National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

New Coatings Reduce Impact Ice Adhesion Strength

Polymer Coatings for Aircraft Surfaces

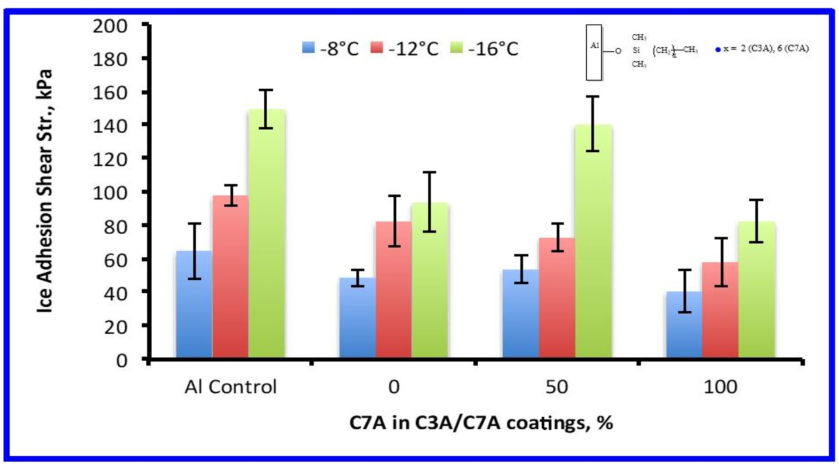
Aircraft icing is a serious problem. Wintry conditions on the ground and glaze, rime and mixed icing conditions aloft can cause ice buildup on aircraft wings increasing weight, creating drag, and causing loss of lift —conditions that compromise performance and safety. For commercial aircraft, active icing mitigation strategies —pneumatic boots, heated surfaces, and deicing agents —prevent or mitigate such ice buildup. The challenge is that they also require extra energy, added weight to the aircraft, and increased maintenance complexity. For general aviation and unmanned aerial vehicles that cannot support active anti-icing technologies, avoidance is the only recourse. Thus, there is a need for a passive durable solution for both commercial and general aviation aircraft. Scientists at NASA Langley have been developing passive solutions to this problem focusing on coatings for aircraft surfaces that will reduce the adhesion of impact ice.

BENEFITS

- Improves safety by reducing icing on aircraft - the coating is an "always on, always working" solution
- Reduces energy consumption and mass of active systems (when used in conjunction with active systems)
- Expands the operational envelope for smaller aircraft: a passive coating would reduce ice build-up in cold and icing climes
- Anticipated to work with current maintenance schedules: NASA is evaluating coating durability to determine application frequency

THE TECHNOLOGY

NASA is developing polymer coatings that reduce impact ice adhesion strength. Current coating compositions are based on epoxy resins due to their availability and ease of fabrication. It is anticipated that a successful composition could be used in other polymer classes such as polyurethanes. Initial molecular modeling studies of silanes terminated with various functionalities suggest that chain mobility effects the interface between ice and the surface. To that end, surfaces coated with these compounds were applied to aluminum substrates and the resulting monolayer coating investigated to assess the effect of chemical functionality and chain length under simulated in-flight icing conditions. As shown in the figure below, these molecular coatings demonstrated reduced ice adhesion strength, presumably as a result of the molecular flexibility imbued by the aliphatic chains that has been incorporated into polymers either within the polymer backbone or as pendant groups. Compared to an untreated aluminum alloy surface, a test polymer coating employing in-chain molecular flexibility exhibited a 56% reduction in ice adhesion strength at -16 C. Similarly, another test polymer coating employing pendant group molecular flexibility exhibited a 19% reduction and a 63% reduction in ice adhesion strength at -16 C compared to an aluminum alloy surface and a rigid epoxy control surface, respectively. The reduced ice adhesion strength may lead to decreased energy requirements for active ice mitigation strategies currently used on aircraft when used in conjunction. These anti-icing coatings are a passive approach that are anticipated to be applied to the aircraft surface either as a topcoat or as a constituent of aircraft paint. The coatings need to be optimized for durability, with the goal of achieving a reapplication frequency consistent with routine aircraft maintenance and painting requirements.



Non-HB: Different Chain Lengths

APPLICATIONS

The technology has several potential applications:

- Commercial Aircraft: reduce in-flight ice accretion on frontal surfaces including the critical wing leading edges
- General Aviation: passive method to reduce ice accretion
- Unmanned Aerial Vehicles (UAVs): passive solution to reduce ice accretion
- Wind turbines passive solution to reduce ice accretion

PUBLICATIONS

Patent No: 10,899,937; 10,377,916; 11,149,165; 10,501,840

Patent Pending

Joseph G. Smith and Christopher J. Wohl, et.al. Effects of Hydrogen Bonding and Molecular Chain Flexibility of Substituted n-Alkyldimethylsilanes On Impact Ice Adhesion Shear Strength. NASA/TM-2020-220567. February 1, 2020.

Joseph G. Smith and Christopher J. Wohl, et.al . Effect of Molecular Flexibility upon Ice Adhesion Shear Strength. Annual Meeting of the Adhesion Society, February 21,2016.

Joseph G. Smith and Christopher J. Wohl, et.al . Durability Characterization of Low Ice Adhesion and Impact Resistance Coatings. 43rd Annual Meeting of the Adhesion Society. March 23, 2020.

technology.nasa.gov

More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Langley Research Center

Mail Stop 020
Hampton, VA 23681
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

NP-2021-12-3016-HQ

LAR-18585-1, LAR-18585-2, LAR-18755-1, LAR-18755-2, LAR-18780-1, LAR-TOPS-353