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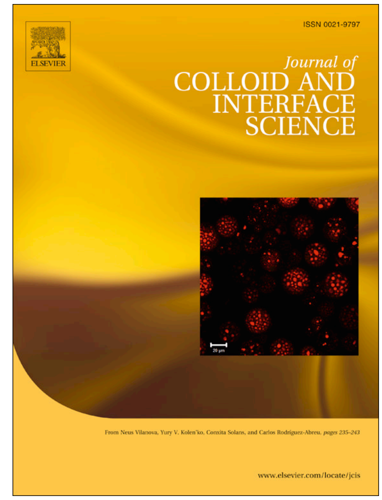

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Measurements and simulation of liquid films during drainage displacements and snap-off in constricted capillary tubes

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Abstract

When a wetting liquid is displaced by air in a capillary tube, a wetting film develops between the tube wall and the air that is responsible for the snap-off mechanism of the gas phase. By dissolving a dye in the wetting phase it is possible to relate a measure of the absorbance in the capillary to the thickness of liquid films. These data could be used to compare with cutting edge numerical simulations of the dynamics of snap-off for which experimental and numerical data are lacking.

Drainage experiments in constricted capillary tubes were performed where a dyed wetting liquid is displaced by air for varying flow rates. We developed an optical method to measure liquid film thicknesses that range from 3 to 1000 µm.

The optical measures are validated by comparison with both theory and direct numerical simulations. In a constricted capillary tube we observed, both experimentally and numerically, a phenomenon of snap-off coalescence events in the vicinity of the constriction that bring new insights into our understanding and modeling of two-phase flows. In addition, the good agreement between experiments and numerical simulations gives confidence to use the numerical method for more complex geometries in the future.

Keywords: two-phase flow, thin films, optical method, snap-off

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Introduction

A good understanding of the physics that govern multiphase flow in porous media is of great importance for a wide range of applications, including enhanced oil recovery [1], geological CO_2 sequestration [2, 3], fuel cells [4], nuclear safety devices [5] and separation processes in chemical engineering [6]. Immiscible two-phase displacements depend on the physical and chemical properties of both the injected and displaced fluids, the