Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

MIE498H1: Research Thesis 2023-2024

Supervisor	Patrick Lee
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Number of Positions	1
Open to	Mechanical Engineering Students
Term Offered	Full-Year (Y)
Research Area	Materials
Research Topic	Transforming Polymer Waste into High-Value Carbon Products and Composites: A Sustainable Solution

Project Description

Hierarchical fibre-inspired structures are key to creating hybrid composites with high strength and toughness. These structures mimic the design of natural materials, such as bone, seashells, and silk, which have evolved to overcome the limitations of their constituent elements and compounds. By arranging these components hierarchically, from molecular to macroscopic scales, natural materials achieve enhanced mechanical and functional properties that are not predictable by the rule of mixtures. This work aims to apply the same principle of bioinspired materials design to develop synthetic composites with superior performance and durability. Graphene nanoplatelets (GnPs) are plate-shaped nanocrystals made of stacked graphene layers held together by van der Waals forces. They have attracted much attention for their potential to improve the mechanical, thermal, and electrical properties of composites. By combining GnPs with conventional fillers like glass fibre (GF), a hierarchical structure can be formed that enhances load transfer at the fibre/matrix interface and improves the composite's mechanical behaviour. GnPs can form chemical bonds with GF sizing and create GnP-rich regions at the fibre/matrix interface. Adding a small amount of GnP can create a hierarchical structure and cause trans-crystallization and grain refinement in the fibre/matrix interface, leading to higher mechanical performance of the composite under tensile and flexural loading. The hybrid composite can also offer high electrical and thermal conductivity lightweight solutions for EMI applications. Other hybrid nanofiller work is ongoing.

Additional Information	N/A
Application Instructions	Please submit CV, unofficial transcript, to Prof. Patrick Lee (patricklee@mie.utoronto.ca)