What is...

supercritical fluid extraction?

The low environmental impact and high extraction yields of supercritical fluid extraction have made it a popular processing technique for cosmetic ingredients. But what does supercritical fluid extraction entail and how far do the benefits over traditional techniques stretch? **Fritz Chess** explains

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Supercritical fluid extraction is an increasingly popular processing technique. In spite of its expanded usage, however, few people actually understand what it means.

Supercritical fluid extraction was first developed by the Germans in the 1930s. The most visual description is to imagine a pot of boiling water on the stove. A lid is clamped down onto that pot so that no steam can escape, regardless of how much pressure builds up; the pot would have to be very robust as the critical point of water is 373°C and 3,191 psi pressure.

As the pressure and temperature build, the steam becomes increasingly dense, while the elevated temperature makes the water less dense. When the two phases have equalised into one even chamber of dense fog, it is now in its supercritical fluid state. Once a substance has passed the critical point, it has characteristics of a gas and a liquid. It can penetrate through solids like a gas and dissolve solid materials like a liquid. These dual properties are particularly useful when it comes to the extraction, or separation, of solid materials.

It is also important to note that as a liquid is being heated and pressurised, it passes through what is called its subcritical phase before it reaches supercritical conditions. Subcritical liquids have their own unique extraction properties and a well-designed extractor will be able to take advantage of these traits.

Another distinct advantage of supercritical fluid extraction, particularly CO_2, is tuneability. This means that subtle changes in temperature and pressure can cause dramatic differences in the solubility of various compounds in the extraction chamber. A good example is the extraction of oregano. At the low end of the supercritical range of CO_2, 31°C and 1,100 psi, light essential oils, or monoterpenes, extract very quickly; oleo resins begin separating shortly after.

In this temperature and pressure range, the supercritical CO_2 is a very non-polar solvent. If the pressure is increased, the CO_2 becomes more polar. This gradient increases and peaks at about 15,000 psi. At 1,800 psi, the higher polarity will cause compounds like waxes and chlorophyll to extract.

This peculiar relationship between solubility and pressure gradients also allows for the fractionation of extracts, which can be extremely useful. The way this works is that there is a series of chambers after the extraction chamber for extracted compounds to fall out into. The pressure and temperature of each chamber cascades downward. An example would be an extraction done at 5,000 psi. The first separation chamber might be set at 2,000 psi with the idea being that unwanted compounds like chlorophyll and wax would fall into this chamber. The second chamber might be set at 900 psi where the thicker oils and resins would end up. A third chamber is at 350 psi; light essential oils would end up here.

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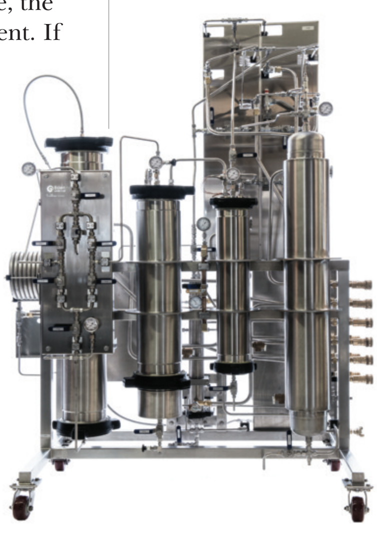

During supercritical fluid extraction with water, temperatures can reach 373°C and pressure builds up to 3,191 psi

Another advantage is the process' cleanness. Conventional extractions use organic solvents such as hexane and acetone to isolate the desired compounds from a solid material. This type of extraction leaves solvent residues and many of these residues can be harmful even in the parts per million range. Supercritical CO_2 is harmless; we are breathing it constantly as it is one of the natural gases that makes up our air. A second reason is its low boiling point; it quickly evaporates out of anything extracted with it once the extract is removed from the separation chamber and de-pressurised.

The third advantage of supercritical CO_2 is that it is a natural disinfectant. The very act of extracting an oil with CO_2 destroys any bacteria and viruses in the material. This is a form of pasteurisation that does not require high heat, thus protecting delicate essential oils.

Although CO_2 is the most popular and useful supercritical fluid, water is also gaining ground as a supercritical, or subcritical, fluid. Water, in terms of solubility characteristics, is the opposite of CO_2. Whereas CO_2 becomes more polar as pressure is increased, water becomes more non-polar. This allows water extracts to be fractionated as well. An extraction vessel full of material can be filled with low-pressure water and then the extract-saturated water can be vented off and polar compounds can be retrieved. After this, the same vessel full of material can be re-filled with high-pressure water, which causes the non-polar compounds to dissolve into the fluid ●