BIO-BASED AND BIODEGRADABLE INDUSTRIES ASSOCIATION

Reply to: admin@bbia.org.uk

Dated: 28.09.2023

	Content
1	About the BBIA
2	The Role of Engineering Biology in Climate Change
3	The Role of Bio-based and Biodegradable Materials in Climate Change
4	The Role of Engineering Biology in the Production of Bio-based and Biodegradable Materials
5	Keeping the UK Competitive
6	BBIA Recommendations
7	Case Studies

1. About the BBIA

The BBIA represents UK and non UK manufacturers, developers and distributors of products, chemicals and materials that have a common identity in their sourcing (partially or totally bio-based which means derived from plant-based, renewable sources) and in their end-of-waste performance (biodegradable or compostable in various environments which could be natural – in the case of bio lubricants, in soil in the case of soil mulch films - or in industrial composting, in the case of packaging).

The BBIA was established by seven founder members in June 2015 and in 2023 comprises 35 companies which produce: biopolymers for onward conversion into products; building blocks for the chemical industry from bio-based sources that may be used in pharma, cosmetics, paints and coatings, as well as lubricants, packaging, pesticides; members also distribute and sell products in the UK market; and include associations, consultants and the Scottish Industrial Biotechnology Innovation Centre. BBIA members represent most of the value chain in the production, conversion and treatment of compostable packaging materials.

More details about the BBIA can be found on www.bbia.org.uk including reports and research undertaken on compostable packaging, bioplastics, biodegradability, and bio-based feedstocks.

We thank the Department for Science, Innovation & Technology for announcing the Call for Evidence on Engineering Biology dated July 19th 2023 and in this brief paper illustrate how engineering biology can help transform the ecological footprint of a part of the plastics industry.

2. The Role of Engineering Biology in Climate Change

Climate change is one of the largest challenges for modern day society. In terms of climate change, Engineering Biology (EB) and Industrial Biotechnology (IB) are key enablers of defossilisation and decarbonisation and the driving force for a strong and vibrant bioeconomy[i]. Its transformative enabling technologies have the potential to change our relationship with the resources we use and to develop inspiring solutions that improve our lives. EB and IB can reroute our unsustainable extraction, manufacture, and consumption. The opportunities are endless. There is an urgency and scale of change needed, which means 'business as usual' is inadequate. All sectors must change, enforcing a system wide approach, across technologies and policy, including regulators. Collaboration is key.

Our exploitation of the planet's resources has and continues to fuel economic growth and, overall, a general improvement in the human condition. However, these activities bring responsibilities, which perhaps have been neglected, or ignored, until relatively recently. The Earth's resources are finite; its ability to buffer rapid perturbations in the cycling of elements, such as carbon, is being tested to the limit; and so to continue to improve the quality of life for all, a more sustainable economy that is less reliant on petrochemicals is essential. The great promise of IB is that it offers a realistic opportunity to make a major contribution to creating a sustainable circular economy, where waste is closer to zero. It is imperative that the UK leads in leveraging the breadth of possibilities IB offers, not just for the future well-being of the UK population, but for the future of the planet and all its inhabitants. IB can be the highway to a sustainable chemicals industry based on world-class scientific discoveries, but this will not happen spontaneously. We need supportive long-term government policies, investments to nurture academic-industrial partnerships and rapid commercialisation, enhanced access to pilot facilities for SMEs, and simplified but rigorous regulatory frameworks, to make the UK a world leader. We cannot afford to be left behind.

3. The Role of Bio-based and Biodegradable Materials in Climate Change

To date, little attention has been paid to the role of the development and commercialisation of novel and existing bio-based and biodegradable plastics in reaching Net Zero by the UK government. The recent UK Biomass strategy[ii] further highlights the Government's lack of understanding of the contribution that biobased and biodegradable materials can have against climate change. The strategy is focused upon the use of biomass primarily for energy production. The possibility of using biomass for non-energy purposes, for example for biochemicals and materials, receives only a brief mention towards the end of the strategy – concluding that more work is required in this area before any policy recommendations can be made in the longer-term, stating *"Emerging bioeconomy products and markets beyond energy will continue to be reviewed."*

The Biomass Strategy also demonstrates that there is also a clear lack of understanding within the UK Government as to the difference between decarbonisation and defossilisation. The strategy talks about how biomass *"should be prioritised for the hardest-to-decarbonise sectors first",* yet then focuses on the bioenergy sector, which can be decarbonised. There is an opportunity to help communicate that biomass use should focus on sectors that cannot be decarbonised, but can be defossilised, e.g., biochemicals and bioplastics.

The UK is the home of significant and long-standing academic excellence in bio-based chemicals, meaning there is the potential for us to be a leader in this space, but other areas of the world are already implementing policies to drive this sector forwards and the UK is rapidly losing this competitive advantage.

4. The Role of Engineering Biology in the Production of Bio-based and Biodegradable Materials

Engineering biology (EB) involves applying engineering principles to the design and modification of biological systems, including living organisms and biomolecules, to create new functionalities or improve existing ones. One of the fascinating applications of engineering biology is in the development of biobased and biodegradable materials, and in particular, plastics.

Biobased plastics are plastics that are derived from renewable biomass sources such as plants, bacteria, or algae, rather than from traditional fossil fuels like petroleum. These plastics offer several potential benefits, including reduced carbon emissions, decreased reliance on finite fossil resources, and the potential for biodegradability, depending on the specific type of bioplastic. EB also plays a crucial role in the development of biodegradable plastics, which are designed to break down naturally in the environment through biological processes. These plastics offer a potential solution to the global plastic waste problem by reducing the persistence of plastic pollution and its impact on ecosystems.

Below is an overview of how engineering biology plays a role in the development of biobased and biodegradable plastics:

- **Microbial Engineering:** Researchers use genetic engineering techniques to modify microorganisms, such as bacteria and yeast, to produce specific polymers. For instance, bacteria like Escherichia coli or Cupriavidus necator can be engineered to produce bioplastics like polyhydroxyalkanoates (PHAs) by introducing genes responsible for polymer synthesis. Genetic engineering can also be used to modify microorganisms like bacteria and yeast to produce enzymes that can break down specific types of plastics. For example, researchers have engineered microorganisms to produce enzymes capable of degrading polyethylene terephthalate (PET) and polyethylene (PE), common types of plastics.

- **Metabolic Engineering:** Metabolic pathways within microorganisms can be engineered to redirect their natural processes toward the production of precursor molecules needed for bioplastics. This involves manipulating enzymes and metabolic reactions to increase the production of specific compounds. Microorganisms can be engineered to produce enzymes that break down plastics as part of their metabolic processes. This can involve introducing new pathways or modifying existing ones to enable the breakdown of plastic polymers into smaller, more easily degradable molecules.
- **Enzyme Engineering:** Enzymes involved in polymer synthesis can be engineered to enhance their efficiency and specificity, leading to higher yields of desired bioplastics. This can involve modifying enzyme structures through techniques like protein engineering. In addition, enzymes that naturally degrade plastics are identified from microorganisms that have evolved the ability to break down plastic waste. These enzymes can then be further engineered to enhance their activity, stability, and specificity for different types of plastics.
- **Plant Engineering:** Some bioplastics can be produced in plants by introducing genes responsible for polymer synthesis. Plant engineering can lead to the production of bioplastics within the plant tissues, which can then be extracted and processed.
- **Synthetic Biology:** Synthetic biology approaches involve designing and constructing new biological systems or modifying existing ones to achieve specific goals. This can include creating novel pathways for bioplastic production or optimizing existing pathways for higher yields. In addition, synthetic biology techniques are employed to design and construct biological systems that can efficiently degrade plastics. This involves assembling genetic parts and pathways to create synthetic microorganisms with enhanced plastic-degrading capabilities.
- **Enhancing Biodegradability:** Through genetic engineering, researchers can modify the structure of bioplastics to make them more susceptible to microbial degradation. This involves designing plastics that contain specific bonds that are easily broken down by enzymes produced by microorganisms.

Overall, engineering biology plays a pivotal role in the development of biobased and biodegradable plastics, enabling the creation of more sustainable and environmentally friendly alternatives to conventional plastics.

5. Keeping the UK Competitive

As stated in the Biomass Strategy, the Government feels that much more work is needed to understand the role of biomass in the materials and chemicals manufacturing sectors. There is currently no national policy on sustainable materials and little clarity on the future for bio-based chemicals, and government needs to take action so that the UK can achieve a net-zero-compatible materials economy – Engineering Biology sits at the heart of this.

There is a failure to understand what is happening globally, especially in the USA. Under the Inflation Reduction Act in the USA[1], the administration has established new targets for the American bioeconomy, through its new 'Bold Goals for U.S. Biotechnology and Biomanufacturing' strategy, with ambitious goals for their chemicals and materials sector. Engineering biology and biomanufacturing are core to all this work. Theme 2 of the strategy seeks alternative processes to produce chemicals and materials from renewable biomass and intermediate feedstocks by developing low-carbon-intensity product pathways and promoting a circular economy for materials. Achieving these goals will position the United States at the forefront of a vibrant global bioeconomy while producing net-zero or net-negative emissions, reducing use of and reliance on fossil fuels, and increasing use of recyclable-by-design chemicals and materials like bio-based products. Alongside this, they have set ambitious targets:

[1] Inflation Reduction Act Guidebook | Clean Energy | The White House

Theme 2: Chemicals and Materials

Goal 2.1: Develop Low-Carbon-Intensity Chemicals and Materials – In 5 years, produce >20 commercially viable bioproducts with >70% reduced lifecycle GHG emissions over current production practices.

Goal 2.2: Spur a Circular Economy for Materials – In 20 years, demonstrate and deploy cost-effective and sustainable routes to convert bio-based feedstocks into recyclable-by-design polymers that can displace >90% of today's plastics and other commercial polymers at scale.

Whilst the US's aspirational targets may seem difficult to achieve, the administration has put financial resources behind the policy to stimulate production of bio-based plastics. The UK has no such Bioeconomy Strategy having withdrawn the 2018 version in 2021. This means the UK risks losing out on the new manufacturing capacity derived from engineered biology, leaving the field to American competition, and other countries who are adopting similar approaches.

6. BBIA recommendations

Recommendation 1: Develop a clear strategy for Engineering Biology, with sustainable material production as a core focus
The UK should research, design, publish and implement a meaningful Engineering Biology strategy, and significant funding package, that has at its heart the stimulus of bio-based industrial development in the UK through market pull instruments such as targets and mandates for bio-based materials in the UK marketplace. At the same time, renewable carbon, from biomass, is the best placed resource to use for products and materials that cannot easily be defossilised. The chemical industry is an important part of the UK economy but is still heavily dependent upon fossils for its supply of carbon feedstocks. Engineering biology is a key instrument to reducing this dependence.

Recommendation 2: Develop favourable Policy and Regulatory Environment: The UK Government, in dialogue with the traditional chemical and the green chemical industry, should identify target products and materials (e.g., some polymers) that can be produced utilising Engineering Biology and renewable feedstocks and mandate the transformation of those sectors within certain time frames (e.g., 20% of plastic polymers should be bio-based by 2030). Incentives to transition to bio-based plastics could include tax credits, grants, and subsidies for research and development, production, and use of bio-based chemicals.

Successful policy implementation examples include:

- Regulatory incentives would create market pull for biobased chemicals and drop in equivalents. This, for example, has been successful in fuels (RTFO), but no equivalent incentive exists for chemicals and plastics.
- In January 2017 France mandated use of compostable materials for single-use supermarket bags and food packaging, leading to growth in its biomaterials industry.
- The BioPreferred Program[2]. is a USDA-led initiative that aims to assist in the development and expansion of markets for biobased products. The program was created by the 2002 Farm Bill (legislation) and expanded as part of the 2014 Farm Bill. For example, UK government could specify that the NHS must procure certain biobased materials (e.g., compostable or biobased disposable gloves) by 2030. This would drive market demand.

Recommendation 3: Funding and Investment. Consistent long-term funding for research and development in bio-based chemicals, utilising EB, including funding for academic institutions, research organizations, and private companies is required. This financial support would help accelerate technological advancements, scale-up production, and reduce costs, making bio-based chemicals more competitive with their conventional counterparts. Research funding focussed on developing cost-effective ways to produce biobased chemicals and their derivativities, and on ways to scale them up to commercial products, will underpin viable commercial models. UK companies need technology testing and scale up services, and open access piloting and demonstration facilities. Specifically, investment should focus on the following:

- Use EB to identify biological pathways and biochemical processes involved in the production of key molecules and increase the yield and process efficiency for chemicals produced from a range of carbon sources.

[2] FACT SHEET: Overview of USDA's BioPreferred Program | USDA

- Using EB, develop innovations at the interface of biology and chemistry to produce platform chemicals and final products with greatest potential to reduce GHG emissions.
- Conduct research to support regulatory efforts and safe commercialization of new products.
- Expand R&D for process development and scale-up to recycle and/or upcycle waste resources such as plastic waste, including through selective chemical and EB methods, with an emphasis on mixed and multi-component waste that is not recycled today.
- Expand efforts, using EB, to design or redesign materials such as plastics to improve end-of-life properties including increased recyclability and/or composability where appropriate.

---

[i] d390c237-04b3-4f2d-be5e776124b3640e.pdf (bioindustry.org)
[ii] assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1178897/biomass-strategy-2023.pdf