NASA Phase I Project Summary

Nonproprietary

Firm: Creare Incorporated
Contract Number: NNX13CJ24P
Project Title: Renewable Long-Life Biocidal Hydrophilic Coating for Condensing Heat Exchangers

Identification and Significance of Innovation:

Condensing heat exchangers (CHXs) are critical parts of environmental control and life support systems on manned spacecraft, which condense moisture from the cabin environment. The CHX condensing surfaces must be hydrophilic, anti-microbial, and long-lasting. Creare has developed a silver ion-exchanged, crystalline zeolite A (Ag-ZA) coating that meets all the requirements for a CHX coating, but its lifetime is currently limited to eight months. Furthermore, the zeolite coating—like all such coatings—is susceptible to fouling by trace contaminants in the cabin environment, which reduces wettability. The advanced coating system comprises: (1) a zeolite coating with modified chemistry for increased lifetime, and (2) a method for cleaning contaminated coatings in situ to restore their wetting properties.

Technical Objectives and Work Plan:

The overall objective is to improve the performance, reliability, and safety of environmental control and life support systems on manned spacecraft and lunar/planetary bases. The approach is to develop a coating for CHX surfaces that prevents microbial growth while enabling efficient heat transfer and condensate management. The overall technical objectives of Phase I are to increase the lifetime of Creare's zeolite coating while maintaining its excellent adhesion, wetting, and antimicrobial properties and to develop an aerosol-based process that will enable cleaning of the coating in situ.

We ran computational molecular dynamics simulations to understand the effects of coating modifications on zeolite dissolution. We developed methods to modify the chemistry of the zeolite coatings. We also produced samples with thicker zeolite coatings to extend lifetime. We examined the composition of the coatings using electron dispersive x-ray spectroscopy (EDS). We produced small sample coupons with original and modified zeolite coatings for testing and assessment. We measured adherence of the coatings to the stainless steel substrates, wetting properties, and biocidal properties. We ran dissolution tests to measure the effects of coating type and condensate chemistry on dissolution rates. We identified candidate solutions for in situ cleaning and measured their effectiveness for restoring wettability.

Technical Accomplishments:

The molecular dynamic computations show the potential to reduce ion diffusion in zeolites by up to two orders of magnitude by altering their chemistry. EDS analysis shows that the coating process developed in Phase I successfully modified the coating chemistry in accordance with the molecular dynamic computations. The modified coatings are highly adherent to stainless steel substrates and highly biocidal. We identified cleaning solutions that should be feasible to use for in situ cleaning on manned spacecraft. We found that wettability of both the original and modified coatings can be restored by treatment with the cleaning solution, either by soaking or by in situ methods. Substantial increases in lifetime of these coatings are possible. Thicker layers produced by multiple deposition runs should enable a lifetime up to 20 months. Dissolution test results suggest that the modified zeolites and control of condensation conditions can extend the lifetime further.

NASA Application(s):

The primary NASA application for the coating will be in environmental control and life support (ECLS) systems on future manned exploration missions, including spacecraft and rovers designed for long missions that require active ECLS systems. The coating technology will be equally applicable to any active life support system, including potential upgrades to the ECLS system on the International Space

Station. Implementation of our coating and renewal system on the ISS can potentially save large amounts of crew time and large costs associated with reapplying the existing hydrophilic coatings to the condensing heat exchangers.

Non-NASA Commercial Application(s):

The long-life, biocidal coating is potentially inexpensive and can be used to prevent microbe growth in condensing heat exchangers used for dehumidification in terrestrial HVAC systems. Benefits would be enhanced component performance and improved air quality. Another key market will be balance-of-plant equipment for terrestrial fuel cells, which will include water management components that will also require hydrophilic and antimicrobial coatings. The long-life coatings developed in the proposed program will enable these condensing heat exchangers to operate reliably with good performance for a long service life.

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