Paper ID: 86692
oral
student

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures & Specialized Technologies, Including Nanotechnology (9)

Author: Mr. Javier Gómez Sánchez
Universidad Rey Juan Carlos, Spain

Dr. Xoan Xosé Fernández Sánchez-Romate
Universidad Rey Juan Carlos, Spain
Mr. Alberto Jimenez-Suarez
Universidad Rey Juan Carlos, Spain
Prof. Silvia González Prolongo
Universidad Rey Juan Carlos, Spain

SMART REPAIRABLE, RECYCLABLE, AND RESHAPABLE (3R) FIBER REINFORCED POLYMERS (FRP) WITH STRUCTURAL HEALTH MONITORING CAPABILITIES (SHM) BASED ON A VITRIMERIC MATRIX DOPED WITH CARBON-BASED NANOCOMPOSITES

Abstract

Among the serious challenges of space structures, the space waste is becoming a growing concern for the safety and reliability of the Earth-orbiting spacecraft. Despite the development and integration of high-performance materials such as fibre-reinforced polymers (FRP), spacecraft structures still deteriorate over time in the harsh space environment due to small particles colliding at high velocities. Recent research has focused on extending the useful lifetime of these structures. However, the future use of FRPs may be at risk even under Earth environmental conditions due to their difficulties in repair, recycling, and reprocessing. In addition, these materials require periodic inspections based on advanced in-situ non-destructive testing and repair actions which cannot be directly applied in spacecraft due to the complex access and manipulation. To address these issues, a FRP composite has been developed with the ability to be repaired, recycled, and reprocessed (3R) together with Structural Health Monitoring (SHM) capabilities. The developed composite consists of a reversible thermoset matrix, so-called vitrimer, based on dynamic covalent bonds that break and reform when subjected to an activation temperature. To achieve the required temperature without external manipulation, carbon-based nanocomposites have been embedded in the vitrimeric matrix to create electrical pathways throughout its volume. This provides the material with the ability to undergo thermal activation via Joule effect, as well as the ability to detect damage and strain. The composites were characterized in terms of their thermal properties and electrical properties. The repairability was evaluated by inducing a damage in the specimens and subsequently repairing them through resistive heating. Mechanical tests were conducted while simultaneously recording electrical resistance to evaluate the SHM capabilities. The results from the repairability tests demonstrated that the vitrimeric composites exhibit high self-healing efficiency values. The electrical electrical conductivity increases with CNT content due to the generation of a higher number of conductive paths. Finally, the deformation of the specimens during the mechanical testing caused an increase in electrical resistance due to the separation of the CNTs and the rupture of the conductive paths, thus demonstrating the damage sensing capabilities. This highlights the potential use of smart 3R composites in structures that are difficult to access and manipulate once in service such as spacecraft. In the event of damage, these structures can detect it through an increase in electrical resistance. Then, an autonomous repair can be triggered through an increase in voltage which causes a temperature increase via Joule effect.