Phase I Project Summary

Nonproprietary

Firm: Creare Incorporated
Contract Number: NNX11CG20P
Project Title: Long-Life, Hydrophilic, Antimicrobial Coating for Condensing Heat Exchangers

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Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

Future manned spacecraft and lunar or Mars outposts will need a condensing heat exchanger (CHX) to control humidity in the cabin atmosphere. Condensing surfaces must be hydrophilic to control the condensate and ensure efficient operation, and biocidal to prevent growth of microbes and formation of biofilms on condensing surfaces. Coatings must be extremely stable, adhere to the condensing surface, and maintain hydrophilic and biocidal properties for many years. Creare has developed an innovative zeolite coating that adheres extremely well to heat exchanger materials and structures, is extremely hydrophilic, and contains silver ions that prevent microbe growth. However, results of long-term exposure testing show that the coating's life may be limited in prototypical environments. Our innovation is a new coating chemistry and structure that promises to remain stable for many years. The coating uses the same basic zeolite building blocks as the original coating, but incorporates new chemical features that limit the rate of diffusion into and out of the coating. This approach is possible because the antimicrobial action of the original coating was *extremely* powerful. A reduction in biocidal action by several orders of magnitude would still have powerful biocidal effects but have a much longer lifetime.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

The overall objective of this program is to improve the performance, reliability, and safety of environmental control and life support systems on manned spacecraft and lunar/planetary bases. Our approach is to increase the lifetime of Creare's baseline zeolite coating while maintaining its excellent adhesion, wetting, and antimicrobial properties. The goal of Phase I was to prove the feasibility of achieving these goals. The specific technical objectives of Phase I were as follows: (1) Identify and overcome the mechanisms that led to rapid silver transport out of the baseline coatings, (2) Identify and overcome the processes that dissolved the baseline coatings in five months, (3) Measure the performance of the basline coatings under more realistic conditions than prior tests, (4) Develop new coating formulations and process(es), and (5) Demonstrate improved stability and lifetime and excellent coating performance.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

We identified the mechanisms that control dissolution of the baseline coatings. We conceived two candidate coatings based on the baseline coatings that incorporate new chemical features to limit the rate of dissolution. We successfully produced both new coatings on SS347 substrates. The as-fabricated coatings were hydrophilic, and EDS analysis confirmed the desired composition. Visual inspection and XRD analysis confirmed the desired coating structure, and tape tests demonstrated excellent adhesion. We successfully infused silver ions into both candidate coatings. After exposure to simulated crew condensate for 18 days, we observed no change to the crystal structure, chemical composition, or adhesion of either coating. EDS measurements of the Ag^+ concentration in the coatings showed that silver ion diffusion out of the coatings was significantly slower in the new coatings compared to the baseline coating. All coated samples prevented the growth of any gram-positive bacterial cultures, demonstrating greater than six log reduction in colony-forming units compared to control samples with no silver ions.

Phase I has therefore shown the feasibility of modifying the baseline coatings to achieve longer life. Test data confirm reduced diffusion in the new coatings. The coatings can be deposited on complex heat exchange surfaces, and are extremely biocidal.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

The proposed condensing heat exchanger supports future space exploration missions by enabling efficient and reliable operation of the environmental control system on future spacecraft and lunar/planetary bases. By enabling recovery of water from the outpost atmosphere without using consumable absorber materials, the condensing heat exchanger enables simple operation of the environmental control system with minimal logistical support. The coating will be useful for condensing heat exchangers needed for future pressurized rovers and planetary bases. The coating will also be useful for potential upgrades of the ECLSS on the International Space Station.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

Efficient and reliable condensing heat exchangers will be needed for fuel cell generators or fuel reforming systems for portable electric power generation or onboard vehicular fuel cells or reformers. These heat exchangers are required for water-neutral operation and hydrophilic and biocidal surfaces are needed for long-term reliability of the system. The coating developed in the proposed program will be ideal for these applications.

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