Bio-based production of crotonic acid from wastewater

Publieke samenvatting / Public summary

Aanleiding

Paques BV has a well-established line of wastewater treatment installations producing biogas. Next to biogas installations, the company is focusing in recent years on alternative, higher value products that could be produced from wastewater. Especially when wastewater treatment can be done biologically, but there is no direct end user for the bio-gas, production of high value chemicals such as polyhydroxybutyrate (PHB, a high value biopolymer) is very attractive. Paques BV has invested significant effort and capital to produce PHB. However, due to the variation of product composition with variation of the waste from day to day, this route has been unsuccessful. Instead of pure PHB, a mixture of polyhydroxyalkanoates (PHA) is typically produced, which is for many high value applications not useful. Therefore, we propose to develop a new route from wastewater through PHA into crotonic acid, a highly valuable co-monomer for many acrylate products. Crotonic acid is currently produced from oil, but is expensive and bio-based routes such as through PHA appear commercially competitive.

Doelstelling

The overall aim of the project is to develop a competitive route towards crotonic acid. This route consists of the anaerobic biotechnological conversion of waste into volatile fatty acids (VFAs), the recovery of these VFAs from the broth, and use as feedstock for the aerobic biotechnological conversion into PHA. In the final stage, the PHA is

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depolymerized via thermal depolymerisation (pyrolysis). By improving the selectivity of the VFA production towards more butyric acid, and the recovery with fractionation, it is possible to feed butyric acid enriched VFA to the aerobic PHA production. As a result a higher fraction PHB is obtained, and less polyhydroxyvalerate (PHV). In the final stage we aim to extract the PHA from the biomass and integrate the solvent recovery with the pyrolysis in a molecular distillation derived approach. If needed, this will be combined with a fractionation to obtain highly pure and highly valuable (5 – 10 €/kg) crotonic acid. This approach matches perfectly with the aim of the biotechnological conversion line in the BBEG program.

Korte omschrijving

The project contains five work packages, each corresponding with one of the process stages, and testing of the end product: 1) Fermentation of wastewater to produce VFAs will be further improved to steer more towards butyric acid production. (WP1, Paques BV) 2) An adsorption / fractional desorption process for VFAs that has been developed at the UT in a previous project will be further improved by reducing the amount of water evaporation. Magnetic nanoparticles impregnated in the adsorbent are heated by a fluctuating magnetic field, heating up the adsorbent from inside, generating vapor that pushes out most of the water in the liquid state, reducing evaporative removal. (WP2, UT) 3) Microbial PHA / PHB production with butyric acid enriched VFAs will be studied to improve understanding on cell growth and properties as function of operational conditions such as nutrient and temperature. (WP3, Paques) 4) Extraction of the PHA, pyrolysis with integrated solvent removal and condensation/fractionation of the crotonic acid. (WP4; extraction of the PHA from biomass: Paques BV together with UT, pyrolysis, condensation and fractionation: UT) 5) Product testing (WP5, end users).

Resultaat

The project should result in a complete and

competitive crotonic acid production toolbox for Paques BV. Conceptually, except for stage 4, all of the stages have been demonstrated before, but require improvement of selectivity and efficiency to maximize competitiveness. Stage 4 is a crucial stage, and we aim to develop a robust pyrolysis process based on molecular distillation approach to limit the “hot time” of the crotonic acid, in order to limit reaction, and hence, overall efficiency loss. Contributing to the competitiveness are improved selectivity towards butyric acid in stage 1, and the capability of the microbial PHA production to cope with enriched butyric acid streams, therefore these biotechnological conversions will also be studied. A significant reduction in the heat duty (both energy requirement, and CO2 footprint) is aimed at with innovative desorption technology. This technology is potentially applicable in a much wider range of applications in the chemical industry, and may thus have a very significant future impact on reduction of energy requirement and CO2 emission.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.
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