One-dimensional nanomaterials: Applications in physics, chemistry and biology

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One-dimensional nanomaterials (in particular, metallic and inorganic nanotubes and nanorods) have been shown to have possible applications in diverse areas including nanolasers, microcavities, surface enhanced Raman effect, photovoltaic cells, field emission sources, and gas sensing [1]. We show that in certain cases, a nanorod array (NRA) may show emergent properties, i.e. properties that are distinctly different from those of individual nanorods. This includes the application of metal NRAs as an electrode to substantially lower the gas breakdown voltage [2], enhance electron emission [3] and laser-induced x-ray emission [4], and also in the fabrication of super-hydrophobic surfaces [5]. On the other hand, core-shell nanorod arrays (metal core, ZnO or TiO$_2$ shell) appear to specifically suited for use as an electrode in a dye sensitized solar cell [6].

We also review our study of the hydrothermal synthesis mechanism of vertically aligned, multiwalled trititanate (H$_2$Ti$_3$O$_7$) nanotube and nanorod arrays [7]. These high aspect ratio titania-based nanostructures show encouraging performance in the gas phase photocatalytic oxidation of ethylene [8]. Significantly, H$_2$Ti$_3$O$_7$ nanotubes also form a strongly associated nanobio-conjugate with the vital respiratory protein, cytochrome c. Cytochrome c in this nanobio-conjugate exists in an equilibrium of two conformational states with distinctly different formal redox potentials and coordination geometries of the heme center. The nanotube conjugated cytochrome c also showed enhanced peroxidase activity similar to membrane bound protein that is proposed to be an apoptosis initiator, suggesting that this nanobio-conjugate may be a good candidate for cancer therapy [9].

Reference: