

POSTER

BENZENE ADSORPTION ON MICROPOROUS CARBONS OF CONTROLLED STRUCTURAL PROPERTIES

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Introduction

Active carbons found a wide application in industry, science and everyday life. Especially synthetic microporous carbons prepared by carbonization and activation of various polymeric materials are of great interest because they have very low ash content, high mechanical stability and possess better sorption properties in comparison to regular active carbons. In general, microporous carbons are heterogeneous because they possess various surface groups, impurities and/or irregularities (surface heterogeneity) as well as nanopores of different sizes and shapes (structural heterogeneity) [1]. Their porous structure is a combination of micropores (widths below 2nm), mesopores (widths between 2 and 50 nm) and macropores (widths above 50 nm), which are accessible to various adsorbate molecules. An important feature of the porous structure of carbons is a large amount of slit-like micropores formed between twisted aromatic sheets of the matrix. In the case of synthetic carbons this structure depends significantly on the kind of polymeric material used. To a great extent the structural properties of synthetic carbons can be controlled by selecting suitable carbonization and activation conditions.

In the current work two microporous carbons of controlled structural properties were studied by using equilibrium benzene adsorption isotherms measured gravimetrically up to the saturation pressure. In addition to the standard characterization of these carbons, their surface and structural parameters were evaluated according to Jaroniec-Choma method [2] and compared with those for the BPL commercial active carbon. This comparative analysis showed that the microporous structure of synthetic carbons studied differs significantly from that for the BPL carbon.

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Experimental

Equilibrium benzene adsorption isotherms on the A and B synthetic carbons were measured at 293 K by using a custom-built, vacuum sealed gravimetric apparatus. These isotherms are shown in Figure 1 in comparison to that measured on the BPL commercial carbon obtained from Calgon Carbon Co. (Pittsburgh, PA).

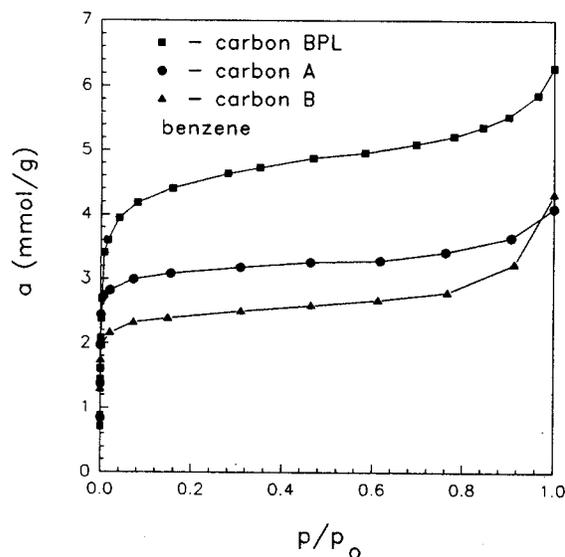


Figure 1 - Comparison of benzene adsorption isotherms on the A and B synthetic carbons and the BPL commercial active carbon.

Results and Discussion

First, benzene adsorption isotherms measured on the A and B synthetic carbons were analyzed by using standard methods such as the α_s -plot and BET-plot. The resulting parameters such as the BET specific surface area (S_{BET}), external surface area (S_{ex}), total pore volume (V_t) and micropore volume (V_{mi}) are summarized in Table 1. This table shows that the BET surface areas and

Table 1
Structural parameters of the carbons studied.

Sample	$S_{\text{BET}}(\text{m}^2/\text{g})$	$S_{\text{ex}}(\text{m}^2/\text{g})$	$V_t(\text{cc/g})$	$V_{\text{mi}}(\text{cc/g})$
Carbon A	670	40	0.36	0.25
Carbon B	520	50	0.34	0.19
Carbon BPL	970	65	0.55	0.40

total porosities of the A and B samples are smaller than the corresponding values for the BPL carbon. Also, their micropore volumes are smaller than the value reported for the BPL carbon.

In order to characterize structural properties of the synthetic carbons studied the benzene adsorption data were analyzed by using Jaroniec-Choma (JC) equation [2]. First, the amounts adsorbed in micropores (a_{mi}) were extracted from the overall isotherm by using the benzene standard isotherm measured on a non-microporous reference carbon. Next, the adsorption data a_{mi} were described by the JC equation [2]:

$$a_{\text{mi}} = a_{\text{mi}}^{\circ} \left[1 + \left(\frac{A}{\beta p} \right)^3 \right]^{-\nu/3} \quad (1)$$

where

$$A = RT \ln(p/p_0) \quad (2)$$

Above a_{mi} denotes the amount adsorbed in micropores at the equilibrium pressure p and absolute temperature T , a_{mi}° is the maximum amount adsorbed in micropores, A is the adsorption potential, p_0 is the saturation vapor pressure, β is the similarity coefficient (which for benzene is equal to unity), ρ and ν are parameters of the micropore-size distribution. Equation (1) gave a good description of the benzene adsorption isotherms shown in Figure 1.

The JC eq. (1) corresponds to the gamma-type distribution $F(z)$, where z is the inverse characteristic energy, i.e., $z = 1/E_0$ [2]. Using one of the known empirical relationships between z and the micropore width, one can convert the $F(z)$ -function to the micropore-size distribution. Thus, the $F(z)$ -distribution is a measure of structural heterogeneity of a microporous carbon. A comparison of the $F(z)$ -distributions for the A, B and BPL carbons is shown in Figure 2. As can be seen in Figure 2 the maxima of the $F(z)$ -distributions for both synthetic carbons are located about $z = 0.027$, which is much smaller than that for the BPL carbon.

Conclusions

Structural properties of the synthetic carbons studied are much different than those for regular active carbons. A comparison of the $F(z)$ -distributions as well as the micropore-size distributions for the A and B carbons in relation to those for the BPL sample shows that the synthetic carbons studied possess much smaller micropores and much more uniform micropore network.

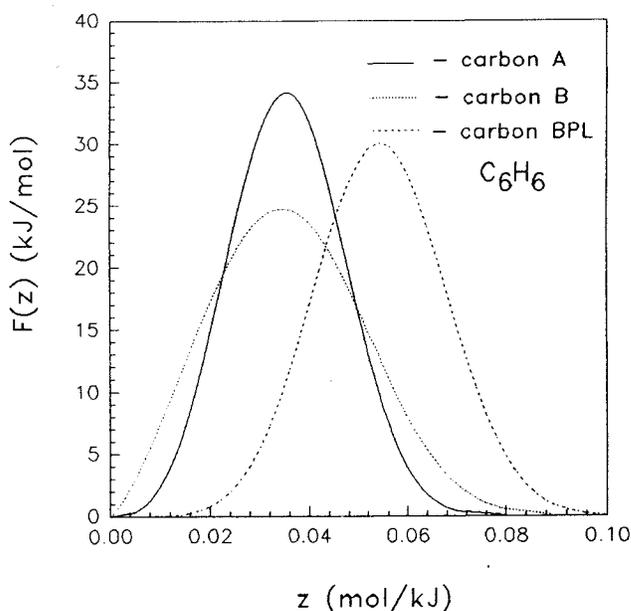


Figure 2 - Comparison of the $F(z)$ -distributions for the A, B and BPL carbons.

Acknowledgment

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References

1. M. Jaroniec and R. Madey, *Physical Adsorption on Heterogeneous Solids*, Elsevier, Amsterdam, 1988.
2. M. Jaroniec and J. Choma, *Chem. Phys. Carbon*, 22 (1989) 197.