BP306T · B.PHARM THEORY

BP306T Pharmaceutical Dosage Forms I

Unit V — Microencapsulation

Pills & Python Notes

From-zero teaching standard: every technical term is defined before use.

Syllabus coverage: Unit V (7 hours).

PILLS & PYTHON

Pharmacy • Data • AI • Healthcare

Instagram @pillsandpython · pillsandpython.com · YouTube @PillsAndPython

Chapter 5: Microencapsulation

5.1 Learning Objectives

After studying this chapter, the student will be able to:

1. Define microencapsulation and related terms.
2. Explain the concept, need, advantages, and disadvantages.
3. Describe methods: spray drying, spray congealing, extrusion–spheronisation, fluidized bed coating, phase-separation coacervation.
4. Describe evaluation tests for microcapsules.

5.2 Definitions

- **Microencapsulation:** The process of enclosing tiny drug particles or droplets in a thin polymer coating, forming microcapsules.
- **Microcapsule:** A tiny capsule (typically micrometre to millimetre size) with a distinct wall (coat) around a core (drug).
- **Microsphere:** A tiny sphere where drug is dispersed throughout a polymer matrix (no distinct core–wall boundary).
- **Core material:** The drug/substance being coated.
- **Coating (wall) material:** The polymer forming the protective wall.

5.3 Terminology (Teach from Zero)

- **Coacervation:** Separation of a polymer-rich liquid phase that wraps around drug particles — like egg white separating and coating something.
- **Atomisation:** Breaking liquid into fine droplets (spray).
- **Fluidized bed:** Particles suspended in upward air flow, behaving like a boiling liquid — ideal for spray-coating.
- **Extrusion:** Forcing damp mass through a screen to form rods.
- **Spheronisation:** Spinning the rods on a grooved plate until they round into spheres.
- **Encapsulation efficiency:** Percentage of drug successfully trapped inside microcapsules.
- **Particle size distribution:** Range of microcapsule sizes — affects release and flow.
- **Burst release:** Initial fast release from surface drug — minimised by good coating.

5.4 Concept and Need

Technical concept: Microencapsulation applies a thin functional coat around each drug particle to control release, mask taste, protect from the environment, or convert liquids to free-flowing solids.

> **Simple explanation:** Imagine coating each grain of sugar with a thin chocolate layer — the sugar is protected, tastes different, and dissolves slower. Microencapsulation does this to drug particles at microscopic scale.

> **Diagram (describe):** Draw two structures side by side: (1) Microcapsule — a circle with a clear wall ring around a solid core (like a chocolate-coated peanut); (2) Microsphere — a circle with dots spread evenly throughout (like a choc-chip cookie).

Need:

- Taste/odour masking (bitter drugs).
- Protection from moisture, light, oxygen.
- Controlled/sustained release.
- Convert liquids to solids for easy handling.
- Separate incompatible drugs in one product.
- Reduce irritation (e.g., gastric irritation).

> **Key takeaway:** One tiny coat gives taste masking, protection, and controlled release together.

5.5 Advantages and Disadvantages

Advantages	Disadvantages
Taste/odour masking	Extra manufacturing cost and complexity
Protection from environment	Scale-up can be difficult
Controlled release possible	Residual solvents (some methods)
Liquids converted to free-flowing solids	Batch-to-batch variation risk
Reduced side effects/irritation	Needs specialised equipment
Incompatible drugs can be combined	Coating defects affect performance

> **Key takeaway:** Powerful tool, but adds cost and complexity — used where the benefit justifies it.

5.6 Methods of Microencapsulation

(a) Spray drying

Principle: Drug + polymer solution is atomised into fine droplets in a hot-air chamber; solvent evaporates instantly, leaving dry coated particles.

Flowchart:

```
Feed: drug + polymer dissolved/suspended in solvent
        ↓
Atomisation into fine droplets (nozzle)
        ↓
Hot air chamber → solvent evaporates in seconds
        ↓
Dry microcapsules collected (cyclone separator)
```

> **Simple explanation:** Like spray perfume — liquid becomes mist, mist dries mid-air into powder.

Advantages: Fast, continuous, scalable. **Disadvantages:** Heat exposure; not for very heat-sensitive drugs.

(b) Spray congealing (spray cooling)

Principle: Same as spray drying, but the feed is a *melt* (molten wax/polymer) sprayed into *cold* air — droplets congeal (solidify) instead of drying.

> **Simple explanation:** Like dripping hot wax into cold water — droplets harden into beads.

Advantages: No solvent; good for heat-stable melts. **Disadvantages:** Limited to meltable coating materials (waxes).

(c) Extrusion and spheronisation

Principle: Damp powder mass is extruded through a screen into rods, then spun on a grooved friction plate (spheroniser) which rounds them into uniform spheres; spheres may then be coated.

Flowchart:

```
Wet mass (drug + excipients) → Extruder → rods/extrudate
        ↓
Spheroniser (spinning grooved plate) → round pellets
        ↓
Drying → (optional) coating → microcapsules/pellets
```

> **Simple explanation:** Like making tiny round ladoos — roll dough into rods, then spin them until they become balls.

Advantages: Very uniform spheres, high drug loading. **Disadvantages:** Multi-step; needs careful moisture control.

(d) Fluidized bed coating

Principle: Core particles are suspended in upward air flow (fluidized) while coating solution is sprayed on them; drying happens simultaneously, building the coat layer by layer.

> **Simple explanation:** Like popcorn dancing on hot air while being sprayed with chocolate — every piece gets an even coat.

Variants: Top spray, bottom spray (Wurster — best for small particles), tangential spray.

Advantages: Excellent uniformity, scalable, in-process drying. **Disadvantages:** Needs specialised equipment; process parameters are critical.

(e) Phase-separation coacervation

Principle: Polymer dissolved in a liquid is made to separate into a polymer-rich phase (coacervate) that deposits around suspended drug particles; the coat is then hardened (cross-linked/dried).

Flowchart:

```
Drug particles suspended in polymer solution
        ↓
Trigger phase separation (temperature change / add non-solvent / pH change)
        ↓
Polymer-rich coacervate droplets form and coat drug particles
        ↓
Harden the coat (cooling / cross-linking)
        ↓
Collect and dry microcapsules
```

> **Simple explanation:** Like oil separating from water and wrapping around floating crumbs — the polymer "rains" onto each drug particle.

Advantages: Works at low temperature; good for sensitive drugs. **Disadvantages:** Residual solvents; complex; batch process.

Comparison table:

Method	Heat	Solvent	Best for
Spray drying	Yes	Yes	Fast, scalable production
Spray congealing	Melt/cool	No	Wax-coated particles
Extrusion–spheronisation	Low	Water (wet mass)	Uniform high-dose spheres
Fluidized bed coating	Warm air	Yes	Even coats, scale-up
Coacervation	Low	Yes	Heat-sensitive drugs

> **Key takeaway:** Five methods, one goal — a uniform coat around each particle; choose by heat/solvent sensitivity and scale.

5.7 Evaluation of Microcapsules

Test	Purpose
Description / appearance	Colour, shape, free-flowing
Particle size distribution	Uniform size → uniform release
Surface morphology	Smooth, crack-free coat (microscopy)
Encapsulation efficiency / drug loading	How much drug is inside
Assay	Correct drug content
In-vitro dissolution/release profile	Release matches target
Flow properties	Handles well in manufacture
Moisture content	Stability
Residual solvents	Safety (solvent-based methods)
Stability	Coat and release unchanged over time

> **Key takeaway:** Evaluation proves the coat is complete, uniform, and releases drug as designed.

5.8 Pharmacy Relevance

Microencapsulated products are everywhere in modern pharmacy: taste-masked paediatric powders, sustained-release capsules filled with coated beads, probiotic protection, and fish-oil powders. Understanding the coat helps pharmacists explain why a product must not be crushed.

5.9 India Context

- Indian industry uses fluidized bed coating and spray drying widely for sustained-release bead products and taste-masked formulations.
- Taste-masked microencapsulated paediatric products are important in India, where bitter traditional and modern medicines need child acceptance.

5.10 Key Points

1. Microencapsulation = thin polymer coat around tiny drug particles.
2. Microcapsule = distinct core + wall; microsphere = drug dispersed in matrix.
3. Need: taste masking, protection, controlled release, liquid-to-solid conversion.
4. Methods: spray drying, spray congealing, extrusion–spheronisation, fluidized bed coating, coacervation.
5. Choose method by heat/solvent sensitivity and scale.
6. Evaluation: size, coat integrity, encapsulation efficiency, release profile, residual solvents.

5.11 Common Confusions

- **Microcapsule vs microsphere:** Capsule = core + distinct wall (chocolate peanut); microsphere = drug spread through matrix (choc-chip cookie).
- **Spray drying vs spray congealing:** Drying = solvent evaporates in hot air; congealing = melt solidifies in cold air.
- **Coacervation trigger:** Temperature, non-solvent, or pH change causes the polymer-rich phase to separate.

5.12 Common Mistakes

- Using spray drying for highly heat-sensitive drugs → degradation; consider coacervation.
- Ignoring residual solvents in solvent-based methods → safety failure.
- Thin/incomplete coats → burst release and failed dissolution specs.

5.13 Mnemonics

- **Five methods:** "**S**pray **D**rying, **S**pray **C**ongealing, **E**xtrusion, **F**luidized bed, **C**oacervation — **D-C-E-F-C** ('Do Coat Every Fine Capsule')."

5.14 Exam Summary

Microencapsulation encloses tiny drug particles in a polymer coat. Microcapsules have a distinct core and wall; microspheres have drug dispersed in a matrix. Need: taste masking, protection, controlled release, converting liquids to solids. Methods: spray drying (hot air evaporation), spray congealing (melt into cold air), extrusion–spheronisation (rods → spheres), fluidized bed coating (spray while suspended in air), phase-separation coacervation (polymer-rich phase coats particles). Evaluation: particle size, coat integrity, encapsulation efficiency, dissolution profile, residual solvents, stability.

5.15 One-Minute Revision

Tiny coat, big benefits: taste masking, protection, controlled release. Capsule = core + wall; microsphere = mixed matrix. Five methods: spray dry, spray congeal, extrude-spheronise, fluid bed, coacervation. Check coat, size, release.

5.16 Infographic Concept Box

Title: "One Coat, Five Ways" Centre: microcapsule cross-section (core + wall). Five arrows to method icons: spray nozzle + heat waves (spray drying), snowflake (spray congealing), rods → balls (extrusion–spheronisation), dancing particles in air stream (fluidized bed), separating droplets (coacervation). Bottom: benefit badges — taste masked, protected, sustained release.

5.17 Exam Questions

Short answers:

1. Define microencapsulation. Differentiate microcapsule and microsphere.
2. List the need for microencapsulation (any four).
3. What is coacervation?
4. List four evaluation tests for microcapsules with purpose.

Long answers:

1. Describe any three methods of microencapsulation with flowcharts.
2. Discuss the advantages and disadvantages of microencapsulation.
3. Describe phase-separation coacervation and fluidized bed coating in detail.

MCQs:

1. In a microcapsule, the drug is: (a) dispersed in matrix (b) enclosed by a distinct wall ✓ (c) dissolved in water (d) uncoated
2. Spray congealing uses: (a) hot air to evaporate solvent (b) cold air to solidify a melt ✓ (c) a spheroniser plate (d) pH change
3. Spheronisation converts: (a) droplets to powder (b) extruded rods to spheres ✓ (c) solution to mist (d) melt to flakes

Viva:

1. Give two examples of microencapsulated products.
2. Why is encapsulation efficiency important?
3. Which method suits heat-sensitive drugs and why?

Application-based: A bitter antibiotic for children needs taste masking with sustained release. Propose a microencapsulation approach with method justification. (Fluidized bed coating of drug beads with a taste-masking + SR polymer; uniform coat, scalable; counsel not to crush.)

5.18 References

1. Allen, L. V., Popovich, N. G. and Ansel, H. C. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems. Lippincott Williams & Wilkins.
2. Aulton, M. E. and Taylor, K. M. G. Aulton's Pharmaceutics: The Design and Manufacture of Medicines. Elsevier.
3. Lachman, L., Lieberman, H. A. and Kanig, J. L. The Theory and Practice of Industrial Pharmacy. CBS Publishers & Distributors.
4. Troy, D. B. and Beringer, P. Remington: The Science and Practice of Pharmacy. Pharmaceutical Press.
5. Robinson, J. R. and Lee, V. H. L. Controlled Drug Delivery: Fundamentals and Applications. CRC Press.
6. Indian Pharmacopoeia. Indian Pharmacopoeia Commission.