

MATERIALS ENGINEERING SEMINAR

“Mechanics of Polymer Interfaces: Pressure Sensitive Adhesive Tapes and Polymer Matrix Composites”

By
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Purdue MSE Ph.D. Final Exam

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ABSTRACT

The interface between two dissimilar materials often presents a challenge for materials engineers. Mismatches of moduli, coefficients of thermal expansion, surface energies and chemical functionalities often create headaches for engineers seeking to control and understand interfacial bonding. In this work, I am interested in two specific interfacial problems: the adhesion of pressure sensitive adhesive tapes to various substrates and the interface in polymer reinforced composite materials between the reinforcement phase and the matrix.

Pressure sensitive adhesive tapes (PSATs) are an important class of materials with applications ranging from medical adhesives to roadway markings. In this work, I present a novel 90° peel fixture to be used in the evaluation of road tapes on roadway surfaces. This fixture overcomes the limitations of traditional peeling fixtures by translating the load along a 45° angle and allowing for testing from immovable substrates. This modular fixture was validated on control surfaces before demonstrating the capability to test pavement marking tapes from road surfaces. Within the context of medical adhesives, I am interested in the deformation of the skin local to the PSAT during peeling. By developing a model to predict this deformation, adhesives can be tailored to mitigate skin damage. I present experimental evidence indicating the independence of peeling force to the elastic modulus of the substrate along with deformation measurements of skin analogs during the removal of a medical tape. A new model for predicting the deformation of soft substrates during peel is reported based on contact mechanics for a rectangular prism on an elastic half space.

Polymer matrix composites are another category of materials which are increasingly adopted to improve performance or efficiency by reducing the weight of components. These materials offer a high specific strength but often fail catastrophically rather than gradually. As such, understanding the stress distribution within the composite material and being able to detect interfacial failure earlier is a priority. Using stress responsive fluorescent molecules called mechanophores, I present a methodology to quantify stresses within the polymeric matrix near the reinforcement phase. By correlating in situ fluorescence intensity measurements during a uniaxial tensile test to stresses predicted from a finite element analysis model, a calibration was developed. This calibration was then applied to increasingly complex composite geometries. Chemically bonding these mechanophores to the interface between two materials allows for the detection of interfacial failures through fluorescence microscopy. I present a technique to synthesize interfacial spirolactam mechanophores on industrially-relevant epoxy and silica material systems. I demonstrate the ability of these systems to detect failures in the system through in situ confocal microscopy during deformation.

Date: Tuesday, July 18, 2023

Time: 10:00 A.M.

Place: ARMS B061 or via this link: <https://purdue-edu.zoom.us/my/chelseadavis>