MECHANICAL ENGINEERING STUDENT SEMINAR

Thursday, July 14 2022 at 13:00, D. Dan and Betty Kahn Building, Auditorium 1.

Structure and Dynamics of Polyelectrolyte Complex Network under Electric Field

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Electrostatic interactions between polyelectrolyte (PE) charges and dissociated counterions provide PEs with intriguing properties and significantly determine their conformation and dynamics in solution. When oppositely charged PEs are mixed, the variety of the compositions spans from poorly processable, kinetically trapped PE complexes (solid) to coacervates (elastic liquid) to dissolved solutions with increasing salt concentration or charge asymmetry. Salt addition reduces the Debye length and screens the Coulomb interactions, thus shortening the electrostatic bond lifetime. In contrast, variation in the charge ratio affects the electrostatic crosslink density. Creating fibers or films from the PE complex typically requires a global network that will impart viscoelastic properties. Nonetheless, controlling the structure and dynamics of a global network comprised of unscreened PE complexes remains a research challenge.

The present research focuses on the formation of networks between charged rod-like cellulose nanocrystals (CNCs) and oppositely charged weak PE macromolecules. Study parameters included varying the concentrations of the constituents below and above the overlap concentration and adjusting the pH to alter the degree of PE ionization. Experiments on light scattering and rheology revealed that the stretched chains, after increasing the charge density, could bridge between CNCs, resulting in a global network. By studying the extensional viscosity under an external electric field, we gained insight into the contribution of electrophoretic and polarization effects to the network dynamics. The electric field did not affect the viscosity of an uncharged PE noticeably, but strongly and weakly charged PEs showed marked changes. We demonstrated the formation of a global network and the processing of the CNC-PE complex into nanofibers by electrospinning in a strong electric field. Within the electrospinning jet, shear and electrostatic forces caused high orientational order in the charged macromolecules.

Note: the seminar will be given in English