



Supercritical Fluid Extraction

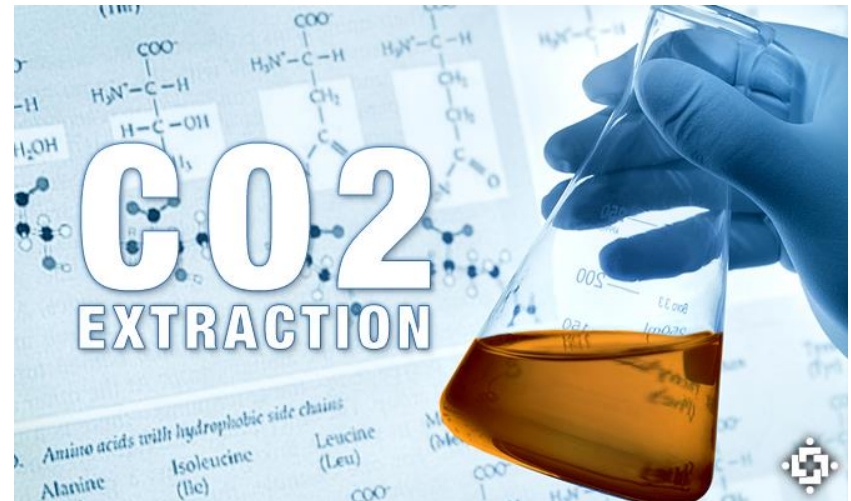


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1. Introduction

- Supercritical fluid extraction technique is an **advance solvent extraction technique** in which various supercritical fluid is used to extract and separate, as a solvent.
- It allows extraction at **low pressure** and near **at room temperature**.
- Extraction done based on adjustment/ modification in the condition like temperature and pressure and fluid properties like density, diffusivity, dielectric constant, and viscosity.
- Most widely used solvent is CO₂ because of its unique properties.
- For non-polar molecules, sometimes small amount of organic solvent is also used.



1.1 SCF Extraction machine

- a. For small scale extractions (up to a few grams / minute): Machine includes **reciprocated CO 2 pumps or syringe pumps**
- b. large scale (Industrial) extractions: **Diaphragm pumps** are used.



Laboratory SCF extraction machine



Industrial SCF machine

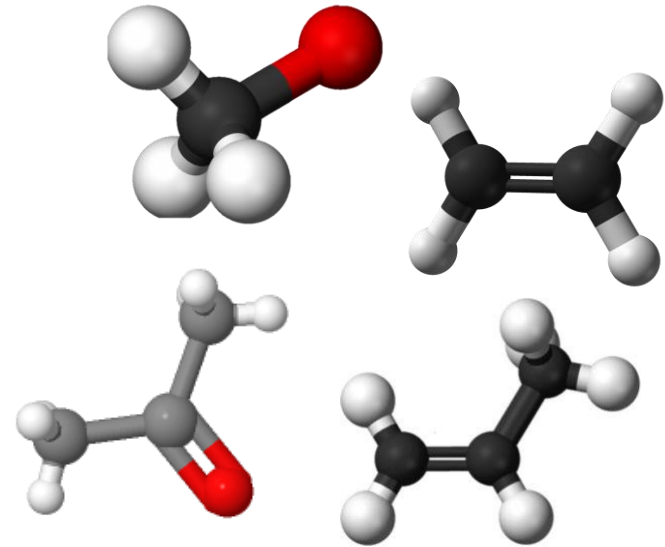
2. Supercritical fluids

- A fluid at temperature and pressure above its **critical point** (highest and pressure at which a substance lie in vapour-liquid equilibrium).
- Display physicochemical properties between liquid and gas.
- Typically characterized by following which can be managed by changing pressure and temperature:

#	Characteristics	Description
1.	Viscosity	Low, Nearly equal to gas & less than liquid
2.	Density	High, Similarly liquid, better transport
3.	Diffusivity	Like gas, efficiency — increases yield
4.	Solvation Power	High
5.	Surface tension	Low

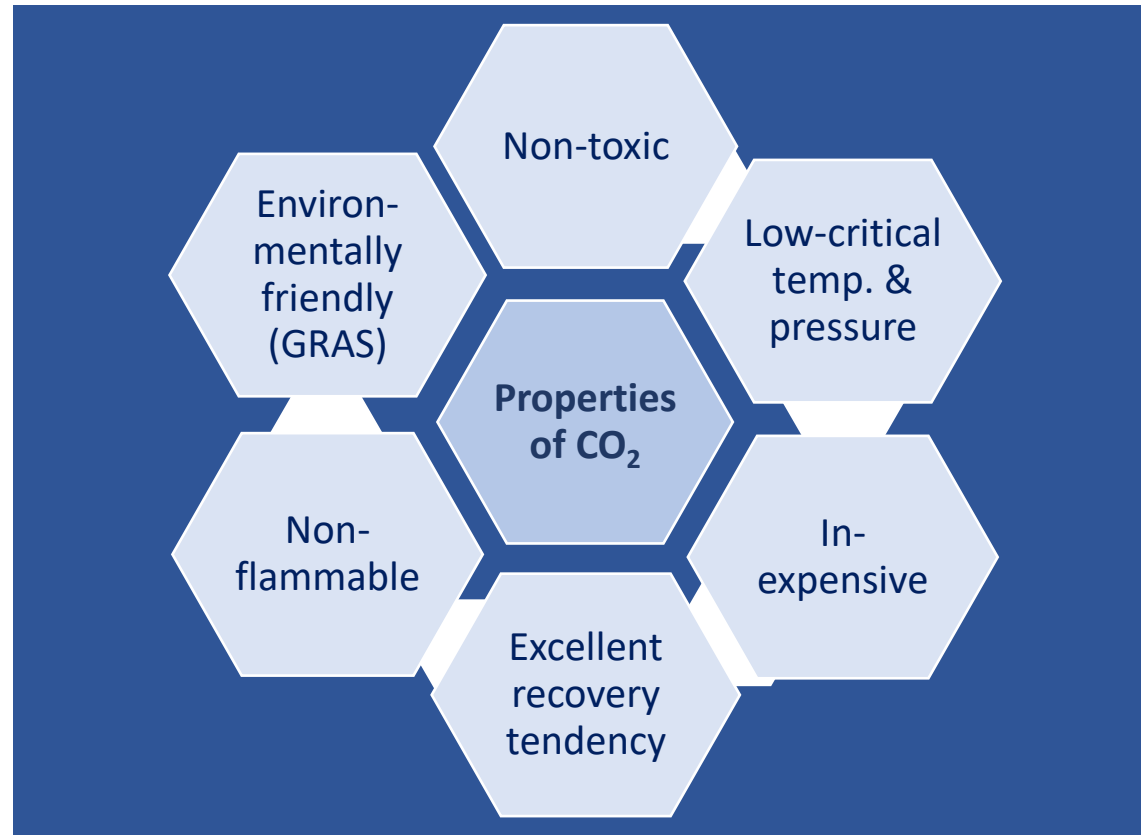
2. Supercritical Fluids (Cont.)

- SCF is heavy as liquid but has penetration power as gas hence, also known as **compressible liquids** or **dense gases**.
- Example-
 - Water, CO₂, methane, ethane, propane, ethylene, propylene, methanol, ethanol, Acetone etc.
- For polar targeted compounds, co-solvents having high polarity are used, which increases polarity of the supercritical fluid, known as **modifier**.
 - Mostly used methanol, ethanol, hexane, etc.



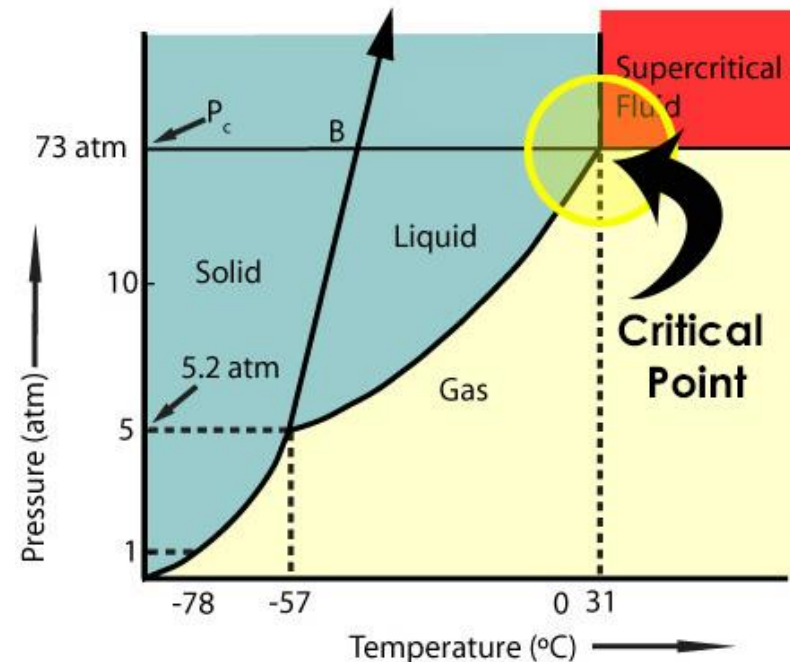
2.1 CO₂ as Supercritical Fluid Extraction

- Properties of CO₂ making it mostly used solvent for extracting non-polar compounds



3. Working principle

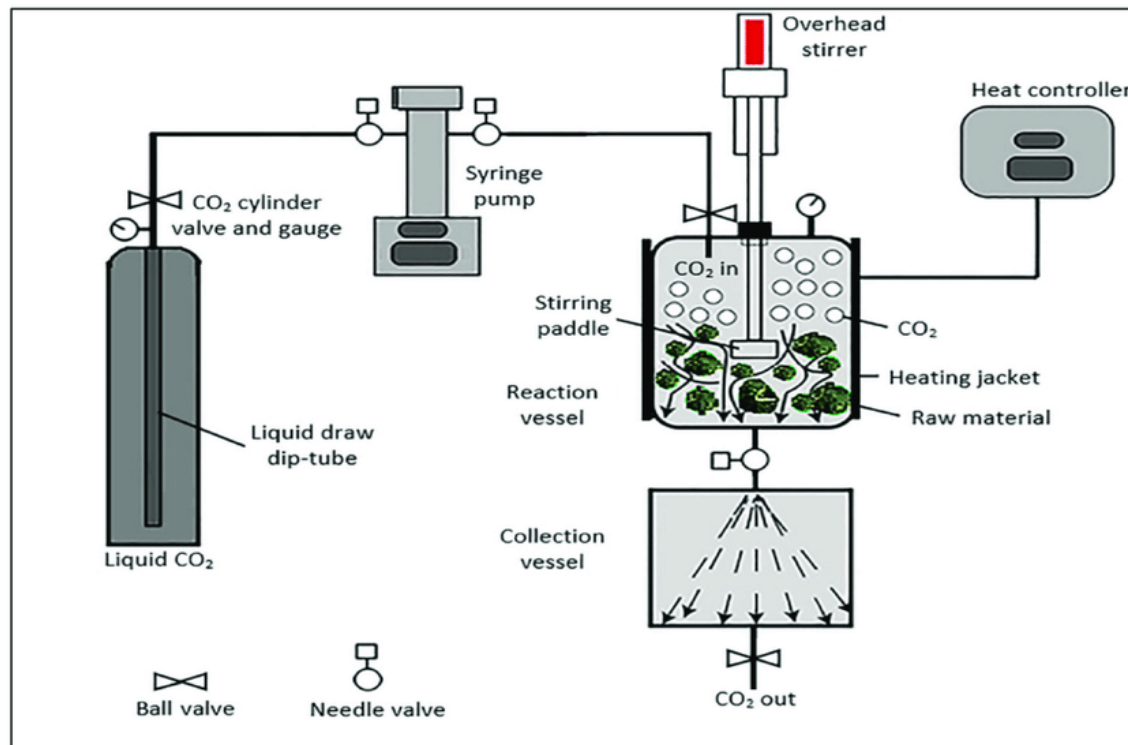
- A potential replacement for **pasteurizing** bioactive chemicals in food and medicine.
- Utilizes **high pressure** in combination with CO₂ to destroy microorganism without affecting nutritional status and organoleptic characteristics of food.
- The principle of supercritical fluid extraction:
 - Based on **solvation properties** of the supercritical fluid
 - By applying temperature and pressure above critical limits of fluid.



3. Working principle (Cont.)

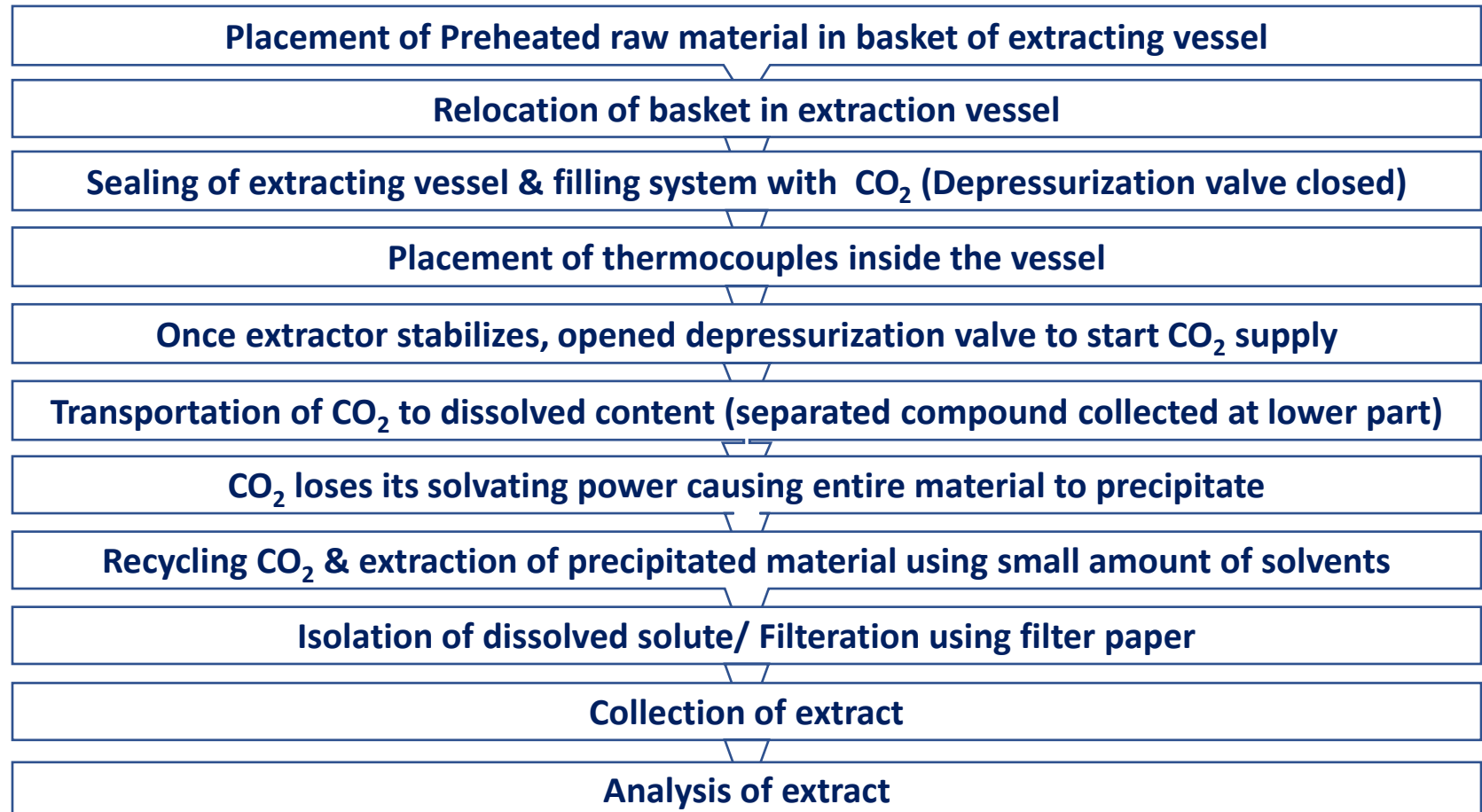
Driving force for extraction: Solubility of targeted compound in the solvent used.

- Depends on **interactions between the solvent and solute**
- polarity increased by addition of a miscible polar compound (Ex- ethanol) as modifier

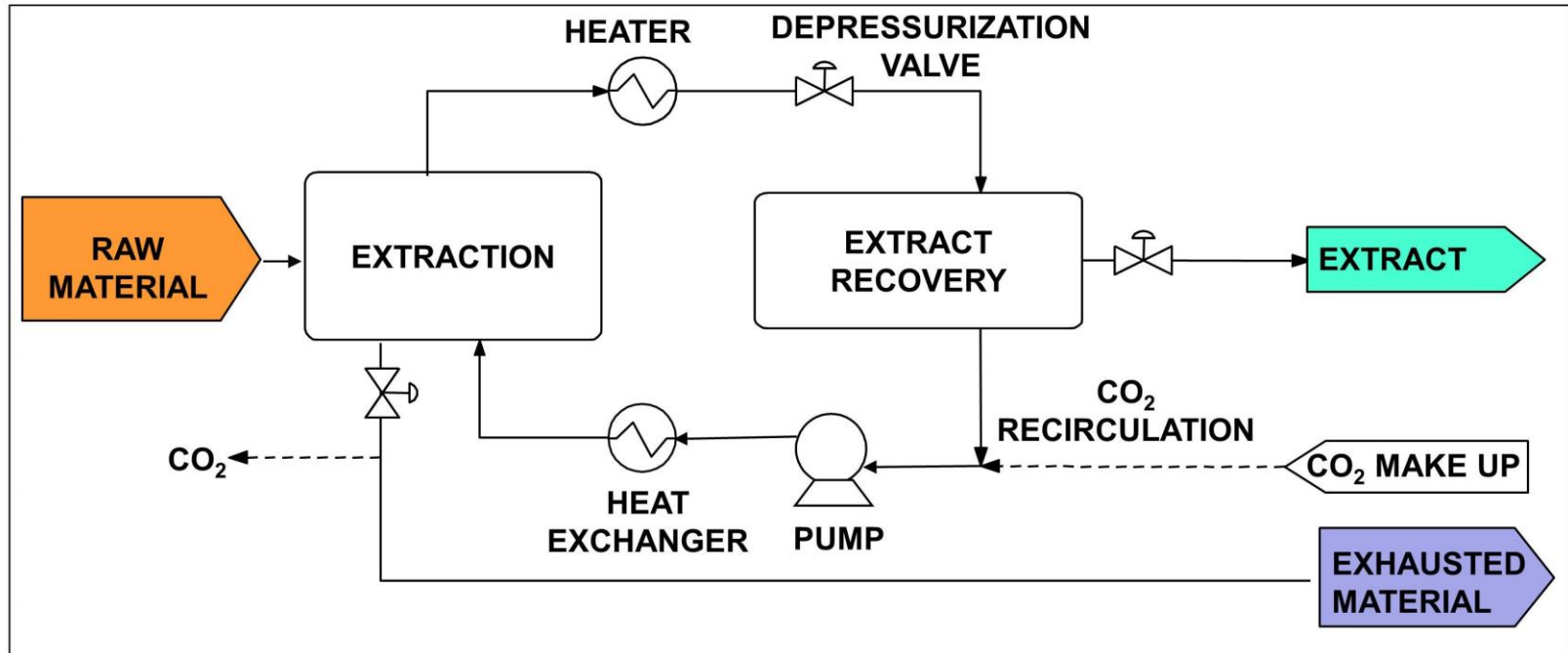


Mechanism of SCF extraction

3.1 Flow Chart of Extraction Mechanism



3.2 Flow Diagram of Extraction Mechanism



4. Benefits/ Advantages

- Lower extraction time,
- Less consumption of organic solvents,
- Suitability for heat liable or thermo-sensitive substance;
- Production of cleaner extracts and environmental benignity
- Easier recovery of solvent.



5. Traditional vs SCF Extraction

#	Characteristics	Traditional Method	SCF Extraction Method
1.	Versatility/Flexibility	Not relatively versatile/flexible	Highly
2.	Organic solvent	Required higher amount	Very less amount
3.	Extraction time	Longer	Shorter
4.	Mass transfer capabilities	Inferior	Superior
5.	Productivity	Lower	Higher
6.	Suitability for heat sensitive compound	Not much suitable	Highly suitable
7.	Environmental impact	May have some impact on environment.	Environment friendly (Eg: CO ₂ has GRAS status)

6. Application

- a. Removal of fat from foods
- b. Enrichment of vitamin E from natural sources
- c. Removal of alcohol from wine and beer, and related applications
- d. Encapsulation of liquids for engineering solid products
- e. Extraction and characterization of functional compounds
- f. Application of SFE in food safety (pesticides, & environmental pollutants (PAHs) etc)
- g. Rapid detection of fat content, pesticide residues content in food
- h. New applications: Nanoparticle formation(such as beta- carotene) and Supercritical drying
- i. Extraction of cholesterol and other lipids from egg yolk
- j. De-caffeination of coffee and tea (extraction of caffeine)
- k. Extraction of bioactive compounds

(Abbas et al, 2008)

7. References

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