Introduction to Colloids and Surfaces – List 1

1. Although the surface tensions of chloroform and carbon tetrachloride are quite similar, the interfacial tensions of these two organic liquids against water (surface tension 72.5 mN/m) are quite different (see the Table below).
   a. Calculate the work of adhesion between chloroform and water and between carbon tetrachloride and water: $W_{adh12} = \gamma_1 + \gamma_2 - \gamma_{12}$
   b. Suggest an explanation for the difference in work of adhesion between these two liquids and water in terms of the intermolecular interactions across the interface.

Compound	Surface tension ($mN\ m^{-1}$)	Interfacial tension against water ($mN\ m^{-1}$)
Chloroform ($CHCl_3$)	27.1	28
Carbon tetrachloride (CCl_4)	26.9	45

2. Based on the following data for surface and interfacial tensions:

System	Interfacial tension (mN/m)	Liquid	Surface tension (mN/m)
Water–hexane	51	Water	72.8
Water–benzene	35	n-hexane	18
Water–C_6F_{14}	57.2	Benzene	28.9
EG-hexane	16	C_6F_{14}	11.5
Water–butanol	1.8	EG	47.7

You can conclude (Yes or No) that:
   a. hydrocarbons are the most hydrophobic compounds;
   b. fluorocarbons like perfluorohexane (C_6H_{14}) are the most hydrophobic compounds;
   c. alcohols are fully miscible with water;
   d. hexane is more soluble in water than in EG (ethylene glycol).

3. The interfacial tension between water and solid hexadecane is 53.8 mN m^{-1} and the contact angle of water on a flat solid hexadecane surface of very low roughness is 110º at 20 ºC.
   a. Using the surface tension of water of 72.8 mN m^{-1} at this temperature, calculate the surface tension of the solid hexadecane via the Young equation.
   b. Estimate the Harkins spreading coefficient of water on solid hexadecane.

4. The spreading coefficient is given by the difference between the work of adhesion of the solid–liquid interface and the work of cohesion of the liquid:

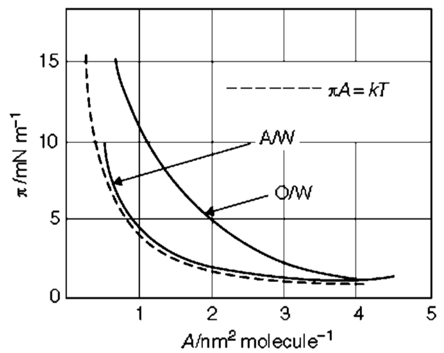
$$S = W_{adh,SL} - W_{coh,L}$$

and the liquid will spread spontaneously on the surface when S> 0.
What is the physical meaning of this equation with respect to spreading?

5. The volume and extended length of an SDS monomer are given below. Assuming that SDS micelles are spherical, estimate the micellar aggregation number at the CMC, the area per molecule of SDS in the micelle and the critical packing parameter (CPP).
V_{surf} = 0.0274 + 0.0269 x 12 = 0.350 nm^3 for a 12 carbon chain.
l_{chain} = 0.154 + 0.1265 x 12 = 1.67 nm for a C12 chain

6. Give three examples of surface phenomena that involve the Marangoni effect.

7. The Figure below shows the surface pressure-area diagrams for the ionic surfactant hexadecyl trimethylammonium bromide (CTAB) at the air-water (A/W) interface and at an oil-water (O/W) interface, together with the curve (dashed line) for an ideal gaseous monolayer (repulsion = attraction) at the interface.



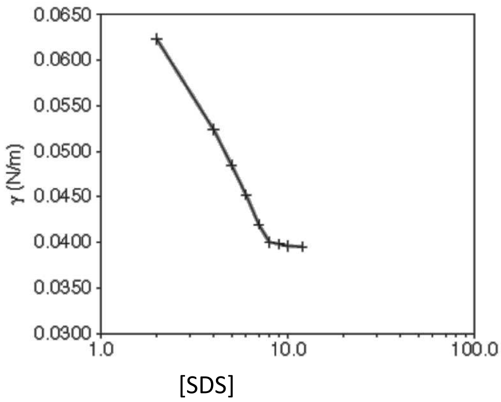
What are the orientations of the CTAB molecules at the two interfaces and why is the CTAB monolayer more expanded at the oil-water interface than at the air-water interface?

8. What type of surface should be the most efficient for collecting water from fog in arid mountainous regions of the world near the coast?

9. How does the nature of the surface roughness determine whether a superhydrophobic surface will exhibit the lotus-effect or the rose-petal effect?

10. How can one design a superoleophobic surface?

11. The Figure below shows a graph of the surface tension of aqueous solutions of pure sodium dodecyl sulfate (SDS, $C_{12}H_{26}$-OSO_3^- Na^+) as a function of concentration at 20 °C. The surface tension of water is 0.0728 N/m.



a. Estimate the critical micelle concentration (CMC) of SDS;
b. Estimate the surface pressure of SDS at the CMC;
c. Estimate the area/molecule of SDS at the air-water interface at the CMC given that $d\gamma/d\ln[SDS]$ = -21 mN/m at the CMC.