

ADSORPTION OF IRON (III) ION FROM AQUEOUS SOLUTION USING *JATROPHA CURCAS* SEED COAT ACTIVATED CARBON

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ABSTRACT

Activated carbon was prepared from *Jatropha Curcas* seed coat using CaCl_2 as the activating agent. The Adsorption Capacity of this Activated Carbon (JAC) together with that of Laboratory (Commercial) Activated Carbon (LAC) were determined and compared, they were made to adsorb Fe^{3+} ion. The result shows that the two adsorbents adsorbed Fe^{3+} adequately, following the order JAC (89.23% Fe^{3+}) and LAC (86.54% Fe^{3+}). The effect of initial concentration of the adsorbate shows a decrease in adsorption of Fe^{3+} . Adsorption of Fe^{3+} increases with increase in contact time and adsorbent dosage. Adsorption data were fitted into Langmuir and Freundlich Isotherm, the data fitted better on Freundlich in the order of JAC (0.968, LAC (0.917) for adsorption of Fe^{3+} . Only the adsorption of Fe^{3+} on JAC fitted well on Langmuir ($R^2 = 0.992$). The result shows that that carbon prepared from the shell of *Jatropha Curcas* seed has a suitable adsorption capacity to remove Fe^{3+} from aqueous solution. JAC competes favourably with LAC as a low cost adsorbent in the adsorption of Fe^{3+} .

Key words: Adsorption, *Jatropha Curcas*, Seed Coat, activated carbon, Iron (III) Ion, Langmuir and Freundlich isotherm

INTRODUCTION

Heavy metals are usually present in wastewaters which are released into the environment from various sources. The adverse effects caused by these heavy metals are of great environmental concern. (Richman, 1997; Nwabanne and Igboke 2008)

Iron is the metal considered in this project is a widely used material. Iron is one of the few metals found in effluent of a number of industries. (Eletta and Adekola, 2005) It is routinely detected in municipal waste effluent, particularly in cities where iron and steel are manufactured. When exposed to air ground water with dissolved iron and also manganese turn to indissoluble material and leave the water with brown red colour. (Cheremisinof, 2002)

Generally various techniques exist in the removal of metals from water and waste water. Some of the techniques which have been used in the removal of metals from effluents include ion-exchange, chemical precipitation, bio-remediation, electrolytic extraction, reverse osmosis and cementation. (Wong et al., 2003; Han et al., 2007; Santhi et al., 2010). However these methods are either expensive or / and too inefficient in reducing metal ion to bearable level (Faur-Brasquet et al., 2002; Bishnoi et al., 2004).

This work therefore intended to employ and determine the potential of activated carbon to be produced from the seed coats of *Jatropha Curcas* in removing iron ions from aqueous solution. The adsorption of the iron is compared with adsorption of methylene blue an organic adsorbate. The adsorption potential of the activated carbon is also compared with a commercial activated carbon

MATERIALS AND METHODS

The *Jatropha curcas* seed coats were the waste material disposed off from research work on biodiesel production from *Jatropha curcas*, University of Ilorin. Commercial activated carbon was obtained from Department of Chemistry Laboratory, University of Ilorin. All the chemicals used were of analytical reagent grade. The apparatus used include; a CamspM106 Spectrophotometer, Atomic Absorption Spectroscopy (AAS) Instrument, Muffle furnace and Mechanical shaker.

Preparation of activated carbon

The seed coats were washed, dried, and pulverized. The powder was purified with 0.5M HCl, dried and then mixed with 25% CaCl_2 and kept at atmospheric temperature for about 18 hours with occasional stirring. The mixture was dried at 150°C and then carbonized at 500°C for 2 hrs in a muffle furnace, after which the charcoal was repeatedly washed with double distilled water. The washed sample was dried at 110°C . The activated carbon was crushed and sieved with 325 μm sieve and stored in a desiccator.

Characterization of Activated carbon

The following parameters were determined to characterise the activated carbons, Ash content (%), Bulk density (g/cm^3), Iodine no (mg/g), Methylene Blue no (mg/g), pH, Percentage fixed carbon (mg/g), and Yield % (Zawan et al., 2009; Ogbonnaya O., 1992; Santhi et al. 2010; Nwabanne and Igboke, 2008).

ADSORPTION PROCEDURE

ADSORPTION OF IRON (III) ION ON ACTIVATED CARBON

Batch Adsorption Experiment Iron (III) ion

This is carried out generally by prepare. a known concentrations of Fe^{3+} followed by adsorption of addition of a measured quantity of activated carbon. A period of time is given for adsorption to take place. Subsequently, the final which is an equilibrium concentration is determined. The amount of adsorption is thus calculated.

The Effects of Initial Concentration for Iron (III) Adsorption

Activated Carbon 2g each was added to 50mL of different concentrations 40, 80, 120, 160 and 200ppm of Fe^{3+} . After shaken for an hour, the final concentrations of the filtrates were determined and thus, the percentages adsorbed in each case were determined using;

$$\frac{C_i - C_f}{C_i} \times 100\%$$

The Effect of Contact Time for Iron (III) Adsorption

Activated Carbon 2g each was added to 50mL each of the 5 solutions prepared, shaken for the different contact times stipulated and filtered. The concentration before and after the adsorption were taken.

The Effect of Adsorbent Dosage for Iron (III) Adsorption

Activated Carbon of different quantities 1-5g were added and added to 50mL of solution of Fe^{3+} of 100ppm concentration. The final concentration was determined and thus, the percentage adsorbed was determined.

RESULTS AND DISCUSSION

Characterisation of activated carbon

Table 1 summarizes the characteristics of the activated carbon from the technique employed. The activated from this work has a relatively high iodine and methylene blue numbers when compared with those prepared from other agricultural by – products. (e.g. iodine numbers for cashew nut 801mg/g , Coconut shell 798mg/g , Corn cob 612 mg/g , coir pith 519 mg/g. and methylene blue numbers for cassava peel 213mg/g, coconut tree saw dust 426 mg/g, coir pith 452 mg/g, coconut shell 513 mg/g. This might be connected to the removal of considerable organic by-products and minerals presented in the activated carbon surface with the phosphoric acid during the activation process.(Chen et al 2003;Uzu and Guzei 2000)

Characterisation of activated carbon

Table 1 contains the summary of the characteristics activated carbons

Parameters	Value
Ash content (%)	14.92
Bulk density (g/cm ³)	0.37
Iodine no (mg/g)	913.5
MethyleneBlue no(mg/g)	512.1
pH	6.7
Percentage fixed carbon (mg/g)	85.08
Yield (%)	84.7

Adsorption Studies

The Effects of Initial Concentration of Fe^{3+} Adsorption

It is evident from the figures1 that the percentage of Fe^{3+} removal decreased with the increase in initial concentration of Fe^{3+} . The percentage of the Laboratory Activated Carbon adsorbed at initial concentration of 40mg/g was 86.54% while that of Jatropha Curcas Activated Carbon was 89.23%.

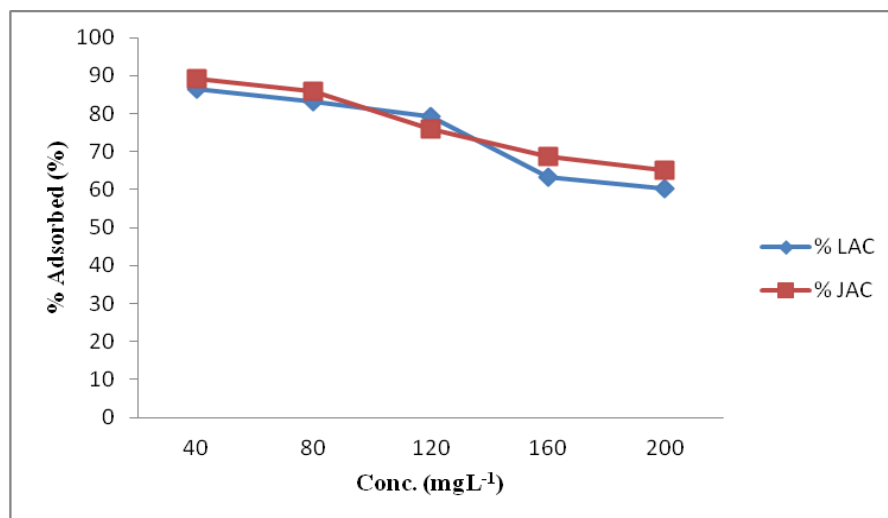


Fig. 1: Effect of initial concentration on Fe^{3+} Adsorption on LAC and JAC

The Effect of Contact Time of Fe³⁺ Adsorption

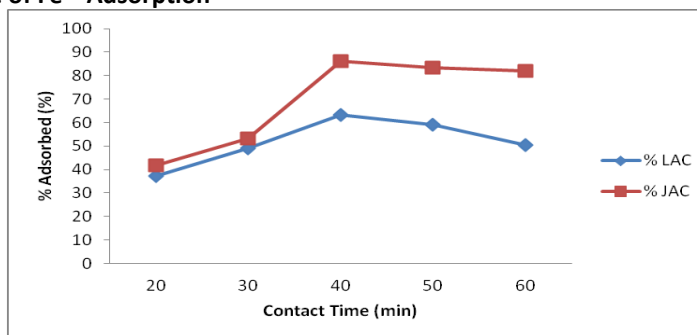


Fig. 2: Effect of contact time on Fe³⁺ adsorption on LAC and JAC

Figure 2 reveals that the rate of percent Fe³⁺ removal is higher at the beginning. This may be due to larger surface area of the activated Carbon powder being available at the beginning for the adsorption of Fe³⁺. As the surface adsorption sites become exhausted, the uptake is controlled by the rate at which the adsorbate

is transported from the exterior to the interior sites of the adsorbent particles. The percentage of the Laboratory Activated Carbon adsorbed at the maximum adsorption time was 63.20% while that of Jatropha Curcas Activated Carbon was 86.09%.

THE EFFECT OF ADSORBENT DOSAGE OF Fe³⁺ ADSORPTION ON LAC AND JAC

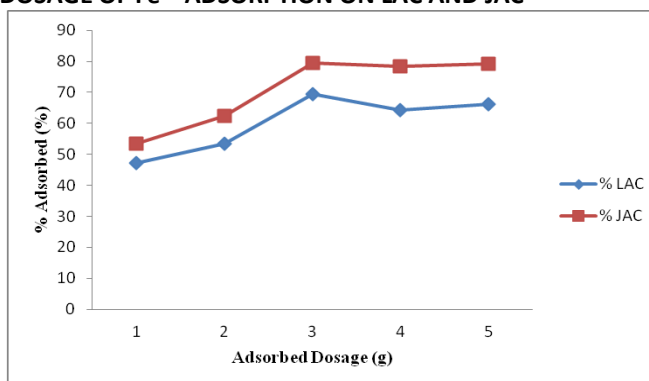


Fig. 3: Effect of Graph adsorbent dosage on Fe³⁺ Adsorption on LAC and JAC

It can be seen from figures 3 that initially, the percentage removal increases with increase in adsorbent dosage, but beyond a certain value (3.0g), the percentage removal reaches almost a constant value.. The maximum removal percentage for Laboratory Activated Carbon was 69.54% while for Jatropha Curcas Activated Carbon, it was 79.50%.

Adsorption Isotherms

The adsorption isotherm indicates how the adsorption molecules distribute between the liquid phase and solid phase when the adsorption process reaches an equilibrium state. The most widely accepted surface adsorption models for single-solute system (i.e. adequate model that can reproduce the experimental results obtained) are the Langmuir and Freundlich models. (Okeola and Odebunmi 2010)

Freundlich and Langmuir Isotherm were used, the linearized form of Freundlich isotherm is given as

$$\text{Log } q_e = \text{Log } K + \frac{1}{n} \text{Log } C_e$$

And that of Langmuir is

$$\frac{1}{q_e} = \frac{1}{q_{\max}} + \frac{1}{q_{\max} K_L} \frac{1}{C_e}$$

Where q_e is also solute adsorbed mg/g at equilibrium, $q_{\max}$ maximum sorption or solute uptake from solution mg/g and K_L is Langmuir equilibrium constant related to overall solute adsorptivity (L/mg).

Where

q_e is the dye adsorbed at equilibrium onto carbon

C_e is the final concentration of dye mg/L in the solution

K is the empirical Freundlich constant that provide an indication of the overall adsorption capacity (mg/g)

K_L is Langmuir equilibrium constant related to overall solute adsorptivity (L/mg).

Langmuir and Freundlich Adsorption Isotherms

The experimental data were fitted with the selected isotherms. Figure 4a a & b and 5a & b shows the isotherm models plot for adsorption of Fe³⁺. The values

of parameters and correlation coefficient for each isotherm model are shown in Table 2

Langmuir isotherm for the removal of Fe^{3+} on shows that the correlation coefficients obtained indicates a strong positive evidence on the adsorption on to JAC

than LAC. Data were also fitted to Freundlich equation. The correlation coefficients shows that the data fitted well to Freundlich model in Fe^{3+} adsorption on both activated carbon and ofcourse better on JAC.

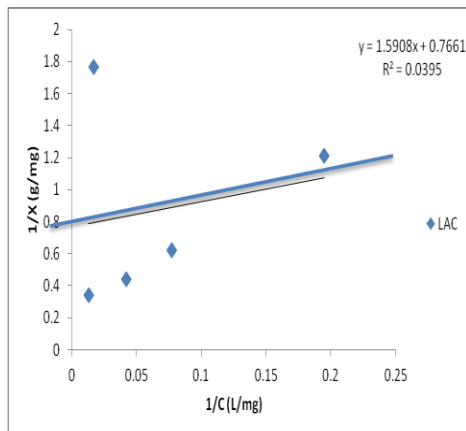


Fig.4a

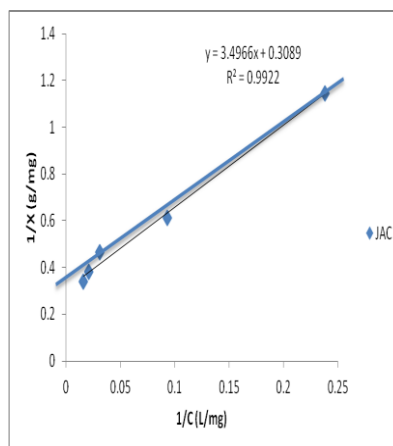


Fig.4b

Fig.4: Langmuir Isotherm for Adsorption of Fe^{3+} (a) on Laboratory Activated Carbon (b) on Jatropha Curcas Activated Carbon

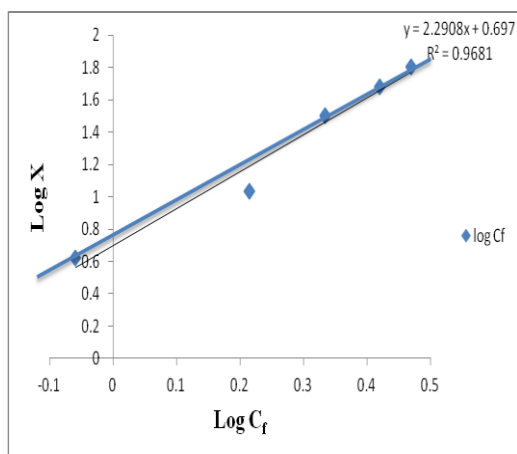


Fig.5a

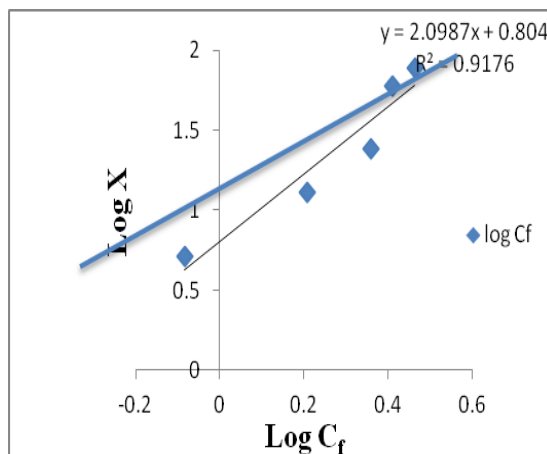


Fig.5b

Fig.5 Freundlich Isotherm for Adsorption of Fe^{3+} (a) on Jatropha Curcas Activated Carbon (b) on Laboratory Activated Carbon

Table 2 Langmuir and Freundlich Isotherm Constants for Fe^{3+} Adsorption

Activated carbon	Langmuir				Freundlich				
	$1/X_m$ (g/mg)	X_m (mg/g)	K	R^2	$1/n$	N	Log K	K	R^2
LAC	0.776	1.2887	0.482	0.339	2.098	0.477	0.804	6.3680	0.917
JAC	0.308	3.2468	0.088	0.992	2.290	0.437	0.697	4.9774	0.968

Conclusion

study indicates that carbon prepared from the shell of *Jatropha Curcas* seed has a suitable adsorption

capacity to remove Fe^{3+} from aqueous solution. The biosorption was found to depend on adsorbate dosage, initial dye concentration and contact time. The

adsorption process follows the Freundlich and Langmuir isotherms.

The project investigation shows that *Jatropha Curcas* Activated Carbon compete favourably with Laboratory Activated Carbon in the removal of Fe^{3+} .

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