FURMAN

Chemistry Department
2021 Summer Research Program

Lauren Jarocha Research Group

Research in the Jarocha group is focused on understanding how weak magnetic fields impact chemical reactions. Photochemically generated radical pairs are common to many applications. These reactions are uniquely sensitive to external magnetic fields through their quantum mechanical property of spin – despite the fact that the strength of this interaction is orders of magnitude smaller than the effects of random thermal motion of molecules. Such radical pairs are believed to act as a molecular compass that allows birds to migrate accurately on a global scale. Our research lab aims, first, to understand the fundamental principles that allow a radical pair to act as a molecular compass and, then, to fine tune these interactions so that those principles can be used to improve upon devices using OLEDs and organic semiconductors.

Characterization of supramolecular structures

The avian molecular compass is light-dependent and likely to be a protein located in the birds' retina. This protein, cryptochrome, is overexpressed in cone cells during migratory seasons. Cone cells have regions of high supramolecular ordering caused by folded lipid membranes; this molecular order is crucial to the ability of a radical pair to detect direction of an external field. We understand the basic properties of spin that allow a radical pair to act as a compass, but we do not yet have a good understanding of how the properties of the supramolecular environment impact the ability to detect weak magnetic fields like Earth's (ca. 50μT).

Micelles and vesicles that provide convenient models for investigating how supramolecular environments alter molecular motion and radical sensitivity to magnetic fields. My research group will examine the interplay between charge, hydrophobicity, and electrostatics to maximize magnetosensing of weak magnetic fields in these environments. Micelles and vesicles are held together by weak intermolecular forces, and incorporating small molecules into them can dramatically affect these interactions. We will employ multiple methods, including light scattering, fluorescence, nuclear magnetic resonance, and electron paramagnetic resonance to examine physical and structural changes that occur to micelles and vesicles when they incorporate small organic molecules, with a particular focus on molecules that participate in photochemical electron transfer reactions.

Instrument Development for detecting MFEs

Detecting magnetic field effects involves measuring a difference in a reaction yield or rate as a function of whether or not an external magnetic field is applied. This requires very sensitive spectroscopic instrumentation. This summer, we will be building an experiment to detect magnetic field effects by fluorescence and then applying this technique to study how electrostatic and hydrophobic interactions affect the magnetically sensitive reactions. Instrument development projects like this one promote skills in electronics, optics, programming, troubleshooting, and process development.