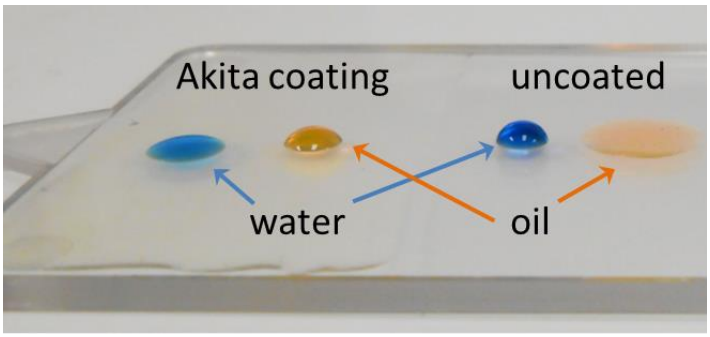
ICE-RESISTANT COATINGS WHITEPAPER

APRIL, 2015

Akita Innovations LLC is a small company located near Boston specializing in development of novel chemicals and materials. We perform contract research and development and product commercialization and sales for government and industry customers. A particular interest of Akita is in coatings which resist or facilitate wetting by aqueous or non-aqueous liquids; we have developed coatings to protect photovoltaics from water, to sequester and decontaminate hazardous chemicals on surfaces, and in recent work funded by the Army, to allow water but not oil to spread to resist fogging. A photo of an Akita antifog coating is shown above.



Water (dyed blue) and hexadecane (dyed orange) droplets on an Akita coating on polycarbonate (left) and bare polycarbonate (right), showing the unusual property of hydrophilicity with oleo-phobicity.

We are interested in developing ice-resistant surfaces and coatings, using some of the same concepts and capabilities as we have applied to our other coating projects. Ice-resistance is desired for a variety of surfaces including aircraft (fixed and rotary wing), vehicles, ships, camera lenses, road signs, protective eyewear, buildings, antennae, power lines, and bridges.

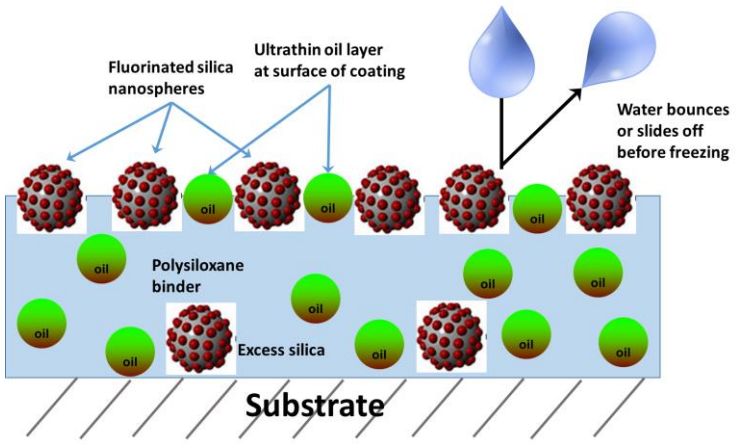
Recently, work in a number of laboratories has established that structured surfaces of suitable materials can resist ice adhesion and frost buildup. Typically, ice resistance is achieved by a combination of a low surface energy coating and a micro or nanostructured surface morphology. Low surface energy coatings are usually a fluorinated material, although other materials such as siloxanes may be used. Micro or nanostructured surfaces are fabricated by lithography (to provide regular surface features) or nanoparticle deposition (to provide rough surfaces with irregular features). One issue with some approaches is that surfaces that are initially ice-resistant may become less so when frost accumulates on the surface. Liquid-infused nanostructured surfaces which use low viscosity oils of very high boiling point can provide frost resistance; use of such oils to reduce ice adhesion dates back to at least 1978.

Prevention of surface icing (i.e. imparting ice-resistance to the surface) and reduction of ice adhesion strength are related but different concepts. ***Prevention*** of surface icing may be achieved either by lowering the freezing point of water on the surface or by reducing the contact angle and adhesion of water on the surface such that droplets roll, bounce, or slide off before they can freeze. ***Reduction of ice adhesion strength*** is generally easier to achieve than complete prevention of icing. Lower adhesion strength has been correlated to both ***higher*** water contact angles and to ***lower*** surface roughness and it is important to decouple these effects when developing structured surface approaches.

Existing anti-ice coatings do not work well and suffer from poor durability, use of environmentally hazardous chemicals, susceptibility to inactivation by frost, difficult application, or other issues. Depending on the application, coatings can require transparency in one or more wavelength ranges, which not all coatings possess.

Akita concepts for ice-resistant coatings use our expertise in polymers and coating technology, and in particular fluorinated polymers and micro and nanoparticle synthesis and use. One such concept is shown below, which relies on a combination of fluorinated silica nanospheres, a low T_g polymer binder, and a high-boiling fluid additive. Other concepts replace the silica nanospheres with functionalized carbon nanotubes, or do not require the fluid additive. A key feature of the Akita approach is control of coating binder and additive compatibility, so that additives phase-separate to the coating surface at the desired degree and rate. Another is the provision for applying the coating by a method appropriate to the desired use, which may be flow, spray, dip, or blade coating, and curing at a desired rate using moisture, heat, or light.

Akita has already formed relationships with potential partners for an ice-resistant coating project. These include the ice-resistance experts at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL, with which we have a CRADA), academic anti-ice research groups at the University of Arkansas, Little Rock (UALR) and the Pennsylvania State University (PSU), and PPG, a world leader in coatings technology.



Cartoon of the Akita acrylic polysiloxane anti-icing coating containing fluorinated silica nanoparticles and a silicone oil

Akita management is highly experienced in commercializing novel technologies and materials, having led the commercialization of explosive vapor sensors for government customers, air particulate sensors for industrial markets, and dyes for use in eyewear and in neurology research for industrial and academic research markets (as examples). Advanced development, manufacturing, and marketing a new anti-ice coating would likely require a partnership with a larger coatings company, and Akita management has an extensive background in the licensing and business development aspects of such partnerships. Akita has also synthesized novel materials in modest quantity for commercial customers, and is versed in QC procedures, compliance with health and safety regulations, and IP protection. We have access to an extensive network of support for manufacturing and marketing activity, including through North Shore Innoventures (a Massachusetts technology incubator of which we are a member) and the Massachusetts Manufacturing Extension Program, an affiliate of the NIST Hollings Manufacturing Extension Partnership.