

Adsorption of VB₁₂ on Mesoporous Activated Carbon Fibers

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Introduction

When activated carbon fibers(ACF) are used to remove impurities with larger molecule dimension from liquid solution, such as waste water and biological fluids, only the surface area corresponding to mesopores and macropores is effective, the micropores are inaccessible to these large molecules. So now there is increasing attention on developing new-type ACF with extensive mesoporosity. In previous paper(1), the new way to produce ACF with high mesoporosity and free from mineral impurity has been reported, in which carbon black particles have been used as the additives to the polyacrylonitrile(PAN) fibers.

VB₁₂ is a kind of large globe molecules with dimension of 2.09nm(2), so only the pore larger than 2.09nm can adsorb it. In the present paper, the VB₁₂ has been chosen as the detective molecule to study the adsorptive ability of the mesoporous ACF.

Experiment

The carbon black (CB) used in this paper is a kind of toner for duplicator. Controlled amount of this kind of CB was thoroughly mixed with PAN polymer, then the mixture was well dissolved in dimethylsulfoxide(DMSO), and the PAN fibers with high dispersion of CB were spinned into by wet spinning technology.

After normal stabilization, carbonization and activation by steam, the ACFI with improving mesoporosity have been prepared.

The ACFII are made from PAN fibers by KOH activation(3).

Adsorptions of VB₁₂ on ACF from aqueous solutions were determined by the changes of VB₁₂ concentrations which were measured by a photometer, all determinations were made at 298K.

Results and Discussion

Table 1 shows the pore structure parameters of two kinds of ACF determined from N₂ adsorption isotherms by α_s method(4), and the Fig.1 shows the curves of mesopore size distribution calculated by BJH equation(5). In ACFI there are much more mesopores than in ACFII. Although there are a few of mesopores in ACFII, these pores are much small and near 2.0nm, while in ACFI there are a lot of mesopores concentrated in 4.0nm and 8.0nm.

Table 1 Pore structure parameters of two kinds of ACF

No.	S _t (m ² /g)	S _{mi} (m ² /g)	S _{me} (m ² /g)	V _{0.95} (ml/g)	V _{mi} (ml/g)	V _{me} (ml/g)
ACF I	849.4	525.3	249.3	0.618	0.248	0.370
ACF II	1332.1	1191.3	140.8	0.550	0.476	0.074

Where: V_{0.95}: total pore volume deduced from the amount adsorbed at P/P₀=0.95; S_{mi}: micropore surface area; S_{me}: mesopore surface area; V_{mi}: micropore volume; V_{me}: mesopore volume.

The adsorption isotherms of VB₁₂ are shown in Fig.2, and it shows that the saturated adsorption of ACFI is more than 142mg/g, but the adsorption of ACFII which is denoted by a point in Fig.2 is less than 10mg/g, which means that there is a very low adsorptive ability in case of microporous ACF for VB₁₂ because its large molecule, which can not pass through the pores less than 2.09nm.

Adsorption of compounds from liquid phase is much more complex than that from gas phase, and it depends not only on the adsorbent characteristics but also on the physicochemical properties of the adsorbate. In particular, the structure, solubility and concentration of the adsorbate are important. In order to simplify the study, in this paper, adsorbent, adsorbate and initial VB₁₂ concentration, temperature had been fixed. In other words, during the experiment there is only one variation, so the effect of the equilibrium concentration on the adsorption had been investigated.

The equilibrium adsorption capacity for pure compounds which can be determined from batch tests, is often described in terms of the Freundlich adsorption isotherm equation:

$$Q = KC^{1/n}$$

where Q and C denote the adsorption capacity and the equilibrium concentration of adsorbate in solution, respectively. The coefficients K and n are characteristic constants of the adsorbent and adsorbate.

The adsorption isotherm of ACF1 in Fig.2 can be represented quite well by the Freundlich isotherm, as is reflected in the linearized curves. Their parameters, K and n, determined by the least squares method, is 26.10 and 3.262, respectively.

For adsorptions from liquid, most are consistent with monolayer coverage. Assuming the adsorption of VB₁₂ from aqueous solution is also monolayer coverage, then from the saturated adsorption (169.7ml/g, deduced from Freundlich equation) and the molecular area (σ as 3.429nm² for VB₁₂ as a global molecule with diameter 2.09nm), the pore surface area can be calculated, which is 263.2m²/g and is the surface area corresponding to the pores larger than 2.09nm. It is comparable to the surface area of mesopores larger than 2.0nm (249.3m²/g) determined from N₂ adsorption isotherm by α_s -method. Therefore it can be said that the adsorption of VB₁₂ from aqueous solution on mesoporous ACF is monolayer coverage.

References

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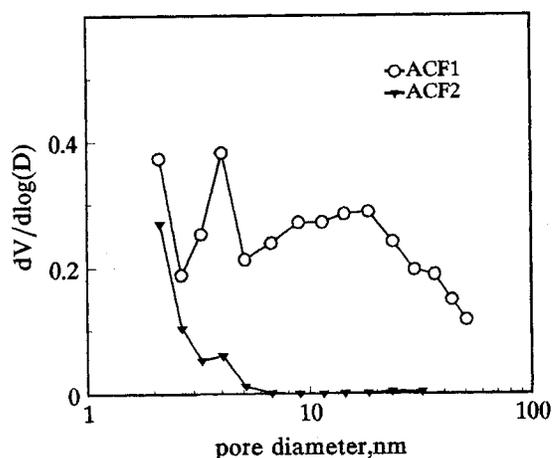


Fig.1 The mesopore size distribution curves of ACF

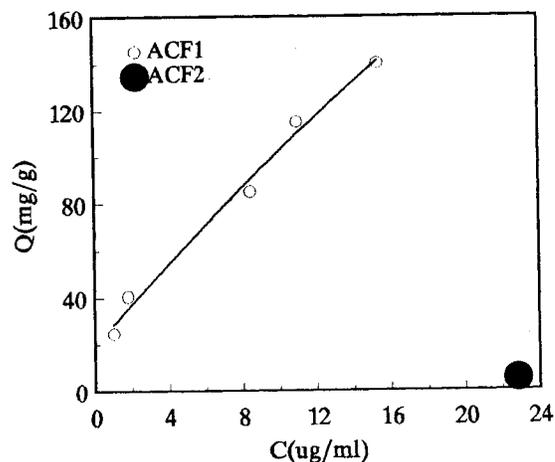


Fig.2 The VB₁₂ adsorption isotherm of ACF