Supercritical Fluid Extraction: Green Solution to Conventional Extraction

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Supercritical Fluid Extraction (SFE) is a novel and environmentally benign separation technology represents a green alternative to the conventional extraction methods to produce natural extracts. The use of a green solvent (supercritical carbon dioxide), a quick and more efficient procedure, and a relatively low rate of chemical compound degradation make the supercritical fluid extraction (SFE) a fascinating alternative. Supercritical fluid extraction (SFE) may be defined as separation, moreover extraction of compounds of interest (from coffee, tea, hops, herbs, and spices) using supercritical fluid as an extracting solvent/mobile phase.

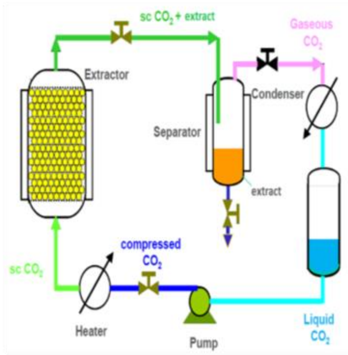
- It resembles Soxhlet extraction except the solvent here being supercritical fluid.
- In this process, the mobile phase is subjected to pressures and temperatures near or above the critical point for the purpose of enhancing the mobile phase solvating power.
- The process begins with fluid in vapor form. It is then compressed into a liquid before becoming supercritical. While supercritical, the extraction takes place.

Principle of SCFE

The principle consists in circulating supercritical CO2, through the raw material (e. g. natural plants), and depressurizing the mixture to recover the extract. Indeed, after depressurization the CO2 is released in gaseous form (re-usable) and lose its solvent property leading to condensation of the extract into liquid or solid form.

Supercritical fluid extraction is the most effective and efficient method for extracting important component phytochemicals. The method of supercritical fluid extraction (SFE), which uses CO2 as the extracting solvent, separates one component (the extractant) from another (the matrix). The king of botanical extraction solvents is CO_2.

The critical temperature and critical pressure for supercritical CO2 extraction are higher than 31°C and 74 bar, respectively. Carbon dioxide is odourless, non-toxic, non-flammable, inexpensive, easy to remove from the product. Also, it is eco-friendly and generally recognized as safe (GRAS) by FDA.



Supercritical Fluid Extraction assembly and cycle

Supercritical fluids are extremely compressed gases that have intriguingly mixed properties of both gases and liquids. Reactions that are challenging or perhaps impossible to achieve in normal solvents can occur in supercritical fluids. Analyte and a supercritical fluid are easily separated releasing pressure can separate the critical fluid from the analyte, leaving almost no residue and producing a pure residue.

Phase diagram of supercritical fluid

Critical temperature (tcr)

Highest temperature at which gas can be converted to liquid by an increase in pressure

Critical pressure (tpr)

Highest pressure at which liquid can be converted to gasy an increase in temperature

Triple point (ttp)

A point at which gas, liquid and solid phases exists in equilibrium.

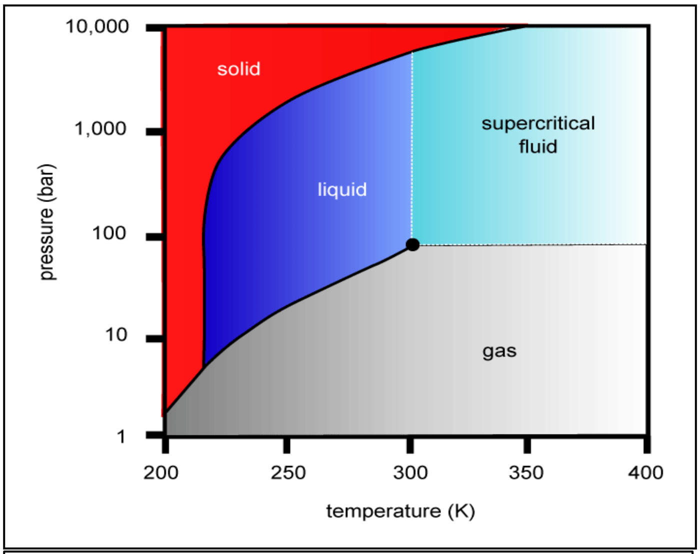
Common Super-critical Fluids:

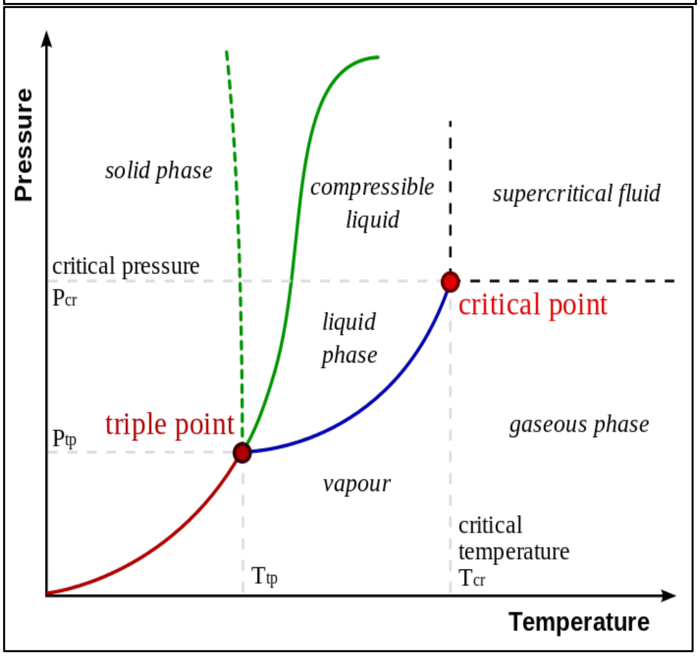
- Water and Carbon Dioxide

Carbon dioxide

- Its low critical temperature, 31.1 °C, and low critical pressure, 72.9 atm, are relatively easy to achieve and maintain.

- Environmentally friendly and generally recognized as safe (GRAS) by FDA.
- Odourless, non-toxic, Non-flammable, inexpensive, easy to remove from the product.





Phase diagram of Super critical fluid extraction

Advantages

➢ SFE have higher selectivity because the solvation power of the Supercritical fluid can be adjusted by changing temperature and pressure.

➢ Supercritical fluids have lower viscosity and higher diffusivity which allow faster mass transfer of solutes from porous plant materials.

➢ SFE can be performed at low temperatures making the process ideal for the extraction of thermally labile compounds.

➢ In SFE can easily separate supercritical carbon dioxide which is dissolved in extract by depressurization with little to no solvent residue left behind.

➢ SFE units can be coupled to a GC-MS or NMR allowing extraction, analysis, and quantification of extracted molecules instantaneously.

- **Limitations:**

➢ Prolonged time (diffusion of SCF into solid is rapid but diffusion of solute into SCF sometime takes time)

➢ Scale is not possible (due to lack of fundamental, molecular- based model of solute in SCF

➢ Very expensive: Due to requirement of very high pressure for extraction

➢ Polar substances cannot be extracted. (As CO2 itself is non-polar)

➢ High power requirement

➢ Use of organic solvents as modifiers makes it less green.

Applications

➢ Extraction of essential oils and its derivatives for use in food, pharma and cosmetics

➢ Extraction of flavours from natural resources.

➢ Extraction of fat from food products

➢ Decaffeinating of tea and coffee

➢ Separation of lecithin from oil

➢ Extraction of hop constituents

➢ Extraction of bioactive compounds from different commodity like beta carotene from carrots, lycopene from tomato

➢ Extraction of oils is used to produce fat-free and reduced fat potato chips and other snacks.

➢ Removal of alcohol from wine, beer, and similar products

Conclusions

Supercritical technology is a promising alternative technology for extracting unusual compounds due to its selectivity, efficiency, and speed of operation. It is eco-friendly method as it uses Carbon dioxide which is non-toxic, and FDA considered as GRAS (Generally recognized as safe). Extracts from natural sources are key elements in the manufacturing of health-promoting functional foods and ingredients. Thus, the development and use of "green" separation processes and technologies will likely continue to be widely employed in the processing of bioactive components, especially for use as supplements for health-promoting foods.

References

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