IL19

NANOARCHITECTURAL ASSEMBLY OF HIERARCHIC FUNCTIONAL SYSTEMS BASED ON NATURAL CLAY NANOTUBES

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There is a good progress in development of functional materials using carbon nanotubes; however, their practical applications are limited due to high production cost, poor biocompatibility and cancerogenic CNT properties if used in pristine form. As alternative, we suggest research and development based on natural nanoscale objects, such as natural clay nanotubes called halloysite [1-2]. Halloysite is available in thousands of tons at low price and is biocompatible and safe ceramic material. Alumosilicate tubes of halloysite have a diameter of 50 nm, length of ca. 1 micrometer and are formed by rolling of ten-fifteen 0.7 nm thick kaolin sheets separated by water monolayer.

Halloysite tubes have different chemistry of inner and outer surfaces. Halloysite structure allows for modifications at three levels with different chemical composition and accessibility for reagents: a) reactions at the external SiO_2 tube's surface charged negatively at pH 4-10; b) modification of the inner lumen Al_2O_3 tube's surface charged positively at pH 4-8.8, and c) work at the interlayer wall space containing water and available for penetration of small organic molecules such as urea.

Halloysite, as well as other clays, has well confirmed biosafety and biocompatibility, which allow its usage for scale up industrial processes. Its chemical core-shell modifications allow for wide spectrum of organic-inorganic nanocomposites with designed electric, magnetic, catalytic and adsorbent properties, as well as a torpedo-like drug nanocarrier for cell penetrating targeted drug delivery.

An intercalation of halloysite nanotubes with metal ions of variable valence (oxides, sulfides, and selenides) allows for high efficiency and selectivity of such catalytic core-shell composites in reactions of aromatic hydrations, photodecomposition of water and Fischer-Tropsch process. Such mesoporous catalytic materials of high surface area of 60 m^2/g seeded with 3-5 nm metal particles are available in amounts of kilograms. Usage of these nanocomposites as fillers for hybrid membranes for fuel elements activated substrates for SERS and for stabilized pigments was proved to be very efficient.

1. Y. Lvov, et al. Adv. Mater., v.28, 1227–1250, 2016, " Halloysite Clay Nanotubes for Loading and Sustained Release of Functional Compounds"
2. V. Vinokurov, et al. Sci. Technol. Adv. Materials, v.18, published on line, 2017, "Formation of Metal Clusters in Halloysite Clay Nanotubes," http://dx.doi.org/10.1080/14686996.2016.1278352

This work was supported by the Ministry of Education and Science of the Russian Federation (Grant № 14.Z50.31.0035).