

Removal of Pb (II) from Aqueous Solutions using Activated Carbon Prepared from Garlic Waste

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ABSTRACT

The recent study explains about the removal of Pb (II) ions from aqueous solution using activated carbon prepared from Garlic waste. Garlic peels have been used for the production of Carbon by treating with conc.H₂SO₄ for metal ions removal. Fourier Transform Infrared Spectroscopy and Boehm titration have been used for various physicochemical characterization of the outcome of activated carbon which proclaimed the presence of oxygen containing surface functional groups like phenolic, lactonic and carboxylic in the carbons. In a batch adsorption process the effect of pH and initial metal ion concentration was calculated. The optimum pH for lead adsorption is found to be equal to 6. The resultant activated carbon showed maximum adsorption capacity of Pb (II) was 210 mg g⁻¹. The waste material which is used in this work is cost effective and easily available for the production of activated carbon. Hence the removal of Pb (II) from water using the carbons prepared from Garlic peels can act as possible low cost adsorbents for the removal of Pb (II) from water.

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KEYWORDS: lead, Adsorption, Garlic peels, Carbon

Introduction

Because of poisonous quality and non - biodegradability even at lower focuses overwhelming metals like lead, cadmium, nickel, chromium etc. are hazardous to the environment [2]. Normal water is polluted with lead discharged from petroleum refining, ceramic industries, textile dyeing and battery manufacture [1]. In commercial water lead tainting happens because of the consumption and draining of lead funnels and Pb/Sn weld joints related with copper administration lines utilized in family unit plumbing [4]. Lead is an exceedingly harmful and total toxic substance, amasses essentially in bones, cerebrum, kidney and muscles. In drinking water lead tainting happens because of the consumption and draining of lead funnels and Pb/Sn weld joints related with copper administration lines utilized in family unit plumbing [4]. Lead is a highly toxic and cumulative poison, accumulates mainly in bones, brain, kidney and muscles. Lead harming in human makes extreme harm kidney, apprehensive and regenerative frameworks, liver and mind [6]. The reasonable dimension of lead in drinking water and surface water planned for drinking as set by EU, EPA and WHO are 0.01, 0.05 and 0.01 mg L⁻¹ individually. Consequently, an exceptionally low convergence of lead in water is lethal.

The expulsion of such a substantial metal from polluted water bodies has been endeavored by a few researchers

utilizing a wide assortment of systems including concoction precipitation, synthetic oxidation or decrease, filtration, particle trade, electrochemical treatment, layer filtration, invert assimilation and adsorption. Be that as it may, the majority of these techniques have impressive disservices including fragmented metal evacuation, high capital, operational expense and the transfer of remaining metal ooze which are not reasonable for little scale ventures [5]. Among different strategies, the adsorption procedure has been utilized only in water treatment and numerous investigations have been done to discover modest and chemico-physically plausible adsorbent. Numerous reports have showed up on the improvement of minimal effort enacted carbon from less expensive and promptly accessible materials. Activated carbons with their high surface zone, small scale permeable character and substance nature of their surface have made them potential adsorbents for the expulsion of overwhelming metals from water. Carboxylic, lactonic, phenolic, and other natural useful gatherings are situated at the edges of hexagonal layer planes and are in charge of surface reactivity of actuated carbon. Ionization of these useful gatherings in arrangement is pH ward and prompts a development of a charged interface between the solid surface and the bulk of the solution [5].

There are a very substantial number of studies with respect to the preparation of activated carbons from agriculture wastes, fruit stones and hard shell of fruit stones. Bagasse, manure compost, oil palm waste, agriculture residue from sugarcane, saw dust, Rosa canina sp. Peels, sewage sludge [3]. Most of activated carbons are prepared by a two-stage process carbonization followed by activation. The first step is to enrich the carbon content and to create an initial porosity and activation process helps in enhancing the pore structure. The activation can be carried by two different processes physical and chemical. Chemical activation has two important advantages as compared to physical activation. One is lower temperature in which the process is accomplished. The other is that the global yield to the chemical activation tends to be greater since burn off char is not required. Among the numerous dehydrating agents, sulphuric acid in particular is the widely used chemical agent in the preparation of activated carbon[8].

Garlic peel, a very common and easily available material, is usually thrown away as an agricultural biowaste. In China, huge amount of garlic is consumed every year, and lots of peel is disposed, causing severe problem in the community, for example, decomposing in the open air and giving off special bad smell. Up to date, the research work on the effective development of garlic peel is rarely reported, so for the environmental interest and reusing of this biowaste, we attempted to use it as the activated carbon to prepare the selective adsorbents for the removal of lead from the aqueous solutions[21].

In this study, activated carbon developed from Garlic peels have been used for the removal of Pb (II) ions from aqueous solution since the stones are readily available and can be used as a viable adsorbent for the removal of heavy metals. The effects of initial adsorbate concentration and pH on the removal of Pb (II) have been studied.

Experimental

Chemicals

All chemicals and reagents used were of analytical grade. Stock solutions of Pb (II) were prepared from lead nitrate in deionized water. Digital pH meter was used to measure the pH values of the solutions. Solutions of 0.1M NaOH and 0.1 HNO₃ were used for pH adjustment. All the working solutions were prepared diluting the stock solutions with deionized water[22].

Preparation of Adsorbents

Garlic peels were first washed with tap water then with distilled water and dried in an oven at 110 °C for 12 hours. The dried peels were crushed into small particles. The Garlic peel particles were treated with concentrated H₂SO₄ in 1:1 weight ratio and kept in an oven maintained at a temperature of 150 °C for 24 hours [12]. The particles were then washed with distilled water till the pH and conductivity of the washing were equal to that of distilled water. The particles were dried in an oven at 110 °C for 12 hours. The particles were then ground and sieved to get the particles size of 70 µm.

Characterization of the activated Carbon

Characterization of the resultant adsorbent was studied by FTIR study and Boehm titration. The Fourier transform infrared (FTIR) spectra were recorded on a Perkin-Elmer Model 100 FT-IR Spectrometer. Oxygen containing

functional groups present on the activated carbons prepared was determined qualitatively by the FTIR spectroscopy. Quantification of the functional groups was determined by Boehm titration.

Adsorption studies

Batch adsorption experiments were carried out in a series of stoppered reagent bottles. A weighed amount (0.05 g) of adsorbent was introduced into the reagent bottles (50 ml) containing various concentration of lead. The total volume of the aqueous solution is equal to 25 ml. The solution pH was adjusted to the desired value by adding 0.1M HNO₃ and 0.1M NaOH. The bottles were then shaken at room temperature (25 ± 2 °C) using an electric shaker for a prescribed time to attain the equilibrium. The solutions were filtered and final concentrations of lead (II) ions were determined by using an atomic absorption spectrophotometer. The instrument calibration was checked by using standard metal solutions. The amount of lead (II) ions adsorbed was calculated by the following mass balance equation.

$$q_e = \frac{(C_o - C_e)V}{M}$$

Where C_o and C_e were initial and equilibrium concentration of metal ion (mg / L) respectively, m was the mass of adsorbent in gram (g) and V was the volume of the solution in liter (L).

Results and Discussion

FTIR

FTIR study confirmed the presence of oxygenated functional groups in Carbon. The FTIR spectrum of the Carbon shown in Fig.1. The bands at about 1650 cm⁻¹ are attributed to ν(C-O) vibrations in the carboxyl groups. The bands at about 2400 cm⁻¹ are attributed to ν(O-H) vibrations in the hydroxyl and phenolic groups. The appearance of bands between 950 cm⁻¹ could be assigned to C-O stretching vibrations. It is obvious that the main oxygen groups present in the Carbon are lactones, carboxyl and phenolic groups[12].

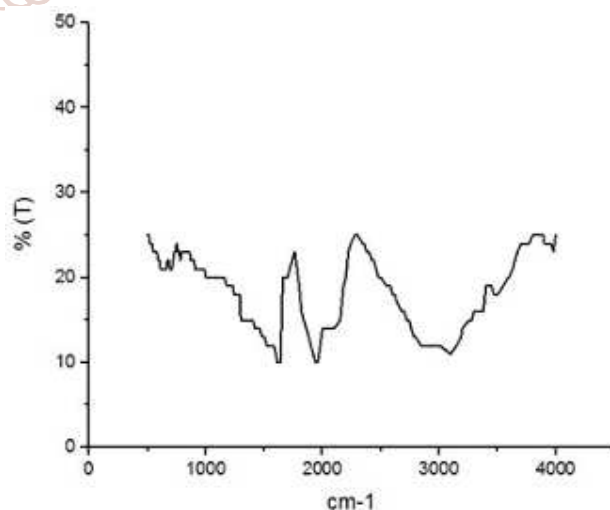


Fig 1: FTIR study of activated carbon

Boehm Titration

The quantification of surface oxygen functional groups in Carbon was measured by Boehm titration method[13-14]. The method based on that the weakest base NaHCO₃

neutralizes only the strongest acidic carbon surface functionalities which are carboxyl groups, while Na_2CO_3 neutralizes carboxylic and lactonic groups. The strongest base NaOH neutralizes carboxylic, lactonic and phenolic groups. On the basis of amount of acid and bases consumed the different kinds of functional groups can be quantitatively calculated. Table-1 shows the milli equivalent of carboxylic, phenolic and lactonic groups present per gram of activated carbon. The large quantities of the acidic functional groups on the surface of Carbon make them high cation exchange capacity and benefit for the Pb (II) ions adsorption[15].

Table 1: Boehm titration result of Activated carbon

Adsorbents	Functional groups in mill equivalent per gram (meq/g)		
	Carboxyl	Phenol	Lactones
Carbon	0.712	0.611	0.49

Effect of pH

The pH of the solution has a significant impact on the uptake of heavy metals since it determines the surface charge of the adsorbent, the degree of ionization and speciation of the adsorbate. The effect of pH on the adsorption of Pb (II) on activated carbon prepared from Garlic peels has been studied by varying pH from 2-6 as shown in Fig. It has been shown in the figure that the uptake of Pb depends on pH, it increases with the increase in pH and reaching maximum adsorption of Pb around pH 5 [16]. The continued increase in adsorptive capacities of Pb with increase in pH is due to the decrease in hydrogen ion concentration as pH value increases. At lower pH higher concentration of H^+ ions present in aqueous medium will compete with the positively charged M^{2+} ion for the surface adsorbing sites thereby leading to a decrease in the removal of metal ions [16]. In other words under acidic condition solutions both adsorbent and metal ions are positively charged (M^{2+} and H^+) and hence their interaction is via electrostatic interaction. The final pH values at equilibrium after adsorption were lower than the initial pH value, indicating that the Pb ions are adsorbed and hydrogen ions are released from the adsorbent. This is also confirmed by the result that the increase of acidic surface groups favored the adsorption process. The effect of pH on Pb (II) adsorption onto carbon was studied over a pH range 2-6 at 25°C in order to avoid the formation of metal hydroxides.

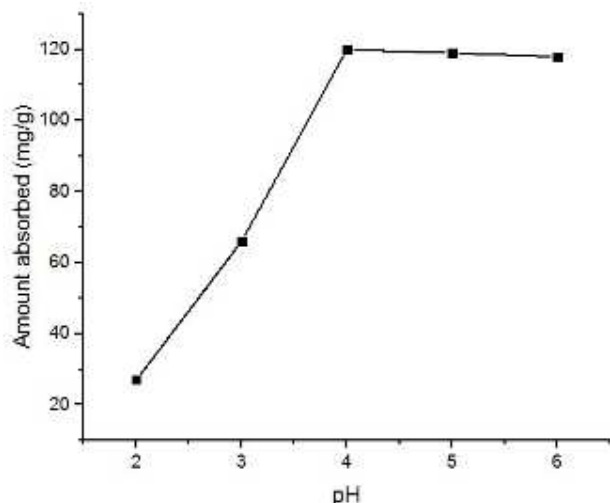


Fig.2: Effect of pH on adsorption of Pb^{2+} on activated carbon

Effect of metal ion concentration

In batch adsorption processes the initial metal ion concentration of metal ions in solution plays an important role as driving force to overcome the mass transfer resistance between the solution and solid phase. So the removal efficiency of Pb ions by activated carbon derived from Garlic peels initially increased with increasing metal ion concentration as shown in Fig.3. At initial stage there were large number of binding sites available for adsorption i.e. the number of lead ions available in the solution is less as compared to the available sites on the adsorbents and the metal ions in solution would interact the binding sites and thus facilitate more adsorption whereas in higher concentrations the metal ions get left unadsorbed in the solution due to saturation of the binding sites [17].

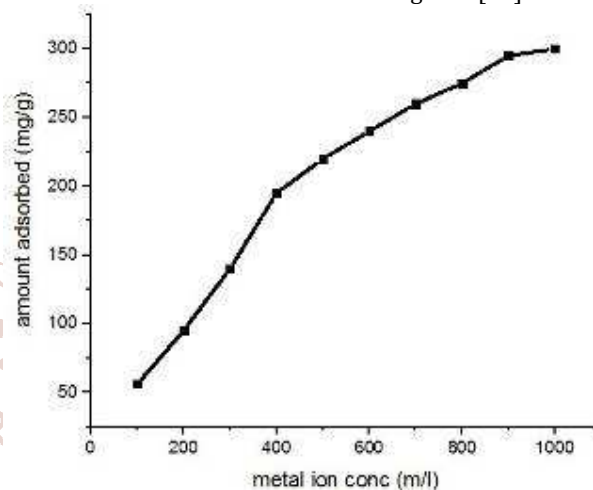


Fig.3 Effect of concentration of Pb (II) on adsorption at pH5

Conclusion

The present investigation showed that activated carbons derived from Garlic peels are effective adsorbents for the removal of lead (II) from aqueous solutions. The amount adsorbed increased with the increase in pH from 2 to 5. Boehm titration study showed that there is a large quantity of functional groups such as carboxyl, phenolic and lactonic groups existed on the surface of Carbon. Batch adsorption experiment showed that Pb (II) ion adsorption properties are great dependence on pH and metal ion concentration. The optimum pH for the uptake of lead adsorption on the adsorbents is 5.

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