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POLYETHYLENE-BASED NANOCOMPOSITES FOR RADIATION SHIELDING: MODELLING IN RADIATIVE ENVIRONMENT AND LABORATORY TESTS IN THERMO-VACUUM CHAMBER

Abstract

Human space missions beyond near Earth orbit call for new materials to mitigate risk factors associated with radiation exposure. Current materials show many limitations in this regard for applications in crew exploration vehicles, spacesuits and human habitats. Novel approaches in the design and development of radiation protection materials are needed. In particular, novel materials should combine multifunctional mechanical/electrical/thermal properties with optimal flexibility, robust radiation shielding, and high durability in space environment. In this context, nanoparticles based on carbon and boron, due to their exceptional properties such as high modulus and high electrical and thermal conductivities, can play an important role in the design of multifunctional radiation protection materials. Hydrogenous materials, such as polyethylene, are the most known effective protection against high-energy charged particles, such as galactic cosmic rays (GCR) and solar particles events (SPE). However, these materials are non-structural and their overall properties are quite low, considering the operative conditions in space. In order to overcome such limitations, the current standard for the aerospace industry is to apply the polyethylene layer to an aluminum structural element. However, the integration of functional and structural properties in one component made of composite material would be a significant improvement in the state-of-art. In the first part of this work, we performed an extensive study modelling the radiation shielding behavior of nanocomposites with polyethylene matrix using the tool OLTARIS, which is an integrated tool set in the software HZETRN developed by NASA. Polyethylene modified with different types of nanoparticles at several weight percentages were modelled to evaluate the radiation shielding effectiveness. The behavior of polyethylene-based nanocomposites were compared with those of a number of materials typically used in space. Simulations involved different radiative environments, such as GCR, SPE and LEO. In the second part of the work, we performed experiments on selected polyethylene-based nanocomposite materials in a thermo-vacuum chamber equipped with a lamp simulating the effects of the solar spectrum. In particular, we investigated the total mass loss of the samples under the simulated space environment in time.