Microfluidic-SANS: in situ molecular insight into non-equilibrium phenomena in complex fluids

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The coupling of microfluidics and small angle neutron scattering (SANS) is successfully demonstrated for the first time. We have developed novel microdevices with suitably low SANS background, high pressure and chemical compatibility for the investigation of flow-induced phenomena and phase mapping of complex fluids. We successfully obtained scattering profiles from as low as 50 micron channels, in 1s -100s second acquisition times. The microfluidic geometry enables the variation of both flow type and magnitude, beyond traditional rheo- SANS setups, and is exceptionally well-suited for complex fluids due to the commensurability of relevant time and lengthscales. We demonstrate our approach by investigating concentrated surfactant solutions and microemulsions, which exhibit strong flow response and relaxation. Specifically, we have studied sodium dodecyl sulphate (SDS)/octanol/brine, cetyltrimethyl ammonium chloride (C_{16}TAC)/pentanol/water, microemulsion ($C_{10}E_4$ /decane/ D_2O), using selective deuterium labeling. We determine relevant lamellae spacing, orientation and order parameter as a function of flow type and rate. Our approach opens opportunities for investigating soft matter under flow and confinement using SANS, with industrial relevance including formulation engineering and oil recovery.