Stanford

Robert Pecora

Professor of Chemistry, Emeritus

Curriculum Vitae available Online

CONTACT INFORMATION

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Bio

BIO

Experimental and theoretical research is being conducted on a wide range of problems on condensed phase dynamics of small molecules, macromolecules and particles of both materials and biological interest. Work includes development of experimental techniques, thorough experiments on specific systems, and theoretical modeling and computer simulation. Our current work may be conveniently divided into two broad areas:

Structure and Dynamics of Semi-rigid, Rigid and Liquid Crystalline Polymers: Many macromolecules and particles of materials or biological importance may be modeled as rigid or semi-rigid rods. The lab's objective in this area is to provide an in-depth understanding of the translational, rotational, and flexing dynamics of such materials in liquid dispersions. This work includes studies of local and overall dynamics of rodlike molecules. For example, oligonucleotides and helical polypeptides of varying lengths are being extensively investigated.

The motions of molecules in solutions in which they interact strongly is of great interest in polymer science since most molecules are processed under these conditions. For neutral polymers these interactions occur in the semidilute and concentrated regions. For polyelectrolytes, molecules may interact strongly in low ionic strength solutions at relatively low concentrations because of unshielded electrostatic interactions. Both neutral and charged systems are being studied by theoretical and experimental techniques, including dynamic light scattering, small angle neutron scattering, transient electric birefringence decay and x-ray photon correlation spectroscopy.

Composite Liquids: Composite liquids are a ubiquitous class of materials which contain polymers, particles and solvent. They are used, among other things, as ceramic precursors, lubricants, paints and coatings, adhesives and in chromatographic columns. They are also important constituents of biological systems (e.g., protoplasm, blood). Due to their complexity and the lack of adequate model systems, the interactions between the species in such systems are not well understood. Rod-coil liquids are liquids composed of a rod polymer, a coil polymer and a solvent. Lab members are currently constructing model rod-sphere composite liquids, and model rod/coil/solvent systems which can be studied by scattering techniques.

ACADEMIC APPOINTMENTS

- Emeritus Faculty, Acad Council, Chemistry

HONORS AND AWARDS

- Fellow, American Association for the Advancement of Science
- Fellow, American Physical Society
- Humboldt Senior Scientist Award, Alexander von Humboldt-Foundation (1986)
- Sloan Foundation Fellow, Alfred P. Sloan Foundation (1967)

PROFESSIONAL EDUCATION

- AB, Columbia University (1959)
- AM, Columbia University (1960)
- PhD, Columbia University (1962)

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The development of the basic principles behind the dynamic light scattering (DLS) technique and its application to a wide variety of liquid systems is one of Pecora's outstanding contributions to physical chemistry. DLS is now an indispensable tool in the repertoire of polymer, colloid and biophysical chemists. It is generally accepted to be one of the best methods for measuring the mutual diffusion coefficients and, in dilute systems, the hydrodynamic sizes of polymers and particulates in solution or suspension. It is widely used, among other things, for studying size distributions of polymer and colloid dispersions; for testing theories of polymer dynamics in dilute and concentrated systems; and for studying interactions between macromolecules and colloidal particles in liquid dispersions. The basic work that established the foundation of this technique was done in the 1960s. Pecora has revisited this area over the years-formulating theories, for instance, of scattering from hollow spheres, large cylindrically symmetric molecules and wormlike chains.

An experimental program began in the early seventies resulted in a now classic series of studies on the rotational dynamics of small molecules in liquids. This work, utilizing mainly depolarized DLS and carbon 13 nuclear magnetic relaxation, has had a wide impact in the area of liquid state dynamics.

It was also during this period that the theoretical foundation for the fluorescence correlation spectroscopy technique (FCS) was formulated. Because of recent advances in equipment and materials, this technique has recently been revived and is now a powerful tool in biophysics.

The experimental and theoretical techniques developed for the study of the dynamics of relatively simple small molecule liquids have been used to investigate more complex systems such as the rotation of small molecule solvents in glassy and amorphous polymers. The resonance- enhanced depolarized light scattering technique was also developed in this period.

Extensive studies using depolarized dynamic light scattering (using the Fabry-Perot interferometer) as well as photon correlation spectroscopy, NMR, FCS and small angle X-ray scattering to the dynamics of oligonucleotides have determined the hydrodynamic diameter of DNA and the internal bending angles of the bases. They also provided support for relations relating hydrodynamic parameters to molecular dimensions for short rodlike molecules and “polyelectrolyte effects” on the translational and rotational motions of these highly charged molecules.

A major area of experimental and theoretical study has been the study of the dynamics of rigid and semirigid rodlike polymers in both dilute and semidilute dispersions. The work on translation and rotation of poly (#-benzyl-L-glutamate) in semidilute solution is a foremost early work in this area.

The Pecora group has synthesized and studied the dynamics of model rigid rod/sphere composite liquids. Studies of the translation of dilute spheres through solutions of the rods as functions of the rod and sphere sizes and the rod concentrations have provided the stimulus for more experiment and theoretical work in this area. Transient electric birefringence decay studies of the rotation of dilute rigid rod polymers in suspensions of comparably sized spherical particles have revealed scaling laws for the rod rotation.

A unique feature of part of this work on rigid and semirigid rodlike polymers is the utilization of genetic engineering techniques to construct a monodisperse, homologous series of DNA restriction fragments. These biologically-produced fragments have served as well-characterized model macromolecules for solution studies of the dynamics of semirigid rodlike polymers.

The well-regarded book of Pecora and Berne on dynamic light scattering, first published in 1976, has become a major reference work. It is now a Dover paperback.

Publications

PUBLICATIONS

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- **Dynamics of biological polyelectrolytes** *1st French-Brazilian-Polymer Conference (FBPOL-2005)*
  Pecora, R.
  WILEY-V C H VERLAG GMBH.2005: 18–23
- **Self-diffusion in solutions of a 20 base pair oligonucleotide: Effects of concentration and ionic strength** *JOURNAL OF CHEMICAL PHYSICS*
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- **Translational and rotational dynamics of rodlike cellulose whiskers** *LANGMUIR*
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- **Dynamics in rod-sphere composite liquids** *Conference of the NATO-Advanced-Study-Institute on Structure and Dynamics of Polymer and Colloidal Systems*
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