Macromolecules Innovation Institute (MII) Seminar Series

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Prof. Alfredo Alexander-Katz

"Blood Clotting-Inspired Polymer Physics"

Massachusetts Institute of Technology
Department of Materials Science and Engineering

Host: Harry Gibson

Abstract: Nature has devised creative and efficient ways of solving complex problems, and one of these problems is that of blood clotting in flowing conditions. In fact, nature has used a novel combination of polymer physics and chemistry that enhances the self-healing propensity of a vessel when strong flows are present while avoiding coagulation when the flow is diminished, a rather counter-intuitive phenomenon. Underlying this process is a globular biopolymer, the so-called von Willebrand Factor, whose function is strongly regulated by flow. In this talk I will present our work on this macromolecule starting from the single molecule approach and building up to the multi component system that more closely resembles blood. I will emphasize how new concepts have emerged from trying to understand such a complex system, in particular I will show how these polymers can display giant non-monotonic response to shear, as well as a very large propensity to form polymer-colloid composites in flow while being a stable dispersed suspension in quiescent conditions. In fact, the aggregation behavior is universal and can be explained with simple scaling arguments. These novel concepts and results are in principle not unique to blood clotting and can have important ramifications in other areas.

Bio: Prof. Alfredo Alexander-Katz' doctoral work focused on understanding the self-assembly of copolymers using novel field-theoretical methods. As an NSF International Postdoctoral Fellow, he moved to Munich to study the dynamics of driven polymers. His work in Munich led to an important discovery that unraveled the mystery behind the process of blood clotting at high shear rates and opened new routes for the development of novel shear responsive materials. He later moved to the Ecole Superieure de Physique et Chimie Industrielle (Paris, France) as a CNRS postdoctoral researcher to study charged polymer solutions and their self-assembly with direct applications to fuel cells.

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His current interests lie in the realm of self-assembly and dynamics of biological soft-materials using a combination of analytical theory and simulations. His group is particularly focused in designing novel polymer-like drug delivery carriers and understanding their response to chemical and physical stimuli. This work aims to enable a new generation of drug-delivery vectors that could target different areas of the body in a very specific manner, and to provide a much deeper understanding of the processes of adhesion and targeting in flow. Other topics that he is currently pursuing is understanding the supramolecular self-assembly of chlorophyls in the antennas of Photosynthetic Bacteria which are the most efficient light harvesting organisms on Earth, as well as studying the dynamics of driven soft systems in general. The research in Prof. Alexander-Katz's group is highly interdisciplinary, and lies at the interface of materials, biology, physics, chemistry and medicine.

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