

Current Research Interests - Prof. Karukstis

A unifying theme of research in my laboratory is the creation of a variety of dynamic supramolecular assemblies on the basis of intermolecular forces (e.g., electrostatic interactions, hydrogen bonding, van der Waals forces). The components of the supramolecular assembly include anionic, cationic, and neutral surfactants including alkyl glucosides (“green” surfactants derived from the reaction of glucose with fatty acids), azo dyes (organic dyes containing the azo functionality N=N with attached aryl groups), and cyclodextrins (water-soluble compounds with six, seven, or eight glucopyranose units in which the overall macromolecule is toroidal-shaped with a hydrophilic exterior and a hydrophobic interior cavity). We use absorbance and fluorescence spectroscopy, optical microscopy, and light scattering to (a) characterize these systems, (b) investigate the role of these assemblies in microencapsulation, and (c) explore whether these systems can function as chemical sensors.

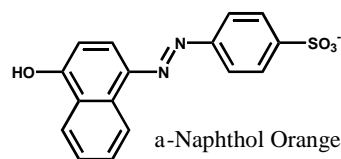
Examples of current projects are highlighted in the following synopses:

Electrostatic Interactions of Azo Dyes and Micelles Jonathan P. Litz, Matthew B. Garber, and Kerry K. Karukstis

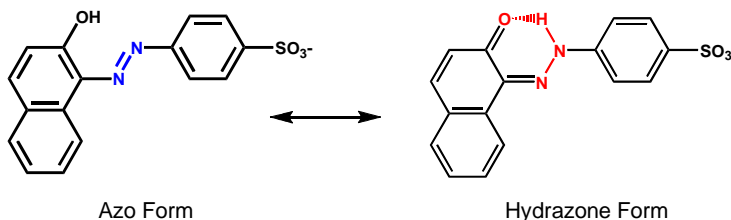
Background: UV-vis spectroscopy is used to probe the electrostatic interaction between supramolecular species and dyes. The sensitivity of azo dyes to their environments makes them ideal candidates for use as nanoprobes.



Approach: Azo dyes were exposed to micelles, vesicles, and solvents of varying polarity. The UV-vis spectra were broken down into component Gaussians to better elucidate the effect of electrostatic interactions on both the structure and environment of the dyes.



The azo dyes studied contain two aromatic rings (naphthyl or phenyl) connected by an azo (-N=N-) group. The dyes differ in substituents located on the two aromatic rings.



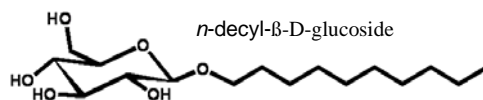
Results: We discovered that dyes with an *o*-hydroxyl group exhibited hydrazone character, which became more pronounced in the presence of micelles and vesicles. The dyes also proved to be effective probes of the polarity of their environment.

Future Work: Dyes with two *o*-hydroxyl groups present an interesting situation with potential for two competing hydrazone forms. We will further probe the interactions between dyes and supramolecular structures by determining which form of the dye dominates upon interaction with micelles.

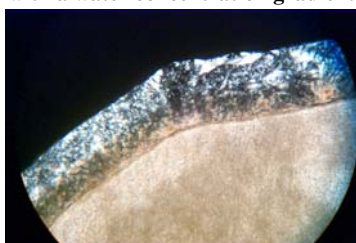
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Determination of the Binary Lyotropic Liquid Crystal Phases Formed by *n*-Decyl- β -D-Glucoside in Water

Alison Lee, Christina Snyder,
Kerry K. Karukstis and Gerald R. Van Hecke



Polarized Light Microscopy of decyl-glucoside with a water concentration gradient



Background Alkyl-glucosides are biologically relevant surfactants which form lyotropic liquid crystal phases in water. We hope to understand the effect of increased alkyl chain length, with the octyl- and nonyl- systems having already been characterized.

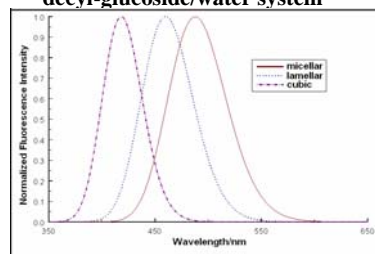
Approach Polarized Light and Fluorescence Microscopy are used in addition to fluorescence spectrophotometry to determine the phases present at various compositions. The spectra obtained from the spectrophotometry are analyzed using PeakFit to determine the location of the fluorescence of different phases.

Results The characteristic curves for the micellar, lamellar, and cubic phases have been determined. The position of these curves is within 10 nm of those found for the octyl- and nonyl-glucoside and water systems. A preliminary phase diagram for the system of decyl-glucoside and water was developed based on analysis involving the fitting of the characteristic curves to the collected spectra

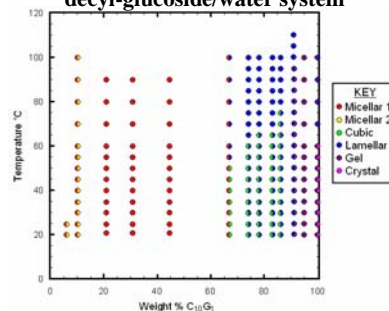
Future Work It is necessary to examine additional samples, particularly those at high weight percent glucoside, in order to fully understand the phase diagram. In addition, a further study of the phase separation at low weight percents would be intriguing.

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Characteristic Phase Curves for the decyl-glucoside/water system



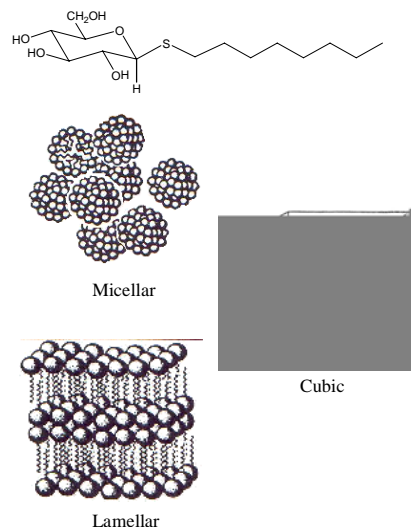
Preliminary Phase Diagram for the decyl-glucoside/water system



Determination of the Phase Diagram of Biologically Relevant Liquid Crystals

Kristen Chellis, Professor Van Hecke, Professor Karukstis
Harvey Mudd College

Liquid crystal phases, or mesophases, are semi-ordered phases in which the molecules all tend to align in a common direction. Thermotropic mesophases form depending on the temperature of the substance. Lyotropic mesophases depend on the interactions between a solvent and a solute. Amphitropic mesophases display the properties of thermotropic and lyotropic mesophases. Alkylglucosides are environmentally safe nonionic surfactants that display amphitropic liquid crystal phases. Many of these phases are similar to biological membranes and are useful in drug delivery and cosmetics. *n*-octyl- β -D-thioglucoside (β C8SG1) forms micellar, cubic, and lamellar phases.



Fluorescence Spectroscopy

Fluorescence spectroscopy with a prodan probe offers a highly sensitive method for detecting the phases in liquid crystal systems. It is a simple method for determining phase diagrams by a single process, and allows for more accurate detection of two phase regions. The fluorescence spectrometer uses a 340 nm excitation and measures the resulting fluorescence emission. Prodan in each phase will emit a characteristic wavelength between 350 and 650 nm. The phases that are present can be determined by noting the peak maximum and shoulders of the fluorescence spectra. The lamellar and micellar phases have high peak wavelengths (480-500nm), while the cubic and gel phases have low peak wavelengths (400-440nm).

