Results of the «Bio-EOL» CORNET Project

New Recycling Strategies for Biobased Plastics

Goal of the recently concluded CORNET Project «Bio-EOL» was to identify recycling pathways for various biobased plastics that would ensure maximum valorisation. Successful outcome of the project was achieved in close collaboration between PFI Biotechnology and the Belgian Centexbel research institute. The principal results are outlined in this article.

Biobased plastics such as polylactide (PLA), starch blends, cellulose acetate and the “sleeping giant” polyhydroxybutyrate (PHB) are playing an ever-greater role, for example in the packaging industry. However, sustainable use of biobased plastics will depend upon development of strategies for dealing with the ever-increasing volume of waste which would permit maximum valorisation and conservation of important resources.

Conventional ideas of recycling focus on melting down and repolymerisation of plastics. However, such procedures are frequently associated with loss of quality and impairment of the characteristic properties of the plastics. To avoid this, PFI Biotechnology adopted a new, highly promising strategy: In the «Bio-EOL» project the bioplastics were to be broken down into their individual constituent molecules (monomers) in a thermochemical process.

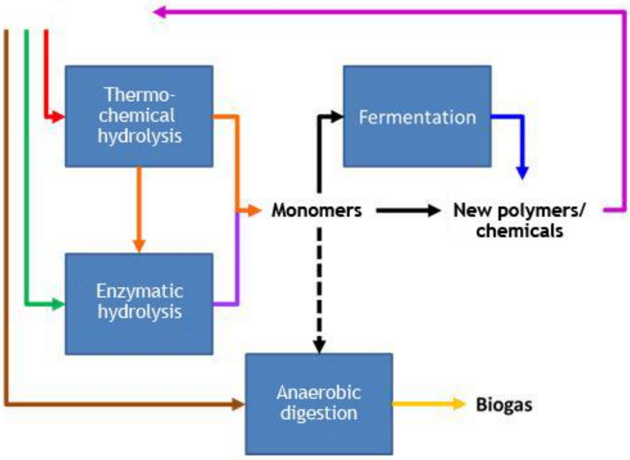

Fig. 1: Recycling strategies for biobased plastics

Ideally these monomers can be repolymerised to produce new plastics (Fig. 1). If this proves impossible, then the degradation products could be used as substrates for generation of chemicals by fermentation. Use as substrate in biogas plant may also be a good option.

Recycling of Polylactides

After these preliminary considerations, attention was focussed on recycling of polylactides because PLA is much more widespread than other biopolymers. Various PLA samples (pure PLA, PLA with stabiliser, or PLA in end products) were therefore subjected to pre-treatment at 160 °C in a thermal pressure hydrolysis (TPH) reactor for 90 min. Nitric acid or lactic acid was added to increase the rate of PLA degradation. In all cases, 90 to 100 percent degradation of PLA to lactic acid was achieved. In a second step, addition of lactic acid from a preceding degradation step to act as a catalyst established an “autocatalytic” process. Figure 2 shows that 90 to 100 percent conversion of PLA into lactic acid could again be attained. Thus the cost of necessary chemicals is reduced and the resulting lactic acid contains fewer impurities than after pre-treatment with nitric acid. The recycled lactic acid can be used, e.g., for production of new PLA; alternatively, it also has uses in the cosmetics industry.

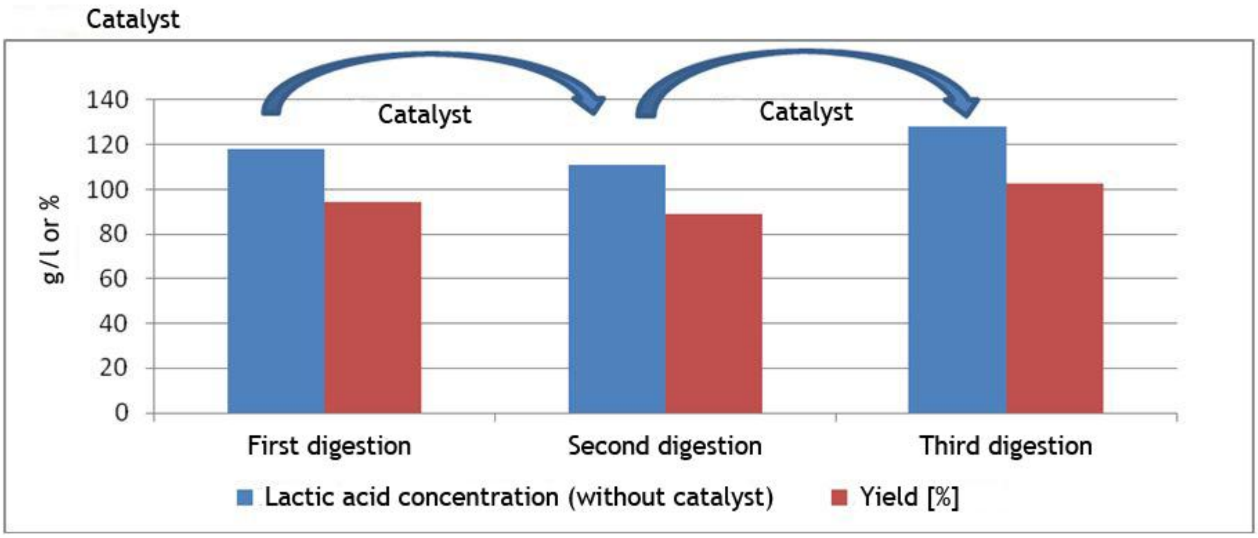

Fig. 2: Lactic acid concentrations and yields after thermal treatment of PLA in an autocatalytic process. The resulting lactic acid served as catalyst in subsequent processing.

Recycling of Starch Blends

Successful recycling strategies could also be developed for other bioplastics in the course of the project. Starch blends were degraded to glucose by pre-treatment in a TPH reactor, and this glucose could be used for production of ethanol with yeasts. All that was necessary was to add ammonium sulphate as a nitrogen source for fermentation. Bioplastics composed of starch blends thus represent an alternative substrate to maize for the production of bioethanol. Moreover, glucose could also be used for biotechnological production of fine chemicals.

Utilisation as a Substrate

A third area of interest in this project was the use as substrate in the production of biogas. Various bioplastics were examined to ascertain their suitability. The most promising material was PHB. It shows a high thermal stability, making pretreatment difficult; moreover, its degradation products are not particularly useful. Nevertheless, PHB is of interest for biogas generation. Figure 3 shows the formation of biogas over a period of 32 days with PHB as substrate.

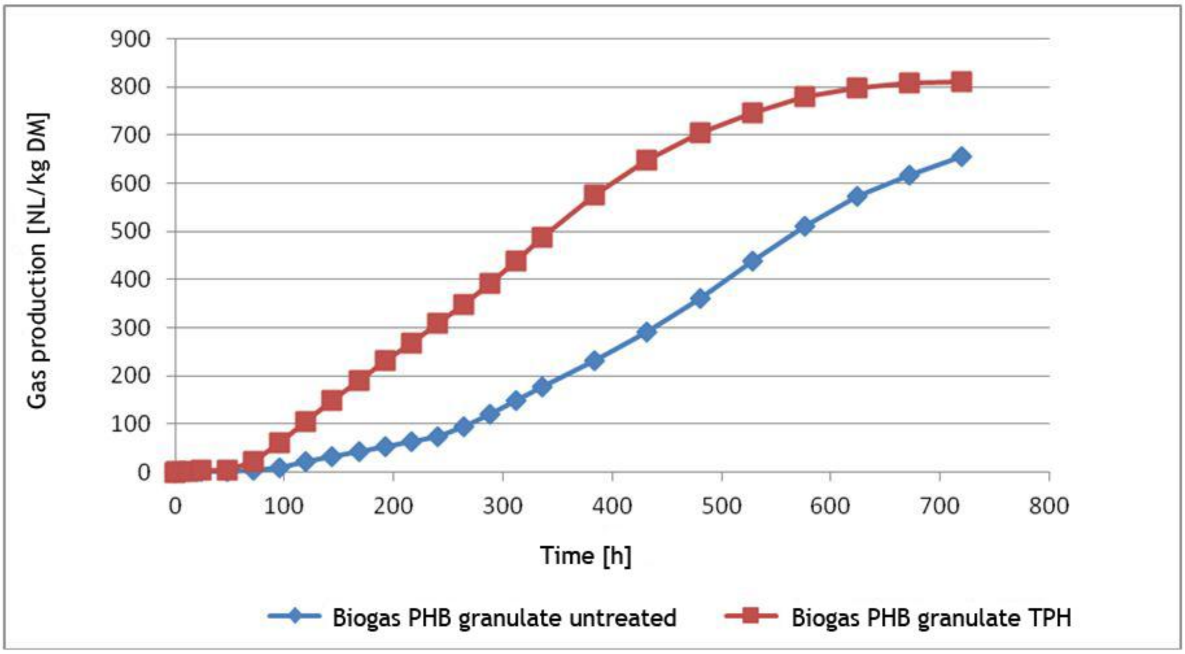

Fig. 3: Biogas production from PHB (untreated / blue and treated / red) as substrate over 32 days in a static fermentation test

Thus PHB could also be used directly as a substrate without any thermal pre-treatment. Compared to conventional substrates such as maize, the biogas yields are also very high. The methane content can be as high as 57 percent and the yield as high as 0.85 m^3/kg.

The results of the two-year project demonstrate the possibility of developing strategies for maximum valorisation of various bioplastics. Above all, the use of PLA waste to recover lactic acid has huge potential. In a possible subsequent project, PFI Biotechnology would be interested in developing valorisation strategies also for mixtures of PLA with other plastics.

IGF Project No. 107 EN of the Test and Research Institute Pirmasens is funded by the German Federal Ministry of Economics and Energy through the German Federation of Industrial Research Associations (AiF) within the IGF programme for promoting industrial cooperative research and development in accord with a resolution passed by the German Federal Parliament. We would like to take this opportunity to express our thanks for this funding.

Further information:

Dr. Michael Müller
EU Project Manager Biotechnology
Tel.: +49 6331 2490 850, E-Mail: michael.mueller@pfi-biotechnology.de

Project information for Bio-EOL

Title: «End-of-Life Possibilities of Biopolymer Based Consumer Products»

Duration: 01.01.2014 – 31.12.2015

Project partner:

CENTEXBEL
www.centexbel.be

Funding agencies:

AiF Forschungsnetzwerk Mittelstand

Gefördert durch: Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages

cornet

FLANDERS INNOVATION & ENTREPRENEURSHIP

Flanders State of the Art