My research is involved in the development of pressure sensitive adhesives for applications in transdermal drug delivery. The highly viscoelastic mechanical properties of pressure sensitive adhesives (PSAs) permit attachment to soft tissue, making them suitable for medical applications. One particular design is the membrane controlled system which consists of a backing layer, drug reservoir, rate-controlling-membrane (RCM), and adhesive. Shown below is a schematic of the system:

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backing layer

drug reservoir

RCM

adhesive

skin
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The drug diffuses through the rate-controlling-membrane and adhesive before it reaches the skin and penetrates. These advanced transdermal systems must fulfill the following requirements: adhesion to the skin for anywhere from 24 hours to 7 days, easy and clean removal, drug compatibility, and no initiation of skin irritation.

Little is known about the adhesion between the PSA and the stratum corneum, the skin’s outer skin layer, with little quantitative data or reproducible test methods available in the literature. Hence, this project will explore the mechanical and fracture properties of model PSA systems. Specimens are of the dual cantilever geometry, consisting of two massive elastic substrates with a thin layer of adhesive between them. The system is loaded such that a crack is forced to propagate down the midline of the specimen. From
the instantaneous load and crack length data, the strain energy release rate can be calculated to quantify the adhesion of the PSA.

Another objective for this research project is to achieve and quantify adhesive failure in PSA model systems. The specimens we have been assembling consist of two polymeric substrates held together by a thin film of Polyacrylate adhesive. As the specimen undergoes loading such that a crack is forced to propagate down the midline, the substrates move apart, yet the adhesive between them resists the separation by undergoing what is known as bridging. The ligaments stretch between the two substrates until they reach their limit and snap. The goal is to achieve adhesive failure, where the adhesive only adheres to one substrate at failure, leaving the other substrate with little or no residue. Below are figures demonstrating the possible behaviors of the model system.

**Figure A:** Cohesive failure as observed by failure in the bulk

**Figure B:** Adhesive failure as demonstrated by failure at the interface
To achieve adhesive failure in these systems, modifications must be made to the sample. Proposed ideas include the application of a thin layer of artificial sebum to one of the substrate surfaces, to more closely model the surface chemistry that a transdermal device would experience in clinical use, and experimentation with substrates of different types. Below is a chronological outline of experiments that describe the modifications to the model PSA system:

I. 60 µm thick adhesive layer between Lexan substrates
   status: cohesive failure observed
II. Same system as I + adhesive failure enhancer
   A. Hi-Temp-Vac lubricant (silicon base)
   B. LPS 1 Greaseless Lubricant (hydrocarbon base)
   status: currently experimenting with different treatments
III. Same system as I + organic-based adhesive failure enhancer that resembles the chemical structure of stratum corneum
   A. Recipes for artificial human sebum
   status: researching the purpose of each of the ingredients/identifying their biological counterparts

Once adhesive failure is accomplished, experimental work will be conducted on the effect of displacement rate, layer thickness, and environment.