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Testing of nanostructure within active carbons particles

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INTRODUCTION

Activation process with water-steam of carbonaceous precursors leading to the production of active carbons is noncatalytic reaction, which takes place in a gas-solid system.

Transport phenomena within porous particles depend strongly on the internal structure of the particles. Not too much experimental work has been done to understand how the tortuosity and hence effective diffusivity within the pore space are affected by the pore size distribution, pore shape, and nanostructure (micro- and mesopores).

The activating gas in the process is thought to penetrate the particle as a result of diffusion accompanied by chemical reactions, the gas concentration decreasing with distance from the external surface. Moreover, the activation reaction is endothermic and leads to temperature decrease in the reaction zone while heat energy flows slowly to the deeper layers of the particle.

Because of these factors, the activating of carbonaceous substance is a function particle radius.

EXPERIMENTAL

Active carbons (A-type, Poland) and N (Norit 2RL type, Holland) were subjected to abrasion in a spouted bed. A method of successive removal of the layers from the carbon particles was applied. A diagram of the experimental equipment is shown in Fig. 1

For core samples of active carbons so obtained, physicochemical properties were determined from densities measurements and by adsorption technique.

It has been shown found that there exists a correlation between the properties of samples obtained via abrasion technique, to the position within the active carbon particles. Anisotropy of nanostructure is due to conversion of the carbonaceous substance, which reduces radially from the outer surface the particle to its inner core.

RESULTS AND DISCUSSION

The following parameters were measured to investigate the properties of samples active carbons obtained: (i) amount of powder abraded from the particle surface; (ii) true density; (iii) apparent density; (iv) benzene vapour adsorption-desorption isotherms. The following parameters were calculated from the isotherms: (i) specific surface area S_{BET}; (ii) adsorbed benzene for p/po = 0.98, V_t; (iii) mesopore volume V_{me}; (iv) micropore volume, from equation $V_{mi} = V_t - V_{me}$.

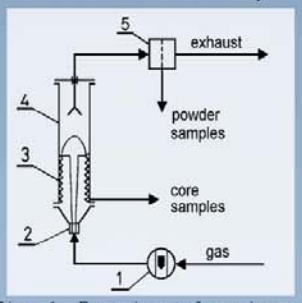

Fig. 1. Experimental equipment: 1. rotameter, 2. nozzle, 3. abrasive lining, 4. column, 5. filter.

Table 1. Properties of active carbon A with external layers removed to 40 and 80%

Sample of active carbon	A	A40	A80
Amount of carbon abraded, %	0	40,4	82,6
True density q_{tr}, g/cm^3	2,447	2,314	2,254
Apparent density q_a g/cm^3	0,621	0,800	0,845
Specific surface area S_{BET}, m^2/g	834	712	650
C_6H_6 adsorbed at p/p_0 = 0,98, V_t, cm^3/g	0,59	0,46	0,42
Mesopore volume, V_{me}, cm^3/g	0,26	0,17	0,15
Micropore volume, V_{mi}, cm^3/g	0,33	0,29	0,27

Table 2. Properties of active carbon 2RL with external layers removed to 40 and 80%

Sample of active carbon	2RL	2RL40	2RL80
Amount of carbon abraded, %	0	42,3	83,3
True density q_{tr}, g/cm^3	2,300	2,181	2,076
Apparent density q_a g/cm^3	0,633	0,718	0,747
Specific surface area S_{BET}, m^2/g	1107	1041	934
C_6H_6 adsorbed at p/p_0 = 0,98, V_t, cm^3/g	0,62	0,54	0,51
Mesopore volume, V_{me}, cm^3/g	0,12	0,10	0,09
Micropore volume, V_{mi}, cm^3/g	0,50	0,44	0,42

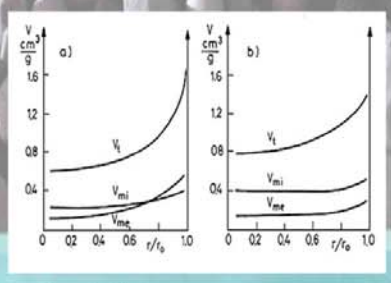

Fig. 3. Changes porous structure inside particles of active carbon: a) A and b) 2RL.

The results of measurements and calculations of parameters are summarized for active carbon A in Tab.1 and for active carbon 2RL Norit in Tab.2.

The analysis changes in true and apparent densities as a function of the amount of carbon abraded from the particle surface enable to conclude that conversion (x) external layers of carbons is higher than in the bulk see Fig.2.

Natural consequences of differences in conversion of surface layers and of active carbon particles are the changes in nanoporous structure as a function of distance from the external particle surface, see Fig. 3.

CONCLUSIONS

The method of successive layer removal based on the phenomenon of intensive abrasion in spouted bed allows determining micro-, meso-, and macropores, adsorption properties and conversion within active carbon particles. It has been shown that there exists a correlation between the properties of samples obtained via an abrasion technique, to the position within the active carbon particles. Property anisotropy of samples is due to conversion of the carbon substance, which reduces radically from the outer surface of the particle to its inner core.

It is possible to separate experimentally from active carbon particles, fragments that have nanostructures dependent on the positions within the particle. Removing outer layers which have undergone a high conversion, leads to better quality of active carbon with increased adsorption capacity and mechanical strength.

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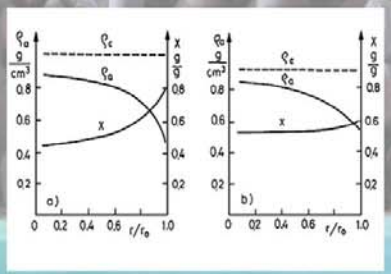

Fig. 2. Relationship between conversion and apparent density and the location within particles of active carbon: a) A and b) 2RL.

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