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Observation of droplet dissolution in aqueous media using a hydrodynamic trap

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We present a novel flow-based method to study the dissolution of individual microdroplets in aqueous solutions. For most two-phase systems, liquid-liquid miscibility is characterized by a small and often negligible quantity, thereby leading to the assumption that many emulsion systems are immiscible. Similarly, during emulsion generation, vast quantities of aqueous microdroplets are produced in host oil-based solutions, and are considered stable for long periods of time. A careful study of oil-water miscibility at the microscale will provide valuable insight into these systems. In this work, we report a new method enabling quantitative analysis of dissolution of an individual microdroplet in immiscible medium. We observed that microdroplets, normally immiscible in host medium, dissolve substantially under planar extensional flow conditions. Furthermore, we developed a model accurately capturing the dissolution dynamics of individual droplets in immiscible medium. We observed dissolution of individual oil microdroplets in aqueous solutions under planar extensional flow. Specifically, we confined single microdroplets at the stagnation point of a planar extensional flow generated at the junction of two perpendicular microchannels. We quantitatively analysed microdroplet dissolution by acquiring consecutive images of a hydrodynamically-trapped microdroplet, and by measuring the change in average droplet diameter as a function of time. We demonstrated that dissolution of the oil phase in host aqueous solution could be substantial under laminar flow. In the absence of flow, the size of the oil microdroplets does not significantly change over a long period of time, as expected. We developed a model to explain flow-enhanced dissolution of microdroplets under planar extensional flow. This study demonstrates flow-induced dissolution of immiscible fluid-fluid systems at the microscale and shows that the dynamics of dissolution can be predicted accurately by a numerical model. This novel method will enable fast and precise measurement of solubility and diffusion coefficients for immiscible two-phase (liquid-liquid and gas-liquid) fluid systems with potential applications towards food, cosmetic and pharmaceutical industries.

Biography

Melikhan Tanyeri has received his PhD in Physics from University of California, Davis, where he developed chemical and biological sensor platforms based on optical resonances in microcavities. He has moved to University of Illinois at Urbana-Champaign for his Post-doctoral training, where he has developed a new class of microfluidic tools for trapping and manipulating micro and nanoscale particles. During 2013-2016, he was an Assistant Professor in the Department of Electrical Engineering at Istanbul Sehir University in Turkey, where his group was pursuing research at the interface of Applied Physics, Engineering and Medical Sciences. He is currently working as a Research Scientist at the Institute of Molecular Engineering at the University of Chicago, developing tools for single cell analysis towards applications in Immunology. His research interests include optical biosensors, imaging and spectroscopy, molecular and cellular biophysics, microfluidics and bioMEMS.

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