

Modern Methods of Extraction

Presented By:-
Samarpan Mishra

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Modern extraction techniques are developed to **obtain maximum amounts of active constituents from crude drugs in less time**, with less solvent and better selectivity than conventional methods such as maceration, percolation and soxhlet extraction.

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1. Microwave-Assisted Extraction (MAE)

Introduction

Microwave-Assisted Extraction is a modern extraction technique in which **microwave energy is used to heat the plant material and extracting solvent**. The rapid heating causes disruption of plant cells and facilitates the release of intracellular constituents.

It is particularly useful for extracting **alkaloids, flavonoids, glycosides, phenolic compounds and essential oils**.



Procedure

- 1) The crude drug is **dried and powdered**.
- 2) A suitable solvent is added to the powdered drug.
- 3) The mixture is placed in a microwave extraction vessel.
- 4) Microwave energy is applied for a predetermined time.
- 5) Microwave heating increases the temperature rapidly and causes **cell-wall/cell-membrane disruption**.
- 6) The mixture is cooled and filtered.
- 7) The solvent is evaporated or concentrated to obtain the extract.

Flow:-

**Drug powder → Solvent addition → Microwave irradiation → Cell disruption → Filtration →
Concentration → Extract**



Advantages

- 1) Very **rapid extraction**.
- 2) Requires comparatively **less solvent**.
- 3) Good extraction efficiency and yield.
- 4) Reduces extraction time considerably.
- 5) Can be suitable for selective extraction by controlling solvent and microwave conditions.

Disadvantages

- 1) High temperature may cause **degradation of thermolabile constituents**.
- 2) Requires specialized equipment.
- 3) Improper microwave power can cause overheating.
- 4) Not all solvents are suitable for microwave extraction.
- 5) Scale-up can be technically challenging.

2. Ultrasound-Assisted Extraction (UAE)

Introduction

Ultrasound-Assisted Extraction uses **high-frequency sound waves** to improve the extraction of active constituents from plant materials.

The major mechanism is **acoustic cavitation**. Formation and collapse of microscopic bubbles produces mechanical effects that disrupt plant cells and improve solvent penetration.



Procedure

- 1.The crude drug is dried and powdered.
- 2.The powder is mixed with a suitable solvent.
- 3.The mixture is placed in an **ultrasonic bath or ultrasonic probe system**.
- 4.Ultrasound waves are applied for a specified period.
- 5.Cavitation disrupts plant cells and facilitates the transfer of constituents into the solvent.
- 6.The mixture is filtered or centrifuged.
- 7.The filtrate is concentrated to obtain the extract.

Flow:

Powdered drug → Solvent → Ultrasonic treatment → Cavitation/cell disruption → Filtration → Concentration → Extract



Advantages

- 1) Requires **less extraction time**.
- 2) Uses less solvent than many conventional methods.
- 3) Good extraction yield.
- 4) Equipment can be relatively simple.
- 5) Useful for extraction of **phenolics, flavonoids, alkaloids and other phytoconstituents**.
- 6) Can operate at relatively low temperatures.

Disadvantages

- 1) Excessive ultrasound may cause degradation of some compounds.
- 2) Temperature can increase during prolonged sonication.
- 3) Extraction efficiency depends on frequency, power and treatment time.
- 4) Difficulties may occur during large-scale industrial application.
- 5) Probe systems require appropriate cleaning and maintenance.

3. Supercritical Fluid Extraction (SFE)

Introduction

Supercritical Fluid Extraction is a technique in which a substance in its **supercritical state** is used as an extraction medium.

Supercritical carbon dioxide (CO₂) is the most commonly used fluid because it is relatively inert, non-flammable and leaves little solvent residue.

A supercritical fluid has properties between those of a gas and a liquid, allowing it to penetrate plant material while dissolving suitable compounds.



Procedure

- 1) The crude drug is **dried and powdered**.
- 2) The material is placed inside the extraction vessel.
- 3) CO₂ is compressed and heated above its critical conditions.
- 4) Supercritical CO₂ is passed through the plant material under controlled pressure and temperature.
- 5) Desired constituents dissolve in the supercritical fluid.
- 6) The CO₂ containing extracted compounds passes to a separator.
- 7) Pressure is reduced, causing the extracted compounds to separate from CO₂.
- 8) CO₂ can be recycled and the product is collected.

Flow:

Drug powder → High-pressure CO₂ → Supercritical extraction → Separator → Collection of extract



Advantages

- 1) Produces extracts with **low solvent residue**.
- 2) CO₂ is relatively environmentally friendly.
- 3) Extraction conditions can be controlled for selectivity.
- 4) Suitable for **thermolabile compounds** because the process can be performed at relatively low temperatures.
- 5) CO₂ is easily removed from the final product.
- 6) Useful for essential oils, lipids, fragrances and other non-polar constituents.

Disadvantages

- 1) Equipment is **expensive**.
- 2) Requires high-pressure operation.
- 3) Skilled personnel are required.
- 4) CO₂ is relatively poor for extracting highly polar compounds unless modifiers are used.
- 5) Scale-up and process control can be complex.

4. Pressurized Liquid Extraction (PLE)

Introduction

Pressurized Liquid Extraction is also called **Accelerated Solvent Extraction (ASE)**.

In this method, solvents are used at **elevated temperature and pressure**. The pressure keeps the solvent in the liquid state even at temperatures above its normal boiling point. This improves penetration of the solvent into plant material and increases extraction efficiency.



Procedure

- 1) The crude drug is dried and finely powdered.
- 2) The powdered material is loaded into an extraction cell.
- 3) A suitable solvent is introduced.
- 4) Temperature and pressure are increased to predetermined levels.
- 5) The hot pressurized solvent penetrates the plant material.
- 6) Active constituents dissolve into the solvent.
- 7) The extract is collected after the extraction cycle.
- 8) The solvent is removed or concentrated.

Flow:

Powdered drug → Extraction cell → Pressurized solvent + heat → Extraction → Collection → Concentration



Advantages

- 1) **Rapid extraction.**
- 2) Requires relatively small quantities of solvent.
- 3) High extraction efficiency.
- 4) Automated and reproducible.
- 5) Suitable for a wide range of plant constituents.

Disadvantages

- 1) Requires specialized and relatively expensive equipment.
- 2) High temperature may damage thermolabile constituents.
- 3) Optimization of temperature, pressure and solvent is required.
- 4) High-pressure operation requires appropriate safety measures.

5. Enzyme-Assisted Extraction (EAE)

Introduction

Enzyme-Assisted Extraction uses enzymes to **break down plant cell-wall components**, thereby facilitating the release of intracellular phytoconstituents.

Commonly used enzymes include:

- ❑ Cellulase
- ❑ Pectinase
- ❑ Hemicellulase
- ❑ β -glucanase

It is especially useful when active constituents are trapped within rigid plant-cell structures.



Procedure

- 1) The plant material is dried and powdered.
- 2) The powder is mixed with a suitable solvent or buffer.
- 3) Selected enzyme(s) are added.
- 4) The mixture is maintained at an appropriate **pH and temperature** for enzymatic activity.
- 5) Enzymes hydrolyze or weaken cell-wall components.
- 6) The released constituents move into the extraction medium.
- 7) The mixture is filtered or centrifuged.
- 8) The extract is concentrated and purified.

Flow:

**Plant material → Solvent/buffer → Enzyme addition → Cell-wall degradation → Extraction →
Filtration → Concentration**



Advantages

- 1) Performed under relatively **mild conditions**.
- 2) Can improve extraction yield.
- 3) Useful for compounds located inside plant cells.
- 4) Can reduce the need for harsh physical or chemical treatment.
- 5) Enzymes can provide some degree of selectivity.

Disadvantages

- 1) Enzymes can be **expensive**.
- 2) Enzyme activity is highly dependent on pH and temperature.
- 3) Excessive enzymatic treatment may modify or degrade desired constituents.
- 4) Enzymes may require removal after extraction.
- 5) Large-scale application can increase process complexity.

6. Pulsed Electric Field-Assisted Extraction (PEF)

Introduction

Pulsed Electric Field extraction uses **short pulses of high-voltage electric fields** to increase the permeability of plant-cell membranes.

The electric field produces **electroporation**, in which pores are formed in cell membranes. This facilitates the release of intracellular compounds into the extracting solvent.



Procedure

- 1) Plant material is prepared and placed in contact with the extraction medium.
- 2) The material is placed between electrodes.
- 3) Short, controlled high-voltage electrical pulses are applied.
- 4) Electroporation increases the permeability of cell membranes.
- 5) Cellular constituents are released more readily.
- 6) The extraction is continued with a suitable solvent.
- 7) The extract is separated by filtration or centrifugation.
- 8) The extract is concentrated if required.

Flow:

**Plant material → Electric field pulses → Electroporation → Enhanced release → Solvent extraction
→ Separation**



Advantages

- 1) Very rapid process.
- 2) Improves cell permeability and mass transfer.
- 3) May reduce solvent consumption.
- 4) Can operate at relatively low temperatures.
- 5) Useful for heat-sensitive compounds.
- 6) Can be combined with other extraction methods.

Disadvantages

- 1) Requires specialized electrical equipment.
- 2) Equipment and process optimization can be expensive.
- 3) Effectiveness depends on electrical field strength and treatment conditions.
- 4) Scale-up may be difficult.
- 5) Excessive electrical treatment can affect sensitive cellular components.

7. Deep Eutectic Solvent (DES) Extraction

Introduction

Deep Eutectic Solvents are solvent systems produced by mixing two or more components that interact to form a mixture with a **melting point considerably lower than that of the individual components**.

DESs are increasingly investigated as alternatives to conventional organic solvents for extraction of **phenolics, flavonoids, alkaloids and other bioactive compounds**.



Procedure

- 1) The plant material is dried and powdered.
- 2) A suitable DES is prepared from selected components.
- 3) The powdered drug is mixed with the DES.
- 4) The mixture is subjected to stirring, heating, ultrasound or another suitable extraction technique.
- 5) Bioactive constituents dissolve in the DES.
- 6) The extract is separated from the plant residue.
- 7) If necessary, the desired constituents are further purified from the DES.

Flow:

Plant powder → DES addition → Mixing/heating/sonication → Extraction → Separation → Purification



Advantages

- 1) Very **low volatility** compared with many conventional organic solvents.
- 2) Good ability to dissolve various phytoconstituents.
- 3) Solvent properties can be modified by changing its components.
- 4) Potentially lower environmental impact for appropriately selected DES systems.
- 5) Useful for extraction of polar and moderately polar compounds.

Disadvantages

- 1) High viscosity can reduce mass transfer.
- 2) Recovery of the extracted compound from DES may be difficult.
- 3) Some DES components can be expensive or unsuitable for certain applications.
- 4) Water content strongly affects DES properties.
- 5) More research is required for large-scale industrial use and complete environmental assessment.



Thank you

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