

Soft Matter exercise, Chapter 3: Micelles

1. Mixing

The change in free energy at 298 K caused by taking one molecule of n-pentane from pure pentane and putting it into water is 4.1×10^{-20} J.

- How does that compare to the thermal energy?
- Explain why pentane is insoluble in water.
- 85% of this interaction arises from a decrease in entropy. How can the insertion of a foreign molecule into water decrease the entropy?

2. Critical micelle concentration

- What is the critical micelle concentration?
- Draw the concentration of free molecules in a solution as a function of molecules added for $0 < \text{CMC} < c_{\text{max}}$.

3. Amphiphiles

You are working for a detergent company and are asked to design molecules with a lower CMC than the currently used detergents have.

- Why are surfactants useful as detergents? Why can they remove water-insoluble dirt?
- Why could it be beneficial for a detergent company to design molecules with a lower CMC?
- How can the composition of hydrocarbon-based amphiphiles be changed to decrease its CMC?

4. Composition of micelles

How can the shape of micelles, composed of anionic amphiphiles, be changed without changing the composition of the amphiphiles?

5. Micelles

Amphiphiles with a molecular weight of 500 g/mol are dispersed at 2.5 wt% in water. They form cylindrical micelles. You measure a critical micelle concentration of 5×10^{-8} mol/l.

- What is the excess energy (ΔE) of these micelles in terms of $k_B T$?
- You change the composition and structure of the amphiphiles such that they form spherical micelles with an excess energy $\Delta E = 20 k_B T$. What is the percentage of aggregates containing 2 molecules? Where are the other molecules that are not assembled in these aggregates?

6. Surface tension

The surface tensions of aqueous solutions containing different concentrations of sodium dodecyl sulfate (SDS), which has 12 C atoms in its hydrophobic chain, at 20 °C were measured:

c (mmol/l)	γ (mN/m ⁻¹)
0	72.0
2	50
4	38
5	20
6	10

7	5.5
8	5.0
9	4.9
10	4.8
12	4.8

- Determine the CMC.
- Assume the packing density of SDS at the liquid-liquid interface to be 1.6 molecules/nm². What is the average area occupied by each SDS molecules?
- What shape would an aggregate made out of this molecule attain?

7. Micelle size

An amphiphile is dispersed in a solution at a concentration of 3.5 vol% and it forms cylindrical micelles. You measure a CMC of 5×10^{-8} . What is the most probable number of molecules contained in such a micelle?