Next generation chemical building blocks and bioplastics

EU projects SYNPOL & BioConSepT – Two approaches, one goal!

The *Bioeconomy Strategy* published by the European Commission in 2012 promotes the use of renewable resources from land and sea for a post-petroleum economy to build an innovative, more resource-efficient and competitive society that aims to optimize the trade-off between food security, the sustainable industrial use of renewable resources and environmental protection. This strategy promotes the production of renewable biological resources and conversion of these resources and their waste streams into value added products, such as chemical building block compounds and bioplastics. European research is helping to gather the fundamental know-how required to develop reliable processes for development and processing of feedstocks from disparate and novel sources. To some extend this is done through two EU-funded projects, BioConSepT and SYNPOL, due to conclude in 2015 and 2016, respectively.

Non-food competing feedstock materials

The need for alternative resources, because of the finite sources of fossil reserves is generally accepted. In order to become a competitive alternative on the market, the price of e.g. bioplastics for a certain application must be in the same range as the competing petroleum-based plastics, which currently, despite of the volatile oil prices, is not the case.

The most promising approach to make bioplastics and chemical building block compounds economically more competitive is the use of waste streams as a source, such as household waste or sewage sludge loadings from water treatment plants that now end up in landfills.

The two European Union KBBE projects SYNPOL and BioConSepT aim to integrate production (fermentation) and

Building block	**Companies**
succinic acid	BASF, Corbion
succinic acid	DSM, Roquette
succinic acid	Bioamber, Mitsubishi, Mitsui, Faurecia
succinic acid	Bioamber, PTT-MCC Biochem
succinic acid	Bioamber, Lanxess
succinic acid	Myriant, PTT chemical
succinic acid	Myriant, Uhde
succinic acid	Bioamber, Cargill
succinic acid	Bioamber, Dupont, Evonik
n-butanol	Granvio, Solvay
maleic acid	Novozymes, ADM
isobutanol	Gevo, Lanxess
farnesene	Amryis, Kuraray
3-hydroxypropionic acid	Novozymes, BASF, Cargill
3-hydroxypropionic acid	OPXBIO, Dow
butanediol	Novamont, Genomatica
butanediol	BASF, Genomatica, Toray

Table 1: Industrial Alliances and Partnerships for the Production of Bio-based Building Block Chemicals

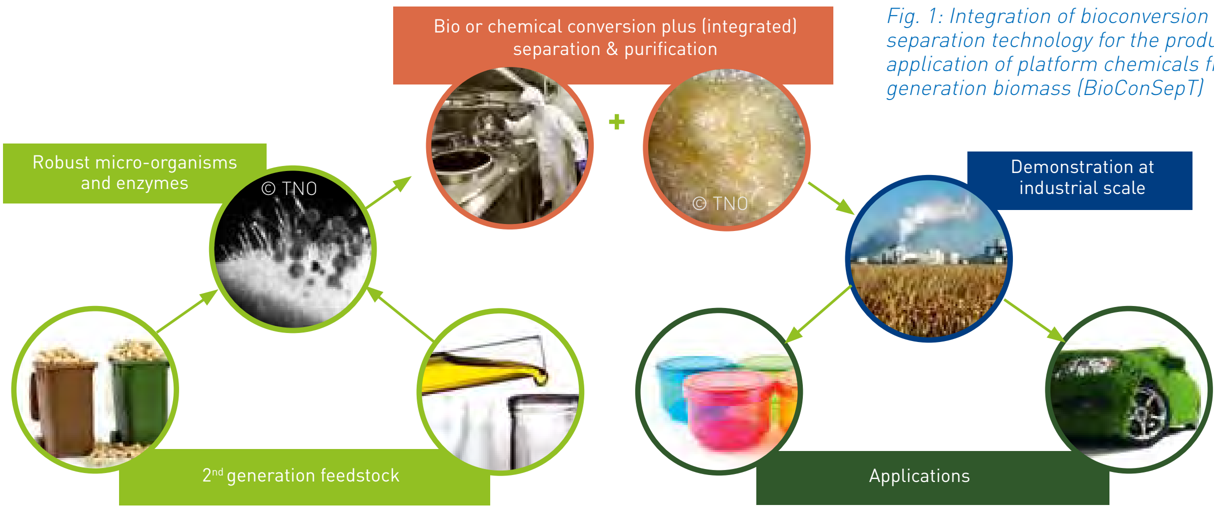

Fig. 1: Integration of bioconversion and separation technology for the production and application of platform chemicals from 2nd generation biomass (BioConSepT)

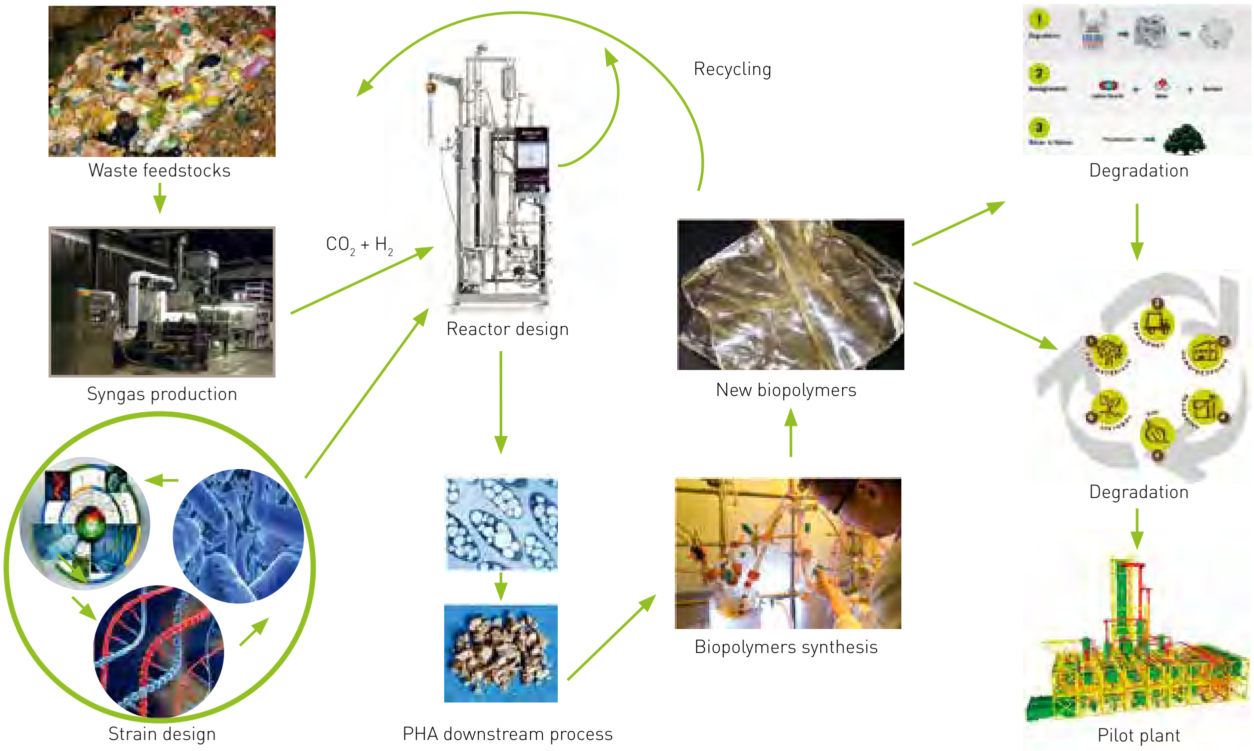

Fig. 2: The SYNPOL platform

separation technologies for the cost-effective commercial synthesis of high added-value chemical building blocks and bioplastics. While SYNPOL uses (bio)waste to produce syngas, which is then fermented, BioConSepT focuses on the use of so-called second generation feedstocks like wood (lignocellulose) and non-edible oils and fats.

The BioConSepT project: From Plants to Plastics

BioConSepT *(Bio-Conversion and Separation Technology)* aims to demonstrate the technical and economic feasibility of white biotechnology processes where 2nd generation biomass will be converted into chemical building blocks. For producing bioplastics two types of biomass, which are not competing with the food chain, are being evaluated: lingocellulosic biomasses, and non-edible fractions of fats and oils.

The main achievements expected for BioConSepT are to develop the robust enzymes and microorganisms suited for recalcitrant 2nd generation feedstocks, to reduce equipment costs and the number of process steps by the integration of bio- and chemical conversion and highly selective separation technologies; and by proving the suitability of the produced platform chemicals for industrial application by demonstrating integrated production chains from 2nd generation feedstocks to platform chemicals at industrially relevant scale.

BioConSepT will bring novel technologies from lab to pilot scale by high-level applied research. The large industrial parties and SMEs expect new products, processes, and services with a potential value of hundreds of million Euros.

Integration Along the Value Chain

BioConSepT was established in line with the newly developing concept within the chemical industry of emerging partnerships and alliances. In this vision, individual partners focus on their own strengths but benefit from their collaborations along the business chain from the source to the consumer. Compared to the food industries, where most chains are owned by single companies/industries, this situation is clearly a new development and is specific for the chemical industry. Table 1 presents some of these partnerships and alliances - including biotechnology start-ups and large industries - for a few common chemical building blocks. BioConSepT aims to demonstrate the feasibility of an integrated chain approach, which is regarded as the basis for the next generation of industrial biotechnology processes.

Note: websites of each Alliance or Partnership can be found at www.bioplasticsmagazine.de/201405

The technological objectives of BioConSepT focus on all individual aspects along the production chain, from plant biomass to pilot plant (Fig. 1). BioConSept focusses on dicarboxylic acids like itaconic acid and furan-dicarboxylic acid for use in bioplastics.

The SYNPOL project: Introduction of novel technologies and biotech approaches in Europe

Complex organic waste raw materials - such as municipal and industrial waste - which are pyrolyzed, gasified and then fermented by microorganisms, are the starting point of the SYNPOL *(Biopolymers from syngas fermentation)* project, which aims at producing 100% biodegradable bioplastics (PHA) and chemical building block compounds such as butanediol, succinic acid, hydroxybutyric acid and crotonic acid.

Pyrolysis and gasification are widely regarded as the main viable large-scale options for (bio)waste disposal. Gasification, combined with biosynthesis processing systems such as fermentations, has become a promising industrial

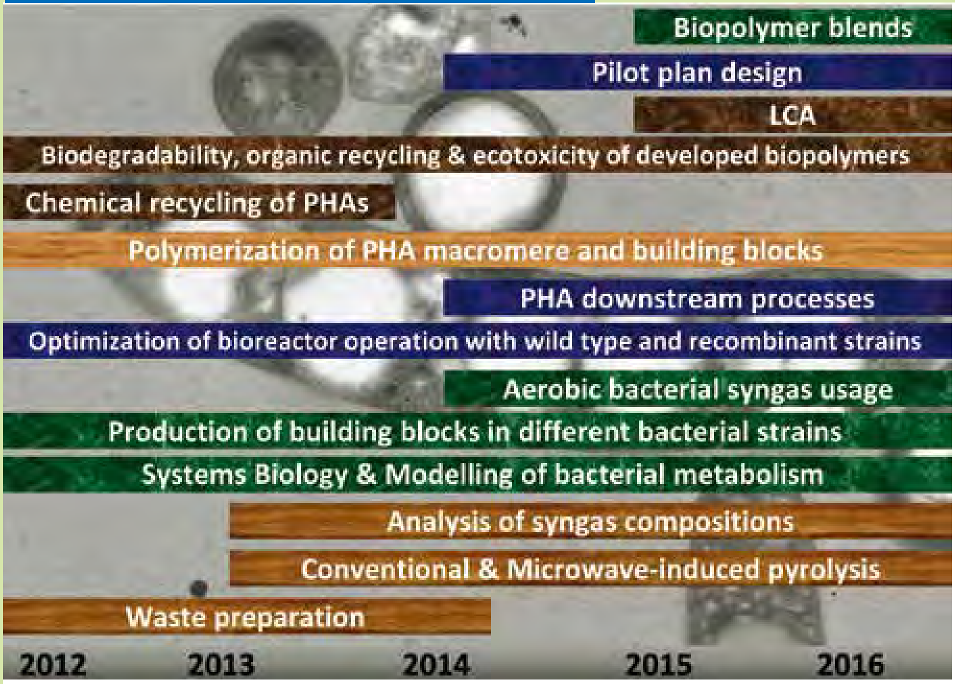

Fig. 3: The SYNPOL roadmap

procedure. Research related to fermentative production of chemicals from CO/CO_2 has greatly increased in recent years The fermentation of synthesis gas (syngas) has become an attractive technology for the production of biofuels for which processes are already available from companies in the USA, New Zealand and Canada, but not in Europe. Therefore, SYNPOL´s technology (Fig. 2) aims to open a new window for the rational design of an innovative European process to convert complex wastes into new biopolymers also using novel processing technologies such as microwave-supported pyrolysis. To this end, SYNPOL will establish an integrated platform for biopolymers production. Reduced energy input and optimised purification of waste streams will contribute to the economic viability of end products.

According to the objectives roadmap of the project (Fig. 3), bacteria will fermentatively produce bioplastic basic compounds, the so-called polyhydroxyalkanoates (PHA), out of the C1 carbon fractions of the syngas. Different prototypes of biopolymers and their blends will be prepared from SYNPOL. Finally, PHA, plasticizers and nanoclays will be further assessed for their physical and mechanical properties, for their appropriate end use in different sectors of the bioplastics industry.

The PHA material has wide applications as it can then be formed and moulded into almost any given design.

SYNPOL aims to convert complex waste into new cost-efficient biopolymers in three major steps:

- Pyrolysis of different waste streams to produce synthesis gas (syngas);
- Fermentation of the carbon fractions of the gas (CO and CO_2) by using different natural and recombinant autotrophic bacteria to produce chemical building blocks and PHAs;
- Synthesis of biobased plastic prototypes (blends) with well-defined structures and improved properties for wide commercial use, through chemical and enzymatic catalysis by utilizing the monomers and polymers produced during syngas fermentation.

Two projects with big expectations

From the perspective of both projects, important progress will be achieved in terms of combining the environmental benefit of future-oriented biopolymers and chemical building blocks with the economic viability of their production. This should finally facilitate the decision of responsible policy makers from agriculture, the waste-generating industrial sectors and from the polymer industry to break new ground in sustainable production. In the future, production of bioplastics and chemical building blocks from different biomass streams applying gasification and/or separation technology should be integrated into existing process lines of biotechnological bioplastic companies, where the feedstock material directly accrues. By taking profit of synergistic effects, this can be considered a viable strategy to minimize production costs and leads to realize the project´s vision of taking organic biomass (waste) streams and turning them into commercially useful products that generate both an environmental and economic benefit. The two projects therefore offer timely strategic actions that will enable the EU to lead modern and future-driven technologies for organic waste revalorization and sustainable biopolymer production on a global level.

www.bioconsept.eu
www.synpol.org

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