Surfactant science and technology

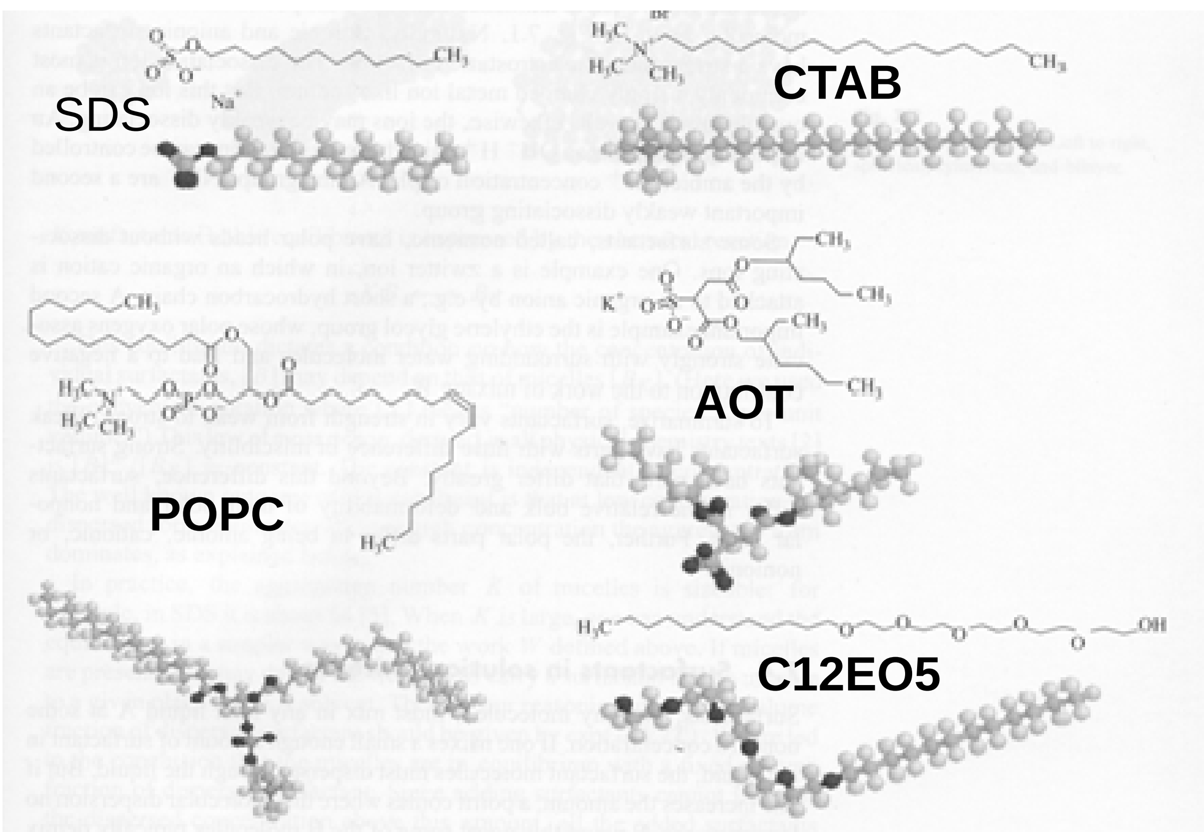
Dispersions in liquids: suspensions, emulsions, and foams

ACS National Meeting

March 21 – 22, 2009

Salt Lake City

Common surfactant molecules

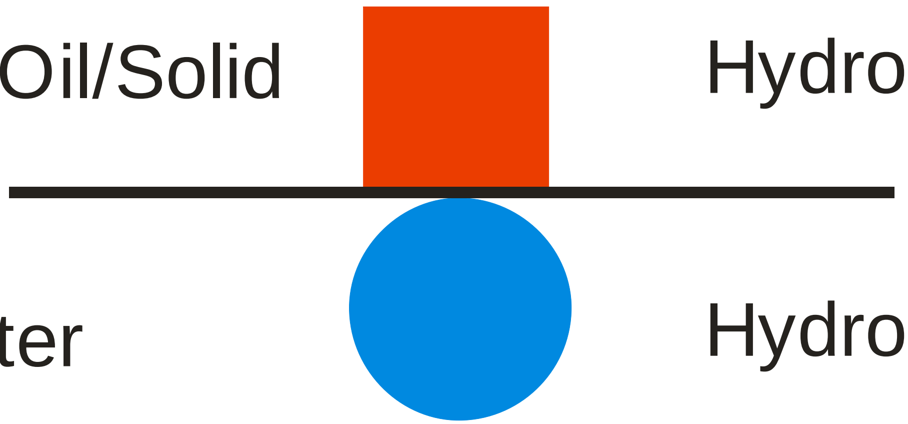


Five common surfactant molecules. Top row: **SDS** also called sodium lauryl sulfate (a leading ingredient in house-hold cleaning products lie soap, detergent, and shampoo, the cationic cetyl trimethyl ammonium bromide (**CTAB**). Bottom, the phospholipid 1-palmitoyl-2-oleoylphosphatidylcholine (**POPC**), sodium bis(2-ethylhexyl)sulfosuccinate (**AOT**), pentaethylene glycol monodecyl ether (**C12EO5**). Witten Fig. 7.1

Surfactant structure

Air/Oil/Solid

Hydrophobic portion



Water

Hydrophilic portion

(I have a 30 minute B&W VCR tape, narrated by Langmuir with Blodgett – any interest?)

Insoluble monolayers

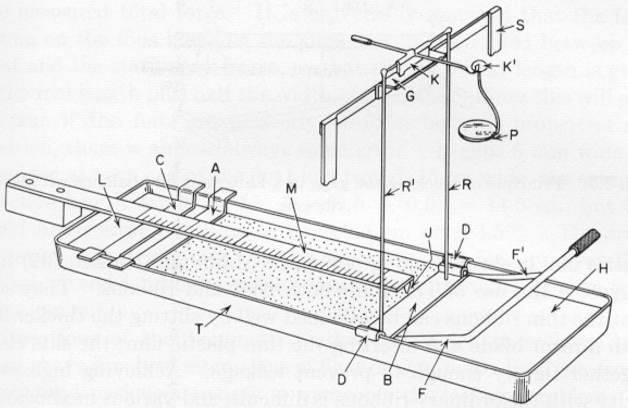
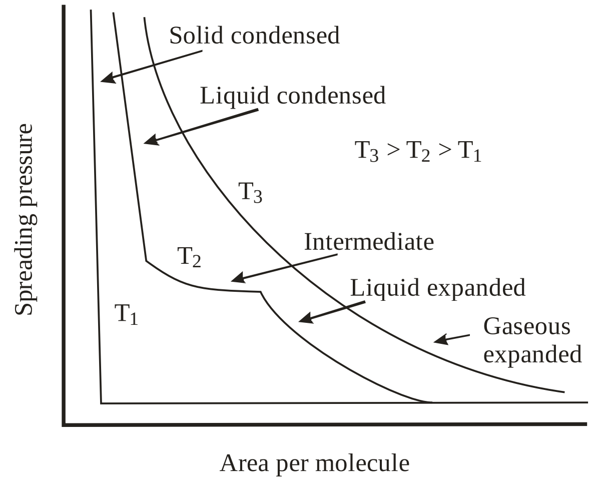


Fig. 3.4. Langmuir's original film balance [reproduced from *J. Am. Chem. Soc.*, **39**, 1869 (1917), by permission].



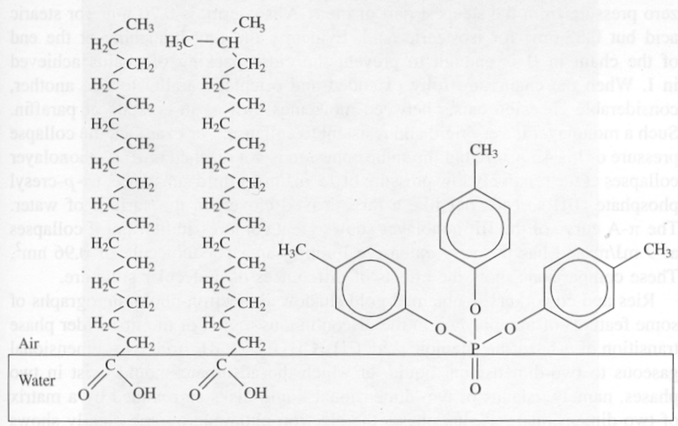
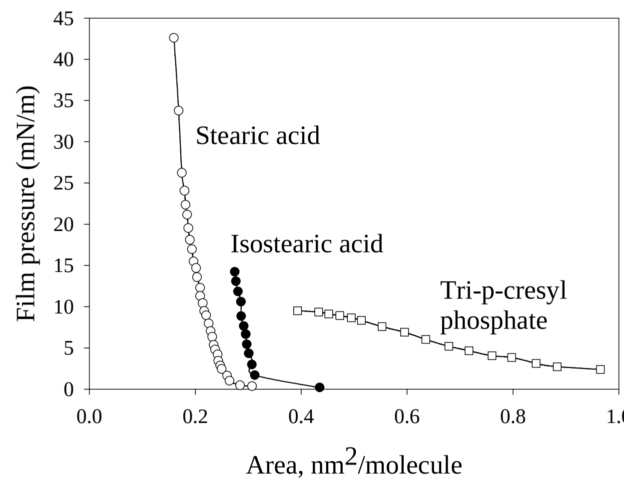
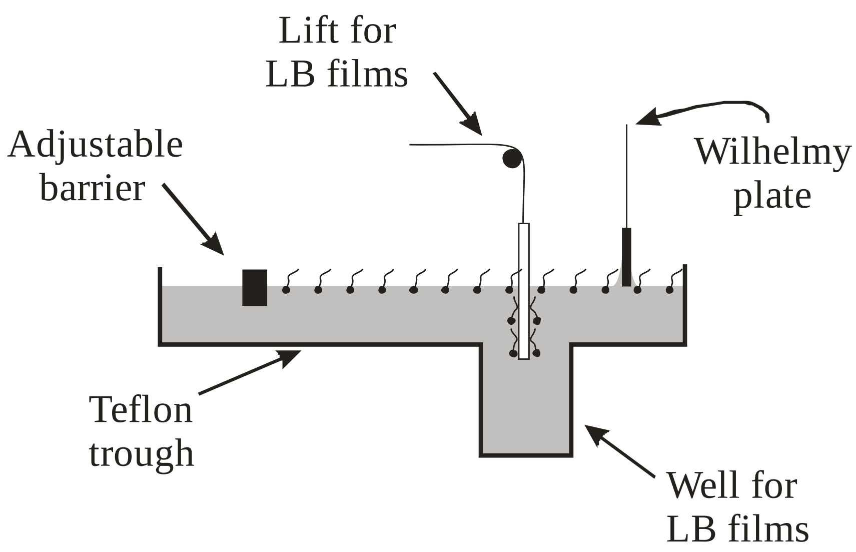
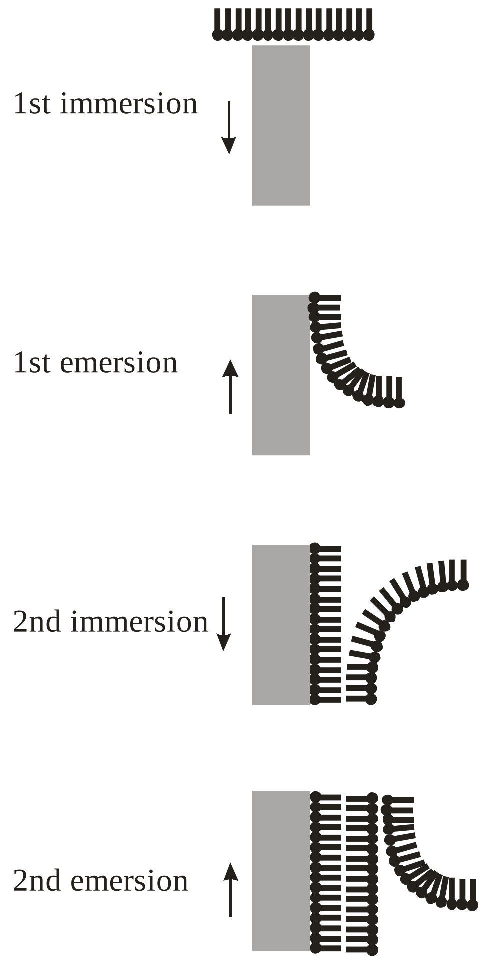


Figure 12.3 Structures of stearic acid, isostearic acid, and tri-*p*-cresyl phosphate at the air–water interface.[2]



Langmuir - Blodgett Films





Etymology

English	Greek	Latin
oil	lipo-	oleo-
water	hydro-	aqua-
solvent	lyo-	solvo-
both	amphi-	
flow	rheo-	
affinity	-philic	
lack-of-affinity	-phobic	
nature	-pathic	
science	-logy	

English meanings are not literal translations, but interpretations of how the words are understood in this branch of science.

Technical terms (neologisms) are formed by combinations of these words, such as the following adjectives:

amphipathic	=	combining both natures (oil and water understood)
amphiphilic	=	with affinity for both (oil and water understood)
hydrophilic	=	with affinity for water
lipophilic	=	with affinity for oil
lyophilic	=	with affinity for the solvent
lyophobic	=	lack of affinity for the solvent

Classification of surfactants

- Anionic – The surface-active portion bears a negative charge
  - Alkane carboxylic salts (soap)
  - Alkane sulfonic salts (detergents)
  - Alkyl-aromatic sulfonic salts
  - Others: Phosphates, phosphoric salts

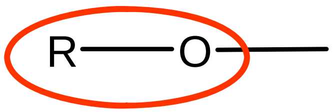
- Cationic – The surface-active portion bears a positive charge
  - Amine salts
  - Quaternary ammonium salts

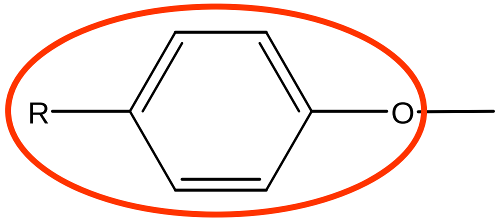
- Zwitterionic – The surface-active portion bears both charges
  - Long-chain amino acid salts
  - Betaines

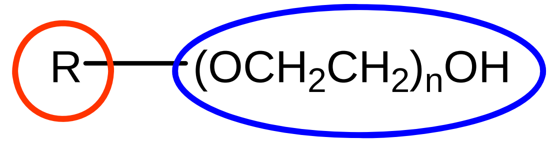
- Nonionic – The surface-active portion contains no charge
  - Long chain ethers
  - Fatty acid esters
  - Amides

Large volume aqueous surfactants

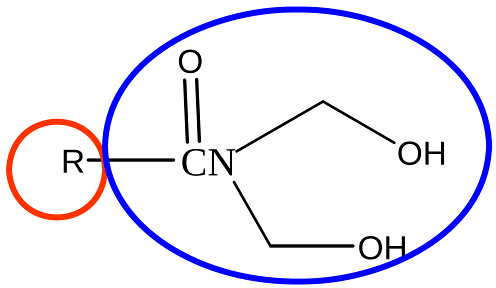
- Fatty alcohols and alkylphenol ethoxylates:



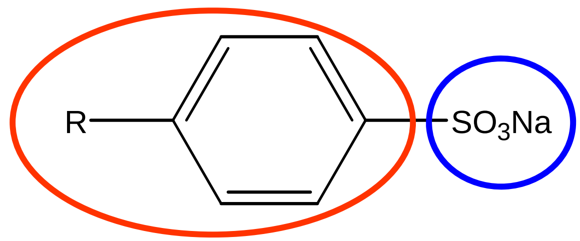




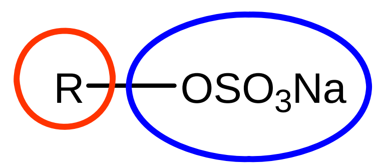
- Alkanolamides:



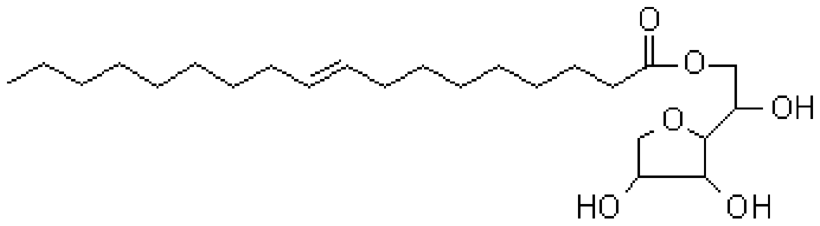
- Alkylbenzene sulphonates



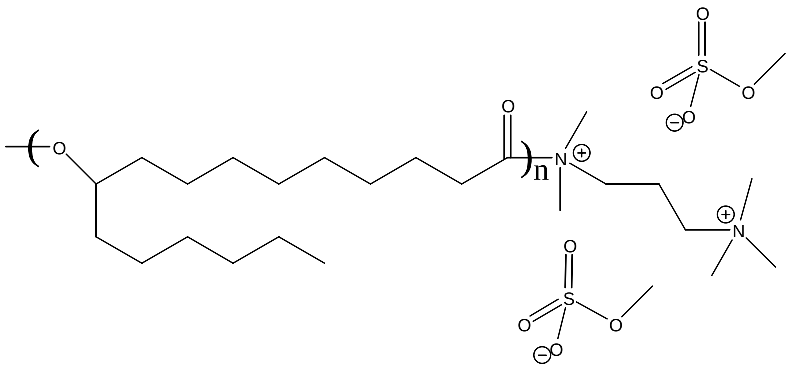
- Fatty alcohol and fatty alcohol ether sulphates:



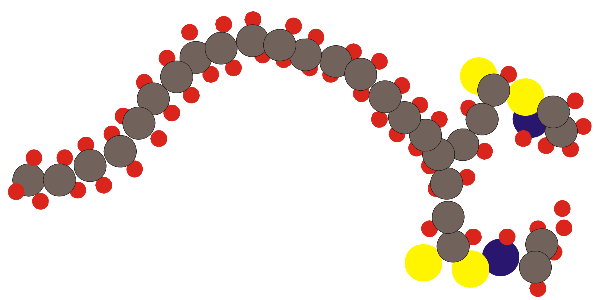
Oil-soluble surfactants



Sorbitan mono-oleate (Span 80)



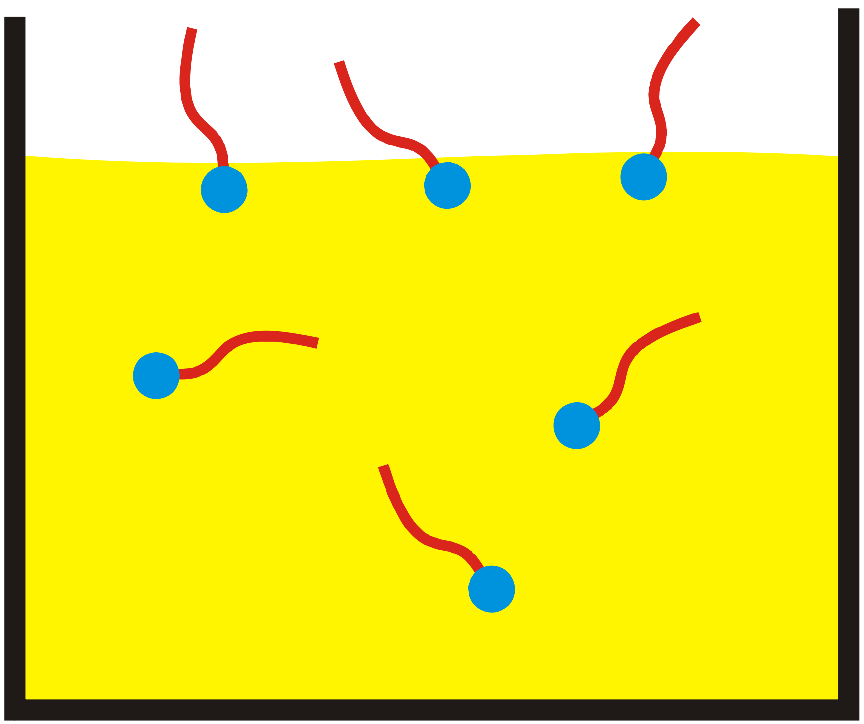
Solsperse 17000



Polyisobutylene succinimide (OLOA 11000)

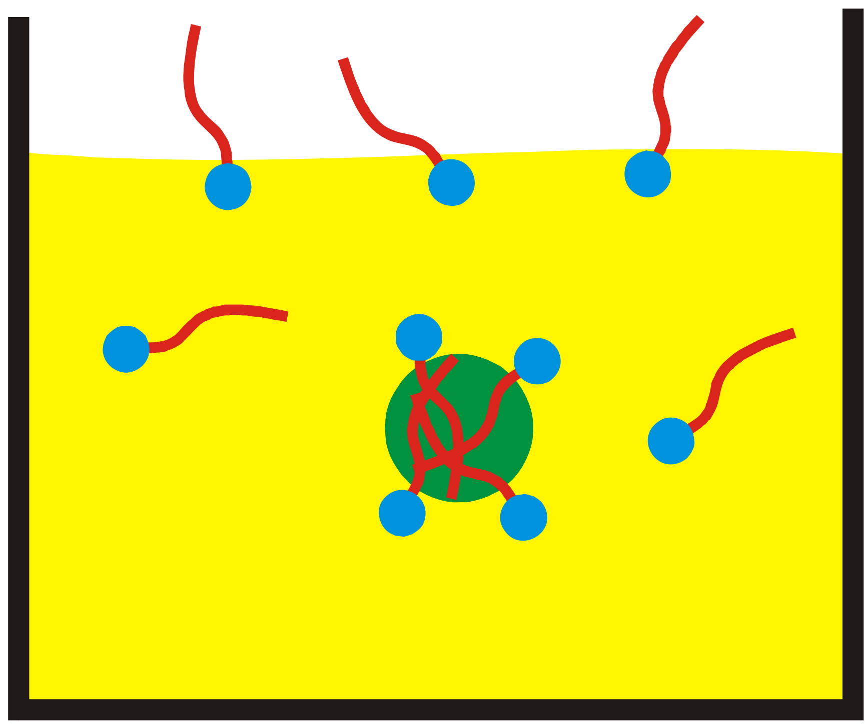
Adsorption lowers the energy

At the air/liquid interface:



Lowers surface tension.

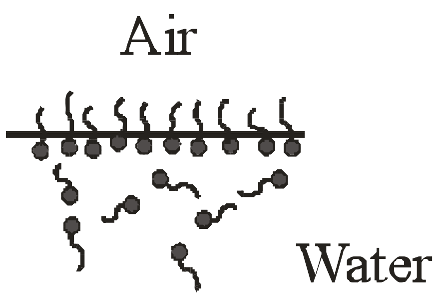
And the solid/liquid interface:



Stabilizes dispersions.

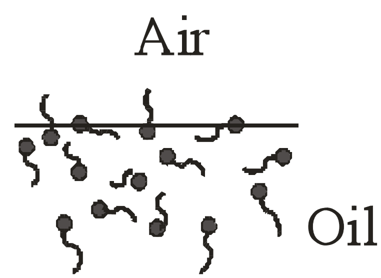
Adsorption at interfaces

Air-water surface



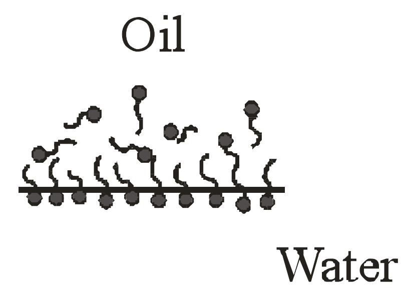
Strong adsorption, substantial lowering of surface tension.

Air-oil surface



Little adsorption, little lowering of surface tension.

Oil-water interface

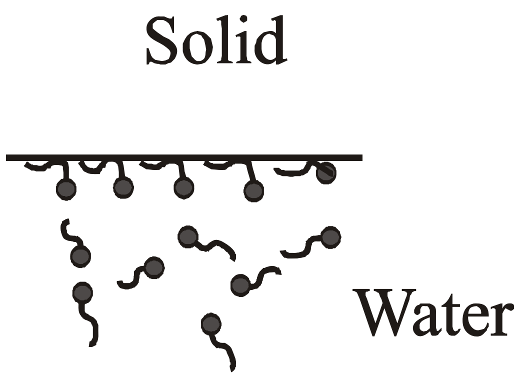


Strong adsorption, substantial lowering of interfacial tension.

Adsorption at solid surfaces

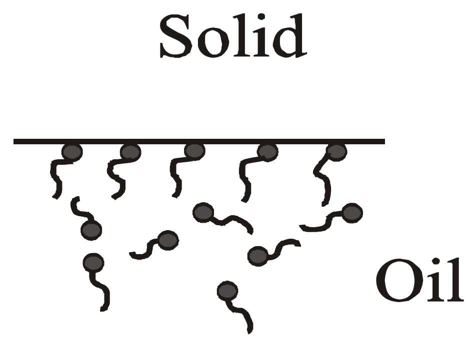
The surfactant must be soluble in the liquid!

Solid-water interface



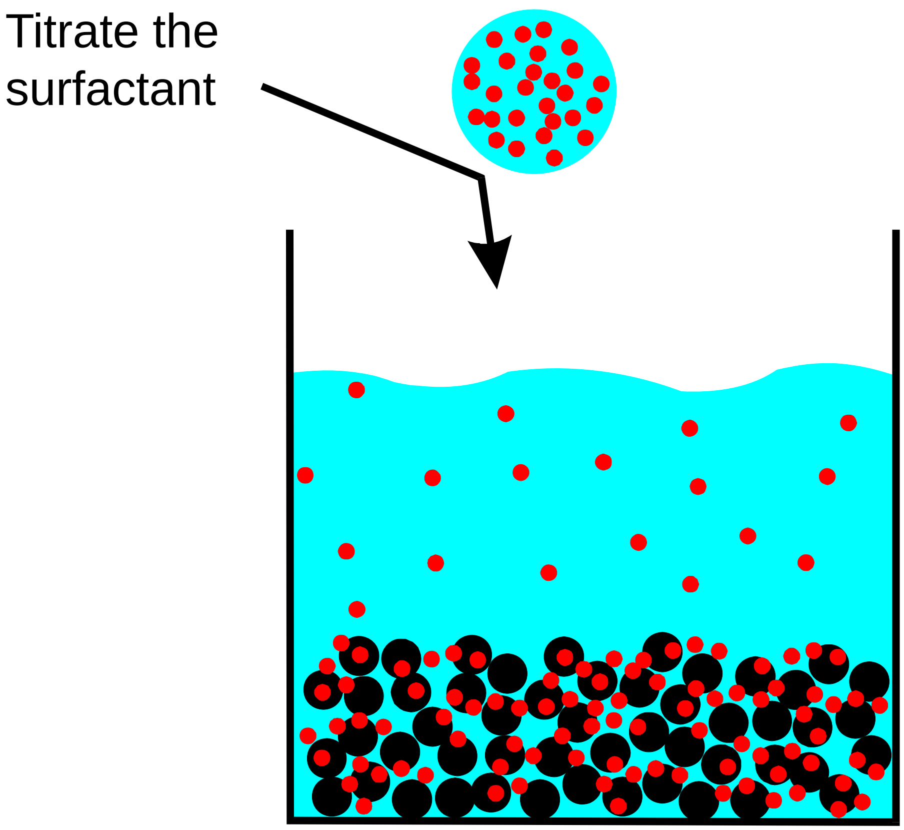
The adsorption is driven by both strong tail/solid interaction and entropy – the hydrophobic effect.

Solid-oil surface interface



The adsorption is driven by strong head group/solid interaction.

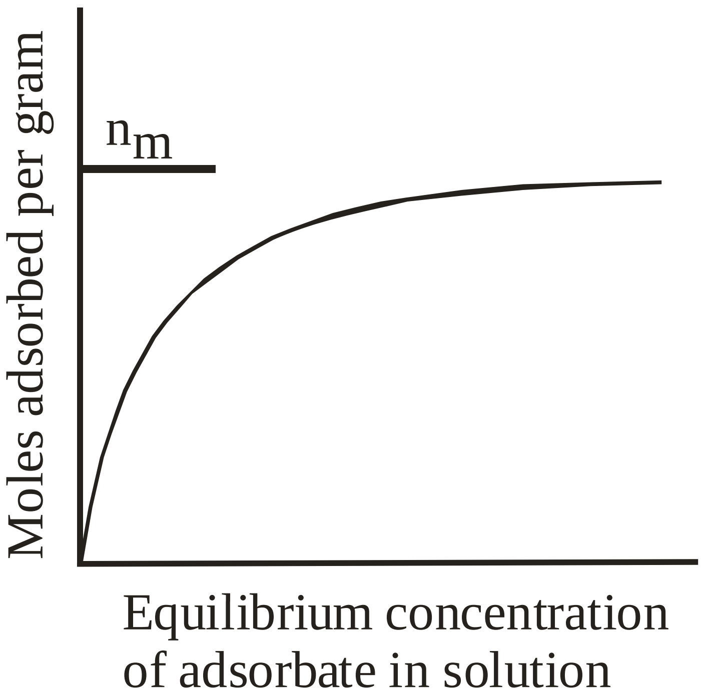
Adsorption from solution



The moles adsorbed is the total number of moles added minus the concentration in solution after adsorption times the volume of the solution.

Since adsorption is “spontaneous”, the interfacial energies must be lower.

Langmuir adsorption isotherm



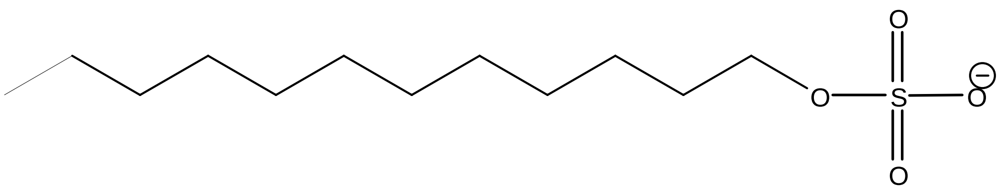
$$\frac{n}{n_m} = \frac{c}{K + c}$$

n_m is called the monolayer capacity and has units of moles per gram of solid.

K is called the Henry's law constant and is a measure of the solid-adsorbate interaction.

Ionic surfactants

If the organic tail is not too large, the surfactant dissolves in water and dissociates into an anion (negative) and a cation (positive):



Na^+

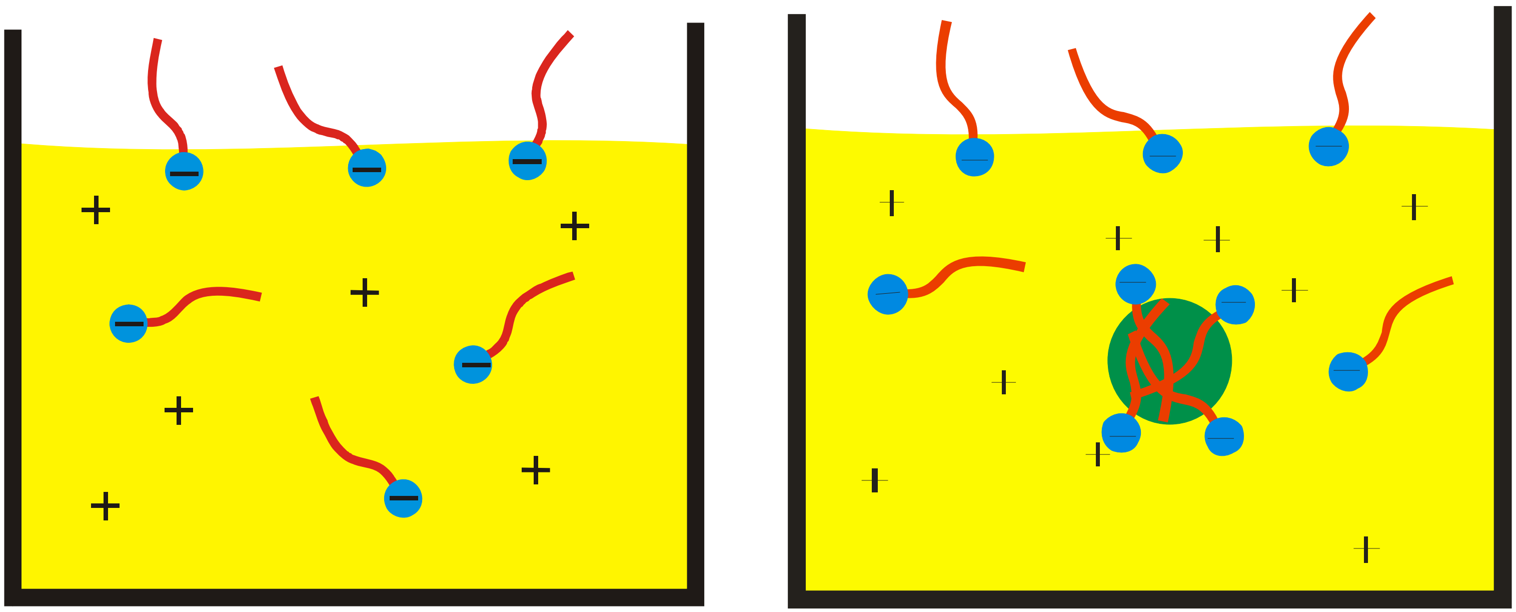
Some of the anions remain in solution.

The highly charged ions are completely solubilized.

And some of the anions are adsorbed at surfaces.

Adsorption of ionic surfactants

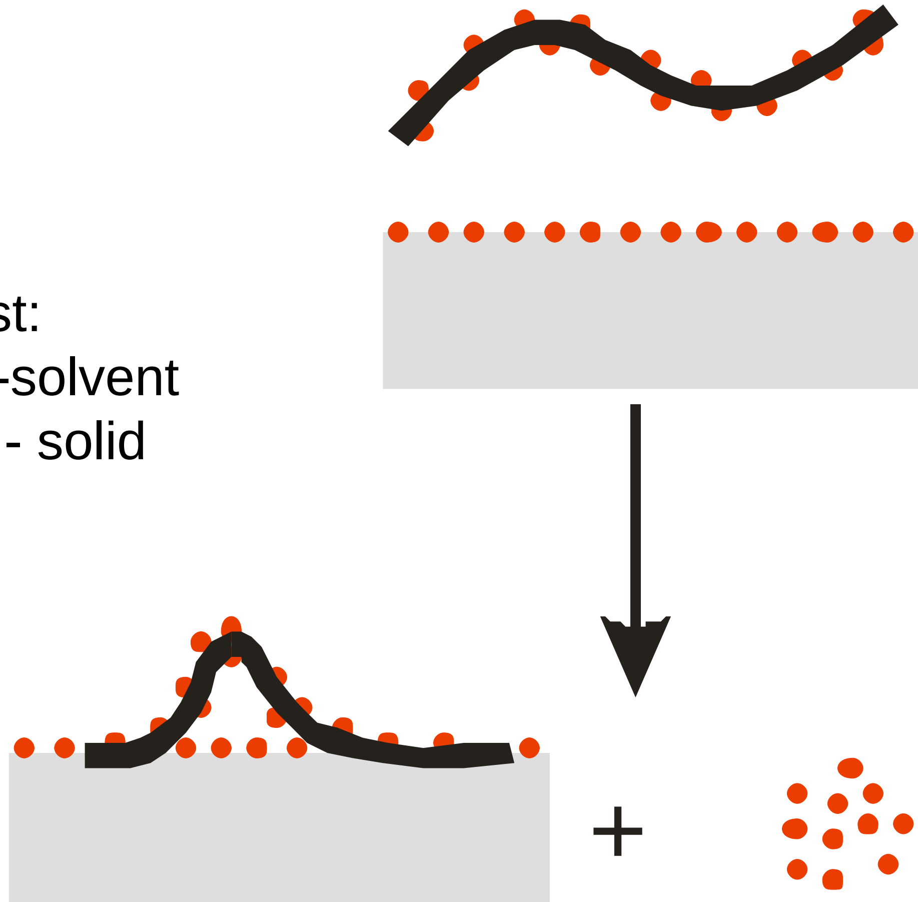
At the air/water interface: At the solid/water interface:



Lowers surface tension.

Charges the particle and stabilizes the dispersion.

Polymer adsorption



Lost:
polymer -solvent
solvent - solid

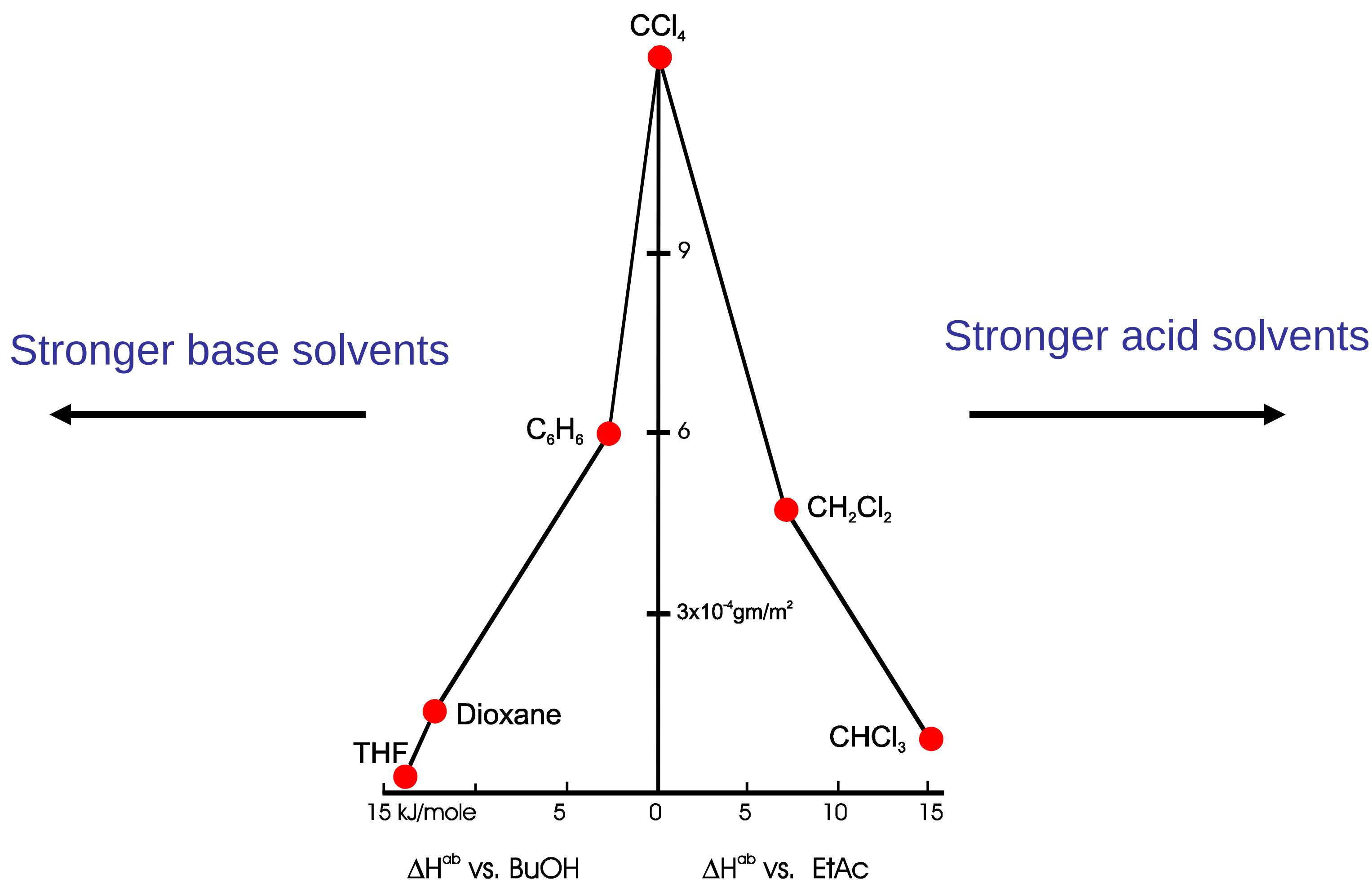
Gained:
polymer – solid
solvent - solvent

Common polymeric stabilizers

Anchor polymer	Stabilizing moieties
Aqueous dispersions	
Anchor polymer	**Stabilizing moieties**
Polystyrene	Poly(oxyethylene)
Poly(vinyl acetate)	Poly(vinyl alcohol)
Poly(methyl methacrylate)	Poly(acrylic acid)
Poly(acrylonitrile)	Poly(methacrylic acid)
Poly(dimethylsiloxane)	Poly(acrylamide)
Poly(vinyl chloride)	Poly(vinyl pyrrolidone)
Poly(ethylene)	Poly(ethylene imine)
Poly(propylene)	Poly(vinyl methyl ether)
Poly(lauryl methacrylate)	Poly(4-vinylpyridine)
Nonaqueous dispersions	
Anchor polymer	**Stabilizing moieties**
Poly(acrylonitrile)	Polystyrene
Poly(oxyethylene)	Poly(lauryl methacrylate)
Poly(ethylene)	Poly(12-hydroxystearic acid)
Poly(propylene)	Poly(dimethylsiloxane)
Poly(vinyl chloride)	Poly(isobutylene)
Poly(methyl methacrylate)	Cis-1,4-poly(isoprene)
Poly(acrylamide)	Poly(vinyl acetate)
	Poly(methyl methacrylate)
	Poly(vinyl methyl ether)

Napper, D.H. *Polymeric stabilization of colloidal dispersions*; Academic Press: New York; 1983.

Adsorption of PMMA (base) on silica (acid)



Acid/Base scale: Drago E and C parameters

Bases	C_b	E_b
Pyridine	13.09	2.39
Ammonia	7.08	2.78
Methylamine	11.41	2.66
Dimethylamine	17.85	2.33
Trimethylamine	23.6	1.652
Ethylamine	12.31	2.80
Diethylamine	18.06	1.771
Triethylamine	22.7	2.03
Acetonitrile	2.74	1.812
p-Dioxane	4.87	2.23
Tetrahydrofuran	8.73	2.00
Dimethyl sulfoxide	5.83	2.74
Ethyl acetate	3.56	1.994
Methyl acetate	3.29	1.847
Acetone	4.76	2.018
Diethyl ether	6.65	1.969
Isopropyl ether	6.52	2.27
Benzene	1.452	1.002
p-Xylene	3.64	0.851

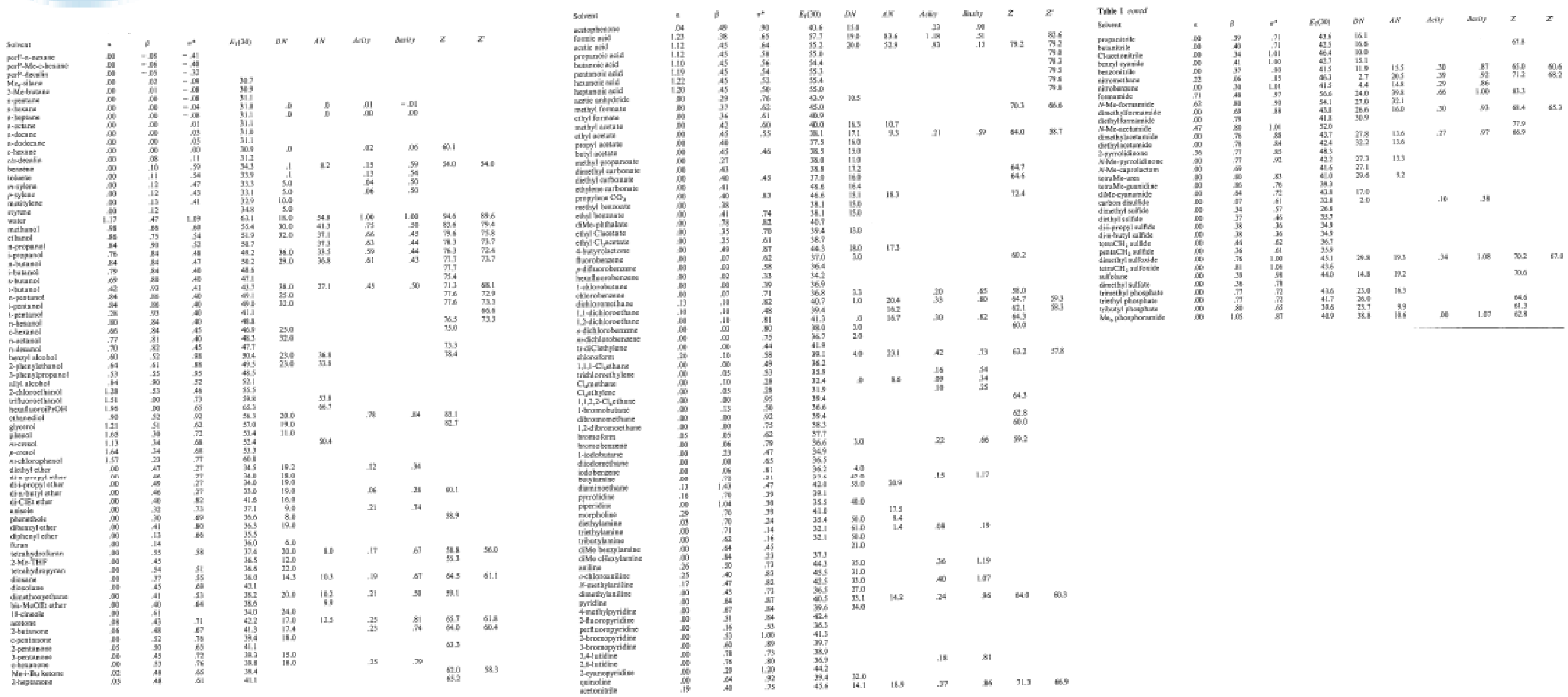
Acids	C_a	E_a
Iodine	2.05	2.05
Iodine monochloride	1.697	10.43
Thiophenol	0.405	2.02
p-*tert*-Butylphenol	0.791	8.30
p-Methylphenol	0.826	8.55
Phenol	0.904	8.85
p-Chlorophenol	0.978	8.88
tert-Butyl alcohol	0.614	4.17
Trifluoroethanol	0.922	7.93
Pyrrole	0.603	5.19
Isocyanic acid	0.528	6.58
Sulfur dioxide	1.652	1.88
Antimony pentachloride	10.49	15.09
Chloroform	0.325	6.18
Water	0.675	5.01
Methylene chloride	0.02	3.40
Carbon tetrachloride	0.00	0.00

Acid/Base scale: Gutmann Acceptor-Donor Numbers

Acidic Solvents	AN kcal mol^{-1}	Basic Solvents	DN kcal mol^{-1}	Basic Solvents	DN kcal mol^{-1}
Hexane (reference solvent)	0	1,2-Dichloroethane		Tetrahydrofuran	20.0
Diethyl ether	3.9	Benzene	0.1	Diphenylphosphonic chloride	22.4
Tetrahydrofuran	8.0	Sulfuryl chloride	0.1	Trimethyl phosphate	23.0
Benzene	8.2	Thionyl chloride	0.4	Tributyl phosphate	23.7
Carbon tetrachloride	8.6	Acetyl chloride	0.7	Dimethoxyethane	~24
Diglyme	9.9	Tetrachloroethylene carbonate	0.8	Dimethylformamide	26.6
Glyme	10.2	Benzoyl fluoride	2.3	*N*-Methyl-2-caprolactam	27.1
HMPA	10.6	Benzoyl chloride	2.3	*N*-Methyl-2-pyrrilidinone	27.3
Dioxane	10.8	Nitromethane	2.7	*N,N*-Dimethylacetamide	27.8
Acetone	12.5	Dichloroethylene carbonate	3.2	Dimethyl sulfoxide	29.8
N-Methyl-2-pyrrolidinone	13.3	Nitrobenzene	4.4	*N,N*-Diethylformamide	30.9
DMA	13.6	Acetic anhydride	10.5	*N,N*-Diethylacetamide	32.2
Pyridine	14.2	Phosphorous oxychloride	11.7	Pyridine	33.1
Nitrobenzene	14.8	Benzonitrile	11.9	Hexamethylphosphoramide	38.8
Benzonitrile	15.5	Selenium oxychloride	12.2	Hydrazine	44.0
DMF	16.0	Acetonitrile	14.1	Ethylenediamine	55.0
Dichloroethane carbonate	16.7	Sulfolane (tetramethylene sulfone)	14.8	Ethylamine	55.5
PDC	18.3	Dioxane	14.8	Isopropylamine	57.5
CH_3CN	18.9	Propanediol 1,2-carbonate	15.1	*tert*-Butylamine	57.5
DMSO	19.3	Benzyl cyanide	15.1	Ammonia	59.0
Methylene chloride	20.4	Ethylene sulfite	15.3	Triethylamine	61.0
Nitromethane	20.5	Isobutyronitrile	15.4		
Chloroform	23.1	Propionitrile	16.1		
Isopropyl alcohol	33.5	Ethylene carbonate	16.4		
Ethyl alcohol	37.1	Phenylphosphonic difluoride	16.4		
Formamide	39.8	Methyl acetate	16.5		
Methyl alcohol	41.3	n-Butyronitrile	16.6		
Acetic acid	52.9	Acetone	17.0		
Water	54.8	Ethyl acetate	17.1		
CF_3COOH	105.3	Water	18.0		
CH_3SO_3H	126.3	Phenylphosphonic dichloride	18.5		
$SbCl_5$ as ref. in DCE	100	Diethyl ether	19.2		

W.B. Jensen
The Lewis Acid-Base Concepts: An Overview
Wiley-Interscience: NY; **1980**

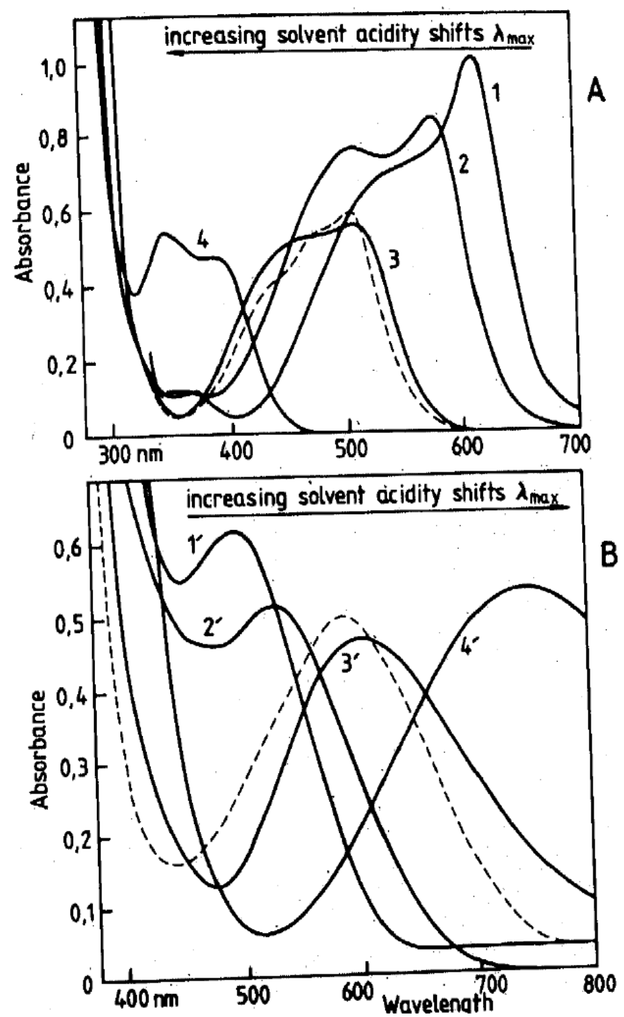
Acid-Base scale:
Hamlet-Taft solvatochromic scale



Marcus, Y. The properties of organic liquids that are relevant to their use as solvating solvents. *Chem. Soc. Rev., 22*, 409-416, **1993**.

Solvatochromic dyes as acid/base probes

Figure 3. Solvent dependent spectra of $Fe(phen)_2(CN)_2$ (A) and $Fe(phen)_2(CN)_2^+$ (B). (A) $[Fe(phen)_2(CN)_2] = 1 \times 10^{-4}$ *M* each in dimethylformamide (1), nitromethane (2), dilute hydrochloric acid (3), and concentrated sulfuric acid (4). Broken line: $[Fe(phen)_3^{2+}] = 5 \times 10^{-5}$ *M* in acetonitrile. Path length = 1 cm. (B) $[Fe(phen)_2(CN)_2^+] = 1 \times 10^{-3}$ *M* each in nitromethane (1′), formic acid (2′), 70% perchloric acid (3′), and concentrated sulfuric acid (4′). Broken line: $[Fe(phen)_3^{3+}] = 5 \times 10^{-4}$ *M* in acetonitrile. Path length = 1 cm.



Soukup, R.W.; Schmid, R. Metal complexes as color indicators for solvent parameters. *J. Chem. Ed., 62*, 459 – 462, **1985**.

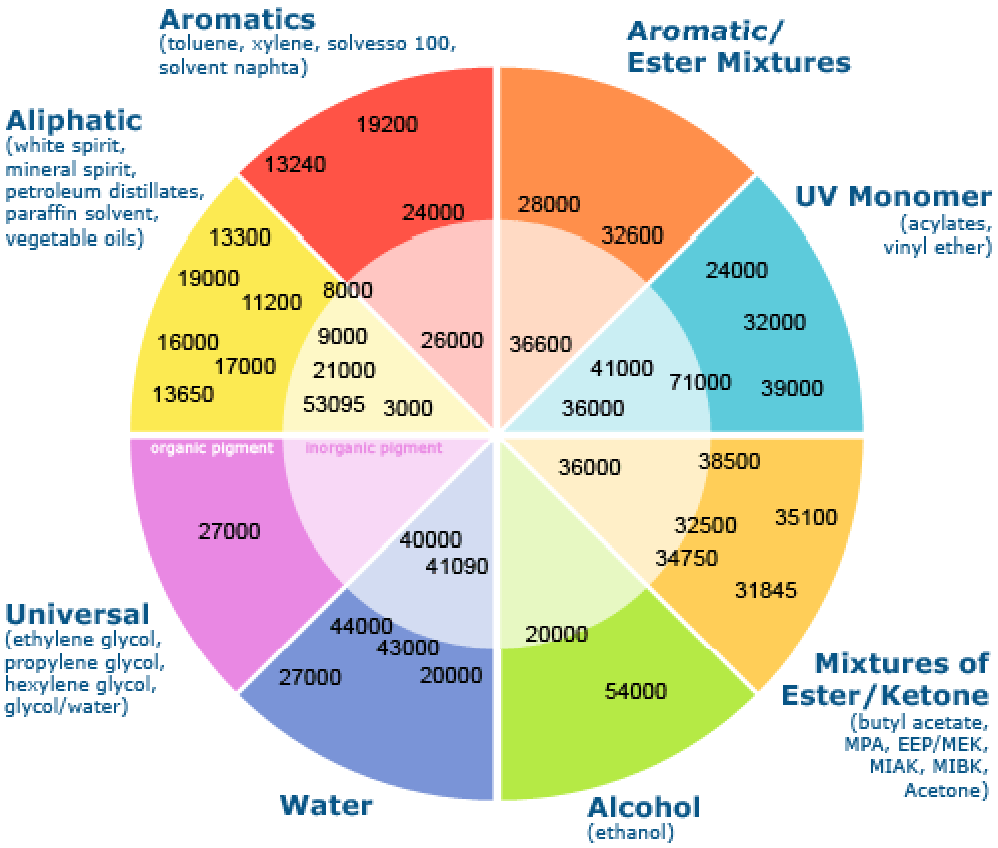
Where do I start?

Surfactant suppliers providing on-line help	
Byk Chemie	http://www.byk.com/additives/controller.aspx?cid=192
Schibley Chemical	http://www.schibley.com/
Surfactants, Inc.	http://www.surfactantsinc.com/
Surfactant manufacturers providing on-line help	
Akzo Nobel	http://surface.akzonobelusa.com/
Arizona Chemical	http://www.arizonachemical.com/
BASF	http://www.basf.com/index.html
Cognis	http://www.cognis.de/
DeForest Enterprises	http://www.deforest.net/
Dow Corning	http://www.dowcorning.com/
McIntrye Group	http://www.mcintyregroup.com/
Rohm and Haas	http://www.rohmhaas.com/

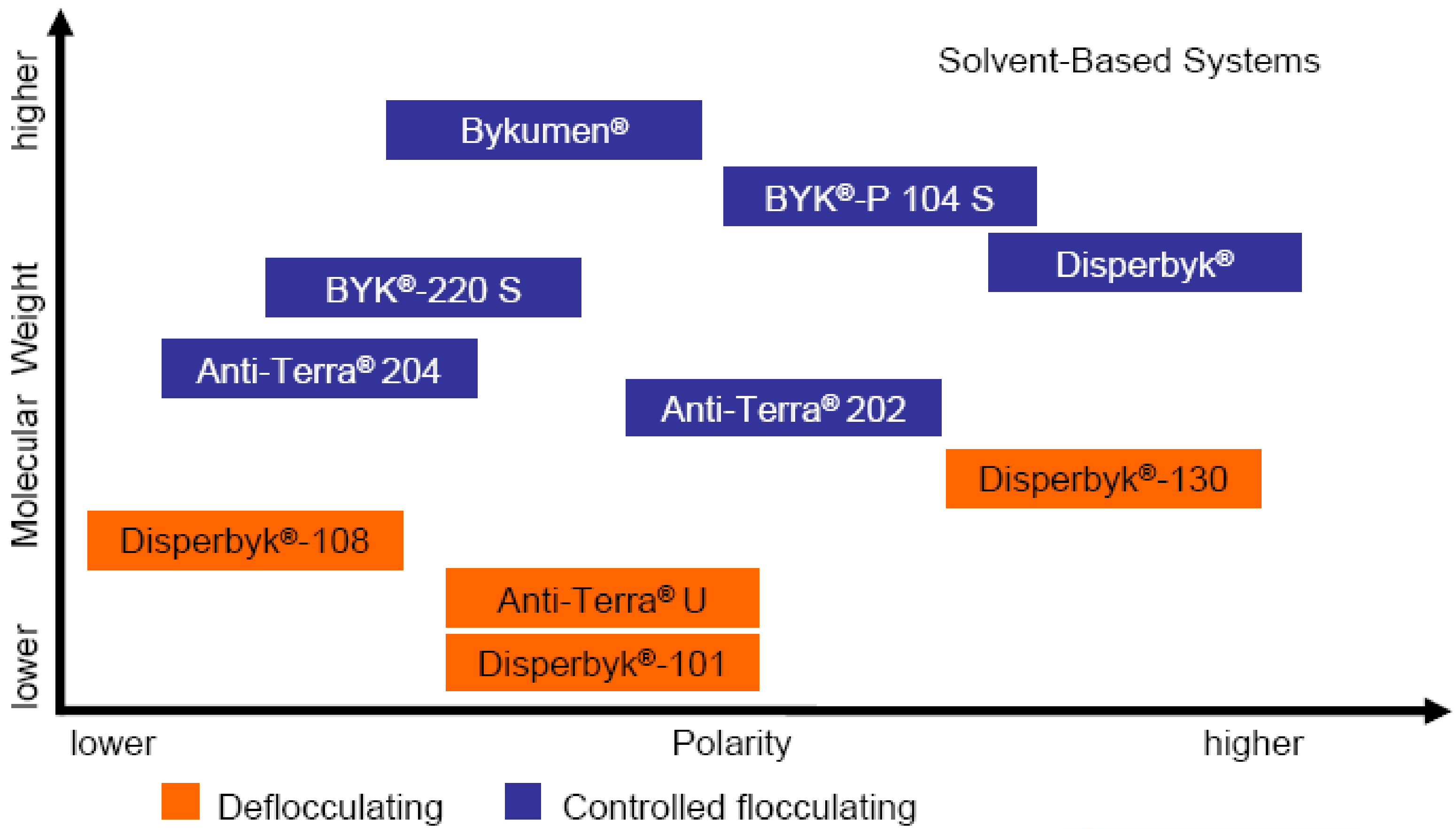
Updated 03/08.

Solsperse® Surfactants

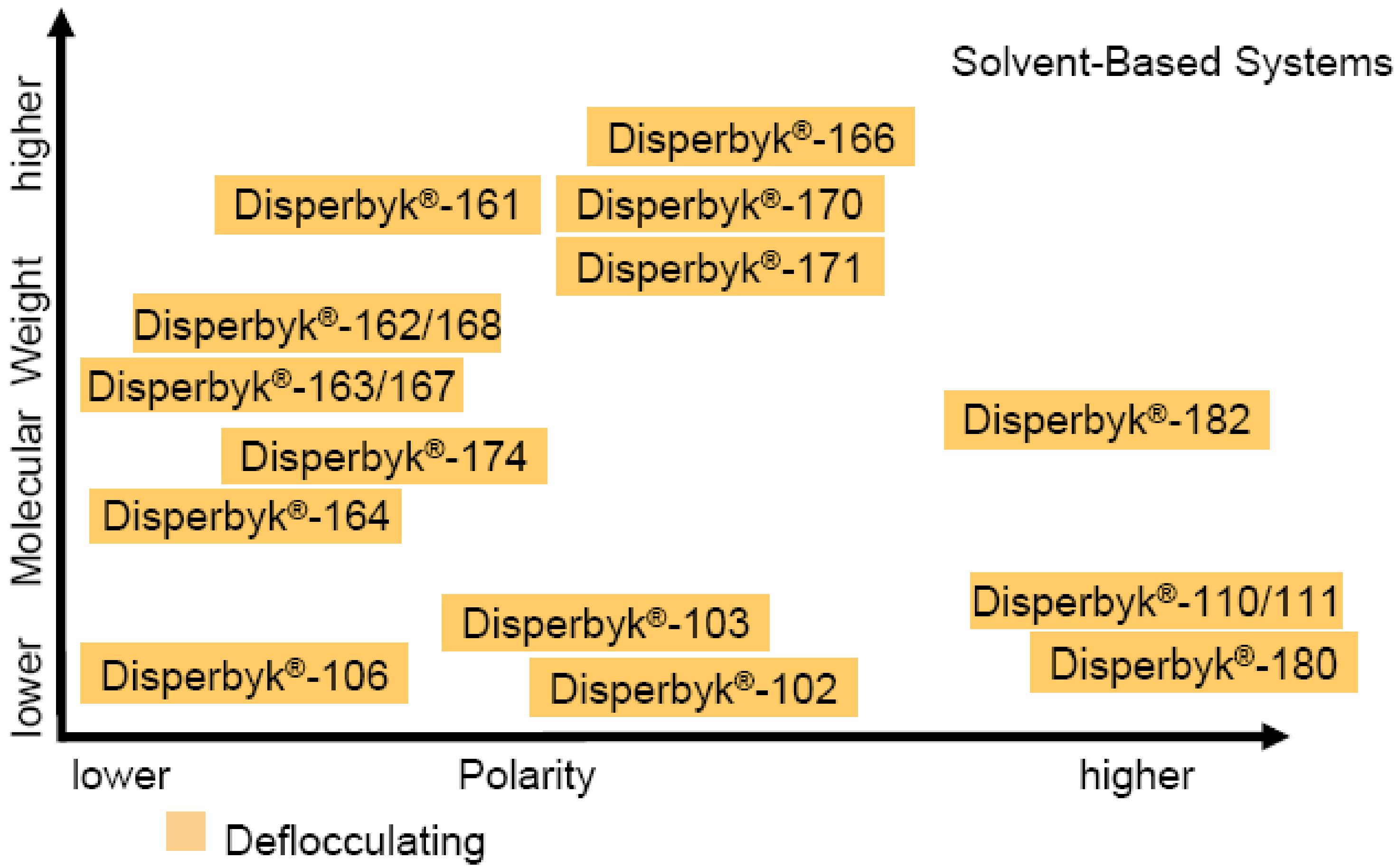
Now from Lubrizol Corp.



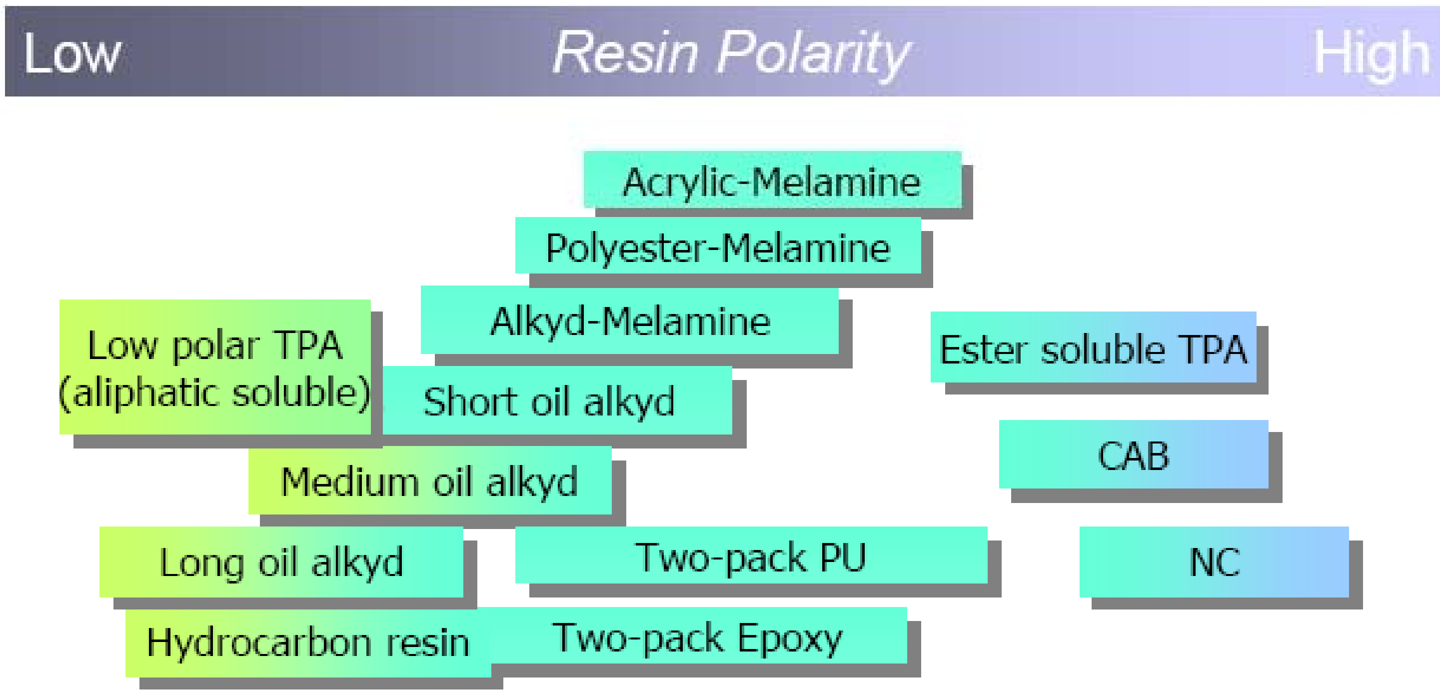
From Byk Chemie – Low MWs



From Byk Chemie – High MWs



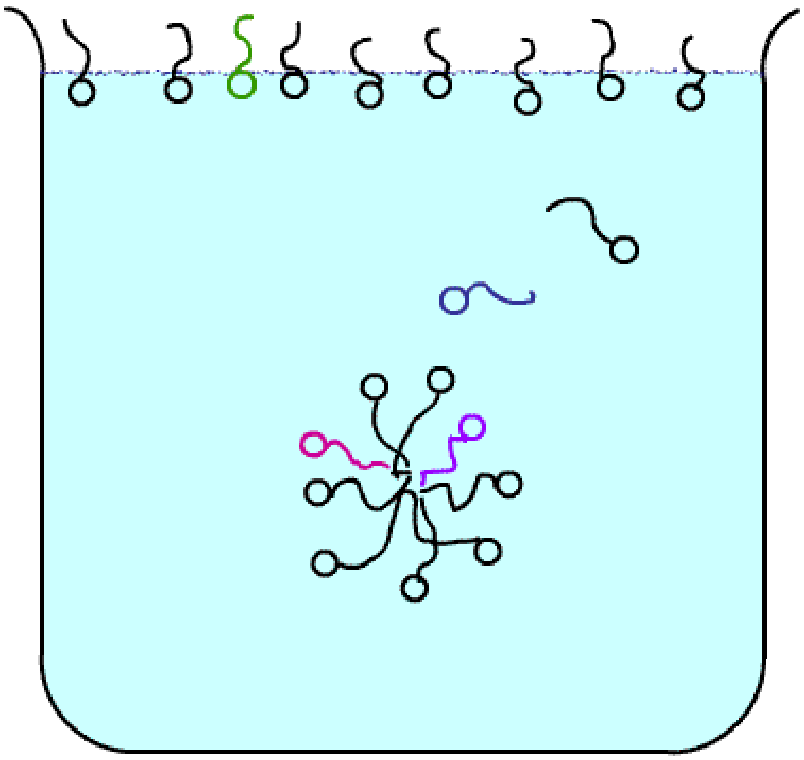
From Byk Chemie – Media properties



Micelles and liquid crystals

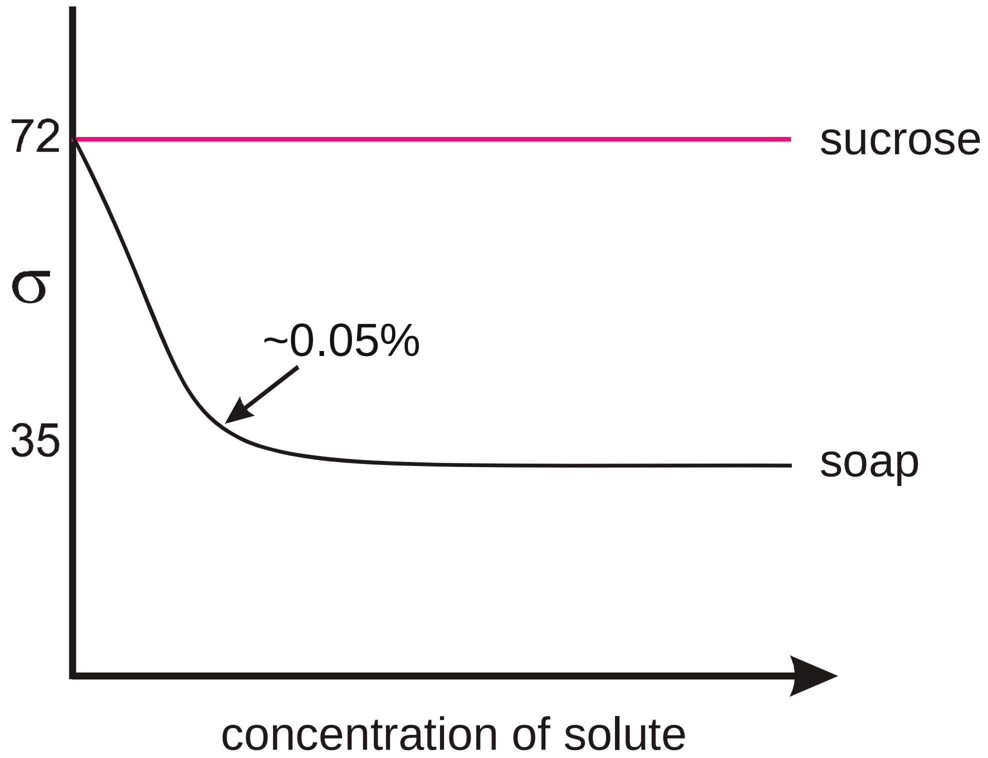
Surfactants “self-associate” at higher concentrations

Surfactants “create their own surfaces”



Adsorption and micellization are competing processes.

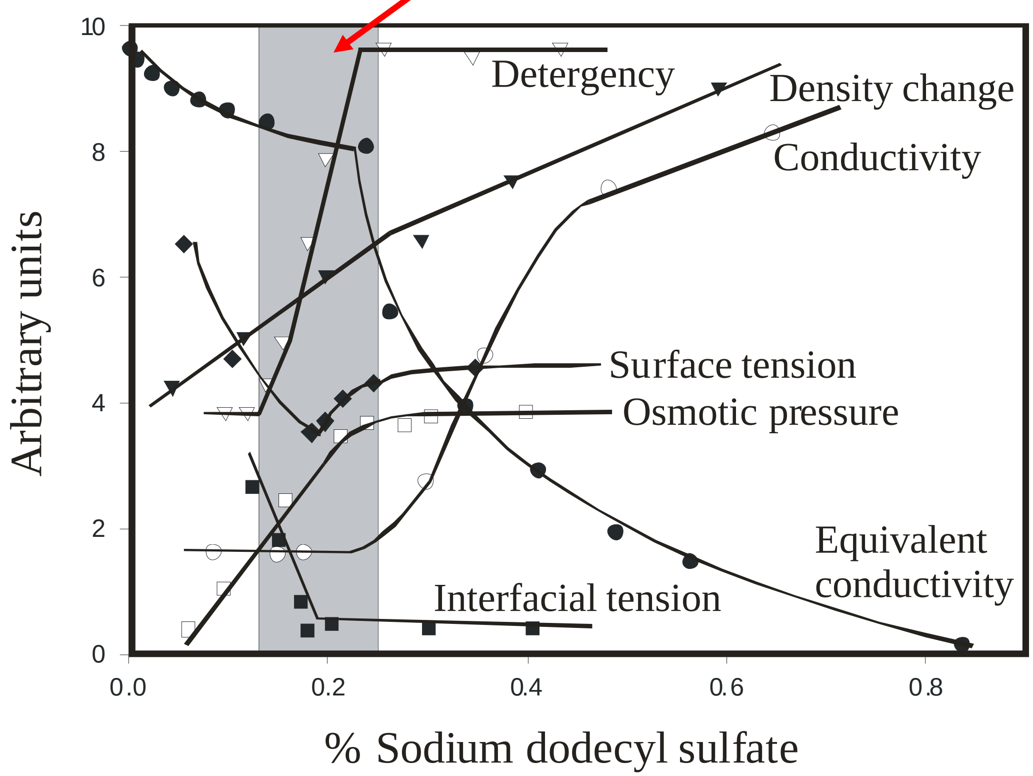
A lower limit in surface tension



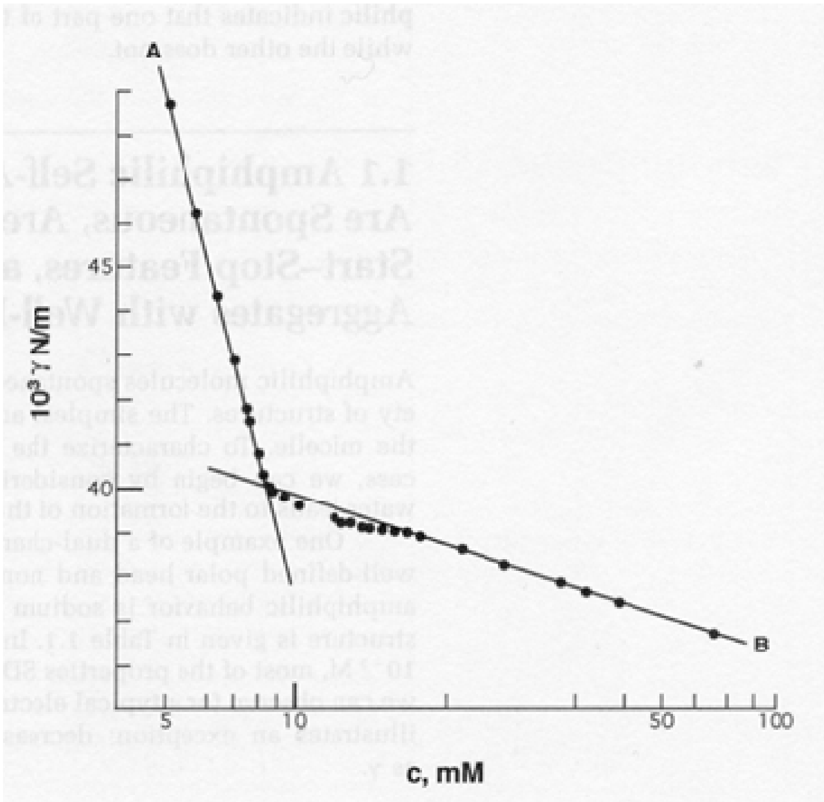
The surface tension drops but reaches a limit.

Other limits in surfactant properties

The critical micelle concentration - cmc.



Micelle formation



Solution surface tension versus sodium dodecyl sulfate (SDS) concentration. (Note the logarithmic scale.)

The Gibbs adsorption isotherm equation is:

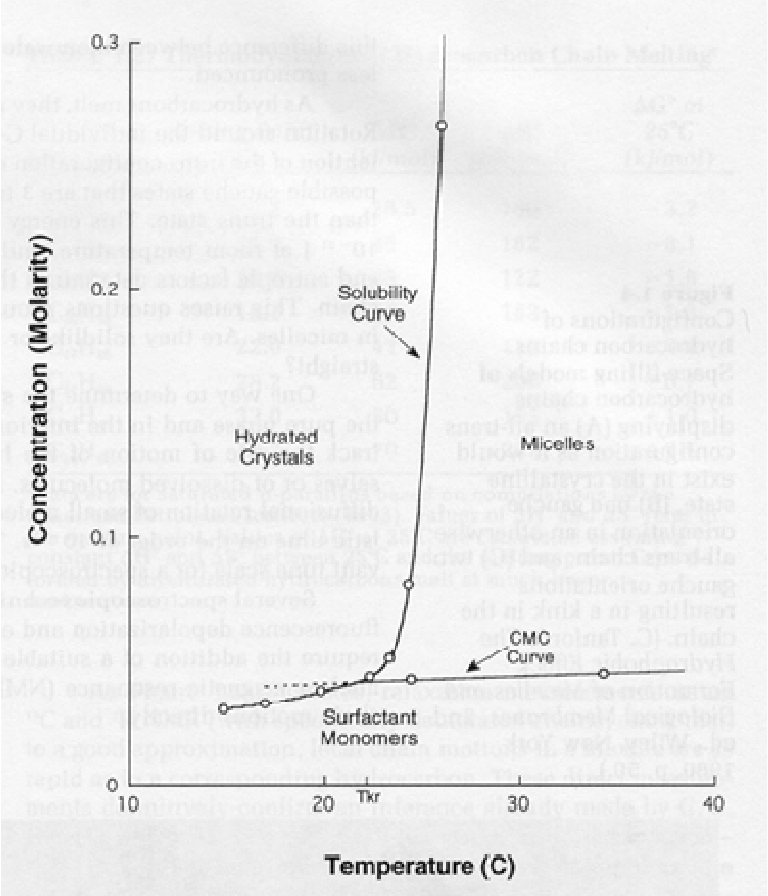
$$d\sigma = -\Gamma_2 d\mu_2$$

$$\Gamma_2 = -\frac{d\sigma}{d\mu_2} \simeq -\frac{1}{kT}\left(\frac{d\sigma}{d\ln c_2}\right)_T$$

Warning – this may be more interesting than you might think.

Evans. Fig. 1.1, p. 6

The Krafft temperature

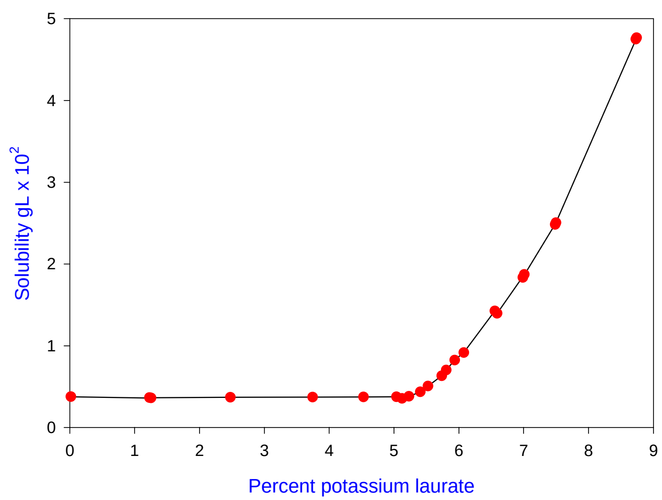


Note the rapid increase in solubility of the surfactant at a critical temperature.

Krafft temperature is the temperature at which surfactant solubility equals the critical micelle concentration. Above the Krafft temperature surfactants form micellar dispersions; below the Krafft temperature the surfactant crystallizes out of solution as hydrated crystals. (Evans, Fig. 1.3, p. 9)

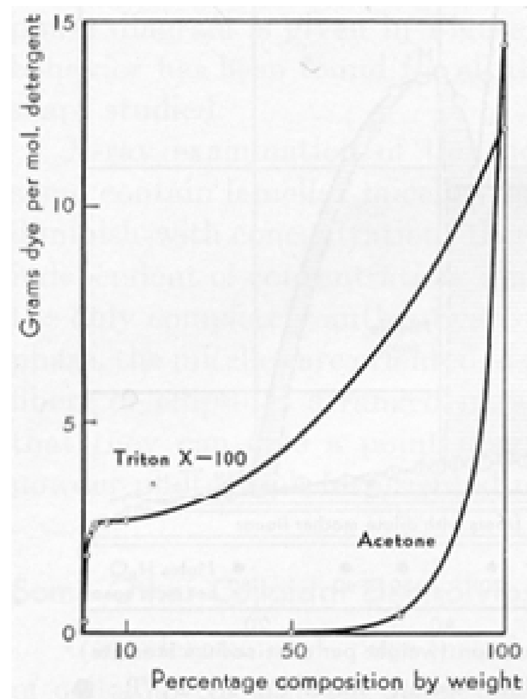
Solubilization above the CMC

Solubilization of 2-nitrodiphenylamine in aqueous solutions of potassium laurate.



The solubility of gas increases sharply after micelles form (at the CMC).

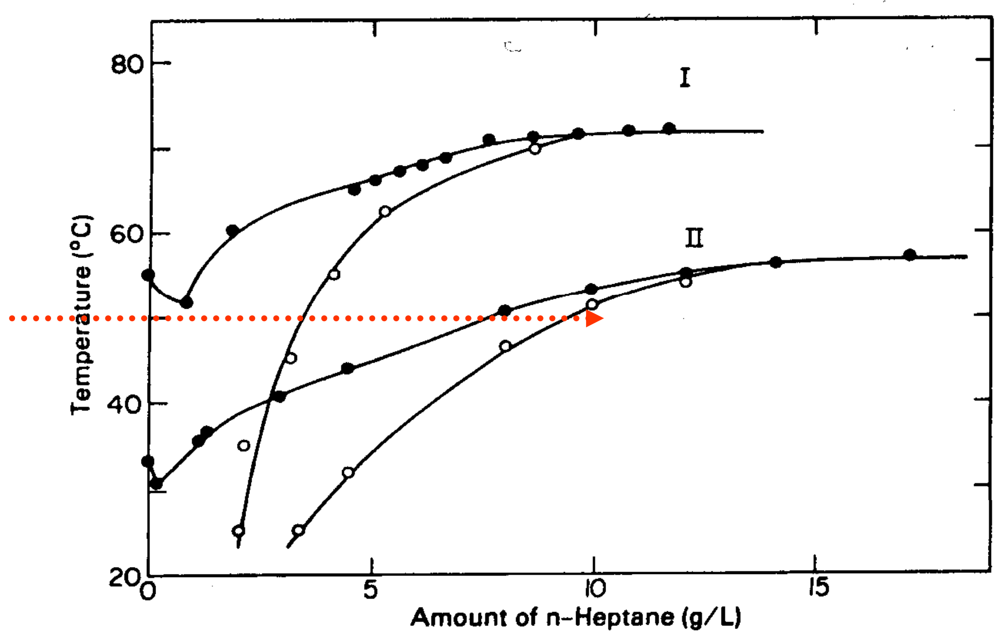
Solubilization of dye in aqueous solutions of Triton X-100 versus solvent action by acetone.



McBain, 1950, Fig. 17.24, p. 264.

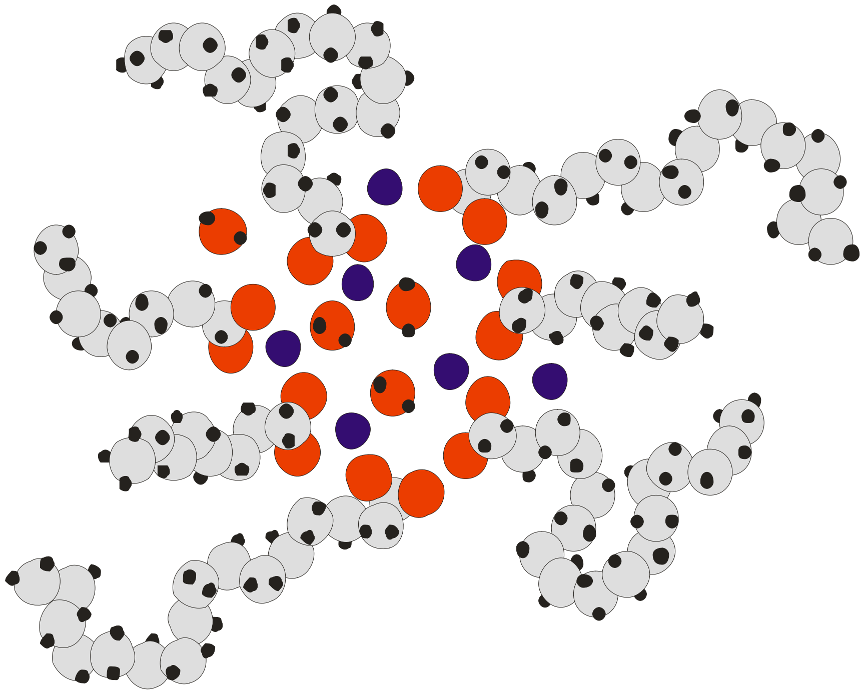
Effect of temperature on solubilization in nonionics

Fix the temperature, add heptane.



Solubilization of n-heptane in 1% aqueous solutions of POE(9.0) nonylphenyl ether (I) and PEO(9.2) dodecylphenyl ether (II). Filled circles are cloud points. Open circles are solubility limits (Rosen, p. 188).

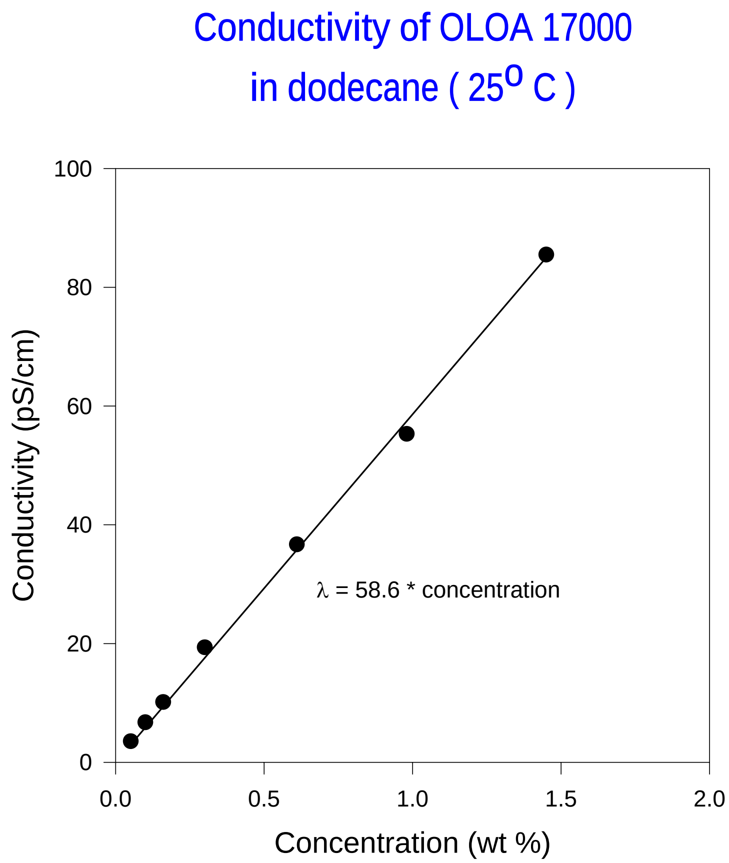
Oil “surfactants” form inverse micelles



The micelle core is highly polar.

The diameters are 10’s of nanometers.

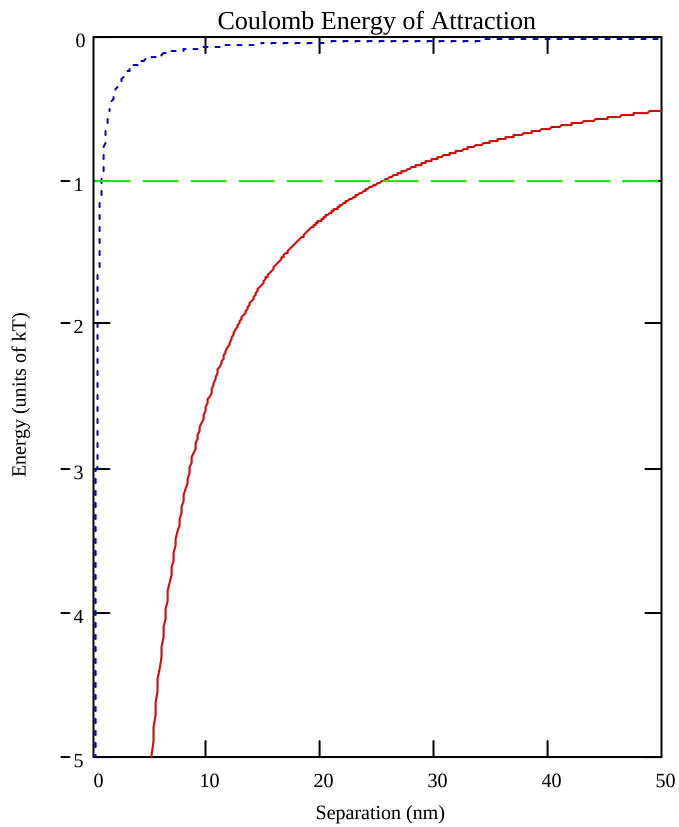
Conductivity vs concentration



Electrical charges in nonpolar media

Liquid	Conductivity ($\Omega^{-1}cm^{-1}$)	Half-time (sec)
Highly purified hydrocarbons	10^{-17}	12,000
Light distillates	10^{-16} to 10^{-13}	1,200 to 1.2
Crude oil	10^{-11} to 10^{-9}	0.012 to 0.00012
Distilled water	10^{-6}	4.8×10^{-6}

Charge separation in inverse micelles



alkane := 2.2·e0

water := 78·e0

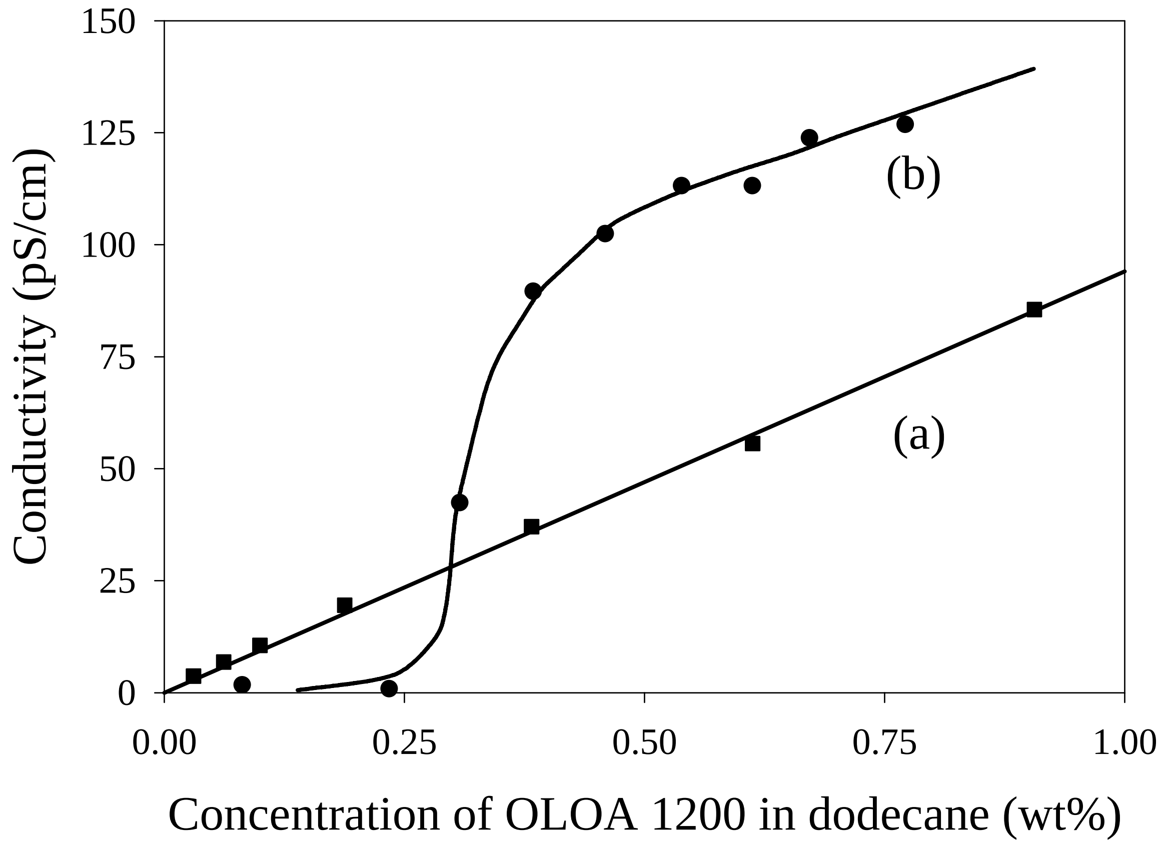
The Coulomb attraction between oppositely charged ions in water is much less than in oil.

Therefore ions in oil must be prevented from coming too close together.

Charging of particles in oils

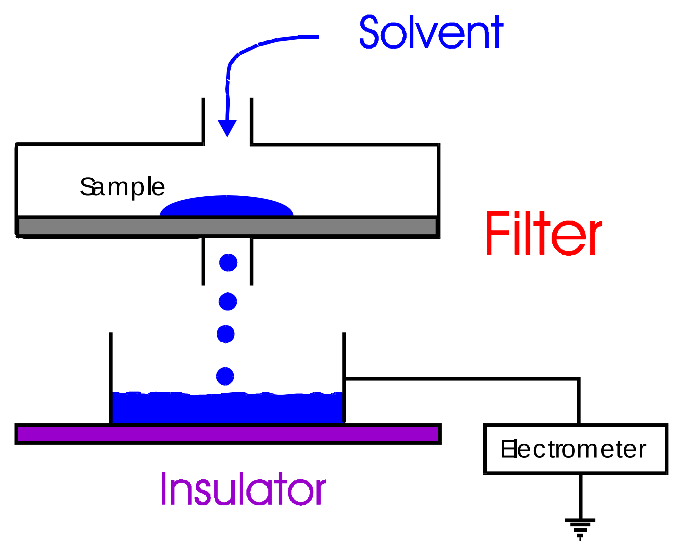
(a) Without particles.

(b) With particles

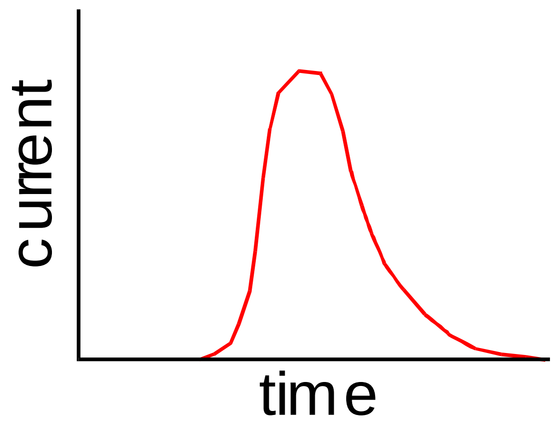


Charge/mass ratio in oil

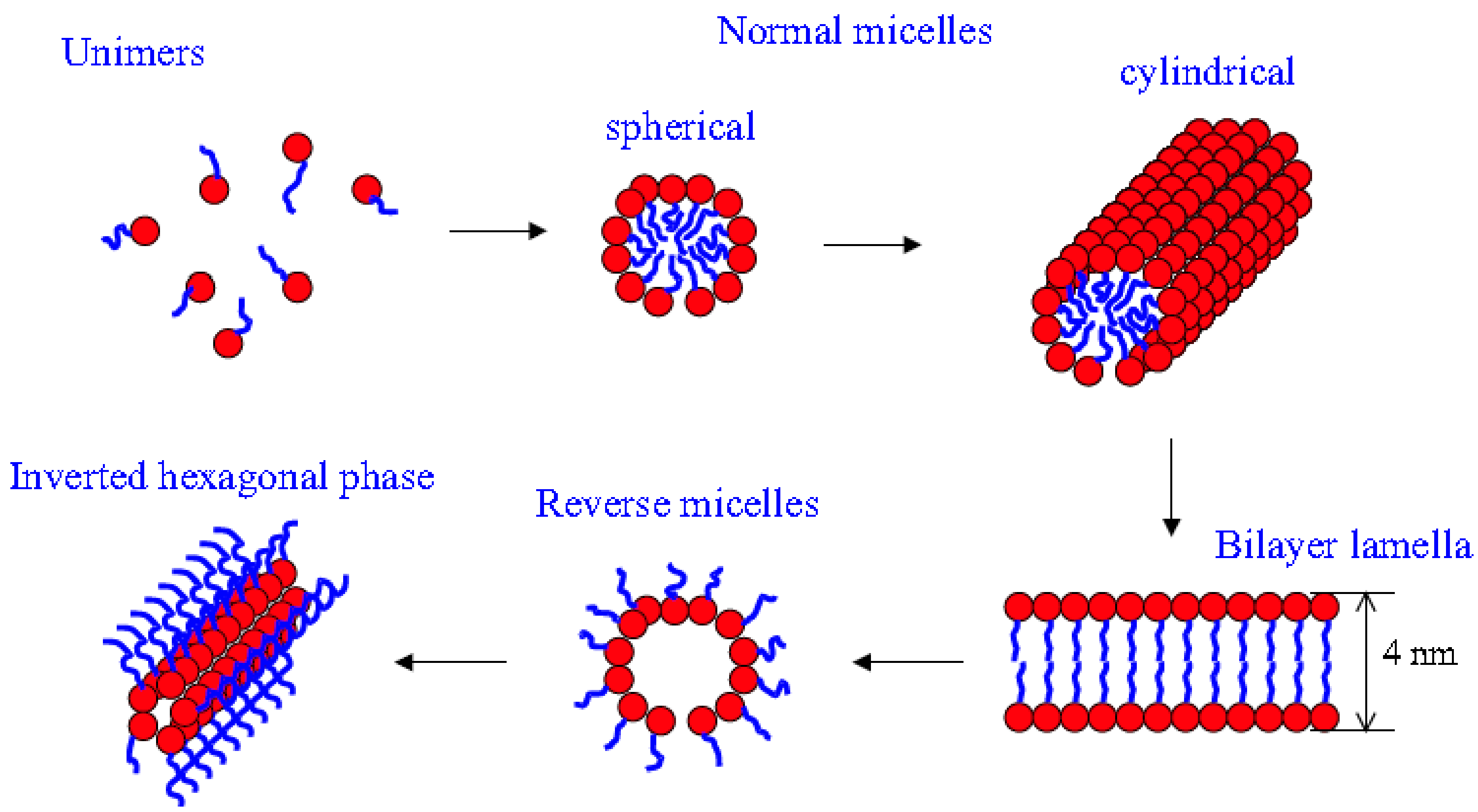
A sample of carbon black dispersed in oil with OLOA 17000 is put on a filter.



A flow of pure oil through the dispersion removes all the countercharges!



Surfactant phases

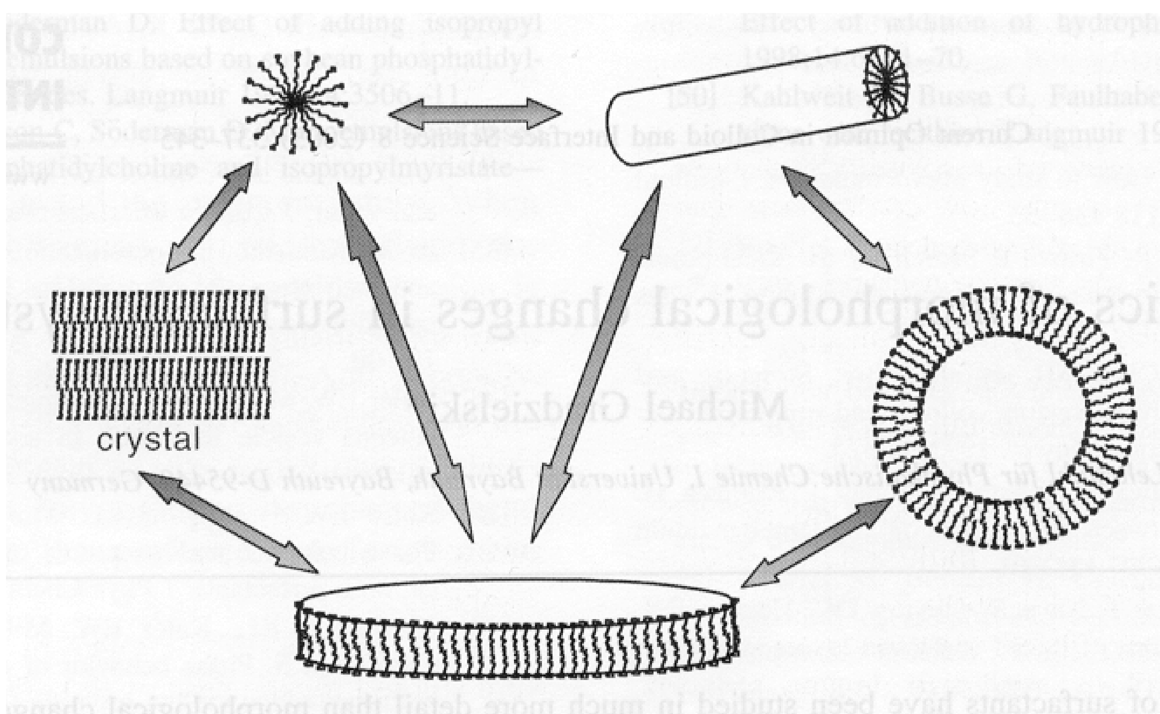


Nicola Pinna, Max Planck Institute of Colloids and Interfaces

Kinetics in surfactant systems*

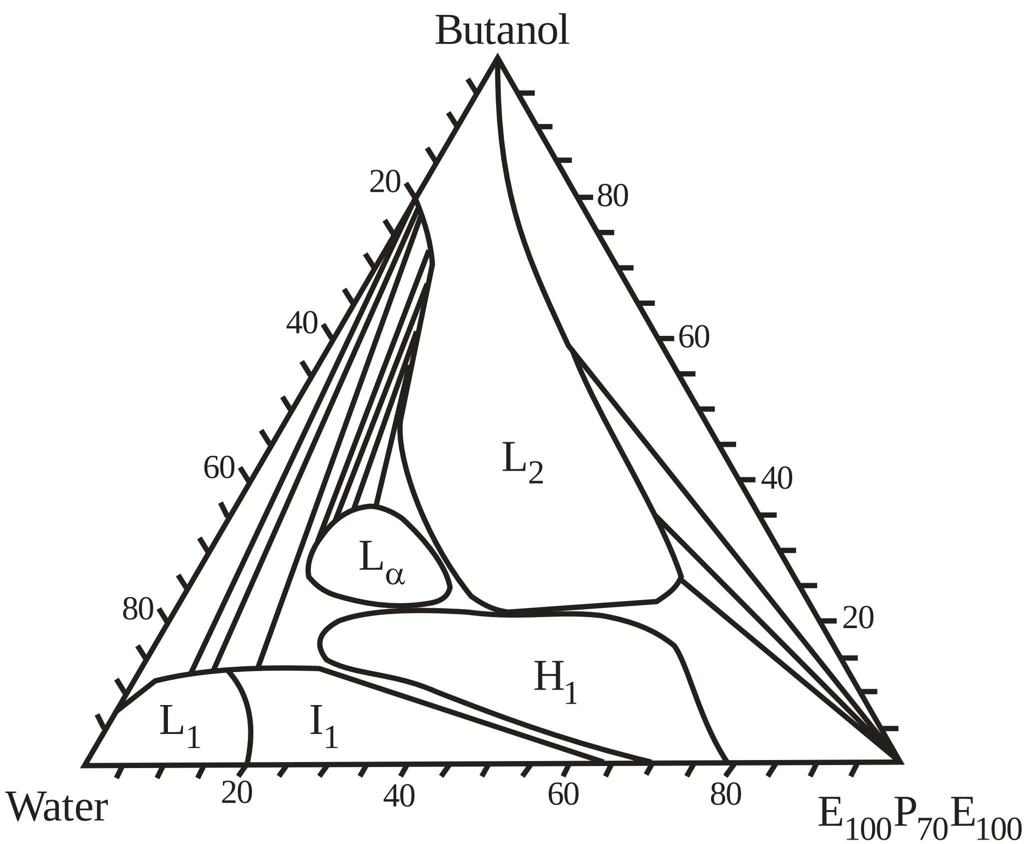
Transitions can be between all phases.

Molecule entering micelles - microseconds
Micelles to molecules - order of a minute.
Micelles to vesicles – order of hours



*Gradzielski, *Current Contents in Colloid & Interface Sci*, *8*, 337, 2003.

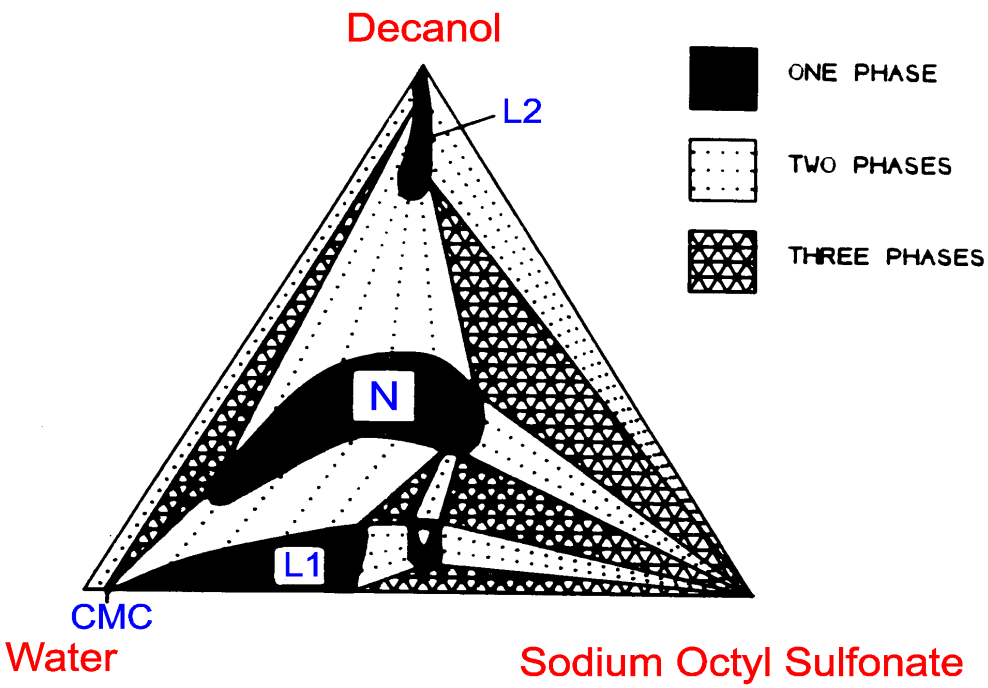
Surfactant phase diagrams



Phase diagram of the $E_{100}P_{70}E_{100}$–butanol–water system at 25°C. The tie-lines are represented by full straight lines. L_1 denotes the water-rich (micellar) solutions region, I_1 the normal ("oil"-in-water) micellar cubic liquid crystalline region, H_1 the normal hexagonal liquid crystalline region, L_α the lamellar liquid crystalline region, and L_2 the alkanol-rich solution region.

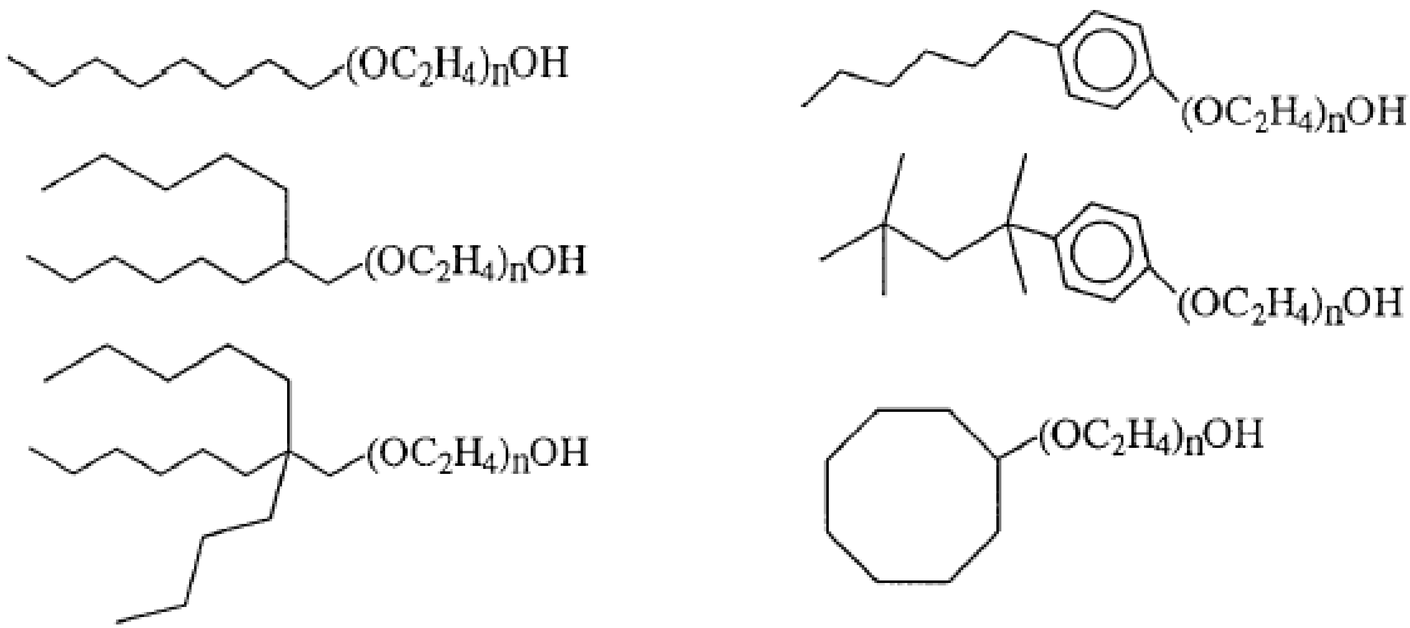
Morrison, Fig. 13.21, p. 272.

Phase diagrams can be constructed



(Consider taking the ACS short course on emulsions for much more information.)

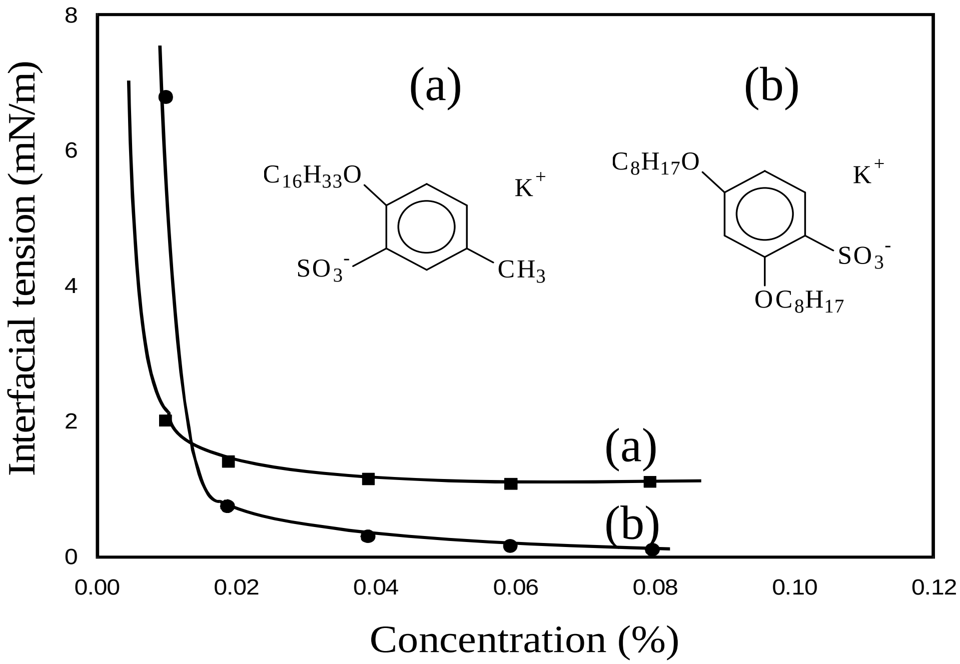
Surfactant structure is significant



Structure affects adsorption, stability, solubility, and temperature dependence, etc.

http://surfactants.net/huibers/Huibers1997.pdf

Effect of structure on micelle formation

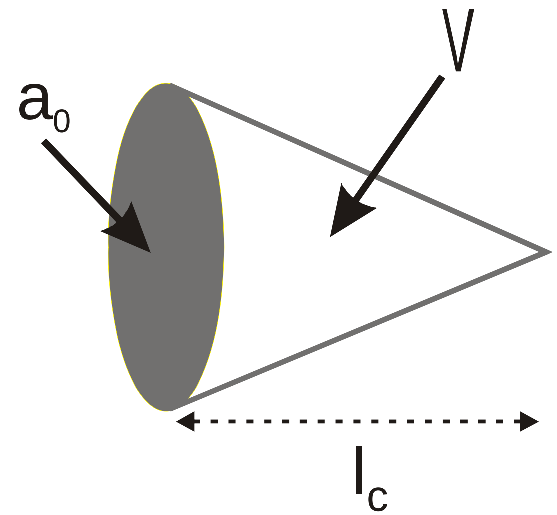


The linear molecule (a) forms micelles quickly.

The branched molecule (b) does not form micelles so readily but lowers surface tension more.

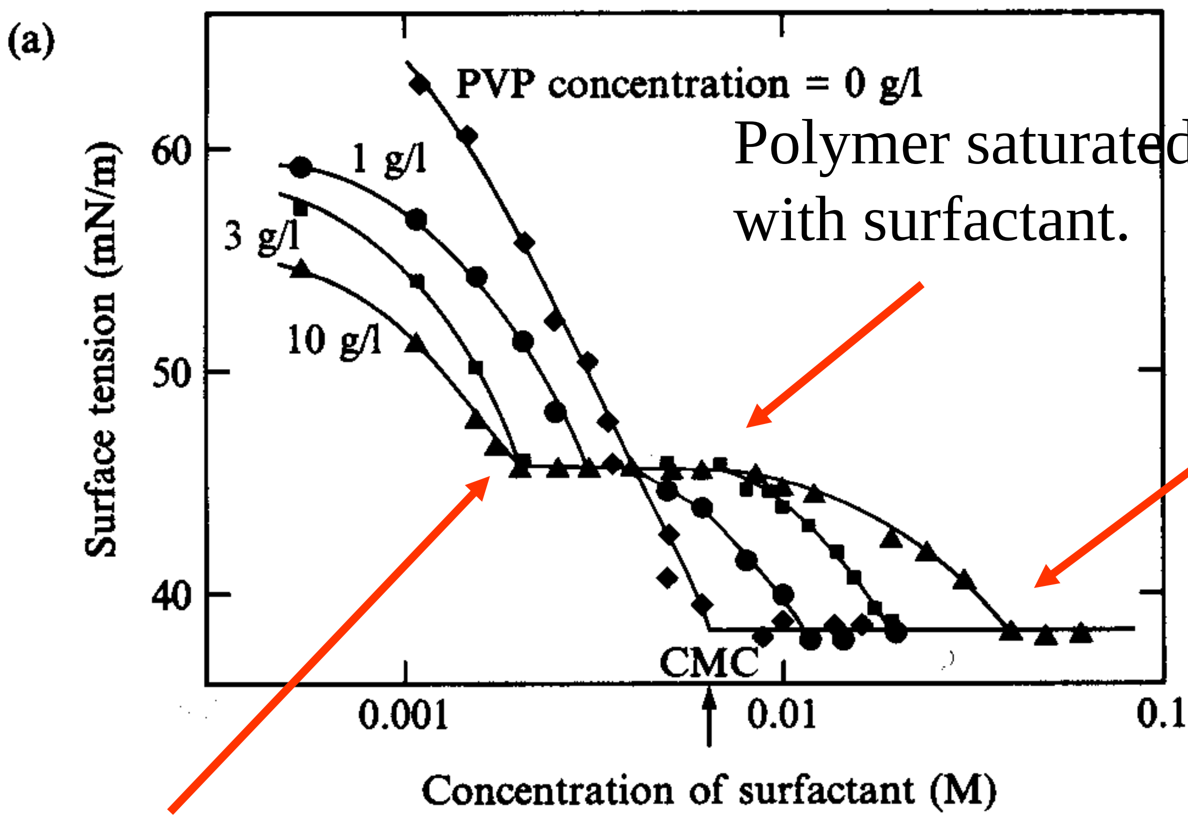
Packing parameters can “explain” shape

V is the volume of the micelle
l_c is the length of the surfactant
a_0 is the optimum packing of the head groups



Value of $\frac{V}{l_c a_0}$	**Structure of micelle**
0 - 1/3	Spheroidal in aqueous media
1/3 - 1/2	Cylindrical in aqueous media
1/2 - 1	Lamellar in aqueous media
> 1	Inverse micelles in nonpolar media

Surfactant(SDS) – Polymer interaction



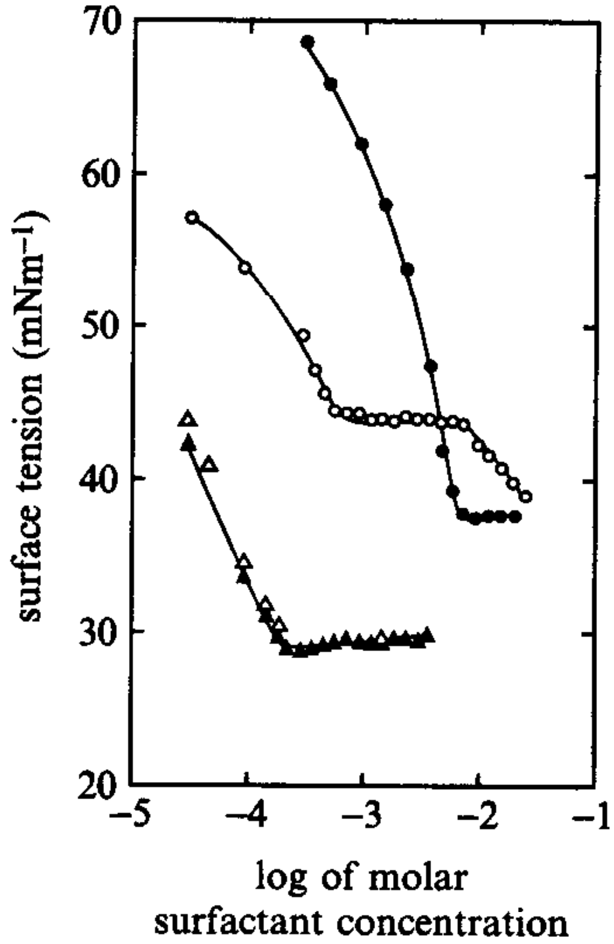
Polymer saturated with surfactant.

Apparent CMC.

Onset of surfactant/polymer interaction.

Holmberg et al., p. 278

Surfactant (SDS) – Protein interactions



The effect of gelatin on the surface tension of solutions of SDS (circles) and Triton-X100 (triangles). Without gelatin (filled) and with gelatin (open).

For Triton X-100: no protein/surfactant interaction.

For SDS: a plateau corresponding to a protein/surfactant association.

Named surfactant phenomena

Name	*Brief statement*
Lundelius' rule	Decreasing solubility increases surface activity.
The Ferguson effect	A balance between lyophilic and lyophobic nature maximizes surface activity.
The HLB scale	Surface-active solutes can be put on a graded scale from W/O to O/W emulsifiers.
Bancroft's rule	The liquid in which the emulsifier is more soluble is the continuous phase.

Reference material

Bibliography for surfactants

Becher, P., Ed. *Encyclopedia of emulsion technology*, Vol. 1 *Basic Theory*, 1983; Vol. 2 *Applications*, 1985; Vol. *3 Basic theory, measurement, applications*, 1988; Vol. 4, 1996; Marcel Dekker: New York.

Conley, R.F. *Practical dispersion: A guide to understanding and formulating slurries*; VCH Publishers: New York; 1996.

Flick, E. W. *Industrial surfactants*; Noyes Publications: Park Ridge, NJ; 2nd ed. 1993.

Karsa, D.R., Ed. *Industrial applications of surfactants II*; Roy. Soc. Chem.: Cambridge; 1990.

Laughlin, R.G. *The Aqueous phase behavior ofsSurfactants*; Academic Press: New York; 1994.

McCutcheon's: *Emulsifiers & Detergents*, American Edition, MC Publishing: Glen Rock, NJ; (An annual publication.)

Mukerjee, P.; Mysels, K.J. *Critical micelle concentrations of aqueous surfactant systems*; Nat. Stand. Ref. Data Ser., *36*; U.S. Government Printing Office: Washington, DC; 1971.

Nelson, Jr., RD. *Dispersing powders in liquids*; Elsevier Publishing: New York; 1988.

Rosen, M.J. *Surfactants and interfacial phenomena*; John Wiley & Sons: New York; 1st ed, 1978; 2nd ed., 1989.

Schwuger, M.J., Ed. *Detergents in the environment*; Marcel Dekker; New York; 1997.

Shinoda, K.; Nakagawa, T.; Tamamushi, B-I; Isemura, T. *Colloidal surfactants, Some physicochemical properties*; Academic Press: New York; 1963.

Shinoda, K., Ed. *Solvent properties of surfactant solutions*; Marcel Dekker: New York; 1967.

Shinoda, K.; Friberg, S. *Emulsions and solubilization*; John Wiley & Sons: New York; 1986.

Tanford, C. *The hydrophobic effect: Formation of micelles and biological membranes*; John Wiley & Sons: New York; 1980.

Dispersants

DISPERSING POWDERS IN LIQUIDS

RALPH D. NELSON, Jr.,
Consultant Engineering Services Division,
E.I. du Pont de Nemours & Co., Inc., Newark, Delaware, U.S.A.

ELSEVIER
Amsterdam — Oxford — New York — Tokyo 1988

Typical entries in Nelson

212 *Dispersing Powders in Liquids*

Nonionic and Cationic Class Characteristics *Table C–7*

class →	Al	Fa	Fe	Gr	Ge	Ao	Ag	Aa	Pm	So	Pp	Fc	Si	An	Qa	Im	Da
CHARGE OF SURFACTANT IN WATER																	
low pH	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+	+
mid pH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	Z	+
high pH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	–	0
SOLUBILITY OF SURFACTANT IN LIQUID																	
acid water	Y	Y	Y	Y	.	.	Y	.	.	.	Y	.	Y	Y	Y	.	N
base water	Y	Y	Y	Y	.	.	Y	.	.	.	Y	.	Y	N	Y	.	Y
H-b org	.	.	Y	Y	Y	.	.	.	.	.	.	.	.	.	.	.	.
polar	Y	.	Y	Y	Y	.	.	.	.	.	.	.	.	.	.	.	.
nonpolar	.	.	.	.	Y	.	Y	Y	.	Y	.	.	.	Y	Y	Y	Y
fluoroc	.	.	.	.	.	.	.	.	.	.	.	Y	.	.	.	.	.
DISPERSING AGENT FOR PARTICLE (SURFACE)																	
metal	.	Y	.	.	.	.	.	.	Y	.	.	.	.	Y	.	.	.
carbon	.	.	.	.	.	Y	.	.	Y	.	.	.	.	.	.	.	.
salt	.	.	.	.	.	.	.	.	.	Y	.	.	.	.	Y	.	.
oxide/h	.	Y	.	.	.	.	.	.	.	Y	Y	.	.	.	Y	Y	.
H-b org	.	.	.	.	.	.	Y	.	Y	Y	.	.	.	.	.	Y	Y
protein	.	.	.	.	.	.	.	.	Y	.	Y	.	.	.	.	.	Y
polar	.	.	.	.	.	Y	Y	.	.	.	Y	.	.	.	Y	.	Y
nonpolar	.	.	.	.	.	Y	.	.	.	.	.	Y	.	Y	Y	.	Y
fluoroc	.	.	.	.	.	.	.	.	.	.	.	Y	.	.	.	.	.
STABILITY AND BEHAVIOR																	
high IS OK	.	.	.	.	.	Y	.	.	.	.	.	.	.	.	.	Y	.
di cat OK	.	.	.	.	.	Y	.	.	Y	.	.	.	.	.	.	.	.
foams	.	N	.	N	.	.	N	Y	.	.	.	.	.	.	.	N	Y
STABILE TOWARD																	
biodeg	N	N	.	.	.	Y	.	.	.	N	.	Y	.	.	Y	.	.
oxidation	.	N	.	.	.	.	.	.	N	.	.	Y	.	.	.	.	.
reduction	.	.	.	.	.	.	.	.	.	.	.	Y	.	.	.	.	.
hot acid	.	Y	N	.	.	.	N	.	N	.	.	Y	.	.	.	Y	.
warm acid	.	Y	.	.	.	.	N	.	N	.	.	Y	.	Y	.	Y	.
cold acid	.	Y	.	.	.	.	N	.	N	.	.	Y	.	Y	.	Y	.
cold base	Y	Y	.	.	.	.	.	Y	Y	.	.	Y	.	.	N	Y	.
warm base	Y	Y	.	.	.	.	.	Y	Y	.	.	Y	.	.	N	Y	.
hot base	Y	Y	N	.	.	.	.	Y	Y	.	.	Y	.	.	N	Y	.

Properties of Surfactant 213

Anionic Class Characteristics *Table C–8*

chemical class →	Sf	Sd	To	Ab	Is	Ss	Ta	As	St	Ap	Ip	Ai	Pl
CHARGE OF SURFACTANT IN WATER													
low pH	0	–	.	.	.	.	.	.	.	.	.	+	.
mid pH	–	–	–	–	–	–	–	–	–	–	–	Z	–
high pH	–	–	–	–	–	–	–	–	–	–	–	–	–
SOLUBILITY OF SURFACTANT IN LIQUID													
acid water	Y	Y	Y	Y	Y	Y	Y	.	.	Y	Y	Y	Y
base water	N	Y	Y	Y	Y	Y	N	.	.	Y	Y	N	Y
H-b org	.	.	.	.	.	Y	.	.	.	.	.	.	.
polar	.	.	.	.	.	Y	.	.	.	.	.	.	.
nonpolar	.	.	.	.	.	Y	.	.	.	.	.	.	.
fluoroc	Y	.	.	Y	.	Y	.	.	.	.	.	.	.
DISPERSING AGENT FOR PARTICLE (SURFACE)													
metal	.	.	.	.	.	.	Y	.	.	.	.	.	.
carbon	.	.	.	.	.	.	.	.	.	.	.	.	.
salt	.	.	.	.	.	.	.	.	.	.	.	.	.
oxide/h	.	.	.	Y	.	.	.	.	.	.	Y	.	.
H-b org	.	.	.	.	.	.	.	Y	.	.	Y	Y	Y
proteins	.	.	Y	.	.	.	.	Y	.	.	Y	Y	Y
polar	.	.	.	Y	Y	.	Y	Y	Y	Y	.	Y	Y
nonpolar	.	.	.	Y	Y	.	Y	Y	.	Y	.	.	.
fluoroc	.	.	.	.	.	.	.	.	.	.	.	.	.
STABILITY AND BEHAVIOR													
high IS OK	N	.	.	Y	.	.	Y	.	.	Y	.	Y	.
di cat OK	N	Y	Y	Y	Y	.	Y	.	.	Y	N	.	.
foams	Y	Y	.	Y	Y	Y	Y	Y	N	N	.	.	.
STABILE TOWARD													
biodeg	.	.	.	N	.	.	.	N	N	.	.	Y	.
oxidation	.	.	.	.	.	.	.	.	.	.	.	.	.
reduction	.	.	.	.	.	.	.	.	.	.	.	.	.
hot acid	.	.	.	Y	.	.	Y	N	N	.	N	.	.
warm acid	.	.	.	Y	.	N	Y	.	.	.	N	Y	.
cold acid	.	.	.	Y	.	.	Y	Y	.	.	N	Y	.
cold base	.	.	.	Y	.	.	Y	Y	.	Y	Y	Y	.
warm base	.	.	.	Y	.	.	Y	Y	.	Y	Y	Y	.
hot base	.	.	.	Y	N	N	Y	Y	N	Y	Y	.	.

McCutcheon’s Handbook

1994
McCutcheon’s
VOLUME 1:
Emulsifiers & Detergents
International Edition

8-6

printed in U.S.A.

The Manufacturing Confectioner Publishing Co.
175 Rock Rd., Glen Rock, NJ 07452, USA
Telephone: 201-652-2655. Telefax: 201-652-3419

ISBN 0-944254-28-4 LC# 82-644576

CONTENTS

Typical entry in McCutcheon's

Span **ICI Surfactants**

Span 20
Chemical Description: Sorbitan monolaurate
Form: liquid **Conc.%:**100 **Type:** nonionic **HLB:** 8.6

Span 40
Chemical Description: Sorbitan monopalmitate
Form: powder **Conc.%:**100 **Type:** nonionic **HLB:** 6.7

Span 60
Chemical Description: Sorbitan monostearate
Form: powder **Conc.%:**100 **Type:** nonionic **HLB:** 4.7

Span 65
Chemical Description: Sorbitan tristearate
Form: powder **Conc.%:**100 **Type:** nonionic **HLB:** 2.1

Span 80
Chemical Description: Sorbitan monooleate
Form: liquid **Conc.%:**100 **Type:** nonionic **HLB:** 4.3

Span 85
Chemical Description: Sorbitan trioleate
Form: liquid **Conc.%:**100 **Type:** nonionic **HLB:** 1.8

Remarks: Emulsifiers. Lipophilic surfactants, insoluble or dispersible in water but generally soluble in oils or organic solvents. Used as o/w emulsion stabilizers and thickeners. Used in the textile industry as fiber lubricants and softeners, used as oil additives for corrosion inhibition. Food emulsifiers.

Chemcyclopedia (ACS annual publication)

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3. Fatty Chemicals
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5. Inorganic Chemicals
6. Industrial and Specialty Gases
7. Pigments and Dyes
8. Plastics, Additives, and Synthetic Elastomers
9. Catalysts and Process Chemicals
10. Environmental Chemicals and Services
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Within each category the respective chemical headings are listed alphabetically. Under those headings, suppliers of the chemical are listed alphabetically. Descriptive information as furnished by suppliers is included.

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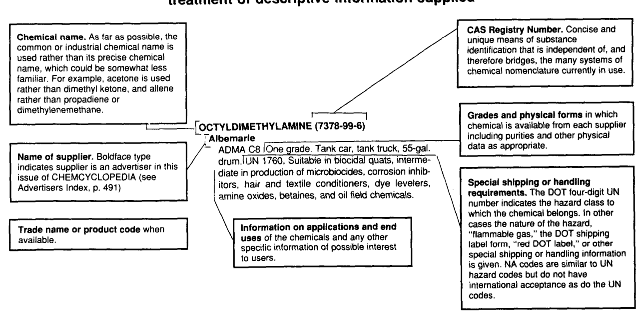
continued on page 6

Shown below is a sample CHEMCYCLOPEDIA listing showing treatment of descriptive information supplied



4 CHEMCYCLOPEDIA 1995

Typical page in Chemcyclopedia

ACETAMIDE MONOETHANOLAMINE (MEA)
Croda, Inc. INCROMECTANT AMEA-70 and -100. Liquids at 70% and 100% active. Clarifying detangling agents in shampoos, conditioners, and cream rinses; humectants in creams and lotions.
McIntyre Chemical MACKAMIDE AME 75. Cosmetic grade. Tank car, tank truck, 55-gal drum, 5-gal pail. NA 1760. Mild amide with humectant properties. Collagen solubilities.
Scher Chemicals, Inc. SCHERCOMID AME. Liquid form. Bulk, 55-gal drums. Humectant, coupling agent, solubilizer.
Tri-K Industries, Inc. 75% and 100% grades. 55-gal drum. Completely water soluble, antistatic effect in hair products; humectant with excellent conditioning properties.

ACETYLENIC DIOL
Air Products and Chemicals, Inc. SURFYNOL 104. Liquid form, defoamer and wetting agent for coatings, inks, adhesives, etc.. Tank truck, 55-gal drum, 5-gal pail, 8-oz samples. SURFYNOL DF-110 SERIES, 4 grades: DF-110, DF-110D, DF-110L, DF-110S. Defoamer for cement systems, metalworking fluids, pressure sensitive adhesives, latex systems, coatings, water-based inks, fountain solutions.

ALCOHOL ALKOXYLATES
BASF Corp. PLURAFAC/ICONOL. Liquid, solid grades. Tank car, tank truck, 55-gal drum. Wetting agents, emulsifiers, detergents.
Norman, Fox & Co.
Procter & Gamble Co., The

ALCOHOL and ALCOHOL ETHER SULFATES
Ashland Chemical Co., Industrial Chemicals and Solvents Div.
Chemron Corp. SULFOCHEM SERIES. Liquids, powders, pastes. Tank car, tank truck, 55-gal drum, 5-gal pail. Shampoos, buibble baths, cleaning preparations, industrial uses.

Harcros Chemicals, Inc. T-DET. Tank truck, 55-gal drum.
Henkel Corp., Emery Group, Cospha/CD Div. STANDAPOL and TEXAPON. Liquids, powders, solids, and pastes. Tank car, tank truck, 55-gal drum. For use in shampoo, bubble bath, dentrifices, cleansing preparations.
Norman, Fox & Co.
Pilot Chemical Co. CALFOAM. Liquid forms. Tank car, tank truck, 55-gal drum.
Sentry/Custom Services Corp.

ALCOHOL-ETHOXYLATED-PROPOXYLATED SURFACTANT DEFOAMER
BASF Corp. PLURAFAC RA. Liquid, 4 grades. Tank car, tank truck, 55-gal drum.
Harcros Chemicals, Inc. T-DET. Tank truck, 55-gal drum.
Trans-Chemco, Inc. TRANS-227. Industrial grade. Tank truck, 55-gal drum, 5-gal pail. Oil-field mud defoamer.

ALCOHOL ETHOXYSULFATES
Harcros Chemicals, Inc. T-DET. Tank truck, 55-gal drum.
Norman, Fox & Co.

ALCOHOLS, ALKOXYLATED LINEAR
Ethox Chemicals, Inc. LF-1226, 2407, 2408, 2680 GRADES. Tank truck, 55-gal drum. Low-foam detergent, dispersant.
Harcros Chemicals, Inc. T-DET. Tank truck, 55-gal drum.
Norman, Fox & Co.
Olin Corp. POLY-TERGENT S-LF SERIES. 6 grades. Tank car, tank truck, 55-gal drum. Biodegradable and low-foaming; emulsifiers, dispersants, wetting agents.

ALCOHOLS, DETERGENT
Albemarle Corp. EPAL 1214. 86%/14% (1285); 70%/29% blend (1270); 66%/27%/7% blend grades (1214). Tank car, tank truck, 55-gal drum. Ethoxylate intermediate, specialty sulfate intermediate, rolling oil additive, defoamer, and foam stabilizer.
Ashland Chemical Co., Industrial Chemicals and Solvents Div.
McIntyre Chemical
Norman, Fox & Co.
Shell Chemical Co. NEODOL. C_9-C_{15} grades. Tank car, tank truck. Base for rapidly biodegradable ethoxylate and ethoxysulfate.
Vista Chemical Co. ALFOL. Wide range of straight-cut alcohols and alcohol blends available. Tank car, tank truck. High-purity, synthetic, linear primary alcohols and alcohol blends C4-C22t..

ALCOHOLS, ETHOXYLATED (74432-13-6)
Ashland Chemical Co., Industrial Chemicals and Solvents Div.
Chemax, Inc. CHEMAL SERIES. 22 grades based on various alcohols and various moles of ethylene oxide. Tank car, tank truck, 55-gal drum, 5-gal pail, 8-oz sample quantities. Emulsifiers, detergents, wetting agents, lubricants, coupling agents and solublizers.
Harcros Chemicals, Inc. T-DET. Tank truck, 55-gal drum.
Norman, Fox & Co.
PPG Industries, Specialty Chemicals MACOL. Liquid, solid, and flaked grades. Tank car, tank truck, 55-gal drum, 5-gal pail. Complete range of ethoxylated fatty derived and synthetic alcohols. Many cosmetic, industrial toiletry and topical pharmaceutical applications.
Rhone-Poulenc, Inc., Surfactants & Specialties Div. RHODASURF. Lauryl, tridecyl, isodecyl, cetyl, stearyl, oleyl, mixed linear alcohol ethoxylates. Tank car, tank truck, 55-gal drum. Emulsion stabilizers, cosmetic emollients, detergents, wetting agents, cleaners, emulsifiers. Broad range of product types for every application.
R.I.T.A. Corp.
Shell Chemical Co. NEODOL. C_4-C_{11}, C_{12}-C_{15} base linear primary alcohol grades. Tank car, tank truck. Rapidly biodegradable nonionic surfactants.
Union Carbide Corp.
Vista Chemical Co. ALFONIC, NOVEL II. Wide range