Simulation of the Coalescence and Subsequent Mixing of Inkjet Printed Droplets

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Abstract

Introduction
The coalescence of droplets is a widely investigated phenomenon. However, most investigations focus on relatively large droplets with sizes starting at 1 mm, primarily because of speed of the coalescence process and the difficulty of imaging smaller droplets. In inkjet printing micrometer sized droplets are deposited on a substrate which when positioned close enough to each other will coalesce and mix.

Although this is common in inkjet printing, still little is known about the flows and mixing behaviour within these small droplets. In this investigation we follow the time evolved coalescence of two droplets with volume ratios ranging from 20 to 80 pl.

As the concentration of an added dye differs over the two droplets, the subsequent material transport of the dye from one droplet to the other is followed as well. A special interest is taken in distinguishing the material flow due to convection, as part of the surface tension driven coalescence, and the diffusion based material flow.

Use of COMSOL Multiphysics®
A 3D simulation of two coalescing droplets was created in COMSOL Multiphysics® based on the combination of the Laminar Two-Phase flow (phase field) and the Transport of Diluted Species Interfaces. The first model describes the surface tension driven flows of the coalescing droplets. The second model describes the material transport of a diluted material, present within one initial droplet, due to the surface tension driven flows, as well as the diffusion based transport.

The results of the COMSOL Multiphysics® simulation are compared to experimentally determined results from the optical observation of two coalescing inkjet printed droplets with dissimilarly coloured dyes (see figure 1 and figure 2). It was found that the COMSOL Multiphysics® simulation predicts the coalescence (surface tension driven flows) reasonably well compared to the experimental observations.

A major difference between the model and the real time experiments was found in the pinning of

the liquid onto the substrate. The model further predicts the transport of the dye over the main axis reasonably. Difficulties in the simulation of the material transport of the dye lie for a large part in preventing of diffusion of the dye over the phase border from the liquid to the air phase.

Figures used in the abstract

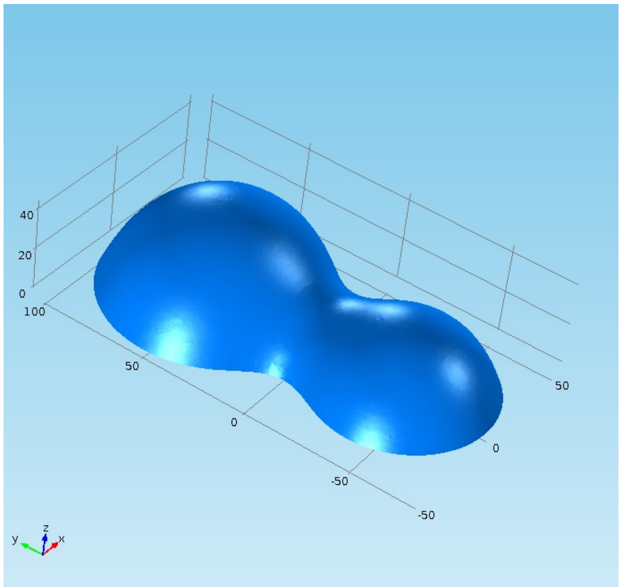

Figure 1: Comsol Simulation of the coalescence of two droplets with volume ratio 2:1

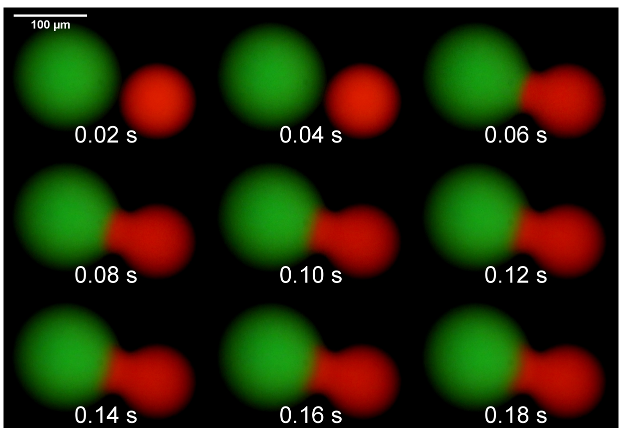

Figure 2: Montage of the experimental coalescence of two inkjet printed droplets containing two different fluorescent dyes (vol.ratio 2:1)