Delayed Coalescence of Sessile Droplets with Different but Miscible Liquids

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Due to capillary forces two sessile droplets of miscible liquids will fuse when they get in contact with each other because one large droplet has a smaller interfacial energy than two smaller droplets of the same volume. Usually the droplet fusion proceeds very fast, delayed mostly by viscous forces. However, quite unexpected, it was observed recently [1] that under certain conditions, the coalescence of sessile droplets of completely miscible liquids can be delayed up to several minutes. Instead of fast coalescence, after a first contact of their three phase lines, the droplets remain separated by a thin liquid neck. Often, the drops even push each other across the substrate before they finally merge (see figure 1).

It is assumed [1] that the coalescence is delayed by a marangoni convection through the thin film connecting the drops. The convection originating from the differences in the interfacial tension of the liquid causes a dynamic pressure, which keeps the drops separated. This suggests that the effect is quite common. The delayed coalescence may be relevant for technical applications, for instance in the field of microfluidics.

We present new experimental results from imaging the droplet shapes/topologies addressing the influence of the liquid properties on the coalescence behavior during the first few tenths of a second after initial contact. A sharp transition from fast to delayed coalescence is found as the difference in surface tensions exceeded approximately 4 mN/m. Other parameters (absolute surface tensions, viscosities, and contact angles) are also systematically varied. Resulting from these experimental data we present a phase diagram of the boundary between fast and delayed coalescence.

FIG. 1: Two sessile drops of different but miscible liquids (view from the top). After a first contact of their three phase lines, they remain separated by a thin liquid neck and travel across the substrate.