Faculty of Engineering and Applied Science
Chemical Engineering Seminar Series

Tailoring Multicomponent Composite and Foam Properties via Micro-structuring

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Dupuis Hall, Room 215

Most new polymeric products contain two or more polymers and/or functional additives resulting in desired properties contributed from each component. Recently, our group is focusing on creating hierarchically structured hybrid composites and coextruded micro-/nano-layered structures to tune the material properties. In this presentation, an approach will be presented to develop synergy-induced hierarchically structured Polypropylene (PP)-based hybrid composites, reinforced with Graphene Nanoplatelets (GnP) and Glass Fibers (GF), capable of achieving advanced properties and functionalities. These advanced multifunctional hybrid composites can be tailored for a variety of high-performance applications by exploiting the mechanisms governing the synergistic effect. In this hierarchical system, the GnPs (i.e., nano-sized filler) are chemically and electrostatically attached to the GFs (i.e., micro-sized filler), favoring load transfer at the interface, while simultaneously enhancing the crystalline microstructure of the PP matrix. Furthermore, the volume exclusion effect induced by the GFs, promotes the formation of GnP-based conductive networks. Strategically controlling the reinforcement concentrations has been proven to directly influence the magnitude of these mechanisms, effectively enhancing the synergistic effect, thereby allowing the mechanical, electrical, and thermal conductive properties of these advanced hybrid composites to be tailored based on their application.

(See slide 2)

Secondly, a fundamental and experimental investigation of cell nucleation and growth mechanisms in advanced Micro-/Nano-Layered (MNL) polymeric structures with alternating film and foam layers will be discussed. Foams can be prepared from any type of plastic by introducing a gas or supercritical fluid (SCF) within the polymer matrix. The applications of microcellular plastics containing billions of tiny bubbles less than 10 microns in size have broadened due to the lightweight characteristics, excellent strength-to-weight ratios, superior insulating abilities, energy absorbing performances, and the comfort features associated with plastic foams, as well as their cost-effectiveness and cost-to-performance ratios. We found that the cell nucleation and growth phenomenon in MNL systems are governed by the synergy of two categories of parameters: morphological parameters (i.e., film and foam layer thicknesses and the number of layer interfaces) and material parameters (i.e., material stiffness and compatibility with neighboring layers). The presence of adjacent film layers can significantly increase cell density through three mechanisms: promoting heterogeneous cell nucleation, preventing cell deterioration, and confining cell growth. The influence of film layers varied in different layer thickness regions and interface densities, where stiffer and more compatible film layers produced higher cell densities.