MATERIALS ENGINEERING

SEMINAR

"Sensing Stress in Polymer Composites Using Mechanophores"

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ABSTRACT

Stress accumulation in the matrix of fiber-reinforced polymer composite materials is a critical phenomenon that substantially impacts the composite's overall performance. However, the instantaneous nature of the fracture event makes it very difficult to obtain experimental data on the damaged region. Moreover, there is a lack of experimental tools for sensing and quantifying real-time stress distribution within the matrix. Therefore, a molecular force probe (mechanophore) was employed within the polymer matrix (polydimethylsiloxane) for visualizing the stress field distribution during loading. The spiropyran mechanophore transitions from a fluorescent inactive state to an active state (merocyanine) via isomerization under the application of force and strain. One single fiber was used with the matrix to simplify the composite model, demonstrating the fundamental failure modes prevalent in traditional fiber-reinforced composites during uniaxial tensile testing along the fiber direction. At the interface, the tensile load transfer from matrix to fiber via shear stress. Confocal microscopy was used to visualize mechanophore activation and quantify the fluorescence intensity. The uniaxial tensile test of dogbone samples showed a gradual stress build-up in the matrix from the fiber/matrix interface and conical stress fields in the matrix around the fragmented fiber. The results indicated that these mechanoresponsive molecules could be promising for visualizing real-time stress distribution and designing high-performance composites.

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