Development of a process for the utilization both the carbohydrate and the lignin content from lignocellulosic materials of annual plants for the production of valuable products

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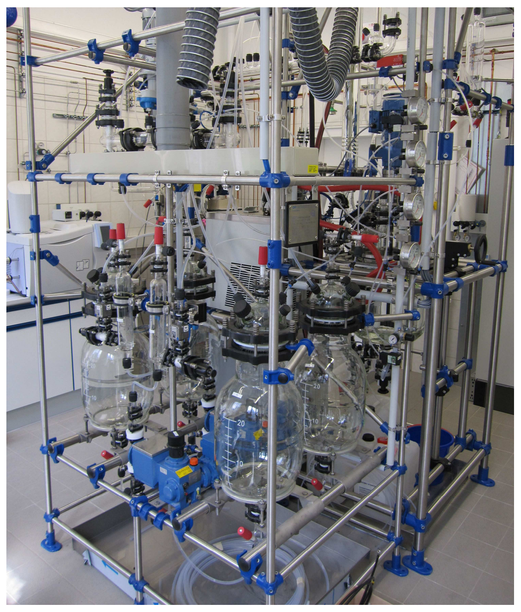
Wheat straw

Pre-treatment of lignocellulosic biomass, preferably according the Natural Pulping process.



Miniplant (system for lignocellulosic pre-treatment).

Lignin powder after extraction from straw.

Enzymatic modification

Haake Minijet (injection moulding machine)

Fibre-reinforced biopolymers ➔

Aromatic basic chemicals

Bioreactor with 400-L working volume for enzyme production and SSF-process in pilot scale (in co-operation with the Centre for Environmental Biotechnology, UbZ).

Enzyme complex for the saccharification of the carbohydrate content

Separated pulp after pre-treatment.

SSF with model yeast strains

Platform chemicals (e.g. ethanol, isobutanol, isopentanol)

Tensile test bars containing 35% lignin; produced by injection moulding.

Introduction

The process for the material utilization of lignocellulosic biomass by enzymatic hydrolysis is up to now not economical. The state-of-art is characterised both by a lack of an economic pre-treatment process and by a lack of sufficiently suitable enzyme complexes, which allow the enzymatic breaking up of lignocellulosic biomass for the economic utilization of the carbohydrate content.
The material utilization of lignin is still subject of extensive research. Additional procedures, materials and methods are needed to achieve profitability. One main point is the development of optimal enzyme complexes for the simultaneous saccharification and fermentation of the carbohydrate fraction from lignocellulosic biomass. Despite many research activities in this field, the application in industrial scale was not possible up to now.

Background

The currently used enzymes for the saccharification of cellulose to free sugars are mainly produced by *Trichoderma reesei*-production strains. The investigated *P. verruculosum* cellulase complex exhibits significant advantages in comparison to the worldwide used *T. reesei* cellulase complex. This is demonstrated both in a higher resistance towards ethanol and in an advantageous composition of the cellulose hydrolysate by an increased content of ß-glucosidase. Furthermore, the activity of the *P. verruculosum* cellulase is obviously less influenced by lignin.
Additional benefit could be reached by conversion of the present side-stream components, especially lignin, into new high value products. The future lignocellulosic-based bio-refineries will thus generate massive amounts of lignin that can be used as a sustainable and renewable polymeric material. Compared to the traditional technical lignin (kraft lignin and lignosulphonates), the lignin residues produced in bio-ethanol production are essentially sulphur free and can also have better performance characteristics due to their different structure, which varies largely according to the used pre-processing technology and raw material, and clearly affects the quality and potential market of the lignin products.

Objectives

The general aim of the project is the development of a process for the material utilization of both the carbohydrate and the lignin content of lignocellulose from annual plants, particularly wheat or maize straw. This concerns in particular the following tasks:

1. a pre-treatment process, which allows the separation both of the lignin content and the carbohydrate content for material application,
2. the development of a *Penicillium verruculosum* enzyme complex which is optimized for the saccharification of the carbohydrate content in a process of simultaneous saccharification and fermentation (SSF),
3. investigations on the SSF-process, using model strains for the production of platform chemicals, e.g. ethanol, isobutanol, isopentanol as well phenyl-ethanol,
4. the modification of the separated lignin for the production of fibre-reinforced biopolymers as well as for the production of basic chemicals.

Expected results

I Optimized pre-treatment process for lignocellulose from annual plants, which enables the material utilization both of cellulose and lignin,

II P. *verruculosum* enzyme complex, optimized for the economical application in the SSF-process with model yeasts for the production of basic chemicals,

III Material utilization of lignin and cellulose.

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