ULTIMATE

WATER SMART INDUSTRIAL SYMBIOSIS

Factsheet:

Subcritical Water Extraction

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The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869318

Subcritical Water Extraction

Unique points:

- ✓ Green Technology
- ✓ Water as an extraction solvent has the advantage of being green, cheap, and readily available
- ✓ Polar, moderately polar, low-polar and non-polar compounds can be extracted separately
- ✓ No use of organic solvents
- ✓ No residual organic solvents in the extract
- ✓ Less expensive instrumentation
- ✓ Faster Extraction Time
- ✓ Continuous operation is possible

Overview of the technology

Subcritical water extraction (SWE) is a promising engineering method, which provides an environmentally friendly technology for extracting various bioactive compounds from natural products. Especially, under high temperature and high pressure, subcritical water can change the polarity and dielectric constant of solvents, thus contributing to a better extraction process, improving the mass transfer efficiency of the extracts and maintaining its biological activities, which has a high application prospect (**Zhang et al., 2020**).

Subcritical Water Extraction (SCWE) is a method that benefits from the solvent properties of subcritical water. i.e. water at temperatures above the boiling point i.e., elevated pressures in order to keep it in liquid state, as seen in the phase diagram below Figure 1, with a working range between 100-250°C and 100-200 bar.

The subcritical water extraction can also be applied directly on undried matrices.

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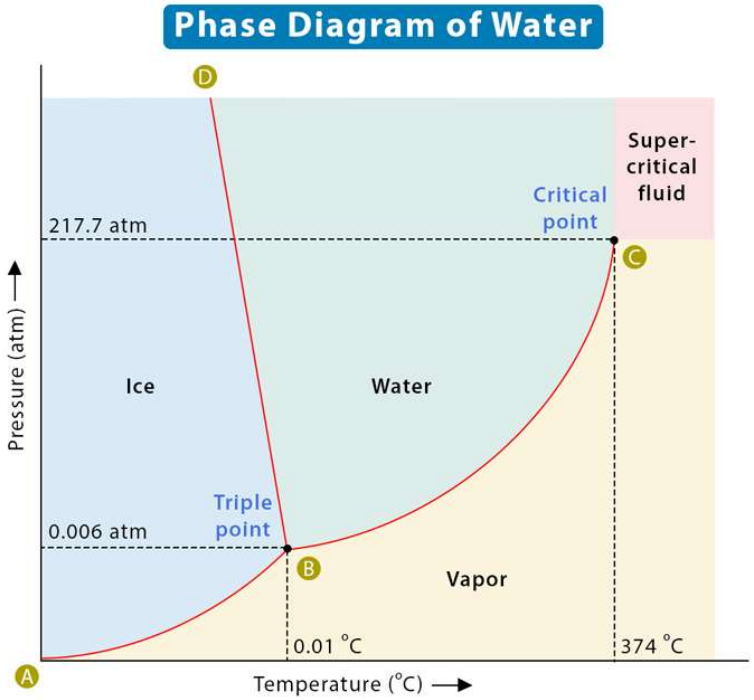

Figure 1 Phase diagram of water.

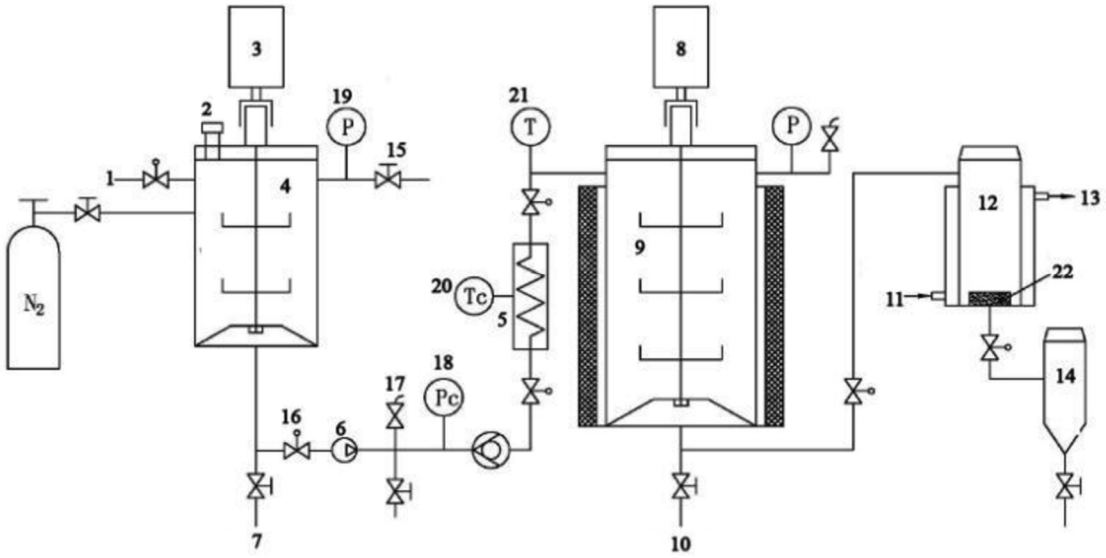

*Figure 2 Schematic diagram of SWE system. (1) water inlet; (2) feed inlet; (3) stirring system; (4) solid samples extraction cell; (5) heat exchanger; (6) pressure pump; (7) impounding reservoir; (8) stirring system; (9) solid samples extraction cell; (10) impounding reservoir; (11) cooling water inlet; (12) cooling pan; (13) cooling water outlet; (14) collector; (15) globe valve; (16) spherical valve; (17) safety valve; (18) pressure regulator controller; (19) pressure indicator; (20) temperature regulator controller; (21) temperature indicator; (22) filter plate (**Zhang et al., 2020**).*

Subcritical water extraction follows the same principles of the liquid extraction but the pressurized conditions diversify the properties of the water as a solvent **(Castro-Puyana et al., 2013**).

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Flow scheme of the technology

In the framework of the ULTIMATE project, in the Case Study 4, Subcritical Water Extraction is applied to extract antioxidants (polyphenols) from fruit processing water by-product. The industrial by-product flows through a macroreticular, non-fuctionalised adsorbent resin where the polyphenols are adsorbed. These polyphenols are recovered by subcritical water extraction.

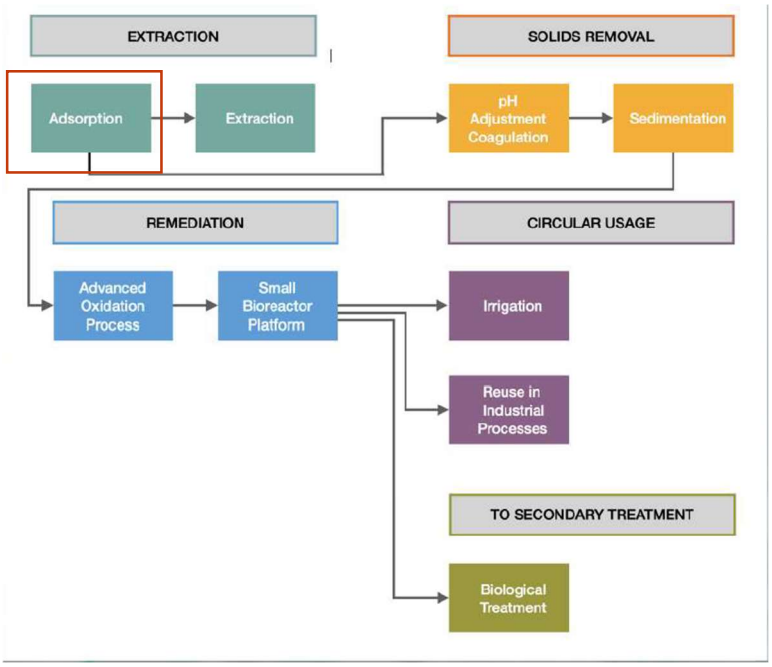

Figure 3 Flow diagram of the process.

Pictures of the technology and product

*Figure 4 Simple static equipment of SWE in laboratory (A); industrial dynamic equipment of SWE (B, C) (**Zhang et al., 2020**).*

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Synergetic effects and motivation for the implementation of the technology

✓ ***Green Technology***

Subcritical Water Extraction reduces or even eliminates the use of organic solvents thus it be categorized as a green environmentally friendly method.

✓ ***Quality of the extract***

A major advantage of the elimination of organic solvents is that the final product/extract is free of organic residues thus it is of higher quality and safer for consumption.

Requirements of the technology and operating conditions

Tab. 1 Operational requirements for Subcritical Water Extraction operation

Parameter	Value	Reference
Water temperature	100-374ºC	Zhang et al., 2020
Water pressure	1-22.1 MPa	
Extraction time	2-120 min	
Solvent flow rate	4mL/min	

Key performance indicators

Tab. 2 Key parameters for Subcritical Water Extraction operation

Parameter	Unit
Extraction efficiency (yield)	(Amount extracted/total amount in raw material)*100%
Solvent consumption	L water consumed/kg raw material
Energy consumption	kWh energy consumed/ kg raw material
Product purity	(Mass of target compound in extract/Total mass of extract)*100%

Links to related topics and similar reference projects

Process/technologies	Reference
Antioxidants from winery waste	**(Aliakbarian et al., 2012)**
Extraction of polyphenols from lotus seed pop	**(Yan et al., 2020)**
Olive polyphenols extraction	**(Xynos et al., 2012)**

References

Aliakbarian, B., Fathi, A., Perego, P., & Dehghani, F. (2012). Extraction of antioxidants from winery wastes using subcritical water. *The Journal of Supercritical Fluids*, *65*, 18–24. https://doi.org/https://doi.org/10.1016/j.supflu.2012.02.022

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Outlook

Case study specific information will be provided, when the results of the other work packages are available:

- **Lessons learned from the case study**
- **Outcome of the assessments**
- **Legal and regulatory information concerning the whole value chain concerning the technology**
- **Business opportunities**

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