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THE ICING PROCESS OF WATER DROPLET POSTPONED ON THE ZINC-DEPOSITED STEEL SURFACE IN A LOW-TEMPERATURE ENVIRONMENT

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ABSTRACT

Ice formation and accretion lead to serve problems for power transmission lines, aircraft, wind turbines, and offshore structures. Superhydrophobic surfaces are featured as static contact angle (CA) above 150° and low CA hysteresis (CAH, < 10°) and present promising anti-icing capability. These surfaces can delay water freezing and reduce ice adhesion. However, the icing process of water droplets is complicated when this process happens on roughened hydrophobic/ superhydrophobic surfaces. Three (super)hydrophobic surfaces were fabricated by electrodepositing a zinc layer on stainless-steel substrates and coating with stearic acid. The primary testing substrates are 30 × 30 × 0.8 mm stainless-steel tiles (SAE 630/17-4, McMaster- Carr). A Vaniman Problast micro-abrasive sandblaster (Problast- 8008, Vaniman Manufacturing) is used for sandblasting as pre-treatment for the stainless-steel tiles. The material of sandblasting media is Al_2O_3 (White Fused Alumina, Vaniman Manufacturing), and the sizes are in 100 µm and 250 µm, respectively. Zinc Chloride ($ZnCl_2$) (ACS grade, 97%, Caledon), Ammonium Chloride (NH_4Cl) (ACS grade, 99.5%, ACP) and Stearic Acid (95%, Sigma-Aldrich) are used for the electrodeposition. The prepared samples were placed in a cold room, and the temperature was set at -10 ± 1 °C, 13 ± 1 °C and -15 ± 1°C. A syringe pump generates a water droplet of 23.6 ± 1.4 µl, and the distance between the needle of the syringe pump and the sample surface is 4.88 ± 0.15 cm. A thermocouple was used to monitor the temperature of initial water droplets. A thermal bath controls the metal surface temperature at -14.73 ± 2.01 °C. A high-speed camera (Phantom V611, Vision research) recorded the whole dynamic and icing process of the water droplet. Wthe temperature of the sample approximately equals to the temperature of the environment (at -10 ± 1 °C and -15 ± 1 °C), the icing process of the water droplet (the initial droplet temperature is 5.1 ± 0.1°C) on sample ED100SS-SA (sandblasted by 100 µm Al_2O_3, then Zinc electrodeposited, followed with the stearic acids coating) can be postponed for more than an hour. After the temperature of the cold room was decreased while maintaining the same temperature of the samples, the icing delay time dropped significantly. Besides, the results show that the freezing rate is proportional to the final contact area between the droplet and the surface. The more hydrophobic surface leads to a smaller final contact area, which causes longer icing delay on the surface.