THE RADIAL DEPENDENCY OF THE POROUS STRUCTURE AND ASH CONTENT WITHIN THE ACTIVE CARBON GRANULE

B. Buczek, A. Świątkowski and S. Ziętek
University of Mining and Metallurgy, 30-059 Cracow, Poland
Military Technical Academy, 01-489 Warsaw, Poland
Military Institute of Chemistry and Radiometry, 00-910 Warsaw, Poland

Introduction

Most active carbons are manufactured by mild oxidation (using steam or CO_2 as an activating agent) of chars obtained from various carbonaceous materials. The activation process leads to development of surface area and porous structure of a carbonized product. The activating agent basically burns away the more reactive portions of the carbon substance giving CO and CO_2. The extent of burn-off depends on the nature of the employed gas and the temperature of the process. The burning out of the carbon substance also occurs at different rates and different parts of the exposed surface. Moreover, the activating gas penetrates the char particle as a result of diffusion accompanied by chemical reactions. The gas concentration decreases with an increasing distance from the external surface [1]. Usually the activation reactions are endothermic and this fact leads to a temperature decrease in the reaction zone while heat energy flows slowly to the deepest layers of the particle. Because of these factors the burn-off the carbonaceous substance is a function of the radial position within the carbon particle [2]. The aim of this work was to perform the balance calculations expressing quantitative differences in properties within granules which are caused by their ununifirmity being a result of the decrease in the burn-off towards the center of granules.

Experimental

Commercial granulated active carbon (A) obtained by activation with steam (at 1173-1223K) of carbonized pellets prepared from hard coal and tar was used in the investigation. In order to carry out a quantitative evaluation of properties within the active carbon a method was used which removes layers from a granule surface [2]. After exposing studied material to the attrition process in the spouted bed the powder from the outer parts of granules and outer parts of cores, as well as cores after powder elimination were obtained [3, 4]. The abrasion treatment was carried out in two steps: elimination of 34.4 and 67.1 % wt. (34.4 + 32.7 %) of the starting granules. This can be schematicaly expressed as:

A ⟶ AP34 (powder)
↓
AC34 (core) ⟶ AP67 (powder)
↓
AC67 (core)

where: A - active carbon (without treatment), C - core, P - powder, 34 and 67 - percent of external layer removal. The ash contents of the starting material and of the products were determined (Table 1). Argon adsorption-desorption isotherms at 77.5K were measured (Figure 1) and the parameters of porous structure were calculated (Table 1).

Table 1. Ash contents and porous structure characteristics of active carbon samples under study

Sample	Ash % wt.	W_o $cm^3 g^{-1}$	$B \cdot 10^6$ K^{-2}	V_{me} $cm^3 g^{-1}$	S_{me} $m^2 g^{-1}$
A	18.0	0.360	1.14	0.073	51.6
AC34	16.2	0.316	0.87	0.070	50.5
AC67	14.3	0.295	0.77	0.057	45.1
AP34	20.9	0.379	1.10	0.106	65.5
AP67	17.1	0.340	1.02	0.076	53.5

W_o and B - Dubinin-Radushkevich equation parameters, V_{me} - volume of mesopores, S_{me} - surface area of mesopores

Results and Discussion

Argon adsorption isotherms show that the porous structure depends considerably on the degree of the external layers removal from the active carbon granules (e.g. in sequence A - AC34 - AC67). Higher burn-off nearer to the external surface (in sequence AC67 - AP67 - AP34) is accompanied by the increasing ash content as well as micropore volume and mesopore volume (or surface).

To perform the mass balance calculations expressing quantitative radial differences in properties within carbon granules, all parameters for cores and powders must be recalculated with respect to one gram of untreated active carbon (A). 1g active carbon (A) gives 0.344g AP34, 0.327g AP67 and 0.329g AC67 after removal external layers by abrasion. The values of some chosen parameters characterizing properties of studied carbon samples were recalculated taking into account masses given above (see Table 2).

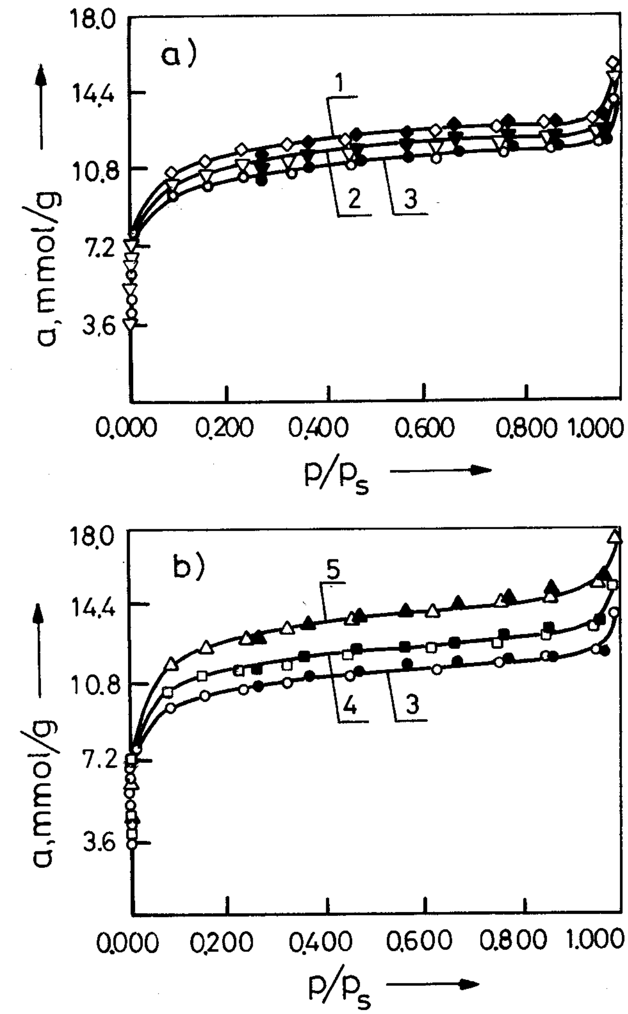

Figure 1. Argon adsorption-desorption isotherms at 77.5K on active carbon samples: a) 1-A, 2-AC34, 3-AC67, b) 4-AP67, 5-AP34

It can be observed that the summarized values of each parameter show differences with respect to the values of the same parameters for 1g active carbon (A). In the case of ash content this difference is practically negligible (decrease of 2.8 %). The micropore volume decreased by 6.1 %, and mesopore surface area increased by 6.4 %. It seems that during abrasion in the spouted bed, a part of micropores can be destroyed (e.g. by opening along their length). However, in the case of mesopores, these closed (or blocked with ash) can be opened during the treatment of active carbon.

Table 2. Results of mass balance calculations

Sample	Mass of sample, g	Ash % wt.	W_o $cm^3 g^{-1}$	S_{me} $m^2 g^{-1}$
A	1.0	0.180	0.360	51.6
AP34	0.344	0.072	0.130	22.5
AP67	0.327	0.056	0.111	17.5
AC67	0.329	0.047	0.097	14.9
Sum	1.0	0.175	0.338	54.9

Conclusions

Abrasion of the external layers of carbon granules produces core samples which have different physical properties in comparison to original active carbon. It was found that the ash content and porous structure development increase radially from the inner core toward the outer surface of granules. The method allows one to obtain carbon adsorbent (or catalyst carrier) of required properties (adsorption characteristics). However, for each individual granulated active carbon preliminary investigations must be made.

References

1. Bansal R.C., Donnet J.B. and Stoeckli F., *Active Carbon*, Marcel Dekker. New York, 1988, p. 1.
2. Buczek B., *Langmuir*, 1993, 9, 2509.
3. Buczek B., Ziętek S. and Świątkowski A., *Fundamentals of Adsorption*, ed. M.D. LeVan. Kluver Academic Publishers. Boston, 1996.
4. Buczek B., Ziętek S. and Świątkowski A., *Langmuir*, in press.