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Dynamic arrest during the spreading of a yield stress fluid drop [1]

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When a liquid drop is gently deposited on a wetting solid surface, it spreads due to capillary forces until it reaches a thermodynamical equilibrium set by the relative surface energies of the system [2]. We investigate here experimentally the spreading ability of drops made of yield stress fluids (here Carbopol gels), which flow only if the applied stress is above a finite value. We observe that in this case, after a spreading phase, the motion stops and a well-defined contact angle can be measured. This contact angle depends on the rheological properties of the fluid and in particular on its yield stress σ_y, on the drop radius and on the hydrodynamic boundary condition at the surface which contrast strongly with what is obtained with simple fluids. These results are quantitatively compared to an analysis showing that, due to the yield stress of the fluid, a mechanical equilibrium is indeed reached which does not correspond to the thermodynamical equilibrium. This complex behaviour that is both liquid and solid and their wetting properties are important for many applications in various industries (food, cosmetics, building or 3D printing) [3,4].

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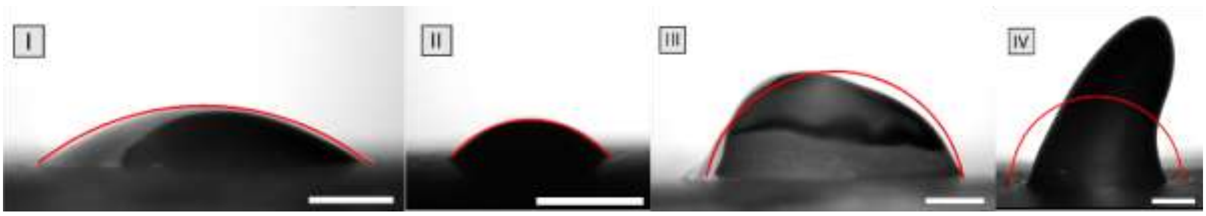

Figure 1: Pictures of drops of various yield stress fluids after spreading on rough surface: (I) Carbopol gel (ETD at 0.3%) with a yield stress $\sigma_y = 6$ Pa, (II) and (III) Carbopol gel (ETD at 2%) with $\sigma_y = 35$ Pa, (IV) Carbopol gel (U10 at 0.5%) with $\sigma_y = 85$ Pa. Fits of the drop shape assuming a spherical cap of a same volume as the drop, are plotted in red. Scale bar corresponds to 1 mm.