# Chemical Engineering Doctoral Defense

## Development of Mechanochemically Active Polymers for Early Damage Detection

School for Engineering of Matter, Transport and Energy

Jin Zou

**Advisors:** Dr. Lenore L. Dai
Dr. Aditi Chattopadhay

## abstract

Identification of early damage in polymer composite materials is of significant importance so that preventative measures can be taken before the materials reach catastrophic failure. Scientists have been developing damage detection technologies over many years and recently, mechanophore-based polymers, in which mechanical energy is translated to activate a chemical transformation, have received increasing attention. More specifically, the damage can be made detectable by mechanochromic polymers, which provide a visible color change upon the scission of covalent bonds under stress. This dissertation focuses on the study of a novel self-sensing framework for identifying early and in-situ damage by employing unique stress-sensing mechanophores. Two types of mechanophores, cyclobutane and cyclooctane, were utilized, and the former formed from cinnamoyl moeities and the latter formed from anthracene upon photodimerization. The effects on the thermal and mechanical properties with the addition of the cyclobutane-based polymers into epoxy matrices were investigated. The emergence of cracks was detected by fluorescent signals at a strain level right after the yield point of the polymer blends, and the fluorescence intensified with the accumulation of strain. Similar to the mechanism of fluorescence emission from the cleavage of cyclobutane, the cyclooctane moiety generated fluorescent emission with a higher quantum yield upon cleavage. The experimental results also demonstrated the success of employing the cyclooctane type mechanophore as a potential force sensor, as the fluorescence intensification was correlated with the strain increase.

November 12, 2014; 9:00 AM; ERC 490