

THE ADSORPTION OF METAL IONS ON SURFACE TREATED ACTIVATED CARBON FIBER

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Introduction

The adsorption of metal ions of hydrous oxide is strongly affected by surface characteristics of carbon materials and pH of solution[1]. It has been proved that activated carbon fibers(ACFs) have not only excellent adsorption capacity due to highly microporous structure but also outstanding reduction property[2]. For some carbon materials, such as carbon blacks, charcoals, graphite, diamond, it is known that the reduction of metal ions in solution is related to oxygen-containing groups of carbon surface[3]. Aim of this study is to modify the ACF surface structure with a relatively large amount of oxygen-containing surface groups, by treating ACF with strong acidic and basic solution, and, therefore, to enhance Cu^{+2} , Ni^{+2} removal efficiency from low-concentrated mixed solution.

Experimental

The activated carbon fiber(ACF-20) was prepared by steam activation of pitch-based carbon fiber. The specific surface area and textural characteristics were obtained from N_2 adsorption at 77K using the Autosorb-1 MP. The activated carbon fiber was, boiled with distilled water at 100°C and dried in vacuum for 24 hours prior to use. Surface modification of ACF with 1N NaOH, 1N HCl was performed at 50°C for 1hr. The metal mixed solution was prepared by adding $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ to distilled water under N_2 purging. The initial pH of solution was adjusted to pH 1~7 with 0.1N HCl and 0.1N NaOH. The adsorption was performed by adding 0.1g activated carbon fiber to 100ml metal solution and shaking 24 hours at 25°C. The concentration of the residual metallic ions was analysed by atomic absorption

spectrophotometer.

Results and Discussion

Fig. 1 shows the amount of metallic ions removed by ACF, NaOH treated, with respect to initial pH of solution. About 80% of dissolved copper(II) was removed between pH_i 5 and pH_i 6. compared to that of nickel(II). Also, copper (II) adsorption increased as initial pH increased but nickel(II) was not affected by pH_i.

From table 1, it was stated that, although specific surface area of ACF-20 was to some extent decreased after treatment with NaOH, HCl, it's surface area do not play important role in adsorption of Cu(II), Ni(II). This point of view was shown in Fig. 2, in which the amount of both Cu(II) and Ni(II) adsorbed was very lower than that of decrease of surface area. It clearly identified the fact that the reduction of metal ions in solution was mostly related to oxygen-containing groups of carbon surface.

According to nomenclature proposed by Steenberg[1], ACFs that are activated in oxygen or air at higher temperature was classified to 'H carbon', so it can be supposed that the surface of ACF-20 is similar to carbons with basic surface oxides. However, this carbon has simultaneously two kinds of surface oxide groups, which are one adsorbs alkali but not acid and another the opposite. Ruowen[4], from studies on the mechanism of the reaction of ACFs with oxidants, shows that the oxidation of ACF involves at least two processes, which are the formation of hydroxyl(or phenolic) groups and of carbonyl(or carboxyl) groups. Furthermore, the oxidation of ACF produces carbon dioxide and H⁺ ion. But, as shown in Fig. 3, the pH_f when the adsorption was completed was increased in case of NaOH treated, and not changed in HCl. This result

deduced the fact that surface acidic groups of ACF-20 was neutralized with strong base, NaOH, therefore a bare carbon surface may act as a Lewis base that accepts complexing protons. According to this reaction, the oxygen-surface groups do not play a role in establishing the alkaline pH, instead the basal plane is the dominant influence for increasing pH.

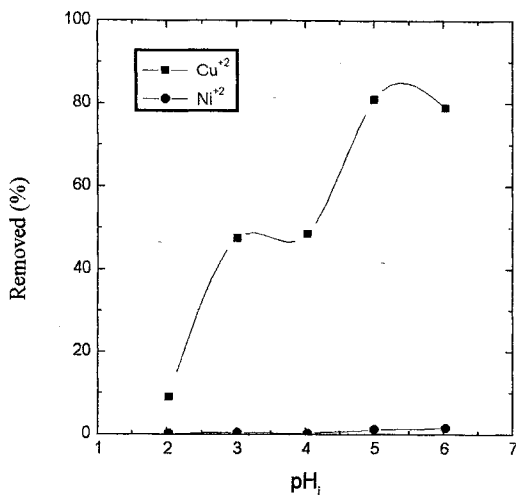


Fig.1 The removal of metal ions on ACF-20 treated with NaOH as to pH_i at 25°C, 240rpm, 24hr, Cu=1mM, Ni=1mM.

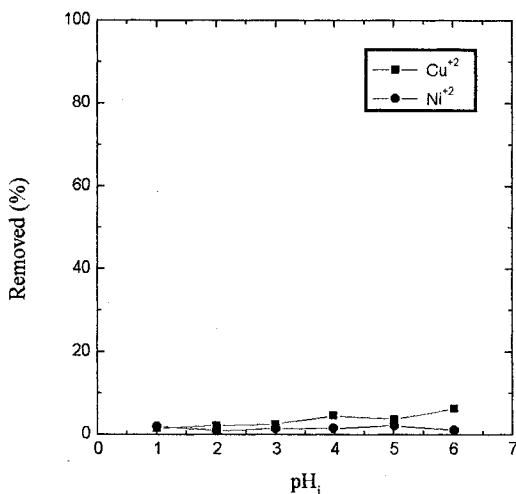


Fig.2 The removal of metal ions on ACF-20 treated with HCl as to pH_i at 25°C, 240rpm, 24hr, Cu=1mM, Ni=1mM.

References

1. Bansal R.C., Donnet J.B., Stoeckli F., in *Active Carbon*, Marcel Dekker. New York, 1988.
2. Puri B.P., in *Chemistry and Physics of Carbon*, vol. 6, ed. P.L. Walker Jr. Marcel Dekker. New York, 1970, p. 191.
3. Ryu S.K., Shim J.W., Jung H.H., Jung C.H., Oh W.Z., in *Carbon'95 (Ext. Abstr. 22nd Biennial Conf.)*, San Diego, CA, 1995. pp. 472-493.
4. Ruowen, F., Hanmin, Z. and Yun, L., *Carbon*, 1994, 32, 593.

Table 1. Textural characteristics of ACF-20.

	ACF	ACF-NaOH	ACF-HCl
BET surface area (m ² /g)	2097	1638	1531
average pore radius (Å)	10.1	9.8	10.7
total pore volume (cc/g)	1.064	0.797	0.816
micropore volume (cc/g)	1.018	0.059	0.269
micropore area (m ² /g)	2064	186	619

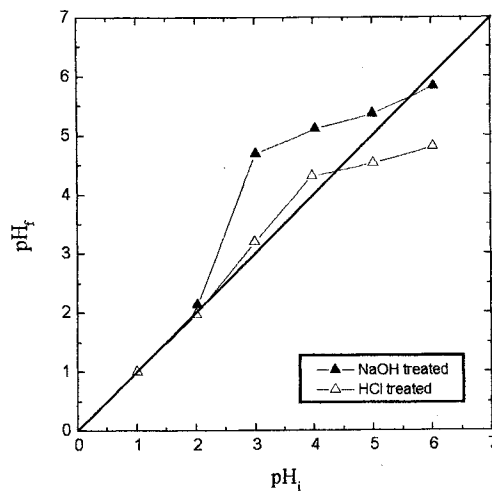


Fig.3 The pH change of solution when metals adsorbed on NaOH, HCl treated ACF-20.