Comparison of subcritical and supercritical CO2 extraction

From customers and heard a little bit versed in the subject of CO2-extraction, we often hear the question - so what is still better, supercritical or subcritical CO2 extraction? Sometimes, the same question is asked in a slightly different form - which will extract the most good, subcritical or supercritical? And this question, it must be admitted, is not idle. Because really, when all the similarity of the two extraction techniques (the most important of which is obvious - in both cases the extractant is a liquefied carbon dioxide), is between them and the notable differences in which an outsider to understand and make informed choices difficult. But we will try to help you do it.

Let's start with a small announcement. In order to comprehensively highlight the theme of differences between the subcritical and supercritical CO2 extraction, our research staff is now preparing for the publication of a large analytical article in which this issue will be discussed at the most fundamental academic level. This article will be published within a month or two, that is, soon enough, but we decided to anticipate its occurrence on the site easier to understand an article in the popular science genre, since the main audience of those who addressed our analysis of this topic, this practice interested in the question is not academic but in a completely practical purposes. And precisely in order to avoid it so happened that someone Forest scientific evidence did not see the trees, and it was decided to highlight this issue in two formats - Academic and popular science.

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The first thing that must be said, comparing the subcritical and supercritical CO2 extraction technology, is that the question of which one is better, it is incorrect. Both technologies are good, both have their own sphere of application, and when used judiciously complement each other perfectly. It is important to understand that the question of "better or worse" for these two types of CO2-extraction can be only applied to the solution of a very specific and clearly defined customer problem, and not "all." Due to its physical characteristics, each of these two technologies ("subcritical" and " supercritical " speaking in the jargon), have a fairly well-defined "area of responsibility", in which each of them will give the whole a better result than the other. Only within these limits, and it makes sense to talk about "what is best". For the decision of a class of problems can help the strongest sides of the same technology, and for another - another.

So what is the range of applicability of technologies have considered? To answer this question, we turn to the process of physics. Solvent (extractant) is in both cases carbon dioxide (CO2 gas), - a non-polar solvent, which may be liquefied at a subsonic, and in the supercritical state. The point of transition is usually considered the pressure of 75 atm and the temperature 31C (although the issue of the transition point in the supercritical state is not as simple as it seems, but we will not dwell on this - more details on this topic will be discussed in the next article). The subcritical state liquefied CO2 gas behaves like a fluid, while simultaneously as supercritical fluid and as a gas (a special state called "fluid"). As the solvent, CO2 gas as a fluid (supercritical state) significantly exceeds the CO2 gas as a fluid with properties (subcritical state), and is able to extract from plant material, any non-polar compound having a molecular weight up to 2000 Daltons.

It would seem that the question is solved. We need fluid! Indeed it is better if it is longer dissolve and extract substances from the raw extract longer, since it is a better solvent in comparison with a same, but in the previous sub-critical state. It sounds like convincing, but only at first glance. Because, in practice, there are a lot of nuances that makes all the difference. We list only some of them.

1. The carbon dioxide in either its state (gas, liquid, fluid), is a non-polar compound. So, extract from plant material he too can only nonpolar same compound (plus, in certain quantities, weakly polar). But the fact is that the vast majority of non-polar and slightly polar lipophilic compounds of interest to the real industry (food, cosmetic, pharmaceutical, perfumery, BAA production), have a molecular weight significantly lower than 2000 Da, which is able to pull out of the raw material fluid. And so great is recovered by conventional liquid (CO2 gas in a liquid, subcritical, state), the fluid is not necessary.

2. What, then, in addition, compared with a liquid ("subcritical") retrieves the fluid? And it further extracts heavy high molecular compounds such as vegetable waxes and paraffins. It is for this reason that on the packaging of supercritical CO2 extract usually indicate "acceptable presence of waxy impurities." But excuse me, why do we need to extract the wax, designed for cosmetic cream, or canned fish? The wax is not necessary. But all that is really needed (biologically active substances and taste- aromatic compounds), you will find in the sub-critical CO2 extract. And without the wax and other impurities.

3. supercritical transition state (phase transition of fluid-liquid) has a price, which is expressed at elevated pressure and temperature. Both have a negative impact on the safety of recoverable materials - part of the heat-labile compounds decomposes, thereby violating the integrity of the extraction matrix and simultaneously contaminating the final product (for example, supercritical extraction uncommon caramelization of sugars, giving the extract virtually irremovable and rather unpleasant smell and taste of burnt Sahara). A high pressure creates a specific environment in which members of the extract substances (both native and thermal decomposition products) come together in a chemical reaction, which predict the course and impact of the results on the final product is extremely difficult. Particularly unpleasant is the fact rancidity of unsaturated fatty acids in the conditions of temperature effects at high pressure, which affects the shelf life of supercritical extracts - many of them smell Rancid oil appears quite quickly. This subcritical CO2-extracts are completely devoid of all the drawbacks described above.

Now, comprehend the reading, we seem to have come to a conclusion opposite to that with which we began. Namely, that the subcritical CO2 extraction in quality definitely superior supercritical. Again, such a conclusion can only be done at first, and the most cursory glance. Because there are other nuances, which makes the picture keeping the supercritical CO2 extraction is not as dismal as it might seem when reading the above paragraphs. We list these new nuances.

1. Yes, supercritical CO2 extraction as a whole gives a contaminated end product than subcritical. But it is faster (due to the higher pressure). Therefore, in cases where the contamination of the extract in terms of further use in particular, advance a certain product is not of a "supercritical" nature (ie, tolerable), the choice is supercritical extraction technology can be commercially justified - it will allow to produce more of the extract for the same time . A specific example to illustrate - the production of hop extract for breweries.

2. As mentioned above, there is a "border" area extraction consisting of high molecular weight nonpolar and weakly polar compounds, which reaches even supercritical extraction, subcritical but no longer. Yes, in most common cases, in this area there is nothing interesting - wax and paraffins ballast. But if you decide to do some less known, and less common raw materials, and all of a sudden as it turned out (to us because not everything is known, and not all types of vegetable raw materials are equally well understood) what you need valuable biologically active compound lies precisely in this border region, this means that your technology - it supercritical.

3. Due to the higher pressure, which in addition to everything else, and can vary widely, supercritical CO2 extraction method provides a sufficiently extensive capabilities yield targeting (targeting a selection refers to the product of the fraction of the extract, which has given the task to extract raw materials from client). Often such enriched (some specific desired customer substance or group of substances) extract phase is not used as a terminal, and as intermediates, which are then used in subsequent stages of production as raw materials for further deep cleaning (for production of pure substances, e.g.). Another embodiment of this scheme is called fractionation - by this is meant an extract separation into several fractions each of which contains a specific set of compounds, and which is then delivered to the customer in the form of several individual products. Either such a "disassembled parts" (rough, but the exact professional slang for such cases) extract can further be distributed to different customers (eg natural dye alone, and other vitamins). Subcritical CO2 extraction method also allows targeting and screening output, but less widely.

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Of course, nuances of the issue of differences "subcritical" and "supercritical" much more than we could fit in the scope of this article - there is between these two types of CO2-extraction, and other differences that are not listed in the list above, and which can be either good and disadvantages, in terms of addressing specific production tasks. But this article and aims to highlight the theme of all the details - our goal was, without overloading detail, provide the reader with the opportunity to catch the main thread, the main nerve problems comparing two types of CO2-extraction and the choice between them. In our view, already this is enough to understand the basic essence of the question.

So, summarizing the above, we state in the most simple, qualitative level, without scientific details, what exactly are the main characteristics as pre- and supercritical CO2 extraction, outlining areas of their practical application.

Subcritical CO2 extraction: A slow, cold and clean. Intact, but less deep matrix removal. Limited opportunities for targeting output and fractionation.

Supercritical CO2 Extraction: Fast, hot and dirty. Damaged, but the deeper matrix removal. Extensive targeting output and fractionation.

These characteristics are quite clearly outline the applicability of the subject area of each of the technologies under consideration: subcritical CO2 extraction is more a universal tool, and supercritical - specialized.

Speaking more simply, subcritical CO2 extraction allows to extract from the source of raw materials "gross" everything useful that there is there, and to do it in the most convenient for later use and storage form. While Supercritical (Fluid) CO2 extraction allows control of the feedstock, "retail" something specific, specialized, needed to solve a specific task set by the customer.

There's also a simple rule of thumb that works in most cases, if you do not know why you need a supercritical CO2 extraction, then most likely it and you do not need. Conversely, the more specialized the task looks standing in front of you, the more likely it is that you are exactly right "supercritical".

Typical applicability subcritical CO2 extraction: the production of universal extraction products as close as possible in composition to natural, containing no impurities, and as accurately as possible the natural transmission matrix properties both in terms of taste and aromatics, and in terms of biological activity. These versatile products (subcritical CO2-extracts) can be used "as is", without further elaboration, in any of the industries consuming extraction products - food, cosmetics, perfumes, pharmaceuticals, production of dietary supplements and functional foods. This ingredient, having a universal character, gives a result of his use of universal well-known result in advance - it will bring the final product taste, smell, and all the useful properties of the feedstock.

Typical applicability of supercritical CO2 extraction: extraction production of specialized products with a high content of a predetermined group of substances. These products are further used as starting substances for the subsequent manufacture of pharmaceutical products, medicines, functional foods and dietary supplements; natural dyes, flavors, preservatives, yeasts, enzymes, natural vitamins complexes, separation of the pure substances; and for many other types of specialized applications. Also " supercritical " is used not only for the extraction in the traditional sense, but also for cleaning of vegetable raw materials from unwanted contaminants - such as pesticides and herbicides.

In addition, it should be noted that supercritical CO2 extraction technology is still fairly wide range of applications, non-living matter. This applications such as cleaning of chips and precision optics, the fractionation of individual grades of oil, creating alloying additives, anticorrosion additives, and the like. Also " supercritical " is widely used as a tool for experimental science.

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