Tardigrade Mech: Boron Nitride Nanotube Composites for Space Radiation Protection

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Radiation exposure for long term space missions currently surpasses limits set by NASA, largely due ionizing radiation in the form of galactic cosmic rays (protons, heavy ions and alpha particles). Current materials containing larger atoms produce harmful secondary radiation when irradiated. A lower effective atomic number, adequate specific strength and thermal conductivity characteristics are needed for a better material. Boron nitride nanotubes (BNNT) have a high specific strength, varying thermal conductivity and when hydrogenated they are superior in radiation protection, while emitting minimal secondary radiation. This project evaluated different low outgassing matrices for the formulation of nanocomposites with BNNT and 5% by mass hydrogen (BNNT+H2). The matrices evaluated are: tetraglycidyl-4,4'-methylene dianiline (epoxy), poly(ether ether ketone) or PEEK and fayalite (a mineral found on terrestrial planets). Formulas were explored and developed to assess radiation protection, thermal conductivity, specific strength and density. It was discovered that BNNT+H2 with the epoxy surpasses water in its radiation protection with 90% composition by mass of BNNT+H2 and has a thermal conductivity approximately nine times greater than that of water. Monte Carlo simulations implementing the novel RadProc Index were used to evaluate conventional materials and BNNT+H2 in epoxy for 10%, 50% and 90% BNNT+H2 by mass. It was revealed that relative to water, this composite has comparable radiation protection for the same mass and 50%-90% BNNT+H2, in addition to outperforming polyethylene. Therefore, BNNT nanocomposites are innovative and competitive materials to use for passive radiation protection in space suits, spacecraft and habitats.