Lab1
Physical Pharmacy
Solubility

The concentration Of solute in saturated solution at certain temperature. **(quantitatively)**

Spontaneous interaction of two or more substances to form homogeneous dispersion **(qualitatively).**

Solubility

Saturated solution: is one in which the solute is in equilibrium with the solid phase (solute)

Unsaturated or sub-saturated solution: is the one containing the dissolved solute in concentration below that necessary for complete saturation at certain temperature.

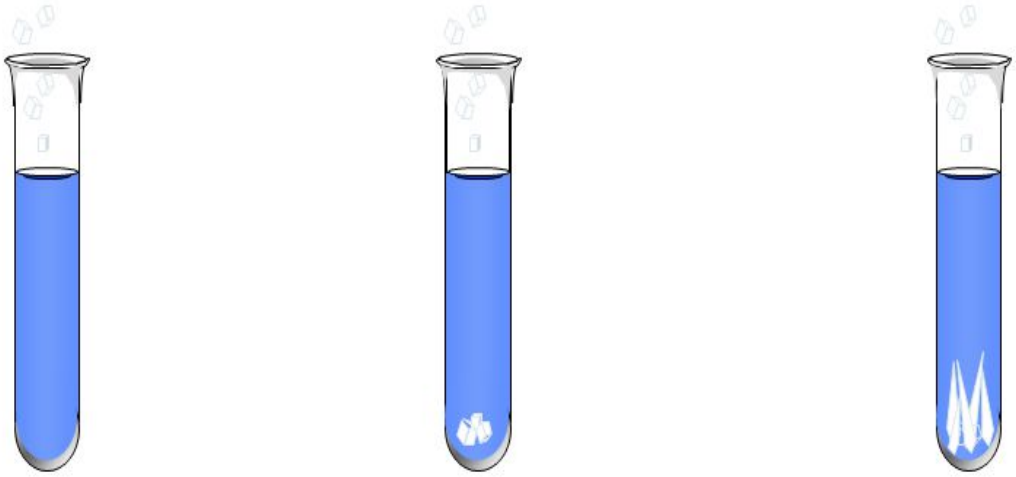
supersaturated solution: is the one containing more of the dissolved solute that it normally contain at certain temperature where the undissolved solute present.

Solubility

UNSATURATED SOLUTION
more solute dissolves

SATURATED SOLUTION
no more solute dissolves

SUPERSATURATED SOLUTION
becomes unstable, crystals form



Increasing concentration

FACTORS AFFECTING SOLUBILITY

The solubility of a compound depends upon the physical (e.g., particle size)and chemical properties of the solute and solvent.

Other factors:

- **Temperature**: in general as the temperature of medium increase the solubility of compound increase.
- **Pressure**: in case of solubility of gas in liquid solubility increases as pressure increases (e.g., as in aerosol)

The interaction between solute and solvent (solubilization)

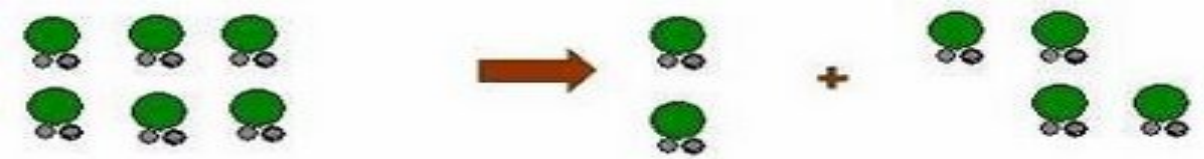
Interaction occur in three steps:

- the breaking of intermolecular or inter–ionic bond of solute
- the separation of molecules of solvent to provide a space for solute
- interaction between solvent & solute molecule or ion

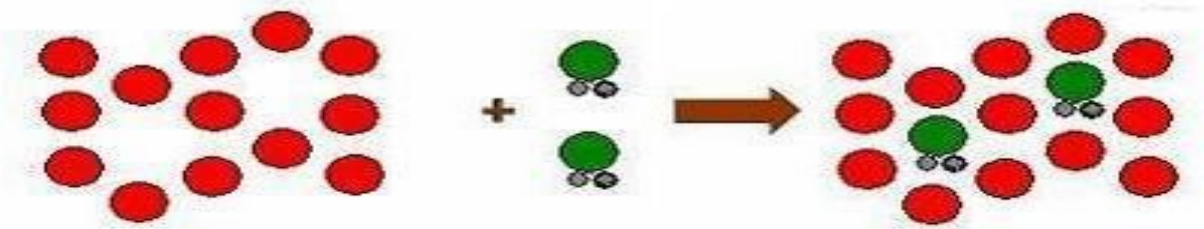
"like dissolves like"

Step 1: Holes opens in the solvent

Step2: Molecules of the solid breaks away from the bulk

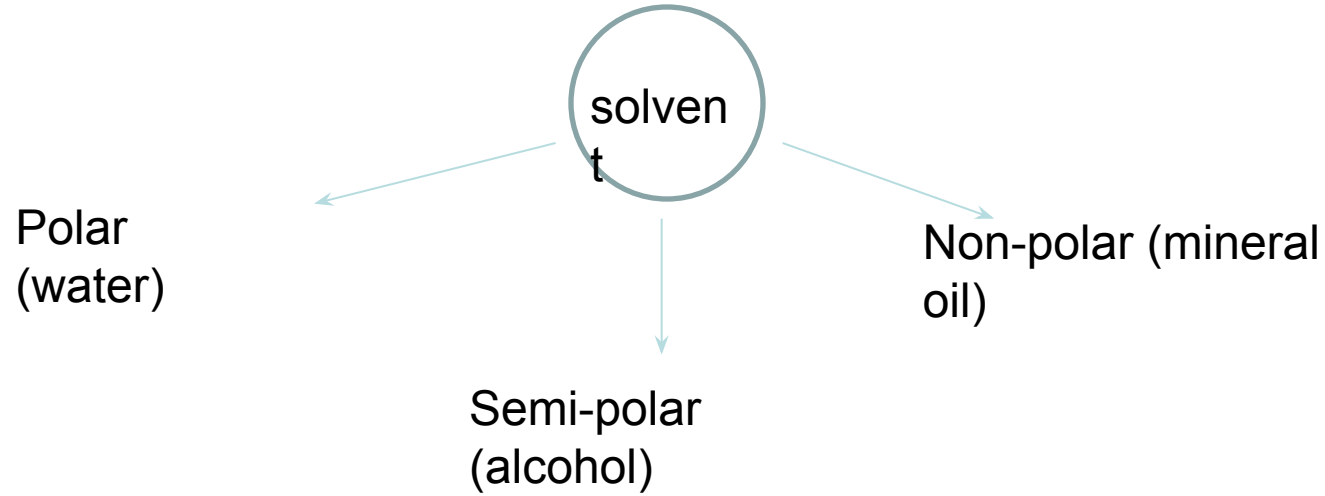


Step 3:The free solid molecule is integrated into the hole in the solvent



Like dissolves like

- Water is good solvent for salt, sugar and similar compounds.
- Mineral oil is good solvent for substance that are normally slightly soluble in water.



Solubility expression in USP

Solubility definition	Part of solvent required for 1 part of solute
Very soluble	Less than 1 part
Freely soluble	1-10 parts
Soluble	10-30 parts
Sparingly soluble	30-100 parts
Slightly soluble	100-1000 parts
Very slightly soluble	1000-10000 parts
Insoluble	More than 10000 parts

Polar solvent

- Water is polar solvent, its solvation action is related to:

1. Polarity or its dipole moment
2. Solvation by H-bond
3. By acid base reaction

Polarity

- The difference in electronic density on H and O atoms of water molecule.
- Electron sharing between H and O atoms is likely unequal (asymmetric distribution) causes shift of electronic cloud in the molecule.
- So the water molecules acts as dipole (having + ve and –ve pole) which is expressed quantitavely as dipole-moment.
- Increasing in dipole moment increases polarity of the solvent.
- The –ve pole attract +ve ion of solute while +ve pole attract –ve ion of solute so water considered as good solvent for ionic compound (e.g., NaCl)

Dielectric constant

- Is the property of solvent which is related to the amount of energy required to separate two oppositely charge bodies in the solvent as compared to the energy required to separate the same bodies in vacuum.
- For water = 78.5 at 18°C so it takes 78.5 more energy to separate opposite charged bodies in vacuum.

H-bonding and solvation

- The ability of solute to form H-bond is more significant factor than polarity.
- Water dissolves phenol, aldehyde, ketone and amine and other nitrogen and oxygen containing compounds due to H bonding.

acid-base

- water consider as good solvent for strong & weak electrolyte because it can break the covalent bond of the acid or base by acid-base reaction since water acts as amphiprotic (proton donor & acceptor)
- $HCL + H_2O \longrightarrow H_3O^+ + CL^-$

Non-polar solvent

- Hydrocarbon and mineral oils can dissolve non-polar solutes (such as CCl_4, benzene, fatty acids and alkaloid bases.
- Non-polar solvent cannot dissolve ionic or polar solute because it is unable to decrease attraction between ions of its low dielectric constant compared to that of water.
- Non-polar solvents cannot break the covalent bond nor ionize strong and weak electrolyte because they belong to aprotic solvent.
- They cannot form H-bond.

Semi-polar solvents

- Ketone and alcohol can induce certain degree of polarity in non-polar solvents.
- They act as intermediate solvent to bring about miscibility of polar and non-polar liquids.
- For example acetone increases the solubility of ether in water, and alcohol increases the solubility of chloroform in water.

Methods to increase solubility

1. Physical method

a. Particle size reduction: by decreasing particle size surface area will be increased and thus increasing solubility.

b. Solid dispersion

2. Chemical methods

a. pH change (salt formation): for weak acid such as salicylic acid; increase in the pH increase the ionization of salicylic acid (i.e., increase concentration of ionized form and thus the solubility).

since most of drugs are either weak acid or weak bases, their solubility can enhanced by adjusting the pH of solution, so keep drug in ionized form (salt form). Salt of weak acid and weak base have higher solubility than weak acid and weak base.

b. Complexation: it has been find that insoluble drug can form soluble complex with some compound.

inorganic and organic material which do not ionize may rendered soluble in polar solvent (e.g., water) by complexation with electrolyte

$$I_2 + KI \longrightarrow K^+I_3^-$$

Slightly soluble — Soluble

c. Prodrugs

3. **Miscellaneous methods:**

a. **Co-solvent (solvent combination):** the solubility of solute is quantitavely related to the dielectric constant of solvent system. For example a given solute will have qualitatively similar solubility profile with respect to the same dielectric constant for various co-solvent combination.

b. Using **surfactant (surface active agent)** in certain concentration.

Experimental work

1. **Solvent combination**

The objective of this experiment is to increase the solubility of salicylic acid (a weak organic acid) slightly water soluble by solvent combination; By addition of alcohol (e.g., ethanol) to water the dielectric constant will change (decrease).

Materials and equipments:

Salicylic acid, distilled water, ethanol 99%, conical flask, pipette, burette.

Procedure

1. Weigh 0.1 g salicylic acid and place it in conical flask.
2. Add 10 ml distilled water and shake the flask to see the solubility of salicylic acid in water.
3. Add from burette drop by drop absolute alcohol i.e., ethanol (99.9%) with continuous shaking until salicylic acid crystals dissolve.
4. Measure the amount of ethanol in the final mixture.
5. Calculate % of alcohol in the final mixture (v/v%).
6. Express the solubility of salicylic acid as 1 part of salicylic acid soluble in X parts of Y% hydro-alcoholic solution.

Discussion: discuss the result of the experiment.

2. Salt formation

The objective of the experiment is to increase the solubility of salicylic acid by salt formation using sodium carbonate (Na_2CO_3)

Material and equipment

Salicylic acid, sodium carbonate, distal water

Conical flask, pipette.

Procedure

1. Weigh 0.1 g salicylic acid and place it in conical flask
2. Add 10 ml distilled water and shake the flask to check solubility of salicylic acid.
3. Add 0.1 g sodium carbonate and shake the flask and observe the result.
4. Add 5 ml diluted HCl (10%) slowly and see the result
5. Develop equation to account for observation in step 3 and 4.

Discussion: discuss the results of the experiment

3- complexation:

The objective of the experiment: is to increase solubility of Iodine in water by forming soluble Complex upon the addition of potassium iodide.

Material and equipment

Iodine, potassium iodide, distal water

Conical flask, pipette.

Procedure

- 1-put (0.1 gm) iodine in conical flask
- 2- add (10 ml) water , shake and observe
- 3- add (0.2 gm) of potassium iodide
- 4-observe the result with equation

Discussion: discuss the results of the experiment

Thank You For Listening

It's time for question???