

# **Determination of Critical Micelle Concentration by Conductivity**

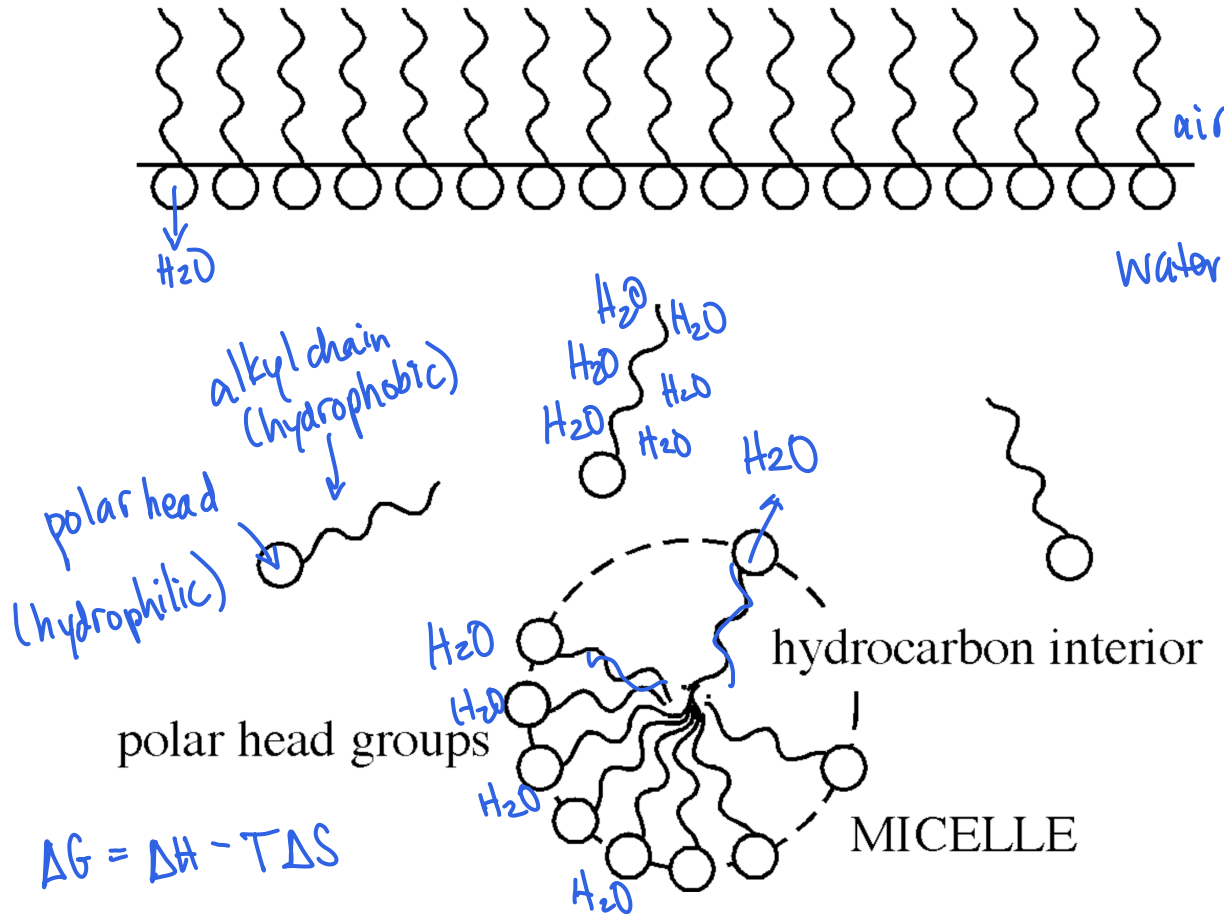
Teng-Jui Lin

Department of Chemical Engineering, University of Washington

**Surface and Colloid Science**

# Micelle formation changes physical properties

- Micelle formation



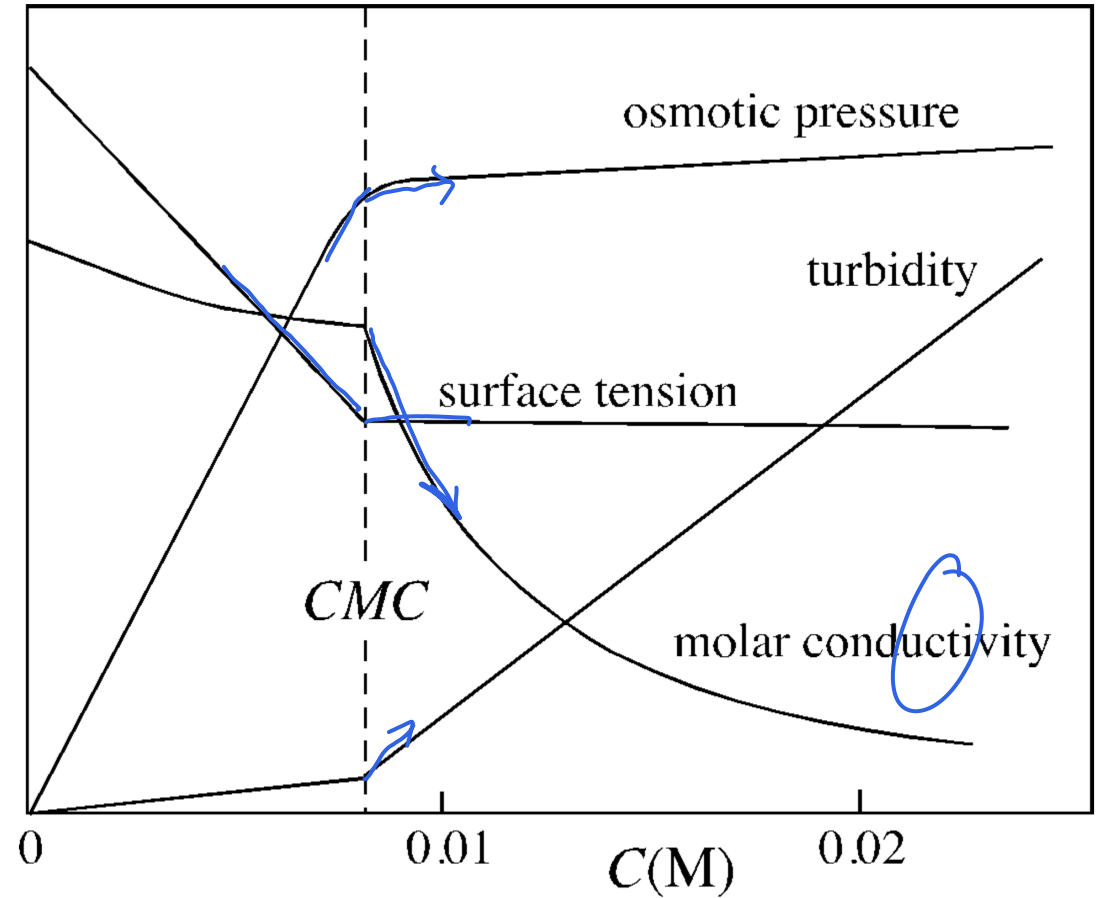
$$\Delta G = \Delta H - T\Delta S$$

$$< 0 \quad \cdot \quad \Delta S_{\text{sys}} > 0$$

$$\Rightarrow \text{spontaneous} \quad \cdot \quad \Delta S_{\text{surf}} < 0$$

$$\cdot \quad \Delta S_{\text{water}} > 0$$

- Physical property of SDS at 25 °C



- CMC = critical micelle concentration

# CMC can be determined using conductivity measurements

- Conductivity  $\kappa [\mu\text{S}/\text{cm}]$  increases linearly with concentration  $C [\text{M}]$

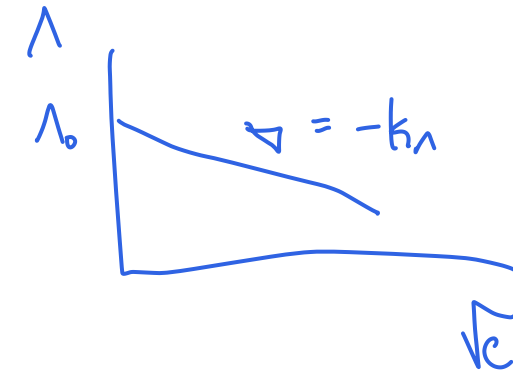
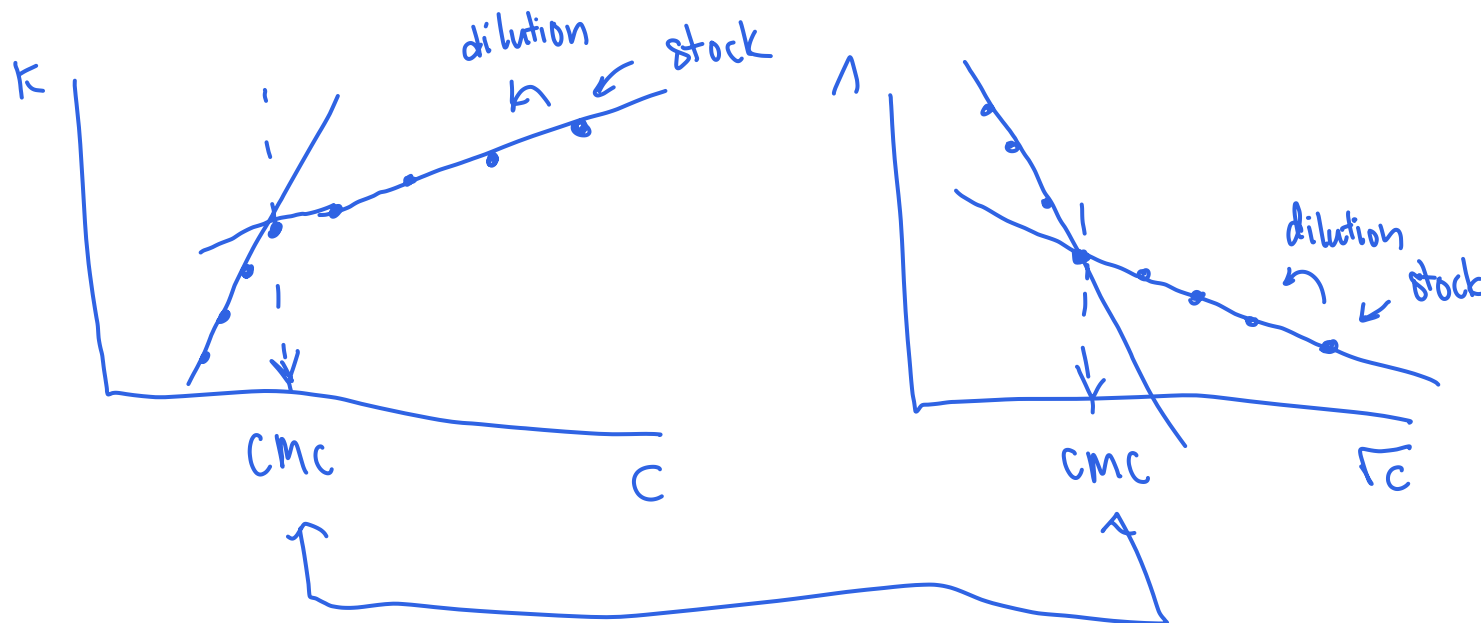
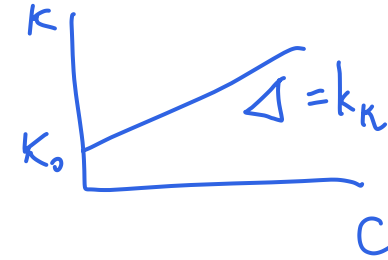
$$\kappa = \kappa_0 + k_\kappa C$$

- Equivalent conductivity  $\Lambda [\text{S cm}^2/\text{mol}]$

$$\Lambda = \frac{\kappa}{C}$$

- Equivalent conductivity decreases linearly with square root of concentration

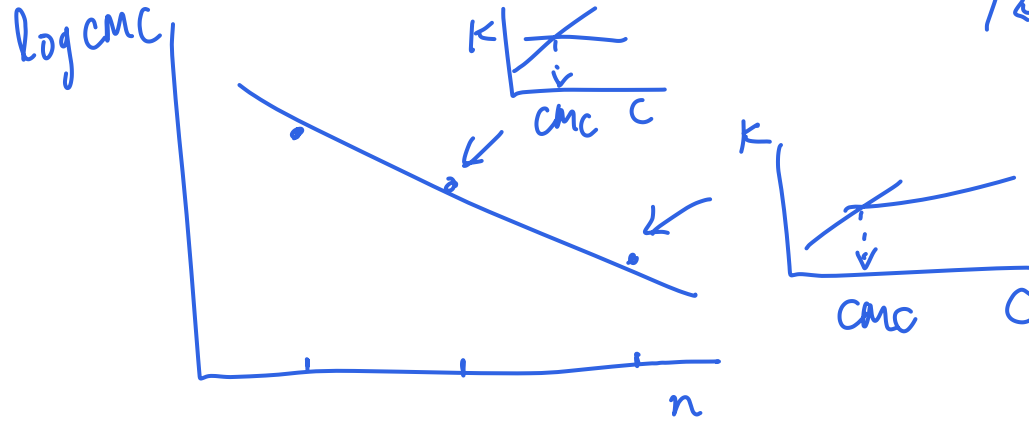
$$\Lambda = \Lambda_0 - k_\Lambda \sqrt{C}$$



# CMC decreases with alkyl chain length: Klevens equation

- Klevens equation: increasing alkyl chain length  $n$  decreases CMC

$$\log \text{CMC} = A - Bn$$



# Surfactants of interest

Surfactant	Chemical Formula	Number of alkyl chains n	Surfactant classification	Ionic classification
SDS	$\text{CH}_3(\text{CH}_2)_{11}\text{OSO}_3\text{Na}^+$	12	Sodium alkyl sulfates	* Anionic
DTAB	$\text{CH}_3(\text{CH}_2)_{11}\text{N}^+(\text{CH}_3)_3\text{Br}^-$	12	Alkyl trimethyl ammonium bromides	* Cationic
HTAB	$\text{CH}_3(\text{CH}_2)_{15}\text{N}^+(\text{CH}_3)_3\text{Br}^-$	16	Alkyl trimethyl ammonium bromides	Cationic
OTAB	$\text{CH}_3(\text{CH}_2)_{17}\text{N}^+(\text{CH}_3)_3\text{Br}^-$	18	Alkyl trimethyl ammonium bromides	Cationic

# Experimental procedure

- Calibrate conductivity meter
- Wait 2 min for the *system* to equilibrate before recording the conductivity measurement
  - The equipment reading may have stabilized, but the system might not have reached equilibrium

