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Tuning Droplet-Surface Interactions via Functional Grafting and Opportunities for Evaporation and Condensation Phase-Change

Abstract: The interactions between liquid droplets/films and solid surfaces are ubiquitous and intrinsic to everyday domestic and industrial applications, which include thermal management of portable electronics, water treatment and harvesting, energy generation, etc. More specifically, functional coatings fabricated via easy and scalable silicone oil grafting are considered as potential candidates for lowering such droplet-surface interactions.

The aim of this talk is two-fold: on one hand, we fabricate and tune the droplet-surface interactions in terms contact angle hysteresis and pinning while maintaining a similar hydrophobic wettability, by adopting different grafting coating parameters. The grafting procedure reported was adopted from Eifert *et al.* while the grafting parameters investigated are the viscosity of the oil, the application method related to the volume of oil as pipette or dip coating, and the number of layers. Grafting procedure has been optimised with contact angle hysteresis values down to <1° after one single grafting step. Moreover, depending on the grafting parameters adopted the contact angle hysteresis of the functional surfaces could be tuned between 1° and 20°, while maintaining the same hydrophobicity with contact angles near 108°.

On the other hand, the wide range of contact angle hysteresis function of the grafting parameters adopted in turn anticipate different droplet-grafted surface interactions during evaporation and/or condensation phase-change. Evaporation behaviours are self-contained within those reported on benchmarked hydrophilic silicon and hydrophobic Teflon, and can be tuned function of the fabrication parameters. Moreover, the complete suppression of the initial contact line pinning typically encountered on benchmarked smooth hydrophobic surfaces is further attained. In addition, the duration of the different evaporation modes and pinning forces arising from the different fabrication parameters are further introduced to support the findings. Last, we enable the control of the droplet size distribution during condensation on surfaces with similar wettability but with different hysteresis for the first time.

To sum up, wetting and phase-change mechanisms introduced here suggest promising capabilities for oil grafted surfaces for microfluidics, self-cleaning, thermal management and condensation phase-change applications.

Bio: Daniel Orejon (Dani) holds a 5-year bachelor's in Chemical Engineering from the University of Seville (Spain) with one year as Graduate Research Assistant at the Institute for Energy Systems at the University of Edinburgh (UoE). Dani completed his PhD on the fundamentals of evaporation phase-change at the droplet scale at the Institute for Materials and Processes at the UoE in 2013. Thereafter Dani joined the International Institute for Carbon-Neutral Energy Research (WPI-I2CNER) at Kyushu University in Japan as a Post-Doctoral Research Associate in 2013 and as Assistant Professor in 2016 where he shifted his research efforts towards condensation. In 2019 Dani joined the Institute for Multiscale Thermofluids (IMT) at the UoE as a Lecturer and he was promoted to Senior Lecture in 2022. In addition, Dani serves at the School Postgraduate Progression Committee for the IMT and as Teaching Laboratory Manager for the Chemical Engineering Discipline. Moreover, Dani holds a WPI-I2CNER Visiting Associate Professor since 2019, a Foreign Visitor Professorship at the São Carlos School of Engineering, University of São Paulo and is Fellow of the Higher Education Academy.

Dani's research interests embrace interfacial phenomena between liquid films/droplets and solid surfaces paying special attention to the effect of surface wettability and structure, liquid nature, and surrounding environment on the fundamentals mechanisms of wetting and spreading encompassing both heat and mass transfer during evaporation and/or condensation phase-change. He focuses on the relevant interactions at different length-scales from the micro- to the nano-scale as well as on the thermophyiscal properties of all three solid, liquid and gas phases present, for interfacial mass and thermal transport related applications. Dani received the Young and Early-Career Scientists Kakenhi award twice (2016 and 2018), has received a Royal Society Research Grant (2020) and a University Strategic Collaboration Award between UoE and University of Rice (2023). Dani also took part in the SciSpacE Microgravity Application Promotion Programme from the European Space Agency (ESA) (2020-2022).