Department of the Navy SBIR/STTR Transition Program

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NAVAIR SPR-2024-0062

Topic # N182-115
Icephobic Coatings or Surface Treatments for Turbomachinery Ice Protection Applications
HygraTek LLC

WHO

SYSCOM: NAVAIR

Sponsoring Program: NAVAIR

Transition Target: JSF F-35

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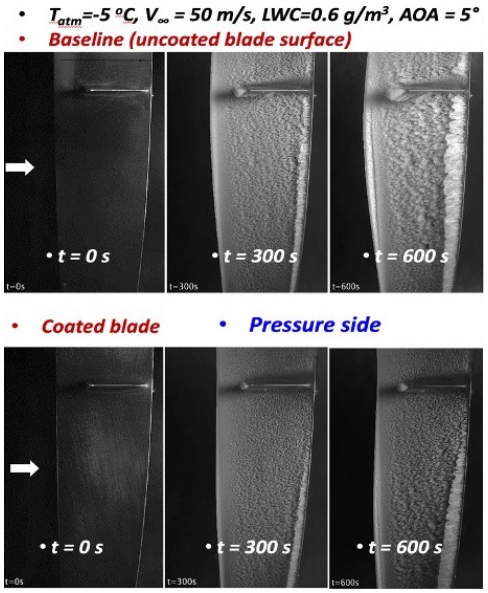
Other Transition Opportunities: Ice accretion threatens the safety, efficiency, and cost effectiveness of aircraft of all types, thus extending the range of target platforms beyond the current transition target. Unmanned aircraft propeller blades and surfaces are particularly susceptible to icing conditions. Additionally, the integration of icephobic coatings having high thermal conductivity represent a promising pathway for heat exchangers operating below freezing temperatures. These applications include aircraft, surface vessels, refrigeration, and heat pump systems.

Notes: Actual wind tunnel testing validated the reduced ice accretion for coated vs. non-coated turbine engine stator air foils. Separate testing for a private corporation in the aerospace industry has validated an energy reduction of greater than 30% for active heating anti-ice measures.



HygraTek image from actual wind tunnel testing conducted during contract period.

WHAT

Operational Need and Improvement: Develop and demonstrate robust and affordable anti-icing coatings for aircraft engine and aerodynamic surface ice protection with minimal performance degradation and environmental impacts. Removing ice is traditionally an energy intensive process resulting in reduced thrust or torque and adversely impacting aircraft mission performance.

Specifications Required: Icephobic coatings can reduce ice accretion by enhancing water repellency and lowering ice adhesion strength for easier removal of ice formations. Coatings, when combined with active anti-ice heating measures, must also endure thermal cycling of resistive heating systems in addition to normal aircraft operating temperature envelope. Icephobic coatings must achieve low ice-adhesion values along with sufficient durability to pass rain-erosion testing. Traditional application methods including single-step spray, brush, or dip-application, with the option of transparent or pigmented color matching. They bond to nearly any surface from composites, glass, metals, polymers, ceramics etc., and maintain performance over multiple icing-deicing cycles and actual winter conditions.

Technology Developed: HygraTek has developed icephobic coatings having the lowest ice adhesion values ever reported. The coatings are also some of the most durable ever developed, with some coatings even passing rain-erosion testing on aircraft indicating their long-term durability. The coatings do not have any nanoscale additives to avoid susceptibility to leaching, performance degradation after subsequent icing events, or loss of effectiveness due to normal abrasion wear and tear.

Warfighter Value: Improving ice management increases the operating effectiveness and readiness of all warfighter assets. For aircraft, there is lower risk of aerodynamic lift losses or large pieces of ice being ingested in their engines. Additionally, there is reduced energy consumption and diversion of engine thrust or torque from core mission performance. Low flying drones, which are more susceptible to icing conditions, maintain their all-weather capabilities and therefore provide increased readiness. Superior ability to manage icing also extends the operating envelope to include the ever-increasing likelihood of Arctic operations.

WHEN

Contract Number: N68335-20-C-0380 **Ending on:** Apr 17, 2022

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Fabricate extremely durable icephobic coatings using commercially off the shelf materials	Low	Ice adhesion < 100 kPa, Taber abrasion, accelerated weathering, corrosion testing, repeated icing / deicing cycles	4	2nd QTR FY23
Reduced ice accretion	Low	Ice accretion reduced by > 20%	5	3rd QTR FY23
Lower performance degradation over long-term weather exposure	Low	Accelerated UV testing maintains > 95% of original ice adhesion strength	5	3rd QTR FY23

HOW

Projected Business Model: HygraTek's objectives are to provide icephobic coatings direct to OEM for newly manufactured assets, and direct to Department of Defense for field deployed assets. HygraTek will leverage contract manufacturing capabilities, preferably with a currently approved Milspec supplier of paints or coatings. HygraTek will continue to perform R&D to extend the icephobic coating performance to functionally maintain laminar flow, therefore increasing the operational range of all aircraft assets even when no icing events take place.

Company Objectives: HygraTek's immediate goal is to work with NAVAIR to define a Milspec standard for the new class of icephobic coatings. HygraTek would like to establish a strategic partnership and R&D collaboration with both aircraft and engine OEMs to leverage performance by modifying designs to take advantage of our icephobic coatings. New design initiatives have been internally funded by HygraTek centered around coatings for heat exchangers which would be beneficial to realize improved ice management for heat exchangers and air foils of all functions, e.g., wings, stators, etc.

Potential Commercial Applications: Icing has an adverse impact on many platforms, including marine surface vessels, communication antennas, radar devices, and other outdoor structures for renewable solar energy and wind power. Solar panels experience snow accretion that limits energy production in colder climates, and wind turbines experience seasonal icing with accumulations on turbine blades and support structures. Finally, ice formation significantly reduces efficiency of all heat exchangers including refrigerators, freezers, and air side heat pumps. Current anti-ice methods (i.e., defrost) for freezers increase energy consumption by greater than 20%, and ice buildup on heat exchangers prevent the deployment of heat pumps which are up to 4X more efficient than boilers or furnaces. The US would increase energy independence and realize significant CO2 emission reductions in line with national and international goals by successfully deploying icephobic coatings on heat exchangers.

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