

SORPTIVE PROPERTIES OF ACTIVATED CARBONS WITH DIFFERENT DEGREES OF SURFACE OXIDATION.

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Introduction

It is well known that surface oxygen-containing functional groups are formed in the course of modification of activated carbon by strong oxidising agents [1,2]. These groups determine the sorptive properties of oxidised activated carbons. The amount of oxygen-containing groups on the carbon surface is usually assessed by titration with bases of different strength [3].

The aim of the present research is to investigate how the degree of oxidation can influence the proportion, the concentration and the type of oxygen-containing groups on the surface of carbon. This study is part of a programme to elucidate the selective sorption mechanism of low concentrations of heavy metals from aqueous solutions.

The present paper considers the effect of degree of oxidation on selective sorption of copper and lead from aqueous solutions.

Experimental

Activated carbon derived from apricot stones was a precursor for oxidised activated carbon used in the present research. Oxidation of activated carbon was performed in hot air resulting in three samples with bulk density of $0.34 \pm 0.005 \text{ g/cm}^3$. The conditions of oxidation of resulting carbons are presented in Table 1.

| Carbon | Conditions of oxidation | |
|---------|-------------------------------------|----------------------|
| | temperature, ($^{\circ}\text{C}$) | exposure time, (hrs) |
| KAU-0.8 | 410 | 3 |
| KAU-1.2 | 430 | 3 |
| KAU-1.8 | 450 | 5 |

Table 1. Air oxidation conditions of activated carbons.

The concentration of different types of surface functional groups after oxidation were determined by titration with sodium hydrogen carbonate, sodium carbonate, sodium hydroxide and sodium ethoxide [3]. Equilibrium sorption isotherms for copper and lead were determined in batch mode by contacting various amounts of the sorbents with the metal-containing solutions for 24 hours at room

temperature. The selectivity tests were performed under dynamic conditions using packed mini-columns. The bed volume of the mini-columns was 0.66 cm^3 . Metal concentrations were determined by acetylene-air AA spectrometry.

Results and Discussion

| Groups | Carbons KAU | | |
|-------------------------------|-------------|-------|-------|
| | 0.8 | 1.2 | 1.8 |
| Carboxylic groups, (meq/g) | 0.130 | 0.370 | 0.540 |
| % of total capacity | 16 | 28 | 45 |
| Lactones-lactoles, (meq/g) | 0.320 | 0.479 | 0.560 |
| % of total capacity | 39 | 36 | 31 |
| Phenolic groups, (meq/g) | 0.362 | 0.457 | 0.680 |
| % of total capacity | 45 | 34 | 38 |
| Total (non carbonyl), (meq/g) | 0.811 | 1.306 | 1.779 |
| Carbonyl groups, (meq/g) | 1.030 | 1.138 | 0.664 |

Table 2. Concentrations of surface functional groups for the carbons used.

From the data presented in Table 2 it can be inferred that acidic groups of weak character are predominantly formed at low degrees of surface oxidation. The proportion of carboxylic groups over other weakly acidic groups increases as the degree of surface oxidation is enhanced. Thus, at low degrees of surface oxidation the ion-exchange of Na^+ for H^+ begins at higher pH values (pH=6.2 for KAU-0.8). As the degree of surface oxidation is enhanced the ion-exchange starts at lower pH values (pH=4.6 for KAU-1.2 and pH=3.7 for KAU-1.8). This confirms that the surface acidity strongly depends on the degree of surface oxidation. It follows that these changes in surface acidity will affect metal sorptive properties of the carbons.

Sorption of heavy metals from aqueous solutions by carbons with different degrees of surface oxidation has been studied. Sorption isotherms for lead and copper are presented in Figures 1 and 2. It can be seen that the degree of surface oxidation affects the sorptive capacity of carbon. The sorptive capacity for copper is greater than for lead.

Sorption of lead and copper by the carbons in the presence of nickel and cadmium under dynamic conditions

in mini-column runs are presented in Figures 3, 4 and 5. It can be inferred that the selectivity of the carbons for copper increases with the degree of oxidation. This is interesting since nitric acid oxidised carbons appeared to show selectivity preference for lead [4].

Conclusions

The proportion of carboxylic groups, compared to the weaker functional groups, increases with the overall degree of oxidation. This affects the acidity of carbon surface. These changes increase the capacity and selectivity of air oxidised carbon for copper over lead.

References

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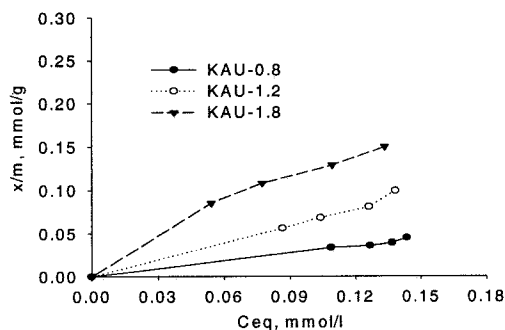


Figure 1. Sorption isotherms for lead on the carbons with different degrees of surface oxidation.

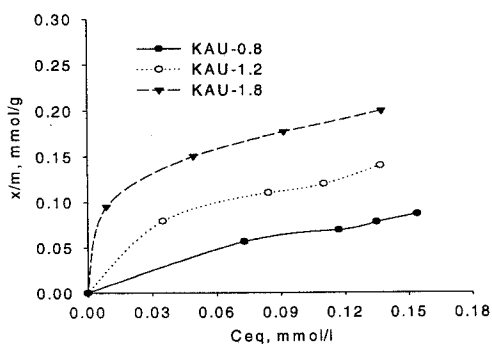


Figure 2. Sorption isotherms for copper on the carbons with different degrees of surface oxidation.

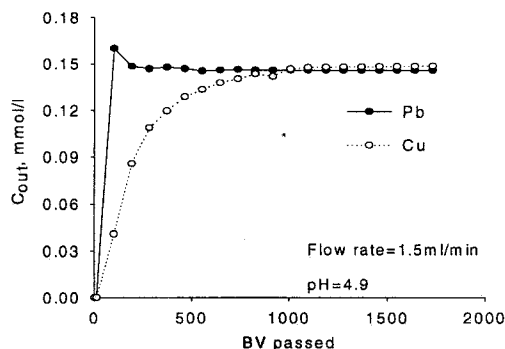


Figure 3. Breakthrough curves for lead and copper on KAU-0.8.

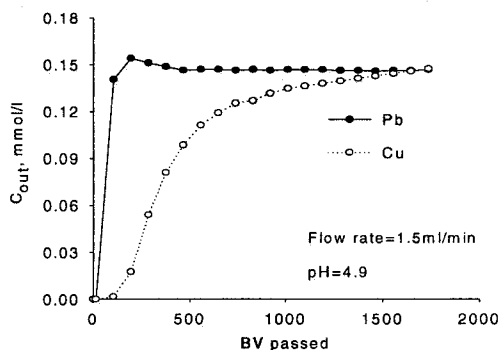


Figure 4. Breakthrough curves for lead and copper on KAU-1.2.

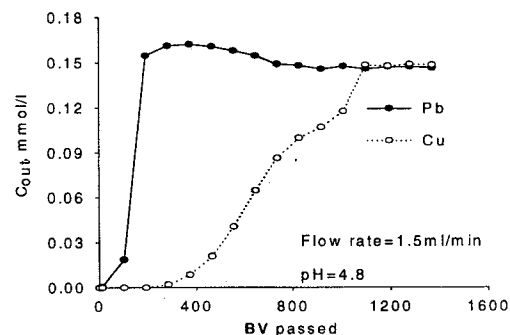


Figure 5. Breakthrough curves for lead and copper on KAU-1.8.

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