Name of Unit	Micromeritics
Subject /Course name	Physical Pharmaceutics-II
Subject/Course ID	BP 403T
Class: B.Pharm. Semester	IV
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Learning Outcome Module 05

	Learning Outcome (LO)	Course Outcome Code
LO1	Students will learn about Particle size and distribution, mean particle size, number and weight distribution, particle number.	BP403.4
LO2	Students will learn about methods for determining particle size by different methods, counting and separation method.	BP403.4
LO3	Students will learn about particle shape, specific surface	BP403.4
LO4	Students will learn about methods for determining surface area, permeability, adsorption, derived properties of powders, porosity.	BP403.4
LO5	Students will learn about packing arrangement, densities, bulkiness and flow properties.	BP403.4

Content Table

Topic
• Particle size and distribution, mean particle size, number and weight distribution, particle number • Methods for determining particle size by different methods, counting and separation method. • Particle shape, specific surface, methods for determining surface area, permeability, adsorption. • Derived properties of powders • Porosity, packing arrangement, densities, bulkiness and flow properties.

MICROMETRICS

Micrometrics study in different formulation • Colloidal dispersion are characterized byparticles that are too small to be seen in the ordinary microscope. • The particles of pharmaceutical emulsion and suspension and the "fines" of powder fall in the range of the optical microscope. • Particles having the size of coarser powder , tablet granulation , and granular salts fall with in the sieve range. Control of particle size and the size range of a drug can be significantly related to its physical, chemical and pharmacological properties. Bioavailability and physical stability in some dosage forms can also be affected by particle size.□Micromeritics is the science and technology of small particles. The unit of particle sizemost frequently used in micromeritics is micrometer, also called as a micron.

Applications

Release & Dissolution Particle size & surface area influence the releaseof a drug from a dosage form that is administered orally, rectally parenterally & topically. Higher surface area brings about intimate contact of the drug with the dissolution fluids in vivo & increases the drug solubility & dissolution.

Absorption & Drug Action Particle size & surface area influence the drug absorption & subsequently the therapeutic action. Higher the dissolution, faster the absorption & hence quicker & greater the drug action.

Physical Stability Micromeritc properties of a particle i.e the particle size in a formulation influences the physical stability of the suspensions & emulsions. Smaller the size of the particle, better the physical stability of the dosage form owing to the brownian movement of the particles in the dispersion

Factors influenced by particle size Surface area : increased S.A. affects the therapeutic efficiency of medicinal compounds that possess a low solubility in body fluids by increasing the area of contact between the solid and the dissolving fluid. Thus compound dissolves in a shorter time.

Extraction : the time required for extraction is shortened by the increased area of contact between the solvent and solid and the reduced distance the solvent has to penetrate the material.

Dissolution : the time required for dissolution of solid chemicals is shortened by the use of smaller particles

Drying : the drying of wet mass may be facilitated by milling, which increase the S.A.and reduces the distance the moisture must travel with in the particle to reach the outer surface.

Mixing : the mixing of several solid ingredients of a pharmaceutical is easier and more uniform if the ingredients are approximately the same and small size.

Lubrication : lubricant used in compressed tablets and capsules function by virtue oftheir ability to coat the surface of granulation or powder.

Properties of powder based on particle size and shape Porosity : the porosity or voids of powder is defined as the ratio of the void volume to the bulk volume of packing. (v) Є = Vb-Vp particle Vb Here ; Vb – Vp = void volume Vb = bulk volume Vp = true volume of Packing arrangements ; powder beds of uniform sized spheres can assume two ideal packing arrangement. closest or rhombohedral most open ,loosest or cubic packing the theoretical porosity of powder of uniform spheres in closest packing is 26% and for loosest packing is 48%.

Density (ρ): density is universally defined as weight per unit volume. Three type of densities can be defined True density Granule density Bulk density

Bulkiness : Specific bulk volume ,the reciprocal of bulk density, it is often called bulkiness or bulk. Bulkiness increase with a decrease in particle size .

Flow properties : powder may be free flowing or cohesive. Factors that affect the Flow properties are particle size , shape , surface texture, porosity and density. Angle of repose (φ) have been used as indirect method for quantifying powder flowability. φ = tan-1 (h/r) Here: h = height of pile r = radius of pile

Compression :The strength of compressed tablet dependson number of factor, most important are which are particle size and compression. As the compression increases the tablet hardness and fracture resistance also increases.

Particle size and the lifetime of a drug • In production : particle size influences the production of formulated medicines as solid dosage form both tablets and capsules are produced Powders with different particle size have different flow and packing properties which alter the volume of powder during each encapsulation or table compression event In Body: after administration of the medicine, the dosage should release the drug in to solution at optimum rate . This depends on several factors, one of which will be particle size of drug. Particles having small dimension will tend to increase the rate of solution

Conclusion Particle size is an important parameter both for the production of medicines containing particulate solids and in the efficacy of the medicine administration .

Methods for determining particle size:

Optical microscopy (range: 0.2 –100 um): • The microscope eyepiece is fitted with a micrometer by • which the size of the particles may be estimated.

Sieving (range: 40 – 9500µm): -Standard sized sieves are available to cover a wide range of sizes. These sieves are designed to sit in a stack so that material falls through smaller and smaller meshes until it reaches a mesh which is too fine for it to pass through.

The result achieved will depend on the duration of the agitation and the manner of the agitation.

The fraction of the material between pairs of sieve sizes is determined by weighing the residue on each sieve.

The stack of sieves is mechanically shaken to promote the passage of the solids.

Sedimentation (range: .08 –300µm): • by measuring the terminal settling velocity ofparticles through a liquid medium in a gravitational centrifugal environment using • Andreasen apparatus.

Particle volume measurement (range: .5 - 300 um): - In this type of machine the powder is suspended in an electrolyte solution . This suspension is then made to flow through a short insulated capillary section between two electrodes and the resistance of the system is measured.

When a particle passes through the capillary there is a momentary peak in the resistance, the amplitude of the peak is proportional to the particle size. Counting is done by a computer

Derived properties of powders:

The porosity or voids ε of powder is determined as the ratioVp is the true volume of particles. bulk volume = true volume + volume of spaces between particles. The volume of the spaces, the void volume, V = Vb - Vp

the total volume occupied is known as the bulk volume Vb . Suppose a nonporous powder, is placed in a graduated cylinder: □Derived properties of powders: 1- Porosity:

Conti.nue of void volume to bulk volume.

Porosity = ε = Vb – Vp/Vp = 1 – Vp/Vb Porosity is frequently expressed in percent, ε x 100 .

Densities of particles: Density is defined as weight per unit volume (W/V). Types ofdensities:

A- true density:The true density, or absolute density,of a sample excludes the volume of the pores and voids within the sample.

B- bulk density (w/v) the bulk density :value includes the volume of all of thepores within the sample.

Densities of particles • During tapping, particles gradually pack more efficiently, the powder volume decreases and the tapped density increases.

(Bulkiness increases with a decrease in particle size). In mixture of materials of different sizes, the smalle particles sift between the larger ones and tend to reduce bulkiness.Thebulk density of calcium carbonate vary from 0.1 to 1.3, and the lightest (bulkiest) type require a container about 13 times larger than that needed for the heaviest variety. It is an important consideration in the packaging of powders.

Bulkiness = Specific bulk volume = reciprocal of bulk density

Derived properties of powders:

Flow properties: Powders may be free-flowing or cohesive ("sticky"). Many common manufacturing problems are attributed to powder flow: •

1. Powder transfer through large equipment such as hopper.

2- Uneven powder flow → excess entrapped air within powders →capping or lamination.

3- Uneven powder flow → increase particle's friction with die wall causing lubrication problems, and increase dust contamination risks during powder transfer.

Derived properties of powders:

Non-uniformity (segregation) in blendingpowder flow problems

Tests to evaluate the flowability of a powder:

1- Carr's compressibility index • A volume of powder is filled into a graduated glass cylinder and repeatedly tapped for a known duration. The volume of powder aftertapping is measured. • Carr's index (%) =Tapped density – Poured or bulk density x 100/Tapped density • Bulk density = weight / bulk volume • Tapped density = weight / true volume

Tests to evaluate the flowability of a powder: Flow discription % compressability Excellent flow 5-15 good 16-18 fair 19-21 poor 22-35 Very poor 36-40 Extremly poor >4. Between 1.25 and 1.5, added glidant normally improves flow. Value greater than 1.5 indicates poor flow (= 33% Carr). more cohesive, less free-flowing powders such as flakes. The powder with low interparticle friction, such as coarse spheres. Value less than 1.25 indicates good flow (= 20% Carr). Hausner ratio=Tapped density /Poured or bulk density Hausner ratio was related to interparticle friction: □Tests to evaluate the flowability of a powder: 2- Hausner ratio: > 1.5 added glidant doesn't improve flow.

r = d / 2□tan φ = h / r tan φ = μ. φ = the maximum angle possible between the surfaceof a pile of powder and horizontal plane = coefficient of friction μ between the particles:

The frictional forces in a loose powder can bemeasured by the angle of repose φ. 3-The angle of

repose φ

Tests to evaluate the flowability of a powder:

The user normally selects the funnel ori The sample is poured onto a horizontal surface and the angle of the resulting pyramid is measured.

3- The angle of repose φ: ***The rougher and more irregular the surface of the particles,the higher will be the angle of repose.

Angle of repose greater than 40 (poor flow)

Angle of repose between 30-34 (Pass flow)

Angle of repose between 20-30 (good flow)

Angle of repose less than 20 (excellent flow)

fice through which the powder flows slowly and reasonably constantly.

Alteration of Particle's size & The size distribution can also be altered to improve flowability by removing a proportion of the fine particle fraction or by increasing the proportion of coarser particles, such as occurs in granulation. Coarse particles are more preferred than fine ones as they are less cohesive. Distribution There is certain particle size at which powder's flow ability is optimum.

Alteration of Particle Shape & texture Particle's Shape:

Generally, more spherical particles have better flow properties than more irregularparticles.

Spherical particles are obtained by spray drying, or by temperature cyclingcrystallization.

Particle's texture: particles with very rough surfaces will be more cohesive and have a greater tendency to interlock than smooth surfaced particles.

Hygroscopic powders, stored and processed under low humidity conditions. Drying the particles will reduce the cohesiveness and improve the flow

Adsorbed surface moisture films tend to increase bulk density and reduce porosityMoisture content of particle greatly affects powder's flowability.

Reduction of electrostatic charges can improve powder flowability Electrostatic charges can be reduced by altering process conditions to reduce frictional contacts. Alteration of Surface Forces

Formulation additives (Flow activators): • Flow activators are commonly referred as glidants. • Flow activators improve the flowability of powders by reducing adhesion and cohesion. • e.g. talc, maize starch and magnesium stearate

Factors affecting the flow properties of powder

Factors affecting the flow properties of powder

1. **Alteration of Particle's size & Distribution**

2. Alteration of Particle shape & texture

3. Alteration of Surface Forces

4. Formulation additives (Flow activators)

Factors affecting the flow properties of powder Alteration of Particle's size &Distribution

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Factors affecting the flow properties of powder Formulation additives (Flow activators) • Flow activators are commonly referred as a glidants. • Flow activatorsimprove the flowability of powders by reducing adhesion and cohesion. e. g. Talc, maize starch and magnesium stearate

Derived properties of powder

Importance of Study of Micromeritics

Knowledge and control of the size and the size range of particle is of profound importance in pharmacy.Size and surface area can be related to the physical, chemical and pharmacological properties of a drug.

1. Particle size affect its release from dosage forms that are administered orally, parenterally, rectally and topically

2. Physical stability and pharmacologic response of suspensions, emulsion and tablets depends on particle size.
3. It is also important in flow properties and proper mixing of granules and. powders in tableting.
4. Both Tablets and capsules are produced using equipment which controls the mass ofdrug and other particles by volumetric filling. Therefore any interference with the uniformity of fill volumes may alter the mass of drug incorporated into the tablet or capsules. Thus reduce the uniformity of the medicine.
5. Powders with different particle sizes have different flow and packing properties which alter the volumes of powder during each encapsulation or tablet compression.
6. The rate of solution depends on the several factors. One factor is the particle size. Thus particles having small dimensions will tend to increase the rate of solution. For example:
   Griseofulvin has a low solubility by oral administration but is rapidly distributed following absorption. The solubility of Griseofulvin can be greatly increased by particlesize reduction.
   Reduction of particles size also increase the rate of absorption of tetracycline, Aspirin and Sulphonamides.
   Reduction of particle size of nitrofurantoin increased the rate of absorption. Therefore the toxic effect due to rapid absorption.
   Different means of expressing particle size.

There are different means of expressing particle size:Millimeter (mm)……. 10^{-3} meter
Micro meter (µ m) ……. 10^{-6} meternano meter (nm)…….. 10^{-9} meter pico meter …10^{-12} meter
fanto meter… .... 10^{-15} meter

Methods of determining particle size

- Optical Microscopy
- Sieving Methods
- Sedimentation Methods

- Particle volume measurement
- Coulter Counter Method (Electrical stream sensing method)
- Laser light scattering methods.

Particle Dimension in Pharmaceutical Disperse systemParticle sizes

Disperse systems	Micrometer (µ m)	Millimeter (mm)
0.5-10	0.0005 - 0.010	**Suspension, fine emulsion**
10-50	0.010- 0.050	**Coarse emulsion, flocculated**
Suspension		
50- 100	0.50- 0.100	**Lower range of sieve range, fine**
Powder range		
150-1000	0.150-1.000	**Coarse powder range**
1000- 3360	**1.000- 3.360**	**Average granule size**

Methods of determining surface area:

Adsorption method

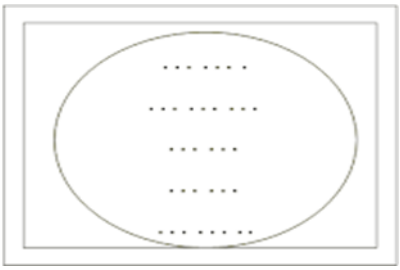
Airpermeability Method

Sieving Method

Sieving method is an ordinary and simple method. It is widely used as a method for theparticle size analysis.

Range of analysis:

The International Standards organization (ISO) sets a lowest sieve diameter of 45 µm and sincepowders are usually defined as having a maximum diameter of 1000 µm, this could be considered to be the upper limit.



In practice sieves can be obtained for size analysis over a range from 5 to 125 000 µm.

Sample preparation and analysis condition

1. Sieve analysis is usually carried out using dry powders.

2. Although, for powders in liquid suspension or which agglomerate during dry sieving, a process of wet sieving can be used.

Principle of Measurement:

Sieve analysis utilizes a woven, punched or electroformed mesh often in brass, bronze or

stainlesssteel with known aperture (hole) diameters which form a physical barrier to particles.

Most sieve analyses utilize a series, stack (Load /Mountain or nest (layer) of sieves which have the smallest mesh above a collector tray followed by meshes which get progressively coarser towards the top of the series.

A sieve stack usually comprises 6-8 sieves with a progression based on a $\sqrt{2}$ or $2\sqrt{2}$ change in diameter between adjacent aperture.

Powder is loaded on to the coarsest sieve of the assembled stack and the nest is subjected to mechanical vibration for, say 20 minutes

After this time, the particles are considered to be retained on the sieve mesh with an aperture corresponding to the minimum or sieve diameter.

A sieving time of 20 minutes is arbitrary and BS 1796 recommends sieving to be continued until less than 0.2% material passes a given sieve aperture in any 5 minutes interval

Advantages : 1. This method is very simple.

2. Not expensive

3. Easy to operate

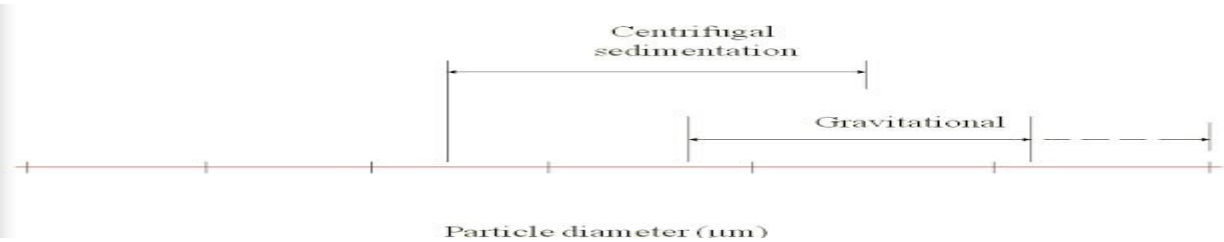
Disadvantages: 1. Not too much precise method.

2. Not applicable for all disperse systems.

Sedimentation Methods

Sedimentation Method is also an ordinary and simple method. It is widely used as a method for the particle size analysis.

Range of analysis:



Sample preparation and analysis conditions

In this method particle size can be determined by examining the powder as it sediments out. (a). In cases where the powder is not uniformly dispersed in a fluid it can be introduced as a thin layer on the surface of the liquid.

(b). If the powder is lyophobic, e.g. hydrophobic in water , it may be necessary to add dispersing agent to aid wetting of the powder.

(c). In case where the powder is soluble in water it will be necessary to use non- aqueous liquids or

carry out the analysis in a gas.

Principle of Measurement

Particle size analysis by sedimentation method can be divided into two main categories accordingto the method of measurement used.

1. One of the type is based on measurement of particle in a retention zone.
2. Another type uses a non-retention measurement zone.

An example of a non-retention zone measurement is known as the pipette method.

In this method , known volumes of suspension are drawn off and the concentration differences aremeasured with respect to time.

One of the most popular of the pipette methods was that developed by *Andreasen and Lundberg and commonly called the Andreasen pipette.*

The Andreasen fixed-position pipette consists of a 200 mm graduate cylinder which can holdabout 500 ml of suspension fluid.

A pipette is located centrally in the cylinder and is held in position by a ground glass stopper sothat its tip coincides with the zero level.

A three way tap allows fluid to be drawn into a 10 ml reservoir which can then be emptied into a beaker or centrifuge tube.

The amount of powder can be determined by weight following drying or centrifuging.

The weight of each sample residue is therefore called the weight of undersize and the sum of the successive weight is known as the cumulative weight of undersize. It can be expressed directly in weight units or percent of the total weight of the final sediment..

The data of cumulative weight of undersize is used for the determination of particle weight distribution, number distribution,

The largest particle diameter in each sample is then calculated from *Strokes' Law.*

The particle size may be obtained by gravity sedimentation as expressed in *Strokes' law.*

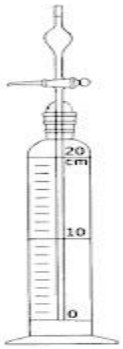


Fig. 16–8. Andreasen apparatus for determining particle size by the gravity sedimentation method.

$$\frac{h}{t} \quad \frac{d_{st}^2 (\rho_s - \rho_o) g}{18\eta_o}$$

$$\frac{18\eta_o h}{(\rho_s - \rho_o) g t}$$

V=h/

Where,

v = rate of settling

h = Distance of the fall in time , t

d_{st} = the mean diameter of the particles based on the velocity of sedimentationρ_S= density of the particles

ρ_o = density of the dispersion mediumg = Acceleration due to gravity

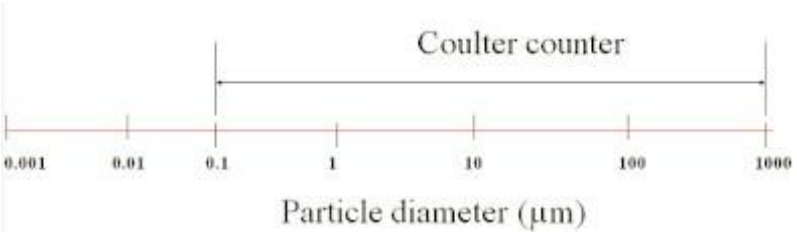
η_o = Viscosity of the medium

Note: The question holds spheres falling freely without hindrance and at a constant rate.

Coulter Counter Method (Electrical stream sensing zone method)

Coulter Counter Method (Electrical stream sensing zone method) is a sophisticated method. It is aprecise and accurate method.

Range of analysis:



Sample preparation and analysis conditions

1. Powder samples are dispersed in an electrolyte to form a very dilute suspension
2. The suspension is usually subjected to ultrasoni agitation for a period to break up any particle agglomerates.
3. A dispersant may also be added to aid particl deagglomeration.

Principle of Measurement

1. The particle suspension is drawn through an aperture accurately drilled through a sapphire crystal set into the wall of a hollow glass tube.
2. Electrodes, situated on either side of the aperture and surrounded by an electrolyte solution.

3. Monitor the change in electrical signal which occurs when a particle momentarily occupies the orifice and displaces its own volume of electrolyte..
4. The volume of suspension drawn through the orifice is determined by the suction potential created by a mercury thread rebalancing in a convoluted U tube.
5. The volume of electrolyte fluid which is displaced in the orifice by the presence of a particle causes a change in electrical resistance between the electrodes which is proportional to the volume of the particle.
6. The change in resistance is converted between into a voltage pulse which is amplified andprocessed electronically .
7. Pulses falling within pre-calibrated limits or thresholds are used to split the particle size distribution into many different size ranges.
8. In order to carry out size analysis over a wide diameter range it will be necessary to change orificediameter used, to prevent
9. Coarse particles blocking a small diameter orifice . Conversely, finer particles in a large diameterorifice will cause too small a relative in volume to be accurately quantified.

Advantages : 1. It is one of the precise and accurate method.

2. Analysis range is wide.

Disadvantages: 1. It is a sophisticated method.

2. It is a expensive method.

Micromeritics Applications

1. Release and dissolution.
2. Absorption and drugaction.
3. Physical stability.
4. Dose uniformity

Release and dissolution • Particle size and surface area influence the release of a drug from a dosage form. • Higher surface area allows intimate contact of the drug with the dissolution fluids in vivo and increases the drug solubility and dissolution.

Absorption and drug action • Particle size and surface area influence the drug absorption and subsequently the therapeutic action. • Higher the dissolution, faster the absorption and hence quicker and greater the drug action

Physical stability • The particle size in a formulation influences the physical stability of the suspensions and emulsions. • Smaller the size of the particle, better the physical stability of the dosage form.

Dose uniformity • Good flow properties of granules and powders are important in the manufacturing of tablets and capsules.

Methods for determining particle size • Many methods available for determining particle size such as optical microscopy, sieving, sedimentation and particle volume measurement. 1. Optical microscopy (range: 0.2-100 µm). 2. Sieving (range: 40-9500 µm). 3. Sedimentation (range: 0.08-300 µm). 4. Particle volume measurement (range: 0.5-300 µm).

Range of particle sizes

A guide to range of particle sizes applicable to eachmethod Particle size Method 1 µm Electron microscope, ultracentrifuge, adsorption 1 – 100 µm Optical microscope, sedimentation, coulter counter, air permeability >50µm Sieving

Optical microscopy (range: 0.2-100 µm) The microscope eyepiece is fitted with a micrometer by which the size of the particles may be estimated

Optical microscopy (range: 0.2-100 µm) • According to the optical microscopic method, an emulsion or suspension is mounted on ruled slide on a mechanical stage. • The microscope eyepiece is fitted with a micrometer by which the size of the particles can be estimated. • The ordinary microscope used for measurementthe particle-size in the range of 0.2 to about 100 µm.

Disadvantage of microscopic method

1. The diameter is obtained from only two dimensions of the particle.
2. The number of particles that must be counted (300-500) to obtain a good estimation of the distribution makes the method somewhat slow and tedious

Wide range of size. • These sieves are designed to sit in a stack so that material falls through smaller and smaller meshes until it reaches a mesh which is too fine for it to pass through

Sieving (range: 40-9500 µm) • The stack of sieves is mechanically shaken to promote the passage of the solids. • The fraction of the material between pairs of sieve sizes is determined by weighing the residue on each sieve. • The result achieved will depend on the duration of the agitation and the manner of the agitation.

Sedimentation (range: 0.08-300 µm) • By measuring the terminal settling velocity of particles through a liquid medium in a gravitational centrifugal environment using Andreasen appartus.

Particle volume measurement (range: 0.5-300 µm) • In this type of machine the powder is suspended in an electrolyte solution. • This suspension is then made to flow through a short insulated capillary section between two electrodes and the resistance of the system is measured. • When a particle passes through the capillary there is a momentary peak in the resistance, the amplitude of the peak is proportional to the particle size. • Counting is done by a computer.

Particle volume measurement (range: 0.5-300 µm)

Density of powders • Density is defined as weight per unit volume (W/V). • During tapping, particles gradually pack more efficiently, the powder volume decreases and the tapped density increases.

Types of Density 1. True density: The true density or absolute density of a sample excludes the volume of the pores and voids within the powder sample. 2. Bulk density:The bulk density value includes the volume of all of the pores within the powder sample.

. Flow properties of powders • Powders may be free-flowing or cohesive (Sticky). • Many common manufacturing problems are attributes to powder flow.

1. Powder transfer through large equipment such as hopper.
2. Uneven powder flow → excess entrapped air within powders → capping orlamination.
3. Uneven powder flow → increase particle's friction with die wall causing lubrication problems and increase dust contamination risks during powder transfer.

Flow properties of powders

Flow properties of powders 5. Powder storage, which for example result in caking tendencies within a vial or bag after shipping or storage time. 6. Separation of small quantity of the powder from the bulk-specifically just before the creation of individual doses such as during tableting, encapsulation and vial filling which affect the weight uniformity of the dose (under or over dosage

Powder flow problems

Flow properties of powders • Tests to evaluate the flowability of a powder. 1.Carr's compressibility index. 2.Hausner ratio. 3.The angle of repose (θ).

Carr's compressibility index • A volume of powder is filled into a graduated glass cylinder and repeatedly tapped for a known duration. The volume of powder after tapping is measure. Tappeddensity-Pouredorbulkdensity Carr's index (%)= X 100

Tappeddensity Bulkdensity=weight/bulkvolume

Carr's compressibility index Flow description % Compressibility Excellent flow 5 – 15 Good 16 – 18 Fair 19 – 21 Poor 22 – 35 Very Poor 36 -40 Extremely poor > 40 Relationship between powder flowability and %

. Hausner ratio Tappeddensity Hausner ratio = Pouredorbulkdensity Hausner ratio was related to interparticle friction: • Value less than 1.25 indicates good flow (=20% Carr

Hausner ratio • The powder with low interparticle friction, such as coarse spheres. • Value greater than 1.5 indicates poor flow (= 33% Carr's Compressibility Index)). • More cohesive, less free-flowing powders such as flakes. • Between 1.25 and 1.5 added glidant normally improves flow. • > 1.5 added glidant doesn't improve flow.

The angle of repose (θ) • The sample is poured onto the horizontal surface and the angle of the resulting pyramid is measured. • The user normally selects the funnel orifice through which the powder flows slowly and reasonably constantly.

The angle of repose (θ) 1. Angle of repose less than 20 (Excellent flow). 2. Angle of repose between20-30 (Good flow). 3. Angle of repose between 30-40 (Pass flow). 4.
Angle of repose greater than 40 (Poor flow). • The rougher and more irregular the surface of the particles, the higher will be the angle of repose.

Short answers (02 Marks)

1. State Edmundson's equation
2. State stokes law
3. Explain frequency distribution curve
4. Explain normal distribution curve
5. Explain percent log normal distribution curve
6. What is polydisperse system
7. What are equivalent diameters? Explain martins diameter
8. Explain ferret diameter and projected diameter
9. What is particle size distribution and particle number
10. What is quantasorb. Explain its principle
11. What are fundamental properties? Give examples
12. What is bulk density ant true density
13. Define angle of repose. Write its significance
14. What is void volume and porosity
15. What is granular density and true density
16. What is compressibility index
17. What is rate of flow of powder and explain carr's index
18. Give packaging arrangement of powders

19. Define volume-surface mean diameter. Give the equation for its calculation.
20. Define shape factor. What is its importance in micromeritics?
21. List four methods to improve the flow properties of granules and powders.
22. List the ways to characterize a powder

Long questions (05 Marks)

1. How do you represent particle size distribution
2. Enumerate methods to determine the particle size. Explain any two methods to determine the particle size
3. With the help of neat diagram explain Andreason's pipette method to determine the particle size
4. With the help of neat diagram explain principle and working of coulter counter method to determine the particle size
5. What is specific surface area? How is it measured by air permeability method
6. What are derived properties of powders? Explain any two

Very long questions (10marks)

1. Define angle of repose. Explain the method to determine the same
2. Explain porosity. Give its applications in pharmacy
3. Enumerate different methods of determination of true density and explain any one.
   List different types of densities of powder/granules. Write the experimental method for the determination of any one of them

4. .