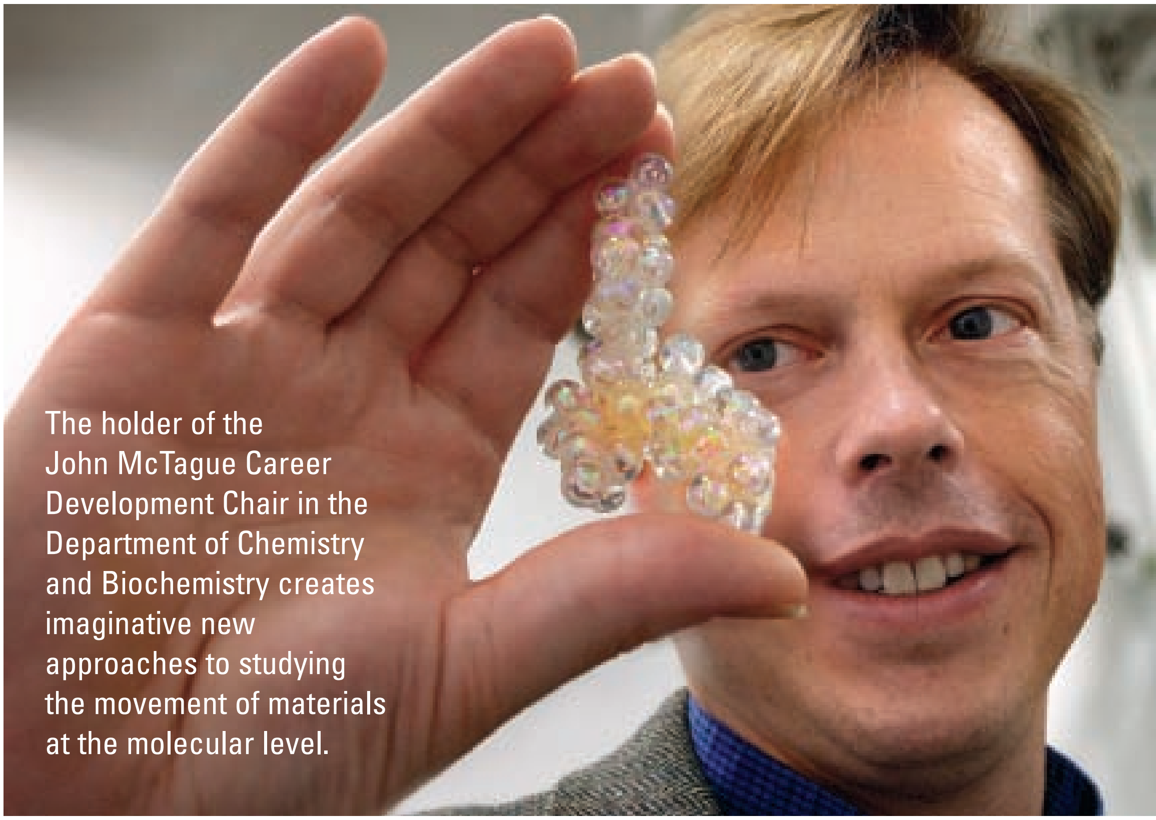
Thomas G. Mason:
Creating a New Field is Just the Start



The holder of the John McTague Career Development Chair in the Department of Chemistry and Biochemistry creates imaginative new approaches to studying the movement of materials at the molecular level.

By Stuart Wolpert

For physical chemist Thomas G. Mason, his research agenda that intersects the microscopic realms in chemistry, physics, engineering and biology began with work in a discipline of his own creation.

As a graduate student at Princeton, Mason created a field called microrheology. Now used by scientists worldwide, microrheology is a method for examining viscosity and elasticity of soft materials on a microscopic scale, with applications for areas as diverse as the structures of petroleum, the interior of living cells, and the biology of cancer.

"Tom is extraordinarily inventive, technically brilliant, and a very fine teacher, and a man of great integrity," said Charles Knobler, emeritus professor of chemistry and associate dean of physical sciences.

Mason, an assistant professor of the Department of Chemistry and Biochemistry, holds the John McTague Career Development Chair, which provides funding for research support. Before joining UCLA's faculty in 2003, Mason worked as a senior physicist for six years at ExxonMobil's Corporate Strategic Research Laboratory, where he conducted both basic research and applied industrial research on heavy crude oils, including studies of tar-like molecules called asphaltenes—the bottom of the barrel in oil production.

"Most of the oils refined in the world are light," said Mason. "The Middle East has large reserves of light oils that are easy to refine. Heavier oils, which are so viscous, are harder to refine.

"Canada and Venezuela have enormous reserves of heavy oil. As lighter oils become scarce, the world will rely on heavy oils as the primary liquid hydrocarbon source."

Mason studied how to control the behavior of asphaltenes in mixtures of crude oils. Heavier oils can contain 10–20 percent asphaltenes; because of this, heavier oils are discounted in price because the lighter crude oils are easier to process. He explored how to blend heavier and lighter oils together, and received patents for this research.

Mason, who also holds a joint appointment in the Department of Physics and Astronomy and is a member of the California NanoSystems Institute, decided to return to academia largely because he enjoys teaching students, and likes the wide range of research options at universities. He teaches thermodynamics, statistical mechanics and physical chemistry for undergraduates as well as graduates.

Why UCLA?

"UCLA's vision of excellence inspires me," Mason said. "When I'm in the UCLA environment, I feel challenged to live up to a very high standard. When I walk by Royce Hall and Powell Library, I think of the great people who had the foresight to make UCLA into what it is. I enjoy the warmth of my colleagues; senior colleagues have been very generous to me."

A significant factor in Mason's decision to come to UCLA was the McTague Chair, an endowment that provides five years of funding for Mason's graduate student support, laboratory equipment and other research needs. John McTague, a distinguished chemist and national science policymaker, was a UCLA professor of chemistry from 1970 to 1982, and later served as vice president of technical affairs for Ford Motor Company. McTague made a gift to the College's Department of Chemistry and Biochemistry that endowed two development chairs for junior faculty members.

The Department of Physics and Astronomy also offered Mason a joint appointment, and the California NanoSystems Institute gave additional start-up funding and membership, providing strong interdisciplinary support for Mason's research.

Mason's work opens innovative new approaches to an established field of study. For centuries, scientists have studied the deformation and flow, or "rheology" of materials on a large laboratory scale. However, until Mason developed the field of microrheology, scientists had not done so on the microscopic scale.

"Can we map out, inside of a cell in three dimensions, the mechanical properties everywhere inside that cell?" Mason asked. "Microrheology is the best technique to help us understand this."

"I'm interested in understanding the degree to which complex soft materials are viscous and elastic," said Mason, whose research is federally funded by a National Science Foundation CAREER Award and by the American Chemical Society's Petroleum Research Fund. Many of these soft materials have a liquid base, and microscale to nanoscale solid particles, liquid droplets and polymers are added; thermal energy keeps these small components moving.

Understanding microrheology in synthetic materials is the first step to insights on what occurs in active materials like the interior of cells, and may help us understand how cells function and die. Cells can have "molecular motors," Mason said, that grab and transport "cargo," such as proteins, to other parts of the cell. Some cells change shape when they engulf particles or a virus; there is motion inside the cells.

A challenge is to understand the motion of particles inside cells.

"Can we map out, inside of a cell in three dimensions, the mechanical properties everywhere inside that cell?" Mason asked. "Right now, microrheology is the best technique to help us understand this."

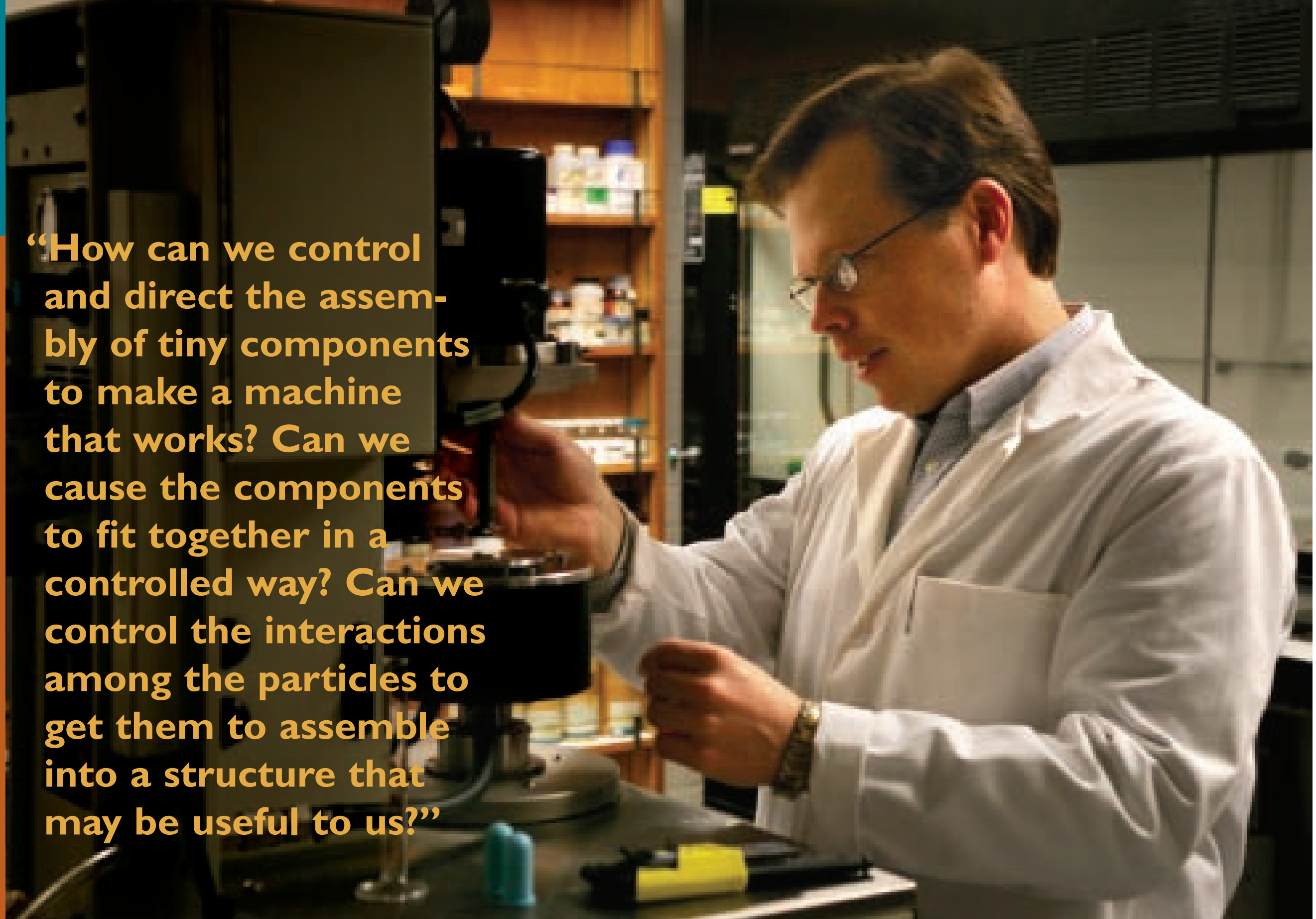
Within a cell, viscosity and elasticity are extraordinarily hard to measure, and can change over time. Mason is collaborating in this area with Michael Teitell, chief of pediatric pathology and associate professor of pathology and laboratory medicine in UCLA's David Geffen School of Medicine; Teitell is an expert on cancer biology.

"Michael and I are interested in understanding differences in the rheology of normal cells compared to cancer cells," Mason said. "Can we use microrheology to determine cell properties that can give us clues about cancer? We are in the process of setting up experiments to test that. How do rheological properties change when cells move, divide or die?"

As with much cutting-edge science, Mason's research opens the possibility for dreams that sound like science fiction. Are microscale devices in solution that can actively identify cancer cells and eliminate them a real possibility? Could Mason's research help achieve this goal? The answer, he said, is not any time soon, but perhaps in his lifetime.

If oil droplets can be coated with the right kind of molecules that enable cells to take in these droplets through membranes or the cell wall, that would be a significant advance in pharmaceuticals, Mason said.

"While this research is still in its formative stages, the fact that we can mass produce droplets as small as 10 nanometers with high pressure microfluidic techniques is cause for optimism."



Chemist Thomas Mason: "UCLA's vision of excellence inspires me. I feel challenged to live up to a very high standard. I want every day to count."

For his doctoral dissertation, Mason studied the transition of an elastic solid into a viscous liquid as it is diluted. Mayonnaise, for example, is an emulsion that has properties of a solid; you can tip the jar sideways, and the mayonnaise stays put. Mayonnaise is made of droplets of oil stabilized by egg proteins and lipid-like molecules in the egg. When the droplets are highly concentrated, they pack together and deform to make the foam-like structure that is mayonnaise.

Mayonnaise behaves like an elastic material; you need a knife to spread it. As you add water, you can thin mayonnaise to the point where it flows like a liquid; you can change it from an elastic material to a viscous material by adding water in between the droplets.

"I wondered, why can't we use optical methods like light scattering and microscopy to study the elasticity of materials by watching how probe particles move in them, instead of using a mechanical device?" Mason said. The idea of using an optical method for determining the local microscopic rheology emerged from that thought. He watched particles move in a viscoelastic material using an optical microscope. At first, his techniques were thermally driven; later, he excited their movement with laser tweezers. He looked at particles that have a variety of shapes and watched how they translated and rotated in the materials; from either type of motion, he figured out ways to determine the viscoelastic properties.

In a new approach to colloid chemistry, Mason can mass-produce billions of microscale particles having many different shapes. He studies how the particles interact and change structure when they are concentrated in solution. He can create, at the microscale, a model of molecular liquid crystals, and uses an optical microscope to observe these microscale particles as they move. Instead of watching microscopic particles move randomly, he can control tiny particles with laser tweezers.

"How can we control and direct the assembly of tiny components to make a machine that works?" Mason asked. "Can we cause the components to fit together in a controlled way? Can we control the interactions among the particles to get them to assemble into a structure that may be useful to us? Can we create useful complex structures out of fundamental parts, in solution, where we can mass-produce a small-scale engine, for example?

"If we can figure out how to control the interactions and shapes of the components, then we may be able to create highly complex assemblies that have a functional purpose. If I make a device, I want to make the parts and control them; I want a directed process. I am optimistic about this research approach." CR

www.chem.ucla.edu/dept/Faculty/Mason