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M4Or1B-05: Investigating dual electrospinning as a means of enhancing passive thermal control coatings for cryogenic propellant storage in extraterrestrial environments

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As space exploration becomes more prevalent, passive thermal control becomes increasingly necessary. Preserved cryogenic compressed fuels in space for exploration must be exposed to as little thermal energy as possible, and the primary objective to accomplish this task is through the reflection of incident sunlight. Current passive reflective thermal control coatings are metallic with relatively high reflectivity; however, they have some absorption, resulting in high surface temperatures on the coatings after extended exposure to sunlight. This shortcoming necessitates active cooling techniques, which are non-ideal for payload efficiency. In this regard, next-generation thermal coatings can have a significant role. Previous studies have shown that electrospun nanofibers have high solar reflectance alongside infrared emittance, resulting in a passive cooling phenomenon even when exposed to direct solar radiation. This study aims to create hybrid electrospun materials through dual-spinning by leveraging known desirable traits of different electrospun materials while minimizing undesirable traits.

Individually, different materials show promise as reflective insulators but with distinct fallbacks. Polymer-based nanofibers made from PVDF-HFP are extremely effective insulators with very high reflectivity, with average solar reflectances around 99.5%. It has satisfactory adherence to its substrate material - an aluminum foil, and is resistant to delamination and tearing. However, it experiences minor degradation in the presence of atomic oxygen. Silica-based nanofibers, on the other hand, are highly resistant to temperature fluctuations and atomic oxygen but are brittle and exhibit minimal adherence to their substrate material. It also has very good reflectivity but less so than its polymer-based counterparts, with a reflectance value averaging around 97%. This research aims to, through dual electrospinning, interweave the silica nanofibers with the polymer nanofibers (PVDF-HFP), with the goal of maintaining the reflective performance of the polymers while adopting the temperature and atomic oxygen resistance of the silica. The resultant composite electrospun material is expected to have a reflectivity value of approximately 98-99%, which is more resilient to atomic oxygen and thermal cycling than the component materials.

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