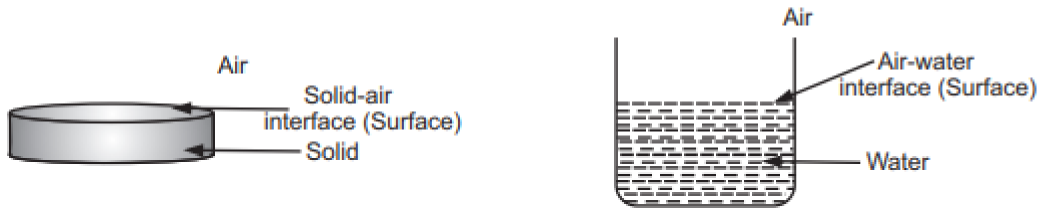
Unit III

Surface and interfacial phenomenon

The term surface is used to represent the boundary between solid-gas and liquid-gas phases. The two words surface and interface often used synonymously, although interface is preferred for the boundary between two condensed phases i.e. liquid-liquid. The cases where the two phases are formed explicitly for example, solid-gas and liquid-gas interface, the term surface is used as illustrated in Fig.



(a) Solid Surface, for example, Tablet

(b) Liquid Surface, for example, Water in Beaker

Figure: Types of Surfaces

The boundary that exists between two immiscible phases is called as interface. Several types of interface are possible depending on whether the two adjacent phases are in the solid, liquid or gaseous state as shown in Fig.

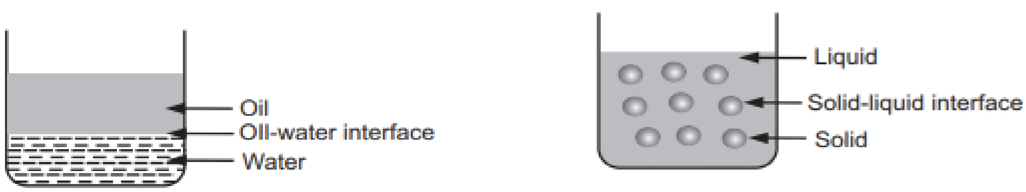
The interface is further divided into solid interface and liquid interface.

Solid interface is associated with solid and gas phases, solid and liquid phases or solid and solid, while liquid interface deals with association of liquid-gas phase or liquid-liquid phase, Table.

Table: Classification of Surface/Interface of Systems

Phases	Type	Example
Gas/gas	No interface possible	Air
Gas/liquid	Liquid surface	Water exposed to air
Gas/solid	Solid surface	Bench top
Liquid/liquid	Liquid-liquid interface	Oil on water surface
Liquid/solid	Liquid-solid interface	Suspension
Solid/solid	Solid-solid interface	Powder mixture

The word surface is used to designate the limit between a condensed phase and a gas phase, whereas the term interface is used for the boundary between two condensed phases.



(a) Liquid/Liquid Interface, for example, Oil on Water Surface

(b) Solid-liquid Interface, for example, Suspension

Figure: Types of Interfaces

The interface has applications such as adhesion between particles or granules, manufacturing of multilayer tablets, application of powders to body, flow of materials, and adsorption of colours etc.

Whereas, solid-liquid interface has applications in the biopharmaceutical study, filtration processes, chemical interaction, adsorption studies, preparation of dispersed systems like colloids, emulsions, suspensions, wetting of solids etc.

Natural process:

The phenomenon of surface tension is responsible for the following processes.

- Formation of spherical globules in emulsion
- Formation of nearly spherical shape of falling water droplets.
- Formation of spherical shape of mercury particles on a flat surface
- Rise of liquid in a capillary tube.
- Formation of hemispherical surface, i.e. lower meniscus, when water is filled in a glass tube.

Important of Interfacial phenomena in pharmacy:

- Adsorption of drugs onto solid adjuncts in dosage forms.
- Penetration of molecules through biological membranes.
- Emulsion formation and stability.
- The dispersion of insoluble particles in liquid media to form suspensions.

Surface tension:

The tension that exists between solid-gas phase and liquid-gas phase is known as surface tension. The origin of surface tension in a liquid is the cohesive force of attraction between the molecules that make-up the liquid. In the absence of other forces, this mutual force of attraction of the molecules causes the liquid to coalesce in accordance with the LaPlace law. In the bulk of liquid each molecule is pulled equally in all direction by neighbouring liquid molecule resulting in a net force of zero, Fig.

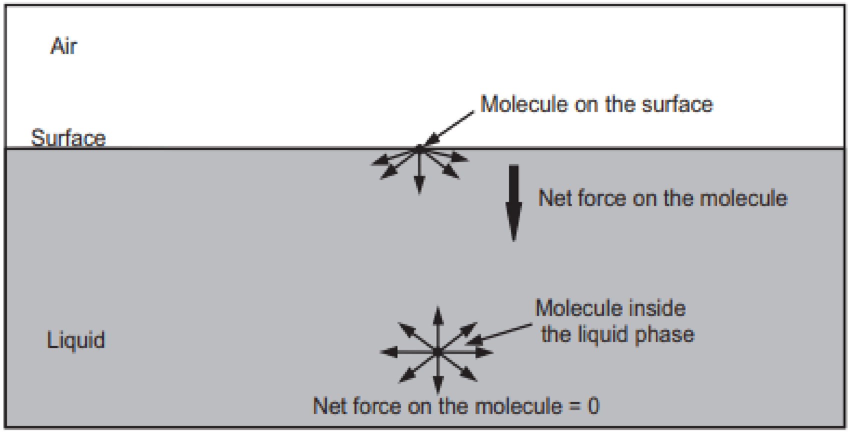


Figure: Tension at the Surface of Liquid

The molecules at the deep inside the bulk of the liquid pulls the molecules present at surface inwards, but there are no liquid molecules on the outside to balance these forces. There may be a small outward adhesive force of attraction caused by air molecule, but as air is much less dense than the liquid, this force is negligible. All of the molecules at the surface are therefore subject an inward force of cohesive molecular attraction leading to squeezing of liquid together until it has the lowest surface area possible. This force is the surface tension, defined as the magnitude of the force acting perpendicular to a unit length of a line at the surface. According to definition, surface tension is expressed as:

$$\gamma = \frac{F}{L}$$

Where, the symbol γ represent surface tension and F is the force perpendicular to the length l. Surface tension is represented by different symbols like γ, τ or σ.

A few examples of liquids with their surface tensions and interfacial tensions against water are given in Table.

Spherical drop:

Liquids has tendency to reduce its exposed surface to the smallest possible area and hence a drop of liquid tends to assume the shape of sphere. This phenomenon is attributed to cohesion, i.e. stronger attractive force acting between the molecules of the liquid, Fig.

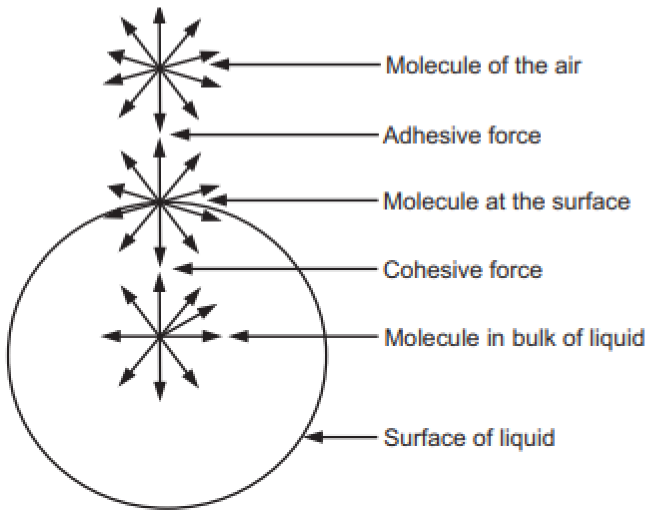


Figure: Forces Acting in the Formation of liquid Drop

The molecules within the liquid are attracted equally from all sides, but those near the surface experience unequal attractions and thus are drawn toward the centre of the liquid mass by this net force. The surface then appears to act like an extremely thin membrane, and the small volume of water that makes-up a drop assumes the shape of sphere. The spherical shape held constant with equilibrium between the internal pressures due to surface tension.

Unit of Surface Tension:

The CGS unit of surface tension is dyne/cm and SI unit is N/m. The relation between these units is as N/m is equal to 1 × 103 dyne/cm or dyne/cm is equal to m N/m.

Interfacial tension:

When two miscible liquids combined together no interface exist between them for example, ethyl alcohol and water mixture. Wherever, if two immiscible liquids combined there exists an interface between them. The tension exerted at the interface between them is due to difference in forces acting on molecules of immiscible liquids.

For example, chloroform and water, olive oil and water etc. Interfacial tension is defined as the force per unit length acting at right angle over the interface between two immiscible liquids.

Interfacial tension represents the strength of adhesive forces at the boundary between two immiscible liquids. Interfacial tension is useful in analyzing fluid reforming, spreading, emulsification, washability and other liquid characteristics. The surface tensions of some liquids and their interfacial tensions against water at 20 °C are given in Table.

Table: Surface and Interfacial Tensions (dyne/cm or mN/m) of Some Liquids at 20°C

Liquid	Surface tension	Interfacial tension against water
Water	72.75	–
n-Octanol	27.50	8.5
Carbon tetrachloride	26.8	45.0
Chloroform	27.10	32.8
Olive oil	35.8	22.9
n-hexane	18.4	51.1
Mercury	470.0	375.0
Oleic acid	32.5	15.6
Benzene	28.88	35.0
Ethyl ether	17.0	10.7
Glycol	47.7	
Ethyl alcohol	22.4	
Isopropyl alcohol	21.7	

Unit of Surface and Interfacial Tension:

Interfacial tension has units that of surface tension, that is dyne/cm or N/m.

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