



Granular Activated Charcoal Prepared from *Cordia Macleodii* Tree Bark A Novel Adsorbent for The Removal of Lead (Ii) Characterization Via Sem-Edax, Ftir Techniques

Umesh E. Chaudhari*, Atul K. Wanjari

Department of Chemistry, Mahatma Fule Arts, Commerce and Sitaramji Chaudhari Science College,
 Warud, Sant Gadge Baba Amravati University, Republic of India.

E-mail: uechaudhari@gmail.com and atulturdik@gmail.com

ABSTRACT

Granular activated charcoal was prepared from cordia macleodii tree bark and its surface were modified by using sodium dodecyl sulfate (SDS), sodium dodecyl benzenesulfonate (SDBS) and Dioctyl sulfosuccinate sodium salt (DOSS). This adsorbent was characterised before and after adsorption of Pb(II) using scanning electron microscopy (SEM), Electron diffraction X-ray spectroscopy (EDAX) and Fourier transform infrared spectroscopy (FTIR). Batch system was conducted to study effect of pH, contact time, temperature, adsorbent dose, initial metal ions concentration. Freundlich and Langmuir models were used for a mathematical description of the adsorption isotherm. The kinetic analysis revealed that the overall adsorption process was successfully fitted with the pseudo-second-order kinetic model.

Keywords: Lead, Cordia Macleodii, Charcoal, Adsorption, Kinetic

INTRODUCTION

It is well known fact that the decrease in particle size increase the surface area and hence number of adsorption sites [1-3]. Water is a source of life and energy, although millions of peoples worldwide are suffering with the shortage of fresh and clean drinking water. The development of industries is the major reason for developing waste water. Heavy metal ion contamination represents a significant threat to the ecosystem [4-5]. Among them, lead is of great concerned. It is well known that 70-80% of all illnesses in developing countries are related to water contamination. The heavy metals are of special concern because they are non-degradable and therefore persistent. Commonly encountered metals of concern include Pb^{2+} , Cu^{2+} , Zn^{2+} , Cr^{6+} and Co^{2+} etc [6]. There are several methods available for removal of these heavy metal ions. These methods include complexation, biosorption, ion-exchange, cementation etc. Activated charcoal has wide applications in wastewater purification. It is effective and less expensive adsorbent for wastewater purification. Activated charcoal has a great tendency to removal metal ions by complexation with surface oxygen containing functional groups. Chemical modification improves the adsorption capacity [7-8].

MATERIALS AND METHOD

Preparation of Solutions

Lead nitrate solution 0.01M was prepared by dissolving 3.312 grams of Lead nitrate in 1 liter double distilled water. An aliquot 10 ml of the 0.01M solution diluted to 1 liter double distilled water and by using this solution different concentration of the solutions was prepared and

measured the absorbance by spectrophotometrically by dithizone method. The Sodium dodecylbenzenesulfonate (purchased from Sigma Aldrich), Dioctyl sodium sulfosuccinate (purchased from Acros Organics), Sodium dodecyl sulphate (purchased from Merck) was used for surface modification of activated carbon. All the solutions of these chelating agents are prepared in 0.01M concentration by dissolving it into 1000 mL volumetric flask with deionised distilled water.

Preparation of Granular Activated Charcoal (GAC)

In the present study granular activated carbon is prepared from the *Cordia macleodii* tree bark. The further activation was done by taking 10 gram of prepared granular activated carbon in a beaker to it 100 ml nitric acid (HNO_3) and 100 ml of water (H_2O) added and kept at room temperature for 48 hours with occasional stirring to increase porosity and make the GAC suitable for present adsorption study.

Surface modification of GAC

Surface modification can be done by taking 200 ml solution of chelating agent (0.01M) and 0.5 gram of adsorbent in reagent bottle and shaken for 3 hours at 1000 rpm at room temperature, then dried in oven. The impregnated GAC with chelating agents before and after metal ions adsorption can be analysed by SEM-EDAX, FTIR technology. The resultant loaded granulated activated charcoal with Dioctyl sodium sulfosuccinate, Sodium dodecylbenzenesulfonate, Sodium dodecyl sulfate designated as GAC-DOSS, GAC-SDBS, and GAC-SDS.

Batch study

Stock solution of Pb (II) was prepared by dissolving appropriate amount of lead nitrate in 1000 ml of double distilled water. The stock solutions were diluted with double distilled water to obtain required standard solution. The dried amount of 0.5 gram of Granular activated charcoal was taken in 250 ml reagent bottle and standard solution containing various concentration of Pb (II) was added and system is equilibrated by shaking the contents of the flask at room temperature. The adsorbent and adsorbate were separated by filtration and filtrate was determined by spectrophotometer at λ = 480 nm against a reagent blank. The UV-Visible spectrophotometer systronic (model 117) was used to measure the concentration of Pb (II). Same experiments were carried out for loaded GAC.

The amounts of percentage adsorption were computed as follows:

$$\% \text{ Adsorption} = \frac{(C_o - C_e)}{C_o} \times 100$$

Where, in equation C_o and C_e represented the initial and equilibrium concentration (mg/L).

RESULT AND DISCUSSION

Adsorption isotherms

The adsorption isotherm gives the idea about the correlation between the amounts of adsorbed adsorbate by unit mass of adsorbent at constant temperature. In the present investigation, the adsorption of Pb (II) metal ions onto GAC and impregnated GAC was studied by Langmuir and Freundlich models.

Langmuir Adsorption Isotherm Model

The Langmuir isotherm [19] model can be given as:

$$\frac{1}{q_e} = \frac{1}{Q^{\circ}b} \times \frac{1}{C_e} + \frac{1}{Q^{\circ}}$$

The Langmuir constant Q^o is a measure of adsorption capacity and b is the measure of energy of adsorption. In order to observe whether the adsorption is favourable or not, a dimensionless parameter ‘R’ obtained from Langmuir Isotherm. The values of Q^o and b were evaluated from the intercept and slope of linear plots of 1/q_e vs. 1/C_e respectively.

$$R = (1 + b \times C_m)^{-1}$$

The value of R indicated the type of the isotherm to be either unfavourable (R>1), linear (R=1), favourable (0<R<1) or irreversible (R=0). Where, b is Langmuir adsorption constant and C_m is the maximum initial solute concentration used in the Langmuir isotherm. The adsorption of Pb (II) on Granular Activated Charcoal and loaded Granular Activated Charcoal is a favourable process as “R” values lies between zero to one shown in table 1.

Freundlich Adsorption Isotherm Model

It is most commonly used adsorption isotherm model which describes adsorption on heterogeneous surfaces with interactions among adsorbed molecules. It helps to investigate the nature of adsorption and the adsorption capacity of an adsorbent. The linear form of Freundlich isotherm model is

$$\log q_e = B. \log C_e + \log K_f$$

Where, B and K_f are Freundlich constant. These constants represent the adsorption capacity and the adsorption intensity respectively. q_e is the amount adsorbed at equilibrium (mg/g), C_e is the equilibrium concentration of adsorbate. Plot of log q_e Vs log C_e was also found to be linear. The values of B and K_f are calculated from the intercept and slope respectively shown in table 1.

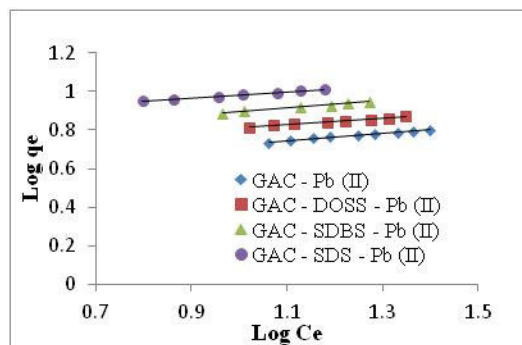
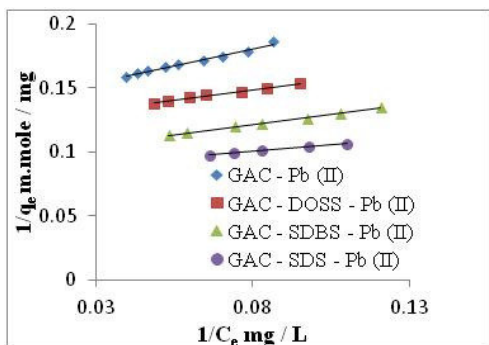


Figure 1. Langmuir Adsorption Isotherm **Figure 2.** Freundlich Adsorption Isotherm

BATCH STUDY

Effect of pH: Experiments were conducted at the constant initial concentration of Pb (II). The adsorbent dose of 0.5 gm with working volume 200 ml having initial metal ions concentration 24.9594 mg/L, and the contact time of 3 hours. The result indicate that maximum uptake capacity for Pb (II) on GAC and impregnated GAC at 5.0.

Contact Time: The effect of contact time on adsorption of Pb (II) metal ions by using GAC and impregnated GAC was investigated by taking initial concentration 21.5270 mg/L at 5.0, pH. It is observed that initially, rate of adsorption is rapid up to 130 min and then there was no further change in equilibrium concentration. Equilibrium time was found to be 300minutes for this adsorption.

Adsorbent Dose: The effect of varying the adsorbent dosage (GAC and impregnated GAC) from 0.2-1.4 g on adsorption of Pb (II) ions, from their aqueous solutions of the initial concentration of 20.5810 mg/L was studied at pH 5.0. It has been found that the percent removal of Pb (II) increases with increase in adsorbent dose

up to some extent, thereafter further increase adsorbent dose, there was no appreciable increase in percentage removal.

Effect of Temperature: The effect of temperature for the removal of Pb (II) metal ions were studied at 25°C, 35°C, 45°C, 55°C, and 65°C by using 0.5 gram of GAC and impregnated GAC with working volume 200 ml having initial metal ions concentration 18.6081 mg/L. Study was carried out at pH 5.0. From the data it is revealed that adsorption capacity of GAC and impregnated GAC increases with increase in temperature. Temperature makes the adsorbent area more porous to which metal ions can easily adsorb.

Effect of Initial ions concentration:The effect of variation of initial concentration of Pb (II) ions on the adsorption efficiency of GAC and impregnated GAC has been systematically investigated by varying the initial concentration of Pb (II) from 10.1081 to 35.0945 mg/L. Sorption capacity is found to decrease with increase in metal ions concentration. The higher uptake at lower initial concentration can be attributed to the availability of more isolated metal ions. Effect was studied at pH 5.

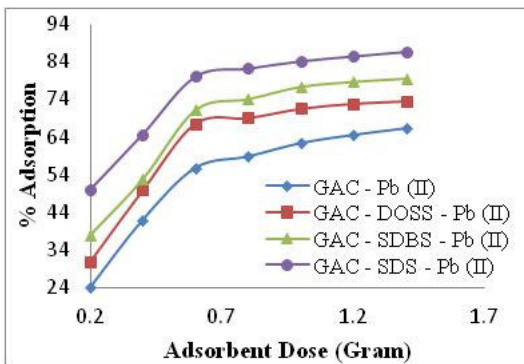
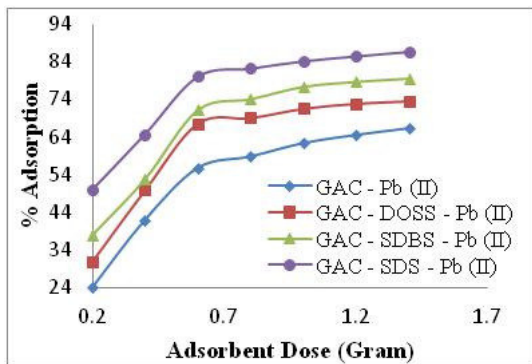


Fig.3 Effect of pH

Fig.4 Effect of adsorbent dose

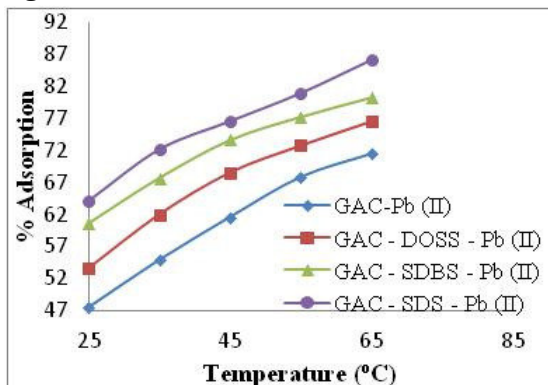
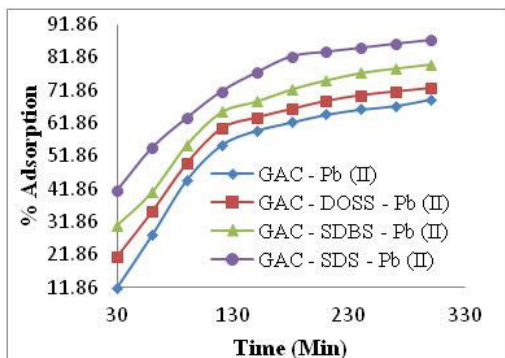


Fig.4 Effect of Contact Time

Fig.5 Effect of Temperature

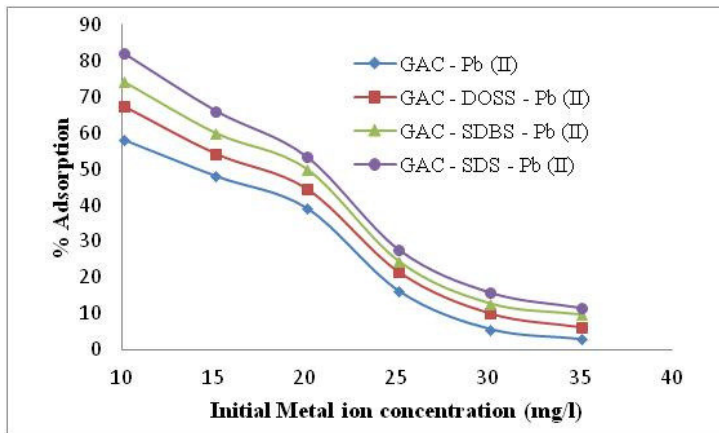


Fig. 6 Effect of Initial metal ions concentration

Table No. 1 ISOTHERM CONSTANTS

System	Q _o	Langmuir Constants			Freundlich Constants		
		b	K _L	R ²	K _f	B	R ²
GAC - Pb (II)	7.2463	0.0055	0.0398	0.987	3.4514	0.186	0.980
GAC - DOSS - Pb (II)	8.1967	0.0048	0.0398	0.990	4.4771	0.159	0.989
GAC - SDBS - Pb (II)	10.4166	0.0038	0.0399	0.993	5.0582	0.190	0.996
GAC - SDS - Pb (II)	12.0481	0.0033	0.0399	0.995	6.5313	0.166	0.998

CHARACTERIZATION SEM-EDAX

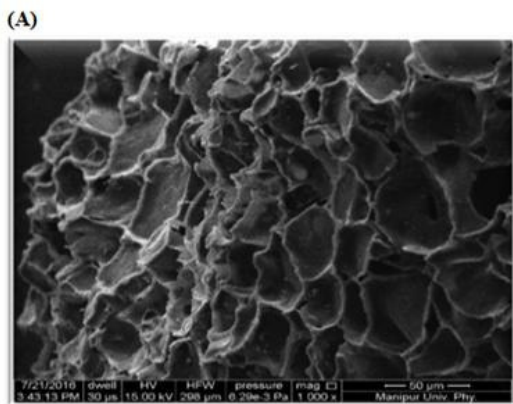


Fig.7 SEM of virgin GAC

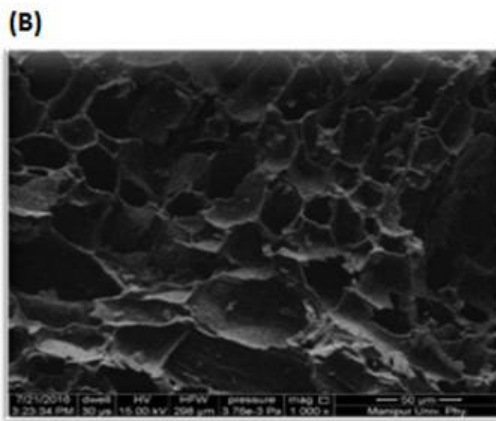


Fig.8 SEM of GAC-SDS-Pb(II)

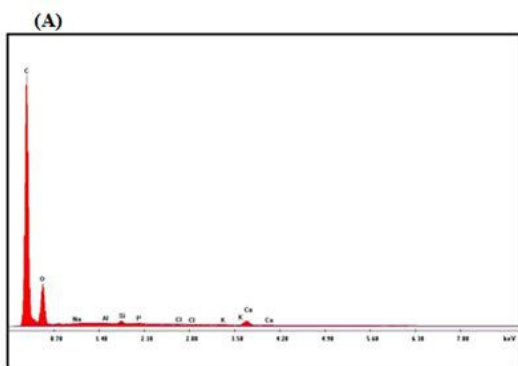


Fig.9 EDAX of virgin GAC

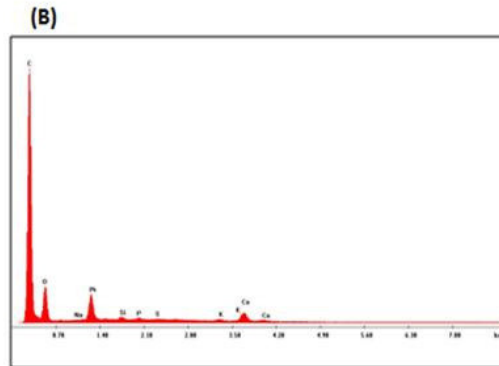


Fig 10 EDAX of GAC-SDS-Pb(II)

Table No.2 Position of FTIR bands in GAC and Loaded GAC after Pb (II) adsorption

Sr. No	Band position, cm ⁻¹				Description
	GAC	GAC – DOSS – Pb (II)	GAC – SDBS – Pb (II)	GAC – SDS – Pb (II)	
1	800	812	818	872	S-O stretching
2	1022	1028	1031	-----	Si-O stretching vibration
3	1390	-----	-----	-----	Al-O as a Si cage
4	1541	1523	1519	1515	C=C stretching vibration in carboxylic chain
5	1710	1707	1703	1708	C=O stretching
6	2362	2340	2339	2329	Carboxylate ion (-COO ⁻)

CONCLUSION:

Lead is one of the toxic metal ions to human being and also environment. In the present study it is found that surface modified GAC effectively removed Pb(II) from aqueous solution than virgin GAC. Batch study successfully employed for the removal of Pb(II). Adsorption isotherm study shows that Langmuir isotherm fitted with the experimental data. SEM-EDAX and FTIR (graphs are not shown) confirms the adsorption mechanism either shifting or reduction in band position. Finally it is concluded that surface modified GAC with SDS effectively removed the Pb (II) than GAC loaded with SDBS, DOSS and virgin GAC.

REFERENCES

Ahluwalia, S.S., Goyal, D., 2003. Removal of lead from aqueous solution by different fungi. *Indian Journal of Microbiology* 43 (4), 237–241.

Ariff, A.B., Mel, M., Hasan, M.A., Karim, M.I.A., 1999. The kinetics and mechanisms of lead(II) biosorption by powdered *Rhizopus oligosporus*. *World Journal of Microbiology Biotechnology* 15, 291–298.

Cordeo, B., Lodeiro, P., Herrero, R., Sastre De Vicente, M.E., 2004. Biosorption of cadmium by *Fucus spiralis*. *Environmental Chemistry* 1, 180–187.

Friis, N., Myers-Keith, P., 1986. Biosorption of uranium and lead by *Streptomyces longwoodensis*. *Biotechnology & Bioengineering* 28, 21–28.

Gabriel, J., Vosahlo, J., Baldrian, P., 1996. Biosorption of Cadmium to mycelial pellets of wood rotting fungi. *Biotechnology Techniques* 10, 345–348.

Kratochvil, D., Volesky, B., 1998. Advances in the biosorption of heavy metals. *Tibtech* 16, 291–299.

Prasad, M.N.V., Freitas, H., 2000. Removal of toxic metals from solution by leaf, stem and root phytomass of *Quercus ilex* L. (holly oak). *Environmental Pollution* 110, 277–283.

Quek, S.Y., Wase, D.A.J., Forster, C.F., 1998. The use of sago waste for the sorption of lead and copper. *Water SA* 24, 251–256.

