In-between full levitation and stable Cassie-Baxter: A range of interesting wetting states enabled by gas perfusion through porous media

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Actuation of droplets and manipulation of their mobility on surfaces is very crucial for a wide range of applications related to interfacial phenomena[1-15]. In treating such challenges various methods have been proposed and demonstrated using respective trigger signals to interact with the liquid phase, the solid phase or the ambient, including electrical magnetic, thermal, acoustical or combinations. For porous hydrophobic surfaces in particular droplet actuation may be enabled also by gas perfusion through the porous body. This was mainly achieved by applying the adequate gas flow rate in order to depin the initially quiescent droplet from the porous surface resting on the solid faction (partially wetting, Cassie-Baxter state), to a fully levitated state on which the droplet move frictionless (non-wetting, Leidenfrost-like state). This actuation required high flow rates and therefore high amount of energy. In this work we explore the states in-between these two extremes and prove that actuation and mobility manipulation may be delivered at ultra-low gas flow rates, corresponding to pressures up to few mbar and accordingly to ultra-low energy consumption. The actuation mechanism was followed employing the continuity equation and the equations of momentum transfer that are coupled with the Volume of Fluid (VOF) method, to track the shape of the droplet in both 2D and 3D calculations. Applications for water droplets on plane surfaces, confined surfaces (fluidics) as well as for viscous fluids will be provided.

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