

ADSORPTION OF LEAD FROM WATER SOLUTION ONTO A ACTIVATED CARBON FROM BOIS CARRÉ SEEDS

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Introduction

The presence of metals in the environment can be natural or linked to the human activities like mining, electroplating industries, fossils combustion. Metals are present in the atmosphere as in the water. Untreated effluents may have an adverse impact on the environment. Heavy metals including cadmium, lead and zinc are toxic to aquatic flora and fauna even in relatively low concentrations. Various technologies such as precipitation, ion exchange, membrane filtration, reverse osmosis are used for the water treatment. The use of activated carbon to remove heavy metal ions from waste water by adsorption is a well established process [1-2]. The economics of this process depends mainly on the cost of the adsorbent material. The bois carré (*Citharexylum Fruticosum L.*) seed is an agricultural by-product since only the leaves of the trees have a medicinal use. The adsorption capacity of bois carré seed activated carbon to remove lead from water is studied in this work.

Experimental

Preparation and characterization of the activated carbon from Bois carré seeds

The activated carbon from Bois carré seeds is prepared by soaking 10 g of seeds (size: 0,4-1 mm) with 30 g of 30 wt% of phosphoric acid solution during 68h resulting in a solvent impregnation ratio of 0,9. Then the solid mixture is heated at 450 °C (heating rate: 10°C/min) for 2h in a nitrogen atmosphere. After cooling to room temperature, the sample is rinsed with hot distilled water in a soxhlet extractor until the pH remains constant. Then, the activated carbon sample is dried at 105 °C for 2 days.

The texture of the activated carbon is characterized via adsorption of nitrogen at 77 K using a Micromeritics apparatus ASAP 2010. About 0.30 g of sample is outgassed prior to effecting the adsorption measurements. The BET surface area (S_{BET}), the micropore volume (V_{mi}), the mesopore volume (V_{me}), the median pore diameter are determined from the N_2 adsorption isotherm.

The surface properties of the activated carbon are characterized via the Boehm method as described elsewhere [2]. The pH ZPC of the activated carbon is determined using the potentiometric titration method. All the titrations (Boehm and pH ZPC) are performed on a 809 SM Titrino automatic titrator (Metrohm).

Equilibrium sorption tests

In a typical adsorption run, a weight (W) of activated carbon is put in contact with a volume (V) of lead ion solution, at a fixed pH, for 47h (equilibrium time). The flask is put in a shaker water bath maintained at the constant temperature of 30°C. The dose adsorbent D is calculated by the ratio W/V. The initial concentration of lead is comprised between 30 and 150 mg/L. Note that the initial concentrations of lead used in this study are in accord with the lead concentration found in industrial effluents. pH 3 and 5 are obtained by mixing predetermined volumes of 0.01 M HNO_3 to the lead solution ; pH 7, 9 and 11 are obtained by adding predetermined volumes of 0.01 M NaOH solution.

At the equilibrium time, 5 mL of solution is removed from the flask, filtered and the concentration of remaining lead in solution is measured. The concentration of lead present in the initial solution (C_0) and in the filtrated solutions (C) are measured with the atomic absorption spectrometer AA240FS from Varian; the pH of the solutions are measured with a Mettler Toledo FG2 pHmeter. All batch sorption tests and absorption measurements are duplicated.

The amount of lead adsorbed at equilibrium (Q_{eq}) is calculated by the difference between the initial (C_0) and the equilibrium lead concentration (C_{eq}): $Q_{eq} \text{ (mg/g)} = (C_0 - C_{eq})/D$ (1).

Results and Discussion

Table 1 gives the physical and the chemical properties of the activated Bois carré seeds. As expected from the low temperature of carbonization, the BET surface area and the micropore volume are moderate contrarily to the acidic properties which are relatively high. It can be noted that the sorption mechanism of lead on the activated carbon is linked to the acid sorption sites. So, this activated carbon can expect to be a good lead adsorbent.

The lead adsorption isotherm of activated bois carré seeds carbon at 30 °C is positive, regular and concave to the concentration axis. The isotherm is of type L (Figure 1). PbII uptake at equilibrium is 48 % with a 30 mg/L lead initial concentration for the activated carbon from Bois carré seeds and decreases at higher concentrations.

The equilibrium results are fitted according to the Langmuir and the Freundlich models [1-2]. The Freundlich model takes into account a variation in the adsorption energy of the sites during the adsorption process while Langmuir not. The linear form of the both isotherm models is used:

- Langmuir : $C_{eq}/Q_{eq} = C_{eq}/Q_m + 1/(KQ_m)$ (2)

- Freundlich : $\ln Q_{eq} = 1/n \ln C_{eq} + \ln K_f$ (3)

Q_{eq} is the amount of lead adsorbed at equilibrium, Q_m is the monolayer amount of lead adsorbed, they are expressed in mol/kg; C_{eq} is the equilibrium concentration, it is expressed in mol/L. The value of the squared correlation coefficient R^2 for the two models is given in table 2. Analyses of the regression coefficients show that the Freundlich isotherm fits the data better. Consequently, the surface of the activated bois carré seeds carbon is inhomogeneous towards the lead adsorption. This result is in agreement with the different acid sites found on this activated carbon implying different ways of sorption

for the lead. The Freundlich constants n and K_f can be determined and compared to those of the literature (see table 3). The values obtained for the activated carbon from Bois carré seeds are classical values for the literature even if the conditions of preparation of the activated carbon are sweet.

The effect of the adsorbent dose (figure 2) and the pH (figure 3) on the sorption are studied. They show that the sorption of lead is favored at the adsorbent dose of 1 g/L, pH 7. At pH inferior to pH PZC, the acid surface groups of the activated carbon are positively charged, consequently, the sorption of Pb^{2+} is not favored because of the repulsive interactions between the carbon and the lead. Moreover, the Pb^{2+} competes with the H^+ for the sorption on the active sites at low pH; at pH superior to pH PZC, the surface groups are negatively charged, consequently the sorption of Pb^{2+} and $Pb(OH)^+$ are favoured. On the opposite, at pH superior to 7.7, there is precipitation of $Pb(OH)_2$, then the sorption is difficult because the lead species is not charged.

Table 1. Physico chemical properties of the activated Bois carré seed carbon.

	Activated Bois carré seeds carbon
S_{BET} (m^2/g)	594
V_{mi} (cm^3/g)	0.28
V_{me} (cm^3/g)	0.08
Median pore diameter (nm)	0.74
Total of acid surface groups (mmol/g)	3.44
- Carboxyl groups	0.58
- Hydroxyl groups	2.25
- Lactone groups	0.61
Total of basic surface groups (mmol/g)	0.0
pH ZPC	6,3

Table 2. Correlation coefficients for the modelizations

	R^2
Langmuir	0.911
Freundlich	0.973

Table 3. Freundlich parameters

	Activated Bois carré seeds carbon
	T = 30°C, pH 5, D = 1g/L
n	3,76
K_f	1,06

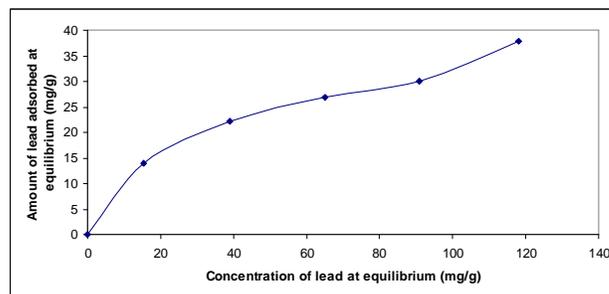


Fig. 1: Sorption isotherm of lead at 30°C

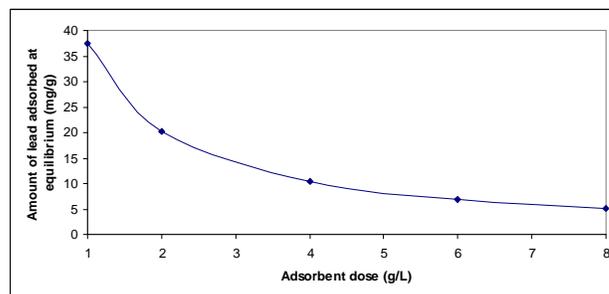


Fig.2: Effect of the adsorbent dose on the sorption of lead

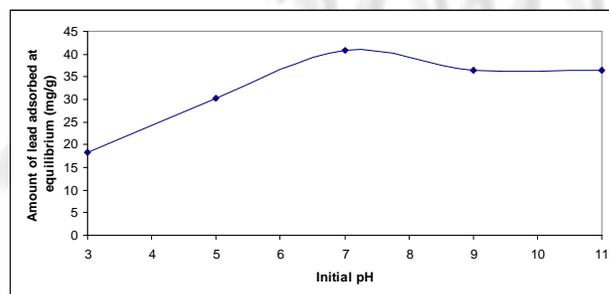


Fig. 3: Effect of the pH on the sorption of lead

Conclusions

A activated carbon from Bois carré seeds is prepared by chemical activation with phosphoric acid at the low activation temperature of 450°C to develop more acid surface sites. The sorption of Pb (II) is investigated at 30°C with varying initial lead concentrations, pHs and adsorbent doses. The study shows that, at 30°C, the optimum initial conditions are a lead concentration of 30 mg/L, a pH of 7 and a adsorbent dose of 1g/L. The equilibrium of adsorption of Pb (II) is explained by the Freundlich model assuming inhomogeneous sorption sites for the lead. This work highlights the importance of the surface sites on the sorption and to conclude with, it appears that production of activated carbons from Bois carré seeds at low temperature might be used successfully like inexpensive sorbents for the water lead treatment.

References

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