"HydroProCellu" Project

Valuable Straw-derived Enzymes for a Sustainable Energy Supply

Production of cellulases (enzyme for the degradation of lignocellulose) from residual agricultural materials has long been a major research focus at PFI Biotechnology. The new research project "Development of a Process for the Production of High Activity Cellulases in Xylose-containing Hydrolysates Based on Agricultural Residues" (or HydroProCellu for short) will permit us to further intensify our expertise in this important area of bioeconomy. The objective is to produce cellulases in straw hydrolysates obtained by thermochemical pre-treatment of wheat straw. These cellulases can be used to break down remaining cellulose in pre-treated straw and to produce biofuels or other high-quality products from the resulting sugar solutions.

Background: Need for Economic Production of Cellulases

Ongoing climate change necessitates replacement of fossil fuels such as petroleum or natural gas by renewable materials as soon as possible. Considerable success has already been achieved in some areas. For example, it has been possible to substitute a certain proportion of conventional petrol by bioethanol (as E10 fuel containing 10 % of bioethanol). However, most of the bioethanol is still produced from starch-containing sources such as maize. Maize is one of the so-called first-generation renewable resources, which have the disadvantage that they compete with food production. For some years now research activities have been focussed on substitution of starch by lignocellulose, a renewable resource of the so-called second generation, which is not in competition with food production. However, lignocellulose is significantly more difficult to process than maize starch, because it requires enzymatic breakdown by cellulases. Moreover, the expensive-to-produce cellulases significantly increase the overall cost of lignocellulose utilisation. It is therefore important to reduce the costs of cellulase production in order to ensure long-term successful economic competition with fossil fuels.

Approach: Use of Cost-favourable Substrates in Combination with Novel Production Processes

The substrate costs are an important economic factor in cellulase production. Numerous research approaches therefore seek to identify new, cost-favourable substrates. PFI's new research project also addresses this point. Thermochemical pre-treatment of straw produced not only a solid cellulose fraction but also a xylose-containing sugar fraction. Owing to the presence of numerous and in some cases growth-inhibiting by-products, the fermentative utilisation of this fraction has so far been restricted. However, various cellulase producers such as filamentous fungi of the genus *Trichoderma reesei* are able to grow without any problems in such hydrolysates. Nevertheless, efficient xylose-based cellulase production requires extensive genetic modifications. Production of enzymes by genetically optimised strains is conducted by a trickle-filter process in a fixed bed reactor. This approach offers not only process-related advantages over conventional fermentation processes but also higher yields of enzymes. The trickle-filter process is to be tested on different scales and scaled up to an industrial level (300-l packed bed reactor, Fig. 1).

Fig. 1: 300-litre packed bed reactor for engineering lab scale enzyme production

The new technology is also to be implemented in the medium term at the Winzeln Energy Park as a further development of the biorefinery concept which will be using greater amounts of lignocellulose-containing biomasses.

The HydroProCellu research project started in October 2018 and has a duration of two and a half years. It is funded by the Federal Ministry of Economic Affairs and Energy via the INNO-KOM programme under the reference number 49VF180029. HydroProCellu is already the second PFI project to be funded within the framework of the new INNO-KOM Programme.

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