Supercritical microfluidic synthesis of nanomaterials and nanocrystals

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Nanocomposite materials are of interest for modern technological application such as reinforced lightweight materials, catalysts, sensors, fuel cell, medical diagnosis and treatments due to improved chemical, mechanical, optical and functional properties compared to bulk materials. Significant effort has been focused on the ability to control the nanoscale structures via innovative synthetic approaches. Synthesis of nano sized specialty materials using multistep batch process suffers from reproducibility of size, size distribution and purity. Continuous laminar flow reactors based on microfluidics, integrated with fluid flow, heat and pressure control elements offer a solution to these problems as well as additional advantages, including feedback control of temperature and feed streams, reproducibility, potential for in situ detection for reaction monitoring, rapid screening of parameters, and low reagent consumption during optimization.

We have demonstrated a continuous microfluidic method for synthesis of nanosized iron oxide materials using supercritical fluid as solvent. Further, we have developed microfluidic devices and methods for continuous supercritical crystallization enabling formation of sub-micrometer to micrometer sized crystalline drug particles (aspirin). The supercritical fluid is used as the anti-solvent that dramatically reduces the solubility of the solute upon its mixing with the solution. As a result, the supersaturation increases rapidly, yielding much smaller crystals with narrow size distribution than achieved in other processes.