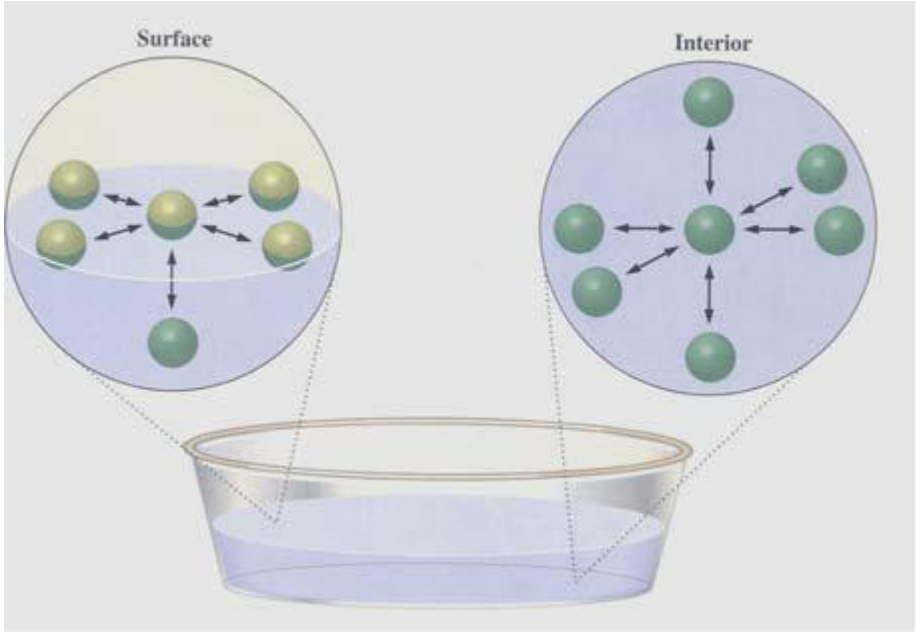
Tegangan permukaan:

Molekul cairan yang berada pada antarmuka cair-udara memiliki energi lebih tinggi daripada molekul dalam interior cairan



Energi permukaan = kelebihan energi per satuan luas dari antarmuka

Tegangan permukaan (N/m) = energi permukaan (J/m2)

TERMODINAMIKA UNTUK PERMUKAAN

Energi bebas (kerja pada suhu tetap) untuk mengkompres gas adalah:

$\Delta F = p\Delta V$

Energi bebas untuk meregangkan permukaan adalah:

$\Delta F = \sigma\Delta A$

dengan σ adalah tegangan permukaan

When *ΔF is negative, the process is spontaneous.*

When *ΔF is positive, the process reverses.*

- **Tegangan permukaan**
  - Surface tension, T=[N/m]=[J/m^2]

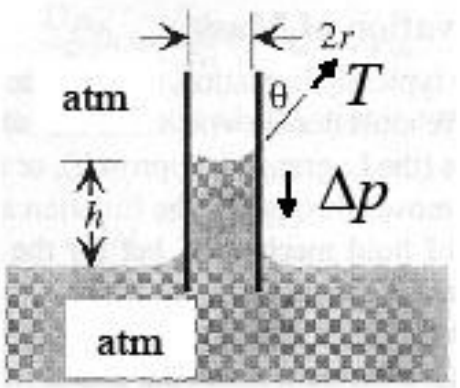
$$\frac{\text{Surface energy}}{\text{volume}} = \frac{\left(4\pi r^2\right)T}{\left(\frac{4\pi r^3}{3}\right)} = \frac{3T}{r}$$

    - smaller bubbles are energetically less favorable
    - large forces associated with formation and collapse (cavitation) of bubbles
  - **Kapilaritas**
    - contact angle, θ
    - θ depends on liquid, surface roughness, contamination, roughness, etc.

At equilibrium, total force on fluid in capillary is zero.

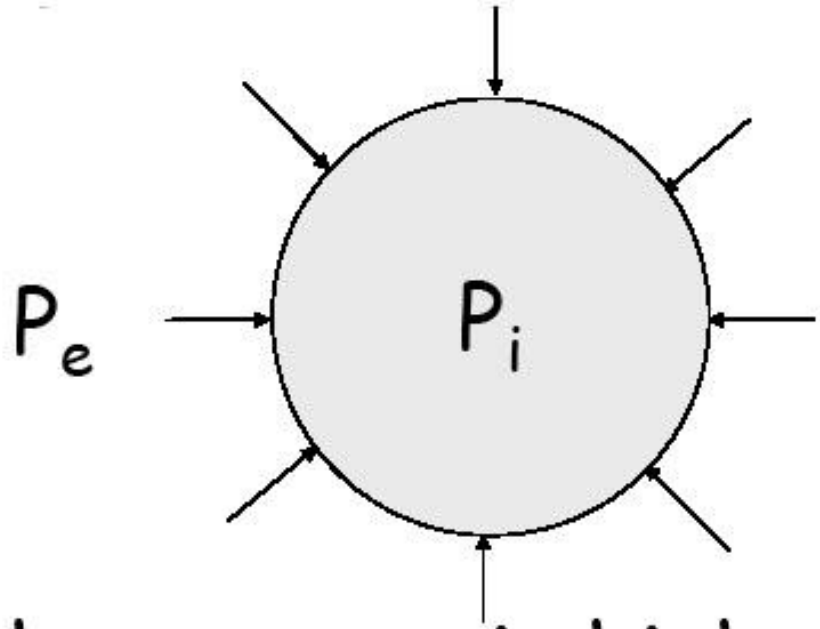
$$\Rightarrow F_{surface\ tension} = F_{gravitional}$$

$$\Rightarrow T(2\pi r)\cos\theta = \rho(\pi r^2 h)g \quad \Rightarrow \quad h = \frac{2T\cos\theta}{\rho g r}$$



Ref. Senturia, Microsystem Design, p.321

KAPILARITAS

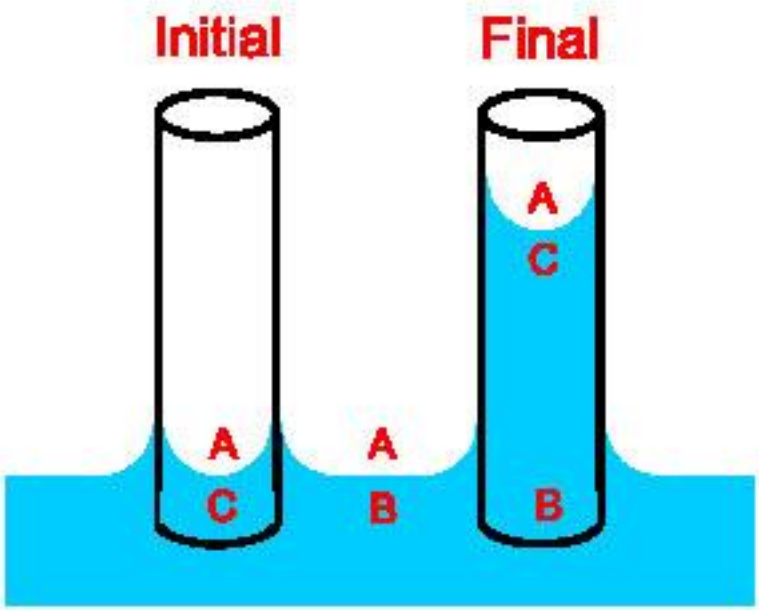


Which pressure is higher? Why?

Should be intuitive: internal pressure is higher! Think of a balloon.

$$P_i > P_e$$

Timbulnya kapilaritas



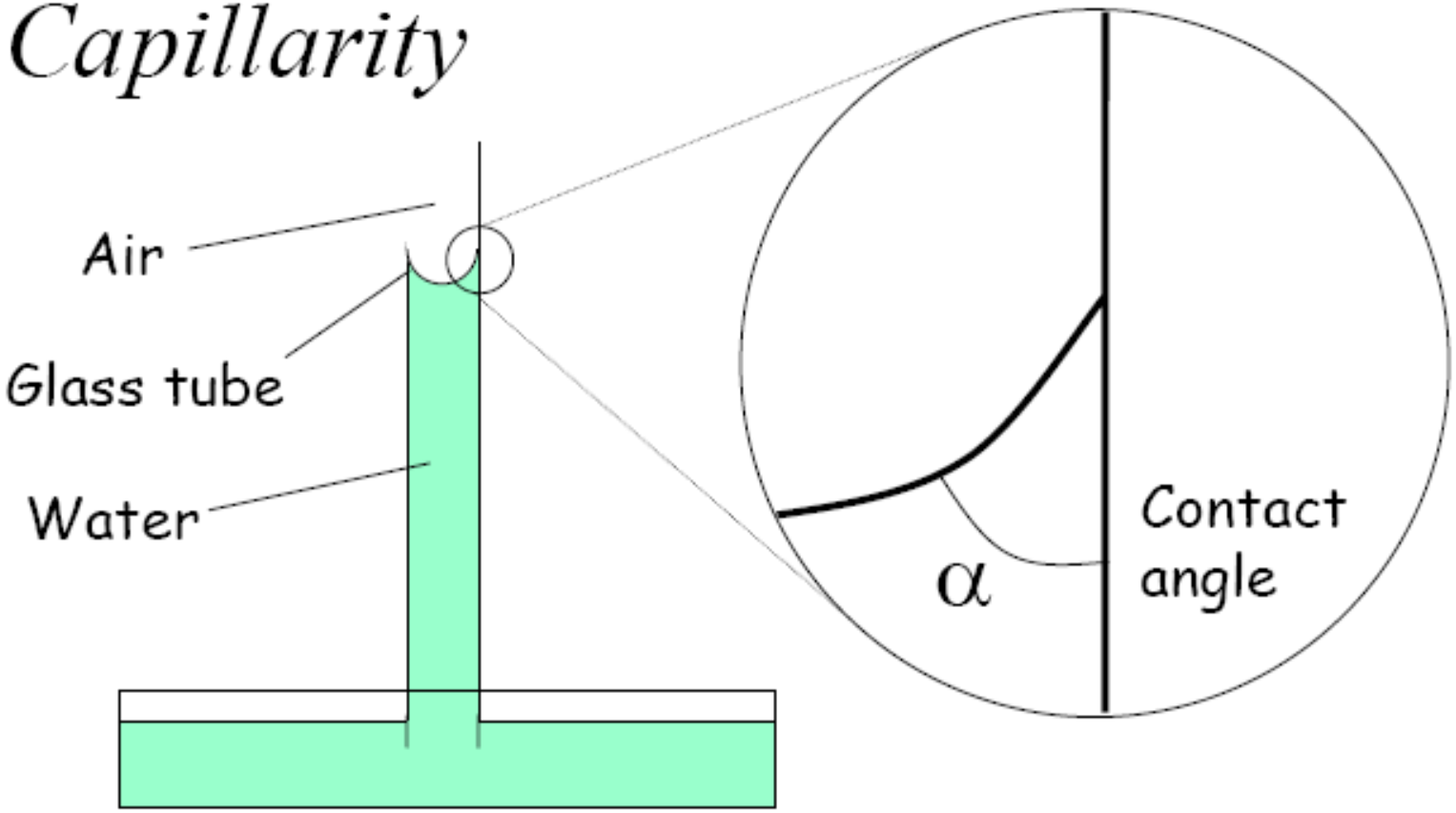
The final position is determined by 2 principles:

(1) The pressure drops across curved interfaces.
(2) The pressure in the liquid must be the same at the same depth.

In the final state the pressure drop across the AC interface equals the hydrostatic pressure from C to B.

$$\frac{2\sigma_L \cos\theta}{R} = \rho g h$$

Capillarity



Water is the wetting fluid that 'invades' the space of the non-wetting fluid (air)

Capillarity

- ***Young's Equation***

$$P_C = \frac{2\,\sigma\, sen\ \alpha}{r}$$

P_c = Capillary pressure

σ = IFT

α = contact angle

r = radius

Capillarity

- *Sen* $\alpha = 1$ *for* $\alpha = 0$, *i.e., for a perfectly wetting fluid* $Pc = 2\sigma / r$
- *Capillary pressure increases as IFT increases and vice-versa*
- *Capillary pressure decreases as the radius of the pore increases*

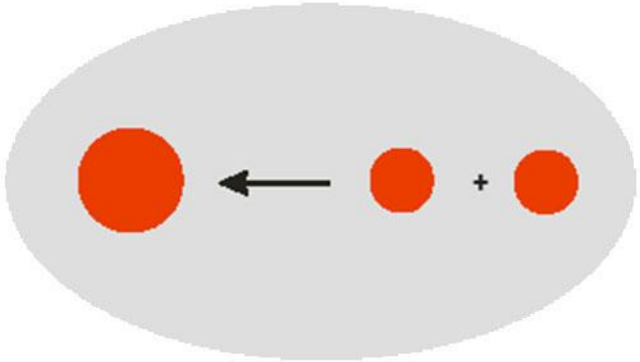
Pembasahan permukaan padat

Hukum dasar penentuan bentuk kesetimbangan tetesan cair pada permukaan dirumuskan oleh Thomas Young, 1807.

Garis kontak tiga fasa adalah garis kontak ketiga fasa udara, cair, dan padat

Bentuk tetesan dibangun oleh aksi gaya penuh pada garis kontak ketiga fasa dari tetesan dalam bidang padat.

PENYATUAN TETESAN



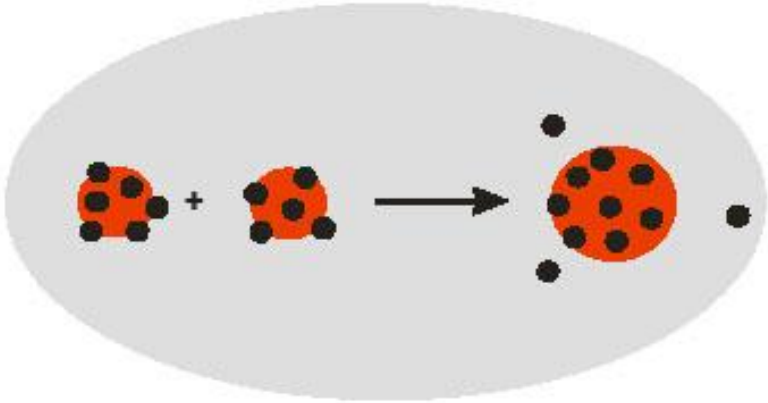
The change in energy is:

$$\begin{aligned}\Delta F &= F_{final} - F_{initial} \\ &= \sigma(A_{final} - A_{initial}) \\ &= \sigma \Delta A \\ &< 0\end{aligned}$$

Therefore the drops coalesce spontaneously.

Penyatuan tetesan dengan pengemulsi

When droplets covered with emulsifier coalesce, some emulsifier must be desorbed. This requires work.



$$\Delta F = \sigma \Delta A + \text{ work of desorption}$$

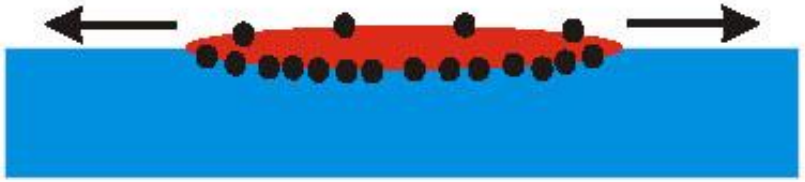
If the emulsifier is strongly adsorbed, the work to remove it is large, and the drops do not coalesce.

PENYEBARAN

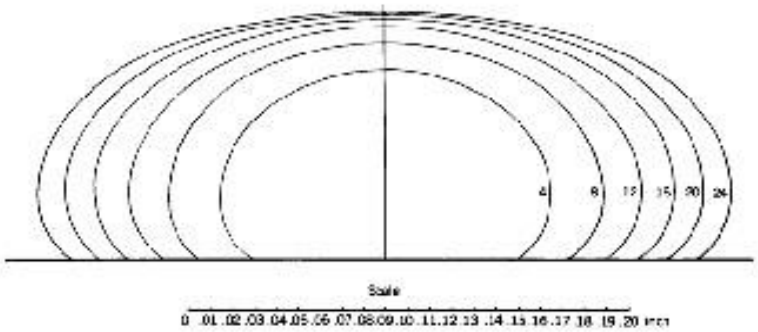
The energy change per unit area for liquid 2 (top) to spread across the surface 1 (bottom) is:

$$\Delta\overline{F} = (\sigma_2 + \sigma_{12} - \sigma_1)$$

Surfactants reduce the two terms positive terms allowing the drop to spread.



SUDUT KONTAK: CAIRAN PADA ZAT PADAT



Mercury drops on glass.*

Drops vary in size from 4 to 24 grains (1 grain = 64.8 mg)

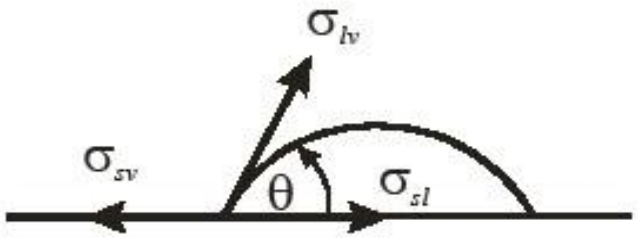
The contact angle of 140° is the same for each drop, independent of drop size.

The observation is that the contact angle depends on the materials but not the particular geometry.

PERSAMAAN SUDUT KONTAK

The Young-Dupré introduces the idea of a solid surface/vapor surface tension, σ_{sv} and a solid/liquid interfacial tension, σ_{sl}. The contact angle, q, is independent of the geometry.

A sessile liquid drop on a solid:



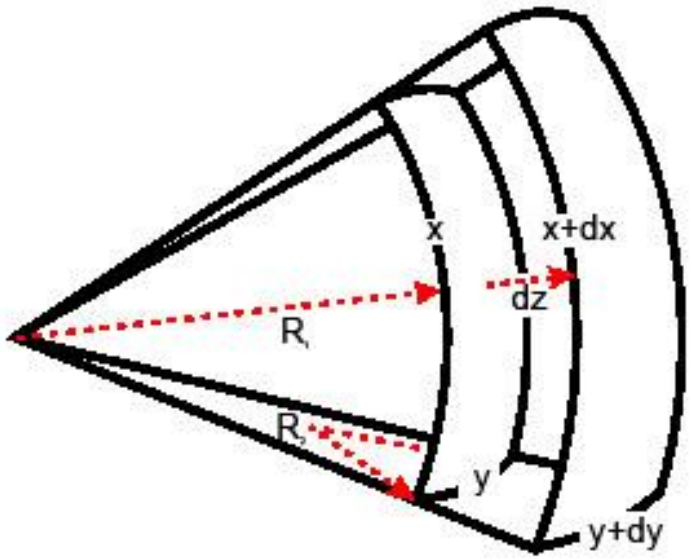
The idea is that the three tensions are balanced:

$$\sigma_{sv} = \sigma_{lv}\cos\theta + \sigma_{sl}$$

or

$$\sigma_{sv} - \sigma_{sl} = \sigma_{lv}\cos\theta$$

Tekanan tetesan melewati permukaan lengkung



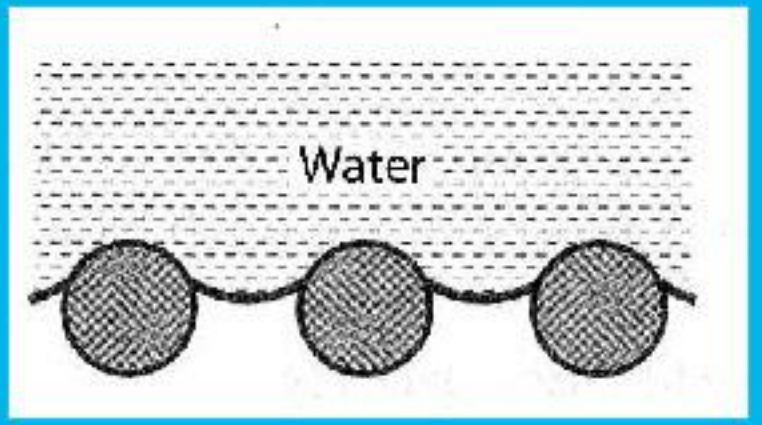
The Laplace equation:

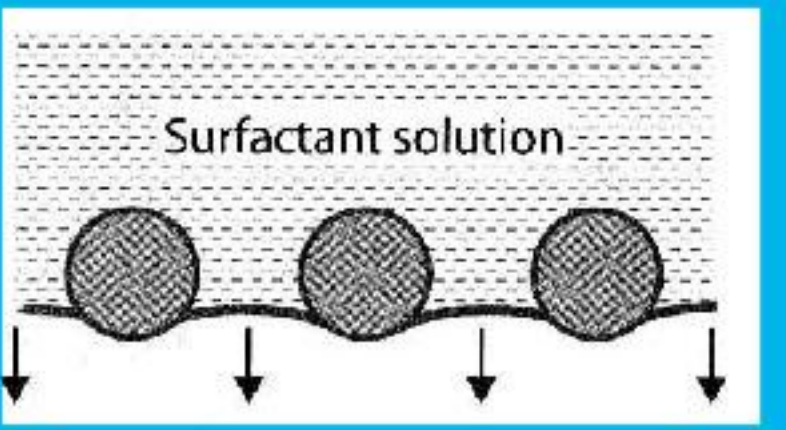
$$\Delta p = \sigma_L \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$$

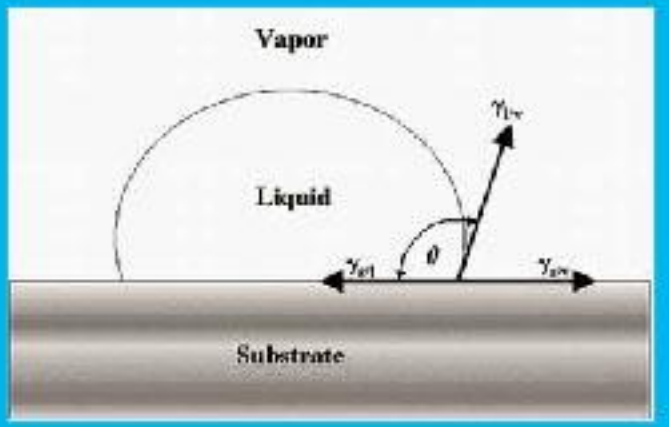
R_1 and R_2 are the radii of curvature.

The pressure is larger on the concave (inside) of the curved surface.

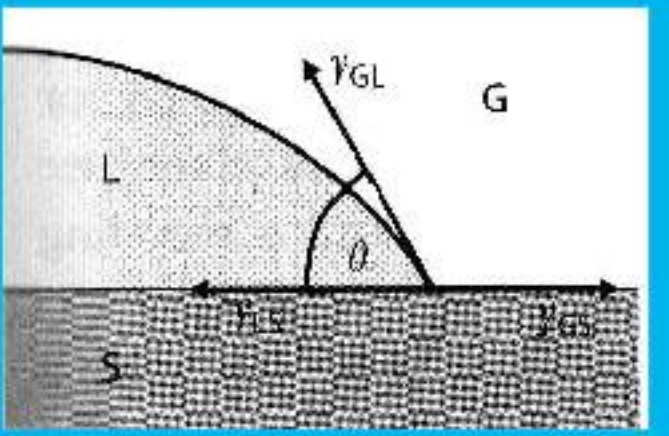
Permukaan hidrofob dan hidrofil





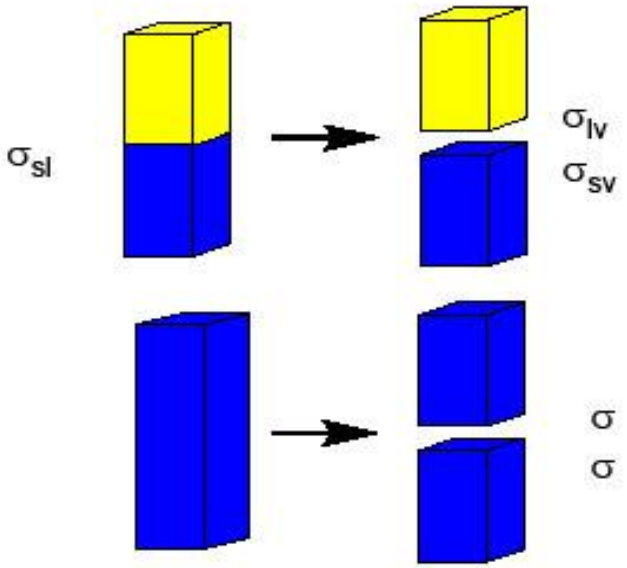


Low wettability, θ>90°, (Teflon)



high wettability, θ<90° (θ=0°)

KERJA KOHESI DAN ADESI



The work of adhesion is the separation to create two new surfaces from one interface:

$$W^{adh} = \sigma_{sv} + \sigma_{lv} - \sigma_{sl}$$

The work of cohesion is the separation to create two new surfaces.

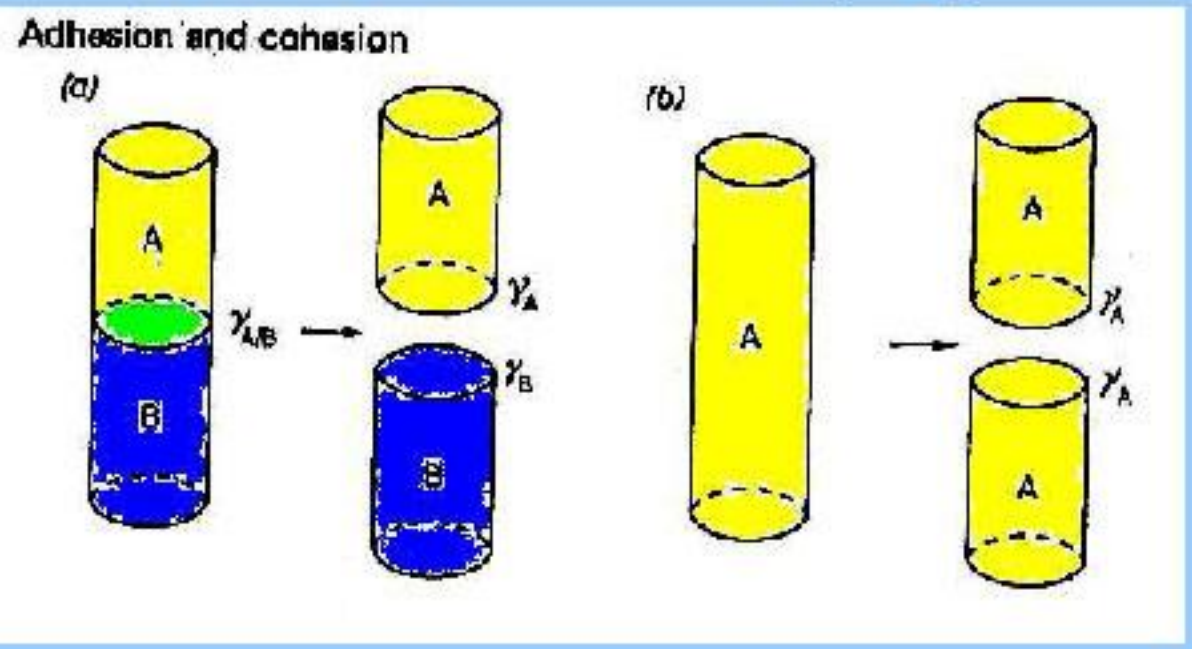
$$W^{coh} = 2\sigma$$

Using the Young-Dupré equation:

$$W^{adh} = \sigma_{lv}\cos\theta + \sigma_{lv}$$

ADESI, KOHESI, DAN PENYEBARAN

$W_a = \gamma_B + \gamma_A - \gamma_{AB}$ $W_c = 2\gamma_A$



interface

spreading coefficient:

$S = W_a - W_c = \gamma_B - (\gamma_A + \gamma_{AB})$

low phase

upper phase

$S = \gamma_{low} - (\gamma_{upper} + \gamma_{interfac})$

$$S_{12} = -\left(\frac{dG}{dA}\right)_{T,P}$$

The work of **adhesion** between two immiscible liquids is equal to the work required to separate unit area of the interface and form two new separate liquid-air interfaces of two pure materials

The work of **cohesion** for a single liquid corresponds to the work required to pull apart a column of liquid of unit area cross-sectional area

If S>0 will spread, if S<0 will not spread