Overcoming hurdles for innovation in industrial biotechnology in Europe

Bioplastics

Summary

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The BIO-TIC project aims to identify hurdles and develop solutions to the large scale deployment of Industrial Biotechnology in Europe. Bioplastics are one of five product groups which we have identified to have significant potential for enhancing European economic competitiveness and introducing cross-cutting technology ideas.

This document is a summary of the findings related to bioplastics at the mid-way stage of the project and it has been produced as a discussion piece in order to collect stakeholder's thoughts on the hurdles within this sector, and ideas for how these hurdles can be overcome to capture the full potential of bioplastics.

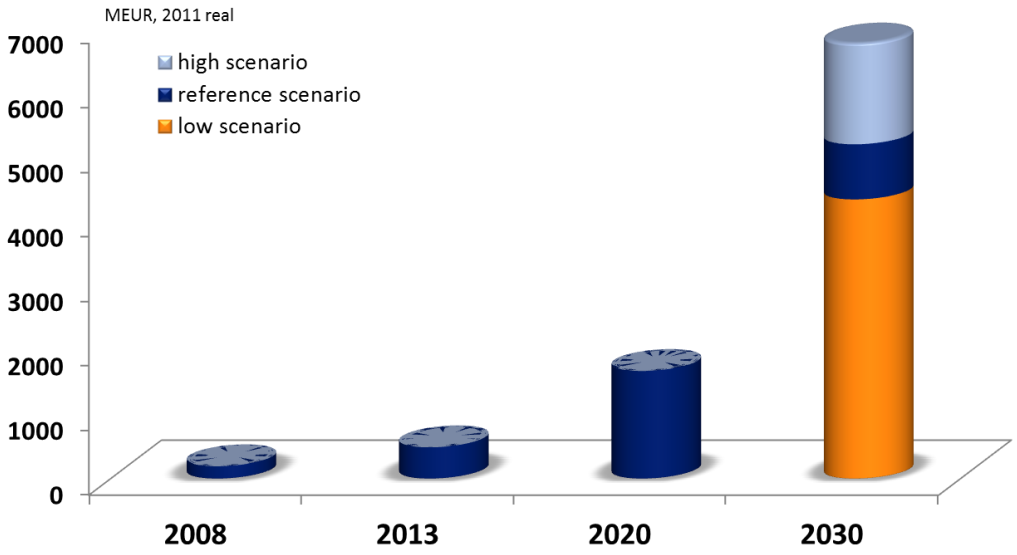
Bioplastics can be divided into two categories: drop-in plastics with an identical chemical composition to their fossil-based counterparts, and novel bioplastics with unique product properties which cannot be obtained with conventional alternatives.

Today, biobased plastics have an established market that is growing rapidly both in Europe and worldwide. In 2013, the EU demand for bioplastics was estimated at 485 MEUR which represents approximately half of the total global production. Biobased plastic markets grew at an annual growth rate of 20% between 2008 and 2013. Bioplastics are sold at the same price or at a premium compared to conventional plastic products.

Europe is expected to remain the main consumer for biobased plastics through to 2030. Although Europe was the largest producer and user of bioplastics in 2013 globally, the future production of bioplastics is expected to move to regions where feedstocks are cheaper and more readily available and where production costs are lower, for example Latin America and Asia.

Published market reviews on bioplastics have very different views on the expected future demand with projected annual growth rates of between 15% to 35% between 2010 and 2020. Stakeholder consultation carried out through the BIO-TIC project suggests that these projections are considered too optimistic and that growth rates of 10%, 12% and 15% may be more realistic. Should these growth rates be achieved, the EU bioplastics market could be between 5.2 BEUR and 6.7 BEUR in 2030. It is thought that specialty polymers and packaging applications will demonstrate the greatest growth rates. Market uptake is however, completely dependent upon bioplastics cost-competitiveness and consumer willingness to pay a premium.

The bioplastics value chain starts with a feedstock supplier and moves either directly to bioplastics production (as illustrated by PHA), or has intermediate steps where a monomer, i.e. a chemical building block such as lactic acid is formed, which is then converted to polylactic acid (PLA). The following steps may include compound formulation; although some plastics can also be used directly without compounding. The final processing step is the conversion into a useful product.



The vision for bioplastics in the EU

In 2030, there will be both biodegradable and non-biodegradable bio-based plastics on the market. Compostable plastics will be will be used in disposable products whereas non-biodegradable bioplastics will be aimed at durable applications and recycling. The demand for bioplastics will be driven by a competitive product price, superior functionality or a biobased premium. Price competitiveness will be challenged by low-cost shale gas derivatives, for example affecting e.g. polyethylene markets. On the other hand, the tightened supply of higher olefins and aromatics may improve the competitiveness of drop-in bioplastics.

Polymer functionality in given end-use applications will be of high importance in 2030. Both 1st generation and 2nd generation raw materials be used in bioplastics production in 2030. Customers will be widely aware of the environmental benefits of bioplastics and familiar with EU-wide labels indicating the bio-based content, compostability and recyclability of bioplastics.

There are several drivers for the use of biobased polymers. These range from rising and increasingly volatile fossil oil prices, the potential for net environmental benefits compared to fossil plastics, and local and national regulatory actions such as bans on plastic bags. Increasingly, positive consumer attitudes towards biobased and biodegradable materials are helping to develop the market.

The brand owner is the main decision-maker in the bioplastics value chain because he takes the risk of opting for biobased plastics rather than conventional counterparts. The key to today's market development is therefore an understanding of the value proposition offered by biobased products.

In order for a bioplastic to be taken into production, it has to be compatible with the existing processing equipment throughout the value chain. It also should have either (new) superior properties, or a certain cost advantage so as to provide companies with additional benefits compared to conventional plastic production.

The future demand for bioplastics may depend on their price competitiveness since some types will most likely be challenged by low-cost shale gas derivatives. In addition to product price, its functional properties in a given end-use application will be crucial for the development of biobased plastics. The functional properties may be improved by developing new and improved additives and plasticisers for polymer compounding or by introducing novel bioplastics. New properties will subsequently foster new end-use applications for bioplastics and drive the demand. Alternatively, a bio-premium could act as a market driver if the price-supplement is justified along the following lines:

- Biobased origin is a key buying criterion (e.g. organic food packaging)
- Environmental sustainability is used as a marketing tool (e.g. branded consumer products such as PlantBottle™*)*
- Bioplastics represent a minimal share of the final product value (e.g. biobased materials in automotives and electronics
- Regulations force the use of bioplastics (e.g. plastic bag bans)

There is currently a definite lack of an appropriate framework to promote biobased plastics. A series of regulatory incentives such as green public procurement, targets for bioplastics use, coherent EU labeling schemes, tax exemptions and other market pull measures would most certainly contribute to a more positive environment for biobased plastics. To accompany these measures, the public perception and awareness of biobased products and the benefits which they can bring will need to be improved. Currently, there is a strong discrepancy between regulations at the national and EU level, too many national level policies and badly defined terms such as 'green', 'biobased' and 'bioplastics create confusion. Common terminologies and targets would help create a more coherent market opportunity in the EU. Although though Europe has a strong R&D base, there is a need for a true industrial policy which is less risk averse and helps start-ups to scale-up and overcome heavy initial expenditures.

The full exploitation of the potential of bioplastics will also depend on several technological improvements and breakthroughs. In PLA production for instance, fermentation with lactic acid bacteria requires control and maintenance of the pH level, and this increases fermentation costs and process energy requirements. Production costs need to be lowered by, amongst others, improving yields, which not only requires the use of specific raw materials but also developing more efficient biocatalytic systems and improving downstream processing. Process modeling could identify steps where technological improvements could improve efficiency. As biobased plastics are not suitable for all desired applications, it is crucial to develop new value chains in order to create critical mass. Subsequently, the research focus should be on adding functionality (e.g. engineered PLA grades) to biobased plastics to open the market further. A lack of cooperation and knowledge exchange between parties in the value chain slows down R&D and innovation. Initiatives to promote cross-sectoral interchange of information and knowledge between industry and academia would be beneficial.

The table below summarizes the hurdles and some solutions that can be envisaged to overcome the bottlenecks related to bioplastics. The hurdles that are highlighted in green apply to bioplastics specifically, but are also an issue for IB in general. The white cells apply only to bioplastics. The cells that have been left blank indicate that no solution has yet been formulated with regards to that barrier.

Stakeholder engagement is crucial in ensuring that actions are developed which best fit the needs of this sector. The BIO-TIC project would greatly welcome any comments you might have on this document, hoping that your valuable input will contribute to setting the groundwork for a targeted workshop dedicated to bioplastics which will be held on ***1st December 2014 in Brussels****.*

We are particularly interested in your views on the market projections to 2030, whether we have missed any key hurdles and on any solutions which you could envisage to overcome these hurdles. Please send any comments to bio-tic@europabio.org by end of October 2014.

Short term hurdles	Solution proposed	
	R&D	Non technological
Quality and functionality (e.g. mechanical/thermal properties)	*-Close cooperation between material scientists and microbiologists*	
Fermentation with lactic acid bacteria (LAB) requires pH control and maintenance	*-Target research towards changing fermentation organisms to genetically modified acid tolerant LAB and yeast*	
Costs of LA production are still too high	*-Use other raw materials than maize and tapioca (starch) by maintaining the high purity of L-lactic acid and/or D-lactic acid* *-Downstream processing without formation of gypsum* *-Continuous cultivation*	
PHA does not have a reasonable market share in Europe	*Strengthen research in PHA as additive or compound material*	*-Provide more information on PHA properties*
Low yields of bioplastics	*-Close cooperation between material scientists and microbiologists*	
Lack of R&D funding		*-Increasing R&D funding at EU, national and regional level for pioneering public research in collaboration with the industrial sector in a co-funding scheme* *-Implementation of a public and private funding scheme* *-Change of policy towards a knowledge-based industrial culture which is less risk averse* *-Development of new programs for new and sustainable technologies*
High price		*-Tax incentives and subsidies*
Low market demand	*-Improve functional properties e.g. by developing new improved additives and plasticisers for polymer compounding or by introducing novel bioplastics → new properties will enable new end-use applications*	*-Public procurement programs* *-Setting (binding) targets for the use of bioplastics in e.g. fast food restaurants, public building, sport and music events* *-Add functionality and extra added value to biobased products to open the market e.g. many chemical companies are shifting from promoting biobased to*

		promoting additional functionality (e.g. engineered PLA grades) *-Create new value chains and obtain critical mass by implementing a carbon tax for consumers to move faster to a carbon low environment* *-Strong political commitment at EU and national level to secure the supply of 'home-made' bioplastics*
No framework to promote biobased products/Lack of incentives to support investment in biobased		*-Implementation of public procurement programmes* *-Implementation of tax and subsidies to close the price gap between biobased and fossil based plastics* *-Setting targets for the use of bioplastics e.g. in fast food restaurants, public building, sport and music halls* *-Implementation of a regulation to make the use of a compostable material compulsory (which will also stimulate raw material production)* *-Development of a regulation for retailers, plastic converters, brand owners and manufacturers to participate in bioplastics through selective bans, taxations etc.* *-Implementation of regulations for the introduction of bioplastics to the market* *-More regulation to push the market towards biobased* *-For biobased plastics and packaging especially, the fact that there is no willingness to pay a bio-premium can be overcome by brand owners: they can make the bridge from development phase until a certain market volume so a product becomes competitive, or pay the premium for a while*
High investment costs and lack of financing		*-Temporary market creation in order to lower investment risks or alternatively make the investment more attractive through e.g. tax breaks or investment grants* *-Government support for supply or demand side could be needed, however, government support only makes sense for those industries that can prove to be cost-*

		competitive at scale
Economics of a start-up industry is less favorable than of a mature industry – New market development is both costly and risky		*- subsidies for promising new products*
Lack of clear definition on "sustainability", "green economy" and "bio" lead to greenwashing, and the large number of "ecolabels" confuse consumers		*-Marketing actions to support biobased plastics* *-Standardisation and common labeling in the EU(e.g. CEN)*
Public perception and knowledge (e.g. about IB)		*-Regulatory bodies have to spread the information about the benefits of biobased as a healthier option compared to current petrol-based materials* *-Lobbying for a clear view on green development* *-Dissemination of information to the public at large*
Lack of necessary infrastructure	*-Consider building mobile or smaller, decentralized biorefineries or opt for specialization and invest in production plants for biobased products that only require 1 or 2 plants to fulfill overall demand*	*-Infrastructure needs to be developed*
Lack of willingness to pay bio-premium because the biobased argument is not sufficient, the functionality is of more importance	*-Development of cheap products with equal or superior properties so that consumers can easily make environmentally friendly choices*	*-People may accept a bio-premium if they know about the benefits of bioplastics*
New biobased plastics are often more expensive than the conventional ones	*- R&D in terms of fermentation processes, energy and water use*	*-Enactment of the true cost/benefit analysis of diverting organic waste from a landfill/incinerator to composter by using compostable packaging* *-Promotion of the use of the cheapest feedstock (currently starches and sugars)* *-Development of efficient logistic streams, based on feedstock procurement* *-Development of new large scale facilities, instead of adapting older plants (in some cases)* *-Creation of investment grants to temporarily create a market and lower the investment risks*
Difficult access to knowledge infrastructure		*-Instead of focusing on strain productivity, shift research focus of academic and public research institutions on extraction, the transformation process*

		of bioplastics into thermoplastics, and improving the quality of bioplastics *-More and better cooperation of academia with industry in order to close the knowledge gap* *-Promotion of collaboration of all players throughout the value chain for an integrated strategic approach* *-Promotion of research that leads to commercially viable products*

Medium term hurdles	**Solution proposed**	
	R&D	**Non technological**
Lack of recycling system for new bioplastics which do not yet have critical mass in the market. (not a problem for bio-PET and bio-PE).		*-Both political and societal pressure is needed* *-Harmonisation of the EU recycling system*
Market entry is slow due to certifications e.g. for food contact regulations		
Difficult and expensive IPR practices		*-Simplification and harmonization of patent procedures in Europe* *-Creation of an open patent environment (following the US model) through patent disclosure of innovative research done at universities (or elsewhere) by technology agents*
Heavy patent portfolios by large players make market entry for others difficult		*-Promotion of public-private ownership stages for alternative biobased companies*
(Incoherent) policies and regulation		*-EU has to agree on common regulations to stimulate market uptake of biobased products* *-Laws and regulations that work in practice* *-Legislation for applications where bioplastics have clear advantages (e.g. biodegradability)*
Subsidies and incentives		*-Subsidies, active promotion and incentives should be short term solutions because in the long term, companies must be able to make it on their own. This*

		needs to be consistent across all of the EU
Acceptance of GMOs		
Trade barriers		