Unit - I Colloidal dispersion

Dispersion system :-

A dispersion system is defined as a system in which dispersed phase is distributed uniformly throughout dispersion medium.

Classification of dispersion system

S.N.	Dispersion medium	Dispersed phase	Example
1-	Gas	Liquid	Fog
2-	Gas	Solid	Smoke
3-	Liquid	Gas	Foam (aerosol)
4-	Liquid	Solid	Colloidal gold in water
5-	Liquid	Liquid	Oil globules or water globules
6-	Solid	Gas	Solid foam
7-	Solid	Liquid	Mineral oil in wax
8-	Solid	Solid	Colloidal gold in glass

Colloidal dispersion

A dispersion system in which dispersed phase size range 1 nm – 1 μm is distributed uniformly through out the dispersion medium are called as colloidal dispersion.

Classification of colloidal dispersion

Colloidal dispersion are classified into following types —

1 – Lyophillic colloid.
2 – Lyophobic colloid.
3 – Association colloid.

1 – Lyophillic colloid –

Lyo means solvent.

* Lyophillic colloids are solvent loving colloids.
* They are hydrophillic and lipophillic types—

Hydrophillic colloids include gelatin or acacia which form colloidal dispersion in water.

Lipophillic colloids include rubber or polystyrene which forms colloidal dispersion in org. solvent.

Ex :- Benzene.

* They are thermodynamically stable.
* Viscosity ↑es with adding dispersed phase.

2- lyophobic callaid :-

* They are k/as solvent hating callaids.
* When dispersion medium is water they are k/as hydrophobic callaids.

Ex :- Callaidal dispersion of gold or silver in water.

* They are thermo dynamically unstable.
* Viscosity does not ↑es on adding dispersed phase.

3 - Association callaids

* They are also k/as amphilic callaids.
* Few molecules or ions have both polar and non-polar groups.
* They exists separatly and associate at critical micelle concentration to form micelle of callaidal size.

* Viscosity ↑es by adding amphiphiles.

Properties of callaids

1- Optical properties —:

Optical properties of callaids are as follows—

ⓐ Ultra microscopy.
ⓑ Electran microscopy.
ⓒ Light scattering.
ⓓ Tyndall effect.

ⓐ Ultra microscopy —:

* When a cell containing callaidal dispersion is viewed through a ultramicroscope against dark background.
* The particle appear as bright spat against dark background.

ⓑ Electran microscopy —:

* The electran microscopy is useful in getting picture of actual particle.
* It help in studying size, shape and structure of callaidal particles.

© Light scattering —:

* When a beam of light is passed through a colloidal dispersion.
* Some light absorbed, some is scattered and remainder is transmited.
* Absorbed light is responsible for coloured nature.
* Scattered light causes the colloidal dispersion to appear turbidity.

(d) Tyndall effect —:

* When a narrow beam of light is passed through a colloidal dispersion.
* The path of light become illuminated.
* This can be observed at right angel under ultra microscope.
* This is k/as tyndall effect.
* Lyophobic system show intence tyndall effect then lyophillic system.

2 - Kinetic properties :-

(a) Brownian movement :-

The colloidal particle in dispersion are always in a state of random motion.

* This random motion can be observed under ultra microscope.
* It was first observed by robert brown.
* The velocity of the particles ↑es with the ↓ed in particle size.

(b) Diffusion :-

Particles diffuse from a region of higher concentration to lower concentration until the system is uniform.

* The rate of diffusion is expressed by ficked's first law —

$$\frac{dq}{dt} = -D S \frac{dc}{dt}$$

where → dq = Amount of material diffusing in time dt.

S = Surface area.

D = Diffusion coefficient.

$\frac{dc}{dt}$ = concentration gradient.

© Sedimentation :-

* In colloidal dispersion, the brownian movement tend to disturb sedimentation.

* Therefore stronger force must be applied for sedimentation.

* Ultra centrifuge is used for studying sediment -ation.

(d) Viscosity :-

Viscosity is an expression of resistance to flow under applied stress (pressure)

* The more viscous a liquid, the greater the applied force to make it flow.

* Viscosity study provide shape of particles in soln.

$$\eta = \eta_0 (1 + 2.5 \phi)$$

where :- η = Viscosity of dispersion

η_0 = Viscosity of dispersion medium

ϕ = Volume fraction of colloidal particles.

3 - Electrical properties :-

When an electric is applied to a colloidal dispersion, the particle carrieng charged moove toward opposite charge electrode.

* The negatively charged particles (such as kaoline and sulphur) move toward anode.
* The +vely charged particles (such as metal hydroxide and ferric hydroxide) move toward cathod.
* The rate of particle movement is observed by ultra-microscope.
* The rate of movement is a function of charge on the particle and related to

zeta potential.

* zeta potential can be calculated by —

$$\zeta = \frac{V}{E} \cdot \frac{4\pi\eta}{\varepsilon} \times (9 \times 10^9)$$

where —; ζ = zeta potential in volt.

V = Velocity of movement of colloidal particles.

E = Applied potential.

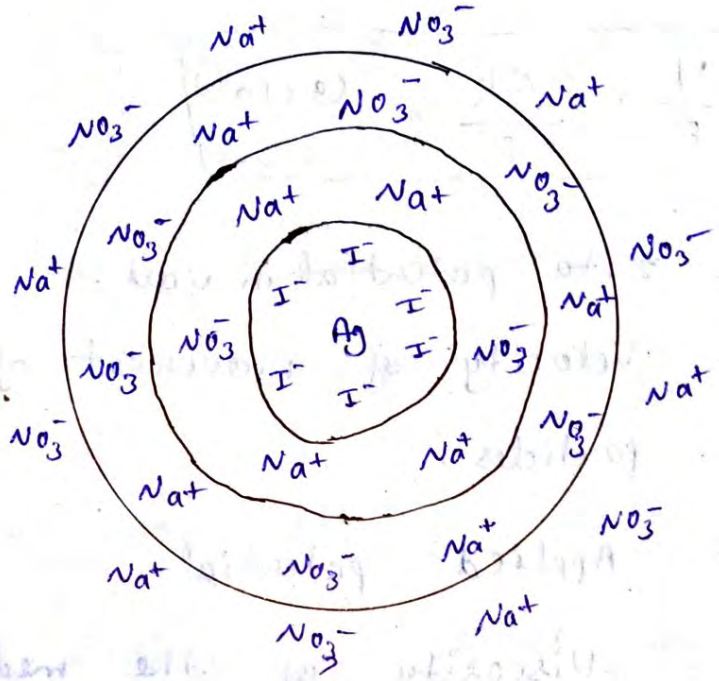
η = Viscosity of the medium

ε = Dielectric constant.

Effect of electrolyte

* Consider a solid surface carrying a -ve charge and is in contact with aqueous solution containing both +ve and -ve ion.
* The -vely charged solid surface will influence distribution of ions.
* The thermal motion also influence distribution of charges.
* The resulting effect will be formation of electric double layer.

Ex-1 $AgNO_3 + NaI \longrightarrow AgI + NaNO_3$



* The surface of AgI contains more I^- ions than Ag^+ ion.
* Aqueous soln contain large amount of Na^+ ion and NO_3^- ion and traces of H^+ and OH^-.
* AgI surface is −vety charge due to I^- ion.
* It attract +ve ions (Na^+) towards its surface.
* The thermal motion causes equal distribution

of ion.

* Na^+ concentration is high over I^- ion surface and form compact layer called as stern layer.

* An other layer of NO_3^- ion forms, called as gouy chapman layer.

* Thus combination of 2 layer of opposite charges are called as electrical double layer.

Protective action :-

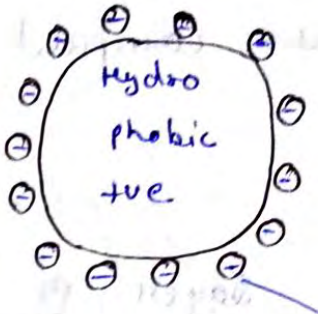
* Large concentration of hydrophillic colloids ↑ the stability of hydrophobic colloids towards precipitation by electrolytes.

* The hydrophillic colloids adsorb on the surface of hydrophobic colloids and form a protective layer.

* This layer prevent them from precipitation on addition of electrolyte.

* This phenomena is k/as protection or protective action.

Ex - 1



+vely charged Large quanty of hydrophillic colloid → Protective colloid

Addition of electrolyte

↓

Most stable ion can not reach the colloidal particles, no coagulation.

* When bismath sub nitrate is suspended in tragacanth dispersion.
* These phenomena involve coagulation of gum by bismath ion.
* The flocculated gum aggregates with the bismuth ion to form gel or hard cake.
* If phosphate, citrate or tarterate added. They protect from coagulating influence of bismuth ion.

Peptization

* It is a process of converting ppt of large particle size to colloidal size by means of electrolyte is k/as peptization.

* Some ionic materials get adsorbed on the surface of finally divided solid and convert it into colloidal dispersion.

Coacervation (Phase separation)

* When oppositly charged hydrophilic colloids are mixed, a colloid rich layer separates out. This process is k/as coacervation.

* The phenomena in which a micro-molecular dispersion on mixing, separated into two layer is called as coacervation.

Ex-1, - Gelatine is positively charged below pH 4.7.

- Acacia is -vely charged at this pH.

- when they 2 are mixed together., 2 layers

are formed.

— The upper layer of low viscosity have poor concentration of colloidal material.

— The lower layer have high viscosity contain high concentration of colloidal material.

Unit - II

Rheology

The term rheology has been derived from the greek word rheo means "To flow" and logos means "science".

Rheology may be defined as the science concerned with the flow of liquid and deformation of matter under the influence of stress applied perpendicularly to the surface or at any angle to the surface of body.

Newtonian System

Liquids which exhibit newton's law of flow are k/as newtonian liquid.

Newton's law of flow :-

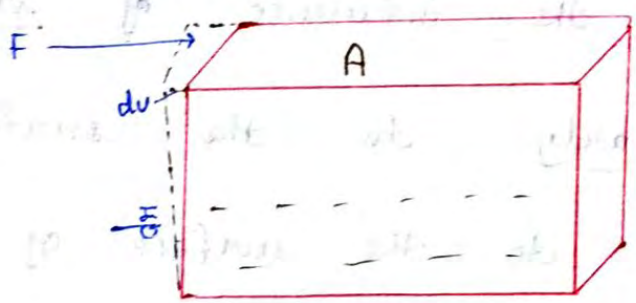
Newton's law of flow states that rate of shear is

directly proportional to the shearing stress.

$$\text{Rate of shear} = \frac{dv}{dx}$$

where :- dv = Velocity difference b/w two planes of liquid separated by distance dx.

$$\text{Shearing stress} = \frac{F}{A}$$ (Force per area).



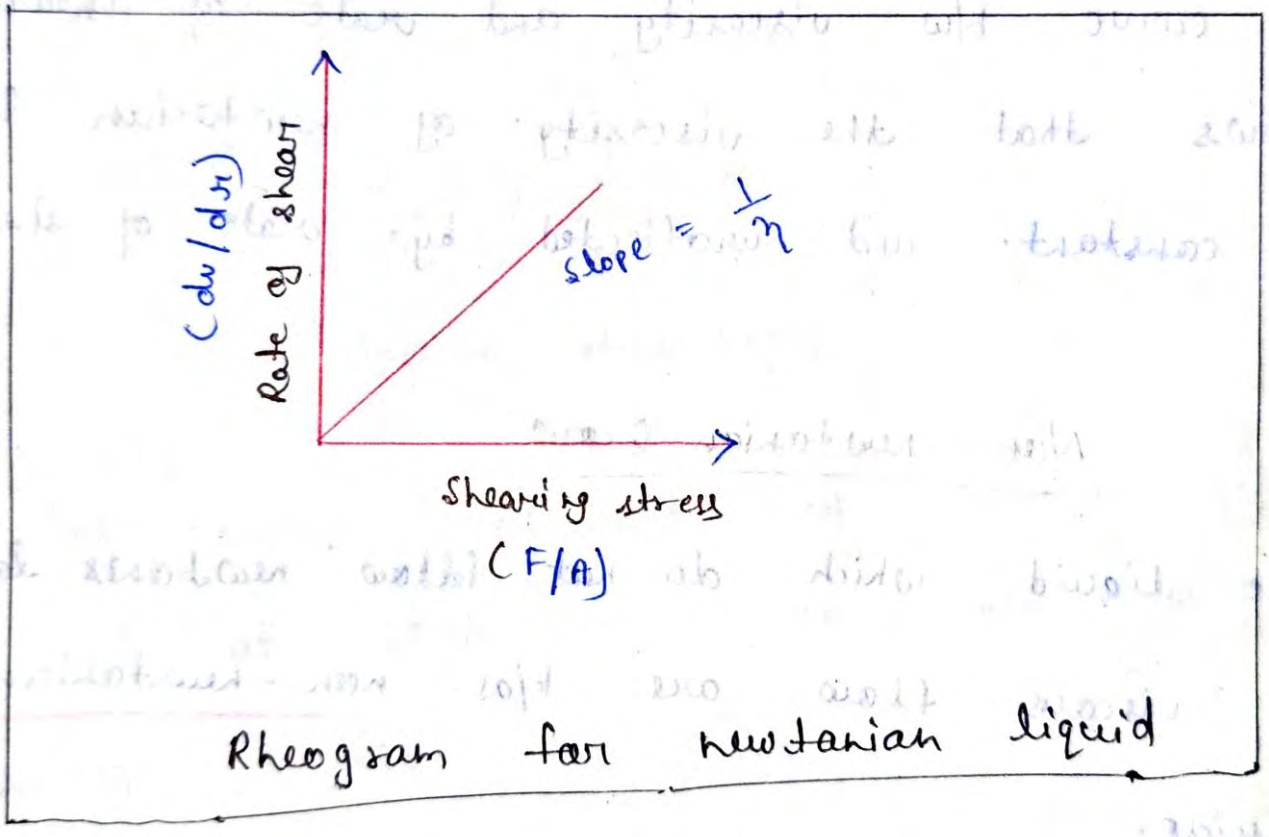
According to newton's law —

$$\frac{dv}{dx} \propto \frac{F}{A}$$

$$\frac{dv}{dx} = \eta \frac{F}{A}$$

where - η = coefficient of viscosity.

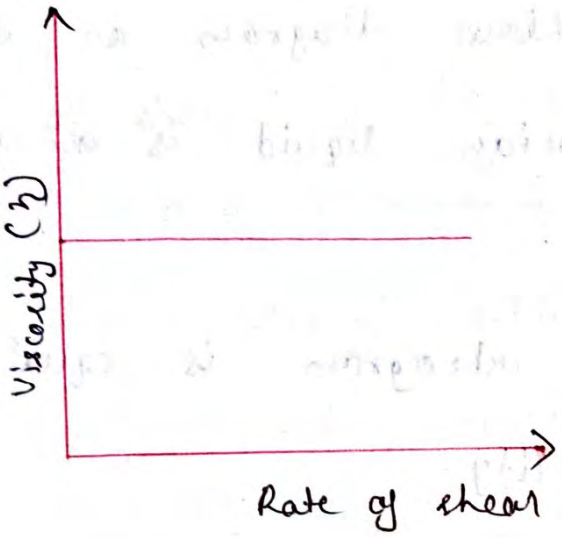
* The rheological property of liquids are expressed in the form of flow diagram or rheograms.
* The plot of newtonian liquid is a strate line.
* The slope of this rheogram is equal to reciprocal of viscosity.



Rheogram for newtonian liquid

* The linear curve indicate that a mild force can induce flowing in this system.

Ex → Benzene, water, CCl_4, the rare



* The curve b/w viscosity and rate of shear shows that the viscosity of newtonian liquid is constant. and unaffected by rate of shear.

Non - newtonian flow

* Those liquid which do not follow newtons laws of viscous flow are k/as non - newtonian fluids.

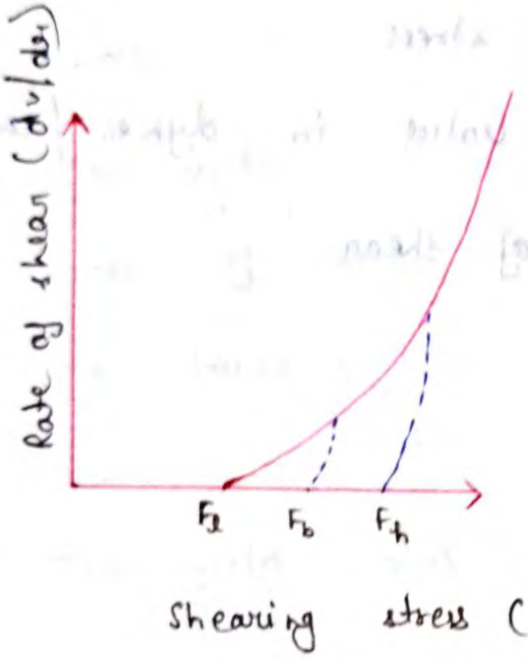
* Viscosity of non - newtonian fluids changes with change in applied shear stress.

* Ex-; Emulsion, ointment, gel, colloidal dispersions are non - newtonian fluids.

* There are following types of non-newtonian fluids —

1- Plastic flow —:

* The characteristics of material which exhibit plastic flow are k/as bingham bodies.



* The curve does not pass through origin, but at some point on shear stress axis intersect k/as bingham yield (F_b).

* F_h is high yield value beyond which flow curve become linear.

* F_s is lower yield value, where actual flow begins.

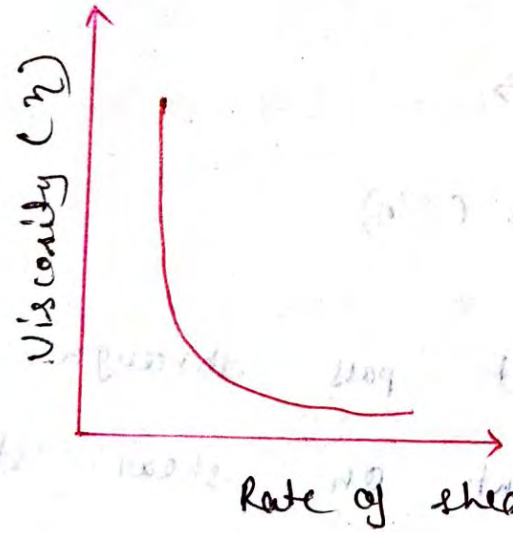
* The plastic viscosity (U) can be calculated from equation —

$$U = \frac{F - F_B}{G_1}$$

Where → F = shearing stress.

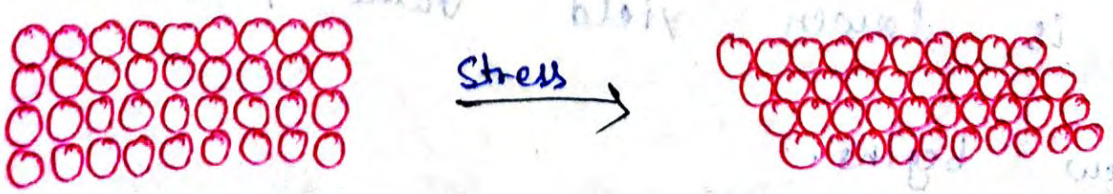
F_B = Yield value in dynes / cm^2.

G_1 = Rate of shear.



* Example of plastic flow are zinc oxide in mineral oil or paints.

Mechanism :-



* Plastic flow is due to contact of flocculated particles.

* Friction b/w the moving particles and force of flocculation contributes yield value.

* The shearing stress in dynes/cm² require to over come these force.

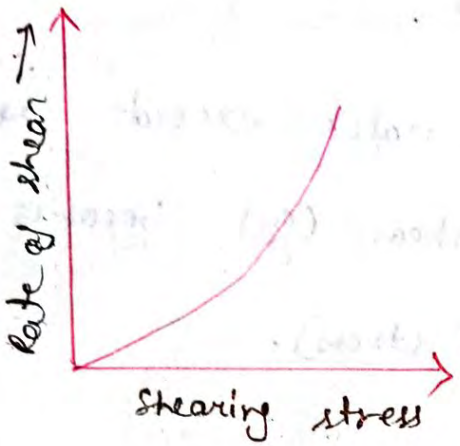
* When the yield value exceed and flow begins, the rate of shear (Cr) becomes directly proportional to the force (stress).

Q-1 → The yield value of a plastic material was determined experimentally to be 6000 dynes/cm² and shearing stress above the yield value, F was found to ↑ linearly with Cr. If the rate of shear was 120 S^{-1}, when F was 8500 dynes/cm² calculate the plastic viscosity of sample.

$$\eta = \frac{F - F_B}{Cr} = \frac{8500 - 6000}{120} = 20.8 \text{ poise}$$

2- Pseudo plastic flow

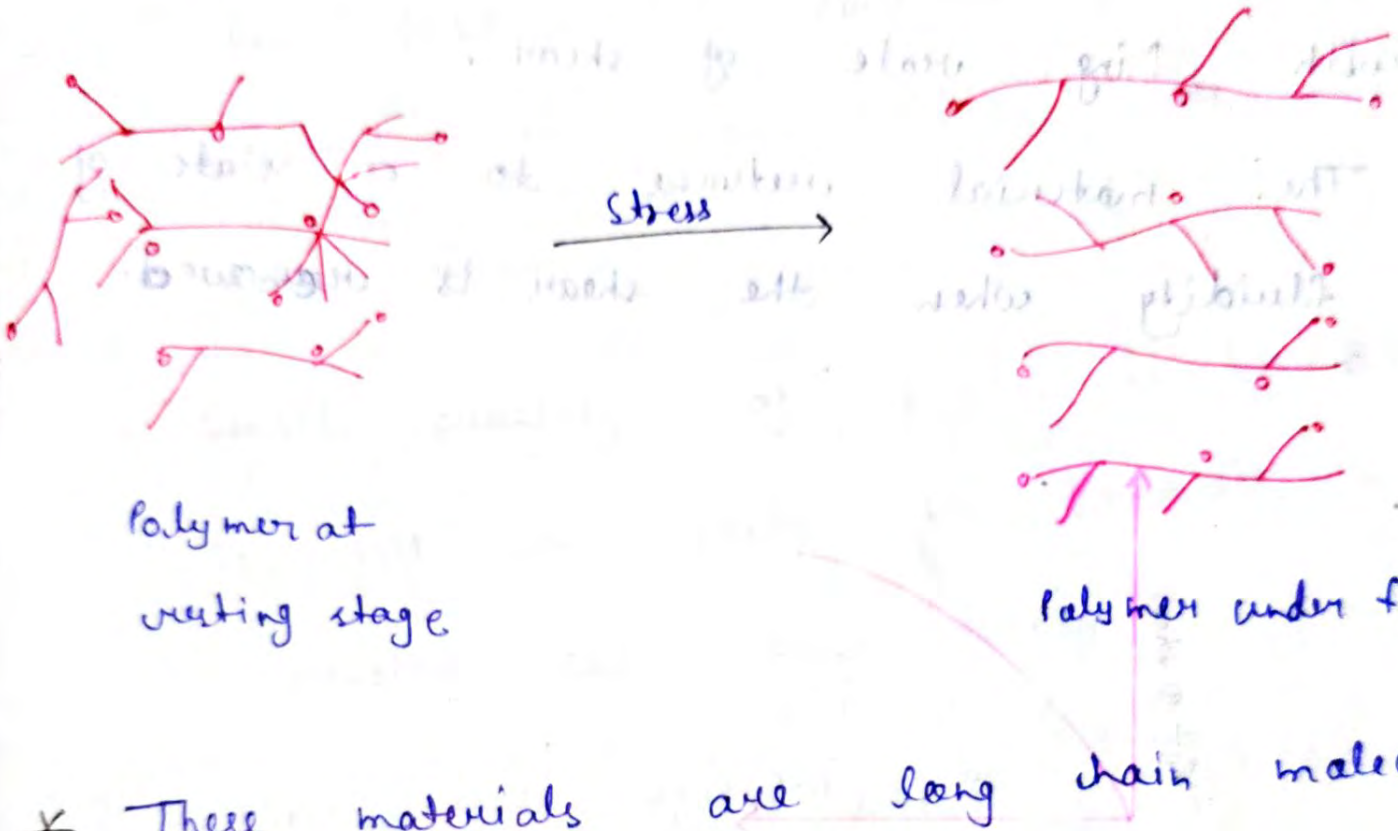
Pseudoplastic materials are characterised by rheological curve which pass through the origin.



* Pseudoplastic flow curve is not linear.
* The shear stress F does not ↑ linearly with the rate of shear.
* Viscosity does not remains constant.
* Viscosity ↓es with rate of shear.

Eg → Salⁿ of tragacanth, gelatine, CMC and gums —

Mechanism :-



Polymer at resting stage

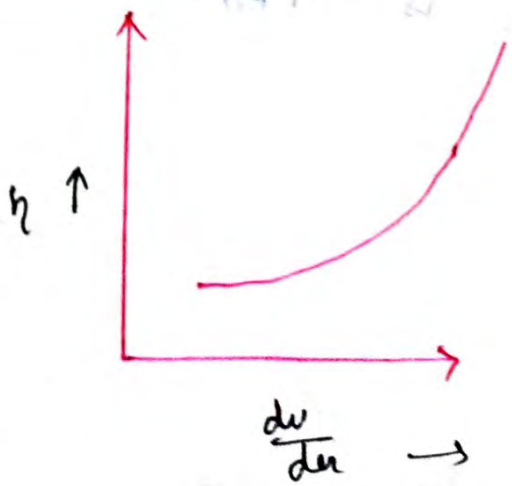
Polymer under flow

* These materials are long chain molecules which are disarrange at low shear rates.
* At high rate of shear they become aligned.
* Thus material becomes less viscous as the shear rate is ↑ed.

3- Dilatant flow

* Dilatancy is a phenomena in which material show an ↑ in resistance to flow with ↑ing rate of shear.
* The material returns to a state of fluidity when the shear is removed.

* This phenomena is k/as shear thickening
* Viscosity ↑es with ↑ing rate of shear.



Mechanism

1→ Dilatant flow is found in suspension containing high concentration of very fine particles.

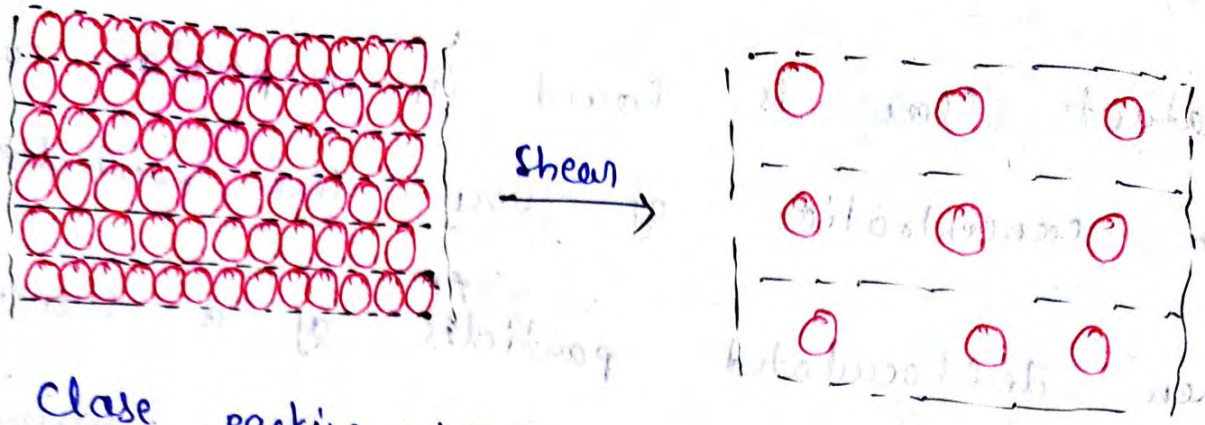
2→ When deflocculated particles of a suspension settle, they pack closely with minimum void volume.

3→ Small quantity of vehicle is needed to fill the voids b/w particles but suspension can flow freely.

4→ When mass agitated, bulk is ↑ed.

5→ The vehicle becomes insufficient to fill the voids.

6→ Particles show and ↑ed resistance to flow.



Close packing minimum void volume

Open packing high void volume

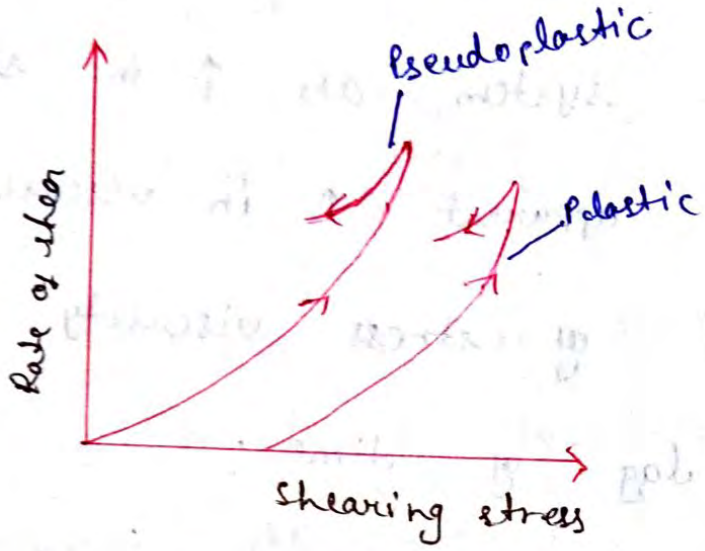
Phixotropy

Plastic and pseudoplastic system :-

* Viscosity ↓es on ↑ing the shearing stress, at any given temperature.
* On removing the shearing stress, the viscosity is regained but after some time lead. This phenomena is k/as phixotropy.
* It is reversible isothermal process.

Gel $\xrightarrow{\text{Application of shear stress}}$ Sol $\xrightarrow{\text{Removal of shear stress}}$ Gel

* Rheogram is obtained by plotting the rate of shear at various shearing stress.



Rheogram

* As shearing stress is Yes and upcurve is obtained.

* On reducing the shearing stress a down curve is obtained.

* The down curve sifted to the left side means the viscosity of down curve is lower than the upcurve.

Ex-1 (i) Example of plastic system showing phixotropy or bentonite gel.

(ii) Pseudoplastic system showing phixotropy or

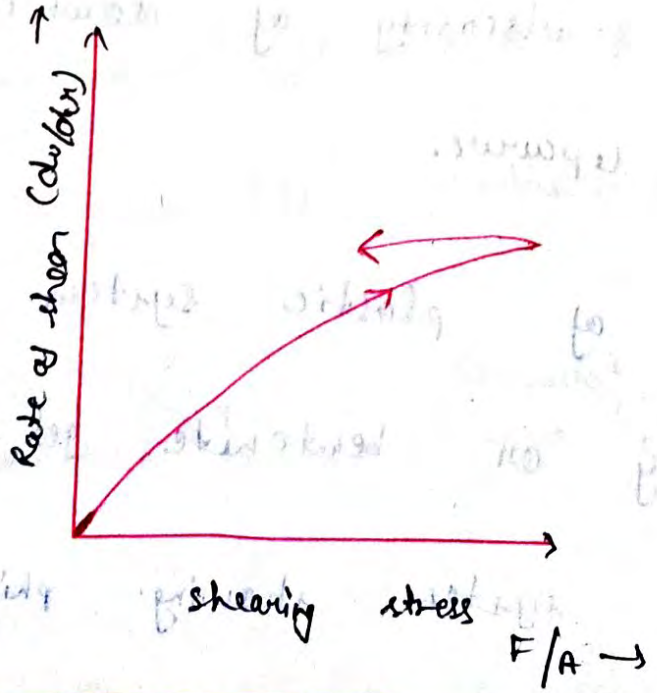
dispersions of synthetic suspending agents.

Thixotropy in dilatant system :-

* In dilatant system, an ↑ in shearing stress causes an apparent ↑ in viscosity.
* On removal of stress viscosity fes but after a lag of time.
* It is reversible isathermal transformation from solution to gel.

Solⁿ —(Application of shear stress)→ Gel —(Removal of shear stress)→ Solⁿ

* Rheogram for dilatant system are as follows—



* Viscosity of system ↑es with application of stress.

Eg → Sand suspension

Kinematic viscosity

Viscosity → Viscosity is an expression of the resistance of a fluid to flow under applied stress, higher the viscosity, greater the resistance

Coefficient of viscosity → It is determined from equation

$$\eta = \frac{F}{G}$$

Where - F = Force per unit area.

G = Rate of shear.

The unit of viscosity is poise or centi poise.

1 Cp = 0.01 poise.

Kinematic viscosity → The kinematic viscosity of a liquid is its absolute viscosity divided by the density at a definite temperature.

$$\text{Kinematic viscosity} = \frac{\eta}{\rho}$$

Effect of temperature :-

Viscosity of a gas ↑es with temperature. In case of liquid the viscosity ↓es with ↑ in temperature.

Generally speed of many rxn can be ↑ed 2-3 times with ↑ of 10°C temp.

The dependence of viscosity of a liquid on temperature is given by Arrhenius equation —

$$\eta = A e^{-Ev/RT}$$

where :- T = Temperature in kelvin.

η = viscosity of liquid.

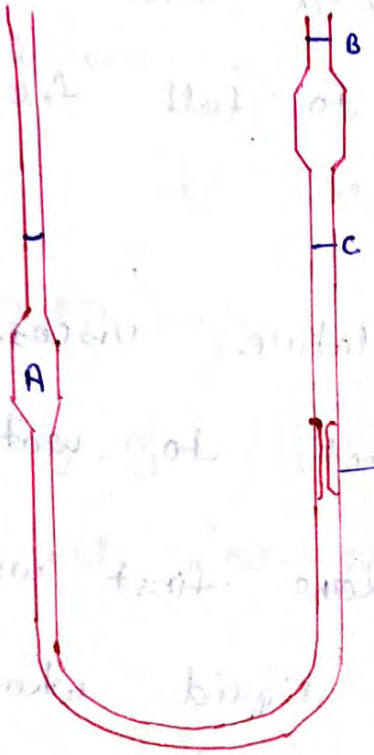
R = Gas constant.

A = Frequency of ~~collision~~ collision b/w molecules.

Ev = Energy of activation required for collision b/w molecules

Determination of viscosity

1→ Capillary viscometer (Ostwald viscometer) —:



Ostwald viscometer

* Capillary viscometer is accurate for measurement of viscosity of newtonian liquids (fluids) having low viscosity.
* Liquid is introduced into the ostwald viscometer through left arm upto mark A.
* The viscometer is fixed vertically on a water bath.

* The liquid is sucked through right arm untill the mark B.
* The pressure is released and time taken from the miniscus to fall from B to C is noted.
* To determine the relative viscosity of a liquid with respect to water.
* The experiment is done first with water and then with the liquid whose viscosity is to be determined.
* The time taken for the liquid T_1 and for water T_2 are determined.
* The relative ——— viscosity is determined by calculation as —

$$\frac{\eta_1}{\eta_2} = \frac{\rho_1 t_1}{\rho_2 t_2}$$

Q-1 → The time required for water and liquid B to flow through a ostwald viscometer was found to be 48 sec. and 20 sec. respectively. at 25°C. If the density of water and the liquid at 25°C are 1 and 0.85 gm/cm³ respectively, calculate the viscosity of liquid B at 25°C. (Given viscosity of water at 25°C is 0.89 Cm. poise).

Answer →

$T_1 = 48$ sec. , $T_2 = 20$ sec.

$\rho_1 = 1$ gm/cm³ , $\rho_2 = 0.85$ gm/cm³

$\eta_1 = 0.89$ cm poise , $\eta_2 = ?$

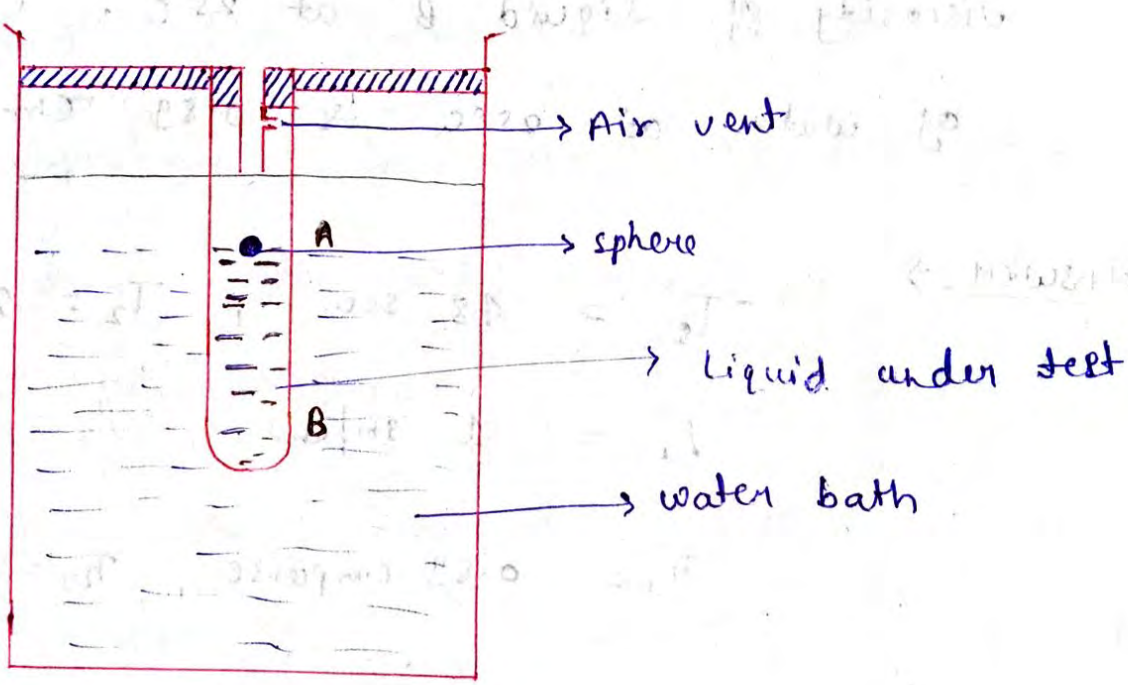
$$\frac{\eta_1}{\eta_2} = \frac{\rho_1 t_1}{\rho_2 t_2}$$

$$\frac{0.89}{\eta_2} = \frac{1 \times 48}{0.85 \times 20}$$

$$\eta_2 = 0.31 \text{ cm poise}$$

2- Falling sphere viscometer :-

This instrument is based on stok's law which states that when a body falls through a viscous medium, it experiences a resistance which opposes the motion of the body.



* It consist of a tube having two mark A and B on the outer surface.
* The tube is filled with the liquid whose viscosity is to be determined.
* The tube is clamped vertically inside a

temperature bath.

* A ball of suitable material such as steel or glass is allowed to fall through the guide tube inside the falling tube.

* The time taken for the sphere to fall from the point A to B is noted.

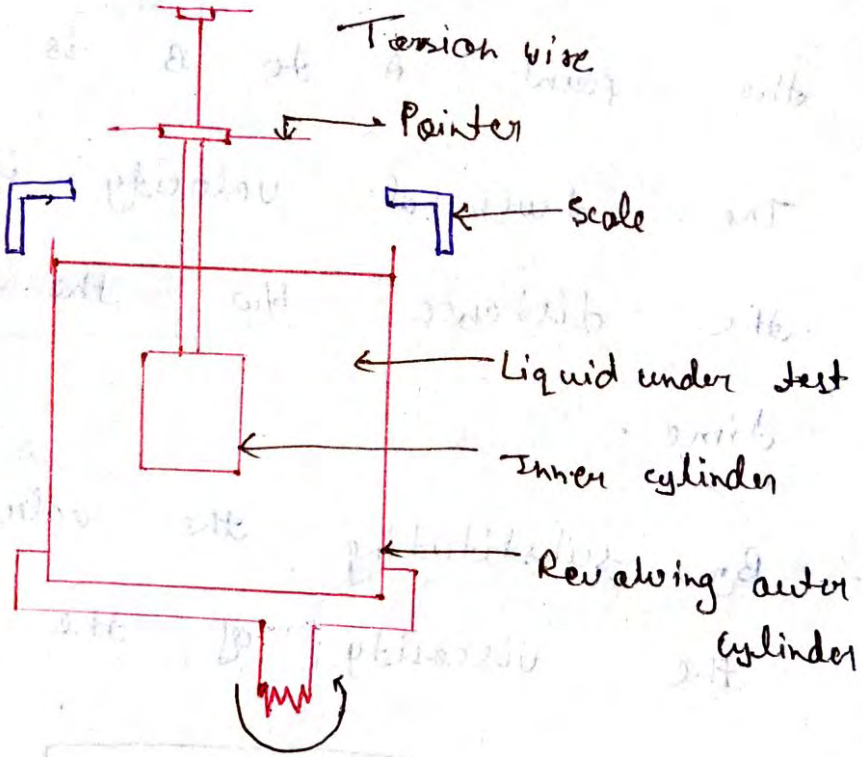
* The terminal velocity is obtained by dividing the distance b/w the 2 marks and the time.

* By substituting the values in the equation, the viscosity of the liquid is determined.

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

3 - Rotational viscometer - (Cup and bob viscometer)

* It works on the viscous drag exerted on a body when it is rotated in the fluid whose viscosity is to be determined.



Cup and Bob visco-meter

* It consists of 2 cylinders of different diameter.
* The outer cyclinder forms the cup into which the inner cylinder or bob is fixed.
* The sample to be analysed is placed

in the space b/w the outer wall of the bob and inner wall of the cup.

The torque set up in the bob is measured by angular diflection (θ) of a pointer that moves on a scale.

Deformation (change) of solid

* Deformation refers to any change in the shape or size of an object due to applied force (energy through work) or change in temperature (heat).
* Applied force can be result of tensile (pulling) forces, compressive (pushing) forces, bending or twisting.
* Temperature can result in structural defect, point vacancies, line and screw dislocation in both crystalline and non-crystalline solids.
* As deformations occurs, internal intermolecular forces arise that appose the applied force.

* If the applied force is not too great, these forces may be sufficient to resist the applied force.

* The object returen to it's original state, when the load is removed.

* A larger applied force may lead to a permanent deformation of the object.

Types of deformation

(i) Elastic deformation → small / large

(ii) Plastic deformation.

(iii) Fracture deformation.

(iv) True stress and strain deformation.

① Elastic deformation :-

* This is also k/as temporary deformation.

* It depend upon the stress level in a material.

* The temperary deformation is recoverable as it disppears after the removal of applied force.

* Upon removal of load, a complete recovery to the undeformed configuration should takes place.

* There are 2 types of elastic deformation—

(a) Small elastic deformation → Deformation in case of material such as concrete and steel.

(b) Large elastic deformation → Deformation in case of elastomer and polymer.

(ii) Plastic deformation →

* This types of deformation is irreversible.
* An object in the plastic deformation range will first undergo elastic deformation and then plastic deformation which is irriversible.
* It depends on both the stress level and strain history of the material.
* Plastic deformation in metals occures after a metal has reached its yield point.
* It results due to dislocation of micro structural sources which are not fully recoverable on removal of load.

* Soft thermo plastic have large plastic deformation such as copper, silver and gald.

* Hard thermo setting plastic have small plastic deformation such as rubber, crystalls and ceramics.

Elastic modulus

* Elastic modulus is the ratio of stress, below the proportional limit to the strain.

* It is the ratio of stress to strain when the deformation is totally elastic.

* This modulus may be thought as a materials resistance to elastic deformation.

* A rigid material has a higher

modulus.

* Elastic modulus is also k/as young's modulus.

Ex:- Magnisium has magnitude of modulus b/w 45 gigapascale and tungstan has 407 gigapascale.

* The parameters used to describe the stress - strain curve is tensile strength, yield strength and % elongation.

* There are 3 types of moduli —

1- Elastic modulus (young's modulus) → The ratio of longitudinal stress to strain.

2- Bulk modulus → The ratio of stress to the fractional decrease in the volume of the body.

3- Shear modulus → The ratio of tangential force per unit area to the angular deformation.

Stress →

It is defined as force per unit area.

Strain →

It is defined as elongation or contraction per unit length.

Heckel equation

* The Heckel analysis is a most papular method of deformation reduction under compression pressure.
* Powder packing with ↑ing compression load affect particle rearrangement, elastic and plastic deformation and particle fragmentation.
* It follow first order with, where's the pores in the powder are the reactant. (Depend on concentration).

$$\text{Log } 1/E = k_y \cdot P + K_n$$

Where → k_y = material constant.

K_n = Initial repacking stage (E_o)

E = Porosity

P = Applied pressure

* For cylindrical tablets —

$$P = 4F / \pi \cdot D^2$$

Where → D = Tablet diameter.

F = Compression force.

* Porosity can be calculated by equation —

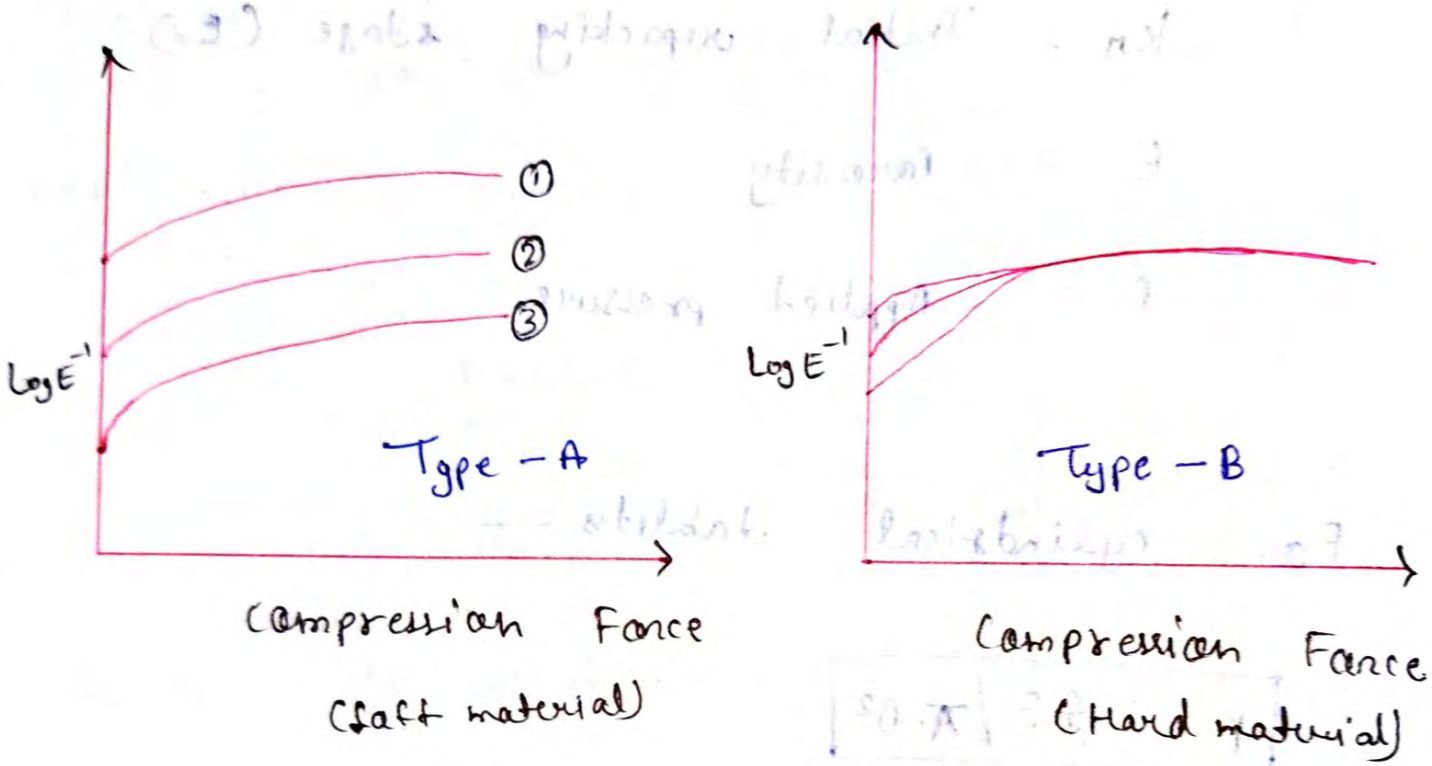
$$E = 100 (1 - 4 W/\rho_t \cdot \pi D^2 H)$$

Where → W = Weight of tablet.

ρ_t = True density.

H = Thickness of tablet.

Heckel's plots –



Type – A → Higher slope and lower yield stress.

Type – B → Lower slope and high yield stress (Hard material).

* It follow first order kinetics.
* As porosity ↑es compression force also ↑es.

* materials which are soft undergo plastic deformation.

* It depend upon shape and size distribution of particles.

Ex → NaCl, NaBr (Type A)

* Harder material with higher yield pressure undergo compression by fragmentation.

Ex → Lactose and sacrose (Type B)

Coarse dispersions are heterogeneous dispersed systems in which the dispersed phase particles are larger than 1000 nm.

Unit – III

Coarse dispersion

* Suspension and emulsion are 2 types of coarse dispersion.

* The size of coarse dispersion ranges from 1 μm to 100 μm.

Suspension :-

A suspension may be defined as a heterogenous (biphasic system) comprising of a solid phase (dispersed phase) uniformally dispersed in a liquid phase (continuous phase).

* A suspension is a coarse dispersion which supply insoluble and distasteful substance in the form of pleasant taste.

Ex :- ① Chloramphenical is very bitter and

can hat be given in liquid form to children.

(ii) Chloramphenical palmitate, an insoluble salt can be formulated in suspension for paediatric use.

Interfecial properties of suspended particles

There are 2 factors in suspended particles —

(1) Surface free energy —:

* In formulation of a suspension, work is done to reduce the particle size (↑ the surface area).

* This makes the system thermodynemically unstable.

* In order to ↑ the stability, particles

flocculate by Vander wall's forces.

* The ↑ in free energy due to reduction of particle size is given by the equation —

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

Where → ΔG = Surface free energy change

γ_{SL} = Interfecial tension b/w solid and liquid.

ΔA = Change in surface area of solid.

* The system try to stable by reducing free energy to zero.

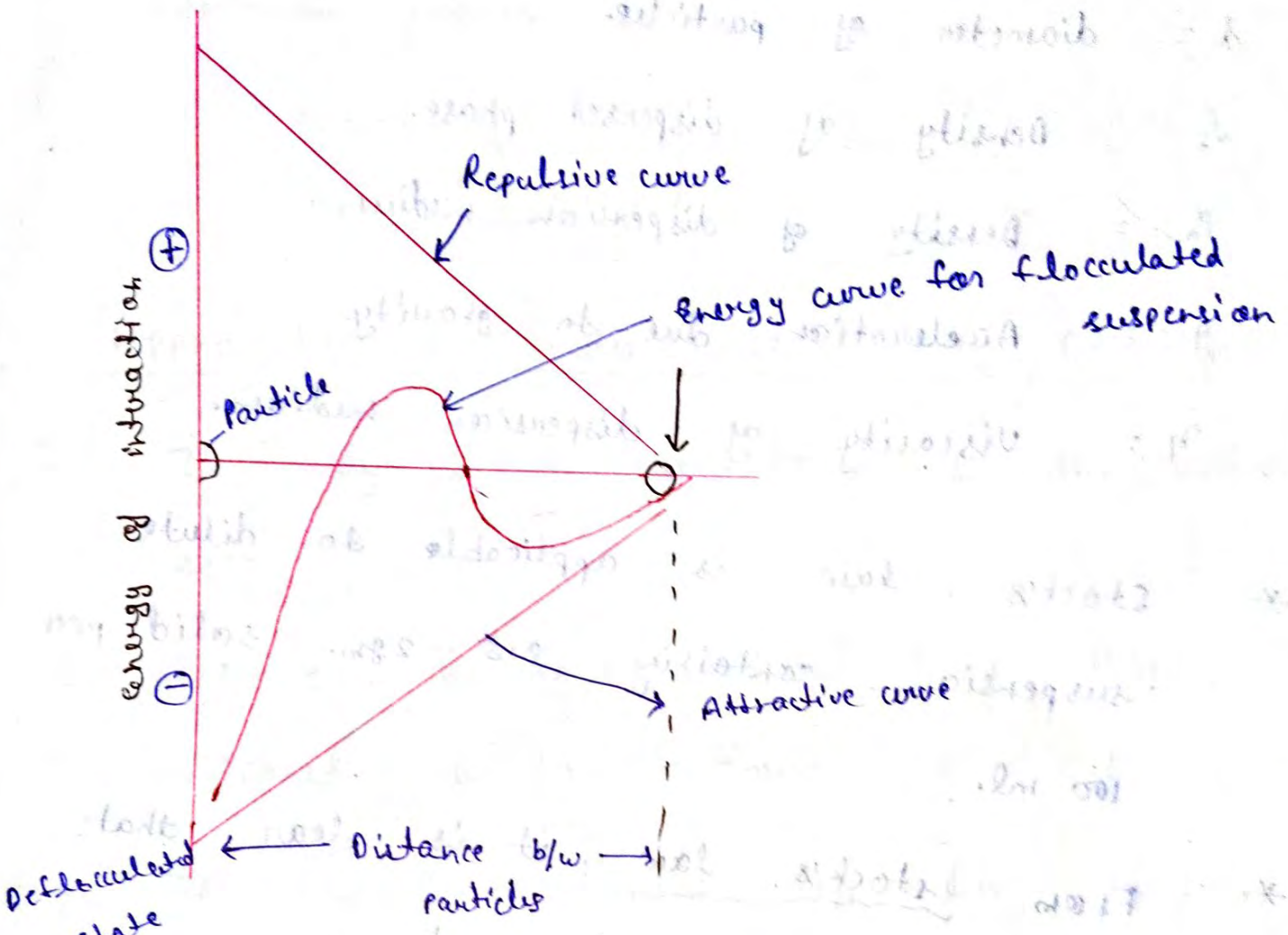
* The interfecial tension can be reduced by wetting agent. which adsorb on the surface of particle.

* wetting agent can not reduce the interfecial tension to zero, hence

Suspension particle tend to flocculate.

(ii) Electrical properties :-

* Force acting on the surface of the suspended particles affect flocculation in a suspension.
* Force of attraction arise from vander wall's forces.
* Force of repulsion results from electrical double layer.
* When the repulsive energy is high, it prevent collision of particles and they remains deflocculated.
* When deflocculated particles settles, they form closed packing.



Settling in suspensions

The sedimentation velocity of suspended particle is given by stokes law.

According to this —

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

V = Rate of settling in cm/s.

d = diameter of particles.

ρ_s = Density of dispersed phase.

ρ_0 = Density of dispersion medium.

g = Acceleration due to gravity.

η = Viscosity of dispersion medium.

* Stock's law is applicable to dilute suspension containing 0.5 – 2 gm. solid per 100 ml.

* From stock's law, it is clear that rate of sedimentation is —

(I) Directly proportional to difference b/w the densities of both phase.

$$V \propto (\rho_s - \rho_0)$$

(II) Directly proportional to square of diameter of particles.

$$V \propto d^2$$

(iii) Inversely proportional to the viscosity of the dispersion medium.

$$V \propto \frac{1}{\eta}$$

Approaches to reduce settling of particles :-

1- It may be reduced by ↓ the particle size.

2- It can be reduced by ↑ing the viscosity up to optimum.

3- It can be reduced by ↓ing the difference in the density of the dispersed phase and dispersion medium

(By adding PEG, Glycerine, sugar etc.)

↓

(Poly ethylene glycol)

Formulation of flocculated and deflocculated suspension

* There are two approaches for preparation of stable suspension.

* There are —

(i) Use of structured vehicle to maintain deflocculated particles.

(ii) Application of flocculation to produce flocs which settle rapidly and easy to redisperse.

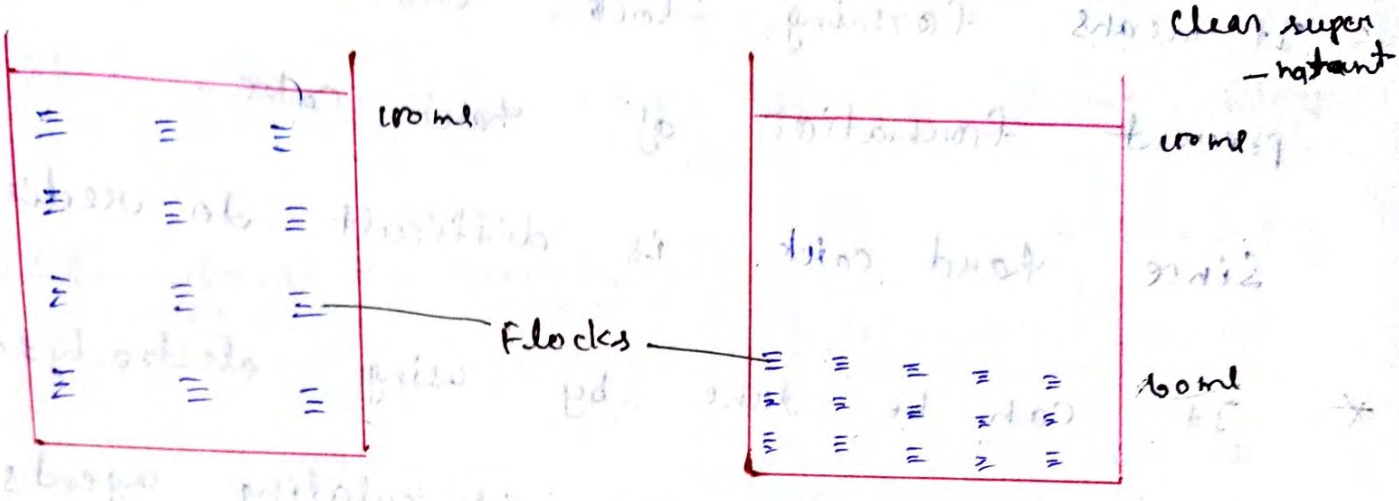
Wetting of particles —

* This is the first step in formulation of suspension.

* The insaluble powder dispersion in vehicle is difficult due to adsorbed air and grease.

* Wetting agents such as poly sorbate -80 help to reduce interfecial tension b/w solid and vehicles.

Flocculated suspension :-



Initial stage

After storage

* In this suspension, group of particles are aggregated into flocs and the flocs tend to fall together.

* Settling results in clear boundary b/w the sediment and the supernatant liquid.

* The supernatant liquid is clear.

Controlled flocculation :-

* It means forming flocks under control to prevent formation of hard cake.

  Since hard cake is difficult to redisperse.

* It can be done by using electrolytes

* Electrolytes act as flocculating agents by reducing electrical barrier. b/w the particles that is (i.e.) by ↓ing charge.

* Ex :-

  → Bismuth subnitrate in water, the particles posses a +ve charge.

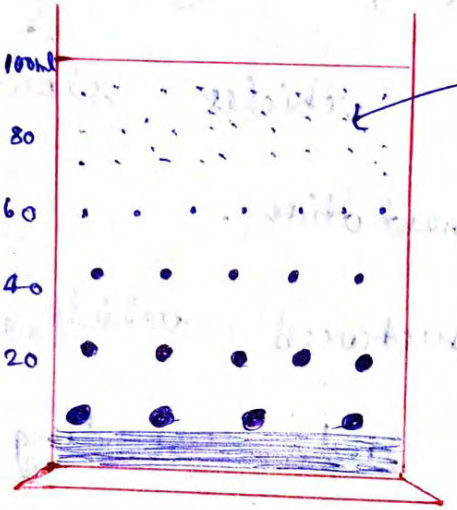
  → Due to repulsion b/w particles, the system is deflocculated and well settle form cake.

  → If monophasic potasium phosphate is added, the +ve charge will ↓ by phosphate ions.

→ On continuous, addition of monophasic potasium phosphate, the +ve charge reduced to zero.

→ This result in formation of loose flocs.

Defflocculated suspension —!



Defflocculated suspension

* In defflocculated suspension, the larger particles settles faster rate than the smaller particles.
* As a result a clear boundary b/w the sediment and the dispersion medium can not be easily distinguished.
* The supernatant liquid remains cloudy for a definite period of time.

Use of structured vehicle :-

* Structured vehicle are those vehicle which are used to reduce the degree of sedimentation.
* Structured vehicle can be prepared by using thickening agents such as tragacanth, Acegum, carbachal, carboxy methyl cellulose etc.
* These structured vehicles slow down the rate of sedimentation.
* To prepare structured vehicle, the charge on flocculating and suspending agent should be kept in mind.

Ex :- (i) +vely charged particle flocculate in −vely charge (anionic) electrolyte (gum).

(ii) The +vely charged particle will be destablised by +vely charged gelatine.

* (iii) Like wise, −vely charged particles flocculated with +vely charged electrolyte.

Emulsion

* An emulsion is a biphasic liquid preparation containing two immiscible liquids, one of which is dispersed uniformaly as minute globules into the other continuous phase.

* The liquid which is converted into minute globules are called the dispersed phase and the liquid in which it is dispersed are called continuous phase.

* The size range of globules may be 0.1 – 100 µm in diameter.

Types of emulsion

1 → Oil in water emulsion (o/w) :-

A system in which oil is dispersed phase and water is continuous phase are k/as oil in water emulsion.

Ex :- Lotion, liniments, creams etc.

2- water in oil emulsion (w/o) :-

The system in which water is dispersed phase and oil is the continuous phase are k/as water in oil (w/o) emulsion.

Ex :- Moisturising cream, cleansing cream.

3- Multiple emulsion (w/o/w, o/w/o) :-

* Multiples emulsion are those emulsion in which the oil in water or water in oil emulsion are dispersed in another liquid medium such as oil or water.

* Finally system forms o/w/o or w/o/w emulsion.

Eg → Sustained released dosage form.

4 - Micro - emulsion :-

Micro - emulsions are emulsions that contain globule diameter less than 0.1 μm and are invisible to

necked eye.

* Micro emulsions are transparent solutions.

Eg → Both external as well as internal preparat^{n}.

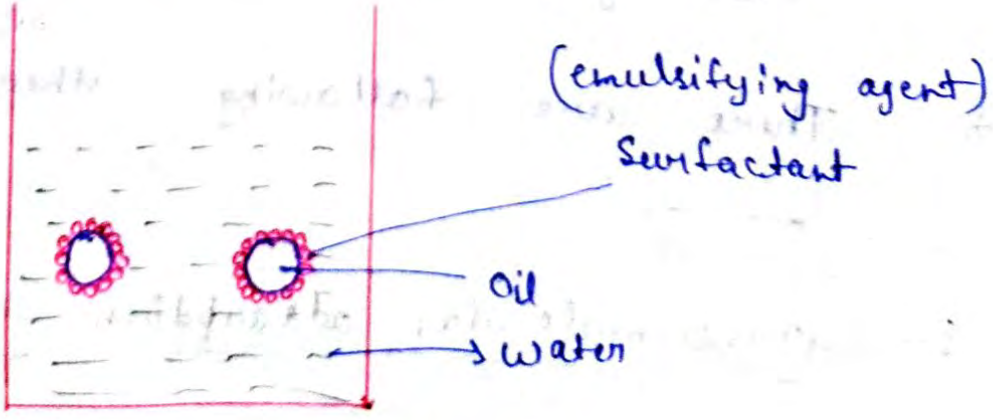
Theorise of emulsion

* If one liquid is broken into small particles as globules, the surface area of liquid ↑es.
* Thus surface free energy also ↑es due to ↑ in surface area.
* Hence the system becomes thermodynamically unstable.
* Emulsifying agents are added to stablized the system.
* Emulsifying agent reduces interfecial tension
* There are following theories of emulsions

1- Mono molecular adsorption theory -:

* Surfactant form a single layer at the inter phase.

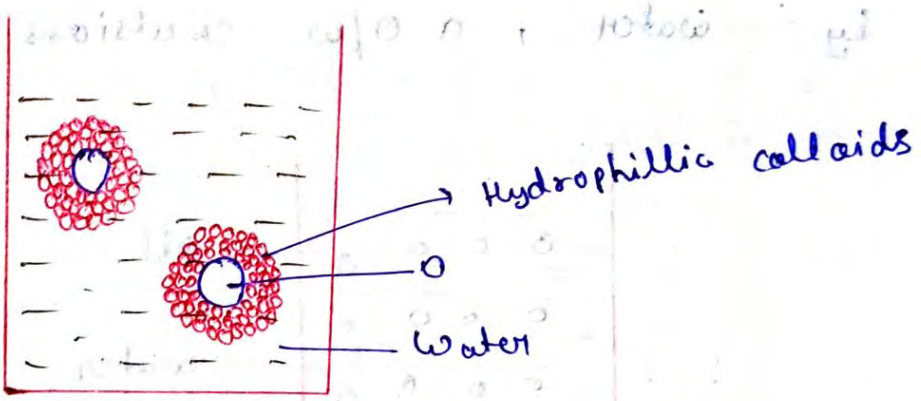
* Surfactant have both hydrophillic and lipophillic regions.
* Surfactants adsorbe at the oil-water interphase such that lipophillic groups orient towards oil and hydrophillic groups orient towards water.
* This film also act as mechanical barrier to coalescence of globules.
* Emulsifying agent reduces interfacial tension, surface free energy also.
* An additional effect is presence of surface charge which cause repulsion b/w globules.



Mono molecular

2- Multimolecular adsorption theory :-

* Hydrophillic colloids act by forming multimole-cular layer at the interphase.
* The layer are strong and resist coalescence.
* Hydrophillic colloids cause ↑ in viscosity of the medium which also ↓ es coalescence.
* Since they are hydrophillic, they form only o/w emulsion.

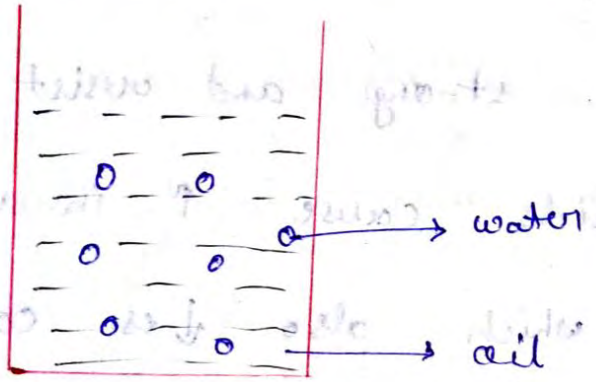


Multimolecular adsorption

3- Solid particles adsorption theory :-

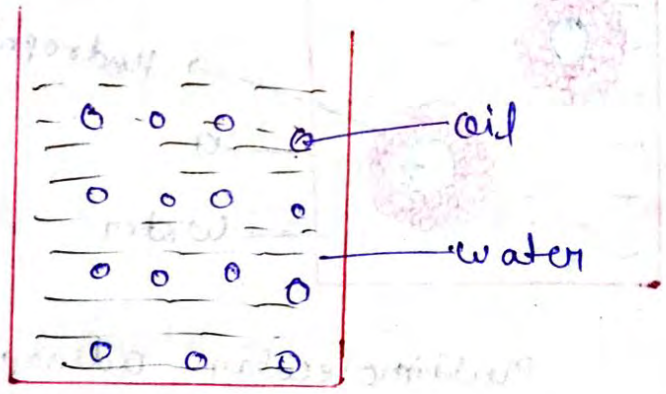
* Some fine solids have balanced hydrophillic and lipophillic properties.
* They accumulate at the w/o interphase and prevent coalescence.

* If the solid particles are initially wetted by oil, a water/oil (w/o) emulsion results.



w/o emulsion

* If the solid particle are initially wetted by water, a o/w emulsions results.



o/w emulsion

Ex → A number of colloidal clays and several in organic substances are used in emulsifying agent.

Stability of emulsion

Causes of instability :-

(i) **Flocculation :-**

It is a condition where neighbouring globules come in contact with each other and form aggregates in the external phase.

(ii) **Creaming :-**

Creaming is the concentration of globules at the top or bottom of the emulsion

* Upward creaming occurs in oil in water (o/w) emulsion.
* Downward creaming occurs in water in oil (w/o) emulsion.

(iii) **Coalescence :-**

The coalescence of dispersed phase result is in breaking up of emulsion and it can not be reformed.

(iv) **Phase inversion :-**

The changes of emulsion type from oil in water (o/w) to w/o or vice-versa.

(v) Physical and chemical changes :-

* Natural gums used as emulsifying agent may contain bacterial growth.
* This may cause change in pH and breaking down of emulsion.

Factors which improve stability of emulsion :-

(i) Particle size :-

It is necessary to choose the optimum size of globules.

(ii) Particle size distribution :-

Globules are uniform size impart maximum stability.

(iii) Viscosity :-

As viscosity ↑es flocculation of globules will be reduce.

An optimum viscosity is desirable for good stability.

(iv) Phase volume ratio :-

74% concentration of dispersed phase is called critical point beyond which phase inversion takes place.

50:50 phase volume ratio give most stable emulsion.

(v) charge of globules (vi) pH of emulsion

Preservation of emulsion

1- Preservation from micro-organism :-

Micro-organism cause change in colour, taste, odour, pH, hydrolysis and even cause breaking of emulsion.

Character of ideal preservative :-

Are as follows-

→ It should be non-toxic, non-irritant.

→ It should not impart any colour or taste to the emulsion.

→ It should have bactericidal rather than bacteriostatic activity.

→ It should be highly water soluble.