Eco-Sustainable Sub- and Supercritical Fluid Extraction, Biocatalysis and Particle Formulation

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Ecologically and economically sustainable processes are increasingly being developed as a response to recent reports concerning the environmental status of our planet [1]. For a process to be ecologically sustainable, it could for instance utilize only renewable feedstock and safe solvents and auxiliaries, as well as catalysis rather than stoichiometric chemical reactions [2]. Furthermore, a “green” process should be energy efficient and it should prevent the formation of wastes and byproducts, and aim at making non-toxic, biodegradable products. The sustainability of a process or product can be evaluated by life cycle assessment. The schematic in Figure 1 demonstrates a product’s (or a process’) life cycle and its environmental impact routes.

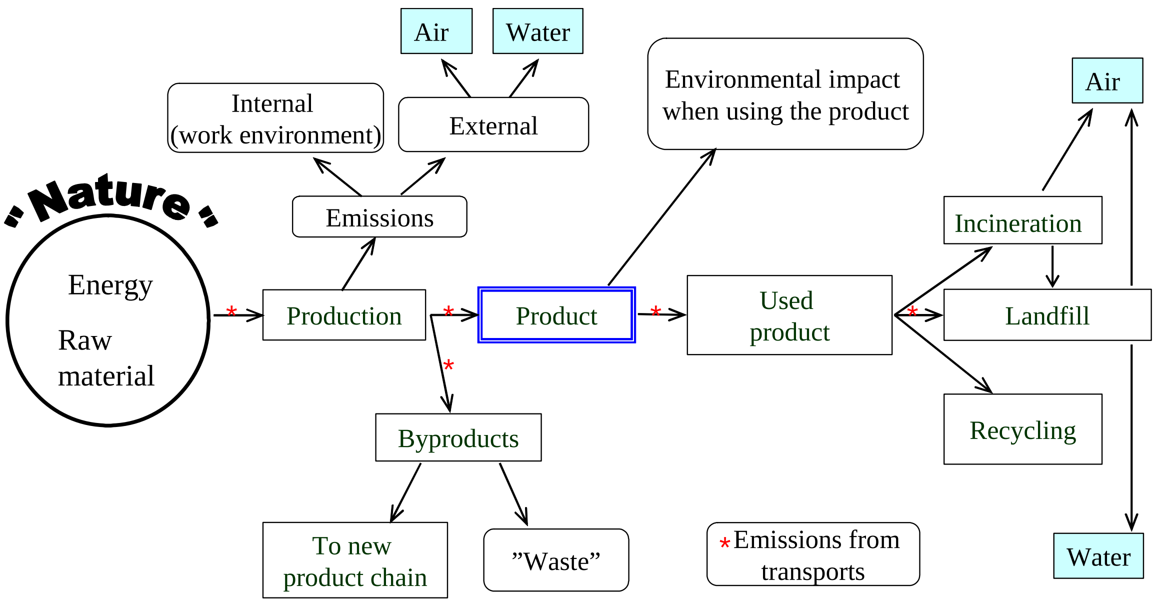

Figure 1. A product’s life cycle with environmental impacts.

The aim of our research is to use byproducts and wastes from different industries as raw material for isolation of valuable compounds that for instance can be used in novel drug and food products. Examples of interesting industrial byproducts and wastes in Sweden are onion waste, bark from birch and pine, carrots and shrimp waste.

Environmentally sustainable solvents have been used to extract high-value compounds from the above mentioned byproducts and wastes. For instance, water at higher temperatures and pressures has been used to extract relatively polar compounds such as anthocyanins and different polyphenolic glycosides. Supercritical carbon dioxide (SC-CO_2) has been used as extraction solvent for astaxanthin from shrimp waste, but also as precipitation media in particle formation processes. Figure 2 shows a schematic on the basic idea of most of our research projects, in which we utilize a waste or byproduct from an agricultural industry and then use an "eco-friendly" high-pressure fluid to extract valuable compounds. These compounds are then further processed aiming at creating high-value products. Particle formulation by supercritical technology is an important step towards more valuable final products. An important point to make is that the processed sample (after extraction) can still be used as animal feed or energy source, since the extraction solvents we use do not adversely affect the samples.

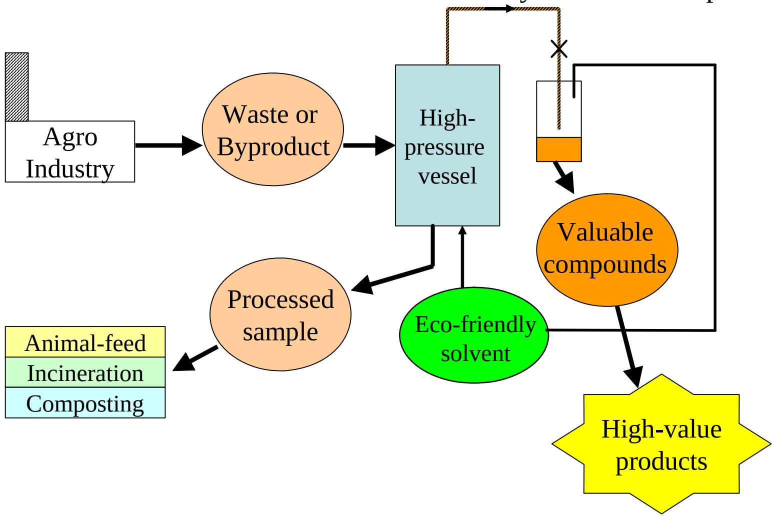

Figure 2. Schematic of an extraction process, in which renewable/waste material is used as raw material, and an eco-friendly solvent such as water, ethanol or carbon dioxide at high temperature and pressure. The processed sample can still be used as animal feed or energy source after the extraction.

In this presentation, results will be shown on subcritical water extraction of quercetin from onion waste [3], anthocyanins from red cabbage [4-5] and antioxidants from birch bark [6]. Furthermore, results on the use of thermostable beta-glucosidases harvested from hot environments to rapidly catalyze the conversion of extracted glycosides to more active antioxidants in hot water will be presented. Issues on stability of anthocyanins and antioxidants in general during subcritical extraction will be discussed. In addition, some preliminary data on particle formation coupled on-line with pressurized hot solvent extraction will be shown. Finally, an interdisciplinary research effort bridging chemistry, biotechnology, life-cycle assessment as well as economic viability analysis will be presented.

ACKNOWLEDGEMENTS

Charlotta Turner acknowledges the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS, 209-2006-1346); the Swedish Research Council (VR, 2006-4084); the Swedish Foundation for Strategic Research (SSF, 2005:0073/13); and the Swedish International Development Cooperation Agency (SIDA, SWE-2005-473) for financing.

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