Non-linear phenomena & Phases induced under flow in the Isotropic phase of Liquid Crystals & Melts

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It has been discovered that flow induces above a critical shear rate, a strong birefringent phase within the isotropic liquid in melts of liquid-crystalline polymers[1].

Above a given shear rate, the isotropic liquid (black left photograph) transits in a birefringent phase (right photographs). Snapshots extracted from the (velocity, neutral axis) plane between crossed polarisers.

This spectacular non-equilibrium phase that occurs in the isotropic phase, even far away from any phase transition, is a fascinating puzzling property. It presents strong similarities with the well-known shear induced phase transition observed in worm-like micellar solutions[2]. But, we will show that a direct flow coupling to the pretransitional orientational fluctuations (models of flow birefringence of de Gennes, of shear induced phase transition of S. Hess, of P.D. Olmsted[3]) rules. Moreover, classical viscoelasticity models (Rouse, reptation models) cannot explain satisfyingly the observed phenomena. Supramolecular correlation scales which persist up to one hundred degrees above the glass transition temperature have been identified in the mesophases and above the nematic-isotropic transition temperature, by different groups[4,5], using different techniques and on different LC-polymers of different chemistry. We interpret the origin of these non-linear phenomena as resulting from a coupling with these huge melt correlation lengths which are not specific to this category of polymers, but reveal a so far unconsidered generic condensed matter property[5] in agreement with very pioneering works of S. Derjaguin[6].

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