

REMOVAL OF HEAVY METALS FROM WASTEWATER USING COW BONE CHARCOAL

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Introduction

Bone charcoal, a mixed adsorbent containing around 10% carbon and 90% calcium phosphate, is mainly produced by thermal treatment of bones. Structurally, calcium phosphate in bone charcoal is in the hydroxyapatite form [1-2]. Traditionally, bone charcoal has been used to remove color in sugar solutions in the sugar refining industry. Recent studies use bone charcoal to adsorb radioisotopes of antimony and europium ions from radioactive wastes [1-6]. Those authors suggested that chemisorption was the main operating mechanism for $^{152}\text{Eu}^{3+}$ removal with a high degree of irreversibility fixation on bone charcoal from the aqueous solution. They claim that sorption is due to cation exchange of metal ions onto hydroxyapatite. In the present work the adsorption of nickel and copper ions from solutions, onto bone charcoal in agitated batch absorber vessels was studied. The main goal of this study is to examine the ability of bone charcoal to remove these ions from aqueous solution and therefore evaluate its potential to be used in wastewater treatment systems.

Adsorption equilibrium isotherm

Batch sorption experiments were conducted using 100 mL aliquots of the test solutions; pH adjusted containing 100 $\text{mg}\cdot\text{L}^{-1}$ of each one of the ions in: Ni^{2+} and Cu^{2+} in monocomponent systems; placed in 250 mL amber closed bottles. A known quantity (0.01–0.15 g) of CBC was added to each bottle. Solutions were stirred at 200 rpm for periods between 5 and 110 min at 298 ± 1 K. Bone charcoal was removed by filtration and Ni^{2+} and Cu^{2+} molar concentrations were measured by atomic absorption spectroscopy (in a Perkin Elmer AAnalyst equipment), at the end of each period of time. Blank solutions were also prepared and analyzed. Solution pH changes as metal ion concentration changes during adsorption process. A previous survey was made to determine solution pH which produces maximum adsorption. pH value of each metal ion solution was adjusted using either 0.01 N NaOH or 0.01 N HNO_3 solutions and employed volumes, registered to calculate final solution volume.

Immersion enthalpy

Immersion enthalpies of CBC were determined in solutions of Ni^{2+} and Cu^{2+} with concentrations ranging from 20 to 100 $\text{mg}\cdot\text{L}^{-1}$ for the maximum adsorption pH of 5.1. Immersion enthalpies were also determined for 100 $\text{mg}\cdot\text{L}^{-1}$ solutions at all pH values studied. This determination was performed in a heat conduction microcalorimeter with a stainless steel calorimetric cell [7]. 30 mL of the solution to be used were pre-heated at 298 K; then placed in the cell. A sample of approximately 0.500 g CBC was weighed and placed inside the calorimetric cell in a glass ampoule. Microcalorimeter was then assembled. When the equipment reached the temperature of 298 K, potential readings were registered after a period of approximately 15 minutes, with readings every 20 seconds, glass ampoule was broken and generated thermal effect registered. Electric potential readings continue for approximately 15 minutes more and at the end of the experience, the equipment was electrically calibrated.

Results and Discussion

Adsorption isotherms from aqueous solution

Linear regression equation for the Freundlich and Langmuir adsorption isotherm is shown on Table 1. Values of K_F and n were calculated from the intercepts and slopes of the Freundlich and Langmuir plots respectively and are shown on this table. Adsorption is favorable for values $0.1 < 1/n < 1.0$ [35]. Freundlich equation frequently gives an adequate description of adsorption data over a restricted range of concentration, even though it is not based on any theoretical background. Apart from a homogeneous surface, Freundlich equation is also suitable for a highly heterogeneous surface and an adsorption isotherm lacking a plateau, indicating a multi-layer adsorption [6]. Values of $1/n$, less than unity are an indication that significant adsorption takes place at low concentration but the increase in the amount adsorbed with concentration becomes less significant at higher concentration and vice versa [5,6]. The magnitude of K_F and n , shows that it is possible an easy separation of heavy metal ion from aqueous solution and a high adsorption capacity. Also, as K_F value increments, the greater the adsorption intensity. Therefore, the K_F values which are higher for the Cu^{2+} confirms by these model that the adsorption capacity of it is greater than that of the others ions. On the other hand, a relatively high R^2 values indicates that this model is adjusted more confidently; this parameter is shown in the Table 4. According to obtained values, Langmuir model fits better the experimental data of the present study.

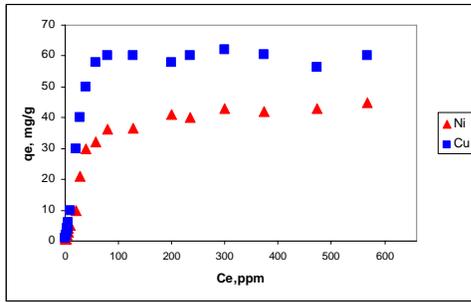


Fig. 4a. CBC adsorption isotherms removal of Ni²⁺ and Cu²⁺ from aqueous solution.

Table 1.

Isotherm parameters of Mn²⁺, Fe²⁺, Ni²⁺ and Cu²⁺ adsorption on cow bone charcoal3.5. Immersion enthalpies

	Freundlich model				Langmuir model			
	Linea r K _D (L/g)	K _F	1/n	R ²	q _{max} (mg/g)	b (L/g)	R _L	R ²
Ni ²⁺	7,89	26.87 6	0.643	0.9745	32.54	1.25	0.005	0.9988
Cu ²⁺	8,88	34.86 5	0.759	0.9876	35.44	1.34	0.005	0.9999

Results show that immersion enthalpies are constant at low initial concentrations. Initial concentrations above 40 mg·L⁻¹ exhibits a steady increment up to 90 mg·L⁻¹. The highest value of enthalpy was obtained for the immersion of cow bone charcoal in the copper ions solutions, with the while the lower value of immersion enthalpy was obtained for the immersion of cow bone charcoal in the solutions of manganese. Enthalpy values were between - 60 J·g⁻¹ (Cu²⁺- CBC) and - 45 J·g⁻¹ (Mn²⁺- CBC), as shown in Figure 6. This behavior agrees with textural characteristics of cow bone charcoal and the sizes of the ions under study. It should be noted that the behavior of immersion enthalpies in the solid prepared in this work, is very similar to that of an isotherm.

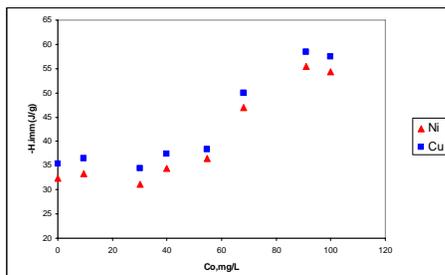


Fig. 6. Immersion enthalpies for Mn²⁺, Fe²⁺, Ni²⁺ and Cu²⁺ aqueous solutions ions concentration at pH 5.1. T= 298 K

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