Salt-Induced Diffusiophoresis of a Neutral Micelle

Eliandreina Cruz Barrios, Taylor Krause, Onofrio Annunziata
Texas Christian University, Department of Chemistry and Biochemistry

Introduction

Diffusiophoresis is the controlled migration of colloidal particles (**P**) due to concentration gradients of other solutes such as salts (**S**).

Particle Migration Rate

$$v_P = -D_P\left(\nabla \ln C_P + \hat{D}_{PS}\frac{\nabla \mu}{RT}\right)$$

Brownian Diffusion — Diffusiophoresis Coefficient

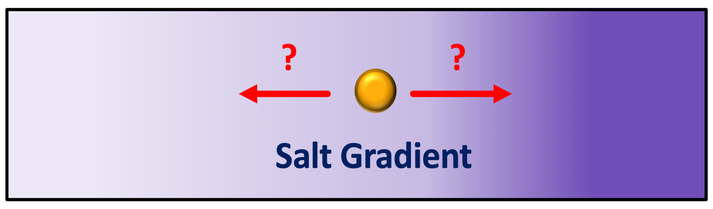
Salt Migration Rate

$$v_S = -\frac{D_S}{C_S}\left(\nabla \ln C_S + \hat{D}_{SP}\nabla \ln C_P\right)$$

Osmotic Diffusion

Migration Direction

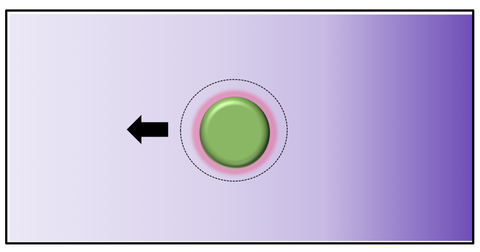
Interfacial Interactions Particle-Water-Salt.



Our Focus: study diffusiophoresis of non-charge colloidal particles.

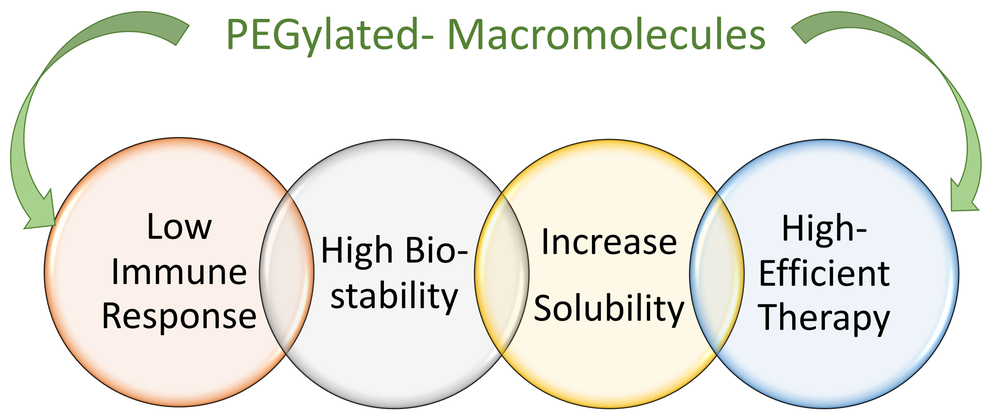
Preferential Hydration Mechanism

Vicinity of particle surface is depleted of salt.

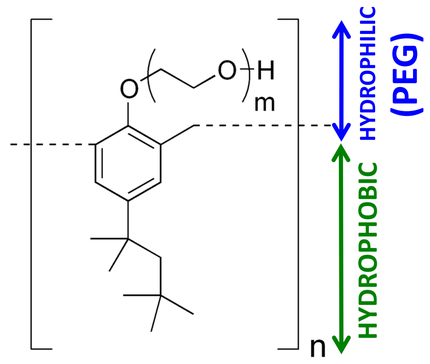


Motivation

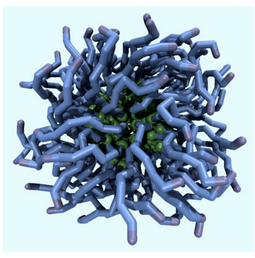
An important example of colloidal particles is represented by those electrically neutral with their interfacial properties governed by polyethylene glycol (PEG) motifs. These particles are extensively used in pharmaceutical applications.



Tyloxapol Surfactant



Micelle



Salt

Sodium Sulfate
Na_2SO_4
(salting-out agent for PEG)

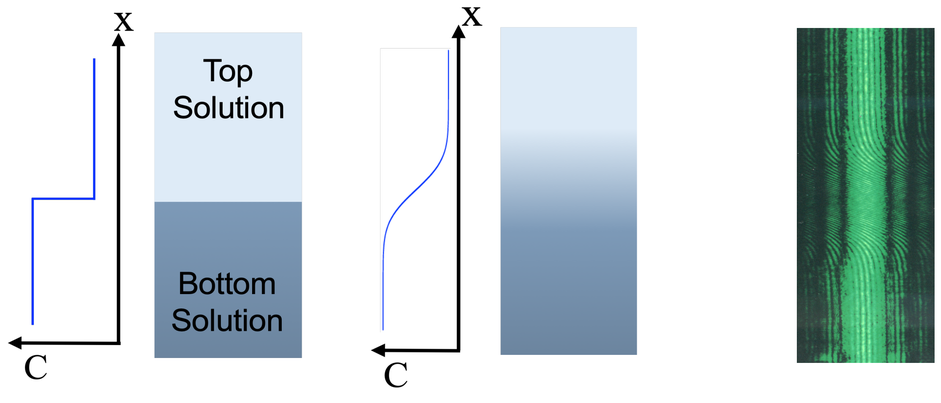
Methodology

TCU Green Monster

Hi, My dungeon is in SWR 101

Rayleigh Interferometry Patterns

A cell with two compartments has a **top solution** with salt (micelles) and a **bottom solution** with salt and micelles. Top and bottom salt (micelles) concentrations are equal.

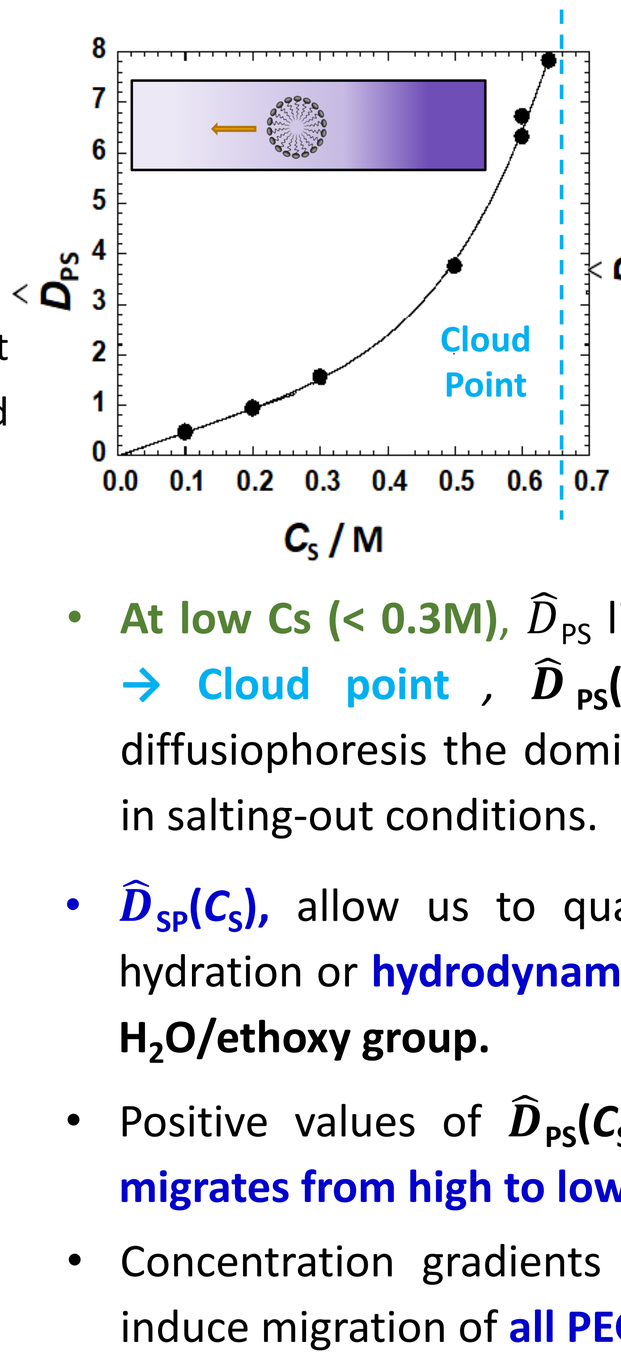


Initially the concentration profile looks like a step. After diffusion starts our concentration profile curves start to change. A green laser that goes through the sample generates an interferometry pattern.

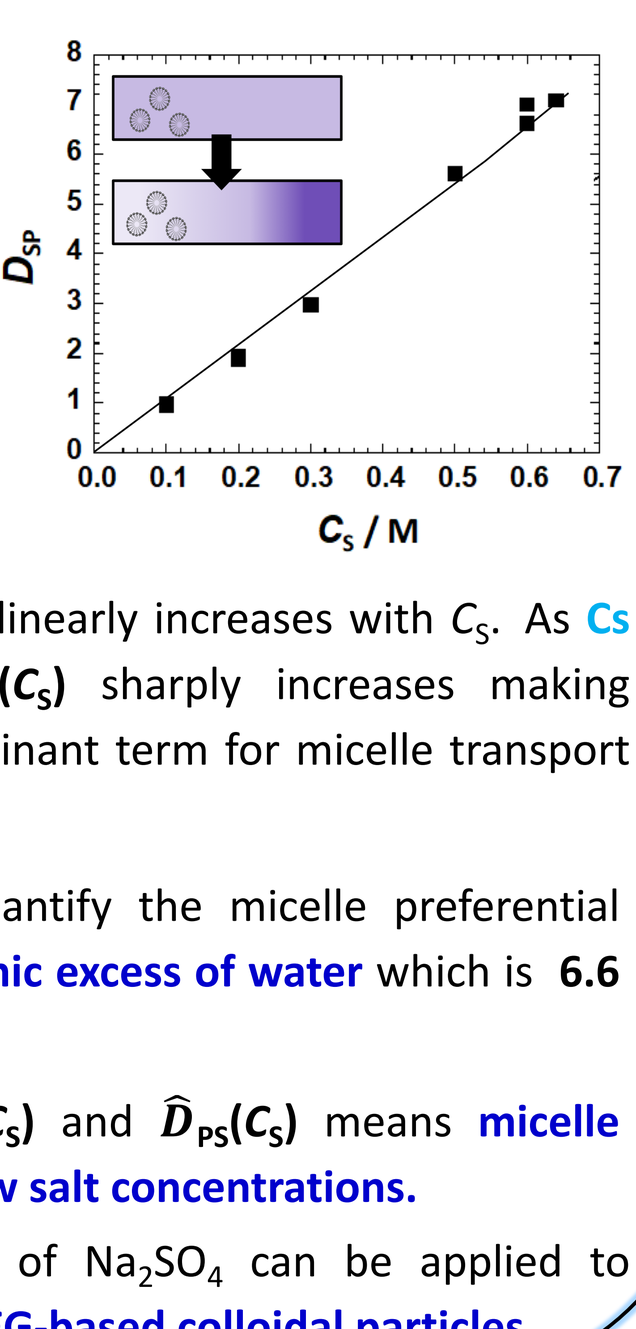
Multicomponent Diffusion Coefficients → $\hat{D}_{PS}$ $\hat{D}_{SP}$

Results and Conclusions

Diffusiophoresis Coefficient



Salt Osmotic Diffusion



- **At low Cs (< 0.3M),** $\hat{D}_{PS}$ linearly increases with C_S. As **Cs → Cloud point**, $\hat{D}_{PS}(C_S)$ sharply increases making diffusiophoresis the dominant term for micelle transport in salting-out conditions.
- $\hat{D}_{SP}(C_S)$, allow us to quantify the micelle preferential hydration or **hydrodynamic excess of water** which is **6.6 H_2O/ethoxy group.**
- Positive values of $\hat{D}_{PS}(C_S)$ and $\hat{D}_{PS}(C_S)$ means **micelle migrates from high to low salt concentrations.**
- Concentration gradients of Na_2SO_4 can be applied to induce migration of **all PEG-based colloidal particles**.

Acknowledgements

TCU COLLEGE OF SCIENCE & ENGINEERING reSEaRCh Science and Engineering Research Center

References

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Velegol, D. et al. Origins of concentration gradients for Diffusiophoresis. *Soft Matter*, 2016,**12**, 4686-4703.
S. Shim., Diffusiophoresis, Diffusioosmosis, and Microfluidics. Chem. Rev. DOI: 10.1021/acs.chemrev.1c00571.