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Theoretical/Experimental Investigations at the Molecular Level for Making Anti-Icing Utility Power Lines

Abstract. Utility companies lose millions of dollars from the build-up of ice on power lines, which can eventually result in catastrophic failure of the lines themselves or support structures holding up the lines as a result of the weight or line galloping. Two highly recognized research groups at the University of Nebraska have been performing fundamental and applied research on various aspects of ice formation and making surfaces superhydrophobic by using femtosecond laser surface processing (FLSP). Anti-icing research performed for Boeing indicates that hydrocarbon attachment chemistry plays a big role in making FLSP surfaces anti-icing. A new $962,000 Leybold high vacuum chamber (10^{-10}) (being installed in September, 2018) containing a laser processing chamber (LPC) connected by a load cell to a material analysis chamber (MAC) allows the researchers to study experimentally the attachment of hydrocarbons to FLSP surfaces at the molecular level. FLSP surfaces start out superhydrophilic and through unknown chemical attachment of carbon/hydrocarbon compounds in the atmosphere become superhydrophobic, which is needed by the utility industry to prevent ice from forming. The molecular carbon chemical species will be studied using the X-ray photoelectron spectroscopy and Auger electron spectroscopy capabilities of the MAC, in order to understand the superhydrophobic properties of FLSP surfaces along with hydrocarbon attachment chemistry. Co-PI Zeng's group will perform complementary classical molecular dynamics (MD) simulations to understand the wetting behavior of model and FLSP surfaces. The MD studies will be first performed on silver and aluminum, and once the basic models are understood, the plan is to move to aluminum alloy 1350-H19 for linkage to electric power line cables. The proposed experimental research, coupled with the molecular dynamic theoretical work, will provide a fundamental understanding at the molecular level for making FLSP surfaces superhydrophobic and how these surfaces lead to anti-icing aluminum alloy 1350-H19 power line cables.