CHEMISTRY/PHYSICS SEMINAR SERIES

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11:00 a.m. to 11:50 a.m. in ENW 115

Molecular Engineering of Poly(lactic acid) for Sustainable Materials: From Reactive Chain Design to Hierarchical Structures

ABSTRACT

Humanity faces an urgent global sustainability challenge, and materials innovation lies at the core of addressing it. Plastics are indispensable to modern life, from transportation and building insulation to advanced biomedical systems; yet their high carbon footprint, fossil origins, linear production and consumption model, and environmental persistence have contributed to severe ecological consequences, including the microplastics crisis. Accelerating the development of sustainable polymer systems that can be produced through environmentally benign processes, without compromising performance, is therefore imperative. Poly(lactic acid), PLA, is a leading renewable and compostable candidate to replace petroleum-based plastics; however, its broader deployment in advanced applications is limited by insufficient melt strength, slow crystallization kinetics, limited rheological tunability, and multiphase incompatibility. This talk presents a unified molecular engineering framework that enables precise control over PLA chain architecture and interfacial chemistry to overcome these constraints. Controlled hydrogen peroxide induced chain scission is introduced as a scalable strategy to tailor molecular weight and increase melt flow index, enabling stable fine fiber melt blowing. Conversely, multifunctional epoxide-based chain extension increases molecular weight and entanglement density, restoring melt elasticity required for high expansion supercritical CO_2 foaming. Together, these complementary strategies establish a bidirectional rheological toolbox. Hierarchical structural engineering is further demonstrated through sacrificial templating to create nanoporous melt blown PLA fibers for high efficiency filtration and through nanoclay assisted crystallization control to reinforce foam morphology. Finally, reactive degradation and compatibilization strategies in PBAT and PLA blends enable uniform biodegradable nonwoven materials while balancing strength and ductility. Collectively, this work establishes an integrated molecular to structure design paradigm for scalable, high performance, and circular PLA materials..

BIOGRAPHY

Tizazu is a Canada Research Chair (Tier II) in Sustainable Multiphase Polymers at the University of Waterloo, and was awarded the Macromolecular Science and Engineering Division (MSED) Early Career Instigator Award in 2024. His research program focuses on materials sustainability, and ranges from developing polymers sourced sustainably to creating compostable plastics, crafting eco-friendly nanomaterials, exploring low-carbon alternatives, and upcycling and recycling of polymers. He has contributed over 150 peer-reviewed publications (h-index = 47), holds 16 patents, and works with industry leaders (DuPont, AirBoss America Corp., CTK Bio Canada, and Mondelez International) and governmental bodies (Natural Resources Canada). He is also the director of the IBET PhD Project (Indigenous, Black Engineering, Technology).