OC-9: Ultrasound Combined with Conventional and Innovative Techniques for Extraction of Natural Products

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Innovative and sustainable techniques in extraction, which typically involve smaller quantities of solvent and energy, such as ultrasound-assisted extraction, supercritical fluid extraction, microwave extraction, controlled pressure drop process, and subcritical fluid extraction, are a quickly developing area in applied research and industry. However, only a few reports have been published that mention the acceleration of extraction processes using a combination of these techniques, the advantages of which would be; more effective mixing and micro-mixing, faster energy and mass transfer. The main advantages of using combined techniques for extraction include increased production efficiency and a contribution to environmental preservation by a reduction in the use of solvents, fossil energy and in the generation of hazardous substances.

1. Introduction

Extraction under extreme or non-conventional conditions is currently a developing area and a hot topic in applied research and industry. Alternatives to conventional extraction procedures may increase production efficiency and contribute to environmental preservation by reducing the use of solvents, fossil energy and generation of hazardous substances. To achieve the development of new extraction technologies or principles, the full potential of conventional and innovative extraction technologies has to be extended by a better use of process conditions, driving forces and media. The first combinations of conventional and innovative technologies could provide some solutions and subsequent combinations of non-conventional processes will permit the development of new operating conditions. Then, combination techniques allows the development of extraction techniques with high affinity, high process intensification, continuous processes and the possibility to scale up or down.

2. Hybrid techniques: combination of ultrasound with conventional techniques

2.1. Ultrasound-Assisted Filtration

Conventionally, membranes of various sorts are employed for filtration, ranging from simple semi permeable osmotic type membranes to size-exclusion principle types for purification. Unfortunately, conventional methodologies often lead to 'clogged' filters and, consequently, a need to replace filters on a regular basis. The application of ultrasound in this case will cause the agglomeration of fine particles (i.e. more rapid filtration), and at the same time, will supply sufficient vibrational energy to the system to keep the particles partially suspended and therefore leave more free 'channels' for solvent elution. The combined influence of these effects has been successfully employed to enhance the filtration of industrial dairy products, which are particularly time consuming and difficult to process (Muthukumaran et al., 2005). Acoustic filtration permits to lower the compressibility of both the initial protein deposit and the growing cake, enhancing the permeate flux of about 50%.

2.2 Ultrasound-Assisted Enzymatic Processes

By controlling power and sonication time, it is possible to increase enzymes activity, which have been successfully applied in the fermentation of sake, beer and wine, since ultrasound drives off produced CO_2, which normally inhibits fermentation (Pitt & Ross, 2003). Also, in enzymatic extraction, ultrasound treatment (or pre-treatment) can be optimized to provide a higher yield in a shorter time (Lieu & Le, 2010).

2.3 Ultrasound-Assisted Soxhlet Extraction

To increase conventional Soxhlet extraction, a combination (followed by optimization) with ultrasound is used to permit the extraction of total lipids from samples with yields comparable to the conventional technique in a shorter time. Sonication destroys the lipid layer separating lipids from proteins and glucides, allowing a better contact with the extraction solvent (Luque-García & Luque de Castro, 2004).

2.4 Ultrasound-Assisted Extrusion Process

Ultrasound assisted extrusion improves the melting, which results in a tougher material without reducing its rigidity in the case of polypropylene, while the decrease of viscosity eases the extrusion process. Ultrasound also provides more homogeneous dispersion of ethylene-propylene-diene terpolymer (EPDM), increasing the polymer cristallinity, toughness, and yield stress (J. Chen et al., 2010). Since the extrusion force decreases with an increase in ultrasound amplitude, the ultrasound-assisted process is faster and consumes less energy.

3. Combination of ultrasound with innovative techniques

3.1. Combination of Ultrasound and Microwave

Ultrasound can dramatically improve the extraction of a target component mainly through the phenomenon of cavitation. The mechanical ultrasonic effect promotes the release of soluble compounds from the plant body by disrupting cell walls, enhancing mass transfer and facilitating solvent access to cell content. Meanwhile, Microwave heats the whole sample very quickly inducing the migration of dissolved molecules. The simultaneous irradiation increases solvent penetration into the matrix, facilitates analyte solvation and usually increases the solubility of target compounds (Cravotto & Cintas, 2007).

3.2. Combination of Ultrasound and Supercritical Fluid Extraction (SFE)

The use of CO_2 as a supercritical fluid extractor limits the polluting hazards, although in the case of extraction of polar molecules, the addition of modifiers to CO_2 is needed. On the other hand, ultrasound allows the extraction of both polar and non-polar molecules, Therefore, the combination of these techniques can enhance the mass transfer of the species of interest from the solid phase to the solvent used for extraction by CO_2 (Balachandran et al., 2006).

4. Conclusions

Combined extraction techniques are proposed to be “green” extraction processes suitable for high value ingredients contained in food and natural products. The reduced cost of extraction is clearly advantageous for the combined methods in terms of energy, solvent used and time. As far as the environmental impact is concerned, the calculated quantity of carbon dioxide emitted into the atmosphere is higher in the case of conventional extraction than in combined techniques.

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