Paper ID: 78229
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Interactive Presentations - IAF MATERIALS AND STRUCTURES SYMPOSIUM (IP)

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DEVELOPMENT OF RADIOPROTECTIVE BIO-COATINGS VIA METAL-DOPING OF MELANIN NANOPARTICLES

Abstract

Long-term space missions necessitate more options to protect and harness space radiation. In space, equipment and personnel are exposed to ionizing radiation capable of damaging electronics and causing serious health risks. The potential answer to these challenges might lie within us. Melanins - a class of pigments found in bacteria, fungi, plants, and animals - are nature's radiation shield and convert absorbed radiation into heat and/or electrostatic potential. Compared to traditional shielding materials like lead, aluminum, etc., melanins are significantly lighter, easier to produce, regenerative, potentially capable of equivalent radiation shielding, and thermally insulating. Most importantly, they can be bio-produced in situ, making them an ideal solution for long-term space missions. The question then fundamentally lies, is it possible to pair the advantages of melanin pigments with traditional shielding materials used in space? Current research on shielding using melanin only scratches the surface of melanin's complex organic chemistry, stifling its potential as a radiation shield and a material capable of converting radiation into thermal and electrical energy. Evidence exists that select metals can chelate melanins, but there remains no broad study assessing the impact of metal chelation on melanin's properties in the context of radiation attenuation and dissipation. We hypothesize that metal doping will only improve radiation shielding and the thermal properties of melanin. In this project, we aim to devise a consistent method to dope melanin with metal nanoparticles, test their impact on radiation attenuation and thermal conductivity, and assess viability of producing tangible products (such as coatings and polymers) utilizing doped melanin. We successfully developed a protocol to dope melanin isolated from the fungus C. neoformans with $Cu2+$, $Zn2+$, $Pb2+$, $Ca2+$, and $Fe3+$ and utilized a dose-response method to indirectly quantify the metal binding affinity. Thermal conductivity tests of $Fe3+$, $Cu2+$, and $Zn2+$ doped samples are higher than plain melanin, corroborating the effect of doping conductive metals to an insulative melanin. Thermography of melanin samples following irradiation with white light show that doped samples heat up faster and reach higher temperatures than controls, suggesting enhanced radiation absorption. Next we will test the effect of metal doping on melanin's ability to shield X-rays. In conclusion, we have found that the binding of metals to melanin produces a marked difference in performance when it comes to absorbing radiation and thermal conductivity. With this project, we hope to cement melanin as a key player in the next generation of space biomaterials.