Name of Unit	Coarse Dispersion
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Learning Outcome of Module 03

LO	**Learning Outcome (LO)**	**Course Outcome Code**
LO1	Students learn about Suspension, interfacial properties of suspended particles	BP403.5
LO2	Students learn about Settling in suspensions, formulation of flocculated and deflocculated suspensions.	BP403.6
LO3	Students learn about Emulsions and theories of emulsification, Microemulsion and multiple emulsions	BP403.5
LO4	Students learn about Stability of emulsions, preservation of emulsions	BP403.6
LO5	Students learn about Rheological properties of emulsions and emulsion formulation by HLB method.	BP403.6

Content Table

Topic
• Suspension, interfacial properties of suspended particles • Settling in suspensions, formulation of flocculated and deflocculated suspensions. • Emulsions and theories of emulsification • Microemulsion and multiple emulsions • Stability of emulsions, preservation of emulsions, • Rheological properties of emulsions and emulsion formulation by HLB method.

SUSPENSIONS

A pharmaceutical suspension is a coarse dispersion in which insoluble solid particles are dispersed in a liquid medium (usually water or water-based vehicle). Generally, the particles have diameters greater than 0.5µm. The concentration of dispersed phase may exceed 20%.

Some desirable qualities of suspension include the following:

- The suspended material should not settle rapidly. If the particles settle to the bottom of the container, they must not form a hard cake but should be readily redispersed into a uniform mixture when the container is shaken.
- The suspension must not be too viscous to pour freely from the orifice of the bottle in case of oral suspension or to flow through a syringe needle in case of parenteral suspension. In case of lotion, the product must be fluid enough to spread easily over the affected area and yet must not be so mobile that it runs off the surface to which it is applied.
- The suspension should have optimum physical, chemical, and pharmacologic properties.

Interfacial properties of suspended particles

The work must be done to reduce a solid to small particles and disperse them in a continuous medium. The large surface area of the particles that results from the size reduction is associated with a surface free energy that makes the system ***thermodynamically unstable.*** It means that the particles are highly energetic and tend to regroup in such a way as to decrease the total area and reduce the surface free energy. The particles in a liquid suspension therefore tend to *flocculate*, that is, to form light, fluffy conglomerates that are held together by weak van der Waals forces. Under certain conditions, the particles may adhere by stronger forces to form *aggregates*. Caking often occurs by the growth and fusing together of crystals in the precipitates to produce a solid aggregate.

The formation of any type of agglomerates either floccules or aggregates are taken as a measure of the system's tendency to reach a more thermodynamically stable state. An increase in the work, W, or surface free energy, ΔG, brought about by dividing the solid into smaller particles and consequently increasing the total surface area, ΔA, is given by

$$\Delta G = \gamma_{\mathrm{SL}} . \Delta A$$

where γ_{SL} is the interfacial tension between the liquid medium and the solid particles.

Therefore, the system tends to reduce the surface free energy to reach a stable state and equilibrium is reached when ΔG=0. This condition can be accomplished by

- A reduction of interfacial tension

- A decrease of interfacial area

The decrease of interfacial area leads to flocculation or aggregation which can be desirable or undesirable in pharmaceutical suspension. The interfacial tension can be reduced by the addition of a surfactant but cannot ordinarily be made equal to zero. A suspension of insoluble particles, then, usually possesses a finite positive interfacial tension, and the particles tend to flocculate. The forces at the surface of a particle affect the degree of flocculation and agglomeration in a suspension. Forces of attraction are of the van der Waals type; the repulsive forces arise from the interaction of the electric double layers surrounding each particle.

When the particles approach each other, they experience repulsive forces because the particles carry a finite charge on their surface. When repulsion energy is high, the potential barrier is also high, and collision of the particles is opposed and aggregation of particles is prevented. So the solids are present as individual particles and the sedimentation of particles are very slow. This system is called deflocculated system. When the particles are separated by a longer distance (10-20 nm), a weak attractive force exists just beyond the range of double layer repulsive forces. This region is called secondary minimum and is responsible for flocculation of particles i.e. the formation of loose fluffy aggregates or open network of aggregated particles (flocs or floccules). This system is called flocculated suspension.

Deflocculated suspension	**Flocculated suspension**
Pleasant appearance due to uniform dispersion of particles	Unsightly sediment and clear supernatant layer
Supernatant remains cloudy	Supernatant is clear
Particles experience repulsive force	Particles experience weak attractive force
Particles exist as separate entities	Particles form loose aggregates
Rate of sedimentation is slow	Rate of sedimentation is higher as flocs are the collection of smaller particles
Particles settle independently and separately	Particle settle as flocs
The sediment is closely packed and form hard cake	The sediment is loosely packed open network and does not form hard cake
Hard cake cannot be re-dispersed	Sediment is easy to re-disperse

Settling in suspension

The physical stability in pharmaceutical suspensions is concerned with keeping the particles uniformly distributed throughout the dispersion. The velocity of sedimentation is expressed by Stoke's law:

$$v = \frac{d^2(\rho_s - \rho_0)g}{18\eta_0}$$

where v is the sedimentation velocity in cm/sec. d is the diameter of the particle in cm, ρ_s and ρ_0, are the densities of the dispersed phase and dispersion medium, respectively, g is the acceleration due to gravity, and η_0 is the viscosity of the dispersion medium inpoise.

Stokes law is useful in fixing factors which can be utilized in the formulation of suspension.

- ***Particle size:*** if particle size is reduced to half of its original size, the rate of sedimentation decreases by a factor of 4.
- ***Viscosity of medium:*** Higher the viscosity, lower is the rate of sedimentation. High viscosity enhances physical stability by preventing sedimentation, inhibits crystal growth and prevents transformation of metastable crystals to stable crystals. However, high viscosity hinders drug absorption from suspension and creates problems in handling.
- ***Density of the medium:*** The density of solids used in suspension is generally from 1.5 to 2.0 gm/cc. If density of medium is made equal to the density of solids, the rate of settling becomes zero. In general, the medium density is about 1gm/cc due to aqueous phase. Therefore, there is a need to increase the viscosity of the medium, so that the differences in densities will be minimal. The density of medium can be increased by using PVP, glycerin, sorbitol. A combination of these yield improved suspension but they should be used inhigh concentration, though the improvement in density is less. Hence, this is not a viable factor to decrease the rate of settling.

Sedimentation of Flocculated Particles

The extent of sedimentation is quantitatively expressed by two parameters:

1) **Sedimentation volume or sedimentation height**
2) **Degree of flocculation**

These are normally used for the comparison of different suspensions and applicable to flocculated suspension only. The term *subsidence* is sometimes used to describe settling in flocculated systems and refers to the descending of the boundary between the sediment and clear supernatant above it. When sedimentation is studied in flocculated systems, it is observed that the flocs tend to fall together, producing a distinct boundary between the sediment and the supernatant liquid. The liquid above the sediment is clear because even the small particles present in the system are associated with the flocs. Such is not the case in deflocculated suspensions having a range of particle sizes, in which, in accordance with Stokes's law, the larger particles settle more rapidly than the smaller particles. No clear boundary is formed and the supernatant remains turbid for a considerably longer period of time. Whether the supernatant liquid is clear or turbid during the initial stages of settling is a good indication of whether the system is flocculated or deflocculated, respectively.

Sedimentation volume:

The sedimentation volume, *F*, is defined as the ratio of the final or ultimate volume of the sediment, V_u, to the original volume of the suspension, V_0, before settling. H_u represents height of the sediment. Thus,

$$F = \frac{V_u}{V_0} = \frac{u}{H_0}$$

For ideal suspension, $V_u = V_0$, because there is no sedimentation and hence $F=1$. Normally, *F* value lies in between 0-1. In general, higher the sedimentation volume, the better is the physical stability.

Degree of flocculation

The sedimentation volume gives only a qualitative account of flocculation because it lacks a meaningful reference point. A more useful parameter for flocculation is β, the degree of flocculation.

If we consider a suspension that is completely deflocculated, the ultimate volume of the sediment will be relatively small. Writing this volume as $V_{\propto}$, we can write

$$\square\square_{\propto} = \frac{\square\square_{\propto}}{\square\square_{0}}$$

Where $F_{\propto}$ is the sedimentation volume of the deflocculated, or peptized suspension. The degree of flocculation, β is therefore defined

$$\beta = \frac{F}{F_\alpha}$$

$$\beta = \frac{\frac{V_u}{V_0}}{\frac{V_\alpha}{V_0}} = \frac{V_u}{V_\alpha}$$

The degree of flocculation is a more fundamental parameter than F because it relates the volumeof flocculated sediment to that in a deflocculated system. We can therefore say that

$$\beta = \frac{\text{Ultimate sediment volume of flocculated suspension}}{\text{Ultimate sediment volume of deflocculated suspension}}$$

Formulation of Suspensions

The formulation of a suspension depends upon whether the desired suspension is flocculated or deflocculated. Two approaches are commonly used. One approach involves the use of structured vehicles to keep particles in a deflocculated state. The second approach keeps particles in a flocculatedstate in order to prevent cake formation. The third method uses a combination of earlier approaches toprevent settling.

Suspensions are prepared by levigating or grinding the insoluble materials in the mortarto a smooth paste with a vehicle containing the wetting agent such as hydrophilic polymers-sodium CMC, water miscible solvents like glycerin, propylene glycol, alcohol and water insoluble but hydrophilic materials such as bentonite, aluminium-magnesium silicates, colloidal silica, surfactants (HLB 7-9) either alone or in combination.

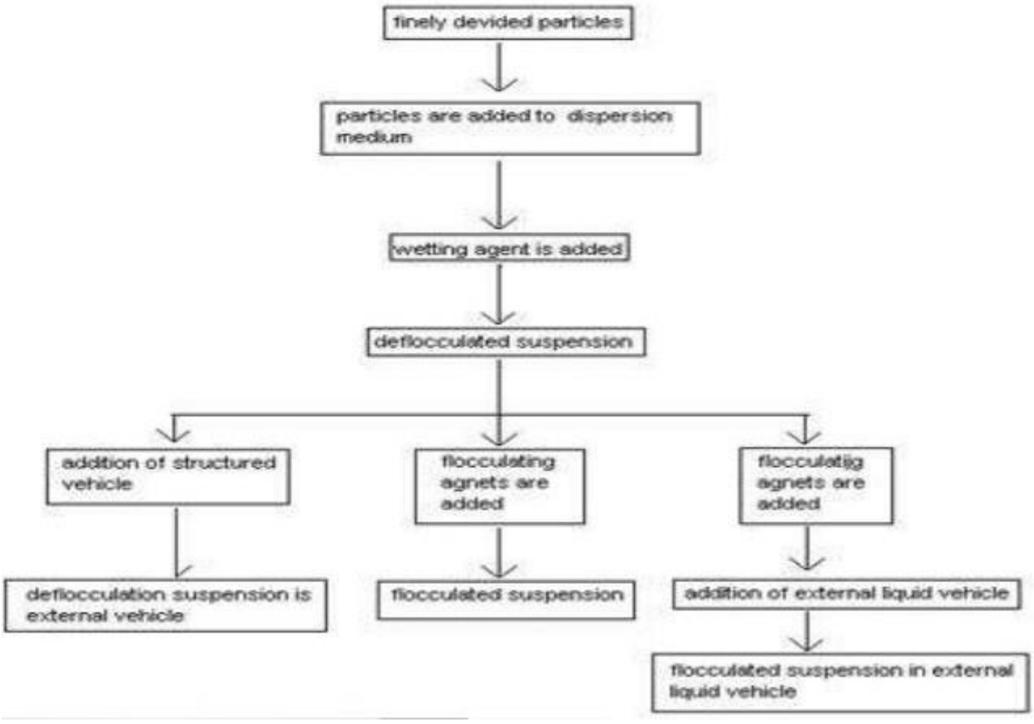
Surfactants aids in dispersion by reducing the interfacial tension between solid particles and the vehicle. As a result the contact angle is lowered and air is displaced from the surface of solids.

All soluble ingredients are dissolved in some portions of the vehicle and added to the smoothpaste to get slurry. The slurry is transferred to a graduated cylinder; the mortar is rinsed with successive portions of the vehicle.

Then decide whether the solids are suspended in structured vehicle or flocculated or flocculated and then suspended. Add the vehicle containing the suspending agent or flocculating agent in the order mentioned in the diagram. Then make the dispersion to the final volume.

It is frequently difficult to disperse the powder owing to an adsorbed layer of air. The powder is not readily wetted, and although it may have a high density, it floats on the surface of the liquid. Finely powdered substances are particularly susceptible to this effect because of entrained air, and they fail to become wetted even when forced below the surface of the suspending medium. The wettability of a powder can be ascertained easily by observing the contact angle that powder makes with the surface of the liquid. The angle is approximately 90^0 when the particles are floating well out of the liquid. A powder that floats low in the liquid has a lesser angle, and one that sinks obviously shows no contact angle. Powders that are not easily wetted by water and accordingly, show a large contact angle such as sulfur, charcoal, and magnesium stearate are said to be *hydrophobic*. Powders that are readily wetted by water when free of adsorbed contaminants are called *hydrophilic.* Zinc oxide, talc, and magnesium carbonate belong to the latter class.

Flow chart of formulation of suspension



Structured vehicle-deflocculated suspension

Many pharmaceutical products, including liquid dispersions of natural and synthetic gums (e.g., tragacanth, sodium alginate, methylcellulose. and sodium carboxymethyl cellulose) exhibit pseudoplastic flow. Pseudoplastic flow is typically exhibited by polymers in solution in contrast to plastic systems which are composed of flocculated particles in suspension. The viscosity of a pseudoplastic substance decreases with increasing rate of shear.

Plastic flow is associated with the presence of flocculated particles in concentrated suspensions. As a result, a continuous structure is set up throughout the system. A yield value exists because of the contacts between adjacent particles (brought about by van der Vaals forces), which must be broken down before flow can occur. Consequently, the yield value is an indication of force of flocculation: The more flocculated the suspension, the higher will be the yield value. Structured vehicles are vehicles which exhibit pseudoplastic or plastic behavior. Moreover, they should possess some degree of thixotropic behavior i.e. gel-sol-gel transformation. Such a behavior improves the physical stability of suspensions. During storage, a shear thinning system acquires a gel-like structure so that particles do not settle. On shaking, viscosity decreases and the suspension becomes a sol so that uniform dispersion of soild can be achieved. If left aside, the suspension regains its gel-like structures. Structured vehicles are extremely used for the preparation of deflocculated suspensions. Structured vehicles are generally prepared using hydrocolloids like carbopol, sodium CMC, bentonite, MC, HPMC.

Controlled flocculation-flocculated suspension

Once the powders are properly wetted and dispersed in a medium, flocculation can be produced by gradual addition of flocculating agent such as electrolytes, polymers, and surfactants.

Most dispersed particles have a surface charge. The intensity of this charge can be reduced by addition of agents with oppositely charged electrolytes. As a result, the zeta potential decreasesand particles establish attractive forces between adjacent particles.

Surfactants and polymers are long chain compounds. These substances act by adsorbing a part of their chains on the particle surface and projecting out the remaining part into the medium, this type of bridging promotes the formation of flocs. The hydrophilic polymers form a mechanical barrier or sheath around the particles and induce flocculation. This mechanism is more useful to improve the appearance of flocculated suspension.

Flocculation in structured vehicle

In a flocculated suspension, the supernatant becomes clear rapidly. This is an undesirable property. Hence the principles of flocculation and structured vehicles are combined to get an improved suspension. The flocculating agents facilitate the formation of aggregates of uniform size, while the structured vehicles prevent the aggregates or flocs from settling. Consequently, in practice, a suspending agent id frequently added to retard sedimentation of flocs. Such agents are CMC, Carbopol 934, tragacanth, and bentonite has been employed, either alone or in combination.

EMULSIONS

An emulsion is a thermodynamically unstable system consisting of at least two immiscible liquid phases, one of which is dispersed as globules (the dispersed phase) in the other liquid phase (the continuous phase), stabilized by the presence of an emulsifying agent.

Either the dispersed phase or the continuous phase may range in consistency from that of a mobile liquid to a semisolid. Thus, emulsified systems range from lotions of relatively low viscosity to ointments and creams, which are semisolid in nature. The particle diameter of the dispersed phase may extend from about 0.01 to 10 µm.

When the oil phase is dispersed as globules throughout an aqueous continuous phase, the system is referred to as an oil-in-water (o/w) emulsion. When the oil phase serves as the continuous phase, the emulsion is referred to as water-in-oil (w/o) emulsion. Medicinal emulsions for oral administration are usually of the o/w type and require the use of water soluble emulsifying agents such as nonionic surfactants, acacia, tragacanth, sodium lauryl sulfate, tri- ethanolamine stearate, monovalent soaps such as sodium oleate.

Pharmaceutical w/o emulsion is used almost exclusively for external application and may contain one or several of the following emulsifiers: polyvalent soaps such as calcium palmitate, sorbitan esters (Spans), cholesterol, and wool fat.

Two additional types of emulsions are: oil-in-water-in-oil emulsion (o/w/o) and water-in- oil-in-water (w/o/w) type emulsion. Such emulsions are known as multiple emulsions.

THEORIES OF EMULSIFICATION

When two immiscible liquids are agitated together so that one of the liquids is dispersed as small droplets in the other, the liquids separate rapidly into two clearly defined layers. Failure of two immiscible liquids to remain mixed is explained by the fact that the cohesive force between the molecules of each separate liquid is greater than the adhesive force between the two liquids. When one liquid is broken into small particles, the interfacial area of the globules constitutes a surface that is enormous compared with the surface area of the original liquid. The surface free energy increase (W) is given by the equation: $W = \gamma_{ow} \times \Delta A$ and $\gamma_{o/w}$ is the interfacial tension between oil and water.

The increase in energy, associated with this enormous surface is sufficient to make the system thermodynamically unstable hence the droplets have a tendency to coalesce. To prevent coalescence or at least to reduce its rate to negligible proportions, it is necessary to introduce an emulsifying agent that will form a film around the dispersed globules.

Emulsifying agents can be divided into three groups, as follows:

1) **Surface-active agents** (Spans, Tweens), which are adsorbed at oil-water interfaces to form monomolecular films and reduce interfacial tension.
2) **Hydrophilic colloids** (acacia, gelatin), which form multi-molecular film around the dispersed droplets of oil in an o/w emulsion.
3) **Finely divided solid particles** (bentonite-hydrated aluminium silicate, Veegum- magnesium aluminium silicate), which are adsorbed at the interface between two immiscible liquid phases and form a film of particles around the dispersed globules.

Monomolecular Adsorption

Surface-active agents reduce interfacial tension because of their adsorption at the oil-water interface to form monomolecular films. Because the surface free energy increase, W, equals $\gamma o/w \times \Delta A$ and we must retain a high surface area for the dispersed phase, any reduction in $\gamma o/w$, the interfacial tension, will reduce the surface free energy and hence the tendency for coalescence.

Further, the dispersed droplets are surrounded by a coherent monolayer that helps prevent coalescence between two droplets as they approach one another. Ideally, such a film should be flexible so that it is capable of reforming rapidly if broken or disturbed. An additional effect promoting stability is the presence of a surface charge, which will cause repulsion between adjacent particles.

The type of emulsion is a function of the relative solubility of the surfactant, the phase in which it is more soluble being the continuous phase. This is sometimes referred to as the rule of Bancroft. Thus, an emulsifying agent with a high HLB is preferentially soluble in water and results in the formation of an o/w emulsion. The reverse situation is true with surfactants of low HLB which tend to form w/o emulsions. In general, o/w emulsions are formed when the HLB of the emulsifier is within the range of about 8 to 16, and w/o emulsions are formed when the rangeis about 3 to 6.

Multi-molecular Adsorption and Film Formation

Hydrophilic colloids differ from the synthetic surface-active agents in that (a) they do not cause an appreciable lowering of interfacial tension and (b) they form a multi- rather than a monomolecular film at the interface. Their action as emulsifying agents is due mainly to the formation of multi- molecular layer film which is strong enough to resist coalescence. An auxiliary effect promoting stability is the significant increase in the viscosity of the dispersion medium. Because the emulsifying agents that form multilayer films around the droplets are invariably hydrophilic, they tend to promote the formation of *o/w* emulsions.

Solid-Particle adsorption

Finely divided solid particles that are wetted to some degree by both oil and water can act as emulsifying agents. The solid particles concentrate at the interface, where they produce a particulate film around the dispersed droplets so as to prevent coalescence. Powders that are wettedpreferentially by water form *o/w* emulsions, whereas those more easily wetted by oil form *w/o* emulsions.

PHYSICAL STABILITY OF EMULSION

A pharmaceutical emulsion becomes unstable due to the following reasons:

1) **Creaming**
2) **Flocculation**
3) **Coalescence**
4) **Phase inversion**

1. Creaming

Under the influence of gravity, the emulsion droplets tend to rise or sediment depending on the difference in densities between the phases and this phenomenon is known as creaming.

According to Stoke's law, if the dispersed phase is less dense than the continuous phase as in case in *o/w* emulsions, an upward *creaming* results. If the internal phase is heavier than the external phase as in case of *w/o* emulsions, the globules settle and results in *downward creaming*.

In the case of pharmaceutical emulsions, creaming results in a lack of uniformity of drug dose unless the preparation is thoroughly shaken before administration. The visual appeal of an emulsion is also affected by creaming.

Creaming is a reversible process. The cream floccules can be re-dispersed easily, and a uniform mixture is reconstituted from a creamed emulsion by agitation because the oil globules are still surrounded by a protective sheath of emulsifying agent. Creaming can be prevented or reduced by the following ways:

The rate of creaming is function of square of the radius of the globules. Thus, larger particles creammore rapidly than smaller particles.

Reduction of particle size to a diameter below 5 µm, Brownian motion helps the particles to settle or cream more slowly.

The viscosity of the external phase can be increased without exceeding the limits of acceptable consistency by adding a ***viscosity improver or thickening agent*** such as methylcellulose, tragacanth, or sodium alginate.

2. Flocculation

Flocculation is defined as reversible aggregation of droplets of internal phase in the form of three- dimensional clusters. Flocculation may take place before, during, or after creaming. Flocculation can be prevented or reduced by the following ways:

An emulsion can be stabilized with the use of ionic surfactants at a particular concentration. The droplets remain deaggregated in the form of single droplets as a result of repulsion between charged droplets.

Uniform size globules also prevent flocculation.

If viscosity of external medium is increased, the globules become relatively immobile and flocculation can be prevented.

The following factors promote flocculation. An increase in ionic strength with electrolytes or an increase in emulsifier concentration tends to promote flocculation. A high internal phase volume and tight packing of the dispersed phase tends to promote flocculation.

3. Coalescence

Coalescence is a growth process during which the emulsified droplets fuse to form larger particles. In this process, the emulsifier film around the globules is destroyed to a certain extent. This step is recognized by increased globule size and reduced number of globules. The coalescence can be prevented by the formation of thick interfacial film from macromolecules or from particulate solids. This is the reason a variety of natural gums and proteins are as useful as auxiliary emulsifiers when used in low concentration but can be used as primary emulsifiers at higher concentrations.

If the globule sizes are not uniform, globules of smaller size occupy the spaces between larger globules. This type of close packing induces greater cohesion of globules which lead to coalescence. Any evidence for the formation of larger droplets suggests that the emulsion will separate into oil and aqueous phase; this is called ***breaking of emulsion***. It is an irreversible process; simplemixing failed to re-suspend the globules into uniform emulsion.

4. Phase inversion

Phase inversion means a change of emulsion type from *o/w* to *w/o* or vice versa. For instance, an *o/w* emulsion is prepared using sodium stearate. Then, calcium chloride is added to form calcium stearate, which is oil soluble. Therefore, oil phase become the continuous phase and *w/o* emulsion is produced. Inversion can also be produced by alterations in phase-volume ratio. The temperature at which phase inversion occurs depends on emulsifier concentration and is called phase inversion temperature (PIT).

PRESERVATION OF EMULSIONS

Certain undesirable changes in the properties of the emulsion can be brought about by the growth of microorganisms. These include physical separation of the phases, discoloration, gas and odor formation, and changes in rheologic properties. Emulsions for parenteral use obviously must be sterile.

The propagation of microorganisms in emulsified products is supported by one or more of the components present in the formulation. Thus, bacteria have been shown to degrade nonionic and anionic emulsifying agents, glycerin, and vegetable gums present as thickeners, with a consequent deterioration of the emulsion. As a result, it is essential that emulsions be formulatedto resist microbial attack by including an adequate concentration of preservative in the formula- tion. However, the main problem is obtaining an adequate concentration of preservative in the product. Some of the factors that must be considered to achieve this end are presented here.

Emulsions are heterogeneous systems in which partitioning of the preservative will occur between the oil and water phases. Mainly the bacteria grow in the aqueous phase of emulsified systems, with the result that a preservative that is partitioned strongly in favor of the oil phase may be virtually useless at normal concentration levels because of the low concentration remaining in the aqueous phase. The phase-volume ratio of the emulsion is significant in this regard. In addition, the preservative must he in an un-ionized state to penetrate the bacterial Membrane. Therefore, the activity of weak acid preservatives decreases as the pH of the aqueous phase rises.

Emulsion Formulation by HLB Method

HLB measures polar and non-polar nature of the surfactant. Each emulsifying agent is given a number on HLB scale. The *o/w* emulsifying agent has HLB vale of 8-16 and *w/o* emulsifying agent has HLB of 3-6. High numbers indicate hydrophilic properties while low numbers represent hydrophobic properties. Emulsifying agents with high numbers give *w/o* emulsion and those with low numbers give *w/o* emulsion.

The HLB required for emulsifying oil in water can be determined by trial and error. Prepare emulsion with emulsifiers having a range of HLB values and then determining HLB value that yields best emulsion. However, a list of required HLB value is given that are of interest in pharmaceutical preparations. The knowledge of required HLB (RHLB) permits selection of an emulsifier or a combination of emulsifiers.

To ensure satisfactory emulsion, oils, fats, and waxes require emulsifying agents of suitable HLB value. Therefore, required HLB values are calculated for oily materials, depending on whether *o/w* or *w/o* emulsions are required.

Table: Required HLB values of oils and waxes

	w/o	**o/w**
Bees wax	4	12
Cetyl alcohol	-	15
Liquid paraffin	5	12
Soft paraffin	5	12
Wool fat	8	10

When several oils and fats are included in a formula the total required HLB may be calculated and an emulgent or blend of emulgents is selected accordingly. The formulation of an *o/w* emulsified lotion illustrates the procedure.

Formula:

Liquid paraffin	35
Wool fat	1
Cetyl alcohol	1
Emulgent	7
Water to	100

Required HLB values of the first three ingredients are respectively 12, 10 and 15 for an *o/w* emulsion. The total percentage of oil phase is 35+1+1=37 %, and the proportions of the oil phase ingredients are-

Liquid paraffin: 35/37*100= 94.6% Wool fat: 1/37*100= 2.7%

Cetyl alcohol: 1/37*100=2.7%

The total required HLB value is obtained as follows: Liquid paraffin: 94.6/100*12=11.4

Wool fat: 2.7/100*10= 0.3

Cetyl alcohol: 2.7/100*15=0.4 Total RHLB= 12.1

Say, a mixture of Span 80 (HLB=4.3) and Tween 80 (HLB=15) is to be used as emulgent blend. The proportions of these two substances that will provide the RHLB value of 12.1 are calculated as follows:

Let x = % of Span 80 in the mixture. Then 100-x = % of Tween 80 Contribution from span 80= 4.3*x/100

Contribution from span 80= 15*(100-x)/100

Since total contribution must be 12.1, the expression for calculating x is: $4.3*x/100 + 15*(100-x)/100=12.1$

$4.3x+1500-15x=1210$

$290=10.7x$ or $x=27\%$

Hence, the percentages of emulsifying agents in the mixture are: Span 80: 27; Tween 80: 73 Since the total percentage of the mixed emulgents is the formula is 7, the percentages of individual substances are Span 80= 7*27/100=1.89; Tween 80= 7-1.89=5.11

Microemulsion

Microemulsion is an isotropic, clear and transparent liquid, representing a state intermediate between solution and ordinary emulsion. Microemulsion contain droplets with diameters of about 10 to 200 nm, and the volume fraction of the dispersed phase varies from 0.2 to 0.8. In addition to emulsifying agent, a co-surfactant is used in the preparation of microemulsion. The addition of co-surfactant (pentanol) temporarily reduces the surface tension to approximately zero, allowing spontaneous emulsification. Both surfactant and co-surfactant molecules form an adsorbed film on the microemulsion particles to prevent coalescence.

Microemulsion can be used to increase the bioavailability of poorly soluble drugs. Microemulsion have also been considered as topical drug delivery systems. For example, *water-in-oil* microemulsion can be used to incorporate polar drugs in the aqueous internal phase. The microemulsion helps in deeper penetration of these compounds into the skin.

SHORT QUESTION

1. Define suspensions
2. Define emulsions
3. Define phase inversions
4. Differentiate between creaming and cracking.
5. Stokes law
6. Sedimentation volume

LONG QUESTIONS

1. Explain the formulation of emulsion by HLB method.
2. Classify emulsions with examples.
3. Write a note on identification tests of emulsions.
4. Settling of suspensions.
5. Write a note on preservation of emulsions.
6. Classify suspension with examples.
7. Differentiate between flocculated and deflocculated suspensions.
8. Write a note on phase equilibrium in coarse dispersions.

VERY LONG QUESTIONS

1. Explain in detail interfacial properties of suspended particles.
2. Discuss formulation parameters of suspension.
3. Discuss in detail the theories of emulsion.
4. Define emulsion. Explain in detail rheological properties of emulsions.