

Research in Dr. Barbee's Lab
URP 2027: Functional Polymer Materials

Polymer materials are incredibly common in the world around us, from common everyday materials used in construction to special biomedical materials. As organic chemists, we have the opportunity to synthesize small molecules and polymers that can control the behavior of a polymer material from the molecular level. In 2027, Dr. Barbee plans to have several new students joining the group to work on the 2 projects outlined below.

Project 1: Block copolymer hydrogels synthesized through PET-RAFT

Hydrogels are polymer materials composed mostly of water by mass, and they have many promising biomedical applications. Many hydrogels are weak and brittle and lack the robust mechanical properties of biological tissues. Most hydrogels are prepared by cross-linking polymer chains or reacting monomers in the presence of a small fraction of bifunctional monomer. Our aim is to prepare block copolymer gels with hydrophobic chains embedded into the network structure, and our hypothesis is that hydrophobic components will aggregate and provide a method of tuning the swelling and mechanical properties of the gel. The student focusing on this project will continue prior work from last summer's URP, when we developed a strategy to synthesize block copolymer hydrogels through photoinduced electron/energy transfer reversible addition-fragmentation chain-transfer polymerization (PET-RAFT). Using a red light during the reaction with a suitable catalyst for PET-RAFT, (figure 1) we were able to make block copolymer gels. The first goals in this project will be to characterize the kinetics of the reaction and prepare a series of polymers and hydrogels. We will conduct swelling studies and measure mechanical properties with a universal testing instrument. In the long term, we hope to use this synthetic method to make hydrogels from folded polymer chains, which we hypothesize could be a mechanism for enhancing the toughness of the gels.

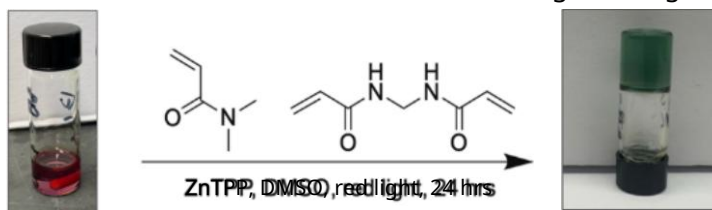


Figure 1: A random copolymer (red solution) reacts with acrylamide and a cross-linker to prepare a gel (green vial) using PET-RAFT.

Project 2: Mechanochromism in commercially available polymer materials

Mechanical forces are typically destructive for materials, resulting in their failure, but in the field of polymer mechanochemistry, mechanical force is used for constructive reactions instead. Mechanically-induced optical changes, where a material changes color or fluorescence or emits photons, provide a map of where forces are in the material. There are many types of polymer materials that are important commercially where mechanochromism has not yet been studied. Our lab has previously focused on polyurethane foams, which are widely used for impact protection and construction, and we have developed a foam formulation that turns purple upon compression (Figure 2). This summer, we plan to expand our research to at least one additional material, commercial epoxy adhesives. The first goals of this project will be to synthesize new mechanochromic molecules and develop formulations for a mechanochromic epoxy. Students who work on this project may also collaborate with engineering students on modeling force distributions within various types of polymer materials.

Meredith H. Barbee
RESEARCH PROPOSAL

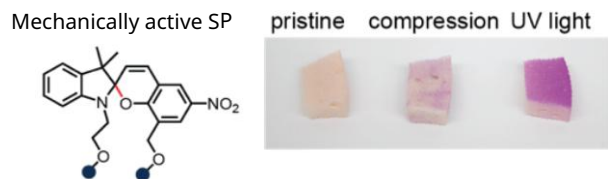


Figure 2: Our research group has recently developed mechanochromic polyurethane foams using spiropyran as a cross-linker. These materials turn purple under mechanical tension.

Student outcomes:

These projects provide an opportunity for students to understand how chemistry dictates material behavior. Students who work on this project will synthesize polymers and small molecules. In recent years, students in our group have characterized small molecules, polymers, and materials with a range of instrumentation techniques, including nuclear magnetic resonance (NMR), size exclusion chromatography (SEC), UV-vis spectroscopy, mass spectrometry, IR spectroscopy, and materials testing.