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Optimisation of Bulk Density of Nanodispersed Medium to Maximise Its Reflectivity for Very Cold Neutrons

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Nanodispersed media, such as nanodiamond powders, are efficient diffuse reflectors of low-energy neutrons [1]. This is due to the intense coherent elastic scattering of such neutrons on individual nanoparticles of a few nanometers in size. Such reflectors can be used for quasi-specular reflection of cold neutrons [2] and in the design of very cold neutron sources for their directed extraction [3]. However, the influence of the bulk density of the nanodispersed medium (packing coefficient) on the reflection efficiency has not yet been studied.

The point is that the transport cross-section for very cold neutrons, which determines the reflectivity of the nanodiamond powders of finite thickness, should increase as the packing factor of nanoparticles in the volume increases. Nevertheless, with a significant increase in the packing factor, when the nanoparticles in the medium are so close together that neutrons can no longer scatter on them independently, the transport cross-section should start to decrease [4]. Theoretically, it should fall to almost zero and be determined only by incoherent scattering on individual nuclei in the case where the nanoparticles completely fill the entire available volume, since the fluctuations of the medium density, on which coherent scattering occurs, disappear.

The change in small-angle neutron scattering intensities with increasing media density has previously been observed when studying the fractal structure of unmodified nanodiamond powders produced by detonation synthesis [5-7]. Predominantly diamond nanoparticles in such powders form unbreakable primary clusters up to 100 nm in size, which do not allow achieving significant powder compaction. In practice, the bulk density of unmodified powders reaches 0.2 –0.3 g/cm3.

In our study, to verify the influence of bulk density on the transport cross-section and reflection of very cold neutrons, we used deagglomerated nanodiamond powder, in which the nanoparticle clusters are almost completely destroyed, and the bulk density reaches 0.6 –0.9 g/cm3 [8]. Total cross-sections and small-angle scattering intensities of thermal neutrons were measured at the YuMO small-angle scattering facility of the IBR 2 pulsed research reactor at the Joint Institute for Nuclear Research. The experimental results will be presented and discussed.

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