

Course 14 – wetting/dewetting – contact angle

Diagram illustrating contact angle θ and wetting states:

Wetting states based on contact angle θ :

- film $\theta = 0^\circ$: $\theta < 90^\circ$ hydrophilic
- $\theta > 90^\circ$: hydrophobic
- $\theta > 150^\circ$: Superhydrophobic

Spreading coefficient $S = \gamma_{SV} - \gamma_{SL}$

$$\cos \theta = \frac{\gamma_{SV} - \gamma_{SL}}{\gamma_{SV}}$$

contact angle θ

$$S = \gamma_s - \gamma_{SL} - \gamma_L$$

$$\gamma_{Ls} \cos \theta = \gamma_{SV} - \gamma_{SL}$$
 Young equation

$S > 0$ complete wetting $\gamma_{SL} + \gamma_L < \gamma_s$

$S < 0$ non or partial wetting $\gamma_L + \gamma_{SL} > \gamma_s$

Young equation: $S = \gamma_{Ls} (\cos \theta - 1)$

$\bar{h}_0^2 = N b^2$ polymer

$\bar{h}_0^2 > e \rightarrow$

$\Delta F = \Delta F_{\text{surface}} + \Delta F_{\text{bulk}}$

$\Delta F_{\text{surface}} \propto \alpha^{-2} \cdot \ln \alpha^2$

$\alpha = \frac{h}{\sqrt{N}}$ $N \rightarrow \infty$

$\Delta F_{\text{bulk}} \propto \alpha^{-2} \cdot \ln \alpha^2$

$-SA + P(h)A$

$-C_3 = 6 \frac{\text{mN}}{\text{m}} \text{ Octane}$

$-C_2 = 18 \frac{\text{mN}}{\text{m}}$

$-CH_3 = 31 \frac{\text{mN}}{\text{m}}$

Diagram illustrating capillary forces and Laplace pressure:

Capillary length $k = \sqrt{\frac{\gamma_L}{\rho g}}$

droplet: $\gamma_s = \gamma_{SL} + \gamma_L - \frac{1}{2} \rho g h^2$

droplet: $V = Ah$

$F_{\text{tot}} = F_{\text{wetting}} + F_{\text{buoyancy}} + F_{\text{gravity}}$

$F_{\text{buoyancy}} = -\rho g d W H$

$F_{\text{gravity}} = \gamma_L \cos \theta [2(d + h)]$

Laplace pressure $\Delta P = P_{\text{inside}} - P_{\text{outside}} = \gamma_L \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$

droplet $R_1 = R_2$ $\Delta P = \gamma_L \frac{2}{R}$

$\bar{h}_0^2 = N b^2$

$\bar{h}_0^2 > e$

$\Delta F = -SA + P(h)A$

Change in free energy $\frac{P}{T}$ Surface tension $\frac{1}{T}$ Van der Waals forces $\frac{1}{T} \approx \frac{HR_1R_2}{R_1 + R_2 + \rho_2 \gamma_L^2}$

$P(h) = \frac{H}{2 \pi h^2}$ h_{bulk} $\frac{H}{R_1 R_2}$

$\Pi(h) = \frac{P(h)}{\partial h}$ $\Pi(h) \approx \frac{P(h)}{\partial h}$ $\Pi(h) \approx \frac{P(h)}{\partial h}$

$\epsilon = a \sqrt{\frac{384}{25}}$ $\leftarrow h \rightarrow 0$ $a^2 = \frac{|H|}{6 \pi b^2}$ $\epsilon \approx 10-100 \text{ \AA}$ $\text{water } 3.7 \times 10^{20} \text{ J}$

$\text{PS } 7.8-9.8 \cdot 10^{20} \text{ J}$

$\text{Au } 453 \cdot 10^{20} \text{ J}$

Disjoining pressure Π : difference between the thermodynamic equilibrium state pressure applied to surfaces separated by a film and the pressure in the bulk phase with which the film is in equilibrium.

Reference of critical surface tension: E.G. Shafrin, W.A. Zisman; J. Phys. Chem. 64, 1960, 519.

Wenzel model

$$\text{Young} \quad \cos \theta_y = \frac{\gamma_{SL} - \gamma_{SV}}{\gamma_{LV}}$$

Surface chemistry term



$$\gamma_{SL} = (\sqrt{\gamma_S} - \sqrt{\gamma_L})^2$$

$$\Delta \gamma_{SL} = 2\sqrt{\gamma_S \gamma_L} \quad \cos \theta_y = 2\sqrt{\frac{\gamma_S}{\gamma_L}} - 1$$

$$\theta_y = 120^\circ \rightarrow \gamma_S < 5 \frac{mJ}{m^2}$$

$$dG = \gamma_{LV} dA_{LV} + \gamma_{SV} dA_{SV} + \gamma_{SL} dA_{SL} = 0$$

free energy A Surface area
interfacial \cdots $\rightarrow dA_{LV} = \cos \theta dA_{SL}$

$$dA_{SL} = -dA_{SV}$$

$$\textcircled{r} = \frac{A}{A'} = \frac{\text{true surface area}}{\text{apparent surface area}}$$

$$r dA_{LV} = \cos \theta dA_{SL}$$

$$\cos \theta_{\text{Wenzel}} = \textcircled{r} \cos \theta_y$$

