Surface Tension

Surface tension

The property of liquid surface by which it act as stretched membrane and always, in tension is called surface tension. Due to surface tension it tends to occupy minimum surface area ie. Spherical shape. Surface tension on liquid surface is force per unit length measured by imaginary line drawn on liquid surface perpendicular to it.

$\therefore$ Surface tension (T) = $\frac{F}{l}$

$\therefore$ Force (F) = Tl

It is a scalar quantity of unit Nm^{-1}

Surface energy

The total amount of work done to bring all the molecules on surface of liquid from body is stored as energy of liquid surface is called surface energy.

Change in surface energy (ΔE)= T $\delta\Delta$A

or, T = $\frac{\Delta E}{\Delta A}$ hence change in surface energy per unit area is numerically equal to surface tension.

$\rightarrow$ Energy required to split a drop of radius R in n drops of equal size is E = 4πR^{2}T $[n^{1/3} - 1]$

Same amount of energy is releases if drop coalesce to form a single drop

$\rightarrow$ Energy required to form a drop of radius 'R' and surface tension 'T' is

E = 4πR$^2 \times$ T.

$\rightarrow$ Energy required to form a soap bubble of radius R and surface tension T is

E = 8πR$^2 \times$ T.

$\rightarrow$ Energy required to increase the radius of soap bubble from r_1 to r_2 is

E = 8π($r_2{}^2 - r_1{}^2$) $\times$ T

$\rightarrow$ Energy required to increase the radius of liquid drop from r_1 to r_2 is

E = 4π($r_2{}^2 - r_1{}^2$) $\times$ T.

Excess pressure

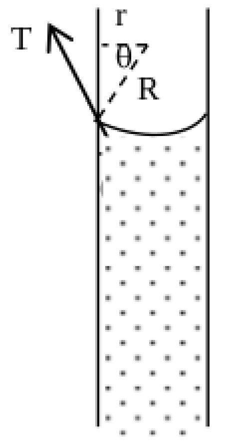
The pressure in concave side is always greater than pressure on convex side so the difference in pressure is called excess pressure

i. For spherical surface, of one free surface excess pressure (P) = 2T/R
ii. For spherical surface of two free surface like soap bubble
   Excess pressure (P) = 4T/R
iii. For a single cylindrical surface
   Excess pressure (P) = T/R
iv. For liquid between two plates at d
   Excess pressure (P) = T/d/2 = 2T/d

Capillarity

Phenomenon of rise or fall of liquid level in a fine bored capillary tube dipped in liquid is called capillarity. Liquid which wet the wall of tube, the level of liquid rises and liquid which does not wet wall, liquid fall.

If a liquid meniscus of radius 'R' is formed in capillary tube of radius 'r' then



$\rho \mathrm{gh} = \frac{2T}{R}$

$\therefore \mathrm{h} = \frac{2T}{\rho g R}$

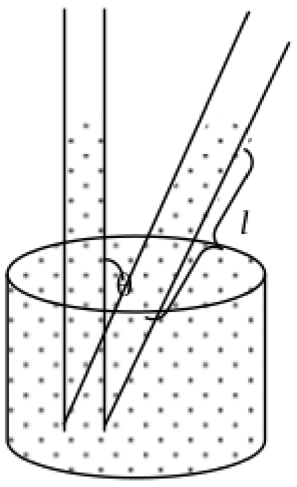
Again $\mathrm{Cos}\,\theta = \frac{r}{R}$

or, $\mathrm{R} = \frac{r}{\cos\theta}$

$\therefore \mathrm{h} = \frac{2T\cos\theta}{\rho g r}$

$\rightarrow$ If length of capillary tube is not sufficient then liquid rises to top at which angle of contact & radius of meniscus increases.

$\rightarrow$ If capillary tube is tilted then height of liquid column remain same but length of liquid column increases



cos$\theta = \frac{h}{l}$

$\rightarrow$ When capillary tube of different radii are in liquid then height of liquid column is related with radius by

r $\propto \frac{1}{h}$

or, rh = contant

or, $r_1 h_1 = r_2 h_2$

Adhesive force & cohesive force & angle of constant

Adhesive force

Force of attraction between molecules of different substance is called adhesive force

Cohesive force

Force of attraction between molecules of same substance

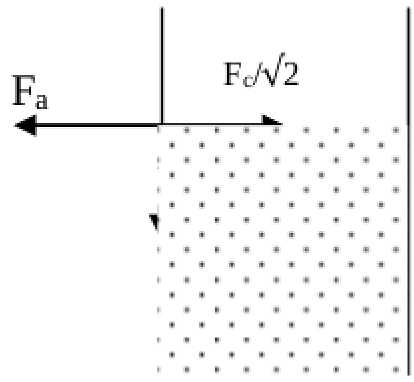
Angle of contact (θ)

The angle made by tangent at point of contact with wall of capillary tube inside liquid surface is called angle of contact.

Value of angle of contact for pure water with glass is 0^o, ordinary water & clean glass is8^o. For Hg is 135^o

Shape of liquid meniscus

Adhesive force act away from wall of capillary tube & cohesive force act towards body of liquid



i. IF $F_a > \frac{F_c}{\sqrt{2}}$, then shape of meniscus is concave

ii. If $F_a < \frac{F_c}{\sqrt{2}}$, then shape of liquid meniscus is convex

iii. If $F_a = \frac{F_c}{\sqrt{2}}$ then shape of liquid meniscus is plane

Effect of temperature on surface tension

The surface tension of liquid decreases on increasing temperature, but surface tension of molten cadmium increases on increasing temperature.

$\rightarrow$ On adding highly solute impurities surface tension increases and on adding slightly soluble impurities surface tension decreases