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# TARDIGRADE MECH: BORON NITRIDE NANOTUBE COMPOSITES FOR SPACE RADIATION PROTECTION

**Abstract**

Human radiation exposure during long term space missions to Mars and beyond currently surpasses safety limits set by NASA, largely due to ionizing radiation in the form of galactic cosmic rays. Currently, materials used to protect against this radiation are composed of larger atoms that produce secondary radiation when irradiated. A lower effective atomic number, adequate specific strength and thermal conductivity characteristics are parameters considered for a better alternative. The inspiration for this project was the tardigrade. A micro-animal that is able to survive harsh environments including space radiation because of the unique Dsup protein it produces that protects its DNA on a molecular level (Hashimoto et. al, 2016). Boron nitride nanotubes (BNNTs) have a high specific strength, varying thermal conductivity and, when hydrogenated, are superior in radiation protection, while emitting minimal secondary radiation. In this work, different low outgassing matrices were evaluated for the formulation of nanocomposites with BNNT and 5% hydrogen by mass (BNNT+H2). The matrices considered were: tetraglycidyl-4,4'-methylene dianiline (epoxy), poly(ether ether ketone) or PEEK and fayalite (Fe2SiO4, an iron rich mineral found on many terrestrial planets). The radiation protection, thermal conductivity, specific strength and density of composites developed from BNNT and these matrices were analyzed. We found that 90% BNNT+H2 by mass in an epoxy matrix surpasses water in radiation protection 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. This composite has similar radiation protection capabilities to water for the same mass with 50%-90% BNNT+H2, in addition to performing better than polyethylene. Therefore, BNNT nanocomposites could be innovative and competitive materials for use in passive radiation protection in space suits, spacecraft and habitats.