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Spraying and Air-Assisted Atomization of Complex Fluids

ABSTRACT

The extensional rheological properties of dilute polymer solutions play a dominant role in many industrially-important free-surface processes such as air-blast atomization. This high deformation rate process is important in the dispensing of diverse materials such as paints, fertilizer sprays and delivery of airborne drugs. Similar hydrodynamic conditions also govern physiological processes such as sneezing and airborne disease transmission. In this talk I will explore the physics behind atomization of complex fluids using model polymer solutions, several industrial paint formulations as well as human mucin. Although the viscosity and surface tension of the polymeric fluids are close to those of the underlying Newtonian solvent, both the mean droplet size and the droplet size distribution change considerably. To understand why non-Newtonian fluids differ so dramatically, one must recognize that the hydrodynamics of capillary breakup and atomization are governed by an independent material function – the extensional viscosity – which was studied theoretically for a number of constitutive models by Bird and colleagues. To probe the response of dilute polymeric solutions at realistic timescales and deformation rates we develop a new instrument, the *Rayleigh Ohnesorge Jet Elongational Rheometer* (ROJER). Analyzing the evolution in the jet diameter before break-up enables meaningful measurement of relaxation times down to values as small as 50 μs, and these values can be directly correlated with differences in spray size distributions. High-speed flow visualization images show that this behavior arises from the non-linear dynamics close to the break-up point which are dominated by an elasto-capillary force balance within the thinning ligaments that sets the magnitude of the extensional viscosity in a complex non-Newtonian fluid.

BIOGRAPHY

Gareth H. McKinley is the School of Engineering Professor of Teaching Innovation at MIT. He was the Director of the Program in Polymer Science & Technology (PPST) at MIT from 2003-2008 and also served as Associate Head of the Department of Mechanical Engineering. He is a Fellow of the American Physical Society (APS), a member of the US National Committee for Theoretical and Applied Mechanics (USNC/TAM), and the recipient of the 2013 Bingham Medal from the Society of Rheology.