Adsorption properties of nanoporous carbon obtained from waste coffee grounds

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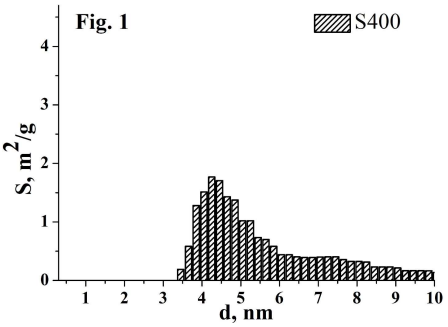
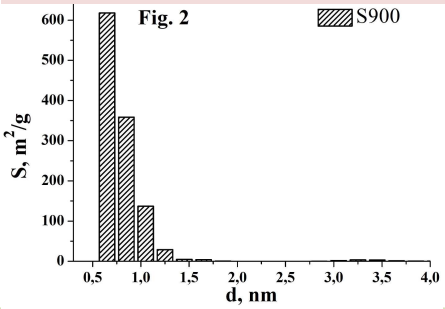
Nanoporous carbon materials (NCM) are used to prepare supercapacitor (SC) electrodes. The high specific energy characteristics of SC are closely related to the physicochemical characteristics of NCM. NCM with a highly developed surface area and controlled pore size distribution we have obtained by chemical and thermal activation of carbon containing precursors [1, 2]. In our work we propose a method of obtaining NCM with a high specific surface area. The NCM is obtained by thermochemical activation of potassium hydroxide waste coffee grounds (WCG). The WCG, from commercial beverage manufacturers, was dried at 65-85 °C for 48 h. The dried WCG was mixed at a weight ratio of 1:0.5:1 with KOH and distilled water. The resulting mixture was stirred thoroughly for 1-2 hours; after which it was dried at a temperature of 90 ºC. The dry material was placed in an autoclave and heated to a given temperature and kept at this temperature for 30 min. After cooling, the resulting material was washed to neutral pH and dried at 90 ºC. The series of samples (S400 ÷ S900) were numbered according to the thermochemical activation temperature. For example, S900 is a material activated at 900 ºC. The table shows the characteristics of the porous structure of NCM.

Following the genesis of the porous structure of carbon materials as a result of different activation temperatures, it can be noted that the microporous structure begins to form at temperatures of 500 ºC, since the material obtained at 400 ºC (Fig. 1) has a mesoporous structure with a surface area of 23 m^2/g (Tab.). In materials obtained at temperatures of 500-700 ºC, micropores with a size of 0.65-1.45 nm are formed (Fig. 2). At higher temperatures, there is an increase of the number of pores with a size of 0.65-1.25 nm, which make up almost 90% of the specific surface area and up to 80% of the total volume of pores.





The parameters of the porous structure of the NCM

Sample	S400	S500	S550	S600	S700	S800	S900
S_{BET}, m^2/g	31	172	246	374	446	703	1056
S_{DFT}, m^2/g	23	193	218	309	478	632	1170
S_{meso}, m^2/g	30	44	30	27	27	22	45
S_{micro}, m^2/g	-	80	175	319	402	671	996
V_{total}, cm^3/g	0.092	0.161	0.176	0.228	0.237	0.331	0.507
V_{micro}, cm^3/g	-	0.038	0.071	0.132	0.162	0.272	0.398

Conclusions. The method of thermochemical activation of coffee grounds waste with potassium hydroxide to obtain nanoporous carbon materials was tested. It is shown that the obtained carbon materials have a specific surface area of 400-1050 m^2/g and a pore volume of 0.23-0.51 cm^3/g, depending on the activation temperature. In the obtained nanoporous carbon materials, the vast majority of pores have sizes of 0.65-1.25 nm.

1. Ostafiychuk B.K., et al. Thermochemically activated carbon as an electrode material for supercapacitors (2015) Nanoscale Research Letters, 10 (1) № 65, 8 p. https://doi.org/10.1186/s11671-015-0762-1

2. Ostafiychuk B.K., et al. Effect of orthophosphoric acid on morphology of nanoporous carbon materials (2019) Journal of Nano- and Electronic Physics, 11 (3), № 03036 https://doi.org/10.21272/jnep.11(3).03036