Emulsions

Emulsion is a dispersion in which the dispersed phase is composed of small globules of a liquid distributed throughout a vehicle in which it is immiscible.

The dispersed phase is the *internal phase* and the dispersion medium is the *external phase* or *continuous phase*.

A third phase which is essential for emulsion formation is the *emulsifying agent.*

Emulsions with an oleaginous internal phase and an aqueous external phase are oil in water (o/w) and vice versa, because the external phase of an emulsion is continuous, an o/w emulsion may be diluted or extended with water and w/o with an oleaginous liquid.

Depending on the constituents and the intended application, liquid emulsions may be employed orally, topically or parenterally.

Purpose of emulsions and of emulsification:

1. Facilitate the preparation of relatively stable and homogenous mixtures of two immiscible liquids.

2. Permits administration of a liquid drug in the form of minute globules rather than in bulk.

3. Administration of distasteful oil by dispensing it in a sweetened, flavored aqueous vehicle.

4. Reduced particle size of the oil globules may render the oil more digestible and more readily absorbed for example increased efficacy of mineral oil as a cathartic when emulsified.

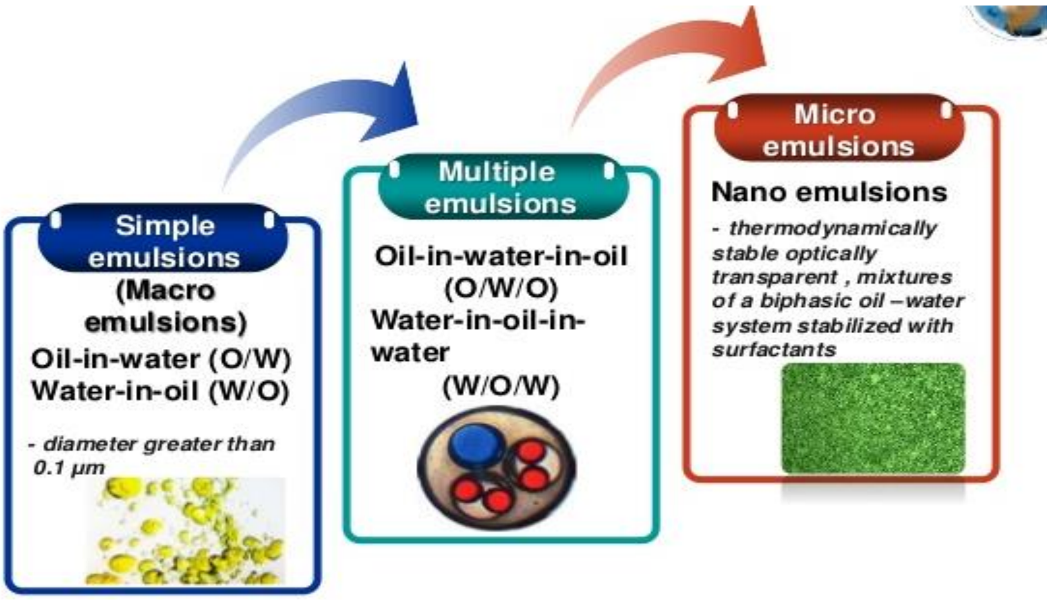
Emulsions applied topically may be o/w or w/o depending on:

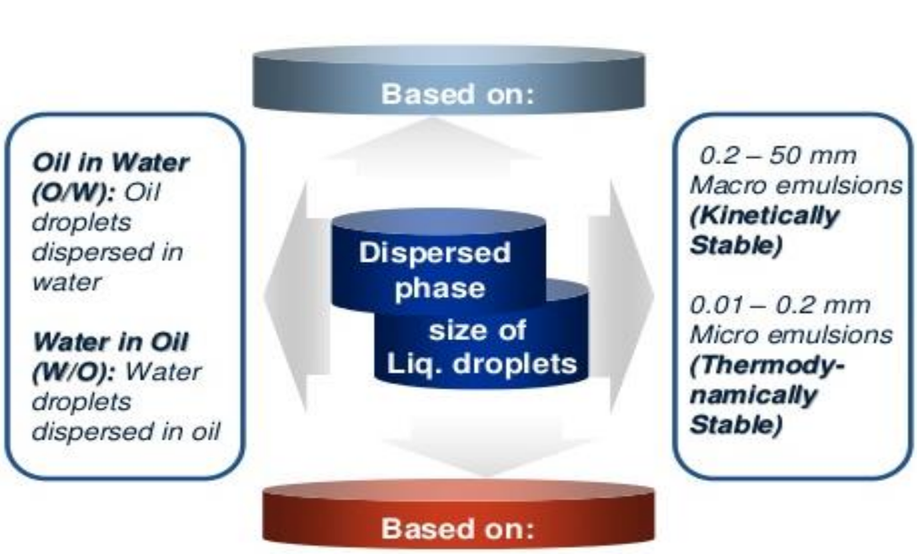
- Nature of therapeutic agents.
- Desirability for an emollient or tissue softening effect.
- The condition of the skin.

Medicinal agents that irritate the skin are less irritating in the internal phase, on the unbroken skin a w/o emulsion can be applied more evenly because the skin is covered within a thin film of sebum, also w/o emulsion is more softening the skin because it resists drying and removal on contact with water.

On the other hand if we desired to formulate emulsion which is easily washed off with water an o/w emulsion is preferred.

Types of emulsions:





Theories of emulsification:

We have many theories to explain how emulsifying agents promote emulsification.

1. Surface tension theory.
2. Oriented- wedge theory.
3. Interfacial film theory.

Surface tension theory

According to this theory, the use of surface active agents (surfactants) lowers the the interfacial tension of the two immiscible liquids, reducing the repellent force between the liquids and diminishing each liquids attraction for its own molecules.

Surfactants facilitate the breakup of large globules into smaller ones, which then have a lesser tendency to reunite or coalesce.

Oriented-wedge theory

This theory assumes monomolecular layers of emulsifying agent curved around a droplet of the internal phase of the emulsion depending on the solubility of these agents in that particular liquid.

Because emulsifying agents have hydrophilic portion and hydrophobic portion, they orient themselves according to solubility.

Emulsifying agents having greater hydrophilic than hydrophobic character will promote o/w emulsion and vice versa.

Plastic or interfacial film theory

This theory places the emulsifying agent at the interface between oil and water, surrounding the droplets of the internal phase as a thin layer of film adsorbed on the surface of the drops, the film prevents contact and coalescing of the dispersed phase.

Water soluble agents encourage o/w emulsion and oil soluble emulsifiers encourage w/o emulsion.

- In a given emulsion system more than one of the theories play a part.
- For example lowering of the interfacial tension is important in the in the initial formation of an emulsion but the formation of a protective wedge of molecules or film of emulsifier is important for continued stability.

Preparation of emulsions

The initial step in the preparation of emulsion is selection of the emulsifier which should has certain criteria:

- Should be compatible with the other formulative ingredients.
- Should not interfere with the stability or efficacy of the therapeutic agent.
- Should be stable and do not deteriorate in the preparation.
- Should be nontoxic with respect to its intended use.
- Should possess little odor, taste, or odor.

Among the emulsifiers for pharmaceutical systems are the following:

1. Carbohydrate materials such as acacia, tragacanth, agar and pectin. These aare form hydrophilic colloids when added to water, generally produce o/w emulsion.

2. Protein substances such as gelatin, egg yolk and casein. These prodce o/w emulsions.

The disadvantage of gelatin is that the emulsion is too fluid and becomes more fluid upon standing.

3. High molecular weight alcohols such as stearyl alcohol, cetyl alcohol and glycerol monostearate, these are employed as thickening agents and stabilizersfor o/w emulsion. Cholesterol and its derivatives used in emulsions to promote w/o emulsion.

4. Wetting agents which may be anionic, cationic or non ionic, these agents contain both hydrophilic and lipophilic groups.

Depending on their individual nature, certain members of these groups form o/w emulsions and others w/o emulsions.

Anionic : sodium lauryl sulfate, triethanolamine oleate.

Cationic : benzalkonium chloride.

Non ionic: sorbitan ester and polyoxy ethylene derivatives.

5. Finely divided solids such as bentonite, magnesium hydroxide and aluminium hydroxide. Generally, these form o/w emulsion.

- The relative volume of internal and external phases of an emulsion is an important, regardless of the type of emulsifier used.
- As the internal concentration of an emulsion increases, so does the viscosity of an emulsion to a certain point after which the viscosity decrease sharply. At this point the emulsion undergo *inversion* that is it has changed from an o/w to w/o and vice versa.
- Emulsions may be prepared without inversion with as much as about 75% of the volume of the product being internal phase.

The HLB system

Is a method whereby emulsifying or surface active agents may be categorized on the basis of their chemical makeup as to their hydrophilic-lipophilic balance.

Each agent is assigned an HLB value or number indicating the substance's polarity. The usual range is between 1 and 20, materials that are highly polar or hydrophilic have higher numbers than materials that are less polar and more lipophilic.

Table show the activity and HLB value of surfactants

Activity	Assigned HLB
Antifoaming	1-3
Emulsifiers (w/o)	3-6
Wetting agents	7-9
Emulsifiers (o/w)	8-18
Solubilizers	15-20

Detergents	13-16

Methods of emulsion preparation

On small scale extemporaneous preparation of emulsions, three methods may be used which are *continental or dry gum method*, *English or wet gum method*, and the *bottle or Forbes bottle method*.

Continental or dry gum method:

- It also referred to as the 4:2:1 method because for every 4 parts by volume of oil , 2 parts of water and 1 part of gum are added in preparing the initial or primary emulsion.
- In this method, the acacia or other emulsifier is triturated with oil in dry Wedgwood or porcelain mortar until thoroughly mixed.
- A mortar with a rough surface rather than a smooth surface must be used to ensure proper grinding and reduction of particle size.
- After the oil and gum have been mixed, the two parts of water are added all at once and the mixture triturated immediately, rapidly and continuously until the primary emulsion is creamy white and produces a crackling sound to the movement of pestle.
- Generally about 3 minutes of mixing is required to produce a primary emulsion.
- Other liquid formulative ingredients that are soluble in or miscible with the external phase may then be mixed into primary emulsion.
- Solid substances such as preservatives, stabilizers, colorants and flavoring agents are usually dissolved in a suitable volume of water and adds as a solution to the primary emulsion.

English or Wet gum method:

- The same proportions of oil, water and gum which are used in dry gum method but the order of mixing is different and the proportions of ingredients may be varied during preparation of the primary emulsion.
- The mucilage of gum is prepared by triturating in a mortar acacia with twice its weight of water.
- Oil is then added slowly in portions and the mixture is triturated to emulsify the oil

- After all oil has been added , the mixture is thoroughly mixed for several minutes to ensure uniformity
- Finally, other formulative materials are added and the emulsion is transferred to graduate and brought to volume with water.

Bottle or Forbes bottle method

- The bottle method is useful for preparation of emulsions from volatile oils and oleaginous substances of low viscosities.
- Powdered acacia is placed in a dry bottle, two parts of oil are added and the mixture is thoroughly shaken in the container.
- A volume of water approximately equal to that of oil is then added in portions and the mixture is shaken after each addition.
- When all of the water has been added, the primary emulsion has formed may be diluted to the proper volume with water or an aqueous solution of other formulative agents.

Stability of emulsions

Emulsion is considered to be physically unstable if

a. The internal or dispersed phase upon standing tends to form aggregates of globules.

b. Large globules or aggregates of globules rise to the top or fall to the bottom of the emulsion to form a concentrated layer of the internal phase.

c. If all or part of the liquid of the internal phase separates and forms a distinct layer on the top or bottom of the emulsion as a result of the coalescing of the globules of the internal phase.

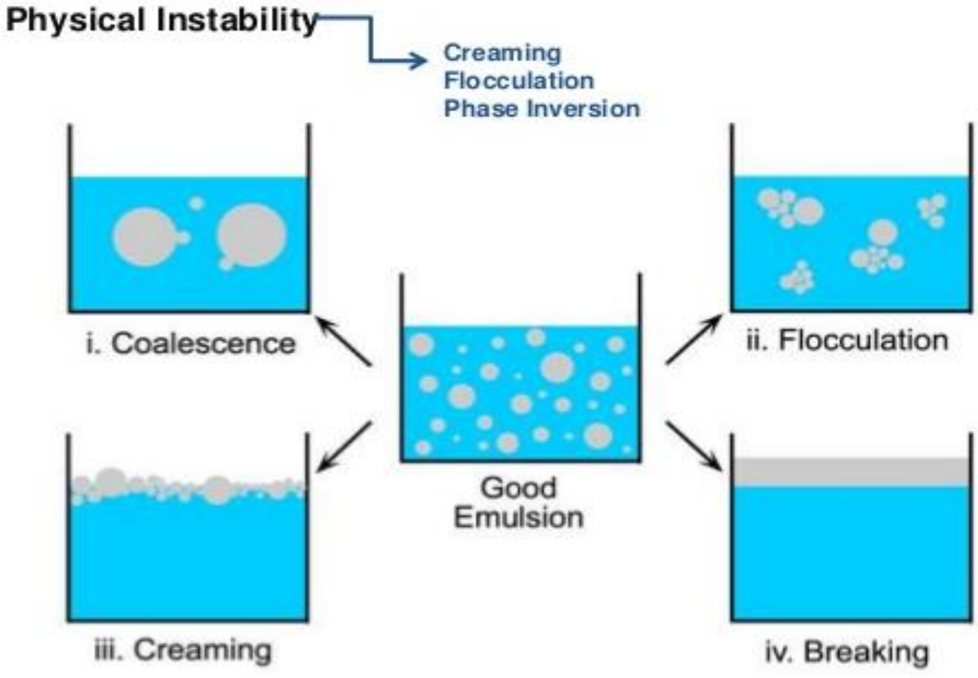
We have many types of instability:

1. Flocculation.

2. Creaming which is either upward or down ward creaming.

3. Aggregation and coalescence.

4. Breaking.



Aggregation and coalescence

- Aggregates of globules of the internal phase have greater tendency than do individual particles to rise to the top of emulsion or fall to the bottom.
- Such a preparation of globules is termed creaming, it is reversible process that can be redistributed upon shaking.
- Rate of separation of dispersed phase of an emulsion depend on many factors which are summarized by Stokes equation.
- More destructive to an emulsion is coalescence of the globules of the internal phase and separation of that phase into a layer.
- Separation of the internal phase from the emulsion is called breaking, it is irreversible process because the protective sheath about the globules of the internal phase no longer exists.
- Generally. Care must be taken to protect emulsions against extremes of cold and heat. Freezing and thawing coarsen an emulsion and sometimes break it.