High pressure high temperature microfluidics as a new tool for studying supercritical fluids

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The recent development of microfluidics systems offers several advantages over conventional macroscale processes. This includes enhancement of mass and heat transfer, reproducibility, potentiality of sensor integration for in situ reaction monitoring, rapid screening of parameters, and low reagent consumption during optimization. Coupling these systems to the specific properties of supercritical fluids is of great interest for both communities. First, it could address part of the limitations of conventional microsystems such as limited number of compatible chemistries and limited number of available solvents and working conditions. Then, it could open new ways for characterizing and studying supercritical fluids processes, generally limited to the use of “blind” stainless steel devices.

We have developed high pressure microfluidic systems able to work under supercritical conditions using silica tubings and/or glass-based microreactors. Typical working conditions are in the pressure range of 10 to 25 MPa for temperature ranging from 25°C to 300°C. These systems allow for easy optical access, which makes possible the use of conventional microfluidic characterization tools, in particular fluid flow characterization with high speed CCD camera. Couple to confocal Raman spectroscopy, it can provide useful information about physical and chemical behavior of a supercritical reacting media during process optimization.

As a first proof of concept, we demonstrate the miniaturization of supercritical antisolvent process (called μSAS) to synthesize nano size polymer beads, as well as the study of supercritical – liquid segmented coflows from jetting to dripping.

The development of supercritical microfluidics should provide new lab-scale tools for studying and using safely supercritical fluids, while opening new potentialities for microfluidic devices by enlarging the set of solvents and conditions available.