UNIT-III Coarse dispersion

Coarse dispersion- It is a heterogeneous dispersion system in which the size of dispersed phase particles range from 1 um to 100 um.

- Particle size have size more than 1000 nanometer so, it can be easily visible with eyes.

Coarse dispersion → ⊜ Suspension
→ Emulsion.

⇒ **Suspension** – It is heterogeneous system in which solid particles (dispersed phase) is uniformally dispersed in liquid medium (dispersion medium).
eg- Chalk in water.

⇒ Suspension is biphasic (both phase visible) and heterogeneous in nature.

⇒ suspension → particle size < 1 um → colloidal suspension.
→ particle size > 1 micron → coarse suspension

- ideal properties of suspension –
  - Solid particles should not settle rapidly.
  - Prevent from cake formation at bottom.
  - Easy to pour.
  - Stable
  - Easily flow out from syringe needle.

⇒ Interfacial properties of suspended particles –

In suspension, the solid particles is uniformally dispersed in liquid medium.

the interface is formed in between the two phases, which influence the stability of suspension.

① Surface free energy –

During formulation of suspension, the solid reduced to fine powder for better mixing in continous medium.

- Due to very fine particles, surface area of particles are increase and ~~also~~ also their surface free energy increase.
- Surface free energy ↑ = stability of suspension ↓.
- Due to excess surface free energy, particles become highly energetics and tends to aggregates itself and resulting in formulation of compact cake.

equation –

$$W = \Delta G = \gamma_{SL} \cdot \Delta A$$

Where, ΔG = Surface free energy

γ_{SL} = interfacial tension b/w solid & liquid

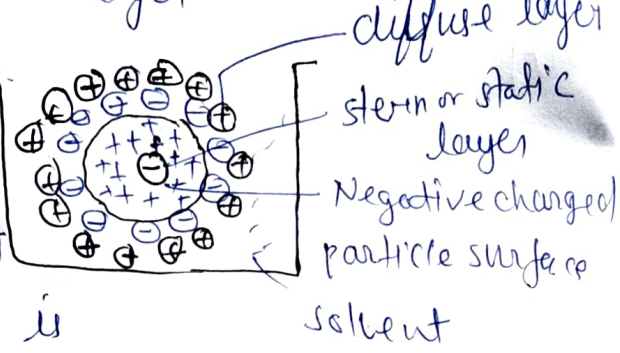
ΔA = change in surface area.

- To reduce surface free energy and make suspension stables, we use wetting agents and surfactants.
- Also system make floccules to redure the surface free energy.

eg - polysorbate-80 (wetting agent) etc.

(ii) formation of Electrical double layer -

The ionic species present in solution get absorbed at the surface. Due to ionization charges on the surface may arise. Time produce the formation of electric double layer.



- When surface charge is negative then their will be layer of tightly bound solvent molecules ~~the layer~~ which is stern layer.
- Whereas the layer of positive charge adjacent to the surface is called diffuse layer.

- Low electrolyte concentration → deflocculated system.
→ more (increasing) electrolyte conc. → flocculated system.

OR

→ Interaction force b/w particles ↑ → flocculated
→ Repulsive force b/w particles ↑ → deflocculated

⇒ Settling of Suspension

- Also known as rate of sedimentation, because settling of suspension is depend on sedimentation rate.
- The settling down of suspended particles of suspension at bottom is known as settling of suspension or also sedimentation.

- The more rate of sedimentation, faster the particle settle down and faster the formation of cake.
- the rate of settling of suspended particles is explained by stoke's law —

$$V = \frac{d^2 (\rho_1 - \rho_2) g}{18 \eta}$$

where,

V = Rate of sedimentation / Rate of settling.
d^2 = diameter of particle.
ρ_1 = density of suspended particle.
ρ_2 = density of solvent (dispersion medium)
g = gravity
η = viscosity of dispersion medium.

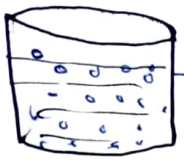
Rate of settling ↑ = stability ↓

→ To make suspension stable —

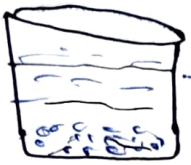
- increase viscosity of dispersion medium by using some agents such as methyl cellulose, natural gums. acacia, tragacanth etc.) (structural vehicle method).
- Stoke's law is valid for those suspension which does not contain more than 2% solid.

Type of suspension — → Flocculated
→ Deflocculated

- On the basis of stability, suspension may be a stable or unstable

Stable  → In which dispersed phase is dispersed well in dispersion medium

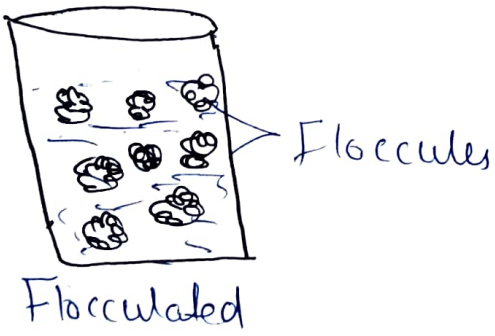
↓ after sometime

Unstable  → In which dispersed phase is not well dispersed in dispersion medium & settle down at bottom.

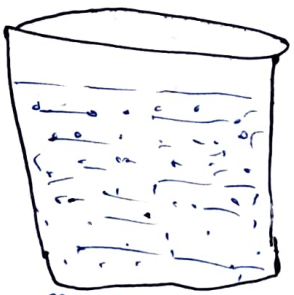
(i) **Flocculated-** Flocculated suspension are those suspension in which particles of dispersed phase aggregates together to form bunch like structure called flocules.

(ii) **Deflocculated Suspension-**

These are those in which particles of dispersed phase remain apart from each other remain dispersed in the dispersion medium.



Flocculated



Deflocculated

- Rate of sedimentation is high
- More stable
- Form soft cake

- Rate of sedimentation is low.
- Less stable.
- form hard cake

- It have large voids, so on settling down it form soft cake
- On shaken, it redisperse and come back to stable condition.
- More stable
- Less bioavailability

- It have less voids, so on settling down it form hard cake
- On shaken, its redispersion is very tough due to hard cake.
- less stable.
- High bioavailability.

Formulation :-

- Three various method which involved in formulation of suspension and increase its stability.

(i) Wetting agent
(ii) Controlled flocculation
(iii) Structure vehicle.

(i) **Wetting agent** – We know that less the particle size, less the rate of sedimentation but small particles size lead to more surface free energy that lead to formation of lymph, which is not a stable condition for suspension.
So, to tackle that we add wetting agent to the suspension that reduce the surface free energy and make suspension stable.

eg- Polysarbate -80 - etc

(iv) Controlled Flocculation :-

In this method, we add electrolytes to the suspension.

- When we add electrolyte ⊕ or ⊖ charge develop on the particles and they repel each other, Hence make suspension stable.
- If they some how make the floccules, they will get easily redispersed.
- We will take the electrolyte in such a way that it will be opposite charge for the solvent (dispersion medium)
- If particle ⊕ then solvent ⊖

eg: Bismuth subnitrate in water etc.

(vii) Structural Vehicle -

In this method, we increase the viscosity of dispersion medium. So, that the particle (light weight) do not sediment early in the suspension and remain dispersed.

eg- Acacia, tragacanth etc.

Emulsion

It is a biphasic system of two immiscible liquid where one liquid (dispersed phase) is dispersed into another liquid (dispersion medium). with the help of any emulsifying agent.

eg: Vanishing cream.

Gel, lotion, ointment etc.

Classification of Emulsion -

It can be classified into four types -

(i) Oil-in-water (o/w) emulsion
(ii) water-in-oil (w/o) emulsion.
(iii) multiple emulsion
(iv) microemulsion

(i) o/w emulsion - (aqueous emulsion) -

These are those emulsion in which dispersed phase is oil and continuous phase is water.

eg. milk, lotions, liniments etc.

- non-greasy nature (easily remove from body).

(ii) w/o emulsion - oil emulsion.

This are those emulsion in which dispersed phase is water and continuous phase is oil.

eg. Butter and cold creams etc.

- Greasy in nature (oily nature, not easily removed from body).

(iii) multiple emulsion - Double emulsion -

Those emulsion which are made up of more than two phase.

- In which the droplets of one liquid are dispersed in droplet of second liquid, which is further dispersed in dispersion medium.

Types

O/W/O

Oil-in-water-in-oil

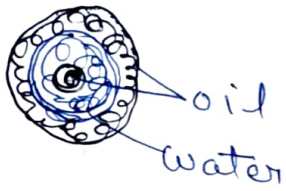
→ In which o/w emulsion dispersed in another oil phase

→ o/w/o.

W/O/W

Water-in-oil-in-water

→ In which w/o emulsion dispersed in another water phase.



W/O/W

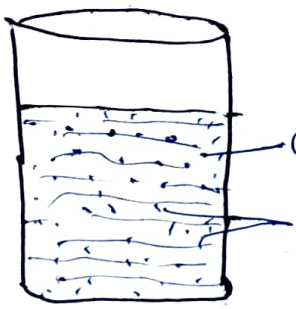
This types of emulsion prepared to prolong the release of drugs.

- It enhance bioavailability.

(iv) Microemulsion

Those emulsion in which particles size of dispersed phase is less than 1 μ.

- It is clear, transparent and thermodynamically stable as compared to normal emulsion.



Theories of Emulsion

Those theories which make and stay emulsion stable -

i) Monomolecular theory
ii) Multimolecular theory
iii) Solid particle theory

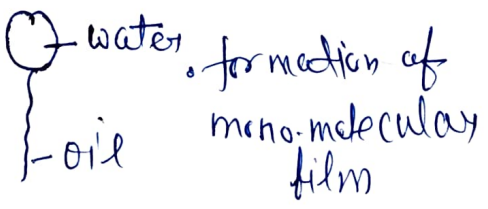
(1) Monomolecular Adsorption theory -

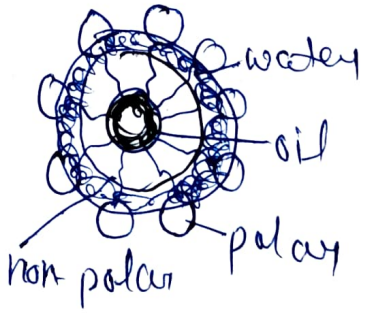
During preparation of emulsion, the oil/water droplet get dispersed in continuous phase particles get atomized (reduce particle size).

- Due to small particle size surface area increases which further increases the surface free energy, therefore system became unstable.

⇒ To resolve this problem or to make system stable we add surfactants or emulsifying agent which reduce the interfacial tension or surface free energy and make emulsion stable.

Mechanism - Surfactant contain polar and non-polar part. Polar oriented toward water and non-polar oriented toward oil and form a stable mono-molecular film on the surface of dispersed droplet.

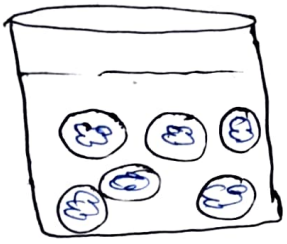




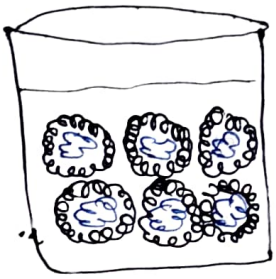
(ii) Multimolecular adsorption theory –

Monomolecular and multimolecular theory both used to stop flocculation, coalescence also prevent the breaking of emulsion.

Mechanism– In this, emulsifying agent's small-small particles join together and cover the dispersed and make multimolecular film.



Monomolecular



Multimolecular

- They also act by making the medium viscous.
  eg. Acacia, methyl cellulose etc.
- **Flocculation –** small particles forms a one big particles called floccule.

(iii) Solid particle adsorption theory –

In this, we add solid emulsifying agent in emulsion which increases the viscosity of emulsion.

↓

sedimentation & cracking.

- It also prevent (reduces) coalescence of dispersed particles.

eg. colloidal clay etc.

(iv) Formation of electrical double layer -

In emulsion, oil droplets contain either negative or positive charge.

- Due to present of charge they develop electrical double layer. (already discussed).
- Due to this oil droplets produce repulsion force into each other and they remain suspended.
- They prevent coalescence and breaking of emulsion.

Stability of Emulsion

A stable emulsion is one in which the globules (dispersed phase) retain their size and as well as remain uniformly distributed throughout the continuous phase.

- Some instability occur during storage and formulation of emulsion -

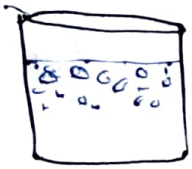
(i) Creaming ✓ (iv) Flocculation ✓
(ii) Coalescence ✓ (v) Phase inversion ✓
(iii) Breaking ✓ (vi) Physical & chemical properties ✓

(i) Creaming - It is a reversible phenomenon.

In which droplets of dispersed phase come together or deposite at the surface of the emulsion.

O/W

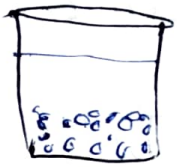
- In this, oil have low density so they come together at the surface of emulsion.
- Upward creaming



O/W upward creaming

W/O

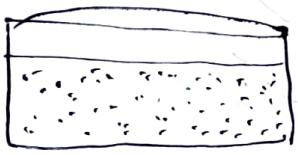
- In this, density of water (dispersed phase) is more than continuous phase so particles come together at the bottom of emulsion.
- Downward creaming

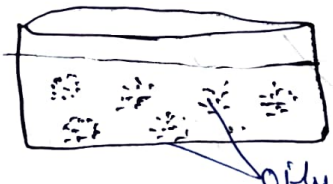


W/O Downward creaming

(ii) Coalescence-

In emulsion, oily particles (dispersed phase) because of sticky nature attract each other and they aggregate to form big particles.





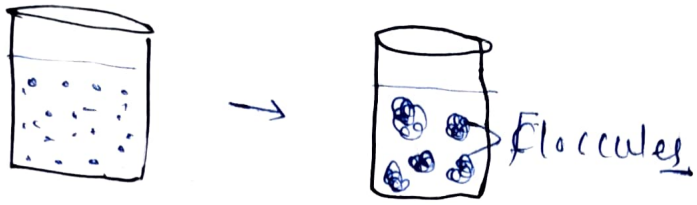
oily particles aggregated.

(iii) Breaking- Due to improper mixing of oil and water in emulsion, emulsion get separated into two layer i.e. oil and water.

- It is also occured due to improper ratio of oil and water.

(iv) Flocculation-

In this, due to increased surface free energy particle get aggregated to form floccule to decrease surface area.



(v) Phase inversion-

. In this, the phase of emulsion get inverted i.e. o/w → w/o and w/o → o/w.

• It happened due to mixing problem or by choosing wrong dispersed phase during formulation.

(vi) Physical & chemical property change-

To prepare an emulsion, we use emulsifying agent to mix and make stable emulsion.

• Sometimes, addition of these agents causes changes in properties like, colour, pH, odour, taste etc.

Preservation of Emulsion

We have to keep emulsion stable and effective till expiry date. for this -

We have to preserve emulsion from microorganism and oxidation.

- Emulsion (ideal properties of preservatives) -
- not change their nature and property
- not react oil and water with each other
- Stable.

(i) Preservation from Microorganism -

Micro organism (m/o) may arises in emulsion due to carbon content of emulsion or due to present of high water content.
- For this, we add preservative like - methyl paraben, propyl paraben, benzoic acid etc. which inhibit the growth of bacteria.

- Preservatives should be -
→ non-irritant and non-toxic.
→ tasteless, colourless and odourless.
→ should be Stable.

(ii) Preservation from oxidation -

Oxygen present in atmosphere cause oxidation such as rancidity and spoilage for this, we use some antioxidant which can prevent the changes occures due to atmospheric oxygen.
Antioxidant should be -
⇒ non-toxic & non-irritant.
⇒ effective at low concentration.
eg:- BHT (Butylated Hydroxytoluene), Ethyle and propyl gallate etc.

⇒ Rheological properties of emulsion –

These properties of emulsion are related to the flow of emulsion.

Applications –

- spreadability (for skin)
- Removal from container (bottle)
- Flow of emulsion through ~~by of~~ hypodermic needle
- proper mixing (during manufacturing)

⇒ It can be of two types –

① **Newtonian flow** – This type of flow show by dilute emulsion.
eg – Micro emulsion etc.

(ii) **Non-Newtonian** – This type of flow show by concentrated emulsion.
eg Lotions, creams etc.

- Optimum viscosity is desirable for good stability of emulsion.
- The increase in the viscosity of the emulsion reduce the flocculation.
- Rheological property of emulsion can be ~~observed~~ controlled by –

⇒ concentration of dispersed phase
⇒ Particle size of dispersed phase
⇒ Viscosity of continuous phase.

→ nature and concentration of emulsifying agents. etc

Formulation of Emulsion

method of preparation of emulsion -

(i) **Dry Gum Method** - used for W/O type emulsion.

- Take a pestle and mortor.
- Add gum to it (emulsifying agent powder form)
- Triturate it and then add some part of oil & triturate.

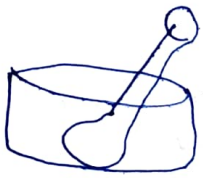
⇒ Again add some more oil and triturate until receive the clicking sound.

⇒ Then add water by part with trituration

⇒ Now make up the volume with bulk phase.

Ration →

O : G : W
4 : 1 : 2



(ii) **Wet gum method** - used for O/W type emulsion

⇒ Take a pestle and mortar.

⇒ Add gum to it and triturate (emulsifying agent) (liquid form)

⇒ Add some water to gum and triturate with adding more water until mucillage forms.

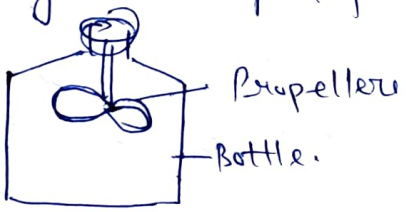
⇒ Then add oily part slowly - slowly with trituration.

⇒ Now make up the volume with bulk phase.
⇒ Ratio will be kept same as in (I).

(ii) Bottle Method :-

This method is used to prepare emulsions of volatile oils or substance having very low viscosity.

⇒ 1 part gum placed in dry bottle then 2 part of oil are added. Now shake the mixture.
⇒ A volume of water (approx. equal to oil) is added in portion then again shake.
⇒ Now, dilute it with proper volume of water.
⇒ On large scale this process is done inside bottle with or along with propeller movement

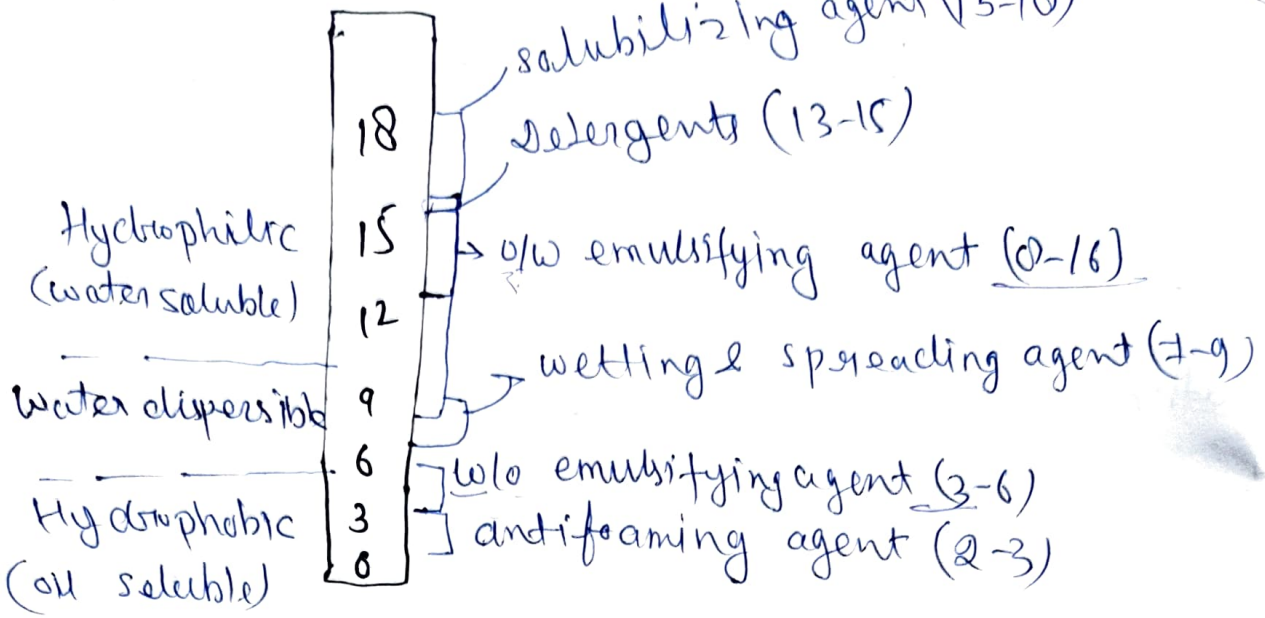


⇒ Formulation by HLB Method –

HLB ⇒ Hydrophilic lipophilic balance.

– With the help of HLB method we choose the emulsifying agent which we to used in preparation of emulsions

• According to HLB method,
⇒ More HLB value, more hydrophilic (water soluble)
⇒ Less HLB value, more Lipophilic (oil soluble)



⇒ High HLB value showing emulsifying agent are mixed in o/w emulsion.

⇒ Low HLB value showing emulsifying agent are mixed in w/o emulsion.

⇒ HLB scale decide to select emulsifier agents.