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A Study of Activated Charcoal Prepared from Ailanthus Excelsa Tree Bark and to Find its Adsorption Efficiency for the Removal of Cr (VI) Metal Ions from Aqueous Solution

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Abstract: ***The detail study for the removal of Cr (VI) metal ions from the aqueous solution was done. The study was done using activated Charcoal prepared from Ailanthus excelsa tree bark. The efficiency of activated Charcoal for the removal of Cr (VI) ions was checked experimentally using batch adsorption process. The study was done by operating different variables like pH, Concentration, Temperature, adsorbent dose, Contact time etc. Langmuir and Freundlich Adsorption model were studied with this. To increase the adsorption efficiency of prepared activated Charcoal, it is loaded with different surface-active agents like Sodium Lauroyl Sarcosinate (SLS), and Sodium dodecyl sulfate (SDS) and compared the results.***

Keywords: Chromium Cr (VI), Adsorption, Tree bark, Charcoal, Langmuir, Freundlich, efficiency

1. Introduction

Activated charcoal adsorption refers to a mechanism in which impurities adhere to the highly porous surface of activated carbon via the physical process of adsorption. The surface area and porous structure of activated carbon make it as a highly effective substance for removing a wide range of contaminants, such as organic compounds, odours, flavours, and colours, from both liquids and gases. Different factors that affect this process include concentration, temperature, Ph, Contact time, adsorbent dose etc. Adsorption is the treatment of wastewater in which physical and chemical process is involved for the removal of contaminants from water. In this, the contaminants are binds to the surface of solid adsorbent materials. This method is particularly effective in removing a wide range of pollutants, such as organic compounds, heavy metals, dyes, and micro pollutants. The primary benefits of this process encompass cost-effectiveness, simplicity, flexibility, and high efficiency. Chromium (Cr) is widely known as one of the highly toxic metals existing in effluents drained from industries such as tanning, textile, electroplating, and pigments [1]. Activated charcoal serves as a highly effective and economical material for the extraction of hexavalent chromium Cr (VI) from water. The efficiency of this removal process is significantly influenced by different factors. The process is regulated by adsorption isotherms, such as the Langmuir model, and Frendulich isotherm. The maximum contaminant level goal of chromium for the drinking water is 0.05 mg/l as per the world health organization (WHO) set standard [2]. The adsorption potential of acid activated carbon prepared from leaves of *Juniperus procera* to remove Pb (II) and Cr (VI) toxic ions from aqueous solutions was investigated in before study. The effects of solution pH, adsorbent mass, contact time, initial ion concentration and temperature on the biosorption process were also studied, and the optimum conditions were determined.[3] This Present study was aimed to analysis, Characterize and finding the adsorption efficiency of activated Charcoal Prepared from Alianthus excelsa Tree barks. In this Cr (VI) metal ions solutions are treated with prepared activated Charcoal and hence further determine its adsorption efficiency with respect to different Parameters like Ph, concentration, temperature, Contact time and adsorbent dose etc.

2. Experimental

Preparation of Solutions

Potassium dichromate is used to make standard stock solution with the use of double distilled water. The estimation of Chromium (VI) can be performed using the 1, 5-diphenylcarbazide method. The concentration of Cr (VI) metal ions is analyzed using a UV-Visible spectrophotometer at suitable wavelength of 540 nm.

Surface activation of GAC

A concentration of 0.01 M of each chelating agent/Surface active agent is used to modify or activate the surface of prepared Granular activated Charcoal (GAC).To achieve this surface modification, a solution containing 250 ml of surface active agent and 2.0 grams of Prepared activated charcoal, prepared from the Alianthus excelsa tree barks, is placed in a reagent bottle and keep for 3 hours at room temperature at a speed of 1000 rpm on rotary Shaker Machine. The activated charcoal is thus loaded with different chelating agents/ Surface active agents like Sodium lauroyl sarcosinate (SLS) and Sodium dodecyl sulfate (SDS), which is represented as Activated Charcoal with Sodium lauroyl sarcosinate as AC-SLS and Activated Charcoal with Sodium dodecyl sulfate as AC-SDS.

Batch Processes: -

The required standard solution was prepared from the known concentration of a stock solution of Chromium (VI) by diluting it with double distilled water. The 250 ml of the

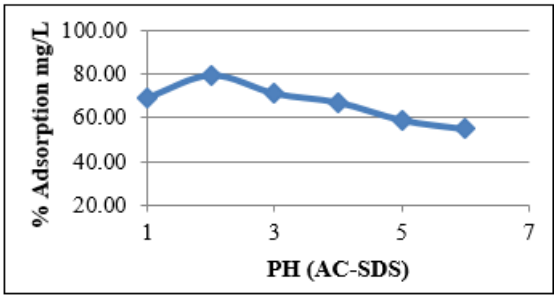
prepared standard solution, which contained Cr (VI) metal ions, was placed in a reagent bottle, to which 1.5 grams of activated charcoal Prepared from the Ailanthus excelsa tree bark was added. Then reagent bottle is kept on rotary Shaker machine for about 3 Hrs continuously. The adsorbent and adsorbate were then separated through filtration, and the filtrate was analyzed using a spectrophotometer at $\lambda = 540$ nm against a reagent blank. Identical experiments were conducted for loaded AC-SLS and AC-SDS. Then percentage of adsorption was calculated by using following equation.

$$\% \text{ Adsorption} = (Co - Ce) / Co \times 100$$

Where Co and Ce are initial and equilibrium concentration respectively in mg/L.

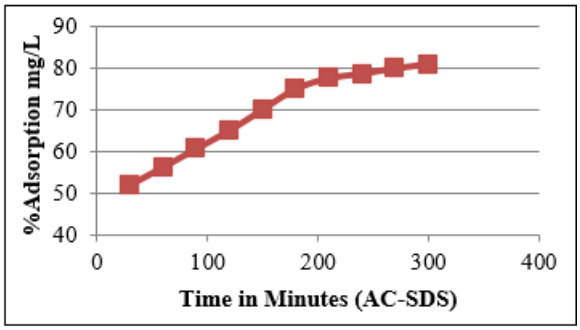
1) Effect of pH

The influence of pH can be examined by utilizing 250 ml of prepared solution with a known concentration of Cr (VI) and 1.5 grams of an adsorbent. This mixture is shaken on a rotary shaker for approximately 3 hours at a speed of 1000 rpm. The findings indicate that the highest removal of Cr (VI) occurs at a pH of 2 when using AC-SLS and AC-SDS as adsorbents. It has been noted that up to a pH of 2, there is an increase in the percentage of Cr (VI) removal, which subsequently declines as the pH increases, which is shown in following graph.



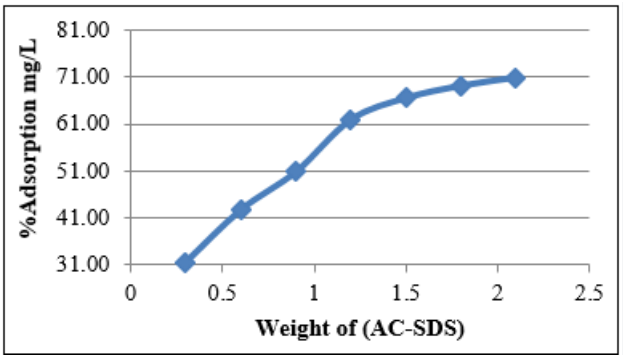
2) Effect of Contact Time

The effect of contact time was examined by taking 250 ml solution of Cr (VI) and maintaining its pH value at 2.0 and an adsorbent dosage of 1.5 grams. It was observed that at a speed of 1000 rpm, the percentage of removal increased rapidly up to 180 minutes, after which it reached an equilibrium stage, with no further adsorption occurring thereafter. The investigation of contact time was conducted at room temperature, specifically at +30°C.



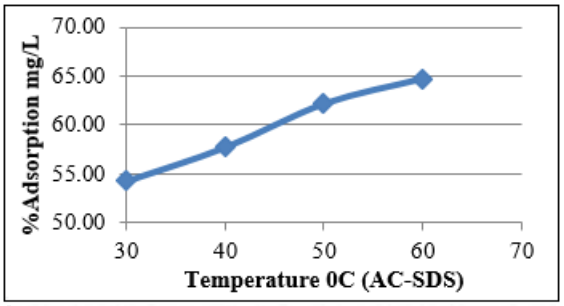
3) Effect of Adsorbent Dose

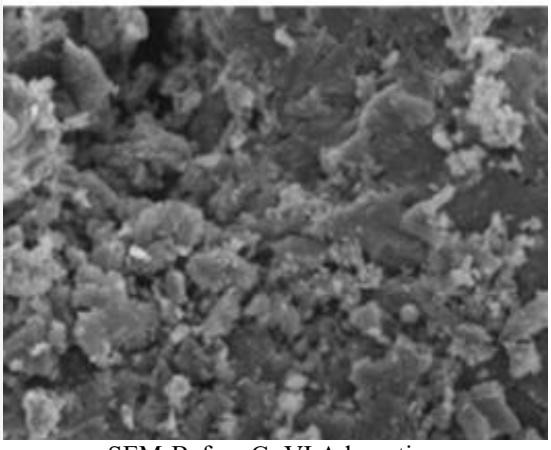
The doses of adsorbent were varied from 0.5 grams to 1.5 gram in order to study the effect for the removal of Cr(VI) from an aqueous solution at a pH 2.0. Different quantities of adsorbent were taken into a reagent bottle containing 250 ml of a Cr (VI) solution of known concentration, which was then shaken for 3 hours at a speed of 1000 rpm on rotary shaker machine. It was observed that as the amount of adsorbent increased, the percentage of Cr (VI) removal also increases, continuing to increase until reaching the saturation point.



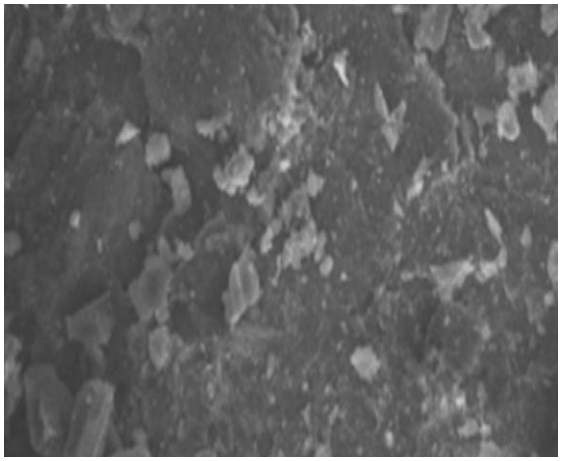
4) Effect of Temperature

To investigate the impact of temperature, the pH of the Cr (VI) solution was maintained at 2 with a working volume of 250 ml. This study was conducted within a temperature range of 30°C to 60°C. The solution was shaken at 1000 rpm for approximately 3 hours. As the temperature rises, the percentage of adsorption also rises to a certain point before it stabilized. In chemisorptions, as the temperature increases, adsorption rises to a specific level and then declines. This Behavior is shown in following graph.





SEM-Before Cr VI Adsorption



SEM-After Cr VI Adsorption

Adsorption Isotherm

Langmuir Adsorption Isotherm

The mechanism of monolayer adsorption was examined utilizing the Langmuir adsorption isotherm, with data presented in Table 1. Qo represents the adsorption capacity, which is found to be nearly equivalent to the adsorption capacity of commercial activated carbon. The RL values range between 0 and 1, indicating a favorable adsorption process. This suggests that the Langmuir adsorption isotherm is suitable for the removal of Cr(VI). The R2 value, calculated from the Langmuir adsorption isotherm, further confirms the applicability of this isotherm.

Freundlich Adsorption Isotherm

A graph was created to analyze the multilayer adsorption for the removal of Chromium (VI) on AC-SDS using the Freundlich adsorption isotherm. The values derived from the Freundlich adsorption isotherm are illustrated in Table-1. An adsorption intensity of $1/n < 1$ indicates the applicability of the Freundlich adsorption model.

3. Results

The study shows that activated charcoal prepared from the bark of the Ailanthus excelsa tree (AC-SDS) works as an efficient adsorbent for the removal of Cr(VI) metal ions from aqueous solution. At a pH of 2, the removal of Cr (VI) is observed to be at its peak due to the electrostatic attraction between the ions present in the solution. The time required to achieve saturation for the extraction of Cr(VI) was determined to be 180 minutes, after which minimal adsorption occurs. The temperature analysis reveals that the adsorption rate is higher up to 50°C, beyond which it stabilizes at the saturation level. The removal of Cr (VI) from aqueous solutions can become economical to an industrial level by utilizing cost-effective bio-adsorbents from the bark of Ailanthus excelsa tree.

Table 1: Adsorption Isotherm Constants

System	Langmuir Isotherm				Freundlich Isotherm		
AC-SDS-Cr(VI)	Q_o	b	R_L	R^2	K_f	1/n	R^2
	4.70366	0.06679	0.01328	0.9703	0.7033	0.2462	0.9521

References

[1] Zhang, Yan-Juan, et al. "Adsorption of Cr (VI) on bamboo bark-based activated carbon in the absence and presence of humic acid." *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 481 (2015): 108-116.

[2] Acharya, Jyotikusum, et al. "Removal of chromium (VI) from wastewater by activated carbon developed from Tamarind wood activated with zinc chloride." *Chemical Engineering Journal* 150.1 (2009): 25-39.

[3] Ali, Ismat H., et al. "Exploring adsorption process of lead (II) and chromium (VI) ions from aqueous solutions on acid activated carbon prepared from Juniperus procera leaves." *Processes* 7.4 (2019): 217.

[4] Altun, Türkan, and Yakup Kar. "Removal of Cr (VI) from aqueous solution by pyrolytic charcoals." *New Carbon Materials* 31.5 (2016): 501-509.

[5] Khan, Taimur, et al. "Cr (VI) adsorption from aqueous solution by an agricultural waste based carbon." *RSC advances* 6.61 (2016): 56365-56374.

[6] Khan, Taimur, et al. "Cr (VI) adsorption from aqueous solution by an agricultural waste based carbon." *RSC advances* 6.61 (2016): 56365-56374.

[7] Muriuki, Cecilia W., et al. "Adsorption of chromium (VI) from aqueous solution by acacia tree (Acacia tortilis) charcoal." *Journal of Sustainable Research in Engineering* 1.3 (2014): 30-38.

[8] Kehinde, O. Olayinka, T. Adetunde Oluwatoyin, and O. Oyeyiola Aderonke. "Comparative analysis of the efficiencies of two low cost adsorbents in the removal of Cr (VI) and Ni (II) from aqueous solution." *African Journal of Environmental Science and Technology* 3.11 (2009).

[9] Yadav, S. Kumar, and A. K. Dixit. "Efficient removal of Cr (VI) from aqueous solution onto palm trunk charcoal: kinetic and equilibrium studies." *Chemical Science Journal* 6.114 (2015): 1-7.

[10] Lopez-Nuñez, Perla Vianey, et al. "Removal of hexavalent and total chromium from aqueous solutions by plum (P. domestica L.) tree bark." *Environmental Engineering & Management Jjhournal (EEMJ)* 13.8 (2014).