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Surface-engineered tungsten disulfide (WS_2) inorganic nanotubes (INTs-WS_2)–novel chemically modified nanoscale CNT-replacement inorganic nanofillers

Statement of the Problem: Tungsten disulfide nanotubes (INTs-WS_2) and fullerene-like nanoparticles (IFs-WS_2) are extremely hydrophobic and chemically inert inorganic nanomaterials, which quite strongly limits their usefulness in numerous mechanical hardness and tribology-relating research developments and subsequent industrial end-applications. Thus, the covalent attachment 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.

Methodology & Theoretical Orientation: In this context of highly challenging functionalization issue of these chemically inert hydrophobic nanomaterials, an innovative method of surface functionalization (versatile poly carboxylation – 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 ammonium salts (Vilsmeier-Haack (VH) complexes) in order to enable the introduction of a chemically versatile poly acidic (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 poly carboxylation shell generation.

Findings: This INTs-nanotube sidewall polyCOOH-enabling functionalization showed extreme COOH-based chemical versatility for innovative-targeted interfacial chemistries. It enabled the effective fabrication of a wide range of covalent WS_2-INTs surface modifications (polyNH_2, polyOH, polySH) via polyCOOH chemical activation (EDC, CDI) and 2nd step covalent nucleophilic substitutions by short □-aminated ligands H^2N-linker-X (X outer surface functionality).

Conclusion & Significance: 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 nano composites, Figure 1). Corresponding novel functional nanomaterials/nanoscale fillers have been also shown to be 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 leads a laboratory dedicated to Nano-biotechnology and Polymer Science. His current R&D activities include "R&D developments in the materials science field interfacing with nano-biotechnology, i.e., conducting functional polymers; chemically modified hard nanoscale fillers; UV-photo-reactive nano(micro)particles [surface nano(micro)structuration of polymeric coatings, hybrid metallic catalytic particles]; antibacterial organic/inorganic NPs and coatings and; innovative surface modifications of iron oxide (magnetite/maghemite) NPs towards gene silencing (siRNA/microRNA in *vitro/in vivo* delivery) and anti-parasitic bio-activity". Recently, he deeply focused on and elaborated various innovative organic chemistry-based methodologies for the development of effective covalent versatile interfacial chemistries towards chemically tailored non-toxic mechanically hard functional inorganic: Tungsten disulfide nanotubes and; tribology-effective fullerene-like tungsten disulfide nanoparticles.

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