IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Environmental Effects and Spacecraft Protection (6)

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DEVELOPMENT OF POLY(VINYL ALCOHOL) ORGANOGELS CROSSLINKED BY BORIC ACID FOR RADIATION PROTECTION IN SPACE

Abstract

Gels are non-fluid colloidal materials characterised by a network of polymers crosslinked in a liquid solvent exhibiting properties of soft materials. Over the past two decades, poly(vinyl alcohol) (PVA) hydrogels have attracted considerable attention due to their properties of biocompatibility, lightweight, flexibility and conductivity. This category of gels, which use water as a solvent, is currently being investigated in the medical and pharmaceutical fields due to its high biocompatibility. In addition, the ability of PVA hydrogels to absorb water makes them promising materials for radiation shielding in space, as a high hydrogen content significantly reduces the damage caused by radiation to astronauts. PVA hydrogels can be prepared by physical or chemical crosslinking processes. Among these methods, only chemical crosslinking can produce a permanent hydrogel by forming covalent bonds between polymer chains and the crosslinker. Boric acid (BA) is recognised as a versatile crosslinking agent because it forms hybrid interpolymeric bonds with PVA molecules, by improving mechanical properties and increasing the water-retention capacity of gel. However, it is crucial to note that BA has a solubility limit of 5%w/v in water. Given the PVA degradation in acidic solutions, the optimal approach to gel fabrication involves initially dissolving the polymer in water and subsequently adding an aliquot volume of a stock solution. This process imposes a limitation on BA concentration in solutions, leading to a reduction in gel properties. This challenge is resolved using an organic solvent to prepare the stock solution to increase the BA concentration in the stock solution. Gels produced through a process involving a mixture of organic solvents are referred to as organogels. Notably, these organogels exhibit superior characteristics compared to hydrogels, particularly in terms of pH resistance, freeze tolerance, and heat resistance. In this work, PVA/BA organogels were fabricated at different BA concentrations (1%, 2%, 3%, 4 %w/v) using water and ethanol as solvents. The PVA and BA bonds were evaluated using Fourier transform infrared spectroscopy (FTIR). The thermo-mechanical behaviour of these gels was investigated by dynamic mechanical analysis (DMA) in compression mode. Finally, to assess the shielding efficacy of gels, numerical simulations were conducted using the On-line Tool for the Assessment of Radiation in Space (OLTARIS) software in different space radiation environments considering galactic cosmic rays, solar particle events, and low Earth orbit radiation.