Small-angle Neutron Scattering on Porous Materials

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To describe structure and properties of objects, which grow due to an aggregation of individual particles, a fractal conception is applied. We studied samples of several porous materials like a carbon fiber, carbon sorbents, zirconium dioxides, nano-composites fabricated from highly-exfoliated graphite (HEG) and magnetic 3d-transition metals by means of small angle neutron scattering (SANS). Our results show that samples show properties of fractal objects.

For example, the carbon fiber is composed of fractal clusters with dimension $D \approx 2.7$ and a size $l_{cl.} \approx 200 - 400$ Å, which are formed from carbon particles of a radius $\approx 18 - 20$ Å. A surface of the clusters is described as a surface fractal with a dimension $D_S = 2.7$. The specific surface area of the carbon fiber is estimated from SANS to equal S = 900 m^2/g.

Carbon sorbents have been synthesized from shell of a coconut, and studied in four stages of thermo-chemical treatment. To describe curves of SANS the following equation was applied:

$$\left(\frac{d\Sigma}{d\Omega}\right)_{\mathrm{mod}} = \frac{8\pi c(1-c)\rho^2}{(1+Aq^2r^2)^{\frac{6-D_S}{2}}} + (\frac{4\pi}{3})^3 \rho^2 N(2+\Delta) R_{\min}^6 (qR_{\min})^{-4+\Delta} \int_{qR_{\min}}^{qR_{\max}} x^{-\Delta} J_{3/2}^2(x)dx \quad . \qquad (1)$$

Using Eq. (1) we found that sorbents possess fractal surface in third and fourth stages of treatment. Distribution of particle sizes has a form of power-series distribution.

Curves of SANS on zirconium dioxide are characterized by a peak near the momentum transfer $q = 0.05$ $Å^{-1}$. The existence of the peak is caused by correlation between solid nanoparticles in the sample. Measurements of SANS on HEG allow us to conclude that the HEG is formed by small and large particles which sizes about 70 Å and (260-300) Å, respectively.

This work is supported by CRDF - UrB of RAS project No. RUP1-7079-EK-12.