The Fluids, Thermal and Chemical Processes Group of
The Division of Engineering
&
Center for Fluid Mechanics

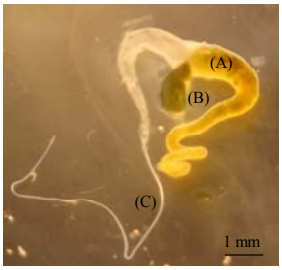
Recent Developments in Microrheometry

Prof. Gareth H. McKinley
Director, Hatsopoulos Microfluids Laboratory,
Dept. Mechanical Engineering, M.I.T.,
Cambridge MA 02139, U.S.A.

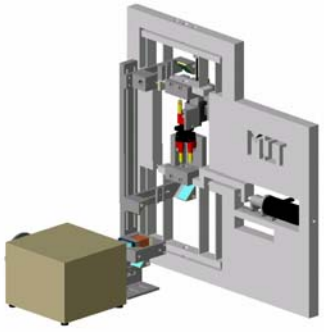
We describe the design and construction of two new microrheometers designed to facilitate the study of complex biological fluids and food stuffs using very small sample volumes (1-10 μl). The shear-rate-dependent viscosity and gap-dependent yield stress of biological gels is measured using a sliding plate microrheometer with optical flats (polished flat to within λ/20, or 30nm) as the shearing surfaces. White light interferometry and a three-point nanopositioning stage employing piezo-stepping motors are used to control the parallelism of the upper and lower surfaces. A compound flexure system is used to hold the fluid sample between a drive spring and an independent sensor spring. Alignment fidelity, device orthogonality and total error stack-up are all optimized by machining the entire instrument frame from a single monolithic aluminum block using water-jet and EDM technology. Displacements in the sensing flexure are detected using an inductive proximity sensor with a resolution of ± 3 nm allowing the detection of loads up to 6 N with an accuracy of 3 mN. The lower plate is attached to a drive flexure which is moved by an 'inchworm' motor with a resolution of 0.1 nm and a maximum displacement of 6 mm, thus allowing large strains to be obtained. The transient extensional rheology is also measured using a 1 μl fluid droplet in a microscale capillary break-up extensional rheometer. In this device the extensional flow is driven by capillarity and resisted by the viscous and elastic stresses in the elongating fluid thread.

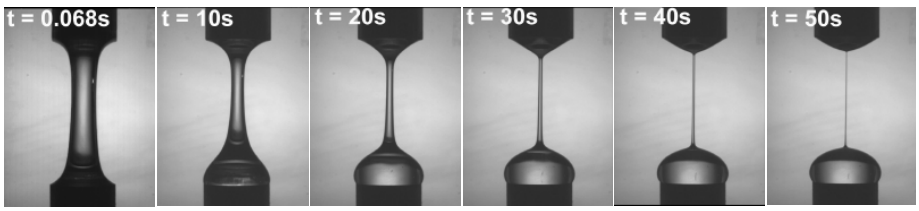
These devices are used to quantify the rheological properties of a wide range of complex fluids from consumer products to biopolymer solutions. Four specific examples we will focus on include; full fat vs. fat-free mayonnaise, the spinning dope extracted *ex vivo* from the silk worm, *Bombyx mori* and from the major ampullate gland of a *Nephila clavipes* spider, plus the physically-crosslinked mucin gel of slugs and snails.

a



b





November 11 (Tuesday)
Barus & Holley, Room 190
4:00 pm