Northeastern University
College of Engineering

Wednesday, April 2, 2025 | 135 Shillman Hall | 12:00 PM

Distinguished Seminar Speaker

Data-Driven Approaches towards Controlling the Structure-Property-Processing Relationships of Soft Matter

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Abstract: Controlling the hierarchical structure of soft matter, like polymers, from monomer to microstructure to process design is crucial for tailoring their functional properties in advanced materials systems. However, achieving scalable production of advanced soft materials is hindered by their inherent path-dependent behavior through a thermodynamic and kinetic landscape. Behavior arising from the kinetic limitations of macromolecular relaxation and diffusion during processing. Understanding and leveraging the path-dependence of structure-property-processing relationships in these hierarchical systems is key to addressing pressing societal challenges such as mixed plastic waste recycling and replacing synthetic plastics with natural polymer alternatives. Accomplishing this requires large many parameter datasets constructed from the combination of process analytical technology (PAT) with physical and computational experiments built into autonomous systems of experimentation, process monitoring, and process control. PAT can be used to generate high-fidelity datasets linking processing conditions to emergent material structure and properties. These experimental datasets (combined with offline thermal, mechanical, rheological, chemical, and structural data) then inform physics-based multiscale simulations and machine learning models. The simulations, parameterized and validated by PAT and offline data, allow the computational exploration of the complex processing-structure landscape and identify optimal processing windows. Hierarchical machine learning algorithms can then be trained on these combined datasets to develop predictive models capable of real-time process monitoring and control, ultimately enabling resilient and scalable manufacturing. This presentation will provide an overview of this approach, applied to three research thrusts: (1) Autonomously Learning the Physics of Polymer Mixing, (2) Mixed Plastic Waste Recycling, and (3) Alginate as a Synthetic Plastic Alternative. Then we will take a deep dive into developing natural polymers, like alginate, as functional replacements for synthetic plastics. This will showcase the Roux Institute research model integrating fundamental and translational research with entrepreneurial engagement and workforce development. This includes a discussion on the value-chain of seaweed-derived polymers, methods for dynamic control of chain architecture and molecular weight, improving the quality of refined alginate, modeling the performance and service life of alginate-based materials, and addressing the technical limitations to creating value in a seaweed biopolymer industrial ecosystem.

Biography: Bill Lenart received his BSE in Polymer Science and Engineering and PhD in Macromolecular Science and Engineering from the Department of Macromolecular Science and Engineering at Case Western Reserve University under the advisement of Prof. Michael Hore. He held his first postdoc appointment in the Department of Chemical Engineering and Materials Science at the University of Minnesota with Profs. Chris Ellison and Chris Macosko and his second at the University of Chicago Pritzker School of Molecular Engineering with Prof. Stuart Rowan. Lenart started as a research scientist at the Roux Institute in Portland, ME in August, 2023.

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