IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Specialised Technologies, Including Nanotechnology (8)

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SPACE-GRADE POLYETHYLENE/CARBON NANOCOMPOSITES FABRICATED BY 3D-PRINTING

Abstract

In additive manufacturing (3D printing) processes, polyethylene (PE) filaments can be taken into consideration to build and recycle components in space, thus reducing costs, risks, and logistics issues that can occur during a long-term mission beyond Low Earth Orbits. In fact, the excellent radiation shielding properties of polyethylene, which are due to its high content of hydrogen, have found consensus among the scientific community. On the other hand, PE shows poor mechanical, electrical, and thermal properties. Adding carbon nanoparticles, such as graphene or carbon nanotubes (CNT), to polyethylene results in nanocomposites with enhanced properties and multifunctional features. In this paper, we studied the process of filament extrusion of polyethylene loaded with different weight percentages of multi-walled carbon nanotubes (MWCNTs) and graphene nanoplatelets (GNPs). In the initial phase, key parameters, such as extrusion rate, nozzle temperature, as well as nanoparticles loading, were optimized to obtain a smooth extrusion and a good uniformity of the filament diameter. Next, PE-based nanocomposite specimens with different nanofiller loadings were fabricated using a 3D printer based on fused deposition modeling (FDM). We investigated the morphology of the extruded filaments and that of the printed nanocomposites using scanning electron microscopy (SEM). The thermal and the electrical properties, as measured by differential scanning calorimetry (DSC) and electrical impedance spectroscopy (EIS) respectively, were analyzed and compared to those of the neat polyethylene polymer. Results from our investigation demonstrated the capability of 3D printers based on fused deposition modeling to successfully manufacture components made of multifunctional polyethylene/carbon nanocomposites starting from extruded filaments with tailored properties.