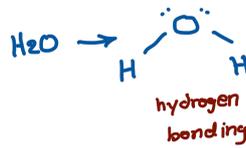


Rheology: the science that is concerned with the viscosity of materials and the ability to flow of liquids and semi solid materials (gels for example).

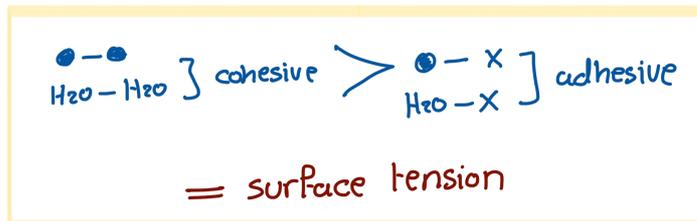
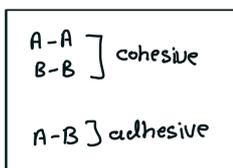
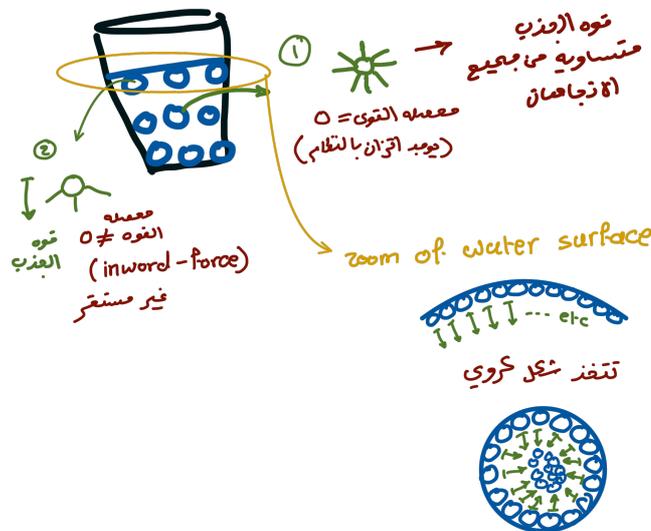
Interfacial Phenomena

Prof. Nizar Al-Zoubi

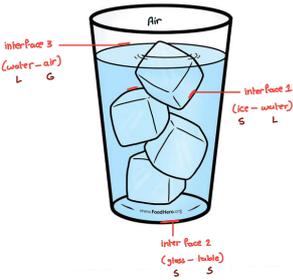


حقدعه كيوتاه

As a result of Δ attraction forces.



Surface and Interfacial Tensions

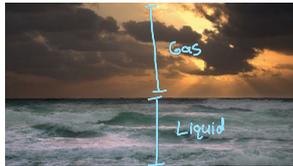


*if the interface was :

G-S / G-L

يسمى surface

ذي سطح البعير



- **Interface** is the boundary between two phases.
- **Surface** is a term used to describe either a gas-solid or a gas-liquid interface.
- **Interfacial phase** is a term used to describe molecules forming the interface between two phases which have different properties from molecules in the bulk of each phase.

الحد الفاصل

مصطلح لوصف الجزيئات الموجودة على الحد الفاصل بين phases

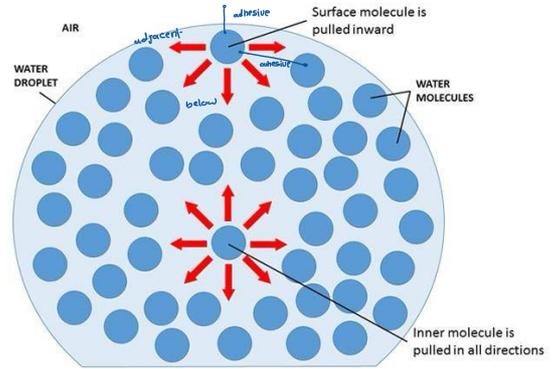
Surface and Interfacial Tensions

Phase	Interfacial Tension γ	Types & Examples of Interface
Gas - gas <i>Always miscible in each other</i>	-	No interface possible
Gas - liquid	γ_{LV} <i>vapor liquid</i>	Liquid surface, body of water exposed to atmosphere <i>سطح</i>
Gas - solid	γ_{SV} <i>vapor solid</i>	Solid surface, table top <i>G-S ✓</i>
Liquid - liquid	γ_{LL}	Liquid-liquid interface, emulsion <i>L-L x not surface</i>
Liquid - solid	γ_{LS}	Liquid-solid interface, suspension
Solid - solid	γ_{SS}	Solid-solid interface, powder particles in contact.

← surface

Surface and Interfacial Tensions

- Molecules in the bulk liquid are surrounded in all directions by other molecules for which they have an equal attraction (only **cohesive** forces).
- Molecules at the surface can only develop cohesive forces with other molecules that are below and adjacent to them; and can develop **adhesive** forces with molecules of the other phase.
- This imbalance in the molecular attraction will lead to an inward force toward the bulk that pulls the molecules of the interface together and contracts the surface, resulting in a **surface tension**.



توتر السطح (الشدة) باتجاه الكالط دائفًا

تفاسه شذ:

قوة الجزيء

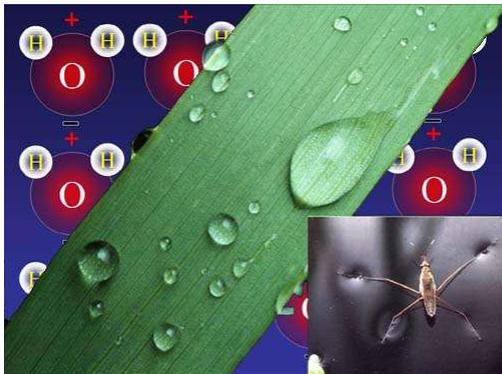
Intramolecular forces:
Ionic>covalent>metallic

Intemolecular forces:
• Ion-dipole>ion-induced dipole>hydrogen bond>keesom>Debye>London

Ⓢ No. molecules

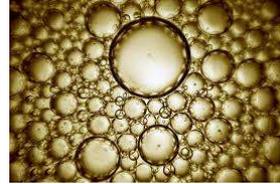
Surface and Interfacial Tensions

- ① **Surface tension** is the work per unit area (force per unit length) that must be applied parallel to the surface to counterbalance the net inward pull. It has the units of **dynes/cm** or **N/m**.
- The term **surface tension** is reserved for the tensions:
 - Liquid-vapor = γLV (written simply as γL).
 - Solid-vapor = γSV (written simply as γS).



Surface and Interfacial Tensions

- ② **Interfacial tension** is the work per unit area (force per unit length) existing at the interface between two immiscible liquid phases (units are dynes/cm or N/m).
- The term **interfacial tension** is used for the force between:
 - Two liquids = γ_{LL}
 - Two solids = γ_{SS}
 - Liquid-solid = γ_{LS}

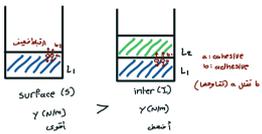


Surface and Interfacial Tensions

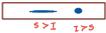
- Interfacial tensions are normally weaker than surface tensions because the adhesive forces between two liquid phases forming an interface are greater than that between liquid and gas phases. Adhesive \propto Surface γ

(يمثل مصفوفة قوى التماسك)

Substance	Surface tension (at 20 °C) (mN m ⁻¹) <small>milliN/m</small>	Interfacial tension (at 20 °C) against water (mN m ⁻¹)
Water	72	water-water (miscible)
Glycerol	63	highly soluble in water
Oleic acid	33	16
n-Octanol <small>(lipophilic, weaker cohesive forces)</small>	27	8.5



b1 pull stronger that means it will resist the forces more making it weaker



سؤال
* $\gamma_{\text{water-air}} > \gamma_{\text{oil-air}}$
why? bc cohesive forces for
water > oil
(hydrophilic) (lipophilic)

"Why does the cohesive forces in lipophilic substances is weaker than it in the hydrophilic substances?"

Great question! It all comes down to the molecular interactions. In hydrophilic substances, the molecules can form strong hydrogen bonds with water, which are cohesive in themselves and also attract each other more strongly. By contrast, in lipophilic substances, the molecules are nonpolar and rely mostly on weaker van der Waals forces, making their cohesive forces generally weaker.



Surface and Interfacial Tensions

تغير بتغير درجة الحرارة ← الحرارة تضعف الروابط
Temp

TABLE 3.1 Surface Tension of Water at Various Temperatures

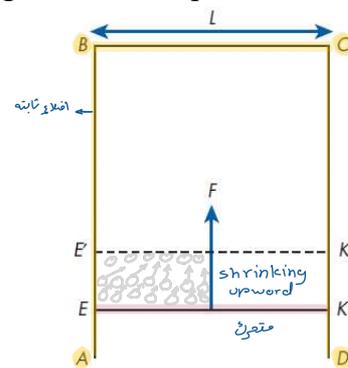
Temperature (°C)	Surface Tension (dynes/cm)
0	76.5
20	72.8
30	71.2
75	63.5
100	58.0

Surface tension

- It is possible to illustrate surface tension by using a wire frame ABCD.
- The ABCD part of the frame is **rigid**, and only the EK part can slide along the frame sides AB and DC.
- If a soap solution is placed on the frame, it will create a thin film, and then **the film will try to shrink itself**, forcing the movable part of the frame (EK) to move closer to the BC side.
- The new position of the movable part will be E'K'.
- **The force F** required to move the EK part is **proportional to the surface tension g times 2** (since the film has two surfaces) times the length L of the EK bar:

$$F = g \times 2 \times L$$

g surface tension
 L length of movable part (EK)

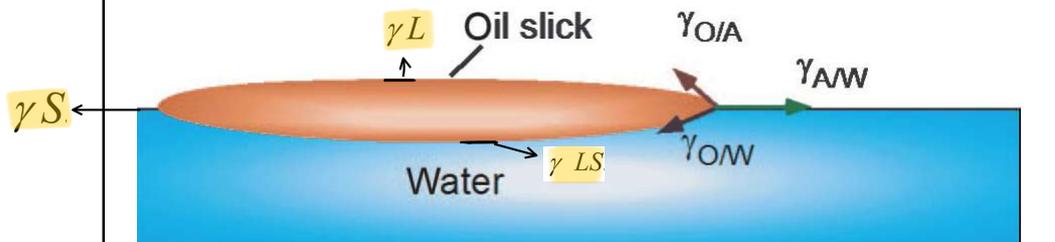


طبقتين من الصابون ←

more molecules higher force

Spreading Coefficient

- When $\gamma_S > (\gamma_L + \gamma_{LS})$, (S is positive), Spreading occurs.
- When $\gamma_S < (\gamma_L + \gamma_{LS})$, (S is negative), the substance forms globules or a floating lens and fails to spread over the surface (e.g. mineral oil on water).



تحويل الوحدات

$$\begin{aligned} \gamma_{LS} &= 0.035 \text{ N/m} \\ &= 35 \text{ dynes/cm} \end{aligned}$$

$0.035 \frac{\text{N}}{\text{m}} \xrightarrow{10^5} \text{dynes}$
 $\xrightarrow{100} \text{cm}$

$\therefore 0.035 \text{ N/m} \xrightarrow{*10^3} 35 \text{ dynes/cm}$

Spreading Coefficient

Example بنزين على الماء \rightarrow الماء \rightarrow البنزين
Spreading (Benzene over Water) water = 72.8 benzene = 28.9

- If the surface tension of water γ_S is 72.8 dynes/cm at 20°C, the surface tension of benzene, γ_L , is 28.9 dynes/cm, and the interfacial tension between benzene and water, γ_{LS} , is 35.0 dynes/cm, what is the spreading coefficient?

Answer

$$S = \gamma_S - (\gamma_L + \gamma_{LS}) = 72.8 - (28.9 + 35.0) = 8.9 \text{ dynes/cm}$$