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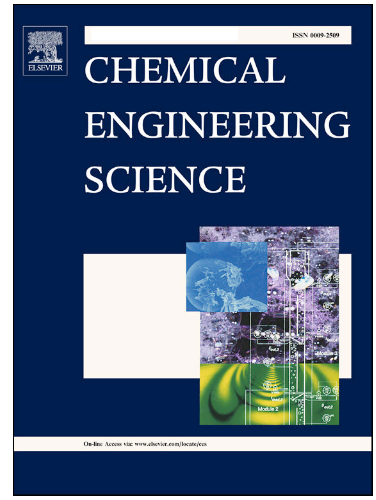

Short Communication

Passing-over motion during binary collision between double emulsion droplets under shear

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Passing-over motion during binary collision between double emulsion droplets under shear

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Abstract: A thorough understanding of the collision motions and involved hydrodynamic behaviors of double emulsion droplets under the influence of an external flow is important for the design and fabrication of a core–shell structured chemical product via droplet-based fluidic processing. In this study, experimental observations are combined with numerical simulation to analyze the hydrodynamic binary collision between double emulsion droplets under shear. The passing-over motion of the colliding droplets is observed and quantitatively characterized by providing the motion trajectories and temporal droplet deformation. In particular, because of an additional interaction induced by the inner droplet, we demonstrate that the double emulsion droplets exhibit similar motion trajectories but different deformation development versus ordinary single-phase ones throughout the collision process. Compared with the ordinary single-phase droplets, double emulsion droplets are demonstrated to exhibit similar motion trajectories but different deformation development during the binary collision process, which arise from an additional interaction induced by the inner droplet. Additionally, the increase in confinement (i.e. the decrease in spacing gap between two parallel moving walls in the typical Couette shear geometry) is found to induce a higher shear rate and larger elongational components at the tips of the deformed double emulsion droplets, which produce further stretched colliding droplets.

Keywords: Double emulsion droplet; Binary collision; Droplet-based microfluidics; Hydrodynamics; Passing-over motion

1. Introduction

Double emulsion droplet with a smaller droplet inside is a promising multiphase template to fabricate a core–shell structured chemical product, which has significant potential in micro-chemical technology (Chen et al., 2011) and advanced materials processing (Wang et al., 2015). Significantly, the microscopic morphologies of double emulsion droplets that develop under an external flow during droplet-based processing, play a fundamental role in determining the properties of the final product (Kim et al., 2011; Shum et al., 2010; Wang et al., 2015). It is worth noting that morphology development under an external flow is strongly influenced by the collision between droplets. In this context, a thorough understanding of the morphology development during the collision between double emulsion droplets is necessary to comprehend and control the properties of the final product during droplet-based fluidic processing.

Since the pioneering work on the coalescence between two single-phase droplets under shear by the group of Mason (Bartok and Mason, 1959), there have been considerable experimental efforts to probe the hydrodynamic behaviors during collisions between single-phase droplets (Chen et al., 2009; Guido and Simeone, 1998). It is reported that the motion trajectories and morphology development of two colliding single-phase droplets are mainly dependent on the competition

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