Inorganic Nanotubes

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Following the first reports on carbon nanotubes in 1991 by S. Iijma[1] and on inorganic tungsten disulfide (WS_2) nanotubes by R. Tenne in 1992[2], intense experimental and theoretical research has been developed, emphasizing the importance of this field for nanotechnology. Tenne reported the formation of equivalent stable structures in the layered semiconductor WS_2 and stated that complete closure of the WS_2 layers required the presence of structural defects regarding edge dislocations and arrangement of atoms in polyhedra other than a planar hexagonal geometry. The main stimulus for the closure of sheets would be the elimination of dangling bonds at the edges, as was pointed out for graphite sheets[2].To date, however, it is essential to make the complimentary forms to pores in self-closed nanoparticles, according to Remškar[3] . In Tenne's group, the nanotubes were grown by sulfurization of the transition metal oxides. The tubular forms were obsereved to grow in voids of the otherwise dense materials, in contrast to the polyhedral forms of Fig. 2, which grow in the bulk of the material.[2] Remškar stated in her review on the structural properties of inorganic nanotubes in 2004, that each growth technique has a perticular effect on the nanotube morphology.[3] She also reffered to the synthesis of six families of inorganic nanotubes, including transition metal oxides NT's -TiO_2-, transition metal halogenous NT's -$NiCl_2$-, mixed-phase and metal-doped NT's -Au-MoS_2-, boron and silicon-based NT's-BN, Si;-, metal nanotubes-Fe- other than Tenne's group. To date, it is noted that halloysite NT's[4], SNT's[5], BNNT's[10][7], Au NT's[6] have been frequently used for biomedical applications. In addition, gold[8], silver[8], graphene[8] and graphene oxide[8], ZnO[8], Ca[8], Ba[8] and their nanocomposites, HNT's[4] have been studied for water treatment. SWCNT's organic/inorganic fillers[9] may be promising for the development of biodegradable materials. Moreover, TiO_2 NT'S[11, 12, 13, 14, 15, 16, 17, 18, 19, 20] may have a signifficant impact in this field of research as they were found to be studied in many fields of applications probably due to their remarkable electrochemical properties they exhibit. Dargouthi in her structural study of TiO_2 in 2017[20] stated that TiO_2 exists in various crystalline forms, including rutile, anatase and brookite, indicating that the anatase form to has the best photocatalytic activity. She also reffered to the recent applications of this material concerning the photo-selective destruction of bacteria and cancer cells, the manufacture of self-cleaning surfaces, the solar cells, the photocatalytic decomposition of organic matter, photo-electrochemical water splitting, gas sensors and electrodes for lithium batteries. A rather captivating application of this material refers to the promotion of osteoblastic differentiation in vivo and in vitro. In order to investigate the influence of surface – biofunctionalized substrates on osteoblastes behavior, Min Lai et al, obsereved a layer of aligned TiO_2 nanotubes that was fabricated on titanium surface in order to conjuct the osteogenic growth peptide (OGP) on to TiO_2 NT's through the intermediate layer of polydopamine[11]. In this study SEM, AFM, XPS and contact angle measurements demonstrate that OGP was sucessfully immoblized onto the surfaces of TiO_2 NT's. Further studies will be conducted to evaluate the potential of this material as a bone implant in vivo.

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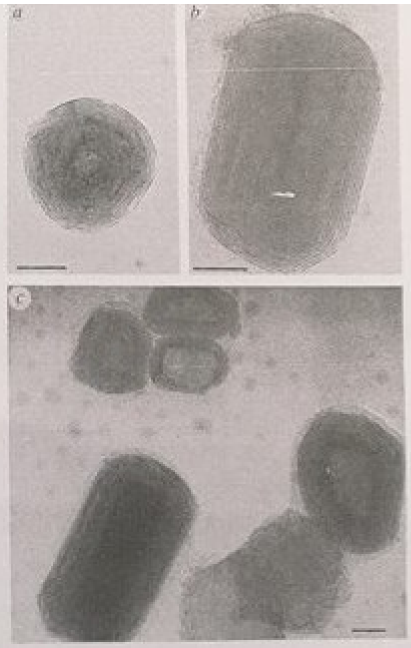

FIG. 2 Electron micrographs of polyhedral crystals of WS_2. *a*, Spheroid crystal; *b*, stir-bar crystal; *c*, a region containing several polyhedral crystal The spacing between fringes is 0.615 ± 0.005 nm, which agrees with th distance between two neighbouring layers (*c*/2) of WS_2 (ref. 16). Tw plate-like crystals partially overlapping are also seen at the bottom. Sca bar is 10 nm.

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