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Rheo-NMR of shear banded flow in wormlike micelles

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Rheo-NMR gives access to detailed information about the flow field generated by the device used to induce deformational flow. It also provides information about colloidal or molecular organisation and dynamics, under conditions of flow. In particular, NMR offers the possibility of measuring nuclear spin relaxation times and molecular self-diffusion coefficients, sensitive respectively to molecular brownian motions and their restrictions due to local structure. Furthermore, through the use of orientation-dependent terms in the spin interactions, such as the nuclear quadrupole or dipolar interactions, NMR permits the measurement of molecular order parameters. When combined with imaging methods, NMR in principle allows such measurements to be spatially localized, often with resolution down to a few 10s of microns In the study of shear banding phenomena in wormlike micelles, Rheo-NMR has proven of especial value, not only indicating the clear existence of shear bands, but also that they are associated with fluctuations, and sometimes, with molecular alignment. The subtlety of the correspondence (or lack of correspondence) between birefringence effects and shear banded flow has also been revealed. Recent measurements of shear-banded flow under Couette flow of the micellar system 10% w/v cetylpyridinium chloride and sodium salicylate (CPyCl/NaSal) molar ratio 2:1 in 0.5 M NaCl in ^1H_2O, indicate that shear banding fluctuations are consistent with the shear stress fluctuations observed in rheological measurements. Furthermore we find a coupling between flow fluctuations in the gradient and vorticity directions. Using ^{2}H NMR spectroscopy on a deuterated probe molecule (n-decane) in the wormlike micellar interior, direct measurement of the shear-induced nematic phase transition is reported. More recently we have used Rheo-NMR to investigate the flow and alignment properties of worm-like micelles formed by a 5% w/w solution of the BASF difunctional block copolymer non-ionic surfactant, Pluronic P105 in water along with 4.3% w/v 1-phenylethanol-d5. A variety of shear-banding and alignment behaviours are observed, along with both stable and fluctuating flows.