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EVALUATION OF ADSORPTION EFFICIENCY OF ACTIVATED CHARCOAL PREPARED FROM PHYLLANTHUS EMBLICA TREE BARK FOR RETRIEVAL OF CR (VI) METAL IONS FROM AQUEOUS SOLUTION

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ABSTRACT

The studies on removal of Hexavalent Chromium were conducted using activated charcoal prepared from Phyllanthus Emblica tree bark (AC-PETB). Chromium (VI) adsorption from an aqueous solution has been studied experimentally using the batch adsorption method. The operating variables studied are pH, initial concentration, temperature, adsorbent dose, contact time. Adsorption isotherm like Langmuir and Freundlich model were studied. To enhance the adsorption capacity of activated carbon, it is loaded with Sodium lauroyl sarcosinate and 2-Acrylamido-2-methylpropane sulfonic acid and compared the adsorption capacity.

Keywords: Chromium (VI), Adsorption, Phyllanthus Emblica, Langmuir, Freundlich

1. INTRODUCTION

Chromium (VI) is one such toxic pollutant due to its harmful and therefore studies are still being done for carcinogenic effects on human health, especially in its other alternative pre-treatment procedures [1-3]. Several processes have been suggested to remove heavy metals from wastewaters. These processes include chemical precipitation, ion exchange, cementation, coagulation and flocculation, complexation, biosorption, and membrane processes [4-5]. Most of these methods suffer from some drawbacks, such as high capital and operational cost or the disposal of the residual metal sludge, and are not suitable for small-scale industries. Adsorption is one of the most effective physical processes and has a great potential for the removal of dyes and heavy metal ions from wastewater [6]. Activated carbons, with their high surface area, micro porous character and chemical nature of their surface, have made them potential adsorbents for the removal of heavy metals from industrial wastewater [7-8].

In most cases, one-step chemically surface activation is a method of choice by researchers in this area to activate the carbonaceous materials. Activated charcoal adsorbent can be selective, cheap and relatively inert and the high surface area along with the ability to chemically regenerate and reuse makes it very useful [9].

Taking these aspects into account, the present study was aimed to characterize the metal-binding ability of activated carbons derived from *Phyllanthus Emblica* tree bark.

2. MATERIALS AND METHOD

Preparation of Solutions

2.94 gram of $K_2Cr_2O_7$ dissolves in 1000 ml standard volumetric flask with deionised water. The concentration of Cr (VI) was analyzed by UV-Visible spectrophotometer (model-117) using 1, 5-diphenylcarbazide as the complexing agent at the wavelength of 540 nm. The Sodium lauroyl sarcosinate, 2-Acrylamido-2-methylpropane sulfonic acid (purchased from Merk), was used for surface modification of activated carbon. All

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the solutions of these chelating agents are prepared in 0.01M concentration by dissolving it into 1000 mL volumetric flask with deionised distilled water.

Surface modification of GAC

Taking 200 ml solution of chelating agent (0.01M) and 0.5 gram of adsorbent (AC-PETB) in reagent bottle, shaken for 3 hours at 1000 rpm at room temperature, then dried in oven for surface modification. Activated charcoal loaded with Sodium lauroyl sarcosinate, 2-Acrylamido-2-methylpropane sulfonic acid designated as

AC-PETB-SLS and AC-PETB-AMPSA.

Batch study

The stock solutions of known concentration of Cr (VI) were diluted with double distilled water to obtain required standard solution. The dried amount of 0.5 gram of activated charcoal was taken in 250 ml reagent bottle and standard solution containing various concentration of Chromium (VI) 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 = 540 nm against a reagent blank. The UV-Visible spectrophotometer systronic (model 117) was used to measure the concentration of Chromium (VI). Same experiments were carried out for loaded AC-PETB.
The amounts of percentage adsorption were computed as follows:

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

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

Effect of pH

The effect of pH can be done experimentally by taking 0.5 gm of adsorbent with working volume of Cr (VI) 200 ml having constant initial metal ions concentration and the contact time of 3 hours with shaking speed 1000 rpm. The result indicates that maximum uptake capacity for Cr (VI) was found to be at pH 2 with **AC-PETB,**

AC-PETB-SLS and AC-PETB-AMPSA. The adsorption capacity of Chromium (VI) as a function of pH it was observed that percentage removal of Chromium (VI) is maximum of pH = 2 and then decrease with increase of pH shows in figure 1.

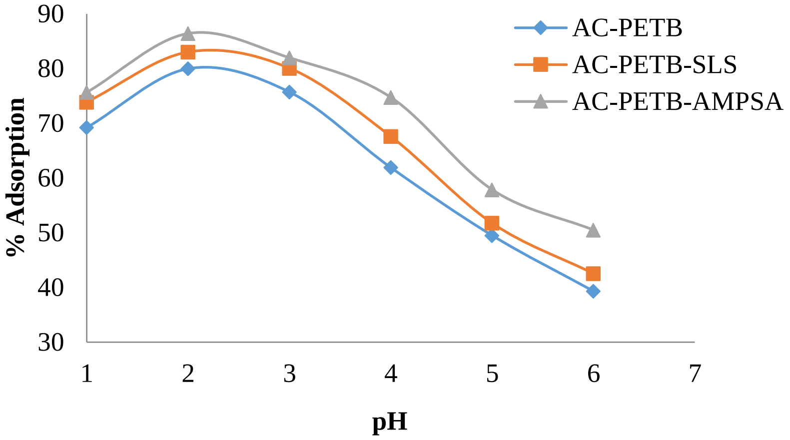

Figure Number 1: Effect of pH

Effect of Contact time

Study was carried out by taking 0.5 gm of adsorbent with working volume of Cr (VI) 200 ml with known concentration of metal ions. It was observed that initially rate of adsorption is rapid up to 160 min with shaking speed 1000 rpm and then there was no further change in equilibrium concentration. Equilibrium time was found

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to be 300 minutes for this adsorption. The result indicates that maximum uptake capacity for Cr (VI) at pH 2 and at 180 minute.

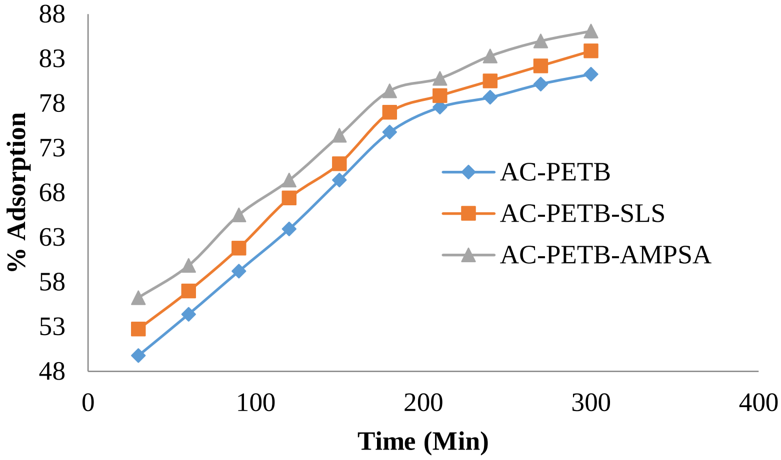

Figure Number 2: Effect of Contact Time

Effect of Adsorbent dose

The effect of varying the adsorbent dosage (**AC-PETB, AC- PETB-SLS and AC- PETB-AMPSA**) from 0.2–1 gram for adsorption of Cr (VI) from their aqueous solutions having known volume of initial concentration was studied at pH 2.0 It has been found that the percent removal of Cr (VI) increases with increase in adsorbent dose up to some extent, thereafter further increase adsorbent dose.

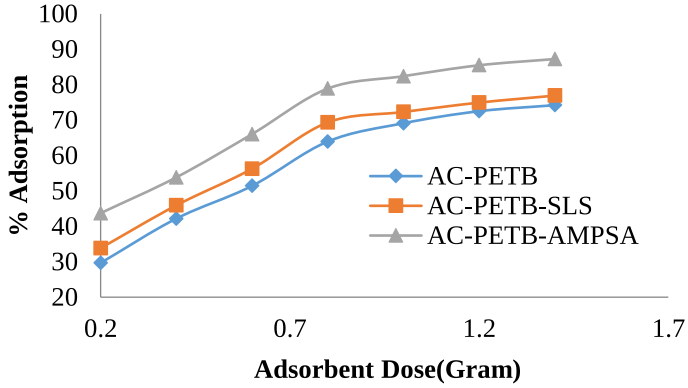

Figure Number 3: Effect of Adsorbent Dose

Effect of Initial Metal ions concentration

Study were carried out by varying initial metal ions concentration **AC-PETB, AC-PETB-SLS and AC-PETB-AMPSA** using adsorbent dose 0.5 gram at pH 2.0 having agitation speed 1000 rpm, contact time 3 hours. Result indicates that with increase in initial metal ions concentration percent of adsorption decreases.

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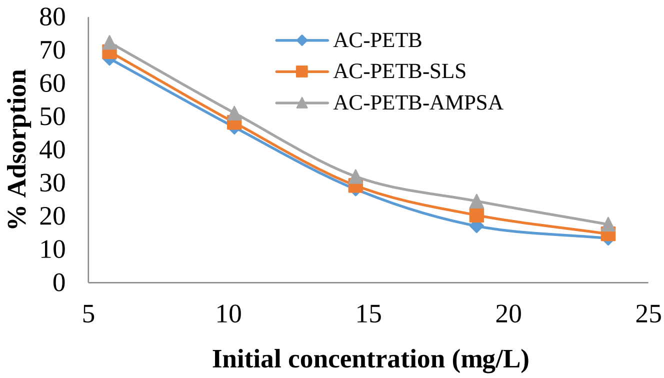


Figure Number 4: Effect of Initial metal ions concentration

Effect of Temperature

Effect of temperature was studied by varying the temperature from 30ºC to 60ºC with working volume 200 ml having known concentration. Study was carried out at pH 2.0 and at 1000 rpm with contact time 3 hours. As the temperature increases porosity increases and percent of adsorption increases up to certain extent and then remains constant this is due to chemisorptions process. In chemisorptions as the temperature increases adsorption increases up to certain extent and then decreases while in physisorption process as the temperature increases adsorption decreases. From the study it was observed that the phenomenon was chemisorptions.

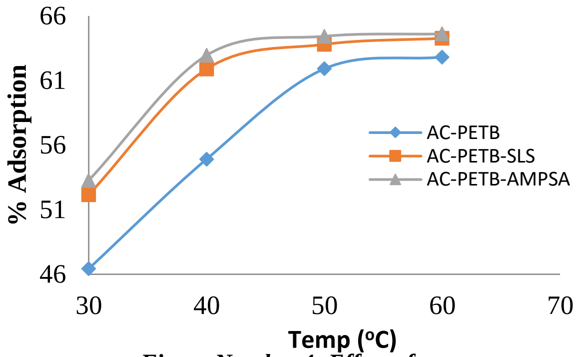
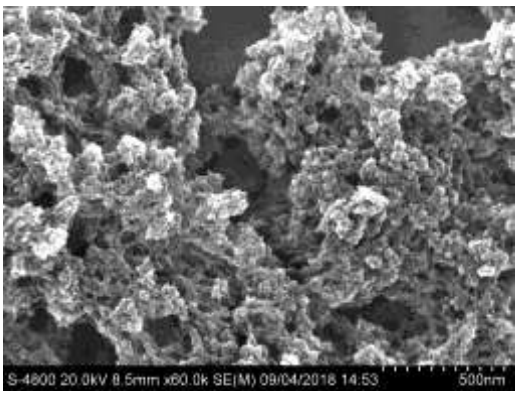


Figure Number 4: Effect of temperature

Scanning Electron Microscopy



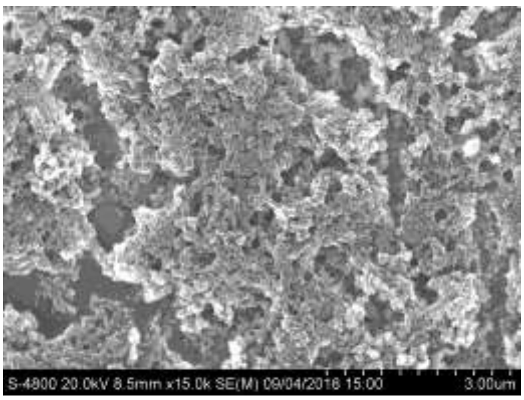


Figure 4: A. Before metal ions adsorption *B. After Metal ions adsorption*

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Isotherm Modelling:-

***Langmuir Adsorption Isotherm*: -** The Langmuir adsorption isotherm is shown in Table 1. Q_o values found to be comparable with commercial activated carbon. Value of R_L lies between 0 and 1 indicate the favourable adsorption. It indicates the applicability of Langmuir adsorption isotherm. The calculated value R^2 confirms the applicability of Langmuir adsorption isotherm.

***Freundlich Adsorption isotherm*: -** Freundlich plot for the adsorption of Chromium (VI) on AC-PETB, AC-PETB-SLS and AC-PETB-AMPSA is given in Table 1. It shows that the values of adsorption intensity 1/n < 1, reveal the applicability of Freundlich adsorption.

Table 1: Adsorption Isotherm Constants

System	Langmuir Isotherm				Freundlich Isotherm		
	Q_o	b	R_L	R^2	K_f	1/n	R^2
AC-PETB-Cr(VI)	5.6967	0.0484	0.1123	0.996	2.1344	0.4743	0.995
AC-PETB-SLS-Cr(VI)	7.3843	0.0345	0.1134	0.998	2.6832	0.4178	0.996
AC-PETB-AMPSA-Cr(VI)	9.2632	0.0121	0.1140	0.999	3.3566	0.3789	0.999

3. CONCLUSION

1) Activated charcoal prepared from *Phyllanthus Emblica* tree bark (AC-PETB) was studied as good adsorbent for removal of Chromium (VI). The removal is found rapid in initial stage followed by slow adsorption up to saturation level. It also depend an initial concentration of adsorbate and agitating time.
2) The present work on adsorption process is in good agreement with Langmuir & Freundlich isotherm indicating monolayer adsorption process.
3) The result of adsorption process reveals that at pH = 2 Chromium (VI) uptake capacities are better.
4) Activated charcoal loaded with 2-Acrylamido-2-methylpropane sulfonic acid shows higher adsorption capacity than Sodium lauroyl sarcosinate and virgin activated carbon.
5) A result indicates that as the temperature, adsorption dose, contact time increases adsorption capacity increases while decreases with increase in initial metal ions concentration.

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