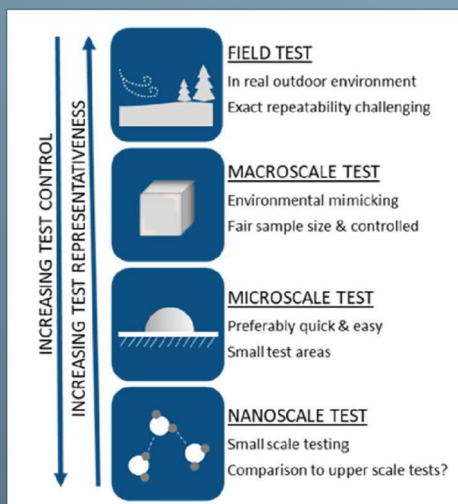


ICING RESEARCH AND TESTING



Depending on the application, it is important to choose the proper testing model.

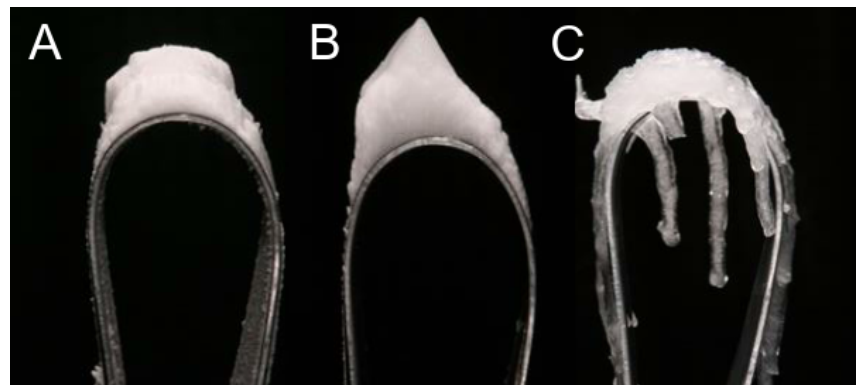
Icing testing possibilities at Tampere University:

- Ice accretion and ice characterization (IWIT)
- Ice adhesion (CAT)
- Droplet freezing behaviour with Peltier temperature control plate
- Wettability, surface analysis

Icing testing in Tampere University (TAU) is focused on ice accretion in a laboratory scale from supercooled micro-droplets onto various surfaces and profiles. This mimics natural ice formation and build-up. The ice accretion can be performed with an icing wind tunnel (IWIT), where common icing parameters are established and set to create different ice types. For quantitative analysis, ice adhesion strength can be evaluated by using a centrifugal ice adhesion test (CAT). In addition, icing related properties can be studied such as droplet freezing behaviour, wettability and surface properties.

ICE TYPES

Different ice types have their own characteristics, certain occurring regions in the nature and thus, exact test parameters in the icing wind tunnel. In TAU's IWIT, rime, mixed and glaze ice, which are illustrated in Picture 1, can be accreted. The dry rime ice is porous, white and contains small amounts of water whereas the more wet glaze ice is dense, transparent and has higher liquid water content. Due to the unfrozen water within, icicles are observed in the accumulation process. Usually in the icing tests, the mixed glaze is used because it has characteristics from both, the rime and the glaze ice. This ice builds up vertically, is relatively transparent and possess the highest ice adhesion when compared with pure rime or glaze ice.



Picture 1. Three different ice types accreted in the IWIT: A) the rime ice, B) the mixed glaze ice, and C) the glaze ice.

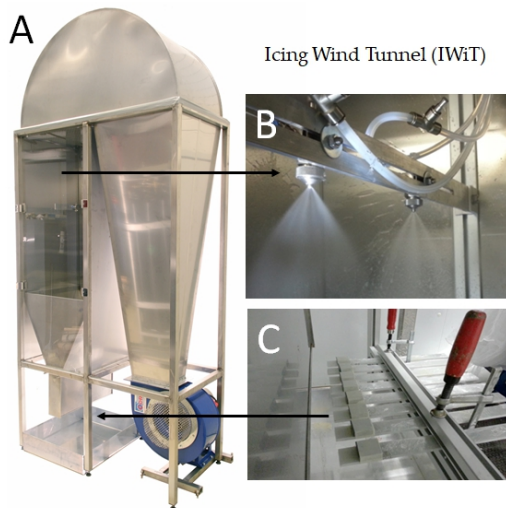
/1/ H. Koivuluoto et al., *Materials*, 2020, 136 (6), 1434

/2/ H. Niemelä-Anttonen et al., *IWAIS 2019, Reykjavik, Iceland, 23–28 June 2019*

/3/ H. Koivuluoto et al., *IWAIS 2015, Uppsala, Sweden, 28 June–3 July 2015*

ICING WIND TUNNEL (IWiT)

For research purposes, ice can be accumulated in IWiT for static icing evaluation as qualitative analysis, icing of various shapes/profiles or for ice adhesion test. The IWiT is in a controlled cold climate room, where the temperature and relative humidity are recorded, Picture 2. In the wind tunnel, a freezing wind is generated and directed to blow behind the two nozzles spraying supercooled water droplets. This supercooled precipitation hits the sample surfaces and specific ice is formed. Icing parameters can be controlled as temperature down to -40°C ; flow velocity of 0-25 m/s and droplet size of 25-1000 μm .

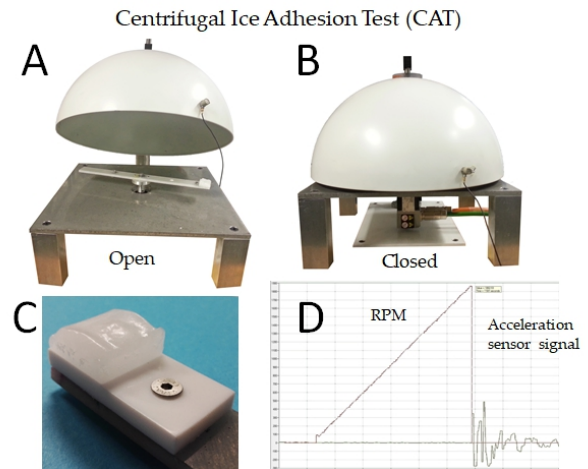


Picture 2. IWiT: A) the wind tunnel, B) the nozzles, and C) the samples ready to be iced.

ICE ADHESION TEST (CAT)

One commonly used method of examining ice adhesion strength is a centrifugal ice adhesion test (CAT). This system mimics ice shedding by centrifugal spinning, Picture 3. The ice detachment is observed by sensors and the ice adhesion is calculated based on recorded data, consisting of the weight and the area of the

accreted ice, the RPM value and the time of detachment and the radial length of a spinned beam.



Picture 3. CAT: A) the test setup open, B) the test setup closed, C) the iced test sample, and D) the ice detachment record.

Goals for the icing research are 1) ranking materials/surfaces for a specific application and application field; 2) selecting the best available material/surface for new application; 3) performing general characterization of icephobic properties of materials; 4) increasing fundamental and general understanding of materials/surfaces and their icephobic profile; and 5) developing of icephobic and anti-icing surfaces.

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