MECHANICAL ENGINEERING DEPARTMENT
ME/IE 8773-8774

THERMODYNAMICS AND HEAT TRANSFER SERIES
Topic: NANO-HEAT TRANSFER
Host: Terrence W. Simon

EXCEPTIONAL PROPERTIES OF POLYMERIC SOLUTIONS SEEDED WITH SILICA NANOPARTICLES

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Wednesday, November 2, 2005
3:30-5:00 pm
Room 1130 ME
Coffee and refreshments will be available at 3:15 pm in Room 1130 ME before the seminar.

ABSTRACT — The addition of silica nanoparticles, in the size range 10-20 nanometers, to solutions of polymers in concentrations of the order of 0.5% gives rise to macromolecular solutions with highly unusual properties previously unknown. The addition of nanoparticles in concentrations of 1 to 3 wt% leads to 10 to 20 fold increases of viscosity with similar increases of the dynamic moduli. The nanoparticles suppress the degradation of these enhanced properties. This suppression of degradation is exceptionally long-lived and possibly permanent; the same polymer solution without particles degrades on the shelf to almost water in one to two months. The nanoparticles also protect the polymers from bacterial attack. The seeded solutions show exceptional flow properties, exhibiting strong stiffening under high rates of extension; this is exhibited in the enhancements of pulling power of seeded solutions in tubeless and open siphons. The mechanism by which the seeding of nanoparticles prevents the degrading of polymer solutions is not understood.

Recent studies using atomic force microscopy (AFM) reveal a special micro-scale cellular structure in the polymer/colloidal-silica samples, which is strikingly different from the uniform structure in the pure polymer samples. This cellular structure may arise from an instability of the uniform state of polymers in solution due to the adsorption of silica in a fabric of polymer strands. This leads to a structure in which self-assembled domains of encapsulated polymer/silica appear to be separated by webs of polymer more or less free of nanoparticles. Variation of the concentrations of polymers and nanoparticles and other factors may lead to different patterns. Self-assembly of particles of all sizes may also be driven by flow-induced stresses, which cause spheres to chain end to end in a row. We could say that this generates a topic in a subject which I call nanoparticle fluid dynamics.

(With the collaboration of Jing Wang)

BIO — Regents Professor Daniel Joseph is the Russell J. Penrose Professor of Aerospace Engineering and Mechanics at the University of Minnesota. Prof. Joseph came to Minnesota in 1963 after receiving his Ph.D. at the Illinois Institute of Technology, and became full professor in 1968. His research covers a wide range of fluid dynamics, including non-Newtonian fluids, dynamics of immiscible two-fluid systems, and particle laden fluids. He has received numerous honors for his research, including his selection to the National Academy of Engineering in 1990, to the National Academy of Sciences in 1991, and to the American Academy of Arts and Letters in 1993. He has a large number of publications and holds ten patents.

Informal Faculty Luncheon: Wednesday, November 2, 2005, 12:00 noon. Meet in 1100 ME and walk to lunch with other faculty. Prof. Daniel Joseph will not be able to attend.