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Surfactant-Based Self-Assembly Systems that Mimic Spider-Silk Producing Protein Sols

Surfactant-Based Self-Assembly Systems that Mimic Spider-Silk Producing Protein Solutions

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Introduction

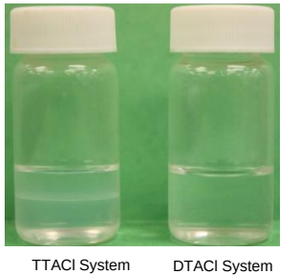
Self-assembly is a process in which molecules autonomously form ordered aggregates held together by non-covalent intermolecular forces. As can be learned from many cellular processes and functions, co-self-assembly using logically chosen additives should be effective in designing self-assembly. By applying this concept, we have assembled cationic surfactant-based self-assembly systems that mimic spider-silk producing protein solutions. Our results reveal that these micelle systems stay as a stable clear solution as long as they are kept sealed and undisturbed. When they are exposed to the air or water, the reactivity of the systems is triggered, which assembles the micelles into liquid crystals having a waxy and flexible nature. The overall assembly very much resembles the assembly process that produces spider silk, where the spidroin-based solutions are kept intact inside a spider's body, but instantly assemble into liquid crystals once they are extruded into the air. Furthermore, we have identified a clear sign of a meta-stable state and the formation of an aqueous two phase system (ATPS), whose reversible phase transitions are possibly driven by the large changes in entropy of the systems. Though initial, these results demonstrate that it is possible to translate the key features of biological self-assembly into artificial self-assembling systems, and possibly create a new class of soft materials.

Goals

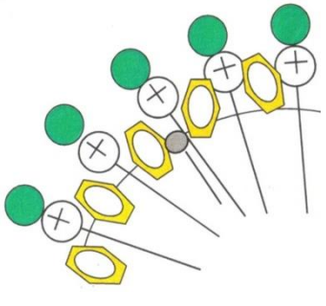
1. Design a cationic surfactant based self-assembly system that mimics the assembly of spider silk production
2. Explore th possibility of new phenomena that emerge from self-assembling systems

Materials and Methods

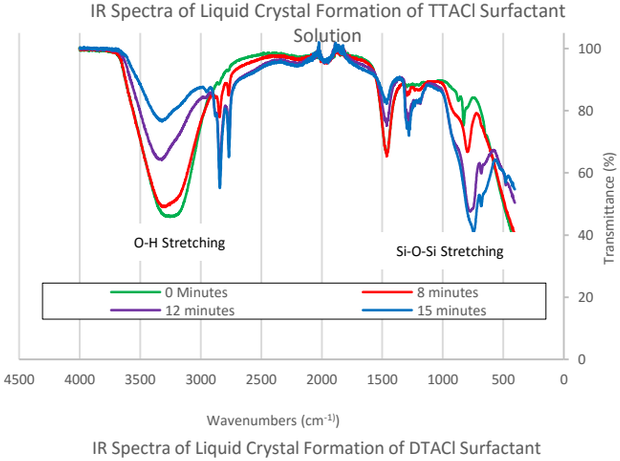
Dodecyltriethylammonium chloride (DTACl) and tetradecyl-trimethylammonium chrloride (TTACl) were dissolved in deionized (DI) water. Sodium hydroxide and decyl alcohol were added, and stirred for 30 minutes. An excess of benzene was added to the solutions, which were stirred for one hour. Tetraethylorthosilicate was added to the solutions. The solutions were stirred for two hours and the stored at room temperature for 4 days. The bottom phases were collected and the aqueous phase and liquid crystals were analyzed.

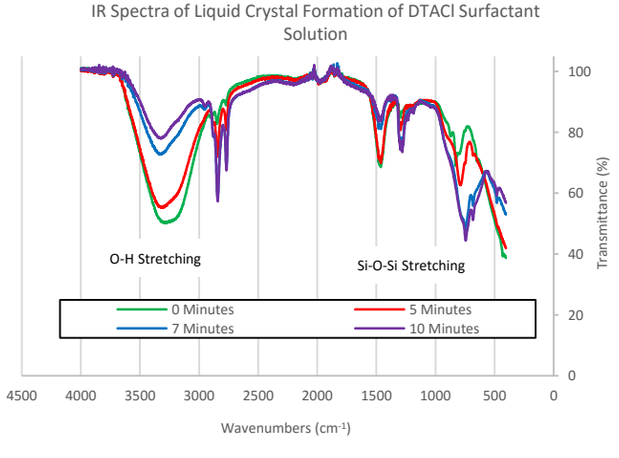


TTACl System DTACl System

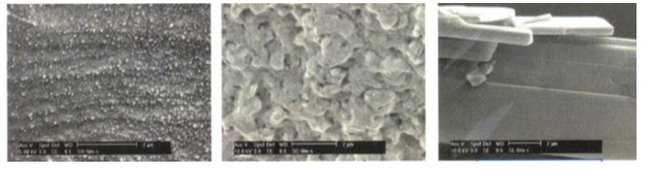


Results No. 1
Mimicking Spider Silk



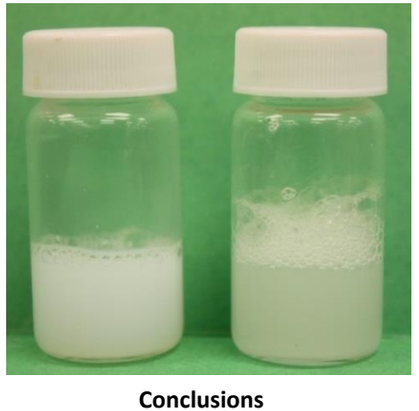


SEM Pictures of Liquid Crystals



Hexagonal Cubic Lamellar

Results No. 2
Aqueous Two Phase System that Shows Cloud Phenomena



Conclusions

- Successfully designed a cationic surfactant-based self-assembly system that mimics the biological self-assembly of silk in the spider spidroin
- Mimicking biological self-assembly systems into artificial ones provides an effective way to design new soft-materials
- Discovered an aqueous two phase system (ATPS)

Future Work

- Elucidate the molecular interactions throughout the overall assembly process
- Elucidate the mechanism of the Cloud Phenomena: Kinetics or Thermodynamics?