

Investigations of hydrodynamic behavior in high pressure microfluidic systems

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ABSTRACT

Coflowing fluids at high pressure are interesting systems, which are largely used in various supercritical fluids processes including emulsion generation or antisolvent. By observing fluid flow behavior in coflow microfluidic devices, both immiscible and miscible mixtures are tested and the obtained results will be presented in this talk. For immiscible fluids (CO₂ and water), a specific focus has been drawn on the effects of inertial forces to the interfacial and viscous forces. Three distinct modes have been identified for jet break-up in confined microfluidic scale: the conventional Rayleigh mode and two additional inertia-driven modes occurring at higher Reynolds numbers, namely: the sinuous wave breakup and an atomization-like mode. All these regimes from dripping to jetting are differentiated by characteristic droplet sizes, size distributions and the evolution of jet length as function of the external fluid velocity. A general phase diagram is proposed to categorize the jet breakup mechanisms based on the inner and outer fluid inertial forces. These results provide fundamental new insight into the flow behavior of co-flowing jets confined at microscale for two immiscible fluids.

In the case of miscible fluids (CO₂ and ethanol), thermodynamics plays an important role over hydrodynamic behavior. Depending on the considered conditions (p , T , X_{EtOH}) and the location within the EtOH-CO₂ phase diagram, several different behaviors can be observed. In the particular case of monophasic mixture (liquid or supercritical), no obvious interface could be noticed, meaning the mixture velocity plays an essential role to characterize the fluid behavior. By applying a micro Particle Imaging Velocimetry (μPIV) to a mixture of ethanol and CO₂ as antisolvent at SAS conditions, fluid mixture velocity field is obtained and compared with numerical simulation in order to provide interesting data like the micromixing time.