Absorption Expansion and Elastic Properties of Wood Charcoal

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The expansion of different charcoal rods due to the adsorption of methanol has been determined together with the coefficient of linear thermal expansion of the evacuated rods, and Young's modulus of elasticity of the methanol-free and methanol-imbibed charcoals, and the results are found to confirm the theory of adsorption expansion proposed by Bangham <u>et al</u>.

Blocks from five kinds of wood were cut in longitudinal or transverse sections and charred at temperatures between 500° and 1100°C. The adsorption extension, coefficient of thermal expansion, and elasticity constant of the carbons are found to be anisotropic, especially when carbonization is at the lower temperatures.

The expansion increases with the quantity of alcohol adsorbed and in no case a contraction is found to precede the expansion at low surface coverages. Plots of percentage expansion (x) versus reciprocal of the amount adsorbed (s) resemble very closely the F-A diagrams of condensed films on liquid substrates, in agreement with the assumption of Bangham <u>et al</u>. that the expansion on sorption measures the two-dimensional surface pressure of the adsorbate. Typical results are shown in Fig. 1. The extrapolation of the linear portion of the x <u>vs</u>. 1/s curves to zero expansion enables us to calculate the specific surface area of the carbons, on the assumption that the limiting area occupied by a methanol molecule is the same as that obtained with normal aliphatic alcohols on the surface of water, namely 21 sq. Å. Specific surface areas obtained from these limiting values are in excellent agreement with the values computed from the application of the Pickett-Anderson-Dellyes equation to the adsorption data using 18 sq. Å as cross-sectional area of the methanol molecule. These values agree also with the specific surface areas calculated from low-temperature nitrogen adsorption. Furthermore, charcoal rods cut in longitudinal or transverse sections are found to give the same limiting values of 1/s, and, consequently, the same specific surface area, although they may differ in their adsorption expansion. This is illustrated in Fig. 1, in which the saturation expansion of Charcoal I (Casuarina equisetifolia carbonized at 500°C) along the grains is almost half the expansion at right angles.

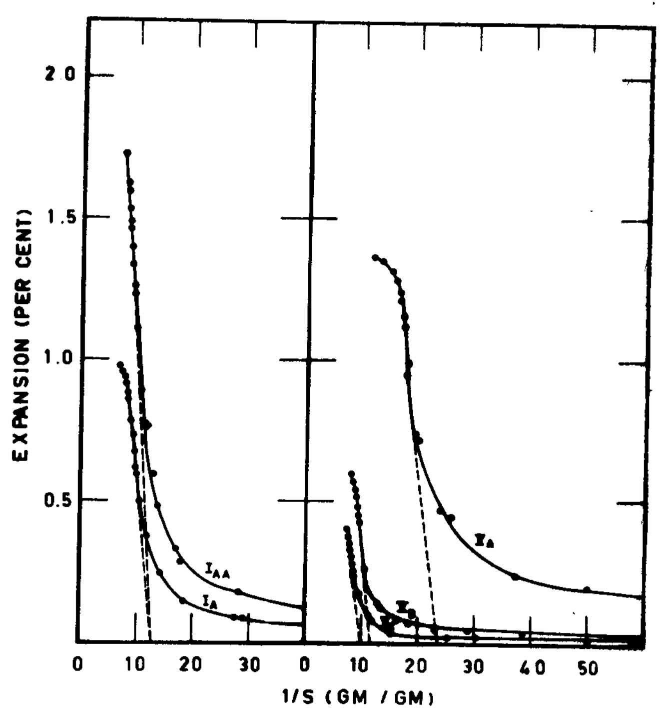

Fig. 1
Percentage expansion (x) vs. reciprocal amount adsorbed (1/s)

IA, Longitudinal; IAA, transverse sections
VA, VB and VC are carbonized at 500, 650 and 800°C

Young's modulii of elasticity were determined experimentally on compression of methanol-free and methanol-imbibed charcoals by measuring the contraction resulting from applying loads on the movable jaw of the same extensometer used for the adsorption expansion measurements. The two sets of values are very close, and are of the same order of magnitude as the modulii calculated from adsorption expansion data by Bangham and Maggs' relation $E_A = 100\rho\Sigma/\lambda$, where E_A is Young's modulus, ρ the true density of the material, Σ, the specific surface area, and λ, the constant of proportionality defined by $x = \lambda F$.

It is found that the adsorption expansion and the coefficient of thermal expansion decrease with rise of temperature of carbonization, whereas Young's modulus increases. The specific surface area, on the other hand, increases with rise of temperature to a maximum for carbons prepared at 800°C, and then decreases rapidly. Typical results are represented in Fig. 2, which shows the dependence of adsorption expansion, coefficient of thermal expansion, elastic constant, and specific surface area, on the temperature of carbonization of Charcoal V (Gossypium barabadense stalks).

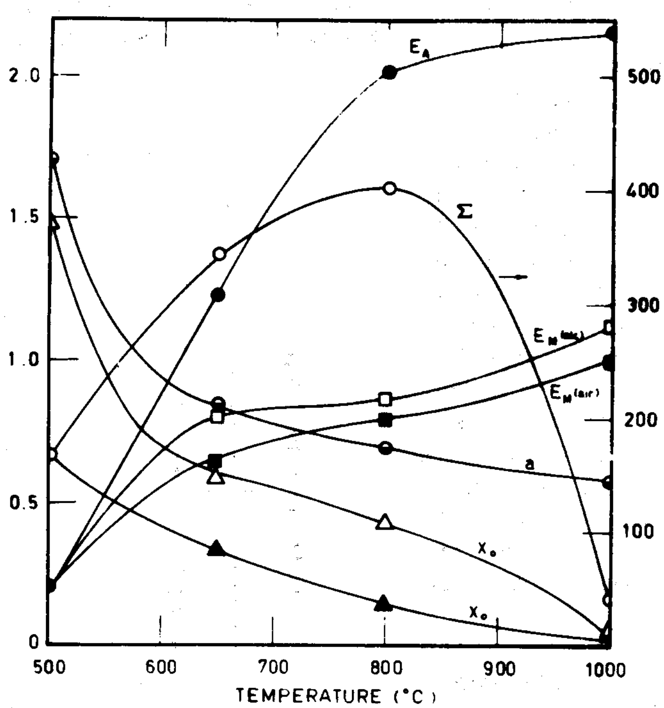

Fig. 2
Dependence of the properties of Charcoal V on temperature of carbonization

a, Coefficient of thermal expansion x 10^{5}, ●
x_m, Monolayer expansion (per cent) ▲
x_o, Saturation expansion (per cent), △
E_A, Young's modulus calculated from adsorption expansion x10^{-11}, ●
E_M(air), Young's modulus of methanol-free charcoal x10^{-11}, ■
E_M(alc), Young's modulus of methanol-imbibed charcoad x10^{-11}, □
Σ, Specific surface area (sq.m./g.), ○