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Effect of Surfactant Concentration on Dissolution of Hydrodynamically Trapped Sparingly Soluble Oil Micro Droplets

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Abstract : Work presented here is based on a novel experimental technique used to hydrodynamically trap oil microdroplets inside a microfluidic chip at the junction of microchannels known as stagnation point. Hydrodynamic trapping has been recently used to trap and manipulate a number of particles starting from microbeads to DNA and single cells. Benzyl Benzoate (BB) is used as droplet material. The microdroplets are trapped individually at stagnation point and their dissolution was observed. Experiments are performed for two concentrations (10mM or 10μM) of AOT surfactant (Docusate Sodium Salt) and two flow rates for each case. Moreover, experimental data is compared with Zhang-Yang-Mao (ZYM) model which studies dissolution of liquid microdroplets in the presence of a host fluid experiencing extensional creeping flow. Industrial processes like polymer blending systems in which heat or mass transport occurs experience extensional flow and an insight into these phenomena is of significant importance to many industrial processes. The experimental technique exploited here gives an insight into the dissolution of liquid microdroplets under extensional flow regime. The comparison of our experimental results with ZYM model reveals that dissolution of microdroplets at lower surfactant concentration (10μM) fits the ZYM model at saturation concentration (Cs) value reported in literature ($Cs = 15\times10^{-3}Kg\backslash m^3$) while for higher surfactant concentration (10mM) which is also above the critical micelle concentration (CMC) of surfactant (5mM) the data fits ZYM model at ($Cs = 45\times10^{-3}Kg\backslash m^3$) which is 3X times the value reported in literature. The difference in Cs value from the literature shows enhancement in dissolution rate of sparingly soluble BB microdroplets at surfactant concentrations higher than CMC. Enhancement in the dissolution of sparingly soluble materials is of great importance in pharmaceutical industry. Enhancement in the dissolution of sparingly soluble drugs is a key research area for drug design industry. The experimental method is also advantageous because it is robust and has no mechanical contact with droplets under study are freely suspended in the fluid as compared existing methods used for testing dissolution of drugs. The experiments also give an insight into CMC measurement for surfactants.

Keywords : extensional flow, hydrodynamic trapping, Zhang-Yang-Mao, CMC
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