ADSORPTION OF INORGANIC VAPORS ON COAL- AND WOOD-BASED CHEMICALLY ACTIVATED CARBONS

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INTRODUCTION

The adsorption characteristics of coal- and wood-based chemically activated carbons with CCl_4 and acetone as adsorbate vapors were described in the previous paper [1]. The organic vapor adsorption data were interpreted in terms of the Dubinin-Radushkevich (DR) equation and micropore volume (W_0) and characteristic adsorption energy (E_0) data were obtained.

In this paper, the adsorption characteristics of coal- and wood-based chemically activated carbons have been further investigated employing water, ammonia and H_2S as vapor adsorbates. W_0 values were again determined and used as a measure of adsorption capacity. E_0 data were also obtained when the DR equation was applicable [2,3].

EXPERIMENTAL

A gravimetric adsorption technique was employed to obtain the single vapor adsorption isotherms of water, ammonia and H_2S at 296 K. The same activated carbon samples that were investigated previously were again investigated [1]. Sample descriptions in terms of starting material and chemical activant are summarized in the footnote below Table 1. Sample preparation details were described previously [4,5]. The relative pressure ranges were 10^{-4} - 0.8 for water, 10^{-4} - 0.12 for ammonia and 10^{-4} - 0.06 for H_2S. The W_0 and E_0 values were compared with BET surface areas (S_{BET}), which had been determined at 77 K using N_2.

RESULTS AND CONCLUSIONS

Adsorption isotherms for water vapor were typical type V isotherms for most of the coal-based activated carbon samples, as shown in Fig. 1a. Wood-based carbon samples, on the other hand, did not always display typical type V isotherms behavior, as shown in Fig. 1b. These differences between coal- and wood-based carbon samples can be attributed to the different pore structures [1]. The micropore development is generally the most important factor in determining the water vapor adsorption isotherms. Typical type I adsorption isotherms were obtained for ammonia and H_2S vapors on both coal- and wood-based activated carbon samples, as shown in Figs. 2 and 3. In the case of the wood-based carbon samples, the ammonia and H_2S adsorption saturated at low relative pressures. Saturation occurred at higher relative pressures for most of the coal-based carbon samples. This leads to some differences in adsorption capacities between the coal and wood-based carbon samples.

To determine the W_0 and E_0 parameters, the DR equation was applied using $\beta = 0.20$ for water, 0.31 for ammonia and 0.48 for H_2S. These values were obtained from the adsorbate molar volumes using benzene as a reference [6]. W_0 values for water vapor were obtained from the high pressure range of the isotherms because the ln (W) versus A^2 plots were non-linear over the full range of pressures investigated. E_0 values for water vapor were therefore not determined. The resulting values of W_0 and E_0 are listed in Table 1. W_0 values with water vapor as adsorbate for both coal- and wood-based carbon samples were found to be generally in good agreement with those obtained with acetone as adsorbate [1]. W_0 values obtained with ammonia vapor in the case of H_3PO_4 activated carbon samples were generally higher than those obtained with H_2S. This indicates a stronger adsorption force between ammonia vapor and the surface due possibly to an acid-base interaction. In the case of KOH activated carbon samples, however, W_0 values with ammonia vapor were similar to those obtained with H_2S.

Fig. 4a shows plots of S_{BET} versus W_0 obtained from ammonia and H_2S isotherms for both coal- and wood-based carbon samples. W_0 values for the coal-based carbon samples increase as S_{BET} increases. On the other hand, W_0 values for the wood-based carbon samples stay relatively constant as S_{BET} increases. The E_0 versus S_{BET} plots in Fig. 4b show that E_0 is relatively constant as S_{BET} increases, which implies that the surface area development does not change the E_0 values in the case of ammonia and H_2S adsorption for both coal- and wood-based carbon samples. In general, the adsorption capacity can be influenced both by the micropore structure and also by surface chemistry interactions. It can also be concluded that the adsorption process in the case of the inorganic vapors investigated can sometimes be dominated by the surface chemistry of the chemically activated carbon samples.

REFERENCES

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Table 1. W_0 data and characteristic adsorption energy (E_0)

No.	S_{BET} (m^2/g)	W_0 (cc/g) (E_0) (kJ/mol)		
		H_2O	NH_3	H_2S
1	580	0.19	0.36 (33.9)	0.26 (27.8)
2	835	0.30	0.37 (36.1)	0.37 (25.7)
3	1081	0.48	0.55 (29.5)	0.53 (23.8)
4	1583	0.62	0.63 (25.8)	0.64 (20.9)
5	1605	0.68	0.63 (25.6)	0.62 (21.6)
6	257	0.28	0.32 (41.4)	0.23 (25.2)
7	935	0.25	0.37 (40.1)	0.22 (26.7)
8	1075	0.34	0.38 (36.7)	0.28 (24.4)
9	1807	0.54	0.39 (39.4)	0.30 (24.8)

- Samples 1-5 were obtained from coal with KOH as a chemical activant and samples 6-9 were obtained from wood with H_3PO_4 as a chemical activant.

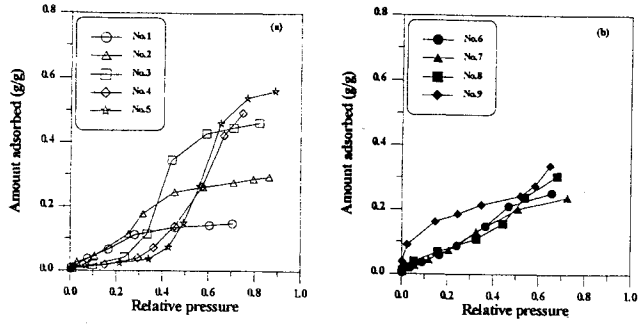

Fig. 1. Water vapor adsorption on (a) coal- and (b) wood-based carbon samples

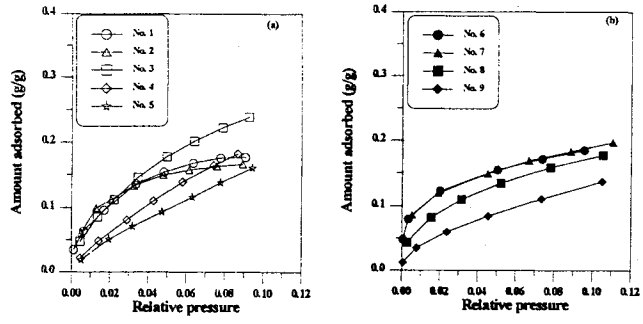

Fig. 2. Ammonia adsorption on (a) coal- and (b) wood-based carbon samples

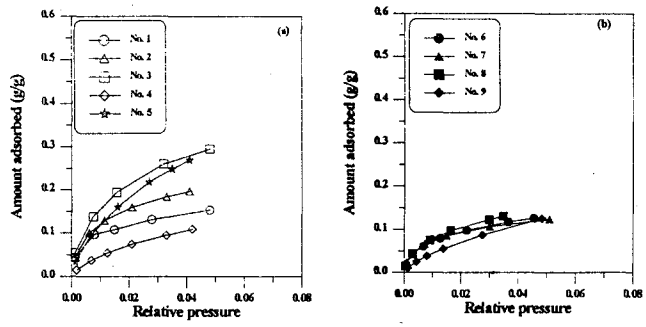

Fig. 3. H_2S adsorption on (a) coal- and (b) wood-based carbon samples

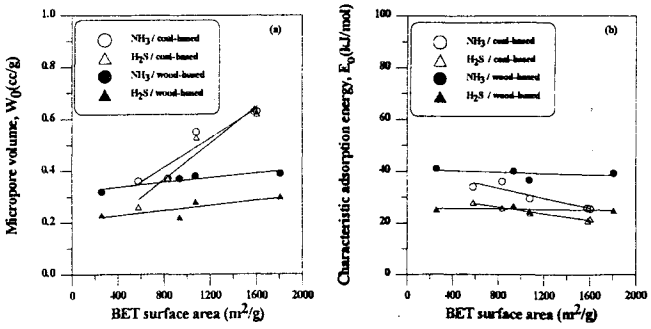

Fig. 4. (a) W_0 versus S_{BET} and (b) E_0 versus S_{BET} for coal- and wood-based carbon samples