

# SURFACE ACIDITY OF ACTIVATED CARBON AND ITS RELATION TO METAL ION ADSORPTION

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## Introduction

Extensive literature can be found regarding the removal of heavy metals by activated carbon. It is well known that solution pH is the most important factor influencing the heavy metal adsorption. Variation in pH affects the speciation of metals in solution as well as the distribution of hydrous surface sites. Other parameters such as metal competition, surface area, presence of organics and complexing agents have been reported (but pH is still the key factor in determining the effectiveness of metal removal by activated carbon process. Another significant parameter affecting metal adsorption is the acidity of the carbon surface. More acidic carbons (or L-type carbons) are better metal adsorbents than so-called H-type carbons (Mattson and Mark, 1971). In this work, the surface acidity of 2 types of activated carbon and its relation to metal adsorption is illustrated.

## Experimental Procedures

Activated carbon samples used were Nuchar SA (Westvaco Co.) and Filtrasorb 400 (Calgon Corporation).

Surface acidic characteristics of the carbon samples were determined by alkalimetric titration. The method consists in titrating two 10 g/L carbon suspensions with perchloric acid (0.1 N) and sodium hydroxide (0.1 N), individually. The acidity constants ( $K_1$  and  $K_2$ ) can be easily calculated and it is described elsewhere (Huang, 1981). Table 1 shows the surface acidity and other physical-chemical properties of the carbon samples used.

The two carbon samples chosen present very distinct surface characteristics with the exception of specific surface area.

Table 1. Some properties of the activated carbon samples.

Sample	surface acidity		$pH_{ZPC}$	specific surface area ( $m^2/g$ )
	$pK_1$	$pK_2$		
Nuchar SA	2.3	5.7	4.0	1351
Filtrasorb 400	8.6	12.2	10.4	1236

source: Corapcioglu and Huang, 1987

Equilibrium batch adsorption experiments were conducted as follows: to a series of 125 mL Nalgene bottles  $NaClO_4$  (1 M), metal perchlorate solution (of the metal to be studied, 0.1 M), 90 mL of distilled water and certain amount of the carbon sample were added. The pH of each of the mixtures were adjusted to desired values using known volume of NaOH or  $HClO_4$  at various concentrations and the volume was completed to 100 mL with distilled water. The bottles were then placed in a mechanical shaker and shaken for preselected. The final pH values were recorded and the suspensions were filtered through 0.45  $\mu m$  filter membrane. The filtrates were analyzed for residual metal concentration using an atomic absorption spectrophotometer. Table 2 presents the experimental conditions of the tests conducted.

Table 2. Conditions for the batch equilibrium experiments.

	Carbon conc.	$[M]_{initial}$	Ionic strength	Equil. time
	(g/L)	( $\times 10^4 M$ )	(M of $NaClO_4$ )	hour
Cd(II)	2	1.0	0.1	2
Co(II)	1	0.5	0.01	24
Cu(II)	10	1.0	0.05	24
Pb(II)	10	1.0	0.05	24
Ni(II)	10	1.0	0.05	24
Zn(II)	10	1.0	0.05	24

## Results and Discussion

Figures 1 and 2 show the metal adsorption as a function of pH onto Nuchar SA and Filtrasorb 400, respectively. As observed in both figures, the percent removal increases as pH increases for all the metals. For the Nuchar SA carbon sample, the extent of adsorption is higher than for the Filtrasorb 400 at the entire range of pH studied. The L-type carbons such as Nuchar SA are more acidic and possess negatively charged surface sites within a large range of pH, which favors the metal adsorption. Figure 1 also shows that there is a slight decrease in metal adsorption at the alkaline region for some of the metals studied such as Cu(II), Pb(II), Ni(II) and Zn(II). This observation can be explained by presence of phosphoryl groups (Corapcioglu and Huang, 1987). These groups may form complexes with metals which are non-adsorbable.

In contrast with the Nuchar SA carbon sample, the Filtrasorb 400 (a H-type carbon) have large pK values and are effective in removing metal ions only at very high pH conditions. The removal percent of Cd(II) and Co(II) have shown to be satisfactory at pH values higher than 10.

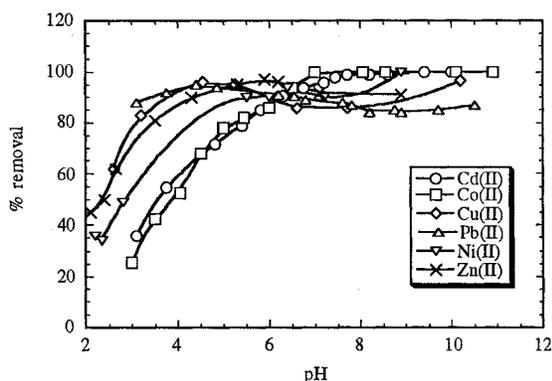
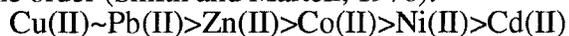


Figure 1. Percent removal of various heavy metals from aqueous solution as a function of pH using Nuchar SA activated carbon. Experimental conditions as shown in Table 2.

Among the metal species studied, Cu(II) and Pb(II) are the ones adsorbed at largest extent while Co(II) and Cd(II) are the metals least removed from aqueous solution. The differences in adsorption behavior between various metals can be better illustrated in Figure 2. Stability constants of metal hydroxide complexes follows the order (Smith and Martell, 1976):



which is in agreement with the results shown in Figure 2.

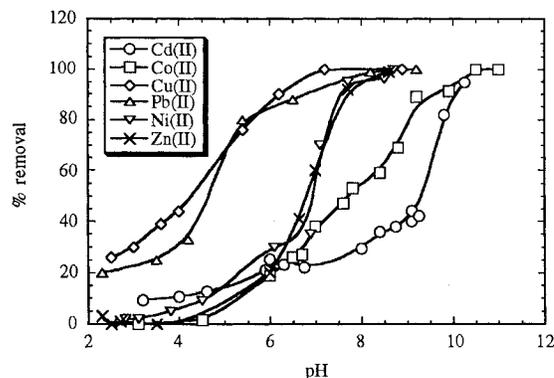


Figure 2. Percent removal of various heavy metals from aqueous solution as a function of pH using Filtrasorb 400 activated carbon. Experimental conditions as shown in Table 2.

## Conclusions

Information on the surface acidity of an activated carbon is crucial to the satisfactory achievement of metal removal from aqueous solution. One should carefully consider the type of carbon (L-type or H-type carbon) to be used in the removal process as well as the chemical characteristics of the metals.

## References

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