INTERNATIONAL JOURNAL OF RESEARCH IN PHARMACY AND CHEMISTRY

Available online at www.ijrpc.com

Research Article

ADSORPTION OF HEXAVALENT CHROMIUM FROM AQUEOUS SOLUTIONS BY ALOE VERA LEAF

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ABSTRACT
In this research, adsorption of chromium (VI) ions on Aloevera has been studied through using batch adsorption techniques. The main objectives of this study are to 1) investigate the chromium adsorption from aqueous solution by Aloevera, 2) study the influence of contact time, pH, adsorbent dose and initial chromium concentration on adsorption process performance and 3) determine appropriate adsorption isotherm and kinetics parameters of chromium (VI) adsorption on Aloevera. The results of this study showed that adsorption of chromium by Aloevera reached to equilibrium after 180 mts and the change of chromium removal efficiency was observed. Higher chromium adsorption was observed at lower pHs, and maximum chromium removal (60 %) obtained at pH of 2. It is clear that Aloevera has considerable numbers of heterogeneous layer of pores sphere is a good possibility for metal ion to be adsorbed.

INTRODUCTION
One of the heavy metals that have been a major focus in water and wastewater treatment is chromium and the hexavalent form of it has been considered to be more hazardous due to its carcinogenic properties. Chromium has been considered as one of the top 16th. toxic pollutants and because of its carcinogenic and teratogenic characteristics on the public, it has become a serious health concern (Torresdey *et al.,* 2000).Chromium can be released to the environment through a large number of industrial operations, including metal finishing industry, iron and steel industries and inorganic chemicals production (Gao *et al.,* 2007). Extensive use of chromium results in large quantities of chromium containing effluents which need an exigent treatment. The permissible limit of chromium for drinking water is 0.1 mg/L (as total chromium) in EPA standard (EPA, 2007). In addition, National Iranian standard for Cr (VI) concentration in drinking water is 0.05 mg/L (ISIRI number 1053, 1991). There are various methods to remove Cr (VI) including chemical precipitation, membrane process, ion exchange, liquid extraction and electro dialysis (Verma *et al.,* 2006). These methods are non-economical and have many disadvantages such as incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that require disposal or treatment. In contrast, the adsorption technique is one of the preferred methods for removal of heavy metals because of its efficiency and low cost (Li *et al.,* 2007). For this purpose in recent years, investigations have been carried out for the effective removal of various heavy metals from solution using natural adsorbents which are economically viable such as agricultural wastes including sunflower stalks. Eucalyptus bark (Sarin and Pant, 2006), maize bran (Singh *et al.,* 2006), coconut shell, waste tea, rice straw, tree leaves, peanut and walnut husks. The obtained results showed that the adsorption of chromium (VI) by Aloevera. The aims of this study are to 1) investigate the chromium adsorption from aqueous solution by Aloevera 2) study the effect of different parameters such as contact time, pH, adsorbent dose and initial chromium concentration on adsorption process.

MATERIAL AND METHODS

Preparation of adsorbent

The Aloevera was ground and particle sizes between 75 and 300 microns were obtained by passing the milled material through standard steel sieves. Then, they used for experiments without washing or any other physical or chemical treatments.

Batch sorption experiments

The sorption studies were carried out at 30 ±1°C. Solution pH was adjusted with H_2SO_4 or NaOH. A known amount of adsorbent was added to samples and was agitated by jar test at 250 rpm agitation speed, allowing sufficient time for adsorption equilibrium. Then, the mixtures were filtered through filter paper, and the Cr(VI) ions concentration were determined in the filtrate using DR/4000U spectrophotometer by colorimetric techniques according to the standard method No. 3500-Cr B (standard methods, 1992). The effects of various parameters on the rate of adsorption process were observed by varying contact time, t (30, 60, 120, 160 and 180 min), initial concentration of chromium ion, Co (20, 40, 60 and 80 mg/L), adsorbent concentration, W (0.5, and 1.5 g/100 ml) and initial pH of solution (2, 3, 5, 7, 9 and 11). The solution volume (V) was kept constant (50 ml). The chromium removal (%) at any instant of time was determined by the following equation

Chromium removal (‰) = C_o- C_t/ Co x 100

Where, Co and Ct are the concentration of chromium at initial condition and at any instant of time, respectively.

RESULTS AND DISCUSSION

Effect of contact time on chromium adsorption

Contact time is one of the effective factors in batch adsorption process. In this stage, all of the parameters except contact time, including temperature (30 °C), adsorbent dose (0.5g/100 ml), pH (2), initial chromium concentration (20 mg/l) and agitation speed (250 rpm), were kept constant. The effect of contact time on chromium adsorption efficiency showed in Fig. 1. As it is shown, adsorption rate initially increased rapidly, and the optimal removal efficiency was reached within about 180 mts to 60 %. There was no significant change in equilibrium concentration after 180 mts and the adsorption phase reached to equilibrium.

Effect of pH on chromium adsorption

The pH of the aqueous solution is clearly an important parameter that controlled the adsorption process. The experiments of this stage were done under the conditions of constant temperature (30°C), agitation speed (250 rpm), contact time (180 mts), adsorbent dose (0.5 g/100 mL) initial chromium concentration (20 mg/L), pH of solution was changed and the chromium removal was investigated. The experimental results of this stage are presented in Fig. 2. As it is shown, the optimum pH of solution was observed at pH of 2 and by increasing pH, a drastic decrease in adsorption percentage was observed. This might be due to the weakening of electrostatic force of attraction between the oppositely charged adsorbate and adsorbent that ultimately lead to the reduction in sorption capacity (Baral et al., 2006). Adsorption of hexavalent chromium varies as a function of pH with H_2CrO_4, $HCrO_4$, Cr $_2$O $_7$ and CrO_4^{2-} ions appear as dominant species (Gaballah and Kilbertus, 1998). At pH of 2, HCrO4 - is the dominant species. The surface charge of Aloevera is positive at low pH, and this may promote the binding of the negatively charged HCrO4 - ions.

Effect of adsorbent dose on chromium adsorption

At this stage, the experiments were done under the conditions described with constant pH of 2 and variable adsorbent dose (.5,1and 1.5g/100 mL).The effect of adsorbent dose on the adsorption of chromium by Aloevera was presented Fig.3, chromium removal efficiency increased with increase in adsorbent dose, sine contact surface of adsorbent particles increased and it would be more probable for $HCro_4^-$ and $Cr_2O_7^-$ ions to be adsorbed on adsorption sites and thus adsorption efficiency increased (Morshedzadeh et al., 2007).

Effect of initial chromium concentration on adsorption process

Initial concentration is one of the effective factors on adsorption efficiency. The experiments were done with variable initial chromium concentration (20,40,60 and 80 mg/L) and constant temperature (30 °C), pH (2), agitation speed (250 rpm), contact time (180mts) and 0.5 g of adsorbent dose (0.5 g/100 mL). The experimental results of the effect of initial chromium concentration on removal efficiency were presented in Fig. 4. As in Fig. 4 is shown, chromium removal efficiency decreased with the increase in initial chromium concentration. In case of low chromium concentrations, the ratio of the initial number of moles of chromium ions to the available surface area of Chromium adsorption by Aloevera.

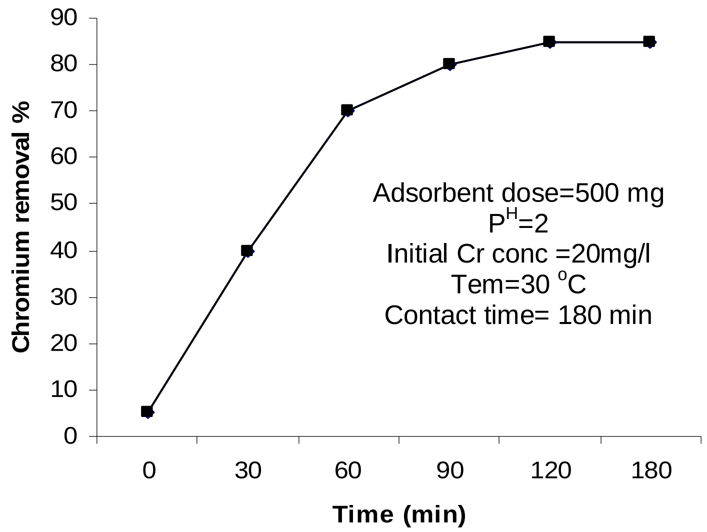

Fig. 1: Effect of contact time on adsorption process efficiency

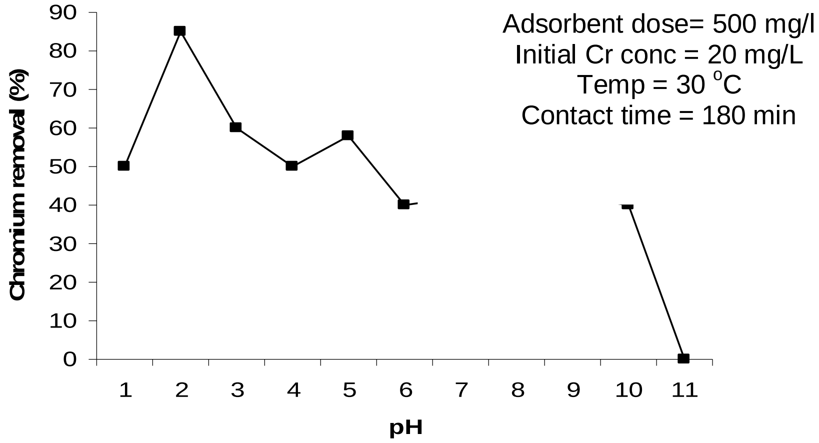

Fig. 2: Effect of pH on Cr (VI) removal

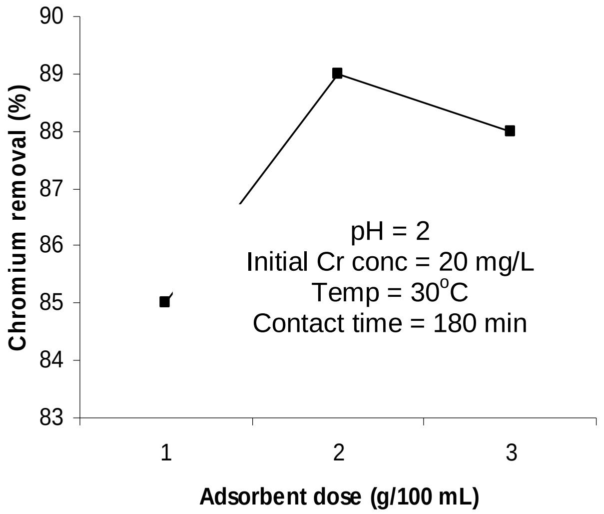

Fig. 3: Effect of adsorbent dose on Cr(VI) removal

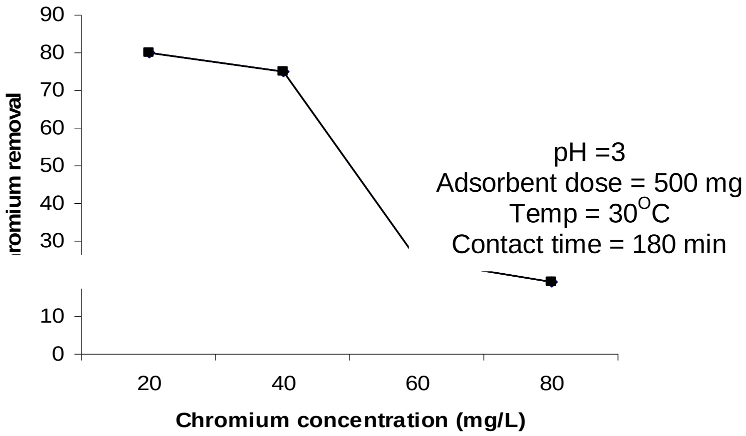

Fig. 4: Effect of chromium concentration on Cr (VI) removal

SEM micrographs of Aloevera particle

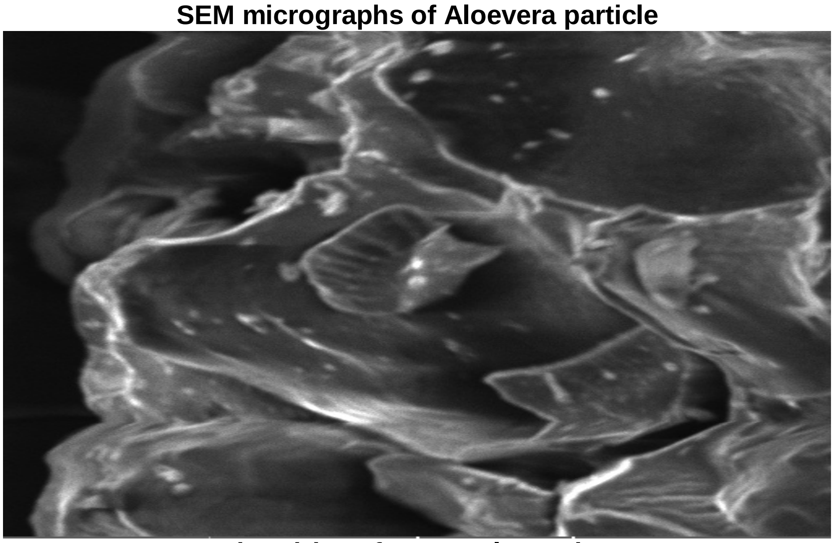

Fig. 5(a): Before metal sorption

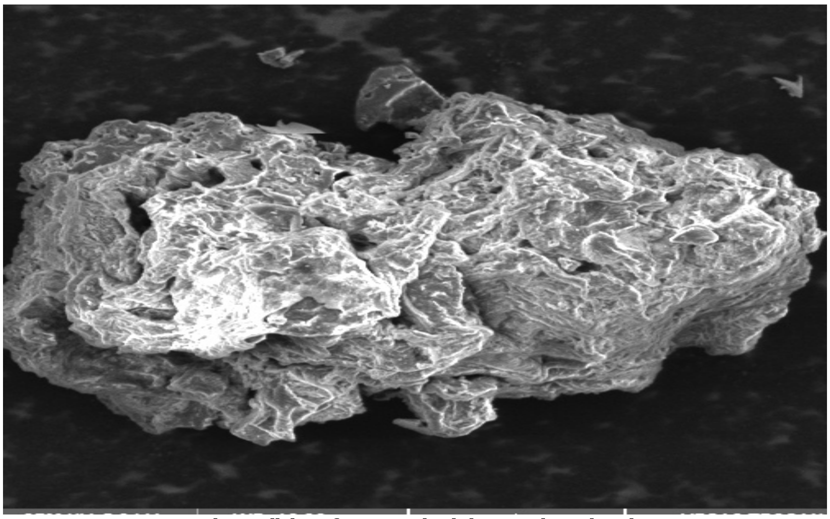
Fig. 5(b): after Cr (VI) ion adsorbed

Fig 5(a &b) show that SEM micrographs of Aloevera sample before and after Cr(VI) ion adsorption It is clear that Aloevera has considerable numbers of heterogeneous layer of pores sphere is a good possibility for metal ion to be adsorbed. The surface of the adsorbent, however, clearly shows that covered with metal ion molecules

CONCLUSIONS

The morphology size distribution of Aloevera presents uimodal distributions at lower temperature. The increasing temperature leads to the decrease of BET surface area, average pore diameter and volume in the mesopore scale. The results revealed the potential of Aloevera, an agricultural waste material, to be a low cost adsorbent for removing metal ion from aqueous solution

REFERENCES

1. Baral SS, Dasa SN and Rath P. Hexavalent chromium removal from aqueous solution by adsorption on treated sawdust. Biochem Eng J. 2006;31(3):216.
2. Gaballah I and Kilbertus G. Recovery of heavy metal ions through decontamination of synthetic solutions and industrial effluents using modified barks. J Geochem Explore. 1998;62 (1-3):241–286.
3. Gao H, Liu Y, Zeng G, Xu W, Li T and Xia W. Characterization of Cr (VI) removal from aqueous solutions by a surplus agricultural waste-rice straw. J. Hazard. Mater. 2007;150(2): 446-452.
4. Li Q, Zhai J, Zhang W, Wang M and Zhou J. Kinetic studies of adsorption of Pb (II), Cr(III) and Cu(II) from aqueous solution by sawdust and modified peanut husk. J hazard Mater. 2007;144(1):163-167.
5. Morshedzadeh, Soheilizadeh HR, Zangoie S and Aliabadi M. Removal of chromium from aqueous solutions by lignocellulosic solid wastes. 1st. Environment conference, Tehran University, Department of Environment Engineering. 2007.
6. Sarin V and Pant KK. Removal of chromium from industrial waste by using eucalyptus bark, Bioresource Technol. 2006;97(1):15–20.
7. Singh KK, Talat M and Hasan SH. Removal of lead from aqueous solutions by agricultural waste maize bran. Bioresource Technol. 2006;9(16):2124-2130.
8. Torresdey JLG, Tiemann KJ and Armendariz V. Characterization of Cr (VI) binding and reduction to Cr(III) by the agricultural byproducts of Avena monida (Oat) biomass. J Hazard Mater. 2000;80(1-3):75–188.
9. Verma A, Chakraborty S and Basu JK. Adsorption study of hexavalent chromium using tamarind hull-based adsorbents. Separ Purif Tech. 2006;50(3):336–341.