Photo-responsive Surfactant Vesicle-to-Micelle Transitions Investigated Through Dynamic Light Scattering

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Introduction

Surfactants

- Surfactants are compounds that lower the surface tension.
- Being amphiphilic molecules, they have hydrophobic tails and hydrophilic heads.

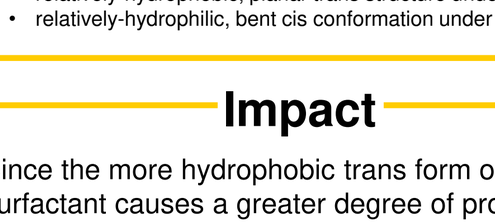


Figure 1: Micelles are single layered while vesicles contain a lipid bilayer, composing of ta surfactant bilayer

Photoisomerization

- Mix 2 surfactants, sodium hexadecyl sulfate (SHS) and azobenzene trimethylammonium bromide (azoTAB),
- Achieve photo-initiated changes in the surfactant microstructure, including micelle-to-micelle, micelle-to-vesicle, and vesicle-to-vesicle.
- Micelles aggregate into vesicles after forming a bilayer.

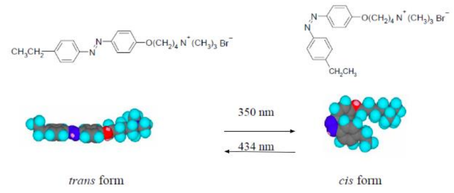


Figure 2: azoTAB isomerization
- relatively-hydrophobic, planar trans structure under visible light
- relatively-hydrophilic, bent cis conformation under UV illumination

Impact

- Since the more hydrophobic trans form of the surfactant causes a greater degree of protein unfolding than the cis form, this provides a means to reversibly control protein folding with light.
- This ability to induce changes in protein structure (with light irradiation) could expose us to developments in drug discovery and enable us to be one step closer to discovering the cure for ailments that root from incorrect protein folding (e.g., Alzheimer's and mad cow diseases).

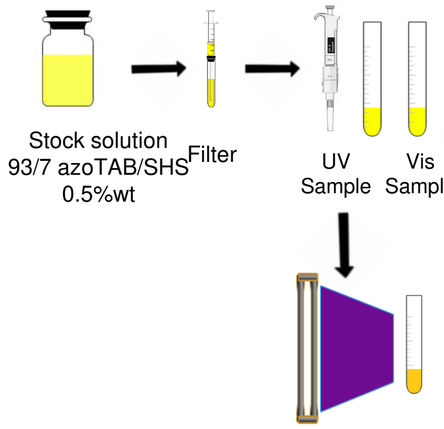
Approach

Procedure

Stock solutions of azoTAB/SHS at a 93/7 molar ratio were prepared for UV light and visible light. UV light solutions were illuminated for 30 minutes before measured with dynamic light scattering. Starting with 0.50% weight mass concentration, the solutions were diluted after ten 5-minute runs were performed at each condition.

Dynamic Light Scattering

- A technique that measures the size of particles by utilizing Brownian motion and the Stokes-Einstein equation.
  - Brownian Motion
    - The random movement of particles due to the bombardment by the surrounding solvent molecules.
  - Stokes-Einstein Equation
    - The size of the particle is calculated from the translational diffusion coefficient.
    - $d(H)=kT/3\pi nD$



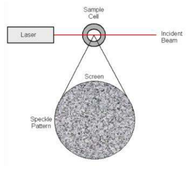


Figure 4: Schematic representation of brownian motion

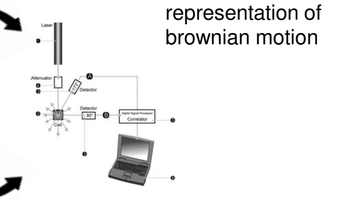
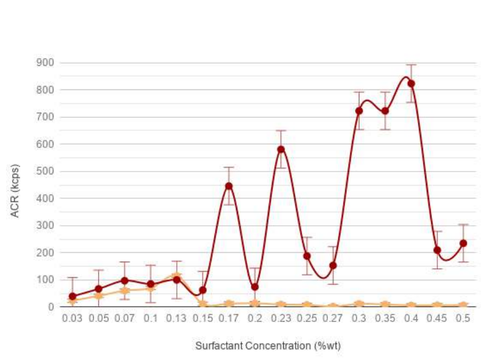
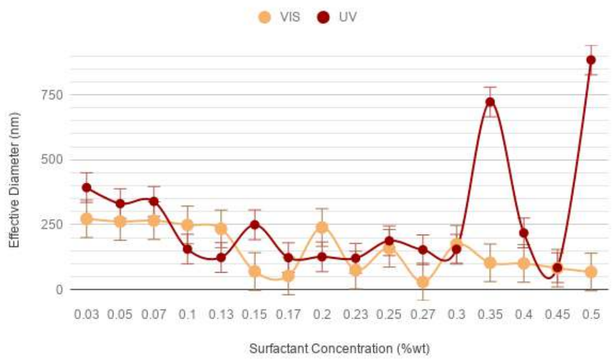
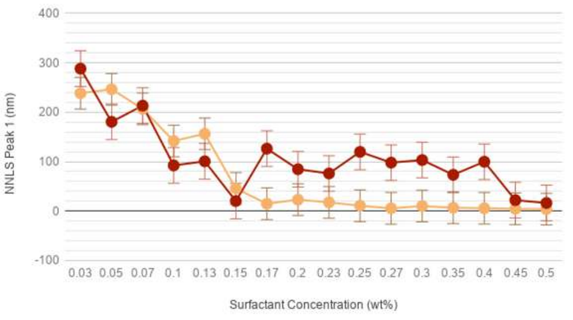


Figure 3: Dynamic Light Scattering

Results







- Vesicle-to-micelle transitions can be observed when the ACR alternates in increasing and decreasing under UV light.
- Under visible light, however, vesicles remain until the surfactant concentration reaches 0.13 wt % , a likely result of the relative ease of *trans* azoTAB packing into a bilayer.
- 3 different populations: 5-10 nm, 80-120 nm and 300-350 nm
- At 0.2 wt% -0.4 wt%, vesicles under UV light and micelles under visible light are present
- 5-10 nm to 100 nm change by UV light exposure
- Presence of micelle-to-vesicle structures at both extreme ends of surfactant concentrations

Relativity to my STEM Coursework

My research was focused on both chemistry and biology concepts. Background knowledge in my Chemistry honors and AP Biology course has exposed me to real-
world applications. I was able to apply the scientific method at a critical level, calculate stock solutions through stoichiometry and molar ratios, and explore the effects of amphiphilic structures.

Acknowledgements

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