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M1Po3B-07: Assessing the Adhesion of Nanofibrous PVDFHFP as Passive Thermal Control Coatings for the Extraterrestrial Storage of Cryogenic Propellants

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Future space missions to distant frontiers could require significantly larger amounts of cryogenic propellants than typical missions. Such missions and esoteric applications, like space tourism, would benefit from propellant storage in space for refueling space vehicles. In this regard, advancements in cryogenic fluid management are necessary to achieve extraterrestrial storage. Specifically, passive cryogen management techniques in space, like radiative cooling, are necessary to reduce the burden on active thermal control methods, like cryocoolers. Particularly, materials with superior optical properties (high solar reflectance and infrared emittance) would be beneficial for passive thermal control to reject most of the incident solar radiation and enhance thermal emission from the storage tank, leading to self-cooling. We developed a nanofibrous passive thermal control material by electrospinning polyvinylidene fluoride-co-hexafluoropropylene (PVDF-HFP) co-polymer onto an aluminum foil substrate. The electrospun nanofibrous PVDF-HFP has a porous nanostructure, as observed by scanning electron microscopy. The material exhibits a very high solar reflectance (>99%) and infrared emittance (86%) when characterized in the ultraviolet-visible-near infrared and mid-infrared wavelengths using spectrophotometers interfaced with integrating spheres.
This study focuses on the adhesion of the electrospun PVDF-HFP to the aluminum foil substrate. We conduct adhesion peel strength testing using an Instron universal testing machine following the ASTM D3330 standard test method. First, we tested a pristine PVDFHFP-aluminum foil material at room temperature to assess the adhesive strength of the nanofibers to the substrate. Subsequent tests, performed at room temperature, incorporated in-lab fabricated and commercial adhesives between the nanofibers and the aluminum foil substrate to improve the adhesion between the nanofiber and the substrate. For extraterrestrial applications that would expose the materials to extreme temperature swings, we studied the effects of cycling between cryogenic and high temperatures on the adhesive strengths of the adhesives used in this study. Further characterization and testing in extreme environmental conditions would provide insights into its applicability for extraterrestrial long-term storage of cryogenic propellants in space depots.

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Author: IBEKWE, Chieloka

Co-authors: NEVEU, Adrien (Rensselaer Polytechnic Institute); AN, Nan (Rensselaer Polytechnic Institute); WANG, Xuanjie (Rensselaer Polytechnic Institute); HARTWIG, Jason (NASA Glenn Research Center); SWANGER, Adam (NASA Kennedy Space Center); NARAYAN, Shankar (Rensselaer Polytechnic Institute)

Presenter: IBEKWE, Chieloka

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