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Supercritical Fluid Chromatography: A Modernistic Approach

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ABSTRACT

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Introduction

The origin of supercritical fluid chromatography (SFC) dates back to 1962, when it was known as "high pressure gas chromatography". It began slowly but was rapidly dominated by the development of high-performance liquid chromatography (HPLC) and already-developed gas chromatography. SFC was not a widely used chromatographic method until the late 1980s, when more papers began to demonstrate its applications and methodologies. The discovering of supercritical fluids resulted in the creation of new analytical applications in the areas of chromatography known as SFC (supercritical fluid chromatography). Together with gas chromatography (GC) and high-performance liquid chromatography (HPLC), the supercritical fluid chromatography is accepted as a column chromatography. Phase diagrams shown in (Figure 1), used to illustrate phase shifts in response to pressure and temperature [1]. The condition of a compound at critical pressure and temperature is known as a supercritical fluid. Critical temperature is the least amount of temperature required to solubilize a gas at its critical temperature when there is no extra pressure, critical pressure is the minimum amount of pressure required to liquefy a gas at its critical pressure when there is no extra pressure. Because it may act like both a gas and a liquid in various ways, supercritical fluids utilize the power of both gas and liquid phases. When a supercritical fluid enters a container and adopts the form of the container, it shows a gas-like property. The particles motion is quite similar to that of gas molecules. A supercritical fluid, at the other hand, acts like a liquid since its density value is close to that of a liquid and hence it has a dissolving action similar to that of a liquid [2].

The density, diffusivity, and viscosity of a supercritical fluid are its distinguishing characteristics. In between liquids and gases, supercritical levels for certain characteristics occur. The various values of Gas, Liquid and supercritical fluid are mentioned in (Table 1). The dynamic equilibrium system results in the production of a supercritical fluid. A dynamic equilibrium is created when a temperature is increased to its specific critical temperature in a closed system under constant pressure. In this equilibrium, the same number of molecules gain energy by migrating from liquid to gas phase and lose energy by migrating from gas phase to liquid phase. The transition slope among liquid and gas phases collapses at this point and supercritical material arises. Based on the temperature and pressure conditions, substances can be solid, liquid, or gaseous. Water as example is a liquid at normal temperature and pressure and it transforms into vapour (gas) at 100 degrees Celsius and ice (solid) at 0 degrees Celsius when exposed to air pressure. While water is placed in a sealed container and exposed to a vacuum as illustrated in (Figure 2), part of the water evaporates while the

rest stays liquid. The evaporation rate equals the condensation rate when the water vapour pressure reaches a specific level. This is known as the saturated water vapour pressure, and it is temperature dependent [3].

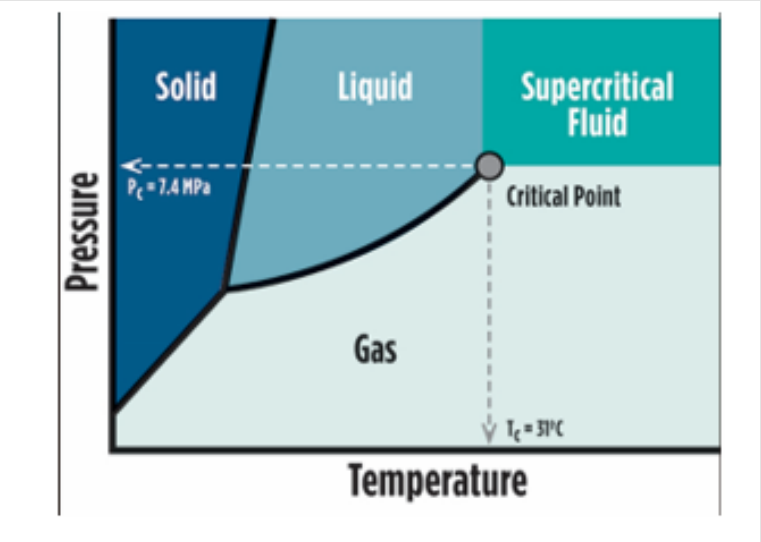

Figure 1: A generic phase diagram.

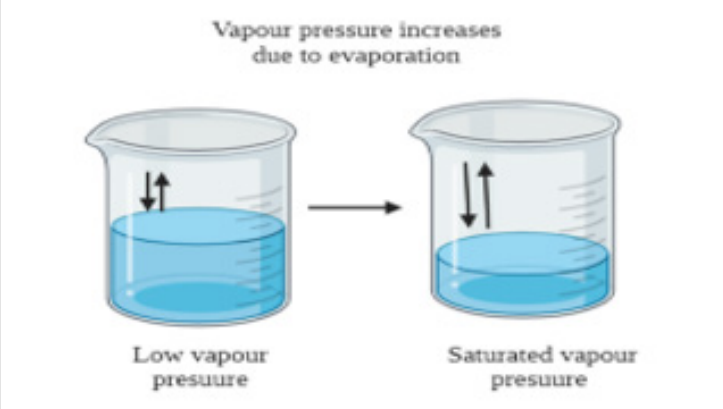

Figure 2: Change in liquid state at various conditions.

Table 1: Supercritical fluid properties compared to liquids and gases.

Parameters	Gas	Supercritical Fluid	Liquid
Density			
(g/cm3)	0.6 x 10 -2 -2.0 x 10-3	0.2-0.5	0.6-2.0
Viscosity			
(cm2/s)	1 x 10 -3 x 10-3	1 x 10 -3 – 3 x 10-4	0.2 x 10 -2 - 3.0 x 10-2
Diffusivity			
(cm/s)	0.1-0.4	10-3 -10-4	0.2 x 10 -2- 2.0 x 10-2

Method Development Cycle in SCFC

In SCFC, the classic basic technique is the most typically employed for developing QC methods. One-Factor-At-a-Time (OFAT) or Quality-by-Testing are other terms for it (QbT) [4]. Pandya etal. developed a method for the determination of four (achiral) anti-diabetic medications, an SFC approach was established. The separation was done on a chiral stationary phase, which was unusual (CSP). The use of CSPs for achiral compound separation is a method that is increasingly being investigated because it has been shown that, in some situations, it can produce superior separation than achiral columns. It's worth thinking about during column screening tests, especially for chemicals that are closely related [5].

Various Applications

The quantity of fundamental studies has increased very somewhat in recent years, the number of application articles has exploded. However, there are still interesting features to explore with modern SFC of pharmaceutical products as shown in (Figure 3). Meanwhile, application domain trends have shifted dramatically. In addition to the advancement of SFC technology, mass spectrometers have become more affordable, allowing SFC-MS to be used to new domains where simpler, less detailed detection techniques such as UV are insufficient [6].

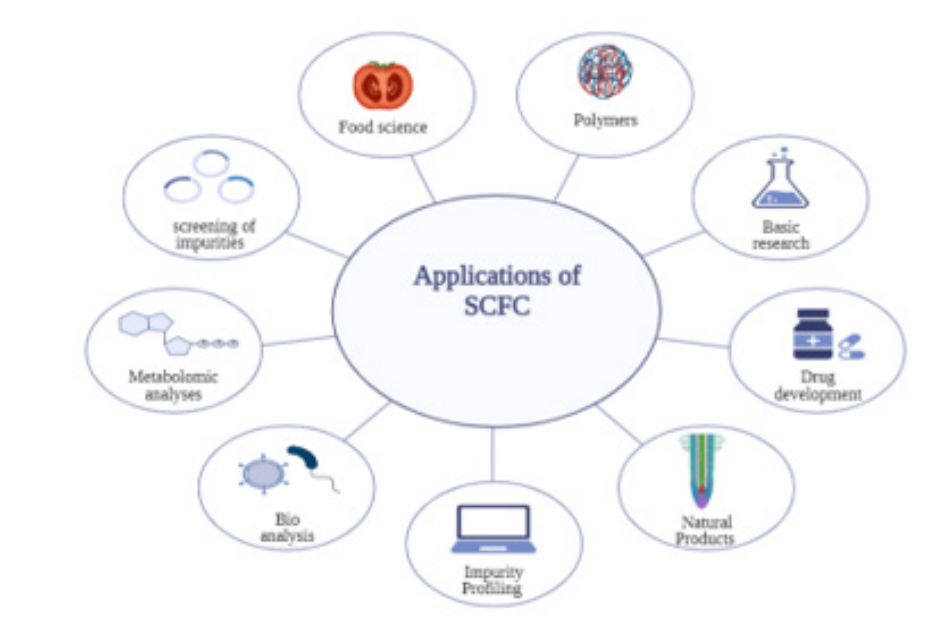

Figure 3: Applications of SCFC.

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