Biomass Biorefinery Network

3rd BBNet Conference

Biorefining – Clean Growth – Net Zero

10–12 April 2024

Mercure Sheffield
St Paul's Hotel & Spa,
Sheffield

bbnet-nibb.co.uk

UKRI Biotechnology and Biological Sciences Research Council

UKRI Engineering and Physical Sciences Research Council

University of York

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Biorefining – Clean Growth – Net Zero

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Welcome

We are delighted to welcome you to the 3rd BBNet Conference, where we will focus on how biorefining can support our journey towards net zero. We are pleased to be joined by participants from industry, academia and the policy sector, gathering together to share knowledge, innovate, inspire and network. We encourage you to use this event as a catalyst to foster pioneering collaborations and ignite novel discussions.

BBNet Team

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UKRI Biotechnology and Biological Sciences Research Council

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University of York

3rd BBNet Conference

Biorefining – Clean Growth – Net Zero

10-12 April 2024

Programme

Day 1: Wednesday 10th April

Time	Event	Abstract
11:00	**Registration** (Hotel Foyer)	
From 11:30	*Lunch* (Yard Restaurant)	
12:45	**Welcome** (Welcome and all sessions in City Suite B & C) ***Neil Bruce, University of York***	
13:00	**Session 1: Demonstrating the clean in 'clean growth'** ***Chair: Gavin Milligan, Green Knight Sustainability Consulting***	
13:05	**What Net Zero means in practice** ***Carol Somper, JRP Solutions***	**01**
13:35	**Making a success of your pitch – communicating biotech to the business world** ***Ed Robinson, Wells & Co***	**02**
14:05	**Cleaner, greener retail – challenges and innovation** ***Moira Howie, Independent Adviser Diet, Health & Sustainability (former Nutrition and Health Manager at Waitrose and Partners)***	**03**
14:35	**Panel discussion** ***Chair: Gavin Milligan*** ***Panel: Carol Somper, Ed Robinson, Andrew Fleming (Wells & Co), Moira Howie***	
15:00	*Coffee break* (City Suite Foyer)	
15:30	**Session 2: Engineering biology for clean growth** ***Chair: Neil Bruce, University of York***	
15.30	**Conversion of lignin to performance-advantaged bioproducts** ***Gregg Beckham, National Renewable Energy Laboratory (NREL)***	**04**
15.55	**From systems biology to metabolic engineering of *Eubacterium limosum* B2 for the conversion of methanol and CO_2 to C4 chemicals** ***Philippe Soucaille, University of Toulouse***	**05**
16.20	**Metabolic engineering of *Cupriavidus necator* H16 for the bioproduction of chemicals** ***Katalin Kovacs, University of Nottingham***	**06**
16.45	**Government's Vision for Engineering Biology** ***India Higgins, Engineering Biology, DSIT***	**07**
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18:30	**Poster session and networking** (City Suite Foyer)	
19:30	*Dinner* (City Suite A)	

Day 2: Thursday 11th April

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09:05	**The co-product market in the UK** *Richard Evans, AB Agri Ltd*	**08**
09:30	**Realising the true value of 'wastes' – linking resource recovery to food, energy, and the environment** *Rebecca Wheeler, Future Biogas*	**09**
09:55	**Waste valorisation at pilot scale** *Mark Gronnow, Biorenewables Development Centre*	**10**
10:20	**Flash presentations:** **Bioremediation of heavy metals using yeast: a comparative study of metal nanoparticle biosynthesis, characterization, and genetic contributions** *Walid Omara* **SPLICE: Sustainable Processes Linked for an Integrated Circular Economy** *Fatemeh Khodaparastan*	**P25** **P28**
10:30	*Coffee break* (City Suite Foyer)	
11:00	**Session 4: Circular bioeconomy** *Chair: Patricia Thornley, Aston University*	
11:05	**Sustainable and inclusive bioenergy for rice growing communities in the Philippines** *Rebecca Fothergill, Aston University*	**11**
11:30	**Circular chemicals and the bioeconomy** *Sarah Davidson, Croda Europe Ltd*	**12**
11:55	**Sustainable feedstock** *Anna Duden, Utrecht University*	**13**
12:20	**Flash presentations:** **From lignocellulosic biomass to chemical wealth** *Mauro Adriel Rinaldi* **Conversion of organic wastes into biodegradable plastics: a dual and synergistic solution in a circular economy** *Yongqiang Liu* **HAROW and REvAR – fuel gases from organic-rich wastewaters** *Malcolm Glendenning*	**P23** **P30** **P36**
12:30	*Lunch* (Yard Restaurant)	
14:00	**Session 5: Challenge of scaling-up** *Mark Gronnow, Biorenewables Development Centre*	
14:05	**Technical and financial challenges in scaling up a bio-refinery using salmon waste** *Kjartan Sandnes, Biomega*	**14**
14:30	**Fermented products: design for manufacture** *Andrew Ellis, Biocatalysts*	**15**
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16:25	**Seaweed production in the UK: status, challenges and developments in aquaculture** *Elisa Capuzzo, Cefas*	**18**
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16:50	**Sustainable packaging in the context of a seaweed biorefinery focused on biopolymeric materials** *Erinc Bahcegul, Notpla Ltd.*	**19**
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18:30	**Poster session and networking** (City Suite Foyer)	
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11:50	**Bioacrylic acid production from seaweed** *Jonathan Todd, University of East Anglia*	**25**
12:05	**Development of enzyme-based biotechnology to support the wool industry transition to a circular system** *Jinsong Shen, De Montfort University*	**26**
12:20	**MSAD: Methanosarcina Detection and Addition for Optimised Anaerobic Digestion** *Samantha Cook* **Catalytic activity of Pulcherrimin: a green, natural, water-tolerant, and highly active heterogeneous biocatalyst for base-free 5-hydroxymethylfurfural oxidation** *Jonathan Wagner*	**P06** **P14**
12:30	**Closing remarks and end of meeting**	

List of speaker abstracts

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Speaker abstracts

01 What Net Zero means in practice

Carol Somper, JRP Solutions

This presentation explains exactly what is meant by the term 'Net Zero', the globally agreed process for achieving it and how emissions sources and reductions are measured, again using globally established standards. Case studies are used to provide examples of how and why global standards need to be rigorously applied to avoid unintended consequences of materials usage. Failure to apply good practice standards can simply displace and possibly worsen adverse impacts deepening climate change impacts, with socio-economic implications.

02 Making a success of your pitch – communicating biotech to the business world

Ed Robinson, Wells & Co

Wells & Co. is a fifth-generation family business. We've been running pubs and brewing beer in the heart of Bedfordshire since 1876. Our emphasis on quality and innovation keeps our consumers at the heart of everything we do.

We at Wells & Co. recognise that there is more to doing good business than money. Like many, we did some serious thinking during the pandemic and decided to emerge with a new way of operating that prioritises our impact both on the natural environment and the communities around us, including our own colleagues.

Over the past few years, we've been working hard to evolve our family business into one that factors people, planet, and profit concerns into every decision it makes. From our beer cellars to our brewhouse, we're constantly seeking out ways to drive down our energy usage, reduce our carbon footprint and derive maximum value from the resources we consume.

A great example of this approach is our recent arrangement to send the spent grain from our Bedford HQ, Brewpoint, to anaerobic digestion (AD) so that it can be used to create energy. Join us to learn more about this project; we'll take you on a whistlestop tour of the brewing process, then talk you though our new AD setup and the insights it can offer when pitching your own biotech innovations to the business world.

03 Cleaner, greener retail – challenges and innovation

Moira Howie, Independent Adviser Diet, Health & Sustainability (former Nutrition and Health Manager at Waitrose and Partners)

The presentation will look at some of the challenges facing innovation in the retailing sector. A snapshot view of customers knowledge with respect to use of ethical claims helps to set the scene. The challenges in seeking more sustainable alternatives in both food and non-food sectors will be explored highlighting the need for new science and technology solutions. An Innovate UK funded 'proof of concept' project on valorisation of waste in the food sector will help illustrate new discovery and associated challenges. The value of building relationships with academic and industrial partners to deliver innovative solutions is critical in moving forward this complex area; to complete the circle, we must be able to convey these benefits to customers who are faced with 'difficult choices' to meet the demands of day-to-day cost of living.

04 Conversion of lignin to performance-advantaged bioproducts

Gregg Beckham, National Renewable Energy Laboratory (NREL)

Lignin has long presented a major opportunity to create another valuable product stream in lignocellulosic biorefineries, but its inherent heterogeneity and reactivity have prevented lignin from being valorised in many cases, except for a few niche products. Over the past decade, our group has been pursuing multiple strategies for lignin valorisation, including a tandem chemo-catalytic and biological funnelling process, wherein lignin is first catalytically depolymerized into a mixture of bio-available monomers and then an engineered aromatic catabolic bacterium is used to convert the mixture of aromatic compounds to a single, targeted product. This talk will highlight 1) recent advances in increasing the yield of bio-

available aromatic carbon using oxidation catalysis, 2) efforts in metabolic engineering and bioprocess development to improve product titers, rates, and yields, and 3) the conversion of aromatic catabolic intermediates to performance-advantaged bioproducts.

05 From systems biology to metabolic engineering of *Eubacterium limosum* B2 for the conversion of Methanol and CO_2 to C4 chemicals

Philippe Soucaille, University of Toulouse

Eubacterium limosum B2, an anaerobic acetogen, holds significance for its ability to convert methanol and other C1 feedstocks into butyrate using the Wood-Ljungdahl Pathway (WLP). Through adaptive laboratory evolution, a strain capable of growing on synthetic methanol medium without yeast extract was isolated, exhibiting a homologous recombination event in genes encoding the type I restriction-modification system. This event led to distinct methylomes between the native and evolved strains. Analysis of total proteomes revealed notable differences in proteins associated with gluconeogenesis, anaplerotic reactions, and sulfate metabolism, suggesting a potential epigenetic mechanism of metabolic regulation.

A systems biology approach was employed to comprehensively characterise the central metabolism of the evolved *E. limosum* B2 in chemostat cultures with methanol or glucose as carbon sources. Physiological parameters and fluxes were determined and integrated into an in-silico genome-scale model to estimate specific enzyme fluxes and energy conversion models under the two conditions. Quantification of mRNA and protein molecules per cell facilitated the assessment of promoter strength, ribosome binding sites, and *in vivo* turnover rates for each enzyme, aiding in identifying limiting factors.

Based on this systems biology characterisation, a rational metabolic engineering strategy was applied to *E. limosum* B2, resulting in recombinant strains capable of producing various C4 compounds from methanol with high carbon yields. This work underscores the potential for manipulating microbial metabolism for the efficient production of valuable compounds from renewable feedstocks.

06 Metabolic engineering of *Cupriavidus necator* H16 for the bioproduction of chemicals

Katalin Kovacs, University of Nottingham

Over the last three decades, *Cupriavidus necator* H16 (formerly known as *Ralstonia eutropha* H16) has attracted significant interest as a platform organism for bioproduction of sustainable green chemicals, metabolites, and polymers from CO_2 and/or organic carbon sources to become the model organism for autotrophic fermentation. Due to its remarkable metabolic flexibility and genetic amenability, it has been successfully engineered to produce a range of industrially relevant molecules, such as solvents, fuels, terpenes, fatty acids and biopolymers.

The presentation will showcase the power of engineering biology and metabolic engineering to establish novel pathways in *Cupriavidus necator* H16 for the sustainable production of platform chemicals such as 3-hydroxypropioninc acid, mevalonate and biopolymers from CO_2.

07 Government's Vision for Engineering Biology

India Higgins, Engineering Biology, DSIT

Last year the UK Government named engineering biology as one of five critical technologies, recognising the UK's existing capabilities and the huge potential for growth in the bioeconomy. In December the Department for Science, Innovation and Technology published the National Vision for Engineering Biology which defines government's collective ambition for engineering biology and sets the direction for government investment, policy and regulatory reform for the next decade.

Government's vision is for the UK to have a broad, rich engineering biology ecosystem that can safely develop and commercialise the many opportunities to come from the technology and the underlying science. Government aims to capture as much economic value, security, resilience and preparedness as possible from the UK's hard-won strengths and ensure these create real benefits for the public. Government committed to investing £2 billion over the next ten years to deliver this vision.

This presentation will outline the commitments made in the Vision, the work Government has already delivered and will highlight the opportunities for the engineering biology community to shape government policy.

08 The co-product market in the UK

Richard Evans, AB Agri Ltd

This presentation will explain the value of many co-products that originate from processing of agricultural crops, the traded market and their valuable nutritional composition in the animal feed industry and beyond.

09 Realising the true value of 'wastes' – linking resource recovery to food, energy, and the environment

Rebecca Wheeler, Future Biogas

The evolution from a linear to a more circular economy inevitably brings together multiple sectors. A key example of this is the bridging of resource recovery and 'waste treatment' with the land-based sector, a multifaceted balance of food production, green energy, and environmental custodianship.

Anaerobic digestion (AD), and the feedstocks utilised play an important role in linking resource recovery to agriculture. The technology provides diversification and decarbonisation opportunities for both sectors as society moves towards a more circular economy.

Implementation of the technology has significant benefits, where many feedstocks, including those often perceived as low value, surplus 'waste' materials are converted into three high value products; green gas (biomethane), biofertiliser (solid and liquid digestates) and carbon dioxide that can be captured and either utilised or stored.

This presentation will focus on the true value of organic wastes, produced by farming, domestic and commercial consumption, and food production/manufacturing. Detailed characterisation of materials and treatment technologies and identification of recovery routes within the current regulatory framework can optimise the use of valuable resources.

It is essential that future technology, innovation, and research developments review potential limitations of existing legislation, and establish the market value, availability and locality of intended wastes and feedstocks to ensure scalability and implementation of successful pilot projects.

10 Waste valorisation at pilot scale

Mark Gronnow, Biorenewables Development Centre

When moving from laboratory discovery to pilot plant and commercialisation many issues and problems can start to appear. From stir-ability, heating times and loading issues, to colour, smells and contamination, various practical issues – unforeseen at smaller scale – become challenges on the route to market. The economics and cost and therefore the commercial viability of a process can only start to be understood once the full process is understood.

This presentation will provide a series of case studies with successes (and failures) including:

- Crude sugar as a platform – issues and challenges with conversion of starchy and lignocellulosic waste to sugar ready for fermentation
- Mapping – challenges and issues
- Up and downstream processing – often the biggest challenge

The Biorenewables Development Centre (BDC) is a not-for-profit company which provides industry with new processes to convert plants, microbes and biowastes into high-value biorenewable products. The primary goal of the centre is to develop, integrate, demonstrate and prove novel technologies at a commercially-interesting scale, linking multidisciplinary expertise and state-of-the-art pilot-scale processing capabilities in one coordinated centre.

The BDC team offers a unique combination of expertise across the areas of biology, chemistry and chemical engineering with a practical and applied outlook. Established in 2012, the BDC's expertise, services and open-access facilities have culminated in over 1,500 projects all along the bio-based supply chain, for a range of clients from SMEs to global multinationals.

11 Sustainable and inclusive bioenergy for rice growing communities in the Philippines

Rebecca Fothergill, Aston University

Rice straw is the third largest biomass resource in the world, after sugar cane bagasse and maize stover. Across Asia, about 700 Mt of rice straw are produced each year. Most of this straw is disposed of unsustainably, causing significant environmental and health impacts. Unlike rice husks, rice straw is left in the field after harvest, and few major uses have been identified. Rice straw is difficult to remove from paddy fields, which are often flooded and in remote areas. It is high in silica, making it a poor fuel or animal feed. It is also unsuitable to incorporate into flooded rice fields due to slow degradation and high greenhouse gas emissions, so burning is often the main option for clearing fields.

This presentation will introduce the sustainability assessment of rice straw bioenergy and share the experiences of an industry-academic partnership based on a tested and piloted biogas facility in the Philippines. Results from the lifecycle assessment show emission reductions through bioenergy integration of 69%, compared to conventional rice straw management approaches. The investigation of different timeframes demonstrates how different climate metrics beyond Global Warming Potential can provide valuable information for decision makers. The stakeholder engagement approaches used in the sustainability assessment provided valuable insights into how commercial business models can be co-created by farmers and communities to design community-based bioenergy interventions that enable positive trade-offs for different key stakeholders. This way multiple Sustainable Development Goals beyond SDG 7 (energy) and 13 (climate) are met.

12 Circular chemicals and the bioeconomy

Sarah Davidson, Croda Europe Ltd

Over the past year, we have reached the devastating position where the world's average temperature increase has exceeded 1.5°C! This urges us to do more, be bigger, and go quicker than ever before when it comes to a transition to circular, carbon negative technologies.

At Croda we recognise the significance of this challenge and have been working over the past few years towards ambitious climate targets, including reducing emissions across all scopes and increasing the renewable content of our ingredients.

We have approached these goals with a concerted effort across our organisation, employing strategies in new product innovation and sustainable sourcing. Examples of this include recent additions to our sustainable surfactants range, swapping petrochemical materials for more sustainable alternatives, and developing net zero roadmaps for our key technology platforms.

As well as internal development, we have embarked on several strategic projects externally in these areas. Funded by UKRI, these partnerships are tackling topics such as biobased, biodegradable polymers, biotech routes to 'hard to abate' technologies and renewable sources to key feedstocks.

This presentation will showcase some of these examples, explaining not only the challenges we face, but what Croda are doing to make a positive change within the chemicals industry.

13 Sustainable feedstock

Anna Duden, Utrecht University

To realise a transition towards a bio-based economy, the sourcing of biomass feedstock for energy and biorefining purposes will increase. We have seen this trend over recent decades, with the demand for renewables increasing strongly, for example in China, the US and Brazil. This increases pressure on natural resources required to grow biomass; mainly land and water.

The transition towards the bio-economy has been linked to many of the sustainable development goals. Land used to produce dedicated energy crops can result in both trade-offs and synergies between climate change mitigation and other SDGs. These impacts of increased biomass demand are context specific and therefore spatially variable. For the bio-economy to provide a holistic contribution to sustainability, biomass impacts need to be quantified and regulated.

We looked at potential increase in the demand for industrial wood pellets, a type of bio-energy currently used in several European countries as a feedstock for electricity and heat production, and found that, added up over the landscape, increased wood pellet demand can have a relatively positive impact on

carbon stocks in biomass and soils. These changes in carbon storage were however spread out over the landscape of the southeastern US, and both losses and gains could be observed. Furthermore, biodiversity was influenced both positively and negatively, depending on the location and the indicator.

These studies highlight trade-offs between and within impact categories or SDGs. Many governance tools exist to sustainably steer the transition towards the bioeconomy, but key challenges remain related to dealing with trade-offs, attribution and system boundaries.

14 Technical and financial challenges in scaling up a bio-refinery using salmon waste

Kjartan Sandnes, Biomega

Biomega was established in 2000, aiming to add value to salmon offcuts from the filleting lines by means of biotechnical processes using industrial enzymes. We were three entrepreneurs with different backgrounds from the aquaculture sector, and the target was to develop products for human consumption, not only for feed ingredients, which was most common.

This presentation will comprise an overview of the technical challenges as well as the financial hurdles met early during the development of the company. For info on the present state, see www.biomegagroup.com.

15 Fermented products: design for manufacture

Andrew Ellis, Biocatalysts

This session will provide an insight into the main considerations for the design phase of new fermentation processes to maximise successful scale up to manufacturing scale. Some focus will be given to stakeholder management as an important feature for successful “Design for Manufacture”. The “time-cost-quality” trilemma will be described as an underpinning theme.

16 From lab to large scale: real-time insights and strategies in bioprocess scaling

Yvonne Armitage, CPI

It seems obvious when developing a new bio-derived product that scaling up is a key step to proving the viability of the process and this is often wrongly considered a straightforward linear operation. Cost of scaling is always a major consideration, however there are many more criteria to factor in to deliver a process that is technically feasible, cost effective and fit for purpose.

A lot of emphasis is put on upstream operations and optimising the fermentation when often a lot of the cost and development steps are in the downstream part of the process therefore a holistic approach to process design is essential. Feedstock type and availability, robustness of the process, reactor design, CAPEX and OPEX are just some of the aspects that need evaluation when scaling a bioprocess. The goal is to deliver a reproducible, robust and sustainable process that will allow the company to secure funding for full scale production and ultimately make money.

Some of the challenges and tips and tricks to consider when scaling a new bioprocess will be highlighted to help develop bioprocesses of the future.

17 Research progress and knowledge gaps in seaweed cultivation and valorisation

Thierry Tonon, University of York

The global seaweed market was valued at USD 6.5 billion in 2021, and is projected to reach USD 14.6 billion by 2031. Raw and processed seaweeds are currently used in many applications, for example for food, feed, cosmetics, and fertilisers. Increasing demand is driven by several factors including the need for new, bio-based, and biodegradable chemicals and materials.

Seaweeds can be farmed or collected from the wild. Seaweeds are classified into green, red, and brown algae, and belong to lineages with complex evolutionary history. Knowledge of seaweed biology has, for a long time, been lagging behind the understanding of other organisms such as plants, fungi, and animals, but this situation is changing thanks to the development and application of new technological approaches to seaweeds. Taking brown algae as examples, this presentation will illustrate how the development of the laboratory model system *Ectocarpus spp*. and studies of the crop *Saccharina spp*. have and continue to push the boundary of seaweed research.

In particular, applications of functional genomics and of genetic approaches are advancing basic knowledge on the physiology and life cycle of brown algae, which can be applied for farming and valorisation of these organisms. Despite such progress, many knowledge gaps remain in seaweed research and biotechnological approaches that are required to improve cultivation, expand processing, and foster innovation to support the Blue Economy in the context of a changing world.

18 Seaweed production in the UK: status, challenges and developments in aquaculture

Elisa Capuzzo, Cefas

Seaweeds have been harvested from the wild for centuries and traditionally used for food, feed and fertilizers. In the last decade, a resurgence in interest in seaweed has led to the development of seaweed aquaculture, with the first UK commercial seaweed farm established in 2015.

In addition to food, feed, fertilizers, seaweed biomass can be used to produce bio-stimulants, nutraceuticals, cosmetics, biofuel, bioplastic and biomaterial. In the UK, around a third of seaweed-related businesses target food and drink production, 19% of the businesses target beauty industry and 13% production of supplements/nutraceuticals. The number of UK seaweed-related businesses has more than doubled in recent years, following a similar trend as observed in Europe. There are no estimates of current seaweed production from aquaculture or wild harvest in the UK; however, as of September 2023 there are 25 marine licences for commercial seaweed farming granted in the UK, with more currently progressing through the licencing process.

Seaweed species farmed in the UK include brown seaweed (*Saccharina latissima*, *Laminaria digitata*, *Laminaria hyperborea*, *Alaria esculenta*), red seaweed (*Palmaria palmata*) and green seaweed (*Ulva spp*.). Farming of other red seaweed species such as *Porphyra spp.* (laver) and *Osmundea pinnatifida* (flat fern-weed) is still at the experimental stage. For the seaweed industry to grow and meet demand, several technical, financial, market and supply chain challenges need to be addressed, including poor knowledge of productivity, yield, reliability of farmed seaweed species and of available suitable sites, complex regulatory process, and knowledge gaps around environmental impacts.

19 Sustainable packaging in the context of a seaweed biorefinery focused on biopolymeric materials

Erinc Bahcegul, Notpla Ltd.

With a vast number of different species, seaweeds provide a wide range of biopolymers that can be used to produce sustainable natural materials particularly focused on packaging applications. Similar to other biorefinery perspectives, such as a second-generation lignocellulosic biomass-based biorefinery, the goal in a seaweed-based biorefinery focused on materials is to use various components found in seaweeds for different products through a multi-product approach that considers the material requirements.

Notpla uses different seaweeds and seaweed process by-products to create various materials intended for different applications. These include coatings for food containers, flexible packaging films, seaweed paper, gel pods, pipettes and rigid materials in various forms such as cutlery and containers. Seaweed-based natural materials compliant with the EU single use plastics directive (SUPD) provide a sustainable solution to the single use plastics problem.

20 The Norwegian Seaweed Biorefinery Platform

Finn Lillelund Aachmann, NTNU Norwegian University of Science and Technology

In recent years, Norwegian research institutions have developed technology for seaweed processing, and analytical methods for characterisation of seaweed biopolymers, chemicals, fibres, feed, food and bioactive compounds. To make better use of these advantages and knowledge, a national consortium has been established to coordinate efforts from research institutions and industry in developing technologies aiming at the creation of economically and environmentally sustainable seaweed biorefinery processes, and corresponding high-value and bulk product pipelines.

This national research-driven knowledge-based platform includes the main research institutions on seaweed in Norway and the goal of the platform is to serve as a hub for research, knowledge, methodology and stakeholder networking. This 5-year project was launched in May 2019 and is funded by the Research Council of Norway. More information and publications can be found under: http://seaweedplatform.no/

21 Interactive session exploring sustainability, biorefineries, and the role of policy

Joanna Sparks, Aston University

This interactive session on sustainability, biorefineries, and policy will delve into critical aspects of sustainable resource management and the role of policy frameworks. The session will feature flash presentations focusing on each of the key aspects of the biorefinery system, including efficient resource utilisation, waste reduction and valorisation and the challenges of scaling up in key industry sectors.

Throughout the session, participants will engage in interactive discussions to explore the intersections of sustainability, biorefineries, and policy, with a focus on identifying actionable strategies for fostering environmental stewardship and economic development.

22 BBSRC support for the clean growth area

Colin Miles, BBSRC, UKRI

BBSRC will describe some of the activities it has been involved in on behalf of the UK Department for Energy Security and Net Zero as well as the performance of the BBSRC funded industrial biotechnology area and what community interactions might look like post 2025, when the current support for the Networks in Industrial Biotechnology and Bioenergy comes to an end.

23 Innovate UK support for sustainable bio-based materials and manufacture

Dana Heldt, Innovate UK Business Connect

Materials and manufacturing are vital for the UK economy and the demand for products is growing. However, to achieve our Net Zero targets, we must adjust how we manufacture them. Sustainable biomaterials and biomanufacturing will be part of the solution. In this talk you will hear about IUK's activities in this area and how we can support you, as well as about funding opportunities.

24 Demonstrating the production of circular biobased textiles

Alexandra Lanot, University of York

The textile industry, exacerbated by fast fashion, is globally responsible for more greenhouse gas emissions than shipping and aviation combined. Consumer concerns, Net Zero targets and the adoption of new legislations such as Extended Producer Responsibility have led retailers and manufacturers to look for more sustainable textile fibres and a solution to textile recycling. Currently, the global production of raw fibre exceeds 100 million tonnes, 80% of them will end up in landfill or incinerated and less than 1% will be recycled into new clothes.

At the University of York, we have developed a biobased process that converts the cellulosic fraction of waste textiles into new cellulose that can be spun into textile fibres. Our biological concept has advantages over mechanical or chemical approaches for recycling. We can produce 500g cellulose per month in the lab, which is enough for spinning trials but not enough to produce fabric and assess the commercial potential of the proposition to investors.

Our main barrier to scaling up is that our fermentation is carried out statically in large shallow trays. Alternatives to static fermentation have been published but none have been used commercially. To improve on this, we have partnered with the Biorenewables Development Centre at York that has expertise in fermentation and access to stirred and airlift fermenters.

Our aim is to produce enough cellulose to manufacture a swatch of fabric and demonstrate our circular approach. We have also engaged with other industry sectors. We have partnered on this proposal with AgrifoodX that has expertise in developing sustainable solutions for packaging.

25 Bioacrylic acid production from seaweed

Jonathan Todd, University of East Anglia

Annually 6.3 million tonnes of acrylic acid, worth > $12 billion, is synthesised from fossil fuels as a platform chemical for e.g., textiles, adhesives, paints. Currently, biosynthetic alternatives are too costly/inefficient for industry, and companies have described this illusive process as the "holy grail for bioindustry". Here we detail our work to reduce carbon emissions from acrylic acid production through a cost-effective microbial biosynthetic route from algal and agricultural waste.

26 Development of enzyme-based biotechnology to support the wool industry transition to a circular system

Jinsong Shen, De Montfort University

There are increasing demands for textile materials to be sustainable and recyclable for circularity, and a reduction of negative impacts to the environment. Enzyme-based biotechnology could provide an alternative solution to improve wool fibre performance and limit the impact of wool processing on the environment.

The current research explored biotechnology for *in-situ* enzyme-catalysed coloration of wool, and for recycling and reuse of low value wool and/or post-manufacture waste wool feedstocks to extract wool polypeptides for their applications. The extracted polypeptides were utilised for grafting on virgin wool fabrics to improve shrink-resist property of wool fabrics during washing and remain recyclable due to no added on chemical additives or synthetic polymer.

Results obtained are being further developed within an ongoing BBSRC-funded project ENZBIOTEX (BB/X011623/1) for developing enzyme-based biotechnology for fibre-to-fibre recycling. Post-consumer/manufacture or waste wool/bast fibre blended upholstery fabrics are currently being explored for recyclability and reuse by separating the fibre components and re-processing extracted bast fibres back to fabric production. In addition, the project has also demonstrated the potential to extract the dyes from waste fabrics and reuse for textile coloration. The outcomes from the projects could support the transition of the textile industry to a circular system.

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P01 On-demand production of bio-ethylene oxide in a two-step dehydration-epoxidation process with chemical looping operations

Joseph C. Gebers, Ewa J. Marek

Ethylene oxide (EO) is a key chemical intermediate produced almost exclusively from petrochemically derived ethylene. Presented herein is a novel process for on-demand production of bio-EO from bioethanol. Ethanol, laboratory-grade or denatured, was first dehydrated to ethylene over HZSM-5 (at 280°C) or γ-$A_{l2}O_3$ (at 350°C) catalysts, producing ethylene and water. The ethylene stream was then selectively oxidised to EO over Ag/$SrFeO_3$ at 270°C using lattice oxygen from a solid – $SrFeO_3$, employed to drive chemical looping epoxidation (CLE).

For a configuration where the dehydration and epoxidation reactions were carried out in separate reactors, the process produced EO with 57% selectivity at 15% conversion of ethylene, thus exceeding the incumbent approach with pure Ag/α-Al_2O_3 and O2(g). In an alternative configuration, experiments were carried out in one dehydration-epoxidation reactor layered with two catalysts: HZSM-5 and Ag/$SrFeO_3$.

The results revealed that water presence at a percentage level enhanced unselective combustion. *In-situ* removal of water, possible with an additional layer of a drying material between the two catalysts, proved effective in boosting the process performance, reaching selectivity to EO of 50% at 12% conversion of ethylene. The catalysts showed no sign of deactivation when using denatured ethanol or when performing experiments intermittently. Hence, our novel process can be kept offline without penalty, allowing for on demand production and complete alignment with renewable resources, including bioethanol waste.

P02 Comparison of extraction and quenching methods for the analysis of intracellular metabolites in microbial cells by UPLC-MS/MS

Daniel Chaplin, Angela Pinnington, Tatyana Chernikova, Anna Khusnutdinova, Rolf Kraehenbuehl

A fast, sensitive and robust method for extraction and quantification of intracellular metabolites in microbial cells is important for the analysis of their metabolic activity and product formation. The data inform synthetic biology approaches and the metabolic modelling of microbial responses to genetic modifications and environmental changes like different feedstocks and the availability of nutrients.

Using ultra-performance liquid chromatography (UPLC) coupled to a triple quadrupole mass spectrometer (TQMS), we compared different extraction and quenching methods for the quantification of eight intracellular metabolites (ATP, ADP, AMP, Acetyl-CoA, NAD^+, NADH, $NADP^+$ and NADPH) in *E. coli* cells.

The extraction and quenching methods can be applied to a range of microorganisms like bacteria and yeasts sampled from a variety of environments including fermentation cultures grown under different growth conditions. The proposed fast UPLC-MS/MS method increases sample throughput, while fast polarity switching and improved chromatographic separation maximise analytical sensitivity.

P03 Woodborer enzyme discovery for lignocellulose decomposition

Katrin Besser, Juliana Sanchez Alponti Millar, Rachael Hallam, Jared Cartwright, Adam Dowle, Christopher Lancefield, Edward Nay, Talia Kirkbride, Wendy Offen, Gideon Davies, Neil C. Bruce

Woody (lignocellulosic) plant biomass is an abundant renewable carbon source, rich in polysaccharides that are bound into an insoluble fibre composite with lignin. It has the potential to replace petroleum as an industrial feedstock, but costs of deconstructing lignocellulose into simple biochemical building blocks are remaining high due to the recalcitrance of the material to degradation.

Understanding how lignocellulose is degraded in nature can provide us with new tools and concepts for its industrial conversion. Marine crustacean woodborers of the genus *Limnoria* (an isopod) and *Chelura* (an amphipod) are among the few animals that can survive on a sole diet of this recalcitrant material without relying on gut resident microbiota. Analysis of fecal pellets revealed that *Limnoria* targets mainly cellulose, corresponding with the abundance of cellulases in their digestive system, whereas hemicelluloses and lignin are largely unconsumed. We have characterised one of the cellulases, a salt tolerant cellobiohydrolase of glycosyl hydrolase family 7 (GH7), and hemocyanin, the O_2-carrier in the hemolymph of arthropods, present in the gut of *Limnoria* where

it enhances lignocellulose digestibility by cellulases, likely due to lignin modifications caused by its phenoloxidase activity.

Here, we report the identification and characterisation of new digestive CAZymes (carbohydrate active enzymes) from the isopod and amphipod crustacean woodborers that play a role in hemicellulose modification during digestion. These carbohydrate esterases function in xylan de-acetylation and may increase the accessibility of the polysaccharides by cellulases.

P04 Valorising nitrogen-rich waste streams as substrates for microbial lipid production

Nicholas A Tenci, Laura K Martin, Wei E Huang, Ian P Thompson

Microbial lipids are a potential renewable source of highly desirable plastics, fuels, and chemicals. However, the limited availability of economical substrates for their synthesis constrains the deployment of these materials. Certain organic waste streams have demonstrated great potential as substrates but these offer their own challenges which must first be overcome. One such stream is the volatile fatty acid rich fermentate generated from acidogenic fermentation of a huge range of biological waste, from food and agricultural residues to manure and sewage. However, this fermentate is often also rich in nitrogen, which is known to inhibit lipid accumulation across the majority of microbial species.

To address this issue, we have investigated a simple, low-cost and scalable nitrogen removal treatment for the fermentate to improve its suitability as a substrate for microbial lipid production. This treatment resulted in a substrate with a high carbon-to-nitrogen (C:N) ratio. Early data utilising this substrate indicates a several fold increase in accumulation of polyhydroxyalkanoates in Pseudomonas putida after treatment, and we are currently probing for similar results in microbial lipids across multiple bacterial species of commercial and industrial interest.

In the next stage of this project, we will focus on the efficiency of nitrogen removal and recovery. We will test several reagents in an attempt to recover nitrogen in a form usable to either industry or agriculture. These data will be used to assess the economic and environmental costs of the treatment and to compare this to the resulting benefits gained by improved bioproduction.

P05 Enhancing sustainability in lignocellulosic biorefineries: enzymatic valorisation of Xylan from residual plant biomass

Ornella Ontañon, Laura Navas, Juliana Topalian, Mercedes Garrido, David Leudo Orozco, Caio de Mello Capetti, Vanessa Arnoldi, Igor Polikarpov, Leonardo Gomez, Eleonora Campos

The valorisation of the hemicellulose fraction from plant biomass processing plays a critical role in the sustainability of lignocellulosic biorefineries. Since aerobic bacteria employ a sophisticated array of enzymes to degrade plant cell wall polysaccharides, in this study we focus on the extracellular proteome of the soil bacteria *Cellulomonas sp*. B6. We have identified the enzymes responsible for its xylan-degrading activity and expressed them in recombinant hosts to purify and characterize their enzymatic activities, as well as determining their structural characteristics. Furthermore, we have explored the specificity and synergy of four xylanases (three from family GH10 and one from family GH11) in tandem with enzymes that act on xylan decorations (specifically α-L-arabinofuranosidases from families GH62 and GH51 and an α-glucuronidase from GH67 family).

Based on the results derived from this research, we designed specific enzymatic blends for diverse residual lignocellulosic biomass feedstocks. This approach enables us to obtain a spectrum of substituted and unsubstituted xylo-oligosaccharides with prebiotic potential, thereby generating value-added products from agro-industrial waste materials.

P06 MSAD: Methanosarcina Detection and Addition for Optimised Anaerobic Digestion

Caroline Hayley Orr, Samantha Cook

MSAD will demonstrate the potential of Methanosarcina as an inoculant for the AD industry and develop an optimised method for detection.

Anaerobic digestion (AD) is a complex biological process whereby organic waste is broken down to produce biogas. Across AD facilities microbial communities present within the digesters differ relating to digester conditions and waste feed which links to system productivity. Methanogenesis, the production of methane, is often the rate limiting step. Previously we have observed *Methanosarcina* abundance being correlated with optimised digestion. Within this study we aim to use *Methanosarcina* as an inoculant for the AD industry to improve biogas production. Monitoring the microbial

communities within AD takes time, money, and expertise. Developing a simple testing system which allows monitoring of key members of the community allows for quick measurement of digester health and targeted optimisation.

We aim to investigate the robustness of *Methanosarcina* inoculants within a trial system to test their ability to colonise. Additionally, we will investigate methods for quickly identifying *Methanosarcina* by optimising a qPCR system.

P07 Biosensors and biocatalysis for biorefinery

Micaela Chacon, Neil Dixon

Linear consumption models maintain our reliance on fossil fuel-based feedstocks and the poor teatment of our waste results in negative impact upon the climate and environment. The use of genetically engineered microbes (GEMs) can provide tractable approaches to address sustainability challenges including the production of energy, chemicals and materials from non-fossil fuel-based sources. Sustainable production from renewable biomass and other carbon-rich waste offers one potential alternative to the continued use of finite geological oil reserves.

However, in order to compete with current petrochemical refinery processes, alternative biorefinery processes must overcome significant costs and productivity barriers. Pathway design and optimization is a major bottleneck due to the vast number of possible genetic and process variables and the metabolic burden associated with bio-production. However, genetically encoded biosensors can provide a solution by transducing the target metabolite concentration into detectable signals to provide high-throughput phenotypic read-outs and allow dynamic pathway regulation.

This poster presents some approaches and activities towards addressing these engineering biology challenges. This includes the development of advanced biorefinery processes by consolidated production of high-value chemicals directly from waste agro-industrial residues, microbial processes to degrade and assimilate plastic and other waste feedstocks, and the development of underpinning genetic toolbox to control GEMs for sensing, regulation and production.

P08 Liquid extracts of the brown seaweed *Ascophyllum nodosum* for the development of antimicrobial marine paints

Nick Sweygers, Luca Verelst, Joeri Horvat, Raf Meskens, Geert Potters, Olena Moshynets, Olga Iungin, Raf Dewil, Lise Appels

The transition toward environmentally friendly active substances prompted the search for replacing tributyltin (TBT). TBT was used as antifouling agent in marine paints that, due to its toxicity, prevents growth of marine organisms on ships. However, when leached into the environment, TBTs exhibit endocrine disruptive effects on these organisms. In the literature, antifouling, antimicrobial and antioxidant properties have been ascribed to brown seaweed compounds, e.g. alginate, fucoidan, etc. Hence, this study explored use of these compounds as antimicrobial agents in maritime paints. Several brown seaweeds (e.g. *Ascophyllum nodosum*) were harnessed for microwave-assisted extraction and a biphasic system was used to separate components of interest in the organic phase (e.g., polyphenols) and remove microorganism nurturing compounds (e.g. mannitol) via water. Additionally, one-phase (organic solvent) extraction was applied. Two organic solvents were investigated, which (i) have relatively low boiling points and (ii) have good miscibility with paint. Both ethyl acetate (EthAc) and methyl isobutyl ketone (MIBK) meet these criteria. First, seaweed extracts were produced. Briefly, 20 wt% dried seaweed powder was added to 400 mL (1:1 organic:water) for treatment at 120°C for 15 min. Next, the extracts were evaporated until 15 mL remained and subsequently processed (16.7 v%) into a marine paint (Sigmacover 456). The antimicrobial and antibiofilm characteristics were evaluated using a plating assay and MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay, respectively. The results showed inhibitive effects on the gram-positive *S. aureus* (5-10 times fewer cells) treated with one-phase *Ascopyllum nodosum* and *Sargassum muticum* in EthAc; however, antibiofilm effect was not demonstrated.

P09 Development of an innovative biomass pre-treatment process for a better biorefinery

Yujie Mao, Ilayda Tarhanlı, Erkan Senses, Eleanor Binner

The production of biofuel and biochemicals from lignocellulosic biomass often require a pre-treatment step to break its recalcitrant structure and to remove the large quantity of lignin as it reduces biomass biorefinery efficiency. Industrial removal of lignin uses Kraft process, which involves strong alkali

solution. Literatures have also extensively studied the use of organic solvents. However, both methods are not sustainable and require hydrothermal condition above 180°C for more than 2 hours, which often cause degradation of the lignin into fragments with no further values. In our previous work, we successfully achieved high efficiency of lignin removal using novel and sustainable Deep Eutectic Solvent (DES) and clean energy from microwaves, and we were able to obtain intact lignin with further application potentials. However, the influence of different solvents on the preservation of cellulose fractions for further biomass biorefinery is still unknown.

Therefore, in this work, we will systematically compare the use of a Kraft solution (2.5 M NaOH and 0.4 M Na_2S), an organic solvent (70% ethanol in water) and a DES (p-Toluenesulfonic acid: Choline Chloride: Glycerol in 2:1:1 molar ratio) on both the cellulose and lignin product streams. We aim to develop the optimum biomass pre-treatment method that can simultaneously achieve the recovery of intact lignin with further application potentials and to best preserve the cellulose fractions that may be more amenable for biomass biorefinery and the production of biofuel/biochemicals. Results will be presented at the conference.

P10 Optimization of high-solid enzymatic hydrolysis of two-step alkaline and dilute acid-pretreated sugarcane bagasse at low enzyme loadings by response surface methodology

Longinus Ifeanyi Igbojionu, Cecilia Laluce

Sugarcane bagasse – a lignocellulosic material derived from sugarcane after crushing and extracting of its juice - is a promising feedstock for bioethanol production. The current study presented a two-step alkaline and acid pretreatment of sugarcane bagasse using sodium hydroxide and maleic acid as a strategy to enhance enzymatic digestibility of sugarcane bagasse. The two-step alkaline and acid pretreatment resulted to a significant increase in glucan content (69.72%) with accompanying decreases in xylan (12.99%) and lignin (4.89%) contents. Preliminary study on enzymatic hydrolysis of the two-step alkaline and acid-pretreated sugarcane bagasse with low solid loading and low cellulase concentrations resulted to high glucose yields. Optimization of high-solid enzymatic hydrolysis of two-step alkaline and acid-pretreated sugarcane bagasse was executed based on Box-Behnken design (BBD). BBD – a response surface methodology - is a powerful method that can be used to test several parameters by applying a minimum number of experimental trials. The optimal level of process variables as indicated by the statistical model namely solid loading (20%, w/w), incubation time (72 h), enzyme loading (2 FPU/g glucan), and substrate feeding (mode 2) were validated. Optimization of the process parameters resulted to 61.85% of glucose yield which was close to its predicted value (65.71%). The current study highlights the potential of high-solid enzymatic hydrolysis using two-step alkaline and acid-pretreated sugarcane bagasse for efficient fermentable sugar production.

P11 Cultivation of chemoautotrophs on electricity and air

Robin Hoeven

This is a proof of concept study that looks at ways to grow chemoautotrophic bacteria on electricity, either with a mediator molecule or via direct electron uptake from an electrode. We solely conduct experiments under aerobic conditions, as the main aim is to use CO_2 from air as the carbon source.

The first step is using axenic strains of chemoautotrophs that will be tested for growth with reduced versions of a mediator molecule. To find the optimal voltage for reduction of the mediator molecule we do cyclic voltametry (CV). This is followed by chronoamperometry to fully reduce all of the mediator compound in solution before it is mixed into the medium.

Furthermore, we will also look at environmental samples to conduct an enrichment experiment to select for organisms that can accept electrons from an electrode and use CO_2 from air.

Any help or suggestions are greatly appreciated, particularly on the electrochemistry.

P12 *Vibrio natriegens*: an ultrafast-growing marine bacterium as PHB producer for industrial production

Roger Romero Jimenez, James Winterburn

Polyhydroxybutyrate (PHB) represents an appealing biodegradable polymer that can be synthesized via microbial fermentation. However, the widespread production of PHB has faced challenges, such as the inefficient use of organic wastes due to inhibitory substances, slow microbial growth, and the high energy input required for feedstock sterilization. In this study, we employed *Vibrio natriegens* to enhance PHB production, the most rapidly growing bacterium known with high tolerance to salt and toxic substances. It was possible to produce 0.45 g/L of PHB in less than 12 hours and 1.97 g/L of PHB

in 80 hours in 2L bioreactors under nonsterilized fermentation conditions. This work underscores the significant potential of engineered *V. natriegens* for cost-effective PHB bioproduction and establishes a foundation for utilizing this strain as a leading model microorganism for the Next Generation of Industrial Biotechnology.

P13 Optimisation of catalytic production of 5-hmf and furfural using phosphotungstic-derived heteropoly acids

Zongyuan Zhu, Kamelia Boodhoo, Fernando Russo Abegão

Phosphotungstic-derived heteropoly acids (HPW) catalysts, where one atom of W was replaced by Cu, Zn or Sn, were synthesised and supported on alumina. The catalysts were applied in C5/C6 sugar dehydration to produce furfural/5-hydroxymethylfurfural. The HPW-Sn/Al_2O_3 catalyst contributed to the best products yields, because its highest Brønsted acidity (0.023 μmol/g) which facilitated sugar dehydration, and moderate Lewis acidity (0.477 μmol/g) which was beneficial to xylose and glucose isomerisation. The influence of process conditions, including temperature (120-160°C), time (1-3 h), and sugar to catalyst mass ratio (50 and 25), on sugar conversion and yields of products was studied using a synthetic sugar mixture. Temperature was the most influential parameter, enhancing sugar conversion and yields of furans. Increased reaction time generally improved sugar conversion, but reduced product yields. Increased sugar:catalyst mass ratio generally had less influence on product yields. The optimised furan yields from synthetic sugar mixture, especially furfural, were obtained at 160°C, for 2 h. Compared to other catalysts, HPW-Sn/Al_2O_3 contributed to good C5 and C6 sugar conversions (56% and 75%) and the highest yields of total furans (27%). The HPW-Sn/Al_2O_3 catalyst was used under optimised reaction conditions to convert an industrial hemicellulose stream with a total furan yield of 33.6%.

P14 Catalytic activity of Pulcherrimin: a green, natural, water-tolerant, and highly active heterogeneous biocatalyst for base-free 5-hydroxymethylfurfural oxidation

Swathi Mukundan, Fabio Santomauro, Noelia Villarroel, Jonathan L. Wagner

This project explores the potential of utilising the bio-based mineral pulcherrimin as an affordable, non-toxic, and fully renewable catalyst for oxidizing 5-hydroxymethylfurfural (5-HMF) into 2,5-furandicarboxylic acid (FDCA). FDCA serves as a crucial precursor for bioplastic synthesis, offering a 45–55% reduction in greenhouse gas emissions compared to conventional PET. Catalytic tests were conducted at 100°C in a high-pressure batch reactor with a 10-bar oxygen pressure, using a pulcherrimin:5-HMF ratio of 1:2.

P15 Sustainable seaweed: analysing environmental impacts of production and use

Tom McMurray, Beatrice Smyth, Pamela Walsh, Joe Livingstone

Seaweed aquaculture is becoming increasingly recognised for its potential utility and sustainability benefits, but the environmental impacts of cultivating seaweed for purposes such as biomass production, feed enrichment or alginate production need to be further examined. This study employs life cycle assessment (LCA) to quantify and understand the environmental impacts of seaweed cultivation and products, addressing a gap in the current literature. The LCA method was chosen as it can pinpoint system hotspots, avoid burden shifting and allow for comparative and sensitivity analysis to further explore findings. Preliminary findings will be presented. Key expected impact areas include global warming potential, eutrophication, ecotoxicity and acidification. Using preliminary data from the various stages across the supply chains, areas with a high environmental impact are identified and recommendations made to help ensure seaweed farming is a viable, eco-friendly approach supporting clean growth and global sustainability goals. Ongoing research will further assess the environmental implications of the seaweed supply chain from production to end-of-life products to help guide future sustainable practices in industry.

P16 Biofabrication of melanin-infused bacterial cellulose via co-culturing approach with *In-Silico* designed acidophilic tyrosinase

Joshua Loh, Katie A. Gilmour , William Cheung, Warispreet Singh, Paul James, Tom Ellis, Martyn Dade-Robertson, Meng Zhang

Bacterial cellulose (BC) has gained recognition for its versatility and emerged as a promising sustainable textile alternative in recent years. However, the application of BC in the fashion industry necessitates a dyeing process, often associated with environmental and health concerns. Recent

efforts have focused on creating self-dyeing bacterial cellulose through the genetic engineering of *Komagataeibacter rhaeticus*, producing recombinant tyrosinase1. Despite promising results, this process requires an additional production step to activate tyrosinase enzyme activity. Addressing this challenge, our study employs *in silico*-designed acidophilic tyrosinase for functional modifications, facilitating a one-pot co-culturing fabrication method.

Utilising Tyr1 from Bacillus megaterium as the template, we designed an acidophilic tyrosinases through *in-silico* modelling. Along with 6 natural acidophilic tyrosinases 2, it was cloned and expressed in E. coli BL21 and *B. subtilis* 168. The enzyme assays were conducted using whole cells and cell free extract, and LC-MS/MS analysis revealed the precursors involved in melanin production and regulation. The product was identified as eumelanin, confirmed by detecting eumelanin breakdown markers and the absence of cysteinyl-DOPA from Tyr-expressing *E. coli*. Melanised BC were successfully fabricated in a single step during BC growth by optimising the co-culturing of *K. xylinus* with *E. coli* Tyr+ or *B. subtilis* Tyr+ strains. Post-production treatments were applied to the melanated BC, revealing that EtOH was more effective than H_2O for colour fastening, and the drying process had minimal impact on colour loss. This method paves the way for biofabricating coloured BC, advancing the revolution of BC as an alternative sustainable textile.

P17 Energising Nigeria: the role of modern bioenergy in a sustainable future

Prince Anthony Okoro, Katie Chong, Mirjam Röder

Nigeria's 2022 National Energy Masterplan shows that the country envisioned a GDP growth from 7% to 13% by 2030 through industrialisation. To achieve the vision, considerable amounts of energy are needed in the industrial and transport sectors. Bioenergy can support the energy supply of these sectors and offer renewable carbon benefits and a high level of flexibility.

This presentation research developed novel bioenergy case studies to support Nigeria's energy and agricultural sectors. In the first step, we used expert interviews with stakeholders from government departments, small- and large-scale industries, and feedstock producers in Nigeria to identify current bioenergy applications and preferences for bioenergy deployment. A qualitative content analysis showed that the current bioenergy deployed in Nigeria is dominated by anaerobic digestion and combustion technologies. There was limited awareness of other modern bioenergy applications and technologies even though Nigeria's Energy Masterplan supports the efficient use of biomass to generate clean heat, electricity and biofuel for industrial, transport and household applications. We have developed novel bioenergy case studies based on these findings to support biomass integration into Nigeria's energy system.

We will show the results of the techno-economic and socio-economic analysis of the bioenergy case studies that cover a range of feedstocks, biological and thermo-chemical processing, energy vectors and uses. The findings can inform policies, industries, and society on the role of modern bioenergy in the industrialisation agenda and the cost of transition to a low-carbon future in Nigeria.

P18 Low carbon transition pathways for the global chemical industry

Fanran Meng, Jonathan Cullen

Chemical products, such as plastics, solvents, and fertilizers, are essential for supporting modern lifestyles. Yet, producing, using, and disposing of chemicals creates adverse environmental impacts which threaten the industry's license to operate. This study presents seven planet-compatible pathways toward 2050 employing demand-side and supply-side interventions with cumulative total investment costs of US$1.2–3.7 trillion. Resource efficiency and circularity interventions reduce global chemicals demand by 23 to 33% and are critical for mitigating risks associated with using fossil feedstocks and carbon capture and sequestration, and constraints on available biogenic and recyclate feedstocks. Replacing fossil feedstocks with biogenic/air-capture sources, shifting carbon destinations from the atmosphere to ground, and electrifying/decarbonizing energy supply for production technologies could enable net negative emissions of 0.5 $GtCO_2eq\ y{-}1$ across non-ammonia chemicals, while still delivering essential chemical-based services to society.

P19 Evaluating the performance of inkjet-printed transparent anode in biological photovoltaic systems

Maira Anam, Helena Gomes, Rachel Gomes, Geoffrey Rivers, Ricky Wildman

Biological photovoltaic systems (BPV) are bioelectrochemical systems that exploit oxygenic photosynthesis to generate electricity from light. This technology has attracted increased attention

in the last two decades due to its potential to harvest energy from water, air, and sunlight. BPV provides an additional advantage over photovoltaic and microbial fuel cells by producing electricity in the dark without continuous media supplementation. Despite the remarkable theoretical potential, BPV technology has struggled to progress from lab to pilot scale owing to the low current output presently achieved in the lab. Moreover, the lack of understanding of the electron transport pathways in cyanobacteria, standardisation of experimental setup, and intrinsic loss of energy to cellular metabolism further hinders the commercialisation of BPV. A worthy improvement in the physical device would be optimising the anode design and architecture to maximise surface area for microbial attachment whilst upholding the spatial area of the BPV device. Similarly, better incorporation of light inside the BPV device will improve light access to photocatalytic material on the anode. The homogenous distribution of light is crucial to add dimension to the anode structure.

P20 The supplant company: the ingredient house for big food's big health and climate commitments

Alexander Nicholls, Gemma Humby-Smith, Tom Simmons, Jeremy Bartosiak-Jentys, Harriet Pope

Diet sodas are everywhere, but despite this the food industry still cannot economically produce sugar free foods, like cookies and cakes, at the quality and price we would expect. Sweeteners like stevia work great in drinks, proving thousands of times the sweetness for the same amount of sugar, but they are no good in cakes; the texture, mouthfeel and colour are all wrong. In summary, the drinks industry can make 'coke zero', but it cannot make 'cake zero'.

Food ingredients generally have one thing in common, they derive from just one part of the crop. Sugar cane is one of the worst - only about 22% of the material harvested is used. The remaining biomass is mostly wasted. Biomass is made of fiber – the only macronutrient we don't get enough of.

At the Supplant Company, we make use of Enzymatic Biotechnology to process the remaining biomass into fibre-rich ingredients for the food industry; first sugars and following up with flours. Thus, we make use of engineering biotechnology to transform valueless plant matter into delicious food, hence solving the 'food system trilemma' (nutrition, environmental impact and food security) all together!

P21 Building a formatotrophic eukaryote – *Y. lipolytica* evolves to grow on formate

William Newell, Piotr Hapeta, Rodrigo Ledesma Amaro

Conventional biomanufacturing feedstocks suffer from both questionable sustainability and limited scalability. While photoautotrophic microorganisms may avoid these problems, the low efficiency of biological light energy harvesting, and the inefficiency of natural carbon fixation pathways limits their utility. Reduced single-carbon (C1) compounds like formate can be made by electrically reducing carbon dioxide and then assimilated with higher efficiency than CO_2. However, few organisms have been engineered to use formate a sole carbon source and no eukaryote able to grow on formate alone has been engineered or isolated. *Yarrowia lipolytica* is a non-model yeast with considerable production capabilities and an increasingly clear ability to use formate as an energy source.

Here, we use HPLC and C^{13} metabolomics to explore *Y. Lipolytica's* ability to use formate as a carbon and energy source. These data are used to inform adaptive laboratory evolution experiments which produce a strain able to grow on formate as a sole carbon source within 30 generations. To our knowledge this is the first example of synthetic formate assimilation metabolism emerging via evolution alone and represents the first example of a THF-mediated pathway supporting full growth in any eukaryote.

We then engineer redox metabolism as well as formate resistance mechanisms to improve growth 5-fold. These experiments are then used to inspire bioproduction of a terpenoid from formate, demonstrating for the first time that a long-chain heterologous product can be produced from formate and proving that *Y. Lipolytica* has great potential as a bioproduction host.

P22 Improving the production of second generation biofuels by exploiting the natural diversity of the yeast *Scheffersomyces stipitis*

Chloe Uyl, Alessia Buscaino

More so than ever, we are noticing the impacts of global warming which is why it is crucial that action is taken now. A significant shift in our approach to energy and low carbon technologies will be required to meet net zero targets by 2050. Biofuels produced from biomass play an important role in the decarbonization of the transport sector. Lignocellulosic represents one of the largest renewable sources of waste biomass which can be used to produce second generation bioethanol. The use

of feedstocks such as lignocellulosic prevents compromising food security by using biomass that would have otherwise been combusted or left to decompose. Lignocellulose is a complex polymer consisting of cellulose, hemicellulose, and lignin. Hemicellulose is composed of various pentose and hexose sugars that can be fermented into ethanol for second generation biofuel by microorganisms such as yeast. The non-conventional yeast *Scheffersomyces stipitis* has the highest native capacity for pentose fermentation of any known microorganism; and is therefore a suitable choice for second generation bioethanol production as it can ferment both pentose and hexose sugars.

However, low ethanol tolerance and sensitivity to the inhibitory compounds generated during second generation biofuel production limit the potential application of *Scheffersomyces stipitis*. In this study, a collection of *Scheffersomyces stipitis* natural isolates were screened in a range of industrially relevant conditions. Through this screening, several natural isolates were identified as superior bioethanol producers. Whole genome sequencing and CRISPR-Cas9 were used to link differences in genome organization to the different phenotypes observed.

P23 From lignocellulosic biomass to chemical wealth

Mauro Adriel Rinaldi

Our society needs to transition away from petrochemicals in the manufacturing of high-value chemicals to meet global sustainability and carbon goals. These everyday chemicals include life-saving medicines, agrichemicals, and flavours and fragrances in our toothpaste and cleaning products. The challenge is that manufacturing of carbon-based chemicals cannot be decarbonised, and biomass is the only material abundant enough to displace petrochemicals. However, bio-based conversion of biomass into chemicals is challenging and has relatively low yields.

We are exploring a new solution. In partnership with companies, we are using cellulose purified from wood waste as a feedstock to grow chemical-producing microbes in an industrial biotechnology approach. We are also using new engineering biology approaches to create subcellular compartments and new microbial industrial strains to overcome production limitations given by chemical toxicity. Our preliminary data shows that this type of cellulose is readily digested to glucose and converted to a target chemical, and that expressing subcellular compartment making proteins increases high-value chemical production.

This is promising preliminary data for the use of synthetic organelles for applications in biotechnology. Further research and optimization, and developing a process with techno-economic and life cycle assessments to evaluate the commercial viability and sustainability claims of the technology, respectively, will guide future development.

We thus aim to provide environmentally friendly options for low-carbon chemical manufacturing while contributing to global Net Zero targets and growing the Bioeconomy.

P24 Exploring the potential of cyanobacteria to produce extracellular polymeric substances

Christine Steffen, Yanming Wang, Alex Conradie, Jon McKechnie, Konstantina Kourmentza

Cyanobacterial extracellular polymeric substances (EPS) are naturally occurring compounds with potential for various biotechnological applications, due to their emulsifying, flocculating, gelling and bioactive properties. The aim of this study is to attain a carbon-neutral, economical EPS production process with cyanobacteria. The research focusses on screening novel cyanobacteria species and optimizing the culture conditions for the most promising species.

The results of the screening experiment were promising, as all 15 novel species were found to produce EPS (up to 2.8 g/L). Composition analysis revealed that the EPS consisted mainly of sugars, and smaller fractions of proteins and sulphate. Presence of at least 11 different monosaccharides was found. Based on the results of EPS production and composition, seven species were selected for biotechnological properties analysis. The results revealed that the EPS exhibited antioxidant, metal-chelating, emulsifying and flocculating activities. This makes the EPS suitable for applications in cosmetics, food and wastewater treatment. Especially the emulsifying properties were noteworthy, as the EPS of three species showed emulsifying properties similar to Tween20 (synthetic emulsifier) and 2-3x better than xanthan gum (natural emulsifier) at 2g EPS/L.

The most promising species was selected for optimisation of cultivation conditions. The EPS production was doubled using single-factor-optimisation (light intensity). This was further enhanced using multi-factor-optimisation to investigate the combined effect of light intensity, temperature and media composition. Further experiments on the effect of CO_2 on EPS production are planned. The

obtained data will be used to perform a techno-economic assessment and determine the feasibility of the production process.

P25 Bioremediation of heavy metals using yeast: a comparative study of metal nanoparticle biosynthesis, characterization, and genetic contributions

Walid Omara, Philip Gardinar

The contamination of the environment by heavy metals poses significant risks to ecosystems and human health. In response, eco-friendly bioremediation methods are gaining attention. *Saccharomyces cerevisiae*, a well-known yeast, is promising for remediating heavy metal pollution through biosynthesis of metal nanoparticles. This project explores *S. cerevisiae's* role in bioremediation, focusing on various metal nanoparticle production, including gold, selenium, chromium, vanadium, and more.

It examines the mechanisms behind metal nanoparticle production by *S. cerevisiae*, detailing the biochemical pathways and enzymes responsible for reducing and stabilizing heavy metal ions. Comparative analyses highlight differences in nanoparticle synthesis efficiency and specificity for different heavy metals, revealing the selective nature of these processes.

The project discusses characterizing the metal nanoparticles produced by *S. cerevisiae*, emphasizing their physicochemical properties and potential applications in environmental and biomedical fields. Various analytical techniques are used to determine size, shape, surface charge, and crystallinity, influencing their suitability for different applications.

Genetic contributions and metabolic pathways in *S. cerevisiae* for nanoparticle biosynthesis are evaluated, with genetic engineering enhancing metal tolerance and nanoparticle production. This underscores the potential for optimizing bioremediation processes.

Overall, *S. cerevisiae's* utilization in heavy metal bioremediation through metal nanoparticle biosynthesis demonstrates its versatility and potential in addressing environmental pollution. This project offers insights into the genetic and biochemical factors influencing nanoparticle production, contributing to sustainable environmental management efforts.

P26 Using crops, not food waste, as a feed-stock will reduce chemical use on farms

Michael Lewis

Chemicals are needed on farms to suppress weeds and protect crops from attack by insects, viruses and fungi. Although products are safety tested, and regulations about application are in place, it is impossible to eliminate all risk to farmers, bees, wildlife and the general public. The question is – how can pesticide use be reduced without reducing farm incomes? A large part of the answer is – longer crop rotations. On my farm, some fields have been growing wheat continuously for 11 years, others are on a 3-year rotation of wheat, barley, oil-seed rape. Potatoes can only be grown one year in six. If farmers are to reduce chemical use, they need a wider range of profitable crops to extend the rotation to 4, 5, 6 years.

P27 Addressing plastic recycling impacts in the UK

Zeinab Zandieh, Patricia Thornley, Katie Chong

This research delves into the environmental consequences of recycling High-Density Polyethylene (HDPE) and Polyethylene Terephthalate (PET) plastics, which are the most common commercial plastics in plastic packaging in the United Kingdom. Employing a life cycle analysis (LCA), we systematically evaluate HDPE and PET plastics, including recycling.

The study quantifies ecological impacts and energy requirements by examining plastic waste reprocessing routes via mechanical or chemical recycling. We aim to comprehensively understand the environmental costs of recycling these plastics, considering the circular economy and waste management metrics.

The practical implications of the research findings for sustainable waste management techniques are notable as they provide valuable insights that can guide industries, inform governmental decisions, and raise public awareness. Understanding the environmental costs associated with plastic recycling is essential as the globe faces growing waste concerns. Findings indicate that some recycling metrics cannot be measured sustainably due to adverse environmental effects, while circularity crosses the recycling aims. This poster seeks to provide clear insights by highlighting the evident environmental effects of waste plastic and the necessity of a thorough assessment to move towards a more sustainable future.

P28 SPLICE: Sustainable Processes Linked for an Integrated Circular Economy

Tarek Rashwan, Harri Williams, Simon Collinson, Michael Macey, Nicholas Power, Daniel Payne, Fatemeh Khodaparastan, James Bowen

Sustainable Processes Linked for an Integrated Circular Economy (SPLICE) is an Open Societal 'Challenge' at The Open University (OU). That is, SPLICE is a collaborative effort that connects multidisciplinary research excellence at the OU to tackle various circular economy challenges. Our vision aims to accelerate societal change towards reimagining wastes as sources of valuable energy and material resources. Current waste management and resource recovery schemes rely on expensive infrastructure that limit their applicability. Through a novel combination of low-cost technologies being investigated at the OU, we aim to provide disruptive technical solutions to support a circular economy and improve sustainability, well-being, and reduce inequalities in the UK and globally.

Current OU research in waste management and chemicals recovery include: (i) anaerobic microbe cultivation, (ii) biomass smouldering combustion, (iii) chemical adsorbents, and (iv) photocatalysis. Recent research also includes geological hydrogen storage, the purification and analysis of bioderived chemicals, and new packaging materials from waste biomass.

P29 Optimised decision-making platform for sustainable food waste valorisation: guiding research and policy

Rendra Hafyan, Jhuma Sadhukhan and Siddharth Gadkari

Addressing the global issue of food waste requires innovative strategies that optimize the valorisation of waste in a sustainable manner. In this study, we introduce a groundbreaking decision-making platform, purposefully designed to guide researchers and policy-makers in selecting the most sustainable food waste management options. Our platform employs a meticulous optimization process grounded on a comprehensive sustainability assessment that encompasses environmental, economic, and social dimensions, ensuring a holistic evaluation of each management option.

The proposed decision-making tool prioritizes various food waste valorisation options such as Biorefineries, Anaerobic Digestion, Composting, Incineration, and Landfill. Each option is carefully evaluated and ranked based on its overall sustainability value. The platform fosters informed decision-making, providing clarity and strategic direction to stakeholders, and facilitating the prioritization of options that deliver maximum sustainability benefits. This innovative approach promises to enhance the effectiveness and impact of food waste management practices, driving progress toward a more sustainable and resilient global food system.

P30 Conversion of organic wastes into biodegradable plastics: a dual and synergistic solution in a circular economy

Yongqiang Liu, Seongbong Heo

The burgeoning environmental challenges posed by synthetic plastic waste underscore the need for sustainable alternatives. Polyhydroxyalkanoates (PHA), a kind of biodegradable plastic, has been commercially produced to replace non-degradable plastic. However, PHA cannot compete with traditional plastic due to the high cost from pure culture and chemical defined medium. Mixed culture with organic wastes for PHA production garnered attraction in recent years. This study presents a novel approach to converting volatile fatty acids from organic wastes into biodegradable plastics.

By employing a mixed microbial culture and uncoupling nutrients strategy in feast and famine phases, we achieved PHA enrichment and accumulation in a single reactor without need for sterilisation, leading to efficient PHA synthesis under dynamic feeding conditions. The integrated system for enrichment and accumulation simplifies the traditional two-step PHA production process, reducing operational complexities and costs. Furthermore, to address poor settling issue of cells in reactors, a process intensification strategy by exerting hydraulic selection pressure at the ends of feast or famine phases was adopted. It was found that cells with settling time aggregated into granules, which significantly improved sludge settleability. This advancement is crucial in enhancing the separation efficiency of the biomass from the water, thereby facilitating more effective and economical PHA recovery. The research demonstrates a significant step towards sustainable waste management and biodegradable plastic production in a circular economy. This study holds great potential for scaling up and can inspire further advancements in sustainable material production, showcasing a viable pathway for environmental preservation and resource recovery.

P31 Hydrothermal catalytic conversion of $NaHCO_3$ with glucose reductant

Mariia Konstantinova, James McGregor

Carbon dioxide is an earth abundant, economic and non-toxic feedstock which can be used in the production of value-added products, but high thermodynamic stability makes conversion challenging. Hydrothermal reduction of carbon dioxide mimics the conditions found around deep-sea vents, where the unique properties of sub-critical water can overcome high CO_2 stability. It has been reported that metals found on the sea floor can act as catalysts for the conversion of CO_2 to C1 molecules and organics. In the absence of sacrificial metals, biomass and its derivatives can act as a source of H_2 for CO_2 reduction. The most reported product of CO_2 hydrothermal reduction is formic acid, a valuable platform molecule. In this work, hydrothermal conversion of $NaHCO_3$, a CO_2 source, with glucose was investigated in sub-critical water. In addition to organic acids, other aqueous, organic and gaseous reaction products were identified to gain insight into the mechanisms in this reaction. Conditions at which the concentration of formate ($HCOO^-$) was maximized were determined by varying reaction time and temperature. Bulk metal powders cobalt, copper and nickel were then investigated as heterogeneous catalysts for enhancing $HCOO^-$ yield.

P32 Enhanced activity and stability of an acetyl xylan esterase through site-directed mutagenesis

Henry Madubuike, Natalie Ferry

Current demands for the development of suitable biocatalysts showing high process performance is stimulated by the need to replace current chemical synthesis with cleaner alternatives. A drawback to the use of biocatalysts for unique applications is their low performance in industrial conditions. Hence, enzymes with improved performance are needed to achieve innovative and sustainable biocatalysis.

In this study, we report the improved performance of an engineered acetyl xylan esterase (BaAXE) in hydrophilic organic solvent. The structure of BaAXE was partitioned into a substrate-binding region and a solvent-affecting region. Using a rational design approach, charged residues were introduced at protein surfaces in the solvent-affecting region. Two sites present in the solvent-affecting region A12D and Q143E were selected for site-directed mutagenesis which generated the mutants- MUT12, MUT143 and MUT12-143. The mutants MUT12 and MUT143 reported lower Km (0.29 mM and 0.27 mM respectively) compared to the wildtype (0.41 mM). The performance of the mutants in organic solvents was accessed after enzyme incubation in various strengths of alcohols. The mutants showed improved activity and stability compared to the wild type in low strength of ethanol and methanol. However, the activity of MUT143 was lost in 40 % methanol while MUT12 and MUT12-143 retained over 70 % residual activity in this environment. Computational analysis links the improved performance of MUT12 and MUT12-143 to novel intermolecular interactions which are absent in MUT143.

P33 Geo-Specific Classification of Global Sugarcane Bagasse Production and Use

Maureen Chiebonam Okibe, Michael Short, Franjo Cecelja, Madeleine Bussemaker

Research in brief:

Sugarcane crop is a carbon-depleting plant predominantly cultivated in over 100 countries from parts of Asia, Central and South America, Caribbean, Africa, USA and Australia. Sugarcane bagasse (SCB) residues are fibrous, agro-industrial lignocellulose derived from sugarcane/ethanol processing. These second-generation residues which are non-edible have gained traction in biorefining domains for numerous green applications in chemical, pharmaceutical and energy industries. Reusing bagasse supports circular bioeconomy focusing on delivering optimal economic and environmental benefits by minimizing wastes and replacing fossil-based materials with sustainable alternatives. In some cases, SCB is dumped on landfill sites and arable farming lands without reaping the benefits of lignocellulose re-use. SCB is also burned in traditional boilers for cogeneration of heat and power. Bagasse producers have been previously classified by country-specific tonnage levels, with Brazil, India, China, and Thailand identified as 'Principal Producers' generating over 100 million tonnes of bagasse annually. Other SCB producing nations registered lower bagasse production when compared to the principal-producing nations.

The aim of this study is to reclassify global bagasse producers by geo-specific regions. Scientific literature and technical websites were secondary sources of data. The knowledge generated may provide insights into the regional factors influencing policies for lignocellulose use. My next work will link bagasse production and use to individual countries. In the UK, this can help inform how policies are made for lignocellulose utilization. The knowledge would be semantically modelled using ontologies creating a semi-automated reference framework for biorefining stakeholders. This reference model would be

useful when making biomass supply chain decisions, advancing towards the sustainability of alternative feedstocks in a defossilised economy.

P34 *Phalaris aquatica L.* energy crop

Ioannis A. Pappas, Emmanouil H. Papaioannou, Zoi Koukoura

Phalaris aquatica L., a perennial grass native to the Mediterranean, has traditionally been utilized for forage production. Recently, it has garnered attention as a promising candidate for sustainable second-generation bioethanol production. This study marks the first comprehensive examination of the long-term performance (over five years of growth) of this energy crop. The investigation encompasses the evaluation of cell wall saccharification efficiency and the production of high-value compounds throughout this extended period. Consistent high biomass production was observed starting from the second year, reaching a peak of 22.4 ± 0.5 t of dry mass (DM) per ha. The concentration of stable structural polysaccharides remained at 68.8% ± 0.8 w/w DM from the third year onward. Regardless of the crop's age, dilute acid pretreatment (120°C, 1.5% H2SO4, 45 min) facilitated the enzymatic hydrolysis of *P. aquatica L.* biomass. The positive impact of dilute acid pretreatment is attributed to both hemicellulose solubilization and the disruption of intermolecular bonds between polysaccharides and phenolic acids. The combined acid/enzymatic hydrolysis processes converted over 80% of cell wall polysaccharides into fermentable sugars. Simultaneously, phenolic acids (2.16% ± 0.48 w/w DM) were released.

These findings underscore the suitability of *Phalaris aquatica L.* as a sustainable biorefinery crop, especially under semi-arid Mediterranean climatic conditions. This not only contributes to the biodiversity of the region but also holds potential for fostering prosperity through the establishment of a bio-based economy.

P35 Scaling up dehydration of sugars to furan with agitated cell reactor technology

Abdullahi Adamu, Kamelia Boodhoo, Fernando Russo Abegao

The dehydration of hemicellulose sugars to furans offers a sustainable route to renewable chemicals. Most often, this process has been confined to lab scale, using pure substrates in conventional batch reactors. Process scale up using industrial feedstocks presents significant challenges. The hemicellulose fractions complexity, high dilution, and presence of impurities leads to inconsistent yields and low selectivity. Additionally, the tendency towards by-product formation, such as humins, can lead to poor yields and reactor fouling. A potential solution to this is to use a biphasic extractive-reaction system, in which the furan products are separated from the aqueous medium in situ, preventing by-products formation. However, when moderate to long reaction times are required, conventional reactors have limited capacity for effective mixing, which is required for the extractive-reaction process.

The agitated cell reactor (ACR) offers a novel design with interconnected cells with individual agitators and has the potential to scale up the sugar dehydration process effectively by decoupling mixing from residence time, allowing conversion to take place in a kinetic regime favourable to main product formation and isolation. This configuration intensifies mixing, enhancing solids flow and minimising the formation of humins. The ability of an ACR to provide consistent contact between reactants, catalysts, and extraction solvent, alongside its suitability for continuous operation, addresses the scale-up challenges head-on. Studies transitioning from pure substrate to real biorefining feedstocks will be discussed, showcasing the capacity of ACR to handle the intricacies of industrial feedstock whilst improving furan yields, bridging the gap between laboratory and industrial application.

P36 HAROW and REvAR – fuel gases from organic-rich wastewaters

Malcolm Glendenning, Jude Onwudili, Claudio Amorese, Brad Forrest, Ifeoluwa Akande, Sergio Blanco-Rosete, Jake Milstead

HAROW – Hydrogen via Aqueous-phase Reforming Of Wastewater took waste glycerol in water from biodiesel production to produce hydrogen.

REvAR – Renewable Energy via Aqueous-phase Reforming looked at methane and hydrogen production from sewage sludge and anaerobic digestion digestate.

In both cases, reactions that had previously been carried out in batch reactors at Aston were transferred to a custom-built continuous flow system to examine the potential for further scale up with success. Concept plans were developed for the deployment of a containerised system at 5-10x scale. The process could be allied to a range of process flows as part of a larger bio-refinery. Funding from BEIS H2BECSS program and Ofwat Discovery Challenge.

P37 Developing an alternative political bioeconomy in the UK

Dan Taylor, Katie Chong, Mirjam Roeder

This research investigates how the incorporation of net zero into the political agenda has influenced the deployment of bioenergy systems, and the resulting potential benefits of biomass in addressing current climate, ecological, and energy emergencies. As a renewable energy source intrinsically linked to atmospheric systems, biomass holds a unique position by offering the potential for negative emissions. However, an overemphasis on carbon removal risks neglecting the broader social, economic, and environmental advantages associated with biomass use.

To address this, the research employs a stakeholder engagement through semi-structured interviews with biomass and bioenergy experts from policy, industry, and society. Utilising a political economy approach, the qualitative study analyses responses to uncover the non-technical factors influencing bioenergy deployment and identifies inequalities within the UK bioenergy sector. The resulting framework aims to inform policy design by addressing deficiencies in the current political economy, aiming to maximise benefits for climate, society, and nature.

This poster presents data gathered from interviews with UK biomass and bioenergy experts, emphasising crucial considerations for future biomass policy design. Drawing on experiences collaborating with policymakers in crafting the UK's Biomass Strategy and engaging with the UK's 'Public Dialogue on Biomass', the analysis explores preliminary results to understand how a policy design framework for sustainable biomass could enhance outcomes in tackling the climate, ecological, and energy emergencies.

Notes:

Delegate list

Finn Lillelund Aachmann	NTNU Norwegian University of Science and Technology
Abdullahi Adamu	Newcastle University
Ashraf Alkhtib	Nottingham Trent University
Ariyan Amirifar	The University of Manchester
Maira Anam	University of Nottingham
Yvonne Armitage	CPI (Centre for Process Innovation)
Erinc Bahcegul	Notpla Ltd.
Hemaka Bandulasena	Loughborough University
Meredith Barr	London South Bank University
Gregg Beckham	National Renewable Energy Laboratory (NREL)
Katrin Besser	University of York
Catherine Birch	AgriFood X Limited
Ife Bolaji	Queen's University Belfast
Graham Bonwick	AgriFood X Limited
Lucy Booth	University of York
Stephen Boothroyd	Unilever
David Bott	SCI (Society of Chemical Industry)
Neil Bruce	University of York
Eleonora Campos	INTA (Instituto Nacional de Tecnología Agropecuaria)
Elisa Capuzzo	Cefas
Micaela Chacón	The University of Manchester
Daniel Chaplin	Bangor University
Dimitris Charalampopoulos	University of Reading
Roberto Chiocchio	BIOHM Ltd
Katie Chong	Aston University
Samantha Cook	Teesside University
Mark Corbett	Biorenewables Development Centre
Sarah Davidson	Croda
Rashmi Deshpande	University of York
Ioanna Dimitriou	University of Nottingham
Neil Dixon	Manchester Institute of Biotechnology
Bipro Nath Dubey	Sheffield Hallam University
Anna Duden	Utrecht University
Andrew Ellis	Biocatalysts
Richard Evans	AB Agri Ltd
Laura Faas	University of York
Nasim Farahmand	Biotech Consultants Limited (BTCL)
Andrew Fleming	Wells & Co.
Rebecca Fothergill	Supergen Bioenergy Hub, Aston University
Nichakorn Fungprasertkul	University of Manchester
Siddharth Gadkari	University of Surrey
Malcolm Glendenning	ICMEA-UK Ltd
Leonardo Gomez	University of York

Erin Gray	University of York
Mark Gronnow	Biorenewables Development Centre
Jason Hallett	Imperial College London
Claire Halpin	University of Dundee
Dana Heldt	Innovate UK Business Connect
India Higgins	Department for Science, Innovation and Technology
Bethan Highley	University of York
Adrian Higson	NNFCC The Bioeconomy Consultants
Bjartur Hilmisson	The University of Manchester
Robin Hoeven	The University of Manchester
Janina Hoßbach	University of York
Moira Howie	Independent Adviser Diet, Health & Sustainability
Beatrice Ifie	Aberystwyth University
Longinus Ifeanyi Igbojionu	Aston University
Muhammad Javed	Biotech Consultants Limited (BTCL)
Mary Jenkinson-Finch	BBSRC
Ushna Khalid	The University of Manchester
Fatemeh Khodaparastan	The Open University
Katalin Kovacs	University of Nottingham
Rolf Kraehenbuehl	Bangor University
Jai Lad	ARCITEKBio Ltd
Alexandra Lanot	University of York
Michael Lewis	Heugh Farm Ltd
Rhiannon Leyden-Preece	Defra
Yongqiang Liu	University of Southampton
Henry Madubuike	University of Salford
Yujie Mao	University of Nottingham
Ewa Marek	University of Cambridge
Laura Martin	University of Oxford
James McGregor	University of Sheffield
Tom McMurray	Queen's University Belfast
Fanran Meng	University of Sheffield
Philip Metcalfe	Biopower Technologies Limited
Colin Miles	BBSRC
Gavin Milligan	Green Knight Sustainability Consulting Ltd
Paul Mines	Biome Bioplastics Limited
Nigel Minton	University of Nottingham
Emily Newcombe	University of Leeds
William Newell	Imperial College London
Alexander Nicholls	The Supplant Company
Maureen Okibe	University of Surrey
Prince Okoro	Energy and Bioproducts Research Institute (EBRI)
Omotola Olagunju	Teesside University

Walid Omara	Sheffield Hallam University
Veronica Ongaro	Biome Bioplastics Limited
Samson Oyeyinka	University of Lincoln
Daya Pandey	University of Leeds
Emmanouil Papaioannou	Lancaster University
Christine Parry	AB Agri Ltd
Huw Parry	Network New Europe Ltd
Joe Penhaul Smith	Sustainable Sailing
Anh Phan	Newcastle University
Davide Poggio	University of Sheffield
David Raine	Back 5 Ltd
Deborah Rathbone	Biorenewables Development Centre
Beth Redfern	Deep Branch
Mauro Adriel Rinaldi	University of Hull
Ed Robinson	Wells & Co.
Roger Romero	The University of Manchester
Fernando Russo Abegão	Newcastle University
Federico Sabbadin	University of York
Haris Saeed	University Of Oxford
Kjartan Sandnes	Biomega Group AS
Kareemuddin Shaik	KNAFT LTD
Jinsong Shen	De Montfort University
Carol Somper	JRP Solutions
Philippe Soucaille	University of Toulouse
Joanna Sparks	Aston University
Michele Stanley	Scottish Association for Marine Science
Christine Steffen	University of Nottingham
Nick Sweygers	KU Leuven
Dan Taylor	Aston University
Ian Tebble	Cambridge Glycoscience Ltd
Nicholas Tenci	University of Oxford
Chidinma Angela Tennison-Omovoh	Colorifix
Patricia Thornley	Aston University
Jonathan Todd	University of East Anglia
Thierry Tonon	University of York
Chloe Uyl	University of Kent
Jonathan Wagner	Loughborough University
Ryan Watkins	Cambridge Glycoscience Ltd
Rebecca Wheeler	Future Biogas
Stephen Wright	CPI (Centre for Process Innovation)
Zeinab Zandieh	Aston University
Meng Zhang	Northumbria University
Anna Zhenova	Green Rose Chemistry

Notes:

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