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Research area: Product aims

Raw materials // Arable crops

Key words:

Subcritical water extraction, food additives, non-wood raw materials

TITLE:

Subcritical water as a green solvent for extraction of plants

Background/Problem area

The use of subcritical water as a solvent allows current extraction processes that are based on problematic chemicals like acids, bases or organic solvents to be replaced. Indeed, when the water is heated above 100 °C and maintained in a liquid state under pressure, the polarity can decrease significantly. Valuable chemicals can be extracted from vegetal material and hemicellulose can be partly hydrolysed. Two types of extract substances are expected to provide substantial added value: antioxidant substances to be used as additives in food or as ingredients in cosmetics, and antimicrobial substances for preserving food and cosmetics.

Paper manufacturers have been encountering skyrocketing fibre raw material prices, paralleled by increasing competition for wood fibre feedstock. Alternative fibre sources are needed to re-gain a competitive edge. The key concept of this project is to investigate the implementation of Subcritical Water Extraction (SWE) in synergy with paper manufacturing.

Objectives/Research results

Objective of the project was to develop an integrated process chain to add value to agricultural by-products, produce “green” valuable bioactive additives for the food and cosmetics sectors and at the same time feedstock for the paper industry to replace costly fibre raw materials. Subcritical water extraction is at its core.

Based on criteria like availability, competitive uses, suitability and paper-technological potential, the four most promising materials were selected from a group of 29 agricultural and food residues like stalks, hulls, skins and oil extraction residues: oat hulls, apple pomace, barley straw and corn straw.

First extraction tests were made on a lab scale for the exploration of favourable conditions. The optimisation was carried out on a pilot scale. Optimum extraction conditions included solvent recirculation, nitrogen atmosphere and a temperature range of 140-160 °C.

Active substances in the extracts included organic acids, polyphenols, and other specific substances. Polyphenols and cathechins are antioxidants which are interesting for food and cosmetic application due to their capacity of reducing oxidation of the final product. Fresh extracts were effective as antimicrobials and antioxidants. The antimicrobial activity decays with time. Extracts can be applied where antimicrobial efficacy against S.aureus and E.coli is needed, e g. bio-cosmetics and fresh organic food products.

The extracted materials are capable of replacing part of the conventional fibrous raw materials used for papermaking. They are suitable for papermaking after refining or milling, but must be further optimised in terms of drainability and process water pollution for industrial implementation. Compared to recycled fibres, the use of up to 40 % straw after extraction at 160 °C for 60 min led to higher tensile strength levels in handsheets. However, these extraction conditions also lead to by-products in the extracts that are incompatible with food sector applications.

These by-products can be avoided by extracting in more gentle conditions. Extracted straw or oat hulls gave less tensile strength when replacing part of the recycled fibre pulp in papermaking, but led to considerably higher volume and bending stiffness. This makes them particularly suitable for paperboard production, especially for the middle layers of multiply board.

Integrating an extraction plant on-site at a paper mill proved to be an advantage for the implementation.

Application/Economic benefits

It could be demonstrated that the process chain developed in this project generates significant profit potential. The new technology links agriculture with food, cosmetics and papermaking industries, thus opening up attractive new business areas for start-up firms and established SMEs in these sectors.

The results represent a unique approach to add value to vegetal residues. By its coupled approach and the total material use it goes far beyond existing approaches of biomass use.

Period of time: 01.01.2013 – 30.04.2015

Remarks

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