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POLYIMIDE/GRAPHENE NANOCOMPOSITES AS ANTIBACTERIAL COATINGS FOR HUMAN EXPLORATION MISSIONS IN SPACE

Abstract

Bacteria can survive and thrive in the extreme space environment, and their presence can compromise the astronaut's health, the integrity of spacecraft systems and the overall success of a space exploration mission. Indeed, bacteria can colonize the spacecraft internal surfaces inducing mechanical blockages, deterioration, and corrosion. The formation of biofilms occurs during the fabrication of the structures and is favoured by the presence of astronauts. Therefore, materials used for spacecraft components should withstand the hostile conditions of space but also resist bacterial activity. The purpose of this work is to fabricate and characterize coatings used for long-terms human space exploration that prevent bacterial adhesion and destroy their membrane while maintaining good physical/chemical properties. Nanocomposite coatings with potential antibacterial properties were fabricated from a fluorinated polyimide (PI) matrix filled with graphene nanoplatelets (GNP). The PI matrix was synthesized from aromatic diamine (4-BDAF) and dianhydride (6-FDA) in a non-toxic solvent, dimethyl isosorbide, following a green protocol. PIs are attractive polymers widely used in long-terms space explorations for their outstanding mechanical properties, high-temperature and chemical stability, and resistance to UV-induced degradation. The latter property is essential for applications involving UV sterilization of surfaces to kill bacteria. In addition, hydrophobic polyimides with low surface free energy can enhance the inhibition of biofilm formation. Subsequently, different concentrations (from 1 wt% to 30 wt%) of graphene were selected to fabricate nanocomposite coatings. Graphene was chosen for its excellent thermo-mechanical properties, but especially for its bactericidal ability. Graphene-based materials can destroy the bacterial membrane, due to several mechanisms, called membrane stress and oxidative stress. Micrometric-thick polyimide/GNP films were fabricated by spin-coating and investigated using several experimental techniques to assess the potential use for antibacterial applications in space environment. In addition, the role of the filler at different concentrations was analysed in terms of morphology, wettability, and chemical structure. Morphology was evaluated by light microscopy and confocal laser scanning microscopy (CLSM). An optical tensiometer was used to demonstrate that the samples have low wettability and low surface free energy, which are crucial for antibacterial capacity. Raman spectroscopy was used to investigate the chemical structure and interaction between the carbon nanofiller and the polyimide matrix.