Adsorption of Cr (VI) using Low-Cost Adsorbent As a Neem Leaves (Azadirachta Indica) Powder

Ghanshyam Pandhare [*], Nikhilesh Trivedi *, Rajesh Pathrabe *, S.D.Dawande ***
[*]M.Tech , *B.Tech , [***] Associate Professor, Department of Chemical Engineering, Laxminarayan Institute of Technology, R.T.M.Nagpur University, Nagpur, India

ABSTRACT:

Industrial effluents, dyes from textile industry are common water pollutants and they may be frequently found in trace quantities in industrial waste water so there is a need for its purification. Adsorption has been used successfully in the removal of Cr (VI) from effluents. In present study Neem leaves powder activated using chemical treatment as a low-cost adsorbent. And experiment has done with different weight of adsorbent. The potential of Neem leaves powder adsorbent to adsorb Chromium from industrial effluent is good. Adsorption isotherm of adsorbent were determine and correlation with common isotherm equations such as Freundlich Isotherm and Langmuir isotherm models. The maximum removal efficiency was observed up to 80% for prepared Neem leaves at optimum value of parameter. This adsorbent as local replacement for existing commercial adsorbent materials.

Keywords: Adsorption; Neem leaves; $K_2Cr_2O_7$; Freundlich and Langmuir Isotherm

I. INTRODUCTION

Adsorption is effectively in removing trace components from a liquid phase and may be used either to recover the components or simply to remove noxious substance from industrial waste. Any potential application of adsorption has to be considered along with alternatives such as distillation, absorption and liquid extraction. Each separation process exploits a difference between properties of substance to separate. In distillation the property applied is volatility, in absorption it is solubility, in extraction it is distribution coefficient. Adsorbents are available as irregular granules, extruded pellets and formed pellets. The size reflect the need to pack as much surface area as possible into a given volume of bed and at the same time minimize pressure drop for flow through the bed. Size up to 6 mm is common. Adsorption has been used successfully in the removal of impurities from effluents. Activated carbon is the most used adsorbent.[7] Due to its high cost and considering the enormous quantity of effluent produced by textile industries, researches are turning toward the use of alternative adsorbents, also called non-conventional low-cost adsorbents. Industries like plastic, paper, textile and cosmetics use dyes to color their products. Therefore the development of new technologies for the removal of color from waste water is necessary.

In spite of its widespread use in various cleaning procedures, activated carbon remains expensive; therefore, the development of low-cost alternative adsorbents has been the focus of recent research [10]. Adsorption is usually described through isotherms, that is, functions which connect the amount of adsorbate on the adsorbent, with its pressure (if gas) or concentration (if liquid). One can find in literature several models describing process of adsorption, namely Freundlich isotherm, Langmuir isotherm, BET isotherm, etc.

II. LITERATURE REVIEW

The adsorption which results from the influence of vander-waals forces is essentially physical in nature because the forces are not strong, the adsorption may be quickly replaced in some system additional forces bind absorbed molecule to the solid surface. These are chemical in nature involving the exchange or sharing of electrons or possibly molecules forming radicals or atoms. In such cases the term chemisorptions is used to describe the phenomena. This is less readily reversible then physical adsorption.[6] And regeneration may be problem. Adsorption is always accompanied by liberation of heat. For physical adsorption the amount of heat is similar in magnitude to the heat of condensation for chemisorptions it is greater and of an order of magnitude normally associated with a chemical reaction.[9] If the heat of adsorption cannot be dispersed by cooling the capacity of the adsorbent will be reduced as its temperature rises.

The heavy metals of widespread concern to human health are lead, copper, mercury, cadmium, arsenic, chromium, as well as zinc [5]. These are stable metals that cannot be destroyed or degraded in the environment and get passed up in the food chains to humans. At present, these toxic metals have polluted our atmosphere, our water, our soil and our food chain, and have been reported to be slightly toxic even at low concentration. Some conventional methods used to remove heavy metals include chemical or electrochemical precipitation [14], ion exchange, adsorption on minerals, and reverse osmosis [11]. Compared with the other processes, adsorption of metal ions onto insoluble compounds as adsorbent is the most effective and widely used method .

III. MATERIALS AND METHODS

3.1 Preparation of Adsorbent

Initially Neem leaves were washed repeatedly by using distilled water to remove moisture and soluble impurities. Then Neem leaves kept in dryer at 90^0C, for2-3 hrs till leaves turn pale yellow. Then crushed and screen by 10-15um mesh size.

Neem leaves powder washed to remove moisture and free acid and kept in dryer 20-25 minute. After drying powder was mixed with ortho-H_3PO_4 in silica crucible and kept in furnace at 260^0c for 15-20 minute .The heating period depend on atmospheric temperature then solution was cooled & repeatedly washed using hot water to remove free acid and moisture, total 7 washing taken and kept it in dryer for 20-25 minute the prepared black colored adsorbent kept in bottle for further use.

About 20 gm sample and 10ml Ortho-H_3PO_4 acid taken in silica crucible and kept in furnace. The furnace is initially at normal room temperature then furnace set at 260^0C. Heating was carried out for 20 minute. Then sample was removed and cool. After cooling the sample was repeatedly washed for 7 times using hot water to remove free acid and moisture .Then sample kept in dryer for 20-25 minute and the activated black colored adsorbent stored in bottle.

3.2 Preparation of $K_2Cr_2O_7$ solution

In a clean beaker 500 ml water is heated, in this boiling water 18.112 gm $K_2Cr_2O_7$ powder added with constant stirring .The solution is allowed to boil for 5 minute and cooled, then filter the cooled solution to remove suspended matter and undissolved matter. The clear solution is collected and store in beaker for further use.

3.3 Experimental setup

The samples are taken and put in dryer for about 30 minutes. After the sample is dried, the sample is weighed as 1gm, 2gm, 3gm, 4gm, and 5gm. The weighed samples are put in the conical flask of 250 ml. The prepared solution of $K_2Cr_2O_7$ is poured in the flask. Exactly 100 ml of the solution is poured in each conical flask. After the addition of the solution, the flask is well shaken for 10 minutes and allowed to stand still for 48 hours.

After 48 hours the sample is shaken and filtered. The filtered sample is collected in small plastic bottles and the activated carbon is collected. The collected sample kept in dryer. After drying the samples are packed and colorimeter reading taken of all filtered solution.

IV. RESULTS AND DISCUSSION

4.1 Characterization of the synthesized adsorbent obtained from Neem Leaves Powder by BET method:

The specific surface area is found to be 421 m^2/g. The surface area obtained from Neem Leaves Powder is determined by Brunauer, Emmett and Teller (BET) N_2 sorption procedure with liquid N_2 at 195.72^{o}C.

4.2 Colorimeter reading and % Adsorption

The collected solution after the experiment is used for calculating percentage adsorption. At first the reading for water is taken this is blank reading. Then colorimeter reading taken for all sample solution. This is reference reading. Reduce concentration of solution calculate from the standisation graph of $K_2Cr_2O_7$ solution colorimeter reading. The % Adsorption of all sample calculated by following formula,

$$\% \text{ Adsorption} = \frac{Initial\ \ conc.-Final\ \ conc.}{Initial\ \ conc.} * 100$$

Following table shows the colorimeter reading and % Adsorption for $K_2Cr_2O_7$ solution using various weight of adsorbent.

Table-1: $K_2Cr_2o_7$ Solution

Sr.no.	Wt. of adsorbent/Vol. of solution	Colorimeter reading	% Adsorption
1	1gm/100ml	0.46	46.35%
2	2 gm/100ml	0.44	50.61%
3	3 gm/100m	0.40	64.85%
4	4 gm/100ml	0.35	71.01%
5	5 gm/100ml	0.32	74.25%

The figure-1 shows the behavior of amount of adsorbent and the concentration of solution. It can be concluded that the amount of adsorbent increases the concentration of solution decreases as the surface for adsorption increases. The figure-2 shows the behavior of amount of adsorbent and the % Adsorption. It can be concluded that the amount of adsorbent increases the % Adsorption increases as the surface for adsorption increases.

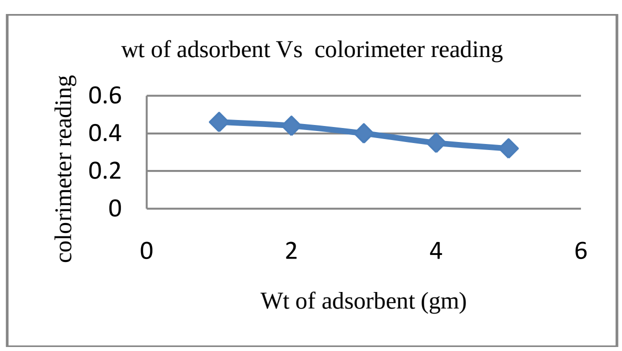

Figure 1: Wt. of Adsorbent Vs Colorimeter reading

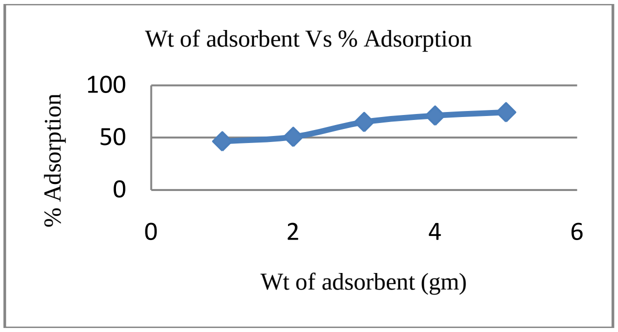

Figure 2: Wt. of Adsorbent Vs % Adsorption

4.3 Adsorption isotherm

Adsorption dosages on the removal of Chromium from $K_2Cr_2O_7$ (conc.36.224gm/lit) solution For modeling of Adsorption, two adsorption model used. The original and linear equations are as following forms,

1. Langmuir isotherm

Original form:

$Q = (q_m . K_f . C)/ (1+ K_f .C)$…………(1)

Linearised form:

$C/q = 1 / (K_f .q_m) + (C/q_m)$………. (2)

2. Freundlich Model:

Original form:

$q = K_f C^{1/n}$……………………….. (3)

Linearised form:

$\log q = \log K_f + (1/n) \log C$ ……… (4)

Langmuir isotherm holds at low concentration but fails at high concentration so C is low, factor (C/k) may be ignored and isotherm assumes form x= K'C Hence at low concentration the amount of gas adsorbed (x) is directly proportional to concentration (C) at high concentration. The mass adsorbed reaches a constant value K'' when the adsorbent surface is completely covered with unimolecular layer of gas at this stage the adsorption is independent of concentration.

$(x/m) = KC^{(1/n)}$

$\log (x/m) = \log K + (1/n) \log C$

This equation straight line plot of log (x/m) Vs log C should be straight line with slope 1/n and intercept log K however it is actually found that the plot were straight line at low concentration, while at higher concentration they showed a straight curvature especially at low this indicate that Freundlich equation approximate and does not apply to adsorption of gases by solids at high concentration.

Table 2: Amount Adsorbed using Different Weight of Adsorbent

Adsorbent dosage (gm/100ml)	$K_2Cr_2O_7$ solution	
	Amount Adsorbed (x/m) gm/lit	Concentration (C) gm/lit
1gm	16.242gm/lit	19.8 gm/lit
2gm	8.987 gm/lit	18.25 gm/lit
3gm	7.708 gm/lit	13.1 gm/lit
4gm	6.431 gm/lit	10.5 gm/lit
5gm	5.304 gm/lit	9.7 gm/lit

In order to determine the adsorption isotherm, chemically activated Neem Leaves Powder adsorbent used. The experiments were performing at various weight of adsorbent. The effect of final concentration (C) on the Cr(VI) adsorbed per specific mass of adsorbent (x/m) is presented in fig.3 the shape of adsorption isotherm indicate that adsorption of color from $K_2Cr_2O_7$ solution on Neem leaves powder adsorbent.

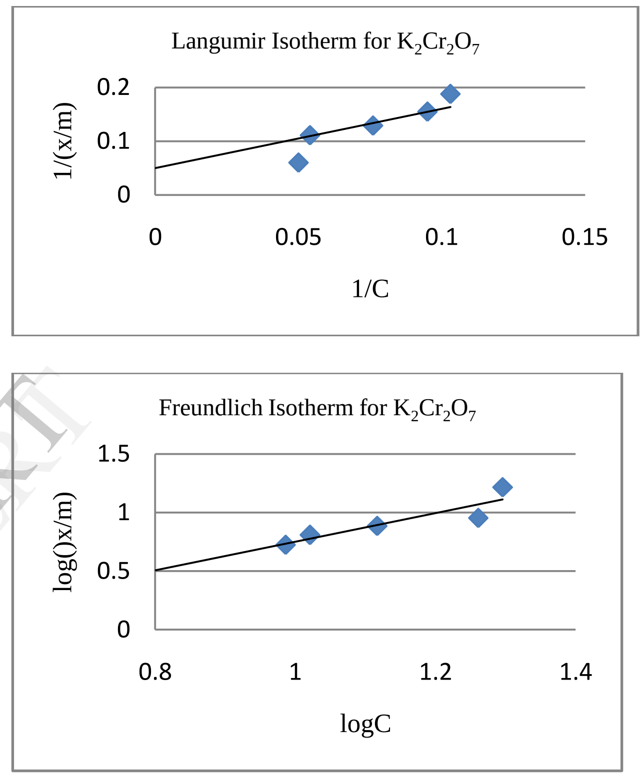

Figure: 3 Langmuir and Freundlich Isotherm for $K_2Cr_2O_7$ solution

The amount of adsorbent (x/m) in Langmuir model for adsorption of Cr(VI) from $K_2Cr_2O_7$ solution was 16.242gm/lit respectively. These results indicate that adsorption of Cr from $K_2Cr_2O_7$ and the affinity of Neem leaves powder for adsorption is high.

The correlation coefficient (R^2) of Langmuir model for adsorption of Cr(VI) from $K_2Cr_2O_7$ solution 0.967, which were higher than R^2 values of Freundlich model and the good applicability of the Langmuir model to these adsorption.

Table 3: Correlation coefficient and constant (n & k) of isotherm model for adsorption of Methyl Red and $K_2Cr_2O_7$ solution.

Solution	Langmuir isotherm model			Freundlich isotherm model		
	R^2	q (gm/l)	K_f	K_f	n	R^2
$K_2Cr_2O_7$	0.967	5.304	0.153	1.64	3.09	0.897

V. CONCLUSION

In the present work the Neem Leaves Powder converted into the activated carbon by chemical activation. This activated carbon was utilized for the adsorption of Cr(VI) from the prepared stock solution of $K_2Cr_2O_7$ solution. Various amount of the sample was taken and the adsorption study was carried out. It was seen that the weight of Adsorbent increased at a desired parameter the percentage adsorption also increases. Thus from the studies carried out it can be concluded that the prepared activated carbon can be used effectively to adsorb Cr (VI). There is a tremendous potential in these materials to be explored as industrial low cost effective adsorbent. The chemically activated Neem leaves powder adsorbent capacities for $K_2Cr_2O_7$ solution were 79% and 74% respectively. The surface area and particle size are $421m^2/g$ and 5um respectively also studied.

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