution. The isotherm parameters are mentioned in table 2.

Table 2: Langmuir, Freundlich isotherm parameter:

Temperature (^{0} K)	**Langmuir isotherm parameter**			**Freundlich isotherm parameter**		
	q_m (mg/g)	**b (L/mg)**	**R^2**	**n**	**k_f (mg/g)**	**R^2**
313	24.69	16.63	1	151.51	13.77	0.9977
323	24.44	17.85	1	158.73	24.59	0.9973
333	24.09	20.00	1	166.66	24.60	0.9972

Conclusion:

Adsorptive removal of Amido black 10B was studied on economical adsorbent from *Vilayti Tulsi*. The current study follows the pseudo second order kinetic model and the Langmuir isotherm model was most applicable to current study. The low pH and low temperature favours the adsoption of Amido black 10B from aqueous solution. The adsorbent prepared from *VilaytiTulsi* can be used as a economical adsorbent for the elimination of Amido black 10B.

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Conflict of Interest:

The authors declared that they have no conflict of interest

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