

Micromeritics

Micromeritics: Introduction

- **Micromeritics** is the science and technology of small particles, particularly in the micron or submicron range.
- It is crucial in pharmaceutical formulations because particle size influences:
 - Dissolution rate
 - Bioavailability
 - Flow properties
 - Mixing and compaction
 - Stability (suspensions and emulsions)

Particle Size and Distribution

Particle Size

- Refers to the **dimension** of individual particles.
- Most pharmaceutical powders consist of irregularly shaped particles.
- Particle size is typically expressed as an equivalent diameter (the diameter of a sphere with similar properties, such as volume or surface area).

Particle Size Distribution (PSD)

- Describes the **range and proportion** of different particle sizes in a sample.
- PSD is more meaningful than just the average size because pharmaceutical properties depend on both **large and fine particles**.

Types of Distributions:

1. **Monodisperse** – particles of nearly the same size
2. **Polydisperse** – particles of a wide range of sizes

Methods to Represent PSD:

- Histogram
- Frequency and cumulative curves
- Log-normal or Gaussian distribution

Methods of Measurement

- **Sieving:** For particles > 50 μm
- **Optical microscopy:** Useful for 1–100 μm range

- **Laser diffraction:** Fast and suitable for wide size ranges
- **Dynamic light scattering:** For nanoparticles (<1 µm)
- **Coulter counter:** Measures electrical resistance changes

Mean Particle Size

- Because particle populations contain a range of sizes, different types of **mean particle sizes** are used:

1. Arithmetic Mean Diameter (D_1)

➤ Where:

- D_i = size of particles in each group
- n_i = number of particles in that group

2. Surface Area Mean Diameter (Sauter Mean, $D_{3,2}$)

$$D_{3,2} = \frac{\sum n_i D_i^3}{\sum n_i D_i^2}$$

➤ Emphasizes **surface area**, relevant for dissolution and reaction rates.

3. Volume Mean Diameter ($D_{4,3}$)

$$D_{4,3} = \frac{\sum n_i D_i^4}{\sum n_i D_i^3}$$

➤ Sensitive to larger particles, often used in laser diffraction.

- Each type of mean gives different insight depending on whether surface, number, or volume is the focus.

Number and Weight Distribution

Number Distribution

- Based on counting the number of particles in each size range.
- Sensitive to smaller particles.
- Determined by methods like microscopy or Coulter counter.

Weight or Volume Distribution

- Based on mass or volume of particles in each size class.
- Sensitive to larger particles.

- Commonly obtained using laser diffraction or sedimentation techniques.

Key Differences

Characteristic	Number Distribution	Weight (Volume) Distribution
Emphasizes	Fine particles	Coarse particles
Methods	Microscopy, Coulter counter	Laser diffraction, sedimentation
Relevant to	Surface-related processes	Mass-based behaviors

Particle Number

- You can estimate the number of particles in a sample if the total mass, average particle diameter, and density are known.

Formula

$$N = \frac{6M}{\pi D^3 \rho}$$

- Where:
 - N = number of particles
 - M = total mass of sample
 - D = average particle diameter
 - ρ = true density of the material

Example Calculation

- If 1 gram of a powder has:
 - Mean particle diameter = 10 μm = 10×10^{-4} cm
 - Density = 1.5 g/cm³
- Then,

$$N = \frac{6 \times 1}{\pi \times (10 \times 10^{-4})^3 \times 1.5} \approx 1.27 \times 10^9 \text{ particles}$$

Methods For Determining Particle Size

- Particle size can be measured using different **principles and instruments**.
- These methods can be broadly classified as:

Category	Examples of Techniques
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