CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

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S0525

Project Title
Ionic Equilibria Control by Hydrophilic Micellar Sequestration Applied to Purification of Oily Mixed Radioactive Waste

Abstract

Objectives/Goals
I investigated properties and application of amphiphilic micelles. I found, atypically, that hydrophilic SDS micelles were able to sequester polar compounds in polar solutions. This suggested that mixed phase extractions could be improved. I was able to obtain enhanced separation of simulated oily mixed radioactive waste by washing ion-contaminated motor oil with water containing hydrophilic micelles.

Methods/Materials
I built a conductivity detector using graphite rods, current meter, and 5 volt oscillator circuit. The rod sides were coated in paraffin. Solutions were magnetically stirred in a beaker in my garage. Calibration was achieved using potassium chloride (KCl) standards. Experimental solutions included deionized water (DI), Chevron 20W50 motor oil, sodium dodecyl sulfate (SDS) in DI and oil, KCl in DI and oil, and Triton X-100 in DI and oil.

Results
Aqueous SDS conductivity increased linearly until 0.007 M, showing the threshold at which SDS molecules aggregated and micelles began to form. Ion sequestration was evidenced by lack of conductivity increase during the addition of KCl to two well-formed micelle solutions, SDS at 0.057 & 0.04 M until KCl concentration reached 0.002 M. The capability of micelles to aid in extraction of ions from regular and KCl-saturated oil was tested by vigorously mixing oil and DI for 15 minutes and then measuring the conductivity of the aqueous component. Further tests with hydrophilic micelles in aqueous phase or with hydrophobic micelles in organic phase revealed that aqueous micelle addition significantly increased the extraction efficiency over DI. Triton X-100 micelles did not sequester KCl and did not enhance extraction, consistent with the hypothesis.

Conclusions/Discussion
The advantage of hydrophilic micelles in extracting ions from simulated oily mixed radioactive waste demonstrates a counterintuitive application of micelles. Ionic equilibrium is affected by micelles as they begin to form (above 0.007 M SDS) and when micellar rearrangements occur (0.013 M and higher SDS concentrations). When initial micellar ion capacity is reached (above 0.004 M KCl), non-equilibrium behavior is observed as the micelles appear to rearrange to increase exposed binding sites. These non-equilibrium behaviors can be exploited to enhance ion extraction, especially in combination with factors influencing micelle development such as stirring rate and pH, as shown in my report.

Summary Statement
I investigated micellar impacts upon ionic equilibrium and found a way to use micelles to improve the extraction of ions (simulated radioactivity) from oil.

Help Received
Deionized water, pH buffers, and conductivity standards were donated by the Metropolitan Water District. My mother and father assisted in board arrangement and critiqued my conclusions.