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Experimental Investigation of Wettability Characteristics with Low Surface Tension Fluids Using the Wilhelmy Plate Technique

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Extended Abstract

Dropwise condensation (DWC) research has been focused on water as condensing fluid. However, other types of fluids (e.g. alcohols, hydrocarbons, refrigerants) are often used in industry and they present a lower surface tension compared to the one of water (0.073 N m^{-1} at 20 °C). For a given fluid, a preliminary step to understand if an engineered surface can promote DWC is the measurement of the dynamic contact angles in moving contact lines. Usually, in the literature, surface wettability characterization is done with the sessile drop method. Nevertheless, when considering low surface tension fluids, contact angles are expected to become smaller and the sessile drop method cannot be used [1].

From this background, a new experimental setup for the measurement of the dynamic contact angles has been designed and built. The objective is to realize a system able to perform accurate measurements of dynamic contact angles even with low surface tension fluids. The present experimental technique is based on the Wilhelmy plate method, which is considered the most accurate method to measure surface wettability [2] and also gives the possibility to integrate the measurement system in a pressure chamber.

The measurement technique has been validated in atmospheric conditions comparing its results with the ones obtained by the classical sessile drop method: the dynamic contact angles of water have been measured over a glass sample with a silane coating. The influence of the immersion velocity on the measured contact angles is also investigated. After validation, a series of measurements using ethanol (which displays surface tension equal to 0.022 N m^{-1} at 20 °C) and refrigerant HFE-7000 (surface tension 0.013 N m^{-1} at 20 °C) have been conducted. Furthermore, a Lubricant Infused Surface (LIS) [3,4] which guarantees a completely smooth surface without defects, has been fabricated. This surface is composed of micro/nanostructures that are subsequently coated with a hydrophobic layer and then filled with a lubricating fluid. The contact angle measurements obtained with the present new technique show very low contact angle hysteresis and thus high droplet mobility. These wettability characteristics can be favourable for the promotion of dropwise condensation.

References

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