Hybrid Polymer Nanocomposites with Low Flammability and Enhanced Mechanical Strength for Transport Applications: Synthesis, Characterization and Toxicity Evaluation

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The introduction of composite materials in the primary and secondary structures of railway materials and marine vessels increased in the last few years, after the latest rules of SOLAS (*Safety of Life at Sea*) and UIC (International Union of Railways) that allow their construction with other materials than steel. In this sense, low FST (Fire-Smoke Toxicity) sandwich structures are the key factor to build lightweight, durable ships and trains with lower maintenance costs. The main aim of this research work is the development of polymer composites/foams from polyvinyl chloride (PVC), via extrusion, that will serve as the core of sandwich structures. The composites/foams are enhanced with modified nanoparticles consisting of either a two-component flame retardant system [Layered-Double-Hydroxides (LDHs) in conjunction with synergistic organophosphorous compounds] or high-purity multi-wall carbon nanotubes (MWCNTs).

MWCNTs were produced in a fluidized bed chemical vapor deposition reactor, using proprietary catalysts that result in MWCNTs low bulk density and efficient dispersion in polymeric matrices. The nanoparticles were characterized with XRD, FTIR, XPS and SEM. Structural characterization of the composites was performed with XRD and SEM. The thermal stability and flame retardancy were determined by TGA and the Limited-Oxygen-Index method, respectively. The results showed enhanced thermal stability for LDHs, whereas the flammability of MWCNTs-PVC composites was drastically reduced with respect to that of PVC. The nanocomposites also exhibited increased Young's modulus as well as improvements in compressive strength of more than 200%.

The toxicity of MWCNTs-based polymer composites at different stages of their life cycle (processing/compounding, aging and end of life) was assessed. In addition, their migration and/or release to the environment were quantified. Toxicological/ecotoxicological data of selected samples were collected in order to evaluate the risks associated with their manufacturing, use, recycling and disposal, aiming at mitigating concerns about their long-term impact on environment and health.