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Capillary Droplet Breakup and the Influence of Wetting

P. Giefer[1] **and U. Fritsching**[1,2]

[1] Leibniz Institute for Materials Engineering-IWT, Badgasteiner Str. 3, 28359 Bremen, Germany

[2] University of Bremen, Particles and Process Engineering, Bibliothekstraße 1, 28359 Bremen,Germany

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Monodisperse droplet production in liquid/liquid systems is a widely demanded emulsification process in industry. The quality of the emulsion is mainly determined by the droplet size and distribution. Porous membranes and microchannels may be used for the liquid fragmentation. While the influence of fluid properties and process parameters on the quality of the emulsion is well known and researched, material effects like wettability on breakup mechanisms is quite unknown. In this context a numerical investigation on the influence of wettability on droplet deformation and breakup in microchannels has been performed. Idealized pore structures are used determine the influence of the pore constriction and wall interactions separately. The Volume Of Fluid method has been utilized using a Continuum Surface Force approach to account for the surface tension.

The results show that the immersed droplet can be divided into five distinct regions which are dominated by fluid dynamic instabilities. The formation of a nose of the penetrating drop is explained and classified into regimes. Altough this phenomenon is mainly determined by the capillary number, the influence of wettability smears the regime transitions. A relation between wettability and the occurrence of fluid dynamic disturbances' resp. interface- and contact line instabilities is shown. The dominant wavelength of such instabilities shifts to lower values in dispersed phase wetting, while the growth rate increases. Inner droplet circulations show significant difference between dispersed phase wetting and non-wetting in the formation of secondary vortices. The influence of leakage flow on the predeformation of the droplet and the resulting rupture is highlighted.

REFERENCES

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