Assessment Report of the Innovation Challenges in the Development of new Bio-based Products

Chemistry Innovation, February 2011

Summary

This Assessment Report of the Innovation Challenges in the Development of Bio-based Products is Task4.3 within work package 4 of the BIOCHEM project.

BIOCHEM is a 3-year project funded through Europe Innova. The overall aim is to develop free-to-access tools to help European SMEs understand the opportunities within and access new bio-based product market areas.

Innovation challenges in the development of new bio-based products within the confines of the BIOCHEM project can be categorised into four main areas:

- Chemical Feedstock
- Process Technology
- Material Technology
- Product Formulation.

The key technical and business challenges covering each area are set out in this report but include; improving feedstock yield, cyclical raw material prices, development of microbial cell factories, access to pilot / demonstrator scale facilities, bio-based composites for construction sector, improving the processability of biopolymers and standardisation of life cycle analysis methodology.

The innovation challenges identified in this report will be used to feed into the online Crowd-sourcing Platform. In addition, the Sustainable Design Guide will provide a valuable tool for identifying potential solution strategies to the problems.

Over the course of the BIOCHEM project a number of new innovation challenges will be identified through SME engagement. As a result this report will be updated on an annual basis throughout the project lifetime.

There are a number of other barriers to bio-based products that fall outside the scope of BIOCHEM and the crowd sourcing database and thus this report. Some of these were identified in D2.3 'Market Assessment Report', however, as with the innovation challenges, it is expected that SMEs will identify new barriers through the course of the project and visit programme. As a result a list of these barriers is included in Appendix 1 and will be updated on an annual basis with this report.

Introduction

This Assessment Report of the Innovation Challenges in the development of new Bio-based Products is T4.3 within work package 4 of the BIOCHEM project.

BIOCHEM is a 3-year project funded through Europe Innova. The overall aim is to develop free-to-access tools to help European SMEs understand the opportunities and access new bio-based product market areas.

Within the chemistry-using industries there are a number of barriers to innovation faced by all sectors, not only those pursuing bio-based product market areas. These include: leadership, culture, funding, involvement of the whole organisation, project management systems, communication etc. Other tools within the BIOCHEM toolkit (Gate2Growth, Imp^{3}rove, and Sustainable Design Guide) will help SMEs address some of these issues.

BIOCHEM deliverable D2.3 'Market Assessment Report' highlights a number of barriers currently faced by SMEs trying to access Bio-based Market Areas. In addition, a number of reports and documents[1-6] recently issued have highlighted other barriers in the drive to a knowledge based bio-economy. These barriers are listed in Appendix 1 and will be updated where appropriate on an annual basis once engagement with SMEs has commenced.

This report highlights specifically, known Innovation Challenges, both technical and business driven, that can feed directly into the Crowd-sourcing Platform as part of the project. However, other BIOCHEM tools such as, the Sustainable Design Guide will provide guidance, information and strategies to help solve these challenges and lower the barriers.

Over the course of the project 250 SMEs will be engaged to evaluate the tools and assist them to move into bio-based products. As a result it is anticipated that new innovation challenges will be indentified. This report will therefore be updated on an annual basis throughout the project.

Innovation Challenges

The innovation challenges in the development of new bio-based products can be broadly categorized into four areas: Chemical Feedstock, Process Technology, Material Chemistry and Product Formulation.

Input for broad and specific challenges within each of these areas has been received from the European community through the BIOCHEM project partners7 and other published reports 4, 6.

Chemical Feedstock

The objective for new chemical feedstocks is to decrease the dependency of the chemistry-using industries on oil by shifting to alternative feedstock. For bio-based products, innovation challenges therefore include identifying new raw materials and supplies, integrating new supply chain and logistic needs and ensuring feedstock supply security.

New renewable raw materials may be needed as fermentation ingredients or platform chemicals and obtained from new bio-refineries or plant extracts. Bio-refineries need to be based on multi-feedstock and multi-product models. Any new feedstock must provide consistent quality with known impurity profile.

The stability of supply of any new feedstock should also be evaluated. Factors such as political conflict areas, genetically modified acceptance, exhaustion of supplies and areas at higher risk of extreme weather events as a result of climate change need to be considered.

Once identified and sourced from a secure supplier, the raw material must be quickly and cheaply integrated into current supply chain operations or the specific logistics must be cost effective to integrate. Quite often new bio-based platform chemicals will require further chemical processing which must also be built into the logistics.

Most notably, any new chemical feedstock must be able to compete with petrochemical equivalents on performance and price if it is to be utilised by the European chemistry-using industries.

Specific Innovation Challenges for new Chemical Feedstock include:

- Development of new plant strains for new products or increased yields
- New densification techniques to improve biomass yield
- Novel preservation techniques to allow effective transport of bio-based chemical feedstocks
- Delivery of high yield, consistent quality feedstock(s)
- Analysis techniques for new feedstock impurities and quality control
- Volume constraints without technological breakthroughs such as algal-derived biomass / chemical component production
- Manufacture of chemical feedstock(s) from ligno-cellulosic biomass
- Feedstock yield and composition of biomass for optimal conversion efficiency
- Feedstock processing and logistics
- Highly coupled feedstock logistics system that can deal with the seasonal nature of production
- Feedstock not in competition with food
- Distribution network, ideally making use of existing infrastructure

- Growth of biomass in politically stable environments
- Growth of biomass in (most) climate stable environment
- Cyclical raw material prices
- Scale of biomass production / transportation pre-liquefaction
- Communication and collaboration with bio-refineries
- Customer perceived conflict of biomass use with food

Process Technology

For new process technologies the main goal is to achieve intensified, more eco-efficient, environmentally benign and competitive process and production technologies with high resource efficiency and reduced amounts of waste.

Biocatalysts will have a major impact on the renewable chemicals market. Development of novel processes and cost & time reductions in biocatalyst development continue to be required if it is to be a wider applicable tool in industry and allow a broader variety of biomass based feedstock to be processed.

Whilst industrial biotechnology will often improve the efficiency of the conversion, quite often the crude product is dilute and impure, resulting in lengthy and expensive downstream processes for isolation and purification. It is therefore important that developments continue to be made in chemical and thermal processes for conversion of renewable feedstock.

The scale-up from laboratory to demonstrator to commercial scale is often expensive and risky, particularly since industrial biotechnology routes are inherently more difficult to scale-up and few facilities are knowingly available for use.

Ultimately the process technology will be chosen based on economic and environmental feasibility. Current technical and business challenges in the area include:

- Development of microbial cell factories incorporating metabolic engineering, bioinformatics and fermenter design
- New process for highly efficient conversion of ligno-cellulosic materials
- New fermenter design giving improved efficiency in terms of yield, productivity and/or lowering energy consumption
- Rapid isolation and purification techniques
- New recovery methods for products and utilities specifically water recycling and recovery
- Efficient and robust enzymes
- Development of new continuous processes for fermentation and / or Biocatalysis conversions
- New process for effective utilisation of low value biomass
- New technologies to enable economically viable small(er) scale production facilities at source or customer.
- New processes which enable the use of a wider variety of biomass sources
- Cost effective manufacture of bio-based composites
- Access to pilot and demonstrator scale facilities
- Awareness of the technology
- Investment cost of new process
- Improved economics of Industrial Biotechnology processes

- Customer (social) acceptance of industrial biotechnology and potential for genetically modified crops

Material Technology

The discovery of new materials with tailored properties, and developing the ability to process them are the rate-limiting steps in new business development.

Quite often new bio-based materials need further modification to achieve the designed functionality and properties. Significant challenges result in ensuring the material remains biodegradable and / or recyclable to not lose the environmental benefits.

Improved computational modelling is required to better predict the material properties. A reduction of material size and better understanding of the structure properties are also needed. The use of nano-technology and nano-materials within bio-based products needs significant further research.

Specific innovation challenges include:

- Improvements in the mechanical properties of bio-based composites e.g. ductility, modulus of elasticity
- Bio-based material technology for the development of materials with unique properties
- Improve the processability of biopolymers e.g. polylactic acid
- Computational studies for improved bio-based material modelling
- Structure analysis of bio-based products
- Efficient modification of the bio-based material functionality
- New bio-based composites with application of the construction, aerospace, automotive and sports industries
- Economically viable processes for bio-based material modifications
- Access to collaborative partners through-out bio-based supply chain to understand requirements and capabilities.

Product Formulation

Product formulation is an essential part of the whole process. Continuous improvements need to be done in order to improve final product properties and to meet the users' requirements.

The substitution of one petrochemical derived ingredient for a single bio-based product in a formulation containing 20+ ingredients is expensive and lengthy to ensure compliance with legislation and product regulations. As a result the new bio-based product must offer an advantage in terms of price or performance since only niche markets will provide "green" demand by consumers.

Regulation challenges also exist around the "naturalness" of a product. What level of bio-based product is needed in the final formulation before it can be considered and sold as natural?

Standard life cycle analysis methodology is required if customers and consumers are to be convinced of the bio-based product advantage.

Specific Product Formulation technical and business led challenges include:

- Development of low environmental impact, bio-degradable alternatives to replace toxic, non-biodegradable formulations
- New approaches for efficient application testing for ingredient replacement
- Quality of bio-derived products
- Ease of manufacture to blend bio-based products into formulations
- Safety and handling concerns of new contaminants (inc bacteria) in products
- Collaboration through the supply chain to understand which products have market pressure to become green
- International specifications on use of bio-based products in formulations
- Acceptance of a standard life cycle analysis methodology

References

1. *'IB 2025: Maximising UK opportunities from Industrial Biotechnology in a Low Carbon Economy*.' Industrial Biotechnology Innovation and Growth Team (May 2009)
2. *'Building a Bio-based Economy for Europe 2020.'* EuropaBio Policy Guide (2010)
3. *'Industrial Biotechnology. More than green fuel in a dirty economy'*. WWF (2009)
4. *'Outlook on Industrial Biotechnology'* OECD Workshop discussion papers I-IV (January 2010)
5. *'Industrial Biotechnology in the Chemicals and Chemistry-using Industries in the UK: Follow up survey to assess Barriers to Implementation and Opportunities for Growth.'* Chemistry Innovation, on behalf of the Industrial Biotechnology Innovation and Growth Team (November 2008)
6. *Chemistry Innovation's Strategy Report*. Chemistry Innovation (June 2009)
7. *Needs assessment questionnaire and consortium response.* BIOCHEM Task T2.4

Appendix 1

Further to the Innovation Challenges described above there are a number of barriers that are outside the scope of the Crowd-sourcing platform (T4.4) and therefore this report. These have been documented in various reports and documents1-6 in recent years and for the purpose of this report have been collated and summarised below.

- Lack of societal knowledge or understanding of industrial biotechnology and bio-based opportunities
- Lack of market driver
- Customer resistance
- Access to well educated scientists and engineers
- Access to funding
- Company size
- Industrial biotechnology not perceived as relevant to business
- Ownership of Intellectual Property
- Awareness and acceptance of bio-based products by investors
- Inability to demonstrate / prove benefit
- No sustainability standards (EU and International)
- Sustainability criteria and definitions
- Available land mass, capability to leverage marginal and non-agricultural land
- Agreement on boundary conditions and common calculations of life-cycle emissions
- New and existing legislation (*e.g.* use of waste as a feedstock)
- Definition of policies (*e.g.* Embedded carbon / water *etc.* definition of bio-based feedstocks)
- Regulation
- Lack of industrial biotechnology in education curriculum
- Lack of tax / levy incentives
- Definition of the best use of biomass
- Ability to track (and reward) provenance of biomass in global trading

Through-out the project and *via* SME engagement it is expected that further barriers will be identified. As a result this list will be updated on an annual basis (in conjunction with the Innovation Challenges) and form part of the Exit Strategy Report for the commission at the end of the BIOCHEM project.