Overcoming hurdles for innovation in industrial biotechnology in Europe

Biobased Chemical Building Blocks

Summary

Funded by
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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. Biobased chemical building blocks are one of five product groups which could have a significant potential for enhancing European economic competitiveness and introducing cross-cutting technology ideas.

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

Background

A chemical building block (CBB) is a molecule which can be converted to various secondary chemicals and intermediates, and, in turn, into a broad range of different downstream uses. The largest markets for biobased chemical building blocks are in the production of biobased polymers, lubricants and solvents. Two types of biobased CBB exist; drop-in biobased chemicals and novel biobased chemicals.

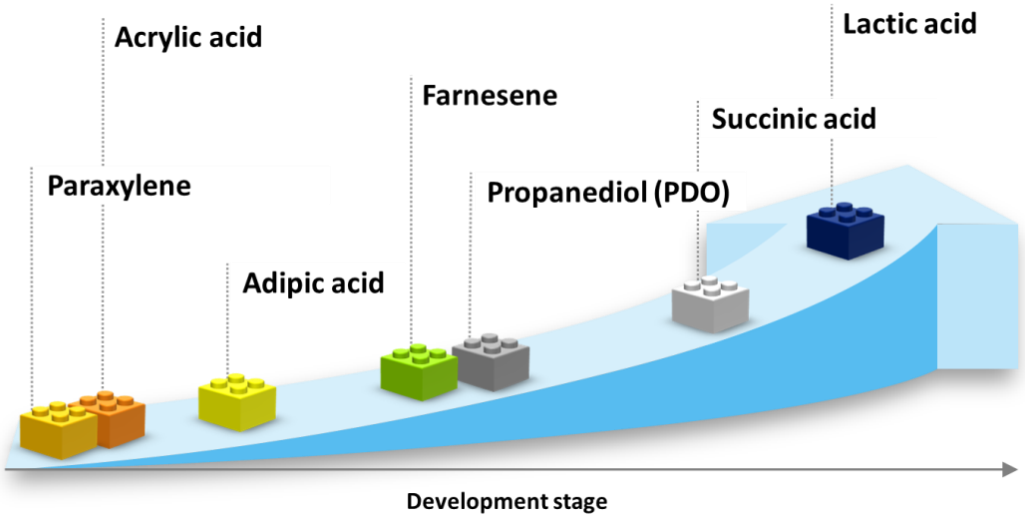
Drop-in biobased chemicals:

Drop-in chemicals are bio-based versions of existing petrochemicals which have established markets. As they are chemically identical to existing hydrocarbon-based products, their use can reduce financial and technological risks and promote faster access to markets for producers.

Novel biobased chemicals:

Novel bio-based chemicals bear higher financial and technological risks for producers, but can be used to produce products such as aconic acid and methylenesuccinic acid that cannot be obtained through traditional chemical reactions and products that may offer unique and superior properties that are unattainable with fossil-based alternatives, such as biodegradability.

There is an existing market for CBBs but it can be considered relatively immature, with development levels varying according to the building block considered and ranging from proof of concept in laboratory to full commercial production. Strong cooperation within the value chain from feedstock producer to end user is required for new chemical building blocks to successfully enter the market. The BIO-TIC project suggests that five CBBs have significant potential for Europe. These are 3HPA, succinic acid, PDO, furfural, and isoprene.

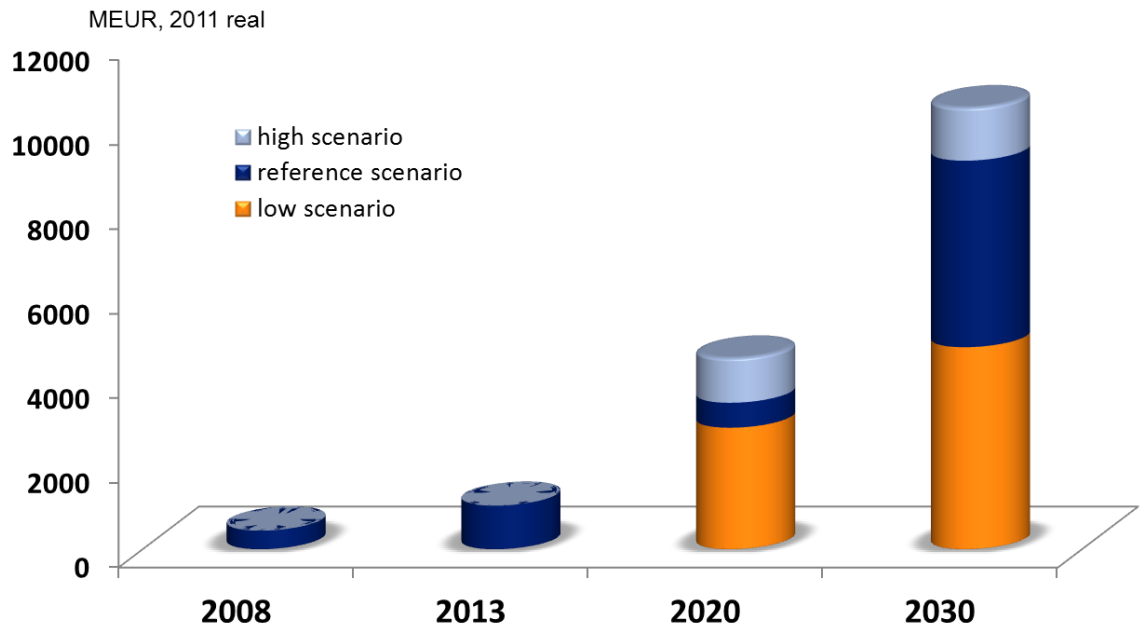


Market Drivers, Innovation Hurdles and Proposed Solutions

In 2013, the demand for biobased CBBs in the EU was 1029 MEUR, equivalent to 35% of the total global production. The market grew at a compound annual growth rate (CAGR) of approximately 18,6% per annum between 2008 and 2013. The EU is currently one of the major consuming regions of biobased CBBs, however the joint influence of several factors i.e. the limited availability of low cost sugars, high operating costs for energy and labour, and the global nature of chemical markets, has resulted in the majority of new CBB production facilities being located outside Europe, mainly in Asia and Brazil.

As shown in the following diagram, the BIO-TIC project estimates that by 2030 the biobased chemical building blocks market in Europe could reach between 4.8 and 10.4 BEUR in the absence of dedicated incentives[1]. The market value could be greater than this if the various hurdles to the development of biobased chemical building blocks are addressed.

[1] Biofuels, biofuel additives and glycerol are excluded from these market projections.



The vision for biobased chemical building blocks in the EU

In 2030, cost and security of supply will still be the dominant sourcing criteria in commodity chemicals, making biobased production more feasible in the value-added fine and specialty chemical markets than in commodity building block market. An increasing number of chemicals and materials will be produced using biotechnology in one or more of the processing steps, leveraging a number of intermediate enabling biobased platform chemicals produced from first and second generation biobased feedstock. This will allow European manufacturers in chemistry and material sciences to produce biobased versions of a wide range of their existing products which are currently produced with petrochemical feedstock.

The greatest driver for the market uptake of biobased CBBs is to overcome increasing volatility in fossil-fuel price and supply. Market prices for chemicals rise when fossil supply is tight, so the subsequent increasing uncertainty and volatility of crude oil prices is likely to push commodity chemical companies towards bringing in alternatives to traditional fossil fuels to ensure that their customers have a stable product supply.

Shale gas may provide one alternative feedstock by which chemical companies can help overcome such volatility and supply issues. The overall impact of shale gas on biobased chemicals production is unclear however because while shale gas may be a good feedstock for many chemicals which could otherwise be produced from biomass, it cannot be used to produce aromatics, or C_3 and C_4- building blocks. In this respect, the shale gas revolution may provide an opportunity for these biobased chemicals. On the other hand, some stakeholders in the EU suggest that shale gas will largely impact the US chemical markets but will leave European markets unchanged.

The value chain can be driven by technology push, market pull or both. Since CBBs are marketed from business to business, the key decision-makers in the value chain can be either chemical companies or brand owners.

In general, it is thought that the time to market, price and commercialization strategy through global partnerships are the key to successfully developing drop-in biobased chemicals, whereas for novel biobased chemicals it is the ability to provide a competitive advantage to the company or brand rather than the price which is the key driver for adoption.

Europe is an important market for CBBs because it contains an established chemical industry with many potential end-users. Research and development is strong, and this is backed up by a well-developed operational know-how and good cooperation in application development. However, despite these strengths, many hurdles hamper the development of biobased CBBs and the relative weight of these hurdles may vary according to which specific CBB is under consideration.

One of the key hurdles to the production of biobased chemical building blocks in the EU is that of feedstock availability and cost. Most of the currently available biobased chemical building blocks are based on commodity agricultural products such as sugars and vegetable oils which can vary significantly in price and are expensive, especially in Europe. Given that many chemical building blocks are bulk chemicals, a large amount of feedstock will be needed. There are concerns by some that the EU's potential for supplying extra sugar and oils is limited, though others believe that there is still much potential for yield improvement in such commodities in Eastern European countries. The use of waste and residue streams would be attractive as they are both cheap and widely available in Europe. The ability to interchange feedstocks according to availability would also be useful for Europe. Many technical challenges, especially relating to downstream processing need to be overcome to help promote the use of alternative feedstock streams and reduce processing costs, but even if these challenges are successfully addressed, it will be necessary to persuade highly conservative processors to change production process to accommodate a new feedstock or a product with new properties.

A combination of high feedstock, conversion and downstream processing costs mean that the cost of producing bio-based chemicals is currently more expensive than processes using fossil fuel feedstocks. Opportunities for biobased premiums to overcome price differentials for CBBs are considered to be lower than for other markets, for instance bioplastics, because the CBB producer is further away from the final consumer.

The greatest hurdle to promoting investments in biobased chemicals however is regulatory uncertainty and instability through its effects on pricing and demand for products. Indeed, it has been suggested[2] that Europe is now being outpaced by North America in the development of biobased chemicals, partially as a result of a more supportive regulatory regime. Furthermore, there is an industry consensus that uncertainty over regulations and their complexity in Europe does not help foster investments in this sector, especially when investors are risk adverse. Vagueness in terms such 'waste' 'residues' and 'green' fail to provide sufficient investment certainty, whilst at present, incentives for bioenergy and biofuel markets mean that these

[2] http://www.businesswire.com/news/home/20130325005279/en/Nexant-Leads-Industry-Discussions-World-Biofuels-Markets#.U8kjyLFH6-U

sectors can pay more for feedstock than non-incentived markets such as biobased chemicals resulting from feedstock prices that are artificially inflated.

The table below summarises the hurdles and some potential solutions that can be envisaged to overcome the bottlenecks related to biobased CBBs. The hurdles that are highlighted in green apply to biobased CBBs specifically, but are also an issue for IB in general. 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 biobased chemical building blocks which will be held during the European Forum on Industrial Biotechnology and the Biobased Economy on ***1st of October 2014 in Reims, France****. 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 September 2014.*

Short term hurdles	Solution proposed	
	R&D	**Non technological**
Market and technologies are not ready for large scale production of biobased chemicals		*-Political support and restrictive measures against foreign standard products (equal to REACH rules)* *-Fiscal incentives to companies that will launch/ commercialise bio-based CBBs/ products and to research organisations that are developing them* *-Focus on products where there is a limited market, where it is not feasible to transfer knowledge elsewhere and/or where 1-3 production facilities can fulfill global demand*
Production costs are high (extraction, productivity, concentration, DSP)	*-Chemical industry needs to commit to using biomass rather than oil in order to create economies of scale* *-Because some CBBs are inherently easier to purify than others, there needs to be an evaluation of the whole production process in order to be more cost-effective* *-Have cost-competitive technologies at different scales e.g. fungal strains producing 3-hydrpxypropionic acid which can be converted into acrylic acid (commonly used in polymers)* *-Integrated optimization and development of bioconversion, product recovery and DSP* *-Sharing of utilities, logistics and feedstock handling between SMEs and companies*	
Raw material availability, quality and price	*-Develop processes that can utilise alternative feedstocks* *-Use microalgae biomass feedstocks* *-Co-production of high value products* *-Reduction in transportation costs and post-harvest losses through decentralized biorefineries*	*-Better collaboration with farmers and the feed sector. Install win-win scheme for buyers and producers (farmers)* *-Create new forms of ownership in the forest sector e.g. collectives rather than traditional family forestry* *-Re-utilization and recycling materials as a resource efficiency strategy, to decrease the demand for feedstock*

	-Develop perennial non-food crops for agriculture on arid land	*-Promotion of cascading use of feedstock in order to decrease the demand for feedstock* *-Feedstock could be partially imported from elsewhere.* *-Wheat is either food grade or non-food grade categorised. The surplus of wheat could be utilized as feedstock.*
Skills, expertise, IP issues and registration costs	*-Collaborations between brand owners, processors and technology partners in order to share the financial burden* *-Closer collaboration between research organisations and industry* *-Multidisciplinary R&D community* *-Increase engagement of chemical engineers*	*-More funding and subsidies (i.e. bio-preferred government drivers as in the USA)* *-Funding to support companies through process (licensing, patenting, intellectual property issues) or a pan-European patent agency* *-Simplify patent procedures*
Processors and brand owners not willing to make changes in their production processes	*-Partnerships involving downstream users*	
Willingness to pay bio-premium		*-Reduction of the price through investments and payment of the premium by companies in a B2B environment* *-Stimulation of engagement of large consumer product companies in biobased products* *-More awareness of producers of Biobased products of the product functionalities and added value of their products compared to fossil based products* *-More communication towards consumers on added value of the Biobased products compared to alternatives on the market. This could be done by the authorities in collaboration with consumer organisations.* *-Awareness creation through outreach activities oriented to the public at large and other specific target groups (e.g. visits at biorefineries for secondary schools)* *-Entering into dialogue with consumer organisations through inviting representatives in workshops, panels, discussion fora* *-Appointment of a good science communicator, spokesman, at*

		government institutions, industry and research organisations
Lack of definition of "green" chemicals		*-Common framework at EU and global level. To be imported in Europe, products should comply with certain standards and parameters set by EU*
Lack of funding/venture capital	-	*-Implementation of a public and private funding scheme* *-Increased R&D funding at EU, national and regional level for pioneering public research in collaboration with the industrial sector in a co-funding scheme* *-Attraction of foreign VC and private investors through capital fiscal incentives.* *-Implementation of tax reduction measures or tax bonuses* *-Creation of a stock option market for green (biobased) or environmental technology companies promoted at EU and national level* *-Development of new long term vision business models for the production of biobased products to attract new venture capital and large corporate investments, private foundations etc.* *-Development of demonstration projects as proof of concept and flagship projects that cover the whole product value chain will minimize the risk and install confidence* *-Develop a communication strategy with branch associations and companies involved to positively influence the image of IB e.g. publication of reports and studies on successful cases will amplify the gained confidence* *-Provide more transparent information about subsidies, tax exemptions and make application procedures simpler*
GM acceptance		*-Branding e.g. "GM fermented" instead of promoting GMO free as only option* *-Clear outlook and regulations for GMOs before products get on the market. This would give some security to companies*

Medium term hurdles	Solution proposed	
	R&D	Non technological
EU cannot produce CBBs at cost competitive price		*-Focus on high value products where quality is more important than price and production volumes small* *-Focus on products with C-O and C-N bonds, since these are available in biomass and difficult to achieve in fossil based products / Production of chemicals that cannot or are expensive to be made from oil/shale gas* *-Target research funding on winning technologies in order to product as ready/advanced products as possible* *-Forget known chemical reactions and instead map most expensive and challenging chemical reactions for industry and start developing new biobased CBBs* *-Spread the research towards new products rather than existing and commercialized ones ie. latatonic acid for power coating or bio-medical applications*
Development of new end uses for CBBs		
Scale-up (infrastructure too costly and takes too long to set up)	*-Collaborations between brand owners, processors and technology partners in order to share the financial burden* *-Realise integrated biorefineries including biofuels*	*-Plant construction financing and partnering* *-Economic incentives for converting chemical plants to biotech ones* *-Infrastructure costs are major and are only feasible when converting existing refineries* *-Opt for mobile or smaller, decentralized biorefineries*
Taxes, regulations and regulation volatility		*-Regulations should be planned and commissioned in a straight forward process with open communication. Decisions once agreed on should not be revised. Changing regulations cost companies millions and make an unsecure business environment for investments*

Lack of incentives and subsidies		*-Regulation in the EU and globally →Imported products must comply with certain standards and parameters set by the EU* *-Laws aimed at supporting bio-based products and to ban petrochemical derived ones* *-policy to require use/inclusion of bio-based products* *-EU regulation that restricts the use of toxic substances and instead encourages their substitution with safer ones* *-Economic incentives and lower taxes for those who buy or produce bio-based products* *-EU to focus on combining product development and early production ie. shortening time-to-market* *-Production cannot be fully dependent on subsidies (especially if production can be moved out of Europe), but there will not be any developments without proper structural support* *-Develop new products at competitive price and with extra functionality* *-Develop CBBs for new applications and new much shorter value chains*
Lack of definition of waste (2G feedstock)		
Financial situation delays investments/availability of credit (risk aversion in markets)		
Negative publicity, public perception and knowledge of IB		*-Informational campaigns in order to educate consumers* *-Involve media to educate public on IB* *-Promotion of bio-based products by policy makers →public procurement measures (like in the US) would guarantee a market*

Long term hurdles	Solution proposed	
	R&D	Non technological
Investments are driven by raw material availability, price and cost of production		