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MoS_2 hybride nanostructures

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Abstract – We report, a novel, very efficient synthetic route for bulk production of pure MoS2 nanotubes and MoS_2 peapods, which represent a new class of hybrid materials. Nanowires based on $Mo_6S_2I_8$, material, synthesized directly from the elements, are used as precursor crystals. The structural studies are performed using X-ray powder diffraction, electron microscopy and atomic probe technique. Synthesized nanostructures dispersed in PAO oil appear to have excellent tribological properties within a definite loading range. Friction is reduced for almost 25% and wear is reduced for more than 60**%** at low loads for nanotubes and peapods.

Transition metal dichalcogenides nanoparticles and nanotubes found several applications, especially as ultra-low friction materials, catalysts and ultra strong impact resistant material. The spontaneous agglomeration on nanoparticles that is usually present in synthesis reduces the efficiency of size effect phenomena. Here we report, a novel synthetic route, the structural studies using electron microscopy and atomic probe technique and tribological properties of the nanotubes and MoS_2 peapods, which represent a new class of hybrid materials [1]. Peapods limits the problem of agglomeration and simultaneously solves many current questions regarding safe production, storage and transport of nanoparticles. The synthetic route developed opens new door to large scale production of MoS_2 nanotubes and peapods for variety of commercial markets.

Nanowires based on $Mo_6S_2I_8$, synthesized directly from the elements at temperature 1250K are used as precursor crystals. The structure of extremely brittle needle like crystals with over a 1: 1000 aspect ratio grown with the long axis along the c-lattice parameter was found to have a one-dimensional chain-like character with the Mo_6 octahedral clusters as a basic unit. The prolonged reaction time resulted in up to several millimeter-long needles having a diameter from several tens to a few hundred nanometers. However, fine needles approximately 30-50 nm in diameter and lengths up to several ten of micrometer were grown directly from elements in the temperature gradient conditions. Nanowires have been sulphurized at 1100 K (for peapods) and 1000 K (for nanotubes) [2] in flowing Ar gas containing H_2S. X-ray powder diffraction and x-ray energy dispersive analysis of the end product reveal the I-free pure MoS_2 compound. The spherical MoS_2 nanoparticles grow in a confined geometry of nanotube reactors, which subsequently serve as nanocontainers and prevent undesired release of nanoparticles into the atmosphere. Synthesized MoS_2 nanotubes and peapods dispersed in PAO oil appear to have excellent tribological properties within a definite loading range in comparison to typical transition metal dichalcogenides. Friction is reduced for almost 25% and wear is reduced for more than 60% at low loads for nanotubes and peapods. This new, very efficient and relatively simple synthesis could be upgraded for bulk production of a wide variety of inorganic peapods and nanotubes, while the already established industrial use of MoS_2 give hope for a prompt applications of MoS_2 peapods and nanotubes.

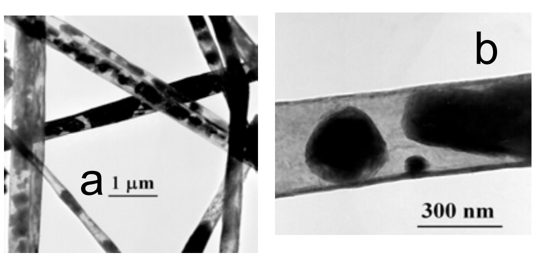

Figure 1: TEM of the final product: a) a general view of the MoS_2 nanotubes with encapsulated MoS2 fullerenelike nanoparticles; b) single MoS2 fullerenes and their aggregates inside a thin-walled MoS2 nanotube;

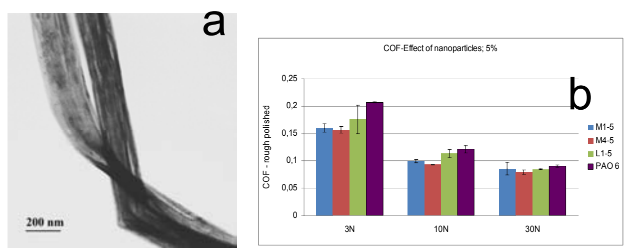

Figure 2: a) Transmission electron micrographs of a typical MoS_2 nanotube hybrid with split walls into several cylinders with gab among them. b) comparison of coefficients of friction for nanotubes, peapods and MoS2 powder dispersed in PAO oil.

References

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