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Jean-Paul (Moshe) Lellouche

Bar-Ilan University, Institute of Nanotechnology &

Advanced Materials - BINA, Israel

Innovative chemistry and nanotechnology-based surface engineering of hydrophobic tungsten disulfide (WS_2) Inorganic Nanotubes (WS_2-INTs) - novel nanoscale functional Bio-Active Inorganic "Nanofillers" (f-WS_2-INTs)

Tungsten disulfide nanotubes (INTs-WS_2) are extremely hydrophobic and chemically inert inorganic nanomaterials. This feature quite strongly limits their usefulness in numerous mechanical hardness and tribology-relating research developments and subsequent industrial/bio-active end-applications. Thus, the *covalent* versatile linkage of any kind of functional organic and/or biology-relating species remains a quite critical developmental step towards highly innovative high-performance nanomaterials and multiphase composites in the field of *essential interfacial versatile chemistries*. In such a highly challenging methodology/functionalization issue context concerning these chemically inert hydrophobic nanomaterials, an innovative method of surface functionalization (versatile *polycarboxylation – polyCOOH shell formation*) of multi-walled inorganic nanotubes (INTs-WS_2) and fullerene-like (IFs-WS_2) nanoparticles has been successfully developed. This *covalent* functionalization method makes use of highly electrophilic and reactive imminium salts (Vilsmeier-Haack (VH) complexes-reactions) in order to enable the introduction of a *chemically versatile polyacidic (polyCOOH) shell* onto the surface of VH-treated inorganic nanomaterials. Moreover, a significant statistical Design Of Experiments (DoE) method has been also involved for global optimization of this multi-parametric polyCOOH shell generation. This novel INTs-nanotube sidewall polyCOOH functionalization enabled innovative-targeted interfacial chemistries. Indeed, it enabled the effective nanofabrication of a wide range of *covalent* WS_2-INTs surface modifications (polyNH_2, polyOH, polySH) via (i) polyCOOH chemical activation (EDC, CDI) and (ii) 2nd step *covalent* nucleophilic substitutions by short -aminated bifunctional ligands H_2N-*linker*-X (X outer surface functionality). Moreover, an additional innovative surface engineering methodology for same multi-walled inorganic nanotubes (INTs-WS_2) has been also discovered via use of small 5.5-6.0 nm-sized lanthanide action/complex-doped magnetic maghemite nanoparticles towards corresponding magnetically responsive inorganic nanotubes for photo-thermal therapy (PTT) anti-cancer bioactivity. Resulting fully characterized functional INTs-WS_2 (f-INTs-WS_2) have a quite wide potential for use as novel functional nanoscale fillers toward new mechanically strengthened and/or conductive composite polymeric matrices (case of hybrid polythiophene-decorated f-INTs-WS_2 nanocomposites, Figure 1). Corresponding novel functional nanomaterials/nanoscale fillers have been also shown to be PTT bioactive and non-toxic in preliminary toxicity studies, which opens a wide R&D route/progress for relating end-user applications (cellular toxic CNTs nanofillers replacement for example).

Biography

Jean-Paul Lellouche (1981 PhD degree/education in Organic Chemistry field, University La Doua, Lyon - France) moved in October 2000 to the Bar-Ilan University (Ramat-Gan, Israel) - Department of Chemistry & Institute of Nanotechnology & Advanced Materials as a *Full Professor* in synthetic Organic Chemistry/Nano(bio)technology (July 2008) & recent Dpt Head (Oct 2017-July 2018). His main current R&D activities concern nanomaterials engineering science (magnetic/non-magnetic drug/siRNA & microRNA delivery systems, theranostic nanoparticles for human therapy). He authored 155 peer-reviewed scientific papers (2,528 citations), 15 patents, and 4 book chapters together with a recent start-up creation activity (January 2019 – NANODROPs project).