Dynamics of Wetting on Submerged Superhydrophobic Surfaces

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Research on superhydrophobic surfaces submerged in water has shown that they remain water-repellent by trapping a layer of air, known as the plastron, within their surface irregularities. Sustainability of plastron is crucial for keeping the superhydrophobic surfaces functional for various underwater applications, such as drag reduction in microfluidic devices and marine vessels **[1]** . In this work, we induce pressure variations on superhydrophobic surfaces and attempt to understand their behaviour at different time scales ranging from a few days to less than a second.
We trap plastron on superhydrophobic surfaces containing micropillars fabricated in polydimethylsiloxane and coated with fluoropolymer. The micropillars are strategically arranged in a complex lattice arrangement inspired by the non-orderly nature of surface irregularities on natural superhydrophobic surfaces. An experimental setup for studying localized wetting transition on superhydrophobic surfaces underwater by focused ultrasound was earlier developed in **[2,3]** . In this work, we study the wetting transitions occurring at various time scales ranging from hours to less than 1 second. We classify our observations in three categories: long time scale wetting studies (under constant hydrostatic pressure), static wetting studies (under varying hydrostatic pressure) and dynamic wetting study (under ultrasound induced pressure). Our initial results indicate that the geometrical features of the microstructures play a key role on their wetting behaviours in the three scenarios. This study will help to understand how complex superhydrophobic samples respond and are resilient under different pressure variations (static and dynamic) as well as in different time scales as these scenarios simulate the real conditions for surfaces in various immersed applications.

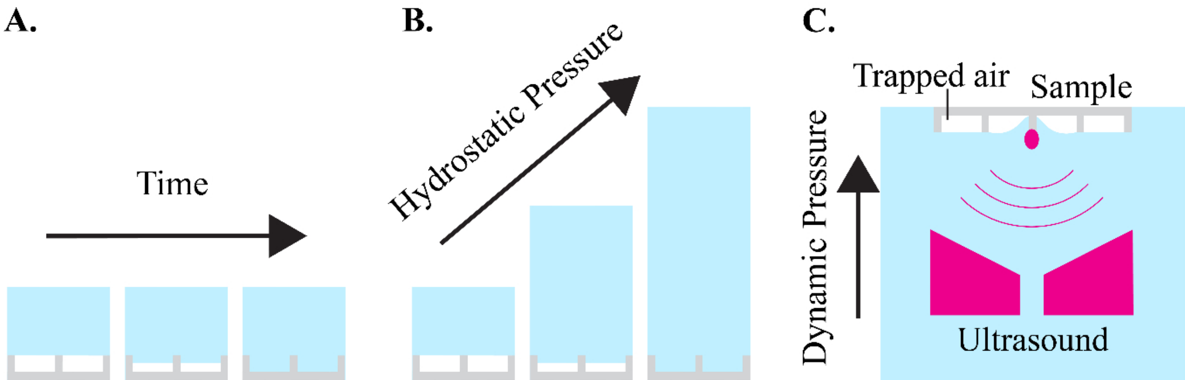

Figure 1: Wetting observations on a submerged superhydrophobic surface under different wetting scenarios. A. Long time scale wetting. B. Static pressure variation by increasing the hydrostatic pressure. C. Dynamic pressure variation induced by ultrasound.

References:

[1] Y. Xue, P. Lv, H. Lin, and H. Duan , *Applied Mechanics Reviews* , vol. 68, no. 3, 2016.
[2] A. Drago-González et al., *Advanced Science* , vol. 11, no. 33, 2024.
[3] M. Fauconnier et al., *Nature Communications* , vol. 16, no. 1, 2025.

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