

# Chemical Engineering Doctoral Defense

## Self-Sensing Polymer Composites for Precursor Damage Detection via Mechanochemistry

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### Abstract

While understanding of failure mechanisms for polymeric composites have improved vastly over recent decades, the ability to successfully monitor early failure and subsequent prevention has come of much interest in recent years. One such method to detect these failures involves the use of mechanochemistry, a field of chemistry in which chemical reactions are initiated by deforming highly-strained bonds present in certain moieties. Mechanochemistry is utilized in polymeric composites as a means of stress-sensing, utilizing weak and force-responsive chemical bonds to activate signals when embedded in a composite material. These signals can then be detected to determine the amount of stress applied to a composite and subsequent potential damage that has occurred due to the stress. Among mechanophores, the cinnamoyl moiety is capable of stress response through fluorescent signal under mechanical load. The cinnamoyl group is fluorescent in its initial state and capable of undergoing photocycloaddition in the presence of ultraviolet (UV) light, followed by subsequent reversion when under mechanical load. Signal generation before the yield point of the material provides a form of damage precursor detection.

This dissertation explores the implementation of mechanophores in novel approaches to overcome some of the many challenges within the mechanochemistry field. First, new methods of mechanophore detection were developed through utilization of Fourier transform infrared (FTIR) spectroscopy signals and in-situ stress sensing. Developing an in-situ testing method provided a two-fold advantage of higher resolution and more time efficiency over current methods involving image analysis with a fluorescent microscope. Second, bonding mechanophores covalently into the backbone of an epoxy matrix mitigated property loss due to mechanophore incorporation. This approach was accomplished through functionalizing either the resin or hardener component of the matrix. Finally, surface functionalization of fibers was performed and allowed for unaltered fabrication procedures of composite layups as well as provided increased adhesion at the fiber-matrix interphase. The developed materials could enable a simple, non-invasive, and non-detrimental structural health monitoring approach.



June 21, 2021; 11 AM;

Zoom Link: <https://asu.zoom.us/j/85146062293?pwd=VjZmbINrL2xxY0tSNnVCbWxaZFdBUT09>