Physico-chemical nanomaterials science

The structure and spectral properties of graphene, mechanochemically functionalized under the influence of ammonium fluoride

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High intensity of the studies of two-dimensional (2D) materials is caused by the prospect of their use in electronics, optoelectronics, energy conversion and storage devices and many other areas. Graphene is one of the promising 2D materials due to its extraordinary properties, which can be tuned via functionalization or doping. In this study we studied the possibility of the functionalization of graphene by mechanochemical method. The idea of the proposed approach was connected with chemical interaction between the initial graphite and inorganic exfoliation agent (ammonium fluoride) during the mechanochemical treatment of the mixture in a planetary ball mill under an inert atmosphere. Functionalized graphene was obtained by liquid-phase exfoliation of the resulting nanostructured graphite material in water and various organic solvents.

Exfoliated graphite material was purified by sublimation of salt and possessed sufficiently low bulk density (0,04 g/cm^3). The approach allowed to obtain stable dispersions of the functionalized graphene in water (0,08 mg/mL) and organic solvents, such as N,N-dimethylformamide (1,2 mg/mL). The concentration of N,N-dimethylformamide dispersion of graphene, prepared by liquid-phase exfoliation of the graphite material, mechanochemically treated with inert exfoliation agent (NaCl), is order of magnitude less, and water dispersion in this case isn't formed.

TEM images showed the particles with the lateral size up to several micrometers. AFM data were consistent with the results of TEM and indicated the presence of the particles with ~0,75 nm thickness and lateral size of 1-5 microns, which possessed an ability to restack and form great aggregates. The analysis of Raman spectra showed that the process of the mechanochemical treatment of graphite in the presence of ammonium fluoride could lead to graphene functionalized with nitrogen. This is consistent with the results of the elemental analysis, which indicated that the resulting nanomaterial contains 2,7% of nitrogen.