

Unravelling the dynamics of polymer solutions in extensional flows

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It is well known that the presence of even a small amount of dissolved polymer can lead to a significant increase in the resistance of a polymer solution to extensional flow. Since several industrially important processes, such as coating, turbulent drag reduction, and atomisation, involve a primarily extensional mode of deformation, it is vitally important to understand the response of polymer solutions to extensional flow. Recent breakthroughs in experimental techniques have permitted the simultaneous measurement of both the tensile stresses in a flowing solution, and the microstructural orientation and conformational shape of dissolved polymer chains. These experimental observations indicate that the evolution of polymer stress in extensional flow is intimately linked to the unravelling of flexible macromolecules, from coil like conformations to aligned and extended conformational states. Using the theoretical methods of molecular rheology, an investigation can be carried out of the link between topological structure and orientation at the molecular level and flow properties measured macroscopically. In this talk, recent results of modelling this micro-macro relationship in extensional flow will be discussed, with a view to highlighting the macroscopic consequences of certain microscopic phenomena, such as the fact that two parts of a polymer chain cannot occupy the same place at the same time, and the propensity of the solvent to propagate the motion of one part of the polymer chain to all the other parts of the chain. In particular, it will be shown that the self-similar character of long polymer chains can be exploited to obtain parameter free predictions of elongational flow properties.