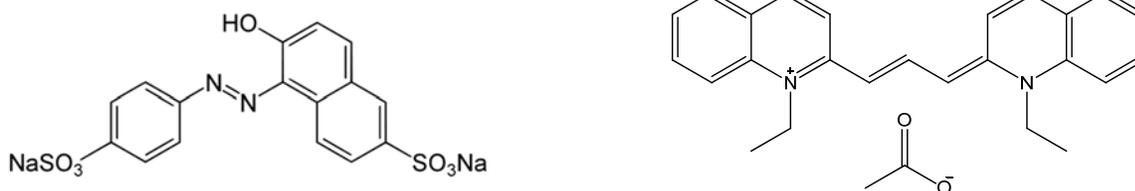


Current Research Projects in Professor Karukstis' Laboratory
Joint Collaboration with Professor Van Hecke

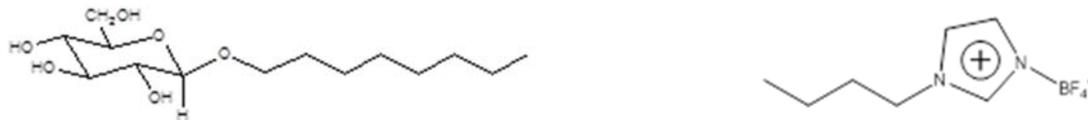
Self-Assembly of Chromonic Dyes. The Karukstis laboratory explores the self-assembly of amphiphilic molecules with dual hydrophilic and hydrophobic character to create complex hierarchical structure via intermolecular interactions. In contrast to conventional amphiphiles, we are currently interested in chromonic molecules which are aromatic structures with hydrophilic solubilizing groups positioned either on the periphery of a polyaromatic central core or as linking groups between aromatic rings. These molecules aggregate by stacking as concentration is increased within a solvent. The behavior of most chromonic systems with increasing concentration is consistent with an isodesmic (i.e., continual) nature of the aggregation process, however there is recent evidence of some chromonic molecules exhibiting multiple aggregation steps. Our spectroscopic studies of two chromonic molecules – Sunset Yellow FCF and pinacyanol acetate – suggest that the molecules aggregate in a continual fashion. We are using a combination of absorbance, fluorescence, and light scattering studies to directly monitor the increasing size of the aggregate with increasing concentration and confirm the nature of the stacking process.



Chemical structure of Sunset Yellow FCF (left) and pinacyanol acetate (right).

Aggregation of Amphiphilic Surfactants in Aprotic Ionic Liquids. The alkyl glucosides are examples of sustainable or “green” amphiphiles based on carbohydrate raw materials that are available in large quantities and at competitive prices in the world market. These glucose-based surfactants are the most important sugar-surfactants today, based on annual production figures [19] as a consequence of their high rate of biodegradation, low level of aquatic toxicity, and favorable dermatological properties. Our current research has accurately identified the phases that exist in aqueous mixtures of alkyl glucosides and alkyl thioglucosides. A rich array of aggregate structures are observed as surfactant concentration is increased, with factors such as surfactant molecular structure and temperature dictating the type of aggregates formed. Aggregates include cylindrical/rod-like micelles, hexagonal structures (i.e., columnar arrays of cylindrical micelles arranged into a hexagonal lattice), lamellar structures (bilayers), and bicontinuous cubic structures (i.e, bilayers twisted into a periodic, three-dimensional minimal surface that yields two distinct [continuous, but non-intersecting] hydrophilic regions or water channels separated by the bilayer). Preliminary investigations in our laboratories reveal that use of an aprotic ionic liquid as a replacement solvent for water can generate highly-ordered

surfactant aggregates. We suggest that the organization of the ionic liquid molecules in solution acts as a template or scaffold to stabilize the surfactant structures. The interest in template materials synthesis in the scientific community is a strong driving force to characterize more fully the self-assembly of surfactants in ionic liquids.



Chemical structure of n-octyl-β-D-glucoside (left) and ionic liquid 1-n-butyl-3-methylimidazolium tetrafluoroborate (bmimBF₄) (right).

An Exploration of Surfactant Aggregation with Quantum Dots. We have significant experience using the fluorescence of organic dyes as a novel and effective approach to characterizing phase diagrams of surfactants in water or other solvents. In particular, our innovative phase diagram construction is achieved using the powerful spectral sensitivity of a particular fluorescence probe (prodan, 6-propionyl-2-(dimethylamino)-naphthalene) to the polarity of its environment. Alternatively, one might use the fluorescence emanating from nanocrystal chromophores such as quantum dots (QDs) made from II/VI and III/V semiconductors. QDs have absorption and emission properties that are tunable by particle size; narrow emission bands of symmetrical shape are possible from highly monodisperse (i.e., narrow size distribution range) QDs. Few systematic studies have been performed on the effect of the microenvironment on QD spectroscopic properties. CdTe QDs functionalized with COOH ligands are commercially available and likely to target hydrophilic regions of aggregates as a consequence of their solubility in water. Other functionalized QDs might optimally target hydrophobic regions in aggregates. We will begin to explore the physicochemical properties of quantum dots and assess their ability to act as probes of surfactant aggregates.

Size-dependent emission spectra of CdTe quantum dots.

