The Hashemite University
Faculty of Pharmaceutical Science

Physical Pharmacy II

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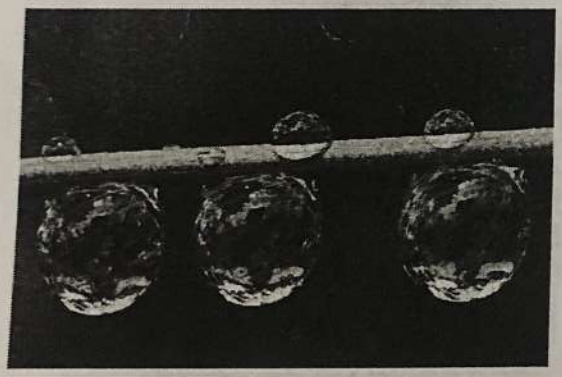


Interfacial Phenomena

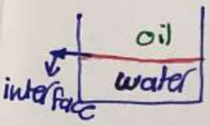
*Surface :- between liquid and air
Solid and air
∴ the other Phase is air (gas)

*interface :- between two
Liquids (immiscible يكونوا لازم)
Solids

Objectives

- To differentiate among different types of interfaces and describe relevant examples in the pharmaceutical sciences.
- To understand the terms surface tension and interfacial tension and their application in pharmaceutical sciences.
- To know the different methods of surface and interface tension measurements.
- To calculate surface and interface tensions, surface free energy, its changes, work of cohesion and adhesion, and spreading coefficient for different types of interfaces.
- To classify surface-active agents and appreciate their applications in pharmacy.

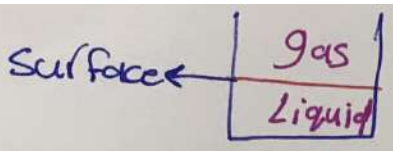
Introduction



- Several types of interface can exist, depending on whether the two adjacent phases are in the solid, liquid, or gaseous state.
- There is **no interface between gases.**
- These various combinations are divided into two groups, namely, **liquid interfaces** and **solid interfaces**.

CLASSIFICATION OF INTERFACES

Phase	Interfacial Tension	Types and Examples of Interfaces
Gas–Gas	—	No interface possible
Gas–liquid	γ_{LV}	Liquid surface, body of water exposed to atmosphere
Gas–solid	γ_{SV}	Solid surface, table top
Liquid–liquid	γ_{LL}	Liquid–liquid interface, emulsion
Liquid–solid	γ_{LS}	Liquid–solid interface, suspension
Solid–solid	γ_{SS}	Solid–solid interface, powder particles in contact



* في حال عندي Liquid وما عندي اشي تاني فوقه فقط gas
interface between Liquid/gas فبكون عندي

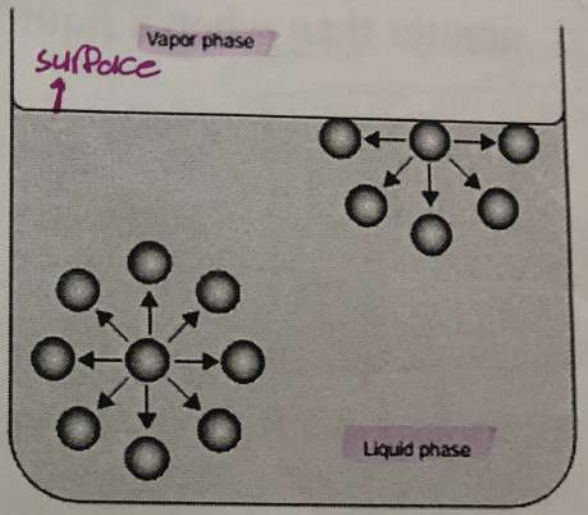
Introduction

interface الـ بيطل one of the phase عنا (gas) لما يكون

- In case one of the phases is gas→ term **surface** is used. يصير اسمه Surface
- **Every physical entity** possesses an interface at its boundary with its surroundings.
- Interfacial phenomena in pharmacy and medicine are significant factors:
  - adsorption of drugs onto solid adjuncts in dosage forms
  - penetration of molecules through biologic membranes,
  - emulsion formation and stability
  - the dispersion of insoluble particles in liquid media to form suspensions.
  - There is a relationship between surface properties of drugs and their biologic activity
  - The interfacial properties of a surface active agent (SAA) lining the alveoli of the lung are responsible for the efficient operation of this organ

Liquid interfaces

- 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 center of the liquid mass by this net force.



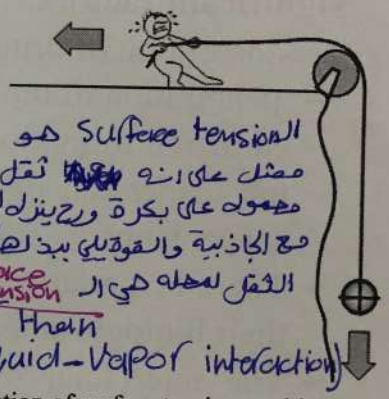
- The surface then appears to act like an extremely thin membrane, and the small volume of water that makes up a drop assumes the shape of a sphere, held constant when an equilibrium between the internal pressure and that due to surface tension is reached.

Definition of Surface Tension

- The surface tension: is the magnitude F of the force exerted **parallel** to the surface of a liquid divided by the length L of the line over which the force acts:

- $\gamma = \frac{force}{length}$

- Unit of surface tension: dyne/cm, N/m



Visualization of surface tension as akin to a person lifting a weight up the side of a cliff by pulling the rope in a horizontal direction.[7]

surface tension هو
مقدار على انه ثقل
محمول على بكرة ويحتاج لقوة
مع الجاذبية والقوة اللي بدنا اياها اكتر اشي
surface tension الثقل لمحله هي ال

Surface tension > interfacial tension
interaction في حسب ال

(Adhesive forces between two liquids usually greater than liquid-vapor interaction)

- the difference between interfacial tension and Surface tension ؟.

- surface tension is defined to a single liquid surface, whereas the interfacial one is defined to the interface of two immiscible liquids.

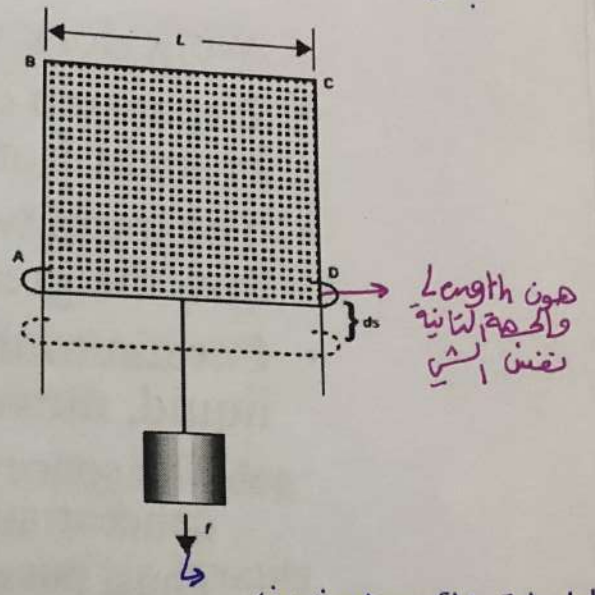
Interfacial tension is defined to the interface of two immiscible li

Definition of Surface Tension

- Interfacial tensions are less than surface tensions because the adhesive forces between two liquid phases forming an interface are greater than when a liquid and a gas phase exist together.

Definition of Surface Tension

- Surface tension as a force per unit length can be illustrated by means of a three-sided wire frame across which a movable bar is placed.
- A soap film is formed over the area ABCD and can be stretched by applying a force f (such as a hanging mass) to the movable bar, length L, which acts against the surface tension of the soap film.
- When the mass is removed, the film will contract owing to its surface tension.
- The surface tension, γ , of the solution forming the film is then a function of the force that must be applied to break the film over the length of the movable bar in contact with the film
- $\gamma = fb/2L$ (fb is the force required to break the film and L is the length of the movable bar)



حتى امنع الشد بأثر على بشغل من تحت

Length هون والجهة الثانية نفس الشي

لما بذلت work هون عن طريق force وشديت لتحت عملت زي إزاحة (ds) ، لما صبت الـ film زادت المساحة

شرح هاد السلايد

ممكن نتخيل الـ three-sided wire frame بكون عندي surface tension بس بقدر احركه (movable) ونفس فكرة بابلز الصابون

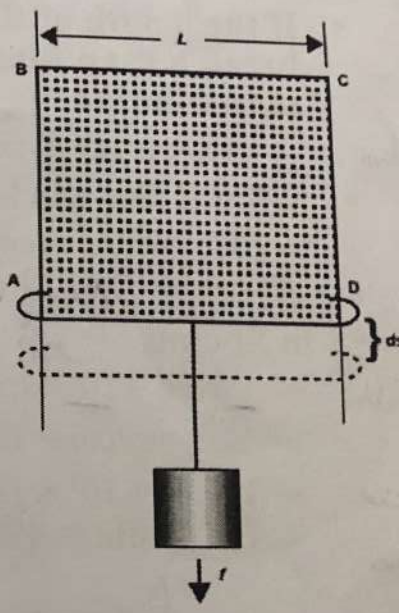
لو حطينا هاد الـ frame بسائل بحتوي على صابون رح يطلع عنا film وكان الـ frame هاد متحرك وحطينا فيه ثقل بالتاي الثقل رح يسحب الـ film لتحت (detachment) وهاي الانفصال هي الـ surface tension يلي بدنا نقيسها

Surface free energy

- Work done (energy) in increasing

Surface free energy

- Work done (energy) in increasing the surface area.
- $f = \gamma \times 2L$
- $dW = f \times ds = \gamma \times 2L \times ds$
- $dW = \gamma \times dA$
- where W is the work done, or surface free energy increase, expressed in ergs, γ is the surface tension in dynes/cm, and dA is the increase in area in cm^2.



work كلما زاد الـ
surface free بزيد الـ
energy

Surface free energy

- Work done (energy) in increasing the surface area.
- Expansion occurs and more molecules must be brought from the bulk to the interface.
- The more work that has to be expended to achieve this, the greater is the surface free energy.
- Certain molecules and ions, when dispersed in the liquid, move of their own accord to the interface.
  - The concentration at the interface then exceeds their concentration in the bulk of the liquid.
  - Thus, the surface free energy and the surface tension of the system are automatically reduced.

Surface tension and surface free energy

Example

- **If the length of the bar, L, is 5 cm and the mass required to break a soap film is 0.50 g, what is the surface tension of the soap solution? (g=981 cm/sec^2)**
  - Answer: 49 dynes/cm
- **What is the work required to pull the wire down 1 cm?**
  - $W = 49$ dynes/cm × 10 cm^2 = 490 ergs
- In SI units
  - 1 dyne = 10^{-5} N, or 49 dynes = 49×10^{-5} N
  - 49 dynes/cm = 49×10^{-3} N/m = 49×10^{-3} Nm/m^2 = 49×10^{-3} joule/m^2
  - 1 joule = 10^7 ergs. Therefore, W = 49×10^{-3} Nm/m2 × 10^{-3} m^2 = 490×10^{-7} joule = 490 ergs.

Surfactants (surface active agents): 1- Polar head, 2- nonpolar tail (two parts)

$W = \gamma * \Delta A \, (dA)$

surface tension $\gamma = \frac{f}{2L}$ (f = force, L = length)

$\gamma = \frac{981 * 0.50}{2 \times 5} = 49$

force: N, dynes

Length: m, cm

(N/m إلى joule/m^2)

ماشرحته

Surface tension

- From thermodynamics, at **T and P constant**, the surface tension can be viewed as the increment in **Gibbs free energy per unit area.**
- $\gamma=(\frac{dG}{dA})_{T,P}$
- $G^S = \gamma = H^S - TS^S$
- $(\frac{\partial G}{\partial T})_{P=} (\frac{\partial G}{\partial p})_{T=} - S^S$
- $\gamma = H^S + T (\frac{\partial G}{\partial T})_P$
- H^S and S^S units are given in two dimensions, ergs/cm^2 deg for S^S and ergs/cm^2 for Hs in the cgs system. In the SI system, Ss is given in units of joule/m^2 deg and Hs in units of joule/m^2.

طريقة أخرى للتعبير عن الـ surface tension

Pressure differences across curved interface

دائمًا بأثر على المساحة

* الـ surface tension دائمًا مرتبط بـ circumstances مثل الطول أو المحيط...

مشابهة عنا قوة خارجية بتعمل contraction للداخل ← كمان في قوة ثانية بتعاكسها والي هي الضغط حتى نصل للاستقرار

- W external= $4 \Pi \gamma (r-dr)^2$
- W internal= $\Delta p \times 4 \Pi r^2 \times (-dr)$

  $\Delta p = 2 \gamma / r$

- This is simplification of Young Laplace equation

المحيط = diameter × π (للـ sphere)

diameter: the length of the line through the center that touches two points on the edges of the circle

Shpere

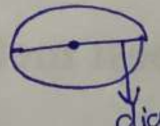
- بالنسبة لـ dA ⇐ الشكل كروي (sphere)

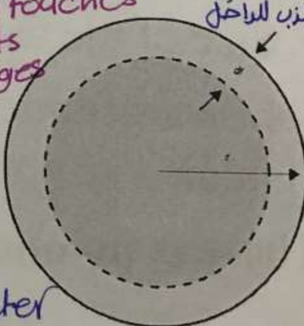
⇐ مساحة الـ sphere

⇐ $A = 4\pi r^2$

- الـ $w = \gamma * dA$ (الـ surface tension الموجودة)

- ولأنه صار عندي contraction (r) رح يقل بمقدار (dr) نصف القطر





في surface tension بتأثر وبتسحب الـ molecules لجوا المحيط

*هاي الطريقة بتفسر ليش الماء على شكل drops ⇐ لأنها أقل surface area بالتالي أقل surface tension (surface free energy).

بالتالي القانون رح يصير $w = \gamma 4 \pi (r-dr)^2$