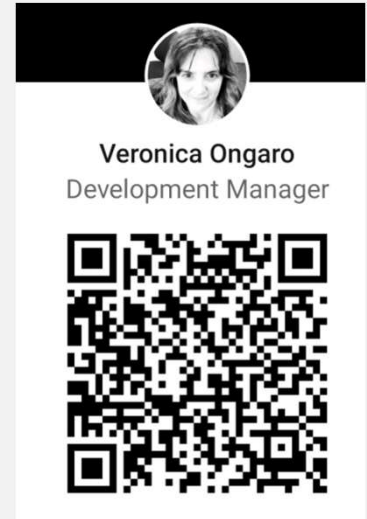


Company Overview

Veronica Ongaro Development Manager



- Headquartered in Marchwood, Southampton, UK
- Biome Bioplastics Inc USA and Biome Bioplastics Inc Canada established in 2022
- All products are partially or completely bio-based
- Focus on product end-of-life. Products are all compostable and suitable for a wide array of plastic processing technologies.
- **Significant commitment to R&D, leading a major programme to manufacture the next generation of sustainable polymers**

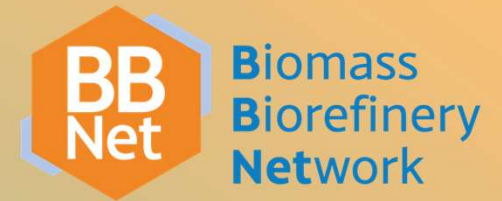
Session 8: Research funded by BBNet and other funding opportunities



Simon McQueen-Mason

Session 8: Research funded by BBNet and other funding opportunities		
<i>Chair: Veronica Ongaro, Biome Bioplastics Limited</i>		
11:00		
11:05	BBSRC support for the clean growth area <i>Colin Miles, BBSRC, UKRI</i>	22
11:20	Innovate UK support for sustainable bio-based materials and manufacture <i>Dana Heldt, Innovate UK Business Connect</i>	23
11:35	Demonstrating the production of circular biobased textiles <i>Alexandra Lanot, University of York</i>	24
11:50	Bioacrylic acid production from seaweed <i>Jonathan Todd, University of East Anglia</i>	25
12:05	Development of enzyme-based biotechnology to support the wool industry transition to a circular system <i>Jinsong Shen, De Montfort University</i>	26
12:20	MSAD: Methanosarcina Detection and Addition for Optimised Anaerobic Digestion <i>Samantha Cook</i>	P06
	Catalytic activity of Pulcherrimin: a green, natural, water-tolerant, and highly active heterogeneous biocatalyst for base-free 5-hydroxymethylfurfural oxidation <i>Jonathan Wagner</i>	P14

BBNet funding opportunities



PoC

Proof of Concept Funds

- Up to £60K
- Open call
- Funds to support innovative new research ideas
- **Deadline—10am 08 May**

BIV

Business Interaction Vouchers

- Up to £10k
- Limited availability
- Funds to enable small confidence-building measures
- **Deadline – 30 June 24**

CIF

Collaborate and Innovate Grant Fund

- Up to £5k
- First come first served
- Funds to support collaborative meetings and workshops
- **Deadline – currently open**



Biotechnology and
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Research Council



UNIVERSITY
of York



Engineering and
Physical Sciences
Research Council



Biotechnology and
Biological Sciences
Research Council

BBSRC Support for the Clean Growth Area

Dr Colin Miles

BBNet Annual Meeting: 12 April 2024

What I'm planning to cover:

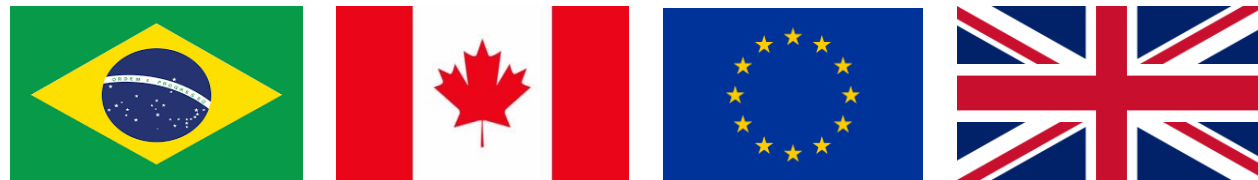
- *Mission Innovation: Integrated Biorefineries* and the forthcoming EC funded competition on biorefining
- Evaluation of the effectiveness and impact of BBSRC's investments in Industrial Biotechnology (2010-2021)
- Future of community interactions: post 2025



Launched on 09th November 2021: COP26



Develop & Demonstrate innovative solutions to accelerate the commercialization of **integrated biorefineries** with a target of **replacing an additional 10% of the fossil carbon** equivalent by **sustainable bio-carbon** in fuels, chemicals and materials from residues and wastes **by 2030**.



International
Energy Agency



Mission Innovation: Biorefineries Background

The **Mission** aims to offer an integrated and holistic zero-waste biorefinery approach to scaling up clean energy innovation for a low carbon sustainable future through a global collaborative alliance.

The [Biorefinery Roadmap](#) (2022) is underpinned by 3 pillars to support the development of bio-based Sustainable Fuels, Chemicals, and Materials (SFCM):

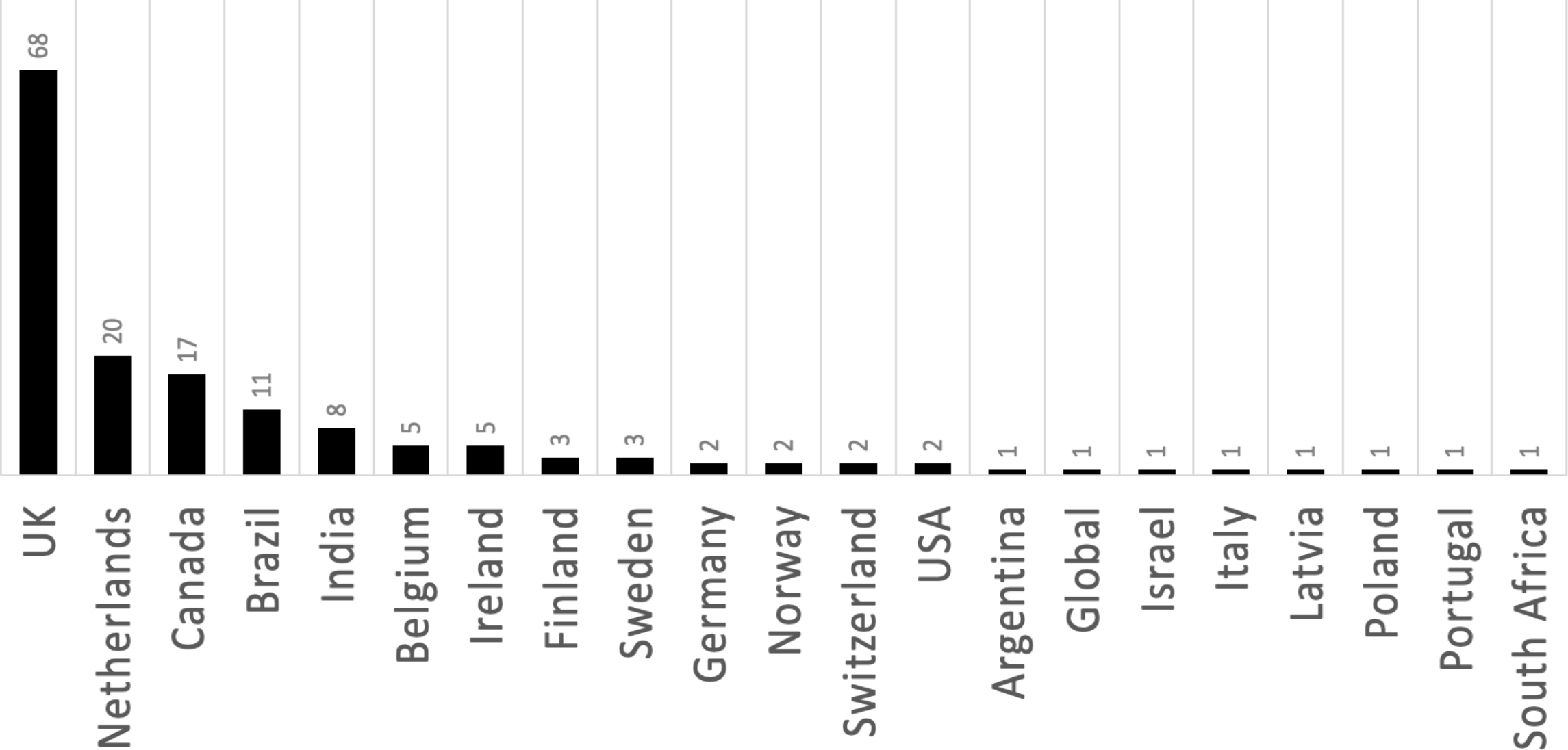
Pillar 1. **Research, development and demonstration (RD&D)** that focuses on *technologies and processes that improve both the cost competitiveness of bio-based SFCMs and the sustainability of their production*. (Action 2 webinar: January 2024)

Pillar 2. **Pilot scale demonstrations** that support new and novel technologies and facilitate cost competitive manufacturing of bio-based SFCMs.

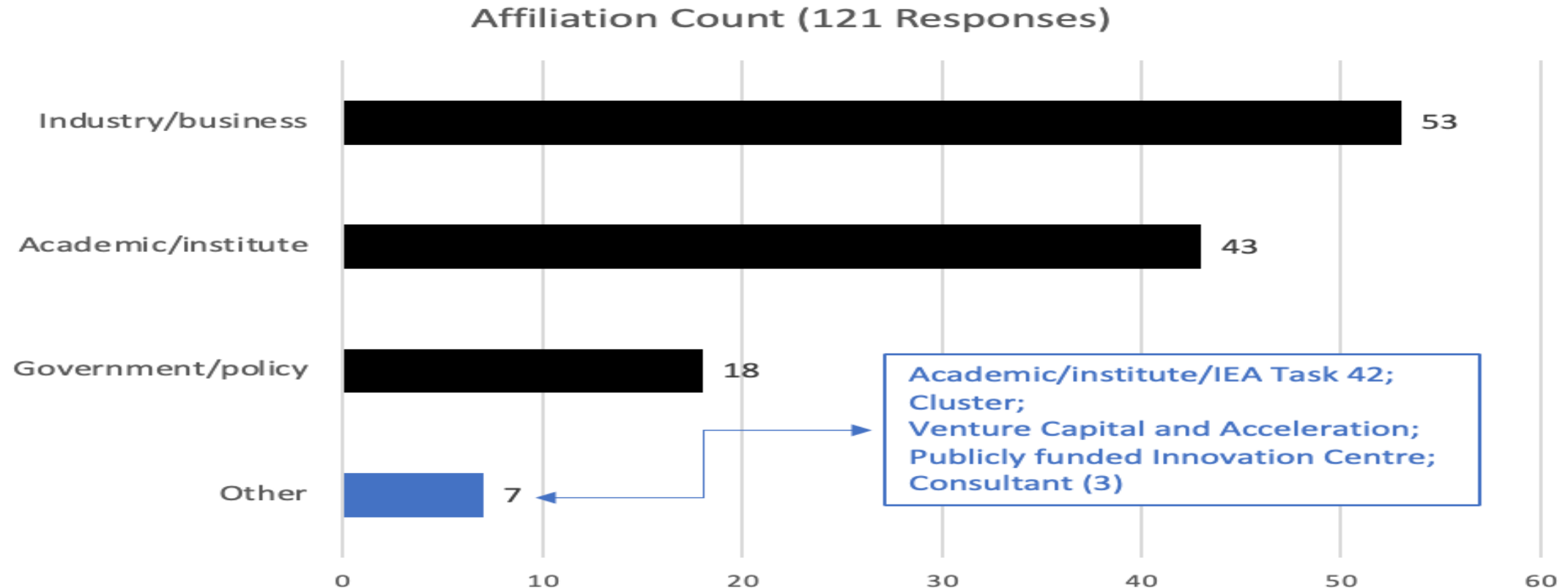
Pillar 3. **Regulatory and policy support** through collaboration with government, academia, industry and other stakeholders develop supportive regulatory environments for bio-based SFCM production.

Mission Innovation Action 2 workshop (January 2024)

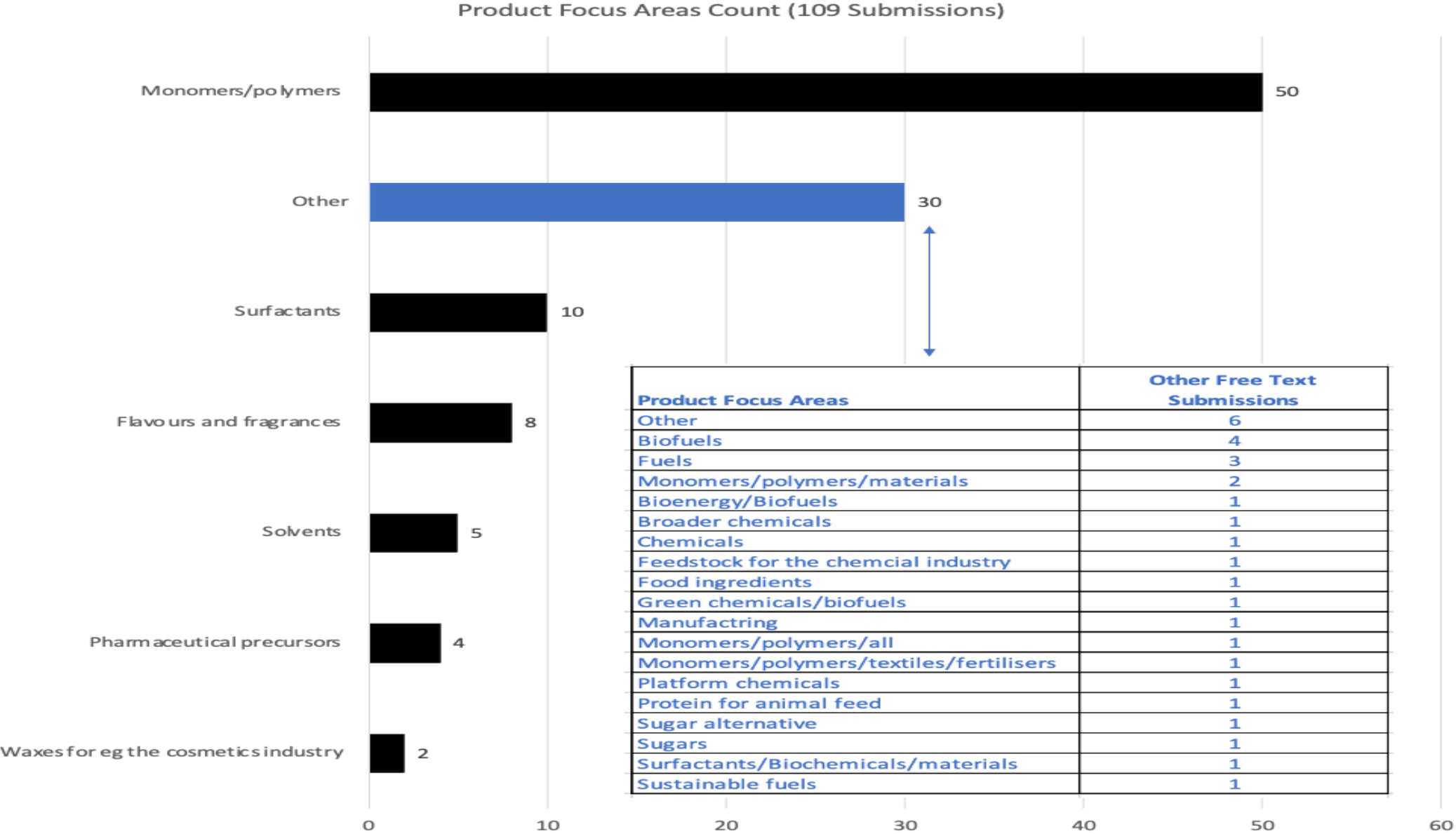
Attendees on the day (156)



Who attended: Mission Innovation Action 2 workshop (January 2024)?



Key product areas: Mission Innovation Action 2 workshop



Moving forwards and making use of EC funds: Biorefining

Development of smart concepts of integrated energy driven bio-refineries for co-production of advanced biofuels, bio-chemicals and biomaterials (HORIZON-CL5-2024-D3-02-03)

Deadline date: 21 January 2025 17:00:00 Brussels time

<https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2024-d3-02-03?keywords=climate%20energy&closed=true&programmePeriod=2021%20-%202027&frameworkProgramme=43108390&pageNumber=9>

- Competition opens in September 2024
- UK, Canada and India are eligible participants
- Consortia building opportunities between now and closing date in early 2025
- Potential international webinars on polymers and fine chemicals to promote collaborations?



Biotechnology and
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***Evaluation of the effectiveness and
impact of BBSRC's investments in
Industrial Biotechnology (2010-2021)***

Evaluation of the effectiveness and impact of BBSRC's investments in Industrial Biotechnology (2010-2021)

The report summarises the views and conclusions of a specialist evaluation panel who were appointed to conduct an independent review

Evidence for the evaluation was obtained from the following sources:

- BBSRC grants database
- Research outcomes data (e.g., collected via the Researchfish platform)
- Bibliographic and bibliometric databases (namely WoS and the InCites platform provided by Clarivate Analytics)
- Surveys of all 13 NIBB Phase I directors, 18 businesses and 48 former grant holders
- Semi-structured interviews with five businesses and five grant holders

Evaluation of the effectiveness and impact of BBSRC's investments in Industrial Biotechnology: Headlines

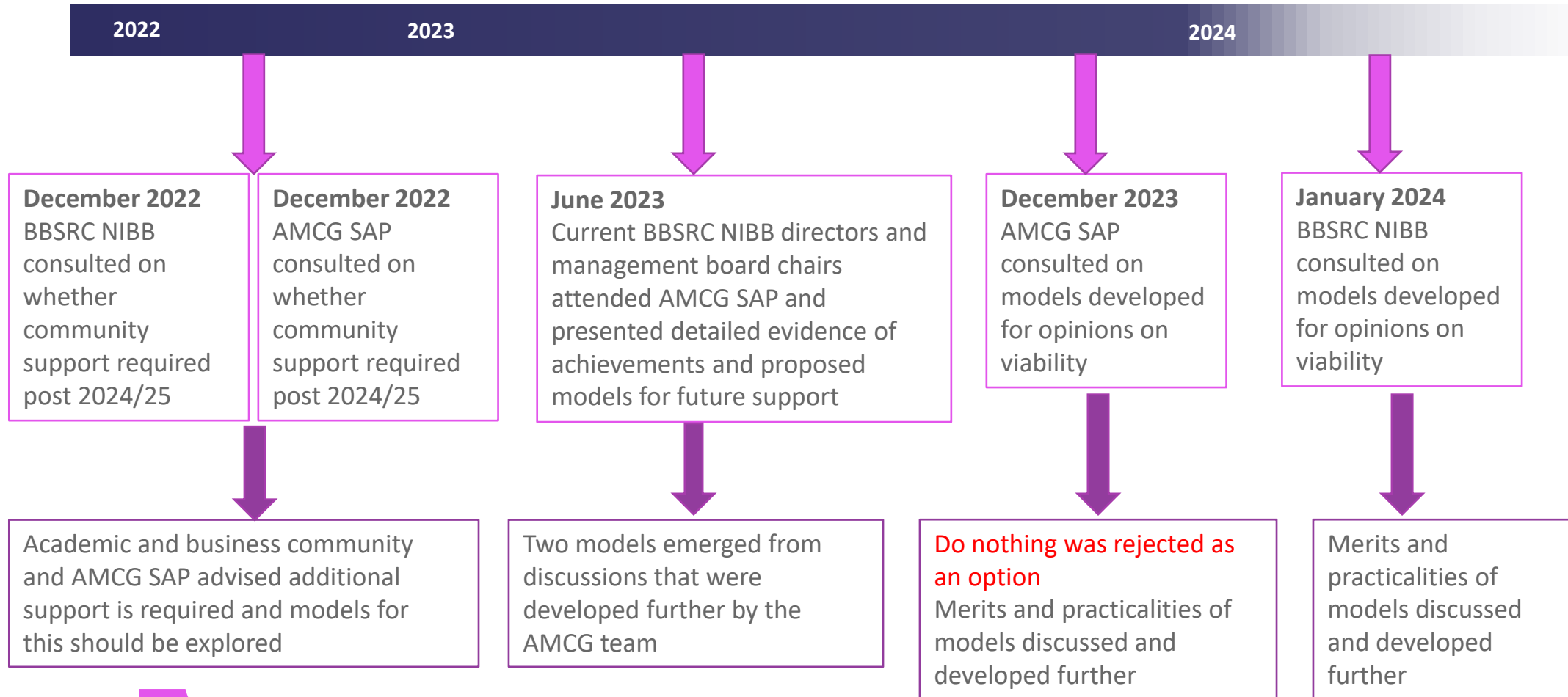
- **Scientific quality:** published outputs from BBSRC funded IB grants are comparable with microbiology in the BBSRC portfolio with 16% being within the top 10% of all WoS publications in terms of citation impact.
- **Novel funding mechanisms:** A stand-out success was the BBSRC NIBB initiative catalysing research communities working on industrially-relevant problems, showing progress along the translation pipeline for multiple projects.
- **Strong and enduring collaborations:** 11% of publications arising from the BBSRC NIBB had an industry co-author, compared to 7% from the whole IB portfolio and 4% of BBSRC's overall research portfolio.
- **High achievement in innovation:** the IB portfolio contributed to 31% of all instances BBSRC-attributable IP and 34% of all BBSRC-attributable spin-outs arising between 2017 and 2021, despite receiving c.10% of BBSRC's budget.
- **Skilled staff in demand:** a significant proportion (26%) of staff arising through BBSRC funding were employed in the private sector as their next destination, higher than the general BBSRC research portfolio (14%).



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Future of community interactions: Post 2025

BBSRC community co-ordination: next phase consultation timeline



What are the aims of the next stage?

- Convening a community of researchers
- Working with business
- Delivering economic growth
- Delivering for early career researchers
- Delivering influence in the UK government
- Delivering influence in UKRI

What I've covered: time for your input!

- *Mission Innovation: integrated Biorefineries* and the forthcoming EC funded programme on biorefining...how useful to hold international webinars?
- Evaluation of the effectiveness and impact of BBSRC's investments in Industrial Biotechnology (2010-2021)
- Future of community interactions: post 2025: views from BBNet?

NSF Global Centres: Bioeconomy Research Programme

The National Science Foundation (NSF) Global Centres call for proposals on bioeconomy research.

The deadline to submit a proposal is **June 11th, 2024**.

NSF defines the bioeconomy is the share of the economy based on products, services and processes derived from living systems. It includes the research results, data, infrastructure, workforce capacity and innovation that enable the discovery, utilization and alteration of living organisms, their constituent components, and their biologically related processes.

UK researchers can make proposals that include the full range of disciplinary, multidisciplinary and transdisciplinary approaches that address the bioeconomy.

To be eligible, your team must include a US-based researcher who assumes the role of Principal Investigator (PI) for the NSF grant. Researchers from Canada, Finland, Japan, Republic of Korea and the UK are also eligible to be part of your team.

NSF Global Centres: Bioeconomy Research Programme

Four eligible research topics:

- **Topic 1: Leveraging Biodiversity Across the Tree of Life to Power the Bioeconomy:** Can for example include biodiversity, precision agriculture, green economy, data for the bioeconomy, socio-economic impact assessment, etc.
- **Topic 2: Biofoundries, also called the Design-Build-Test-Learn process:** Can for example include synthetic biology, metabolic engineering, rapid prototyping of biological designs through automation and AI, tailoring of biomass to bio-refining pathways, developing catalytic, thermo-chemical, and biochemical conversion processes, ethical considerations, governance, and social implications, etc.
- **Crosscutting Theme A: Public engagement and co-generation of research activities to strengthen the global science and technology enterprise:** Can englobe centre-scale investments to bring experts together to address human-centred solutions to societal problems or the development of new biotechnology solutions to problems like climate change, hunger, waste and disease.
- **Crosscutting Theme B: Workforce Development and Education:** Can include enhancing diversity and equity within biotechnology and biomanufacturing research as well as expanding investments in equity-focused science.



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A background image of a person's face, partially obscured by a large purple shape. The person has their hand to their chin, suggesting a state of deep thought or contemplation. The image is in a high-contrast, almost black and white style with some color elements.

Questions?



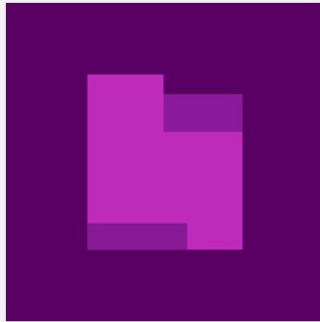
Innovate
UK

Innovate UK support for sustainable bio-based materials and manufacture

Dana Heldt, Innovate UK Business Connect, KTM for Synthetic Biology

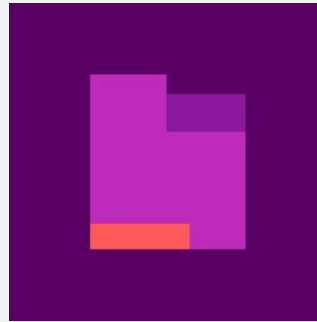
Dana.Heldt@iuk.ktn-uk.org

Innovate UK System



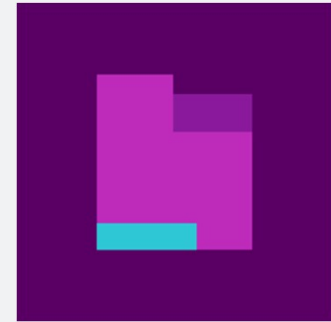
Innovate UK

Innovate UK is the UK's innovation agency: a non-departmental public body operating at arm's length from the Government as part of UKRI.



Innovate UK Business Connect

Innovate UK Business Connect exists to connect innovators with new partners and new opportunities beyond their existing thinking - accelerating ambitious ideas into real-world solutions.



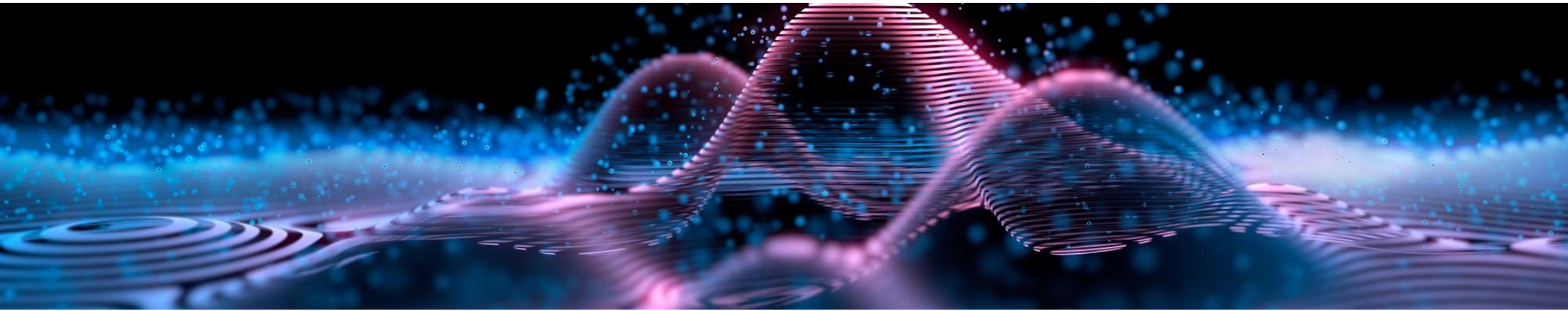
Innovate UK Business Growth

Innovate Business Growth empowers innovation-driven businesses to grow at pace and achieve their industry- and society-transforming ambitions.



Innovate
UK

Introduction to IUK Business Connect



Our Purpose & Vision

- We create diverse connections to drive positive change.
- To establish a network of innovators so powerful its ideas will change the world.

Our Network



46,229
Unique
Organisations



72%
Small

15%
Medium

13%
Large



234,478
innovators



Every university in
the UK

We connect

Diverse communities | Innovation Networks

Regional, national and global | Global Alliance

Research and business | Knowledge Transfer Partnerships

Innovators, funders & collaborators | Innovation Exchange

Insight to impact | Insight reports

...for positive change



Innovate
UK

Reimagining materials and manufacturing

Reimagining Materials and Manufacturing



**Resource-efficient or bio-
based materials and
manufacturing,
Feasibility competition**



Apply for a share of £1M

Open date 2 April 2024

Close date 29 May 2024

Project costs £50k - £100k

Project duration 3 - 6 months

Reimagining Materials and Manufacturing

Sustainable bio-based Materials and Manufacturing (SusBioMM)

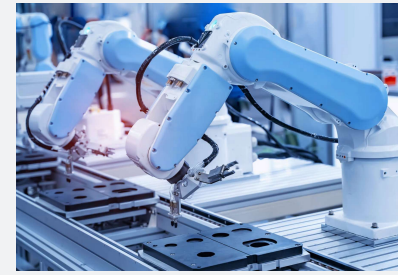
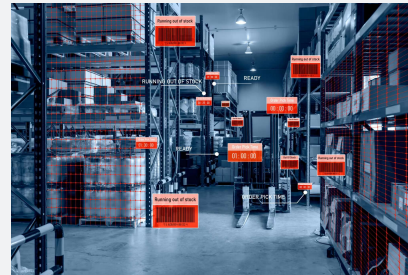
The sustainable bio-based materials and manufacture programme seeks to address the challenge of developing innovations in sustainable and scalable biomanufacturing processes.

Resource Efficiency for Materials and Manufacturing (REforMM)

The programme aims for the UK to be a leader in resource efficiency with organisations understanding the environmental, social and economic impact of the full lifecycle and thriving from adoption of resource efficient solutions which are fundamental to UK and global Net Zero ambitions.



Resource Efficiency for Materials and Manufacturing Sprints (REforMM)



Materials for the future economy

New material applications for cutting-edge products that reduce emissions, energy consumption and costs

Smart design

Effective design methods, design for resource efficiency, and design for maximum through-life value

Resilient supply chains

Sustainable feedstocks, supply chain visibility, and co-location of waste and emission streams

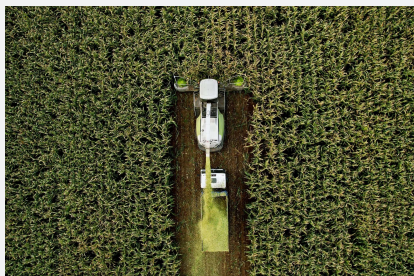
World-class production

Flexible production capacity, minimal material waste, high-quality products, high productivity, and full adaptivity

Longer in use and reuse

Minimising materials use and waste, practising complete traceability, and using new remanufacturing services

Sustainable Bio-based Materials and Manufacture Programme



Bio-based feedstocks

Increasing the use of bio-based feedstocks



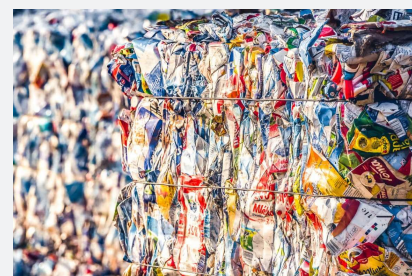
Sustainable biotechnology

Developing alternative bio-based chemical replacements



Innovative bio-based products

Enhancing sustainability profile of biotechnology processes



Feedstock recycling

Innovative use and re-use of renewable feedstocks



Biomanufacturing

Biotechnology based manufacturing processes for sustainable and circular products

Activities

- Showcasing innovators
- Open Innovation opportunities
- Creating networking opportunities
- Facilitating introductions and collaboration (cross sector, innovators, investors)
- Informing government

23rd - 24th April 2024

Business Design Centre, London

MRE2024

Advanced Materials for the Future

23 - 24 APRIL 2024

BUSINESS DESIGN CENTRE, LONDON



MATERIALS
RESEARCH
EXCHANGE



Circular Critical Materials Conference

The Circular Critical Materials Supply Chains programme supports the UK's Critical Minerals Strategy and aims to build and develop resilient supply chains to address this strategically important area with an initial focus on rare earth elements.

Reimagining Materials and Manufacturing Showcase

The UK has clear potential to become a world-class destination of choice for advanced low-carbon manufacturing as set out in the [Materials and Manufacturing Vision 2050](#). To be internationally competitive it is imperative for UK materials and manufacturing to be net zero, resource efficient, responsive, and technologically advanced.

GRIPS Conference

In 2024, we're excited for GRIPS (Global Research and Innovation in Plastics Sustainability) to be featured at Materials Research Exchange 2024. It's a chance to explore the intersection of materials science with sustainability and innovation in plastics across diverse industry sectors.

Investor Showcase

If you are an investor, join us on Day 2 for the Investor Showcase, where innovation converges with opportunity. We will be spotlighting materials innovators from cutting-edge pre-spinout ventures from UK universities in the morning, followed by established companies in the afternoon.

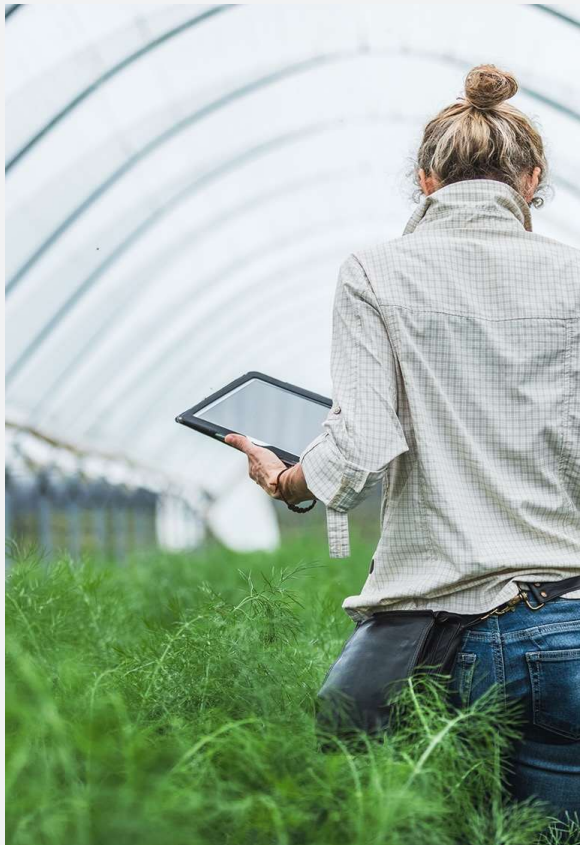
Activities

Materials Research Exchange (MRE) 2024:

- 23rd – 24th April, London Business Design Centre, 1500+ Attendees, 80+ Exhibitors
- Reimagining Materials & Manufacturing Showcase:
 - Bio-village showcasing products 'Made with Biology'
 - LCA Masterclass
 - Short presentations from projects funded through IUK's and BBSRC's Reimagining Materials and Manufacturing calls
 - Open Innovation - accelerating innovation through collaboration
 - Funding update
 - Networking

Open Innovation - iX

Do you have a technology challenge you can't solve?



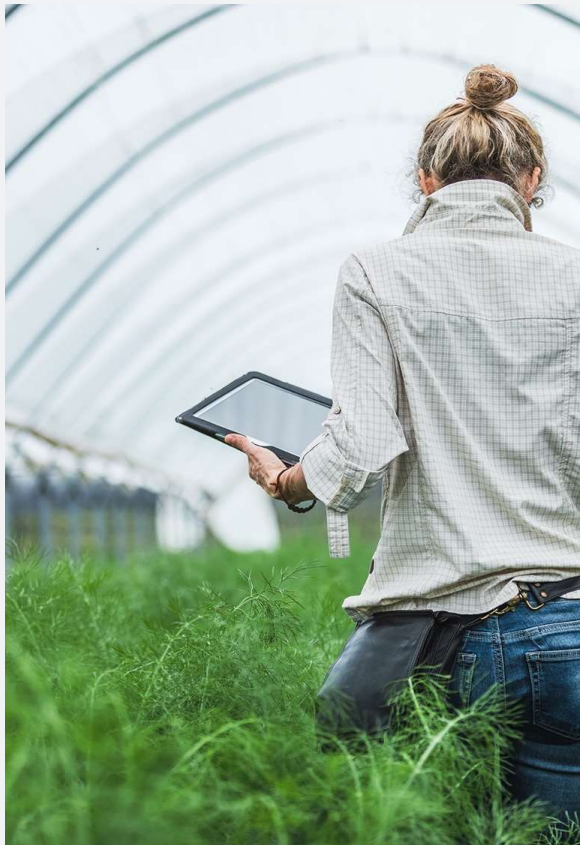
Our **Innovation Exchange** programme connects companies with specific challenges to innovators who are already working on the solutions. Our unique cross-sector approach connects businesses with opportunities beyond their existing thinking.

Net Zero Catalyst live

Innovation Exchange are looking for SMEs with Net Zero technical innovation challenges and offering up to £25k funding per challenge partnership. Closing between 2nd – 10th May.

More to come...

Net Zero Catalyst - iX



Sustainable Packaging: Seeking innovators to support finding sustainable materials for fibre bottle moulding.

Agri-food & Biochemistry: Seeking innovators to develop a sustainable, cost-effective poultry feed using Yeast Protein Concentrate (YPC)

Sustainable Horticulture: Seeking innovators to design, manufacture, and deploy a pilot-scale hydrogel reactor system as a peat alternative.

Funding

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>Resource-efficient or bio-based materials and manufacturing, FS 2</u>	IUK & BBSRC	2 nd Apr 2024	29 th May 2024	Grant £50-100k	3-6 months	By 1 st Oct 2024, end by 31 st Mar 2025

Summary

UK registered organisations can apply for a share of up to £1 million for innovative feasibility studies in advanced low carbon manufacturing.

Your project must relate to one or both of the following themes:

- resource efficient materials and manufacturing
- sustainable bio-based materials and biomanufacturing

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>Industrial Energy Transformation Fund</u>	DESNZ	29 th Jan 2024	19 th April 2024	Grant up to £30K	6 months	By 1 st Sept 2024, end by 30 th May 2025

Summary

Phase 3 of the IETF provides grant funding for feasibility and engineering studies, and for the deployment of industrial energy efficiency and deep decarbonisation projects. The fund targets existing industrial processes, helping industry to:

- Reduce energy consumption by investing in more efficient technologies
- Reduce emissions by bringing down the costs and risks associated with investing in decarbonisation technologies

Funding competition

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>Smart Grants</u>	IUK	18th Jan 2024	24th Apr 2024	£100k-£500k	6-18 months	By 1 st Oct 2024 End 30th Sept 2026
				£100k-£2m	19-36 months	

Summary

- Best game-changing and world leading ideas, designed for swift, successful commercialization. Ideas need to be genuinely new and novel, not just disruptive within their sector.
- Proposal must be business focused, with deliverable, realistic, adequately resourced plans to achieve return on investment, growth and market share following project completion.
- Projects of 6 to 18 months can be single or collaborative. Projects of 19 to 36 months must be collaborative.
- Projects must include at least one SME as the lead or a collaborative grant claiming partner.

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>Innovation Loans Future Economy Round 14</u>	IUK	7 th Mar 2024	1st May 2024	Loan £100k-£2m	Up to 5 years	By 1 st Nov 24

Summary

- This competition offers loans to help businesses overcome barriers to their innovations becoming a successful, commercial reality.
- Your project must lead to innovative new products, processes or services that are significantly ahead of others currently available or propose an innovative use of existing products, processes or services. It can also involve a new or innovative business model.
- Project can include prototyping, demonstrating, piloting, testing, validation.
- Net Zero themes: energy, impact of industrial processes and use of materials, agriculture and food and other sources of emissions, capital intensity

Funding competition

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>Future Leaders Fellowships (round 9)</u>	UKRI	7 th Mar 2024	25 th June 2024	Grant between £300K - £3m	Minimum 4 years	From 1 st Sept 2025

Summary

- UK registered organisations can apply for a share of up to £110 million for ambitious research and innovation projects in any sector, and tailored support to develop careers for future leaders.
- Business and non-academic

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>KTP 2024-25 Rnd 1</u>	UK Government	13 th Feb 2024	10 th Apr 2024	£8.5k per month	12-36 months	-

Summary

The KTP partnership brings new skills and the latest academic thinking into the business partner to deliver a specific, strategic innovation project. The knowledge base partner recruits the ‘associate’ to work on the project. The associate has the opportunity to lead a strategic development within the business, developing new skills and gaining valuable experience. Guidance on [how to apply for a KTP is available.](#)

International Funding competition

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>UK-South Korea CR&D 2024</u>	IUK	26 th Feb 2024	22 nd May 2024	Grant up to £900K	24-36 months	By 1st May 2024, end by 31st March 2026

Summary

The aim of this competition is to fund business led, collaborative research and development (CR&D) projects focused on industrial research. This is for innovative proposals developed between the UK and South Korea. Your project must focus on one or more of the following:

- advanced manufacturing and materials
- artificial intelligence
- future mobility (including batteries)
- semiconductors
- energy storage system
- hydrogen

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>UK-Switzerland CR&D Round 2</u>	IUK	5th Feb 2024	1 st May 2024	Grant up to £450K	18-36 months	By 1st Nov 2024, end by 31st Oct 2027

Summary

Innovate UK, part of UK Research and Innovation and Innosuisse, [The Swiss Innovation Authority](#), will invest up to £4 million from Innovate UK and a minimum of 3 million CHF from Innosuisse in innovation projects.

We encourage innovation in, but not limited to, the following technologies:

- life sciences
- AI
- semiconductor applications
- quantum

International Funding competition

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
<u>UK - Germany Bilateral: Collaborative R&D Round 3</u>	IUK	6 th Feb 2024	3 rd June 2024	Grant up to £500K	18 -36 months	start on 1 December 2024 end by 30 November 2027

Summary

The aim of this competition is to enhance UK and German collaborations and capabilities in the emerging fields of technology in our society.

- Quantum
- AI
- Semiconductor Applications
- Engineering Biology
- Future Telecommunications
- Green Technologies (including hydrogen and battery technologies)

European Funding

Horizon Europe and Circular Bioeconomy – Joint Undertaking 2024 calls

Contact: Belen.Rebollo-Garcia@iuk.ktn-uk.org

International Funding competition

Competition	Funding body	Date opened	Date closed	Total project cost	Project duration	Start
Global Centres addressing global challenges through bioeconomy	UKRI, BBSRC	13th Mar 2024	11th June 2024	Grant up to £1.7m	18-36 months	By 1st Nov 2024, end by 31st Oct 2027

Summary

The Global Centres programme is an NSF-led effort implemented in partnership with like-minded international funders. The programme aims to fund international, interdisciplinary collaborative research centres that will apply best practices of broadening participation and community engagement to develop use-inspired bioeconomy research to address one or more global challenges identified by the scientific community.

Scope:

Bioeconomy is built on the foundation of biotechnology and biomanufacturing, and in addition to biological science and engineering includes contributions from fields such as:

- chemistry
- materials science
- geosciences
- mathematics
- data sciences
- humanities
- social sciences

Follow the [link](#) to explore the scope in more detail



Thank you

Dana.Heldt@iuk.ktn-uk.org

Twitter: @InnovateUK

Facebook: Innovate UK

YouTube: Innovate UK



UK Research
and Innovation



UKRI Interdisciplinary
Textiles Circularity Centre



UNIVERSITY
of York



Biomass
Biorefinery
Network

Demonstrating the production of circular biobased textiles

Alexandra Lanot, University of York
Centre for Novel Agricultural Products

Textile Industry today



- Huge
- Linear supply chain
- Transition toward circular model
- Extremely wasteful
 - of 110 million tonnes of textile fibres produced
 - 80% end up in landfill or incinerated
- Extended producer Responsibility
 - manufacturer accountable for the fate of clothes at the end of life

Currently, only 1% of end-of-life clothes are recycled into clothes

Barriers to recycling

Clothes are dyed, contain accessories

Textile fibres are made of different polymers

- Cellulose: Cotton, viscose, lyocell
- Protein: Wool
- Synthetic polymers: polyester (PET), nylon, elastane

Many textiles are made of polymer blends

Mechanical recycling - damages fibres and not blends

Chemical recycling needs sorting and decolouring



Circular Biobased textiles

Using cellulosic feedstocks

1. The cellulose fraction is converted into glucose by cellulases
2. The glucose is used by bacteria to produce cellulose
3. Bacterial cellulose spun into filaments, yarn
4. Circular design to manufacture fabric and textiles

At the end-of-life, the clothes can go through the process again.





Aim

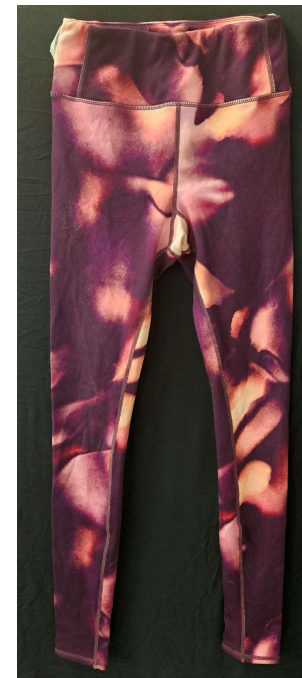
- Produce bacterial cellulose from wheat straw
- Modify surface properties of cellulose to use directly as textile
- Test material for textile application



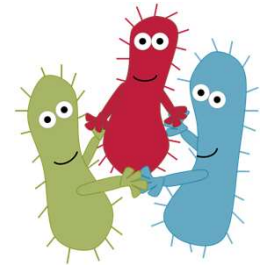
1- feedstocks and enzyme conversion

- Wheat straw, Rice straw
- Organic Fraction of Municipal waste (MSW)
- Viscose, Cotton
- Pre-consumer blended fabrics: Bamboo viscose + cotton, elastane, polyamide, Naia Polycotton
- Post-consumer clothes (charity shops)

MSW and Viscose do not require a pretreatment
Pretreatment of cotton **BBNet BIV 2022**
Over 70% cellulose converted to glucose
40-150g/L



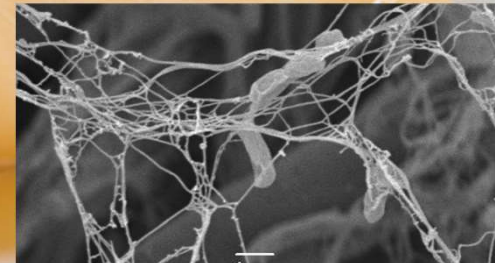
2- Acetobacter fermentation



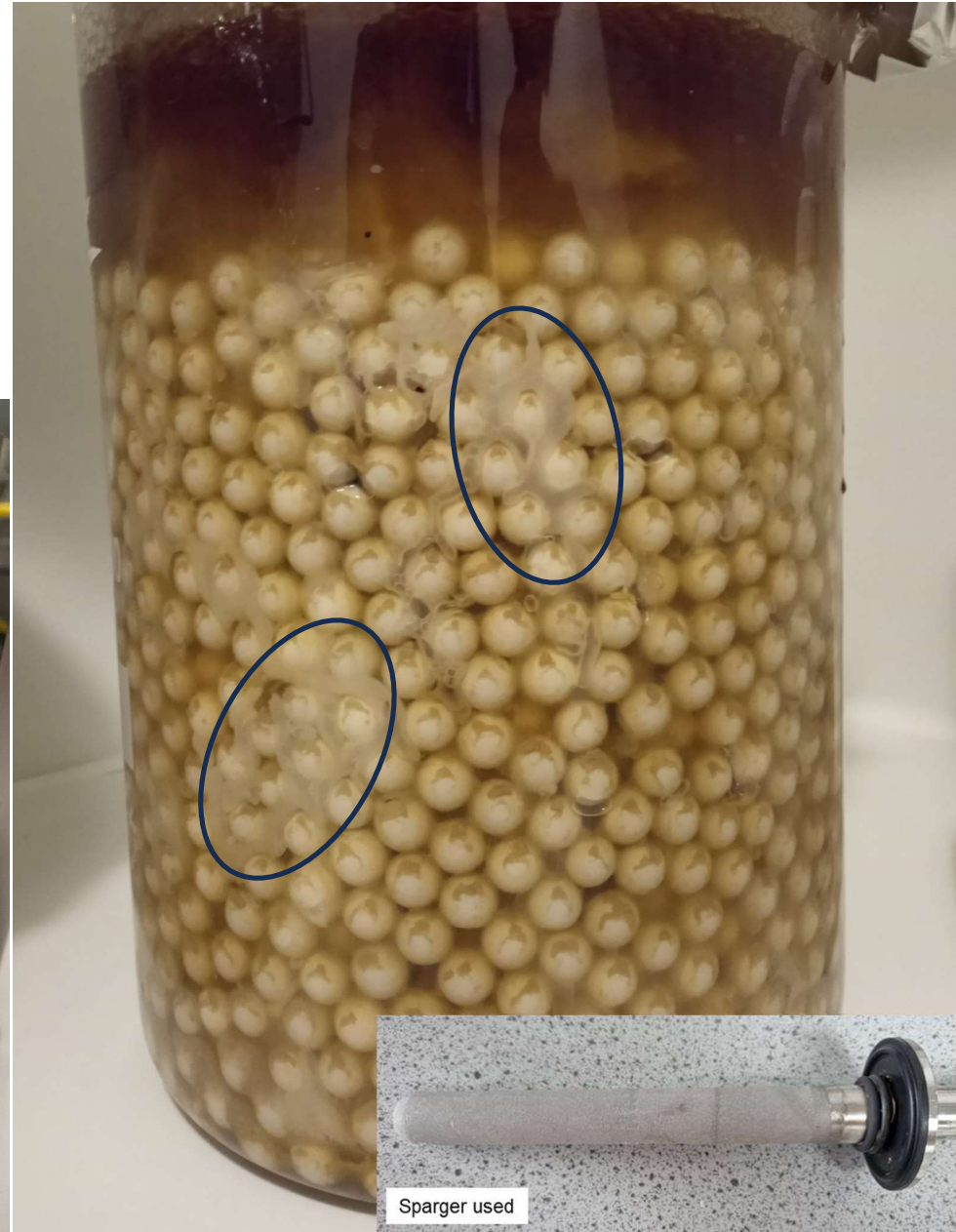
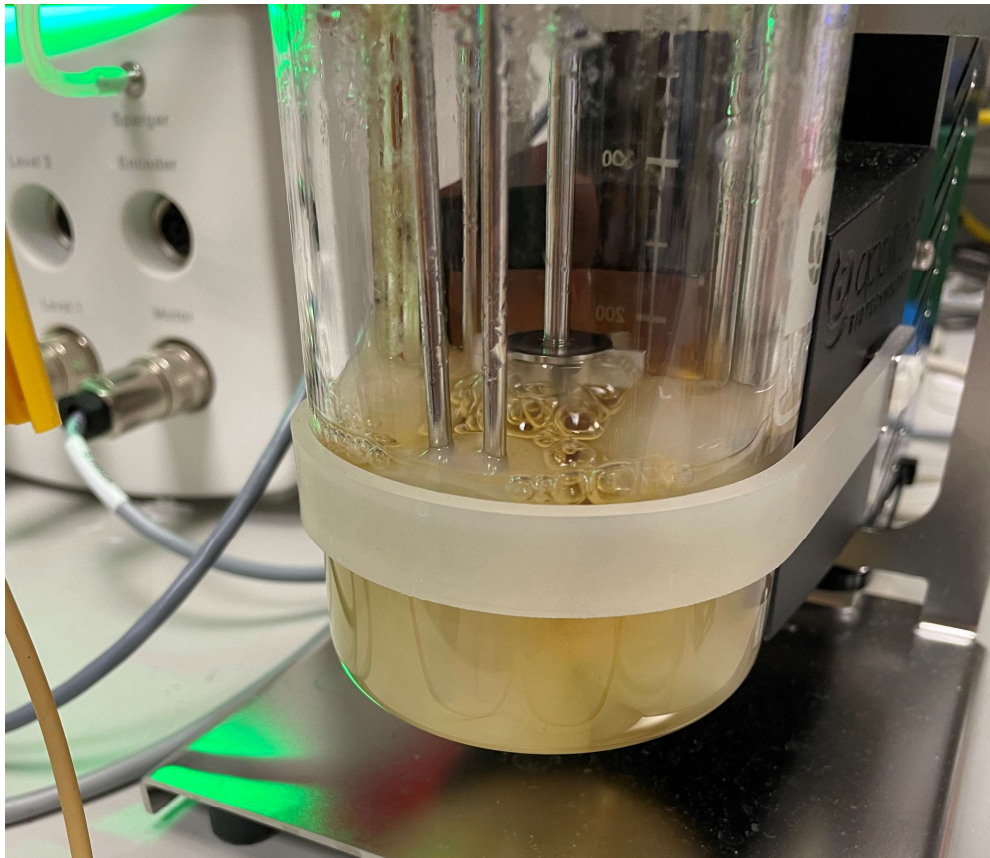
- Cellulose concentration: 6 to 12 g/L
- Cellulose Yield 46 to 100%
- 500 g cellulose/month
- Isolated our own strain



Komagataeibacter sp



Submerged fermentation





BBNet Scale-up Award- 2023

BDC

BAM
BAMBOO CLOTHING

AGRIFOODX



3- 4- Spinning and manufacturing



Ionic Liquids



Lyocell process **BBNet BIV 2024**

- Produce 3kg cellulose
- Tested and processed by Nanollose
- Spun by Birla Aditya using a Lyocell process
- Manufacture staple fibres, yarn, fabric and a garment



Biobased textile to textile Recycling

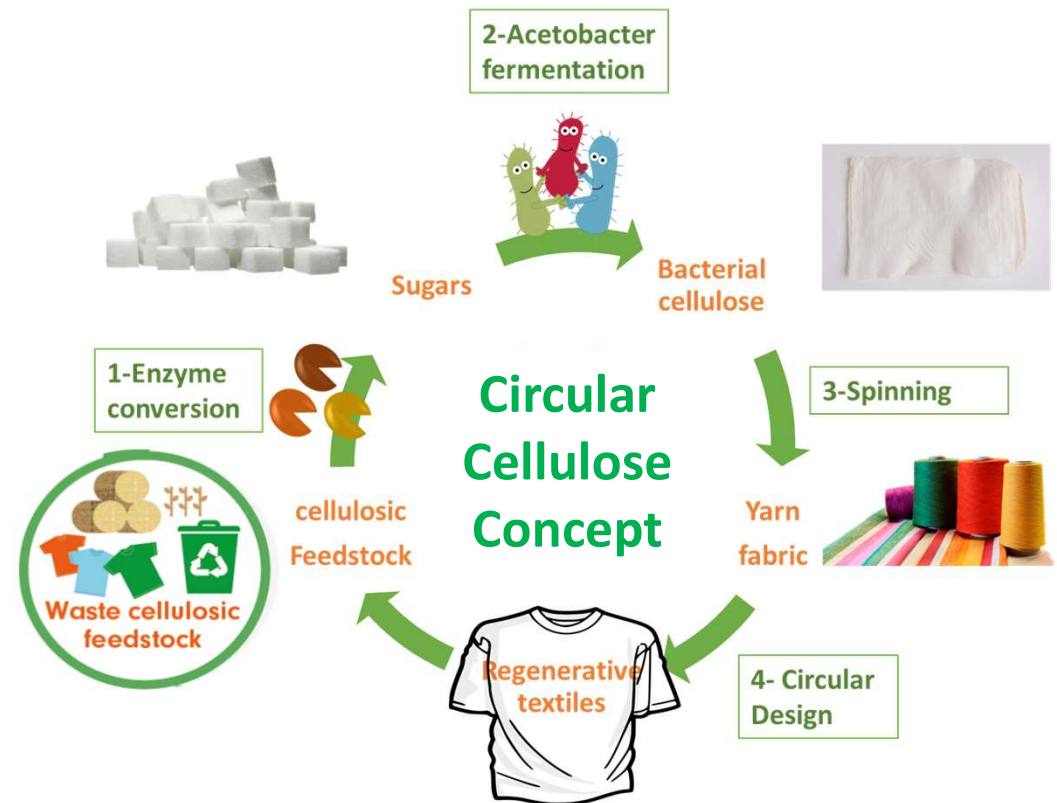


Advantages over mechanical and chemical recycling approaches

- No need to sort, remove finishes or de-colour
- Non cellulosic fraction can be recovered: polyester, nylon, elastane
- Excellent process for regenerated cellulose recycling

Circular cellulose Concept

- Using cellulosic 'wastes': agricultural, MSW, post-consumer blended fabrics
- 50% to virgin like bacterial cellulose
- Looking into other applications for the cellulose



Acknowledgements

University of York

Prof. Simon McQueen-mason

Prof Neil Bruce

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University of Leeds

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Prof Phil Purnell

Cranfield University

Dr Sameer Rahatekar

University of Loughborough

Dr Hemaka Bandulasena

Biorenewables Development Centre

Dr Mark Gronow

Dr Debs Rathborne

Rosie Nolan



Engineering and Physical Sciences Research Council



Biotechnology and Biological Sciences Research Council



Georgia-Pacific



ModernSynthesis

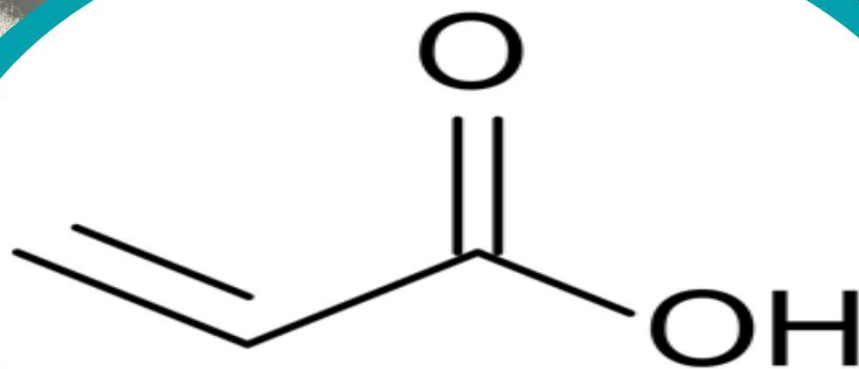




Bioacrylic acid from seaweed

Prof. Jonathan Todd

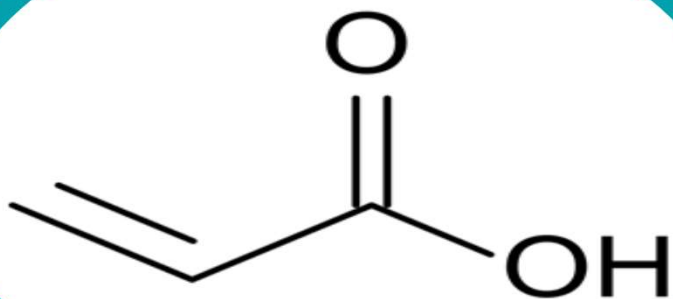




Acrylic acid



Acrylic acid - a platform chemical

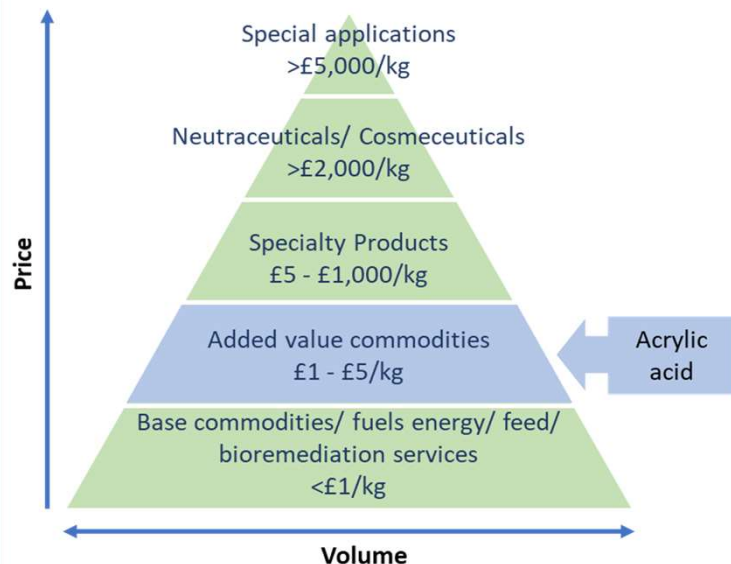


Acrylic acid market			
Global	USD 12 billion (2020)	3.6% CAGR (2020-2027)	6.3 million tonnes (2019)
Europe	USD 4.5 billion (2019)	4% CAGR (2019)	0.64 million tonnes (2020)
UK	~11 million GBP of acrylic acid esters imported to the UK in 2019		

**Global market: 6.3 million tonnes
in 2019**

\$4.5 billion

Acrylic acid - a value commodity



Currently solely made from fossil fuel-derived propylene via a relatively expensive and CO₂ releasing process.

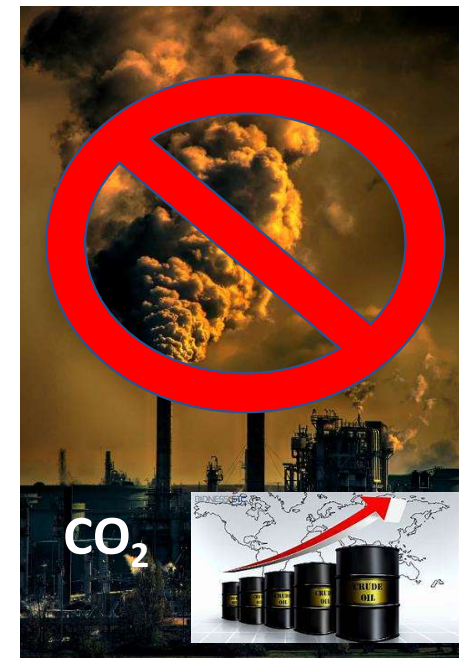
The future of chemicals is 'bio'

Chemical industry shifting to bio-based chemical production due to:

- Government regulations – carbon taxes, UK Net Zero Target 2050²
- Societal and environmental pressures
- Fossil fuel price fluctuation & crisis

But all current BIO-based acrylic acid production strategies are:

- ✗ Too expensive
- ✗ Inefficient
- ✗ Not Scalable
- ✗ Low yields (up to mg/kg)



Our Aim: Establish viable BIO-based acrylic acid production

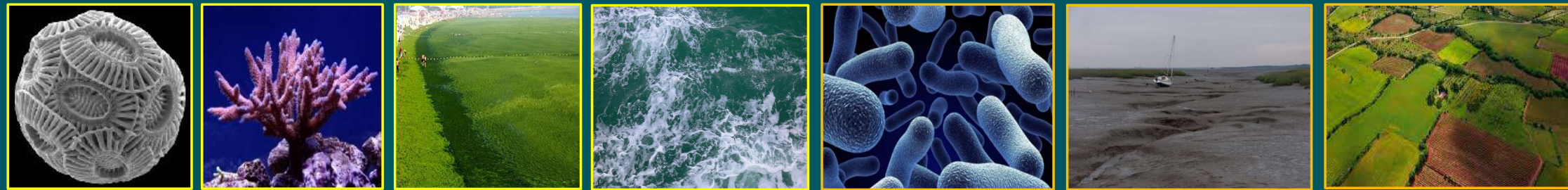
- **Our feedstock is renewable:**
 - Non-competitive for land and water with food crops
 - It is a massive CO₂ sink; important in reducing GHG emissions
 - Combats eutrophication
 - Supports an emerging worldwide industry and will boost its value
- **A bacterial fermentative process**
- **Utilises waste material normally discarded at cost**



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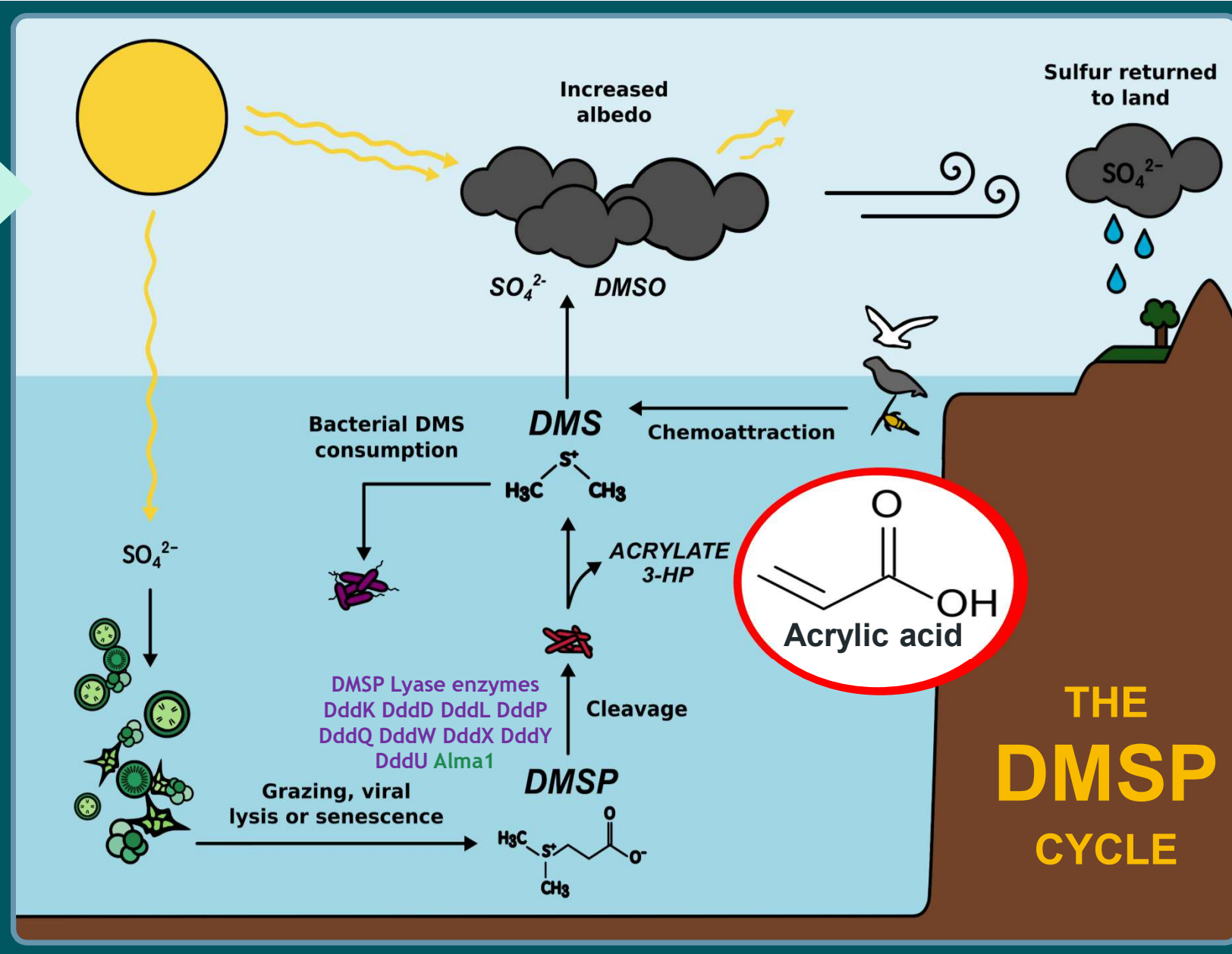


Part 2: An innovative solution informed from our marine research



DMSP catabolism

- Annually marine algae produce >8 billions tonnes of dimethylsulfoniopropionate (DMSP) p.a
- @ up to [0.5M]
- Microbial **DMSP lyase enzymes** cleave DMSP to DMS
- We have identified 9 different bacterial **DMSP lyases**

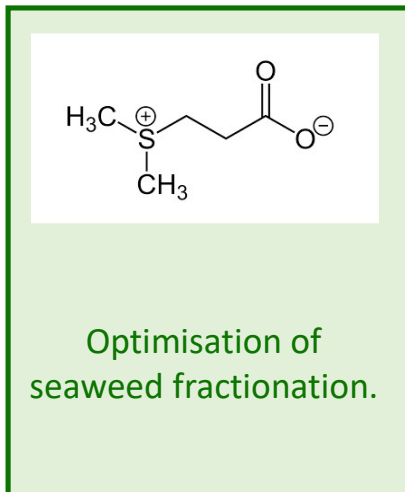


Bioacrylic acid from seaweed - Our Solution

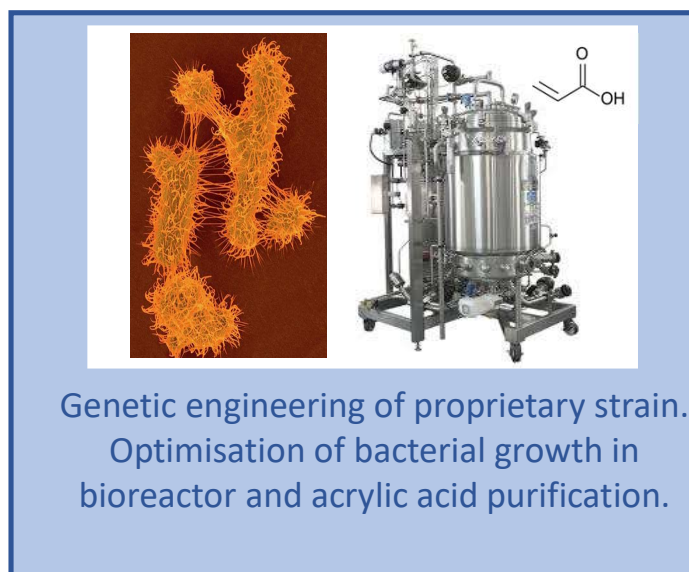
UK Farmed
Seaweed/waste



Seaweed
fractionation/waste



DMSP
fermentation



Acrylic acid
purification

Reduced C footprint of
acrylate polymers



Q1: Can seaweeds provide enough DMSP?



Browns not viable but **Red** and **Green** seaweeds possible yield 5-45 g DMSP/kg (orders of magnitude higher than other bio-methods mg/Kg)

Q2: Can DMSP be efficiently extracted from seaweed?



-95 % of DMSP captured in aqueous solution from *Ulva*

- DMSP stable after extraction

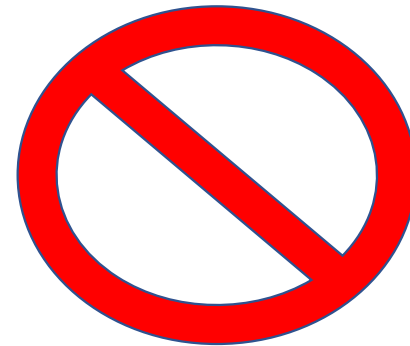
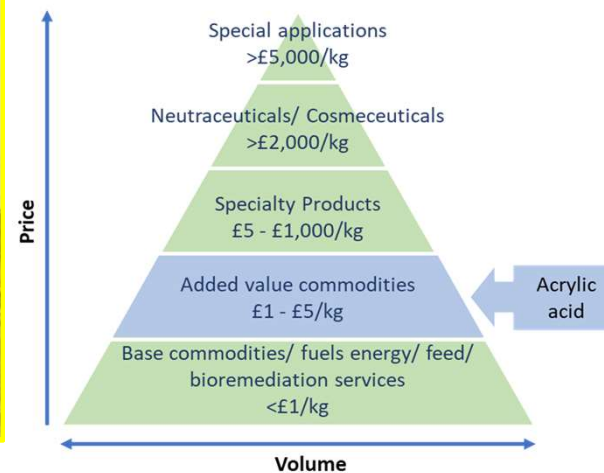


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Q3: Is seaweed really a viable source of DMSP?



With **harvesting and transport costs** seaweed/seaweed waste is expensive for an added value commodity chemical

We have ways to reduce cost & increase profit

WE NEED SUPPLY CHAIN AND LIFE CYCLE ANALYSIS

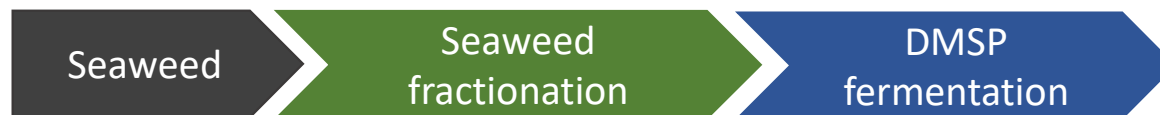
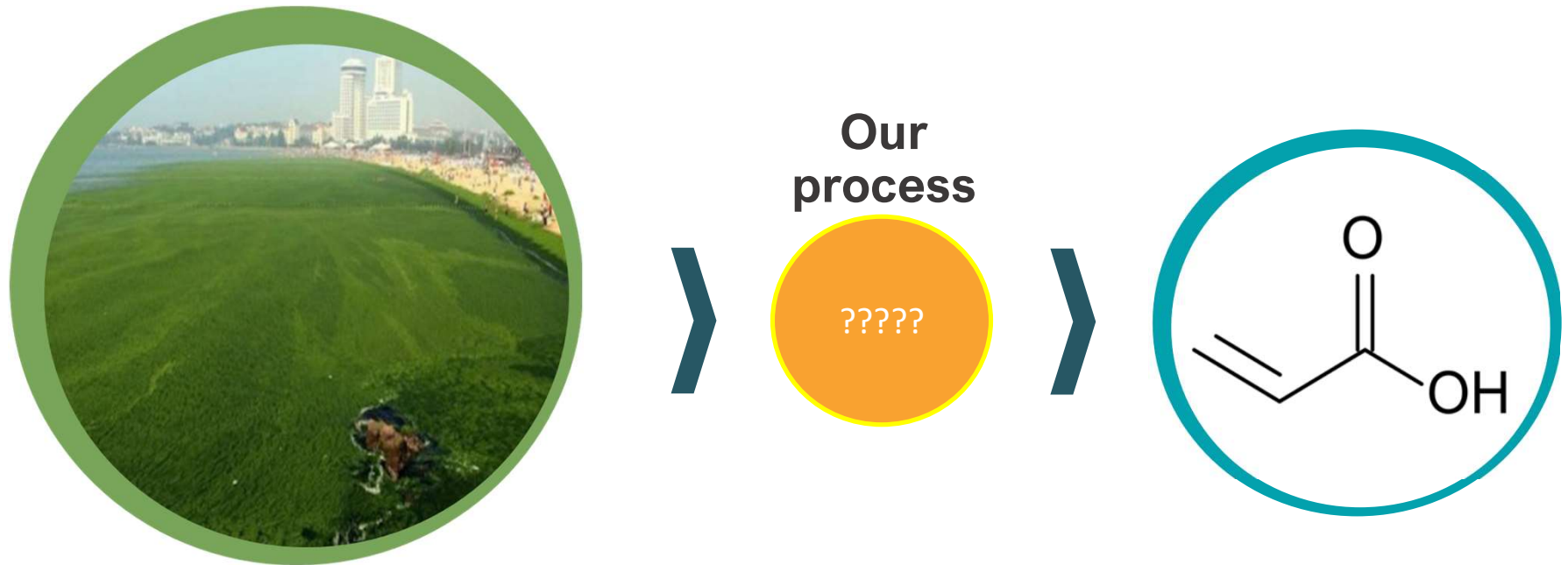


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Q4: How will we produce BIO acrylic acid?

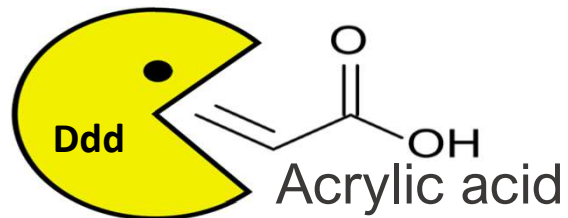


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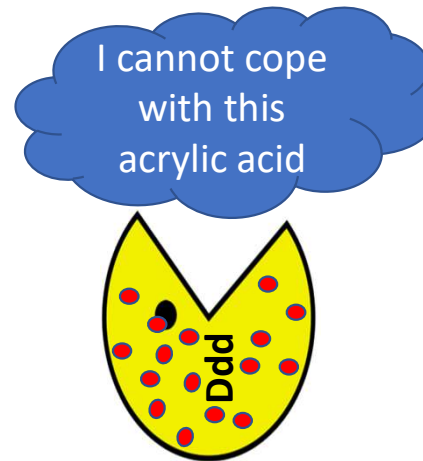


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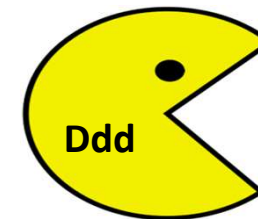
Some key problems:



1. DMSP degraders eat acrylic acid

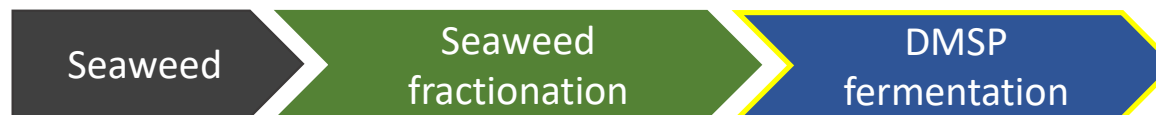
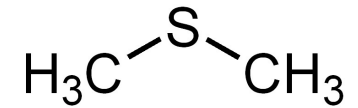


2. Acrylic acid is toxic



3. DMS is very smelly

Dimethylsulfide (DMS)



How did we mitigate these problems?



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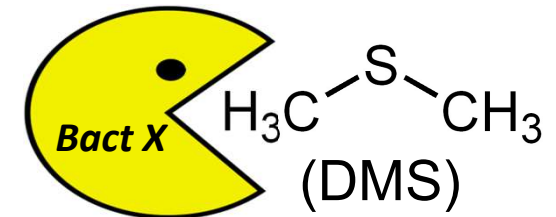
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Problems 1 & 2: Isolation of *Bacterium X*

1. DMSP degraders eat AA

2. Intracellular AA is toxic

3. DMS is very smelly



We isolated *Bacterium X* which derives energy from eating DMS and does not eat acrylic acid

Take home: *Bacterium X* = Suitable host



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Problem 2 & Engineering DMSP cleavage

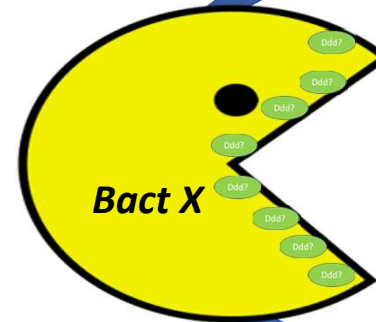
1. DMSP degraders eat AA 

2. Intracellular AA is toxic 

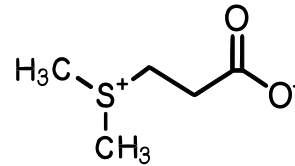
3. DMS is very smelly 



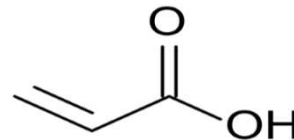
Ddd?



DMSP



Acrylic acid

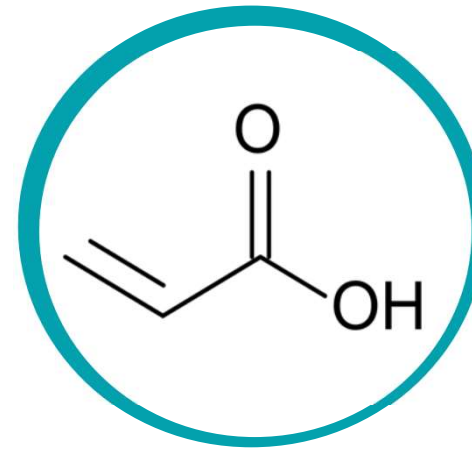
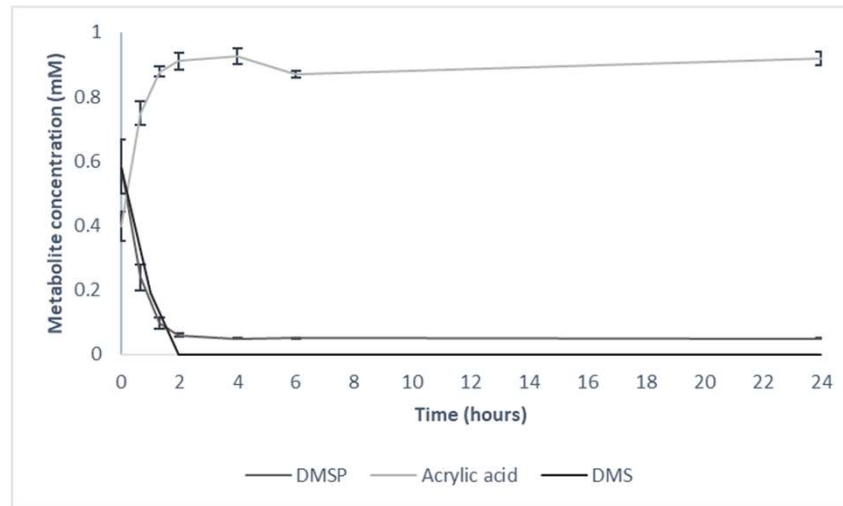
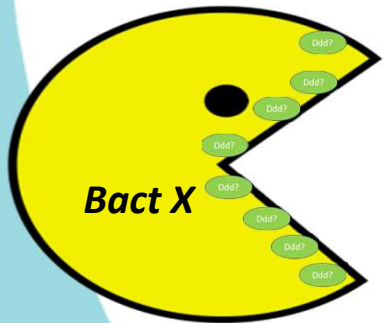


We designed and inserted a membranous DMSP lyase into *Bacterium X*

Take home: *Bacterium X* with Ddd? makes extracellular acrylic acid from DMSP



Proof of principle with pure DMSP (50 ml)



- *Bacteria X* (Ddd?) degraded >95% DMSP in < 2 h generating acrylic acid (1:1) 
- Acrylic acid was stable 
- DMS was efficiently removed 

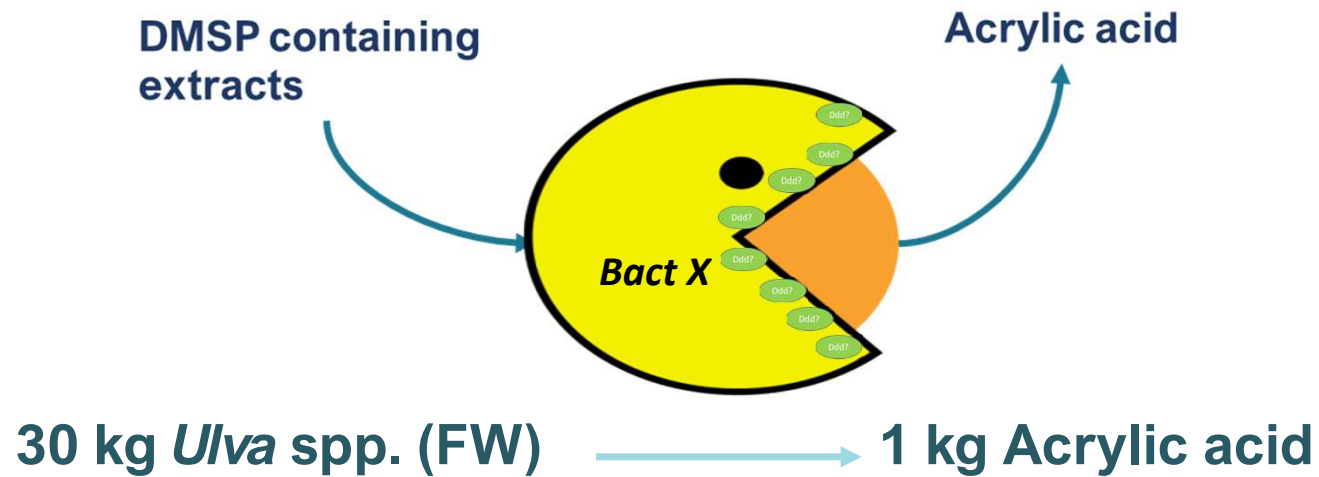


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Proof of concept at bench scale (100 mL)



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Summary:

- Acrylic acid is a widely used platform chemical made from fossil fuels
- Huge Industrial interest for bio-based acrylic acid
- Currently no bio-method for bio-based acrylic acid
- Algal DMSP (up 4.5% of weight) is a viable source of bio-acrylic acid
- Seaweed farming is in a surge in the UK & Worldwide
- Developed a fermentative process for bio-acrylate production (1 kg from 30 kg algae)
- Cost indications imply it is feasible
- Solved DMS smell issues
- Exciting opportunities with transgenic crops!!
- Exciting opportunities for other platform (3HP) and higher value chemicals



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Future work:

- **Purification** and testing of acrylic acid
- **Scale-up** to lab and industrial biofermenters
- **Business model** with Tomas Harrington @UEA and apply for funding for detailed **Life cycle & Supply Chain analysis**



Final comment:



'Bio-based acrylic acid is like the holy grail, everyone wants it, they tried to get it for many years, but I still haven't seen a drop. If you can produce a gram you will already be better than anyone else'



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Bioacrylic acid from seaweed

Prof. Jonathan Todd

Ash Norcott (DTP)

Dr. Ana Bermejo Martinez

Bineta Dia

Peter Paolo Rivera

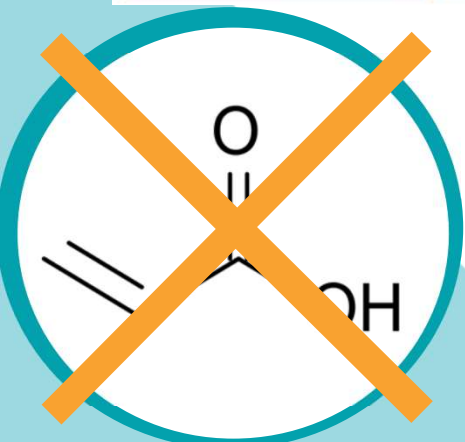
Dr. Tomas Harrington

Dr. Faye Outram



Bioacrylic acid production - Competitors

Party/partnership	Source material	Origin chemical	Process	Cost	Efficiency	Status
	Wait and see !!!					
	Biofuel waste	Glycerin	Two step (anaerobic/aerobic) conversion via 3-HPA	High	Low	Abandoned
	Biofuel waste	Glycerin	Two step (anaerobic/aerobic) conversion via 3-HPA	High	Low	Abandoned
	Land crop (corn)	Lactic acid (toxic waste)	High temperature catalytic conversion	TBD	TBD	Abandoned
	Land crop (corn)	Ethylene, CO	High temperature conversion via β -propiolactone	?	?	Abandoned



- ✗ Too expensive
- ✗ Inefficient
- ✗ Not Scalable
- ✗ Low yields (up to mg/kg)



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



Prof Jinsong Shen

Professor of Textile Chemistry & Biotechnology

Email: jshen@dmu.ac.uk

Textile Engineering and Materials (TEAM)

Research Group

School of Fashion and Textiles

De Montfort University

Leicester, UK



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

- In-situ enzyme-catalysed coloration of wool
- Recycling and reuse of low value wool and /or post-manufacture waste wool feedstocks
 - extraction of polypeptides from waste wool
 - grafting the extracted polypeptides on virgin wool fabric to improve shrink-resist property of wool fabrics.
 - recovery of non-wool fibre components and dyes from waste wool blended fabrics and reuse.



Enzymes are proteins which catalyse specific chemical reactions and are known as 'bio-catalysts'.

Laccase and Peroxidase (oxidoreductases)

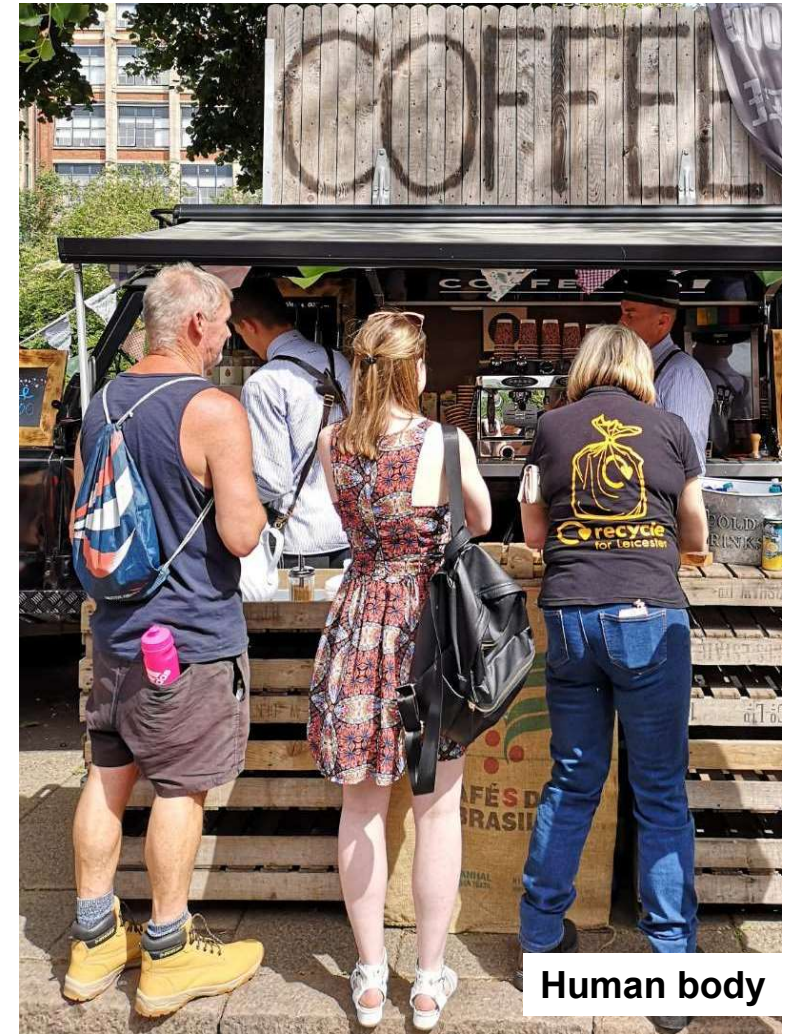
- having capability of catalysing the oxidation of a broad substrate spectrum.

Proteases (hydrolases)

- specific for hydrolysing proteins by catalysing cleavage of peptide bonds in proteins.

Enzymes

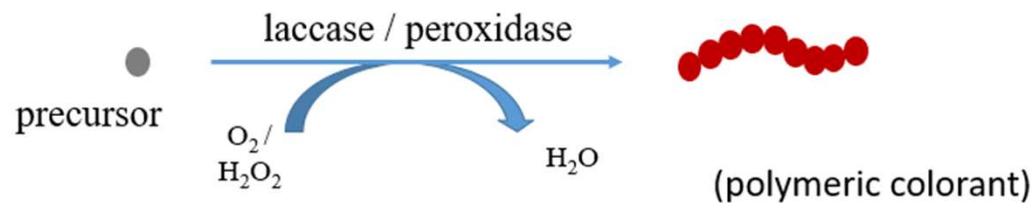
- very specific
- biodegradable and reusable
- operate under mild conditions
- accelerate reactions
- safe and easy to control



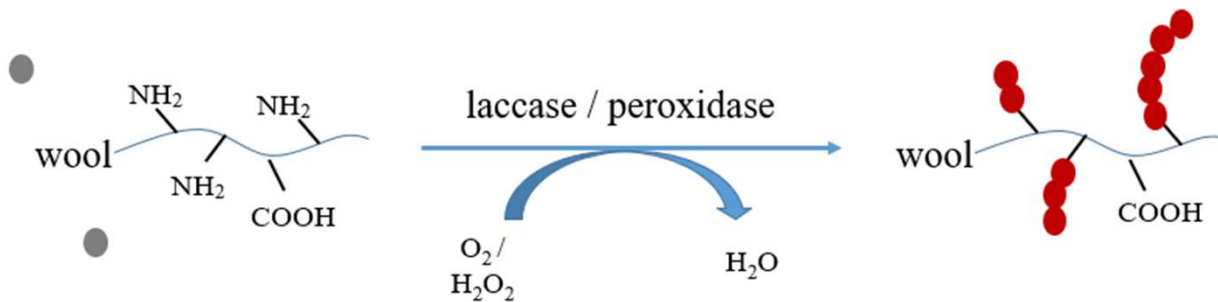
Enzymes are naturally occurring proteins that speed up chemical reactions in living organisms.

In-situ enzyme-catalysed coloration of wool

enzyme-catalysed in-situ coloration process for textiles without the use of pre-manufactured synthetic dyestuffs and chemical auxiliaries, resulting in the benefit of energy saving as well as the reduction of waste effluents.

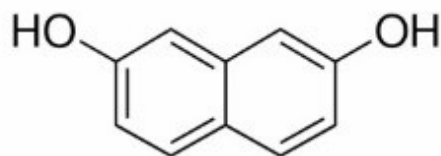


Oxidative polymerisation and grafting on wool



Wool and nylon fabrics dyed *in-situ* by laccase with 2,7DHN precursor under different buffer system and pH

Precursor



2,7 DHN
(2,7-Dihydroxynaphthalene)

Laccase

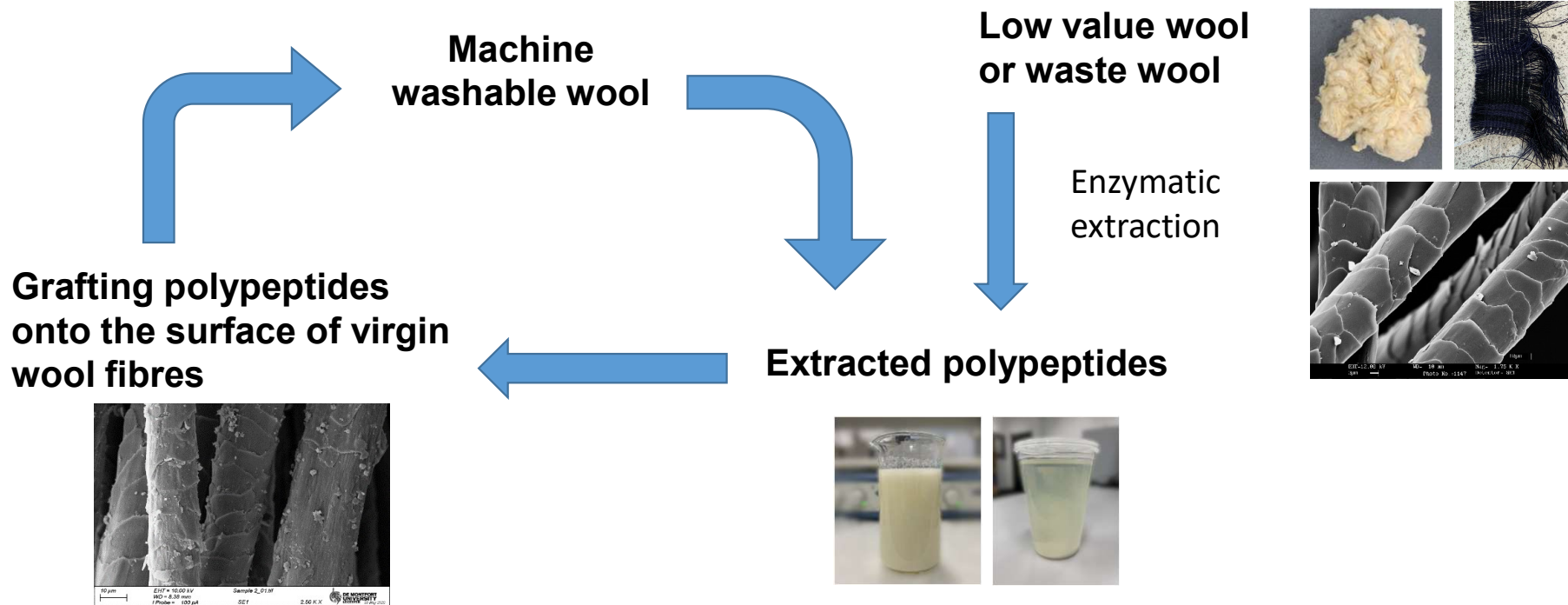
pH 3 - 11 and 50°C

2,7DHN - Wool				
pH	Acetate buffer	Citrate buffer	Phosphate buffer	Bicarbonate - Carbonate buffer
3			-	-
4				-
5				-
6				-
7				-
8	-			-
9	-	-		
10	-	-	-	
11	-	-	-	

2,7DHN - Nylon				
pH	Acetate buffer	Citrate buffer	Phosphate buffer	Bicarbonate - Carbonate buffer
3			-	-
4				-
5				-
6				-
7				-
8	-			-
9	-	-		
10	-	-	-	
11	-	-	-	

Recycling and reuse

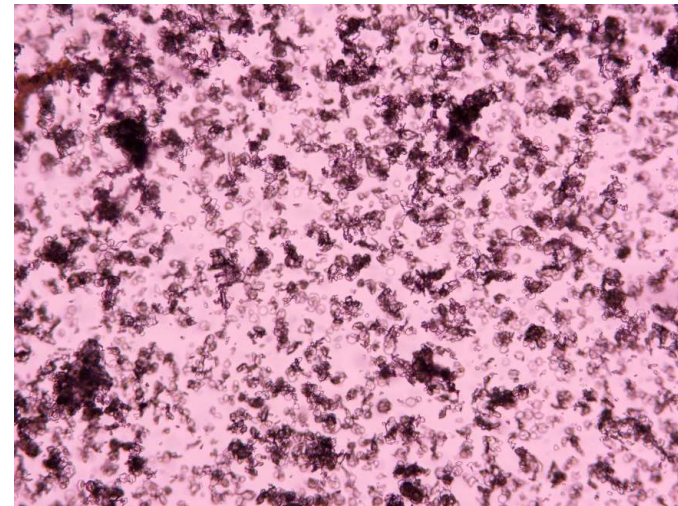
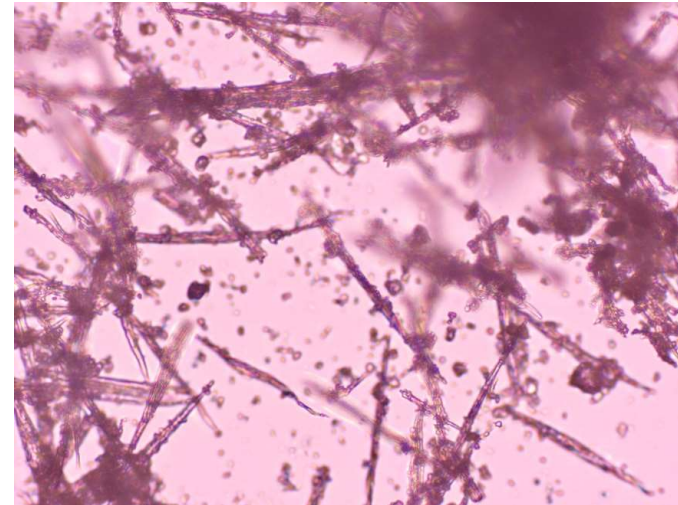
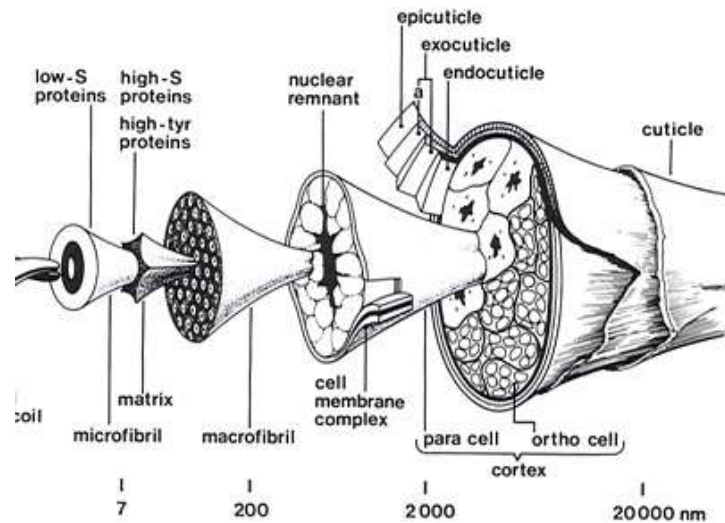
- extraction of polypeptides from waste wool
- grafting the extracted polypeptides on virgin wool fabric to improve shrink-resist property of wool fabrics



Recycling and reuse of low value wool and/or post-manufacture waste wool

Extraction of polypeptides from waste wool

- Degradation of the scales onto the wool's cuticle and breaking the S-S chemical bonds with amino-acid L-cysteine.
- Enzymatic digestion (hydrolysis) for dissolution of wool fibres



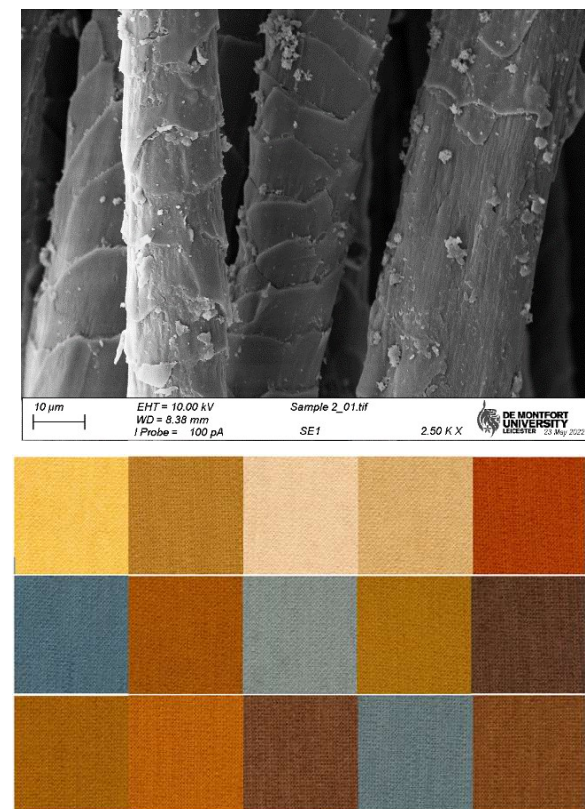
Extracted polypeptides

Recycling and reuse of low value wool and /or post-manufacture waste wool feedstocks

- grafting the extracted polypeptides on virgin wool fabric to improve shrink-resist property of wool fabrics.

Wool fabric samples	Area Felting Shrinkage %			Burst Strength (kPa)
	1 x 4N	2 x 4N	3 x 4N	
Raw wool fabric	20.5	31.2	41.1	497.7
Scoured wool fabric (control)	11.2	19.8	25.7	479.9
Application of extracted polypeptide onto wool cross-linked with GDE and followed by peroxidase coloration	3.7	7.7	10.1	391.3

The extracted polypeptides can be used in the peroxidase-catalysed coloration of wool fabrics, with the potential to achieve the enzymatic coloration of wool and shrink-resist coating of polypeptide on the surface of wool fibres in a single stage process.



BBSRC funded project **ENZBIOTEX** (BB/X011623/1)
Approaches of enzyme-based biotechnology to achieve textiles
recovery and reuse for circularity

**Low value or waste wool materials
(wool/flax fibre blended upholstery fabrics)**

Enzyme
biotechnology

Successfully separation
of fibre components

Extracted polypeptides
for regenerated
protein materials



Recovered dyes for
dyeing virgin textiles



Recovered flax fibres
for re-processing back
to fabric production



Acknowledgements

Loughborough University, Loughborough, UK

Dr Chetna Prajapati

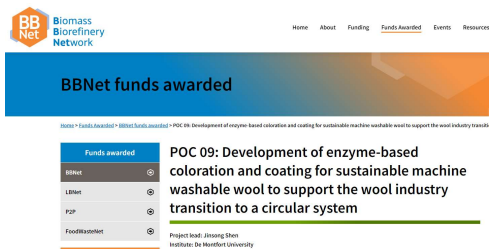
De Montfort University, Leicester, UK

Dr Edward Smith

Dr Mahmudul Akonda

Clémence Belbéoch

Novozymes for providing enzyme samples and their support



Approaches of enzyme-based biotechnology to achieve textiles recovery and reuse for circularity

camira



BBNet POC BIOWOOL
(POC03-Jul21-Shen-09)

BBSRC ENZBIOTEX
(BB/X011623/1)

MSAD

*Methano***sarcina** Detection
& Addition for Optimised
Anaerobic **D**igestion

Samantha Cook and Caroline H. Orr

samantha.cook@tees.ac.uk and c.orr@tees.ac.uk 

Rationale

Problem:

Two digesters operate similarly, but one consistently produces more biogas.

Previous Research:

Bacterial communities are similar, but archaeal communities differ between the digesters (*Figure 1.*).

Hypothesis:

Variations in archaeal communities may explain observed variation in biogas production.

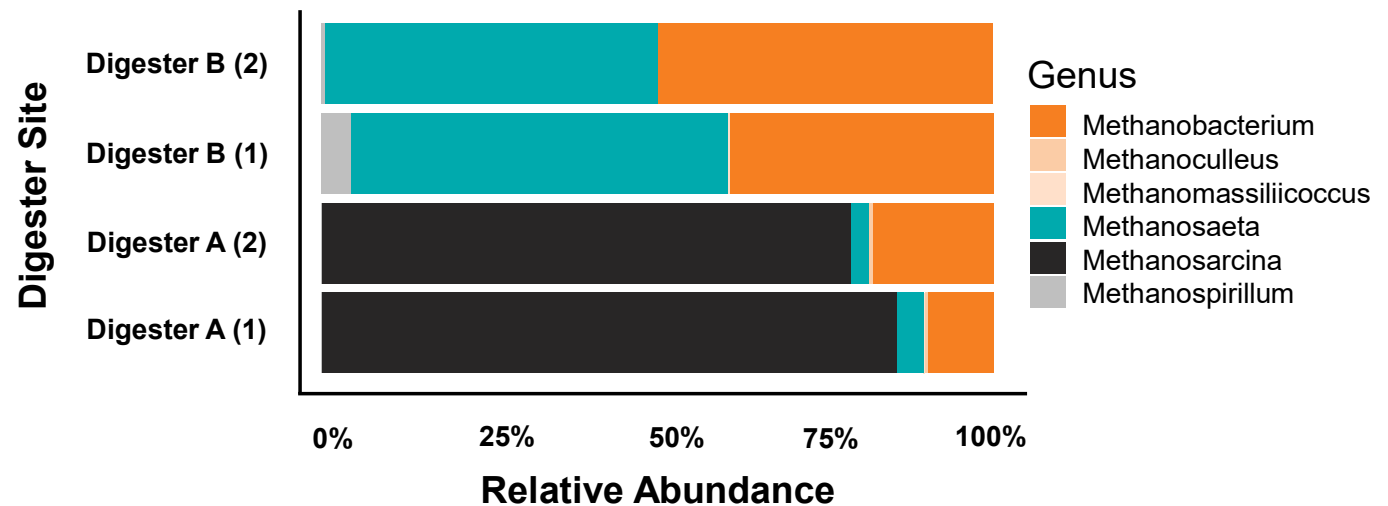


Figure 1: Stacked bar chart illustrating the variances in archaeal community structures between two industrial anaerobic digestion (AD) sites. The chart reveals a prevalence of *Methanosarcina* (*Msar*) in digester A, contrasted by a dominance of *Methanosaeta* in digester B. Thus, indicating potential contributions of archaeal populations to observed variations in methane production between the two AD sites.

Objectives

1

Demonstrate increased biogas production with *Msar* inoculant.

Quantify methane production from wastewater feedstocks with and without *Msar* inoculants.

2

Correlate *Msar* abundance with biogas production.

Microbial community profiling and qPCR to ensure *Msar* remains throughout trial and monitor its impact on other microbes within the community.

3

Optimise a process for monitoring *Msar* within AD.

Optimise qPCR assay for measuring *Msar* abundance.

Proposed Methodology

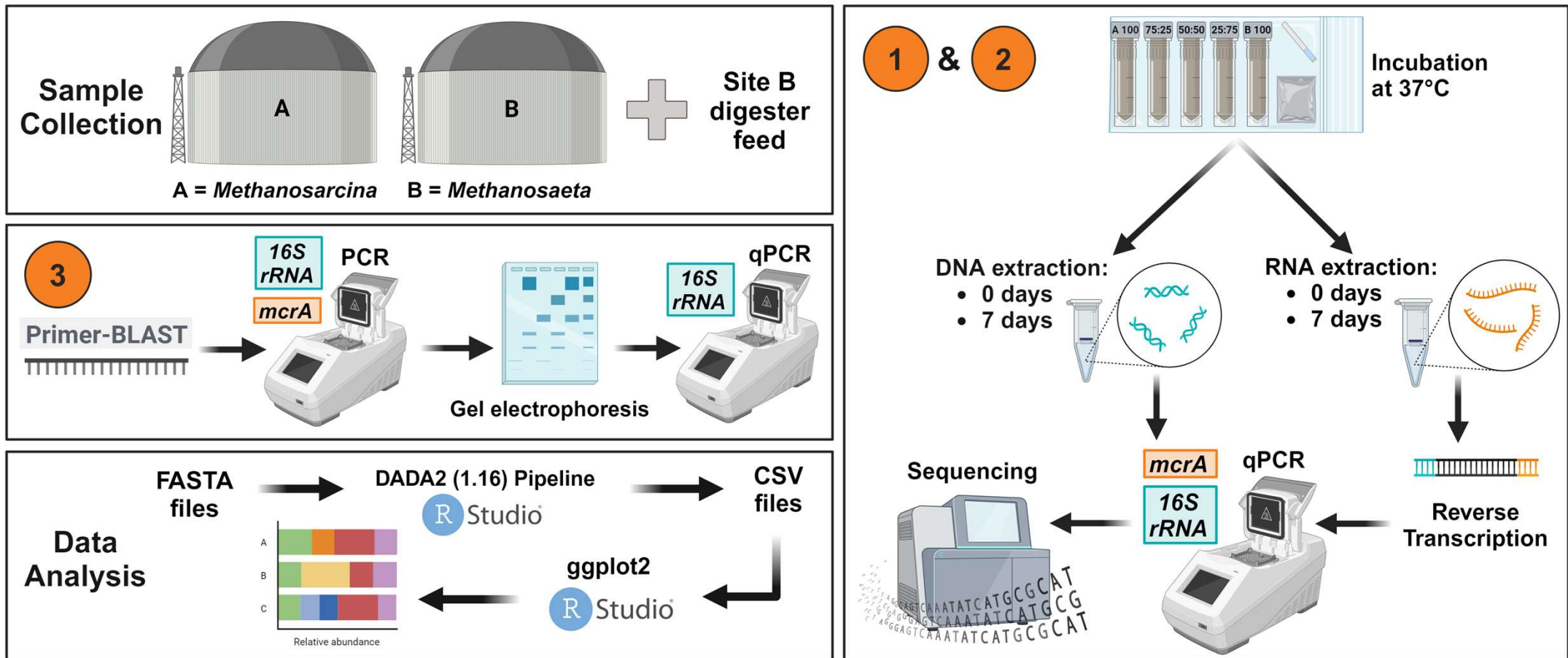


Figure 2: Schematic outlining the methodological approach employed to address the three research objectives. Created with BioRender.com.

Results to Date

Objective

2

Msar can survive and colonise, independent of feed type, microbial community diversity, or other environmental factors (Figure 3.).

Average Copy Number of *Methanosarcina* Within the Trial AD system

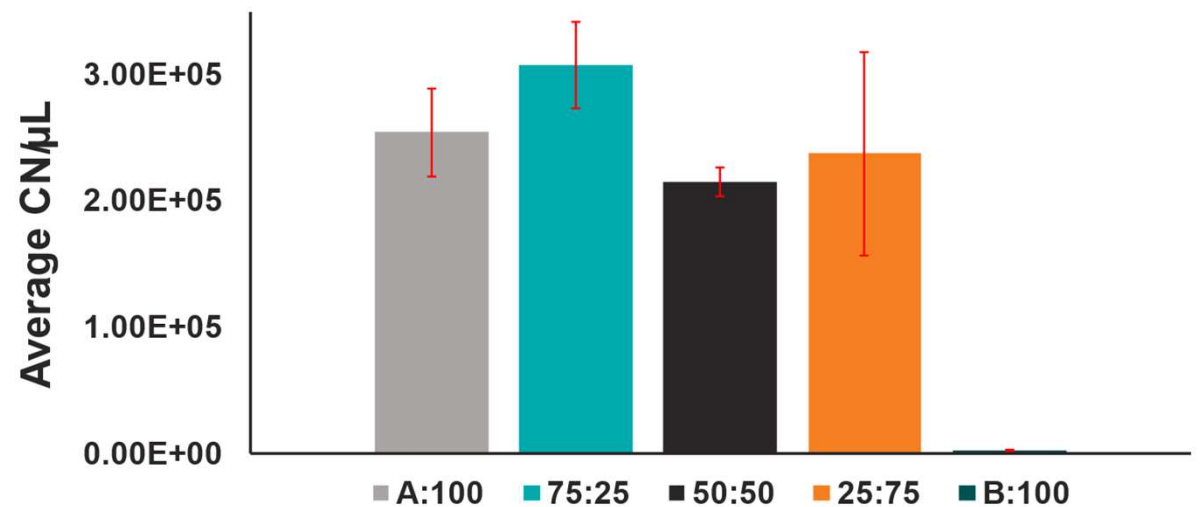


Figure 3: Bar chart depicting the mean copy number ($\pm$ standard error of the mean) of *Msar* for each trial AD ratio ($n=9$). The copy number was determined using the intercept of the qPCR standard curve. Statistical significance (1.897×10^{-5}) was assessed using Kruskal-Wallis test with a significance threshold of $p < 0.05$.

Results to Date

National Library of Medicine
National Center for Biotechnology Information

Input PCR template
Methanosarcina barkeri 227 chromosome, complete genome

Primer-BLAST

Primer pair 1

	Sequence (5'→3')	Template strand	Length	Start	Stop	Tm	GC%	Self complementarity	Self 3' complementarity
Forward primer	AGTTCGGATCGAGGGCTGTA	Plus	20	1246	1265	60.40	55.00	4.00	2.00
Reverse primer	GCAAGGAGCAGGGACGTATT	Minus	20	1340	1321	60.11	55.00	4.00	1.00
Internal oligo		Plus							
Product length	95								

Primer pair 2

	Sequence (5'→3')	Template strand	Length	Start	Stop	Tm	GC%	Self complementarity	Self 3' complementarity
Forward primer	TAGTTCGGATCGAGGGCTGT	Plus	20	1245	1264	60.40	55.00	4.00	0.00
Reverse primer	GCAAGGAGCAGGGACGTATT	Minus	20	1340	1321	60.11	55.00	4.00	1.00
Internal oligo		Plus							
Product length	96								

Check specificity against *Methanosaeta* genus

National Library of Medicine
National Center for Biotechnology Information

Log in

Primer-BLAST > JOB ID:fmWbeetzQId9ZXIrGEVLFQNoeQQd20B

Primer-BLAST Results

Specified left primer cannot be found in template...make sure this primer is on the plus strand of your template.

Objective

3

In silico primer design, using Primer-BLAST was successful and specific to *Methanosarcina* (Figure 4.)

Figure 4: In silico primer design process in Primer-BLAST, using the *Msar* species' 16S *rRNA* gene from GenBank as sequence input and *M.barkeri* 227 as the reference database. Including specificity checking against the *Methanosaeta* species' 16S *rRNA* gene sequences from GenBank.

Results to Date

Objective

3

In vitro validation of the primers was also successful, amplifying the target gene with specificity (Figure 5.).

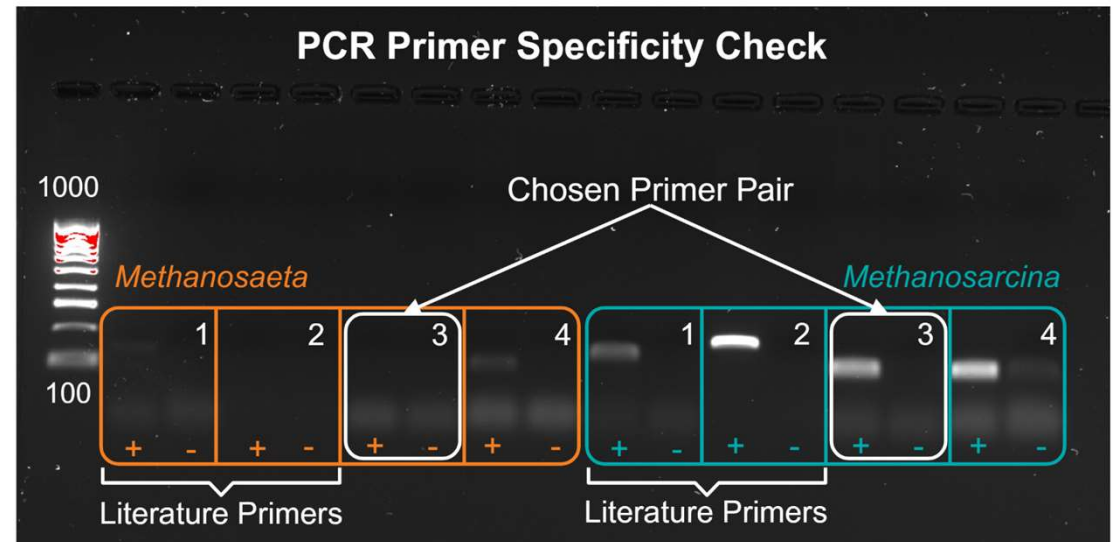


Figure 5: Agarose gel electrophoresis was performed to assess the specificity of the self-designed/literature *Msar* primers against *Methanosaeta*. A 1.5% agarose gel in 1X TBE buffer was prepared and electrophoresed at 150V for 30 minutes. The gel was stained with SYBR safe and visualised using UV transillumination. A 100 bp DNA ladder was used as a molecular weight marker.

Next Steps...

Objective

1

Develop *mcrA* specific primers and receive RNA sequencing results to quantify expression of the *mcrA* gene.

Future Perspectives

- DNA sequencing results for whole community analysis and validation.
- Utilise **Automatic Methane Potential Test System** (AMPTS) to directly monitor/quantify gas production to strengthen the correlation between microbial dynamics and biogas yield.
- Optimise **Loop-Mediated Isothermal Amplification** (LAMP) PCR assay for faster, cost-effective, and accessible characterisation of archaeal communities within digesters, compared to sequencing/qPCR.

 **BPC INSTRUMENTS**



Thank You

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

Jonathan Wagner

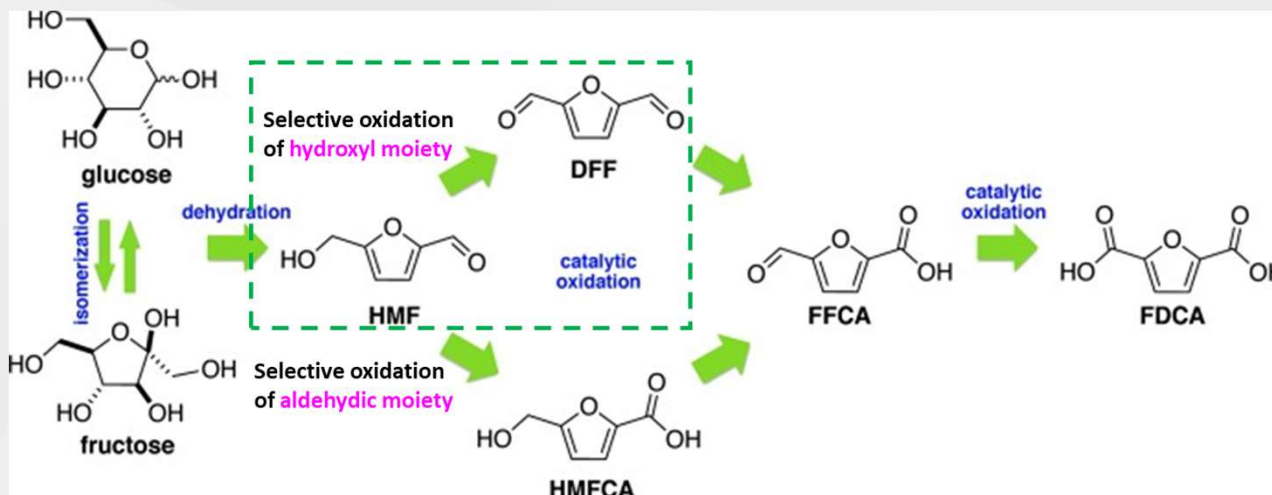


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Oxidation of 5-HMF into FDCA

- 5-HMF is a key bio-based platform chemical which can be produced from dehydration of glucose
- Oxidation of 5-HMF yields 2,5-furandicarboxylic acid (FDCA), a potential substitute for terephthalic acid

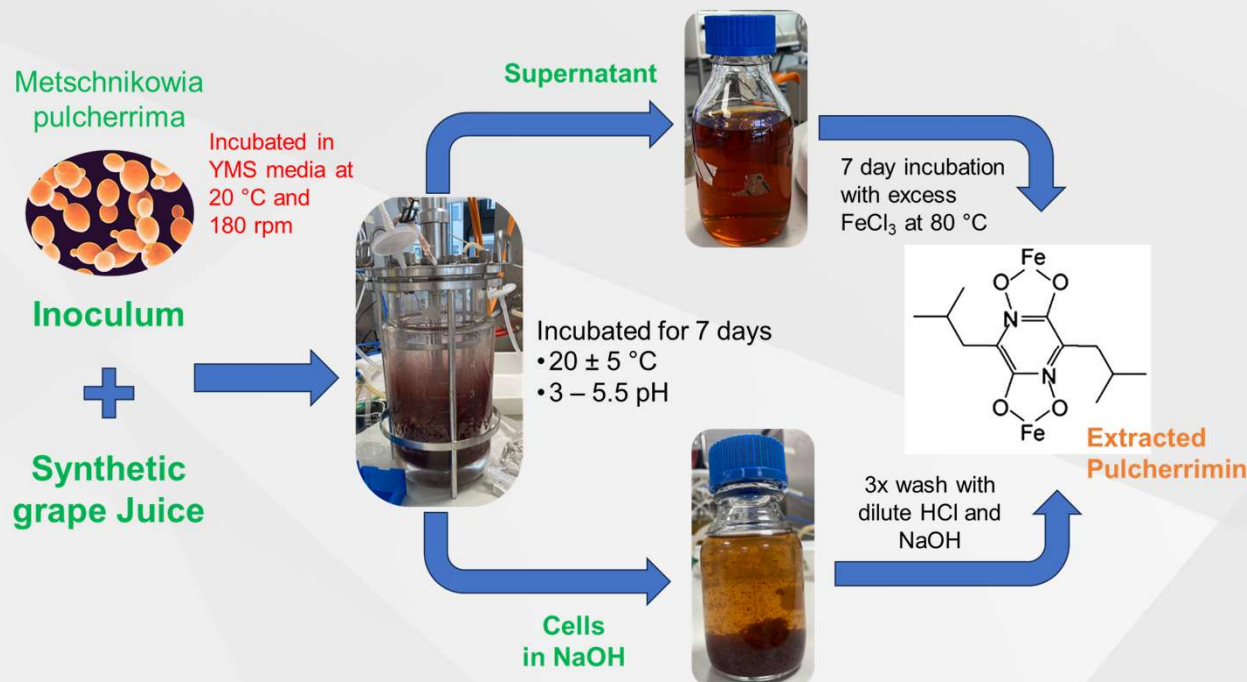


- Reaction can follow two routes, via DFF, or HMFA
- Range of existing catalysts, including homogenous bases, noble metals, transition metal oxides and biocatalysts, including both enzymes and whole cells



Pulcherrimin

- Pulcherrimin is bio-based metal-organic framework produced by some bacteria and yeasts
- Insoluble in water and organic solvents (but highly soluble in strong base)
- Explored as antimicrobial agent, especially in biocontrol applications
- Potential oxidation activity

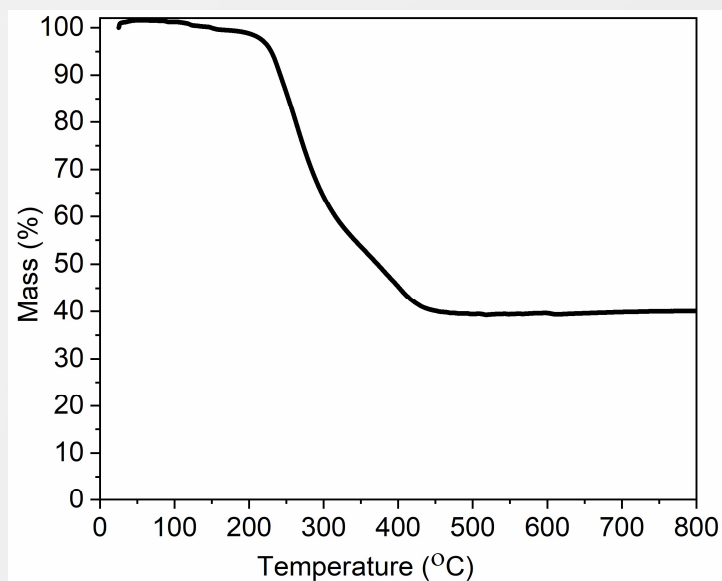


Pulcherrimin synthesis procedure

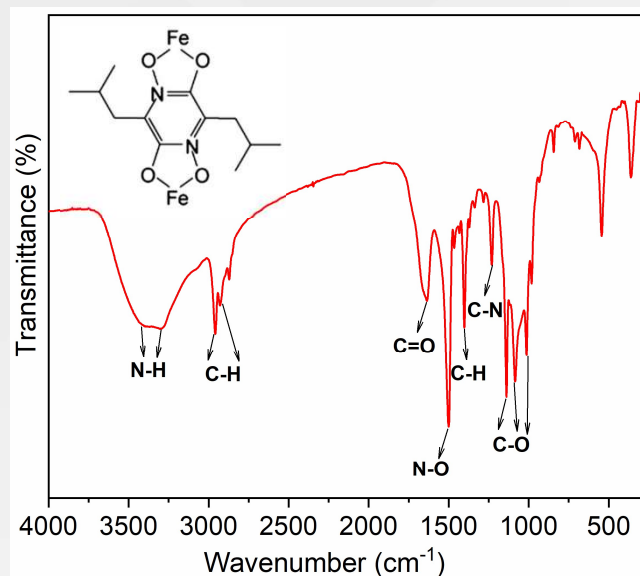


Pulcherrimin characterisation

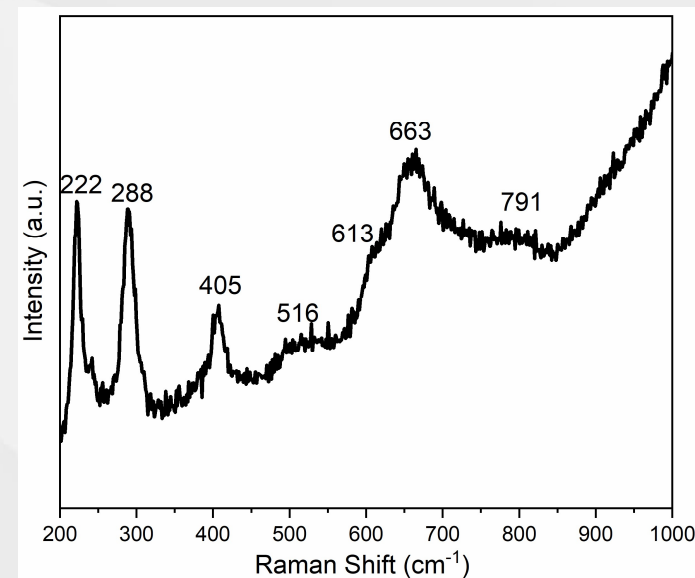
TGA in air



FT-IR

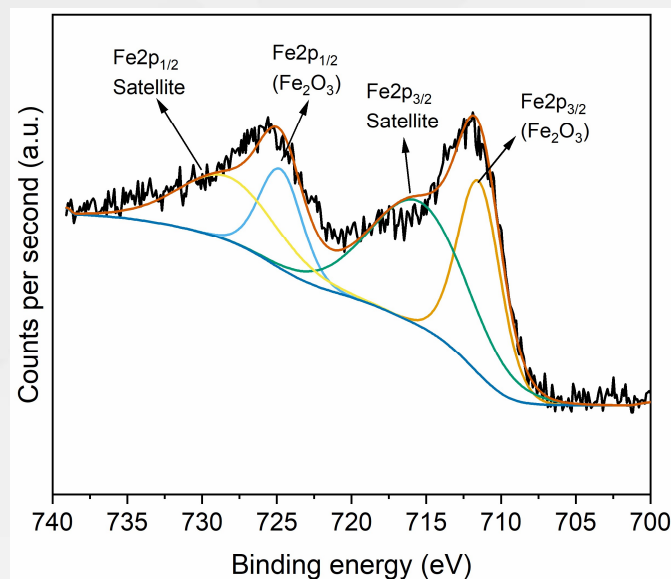
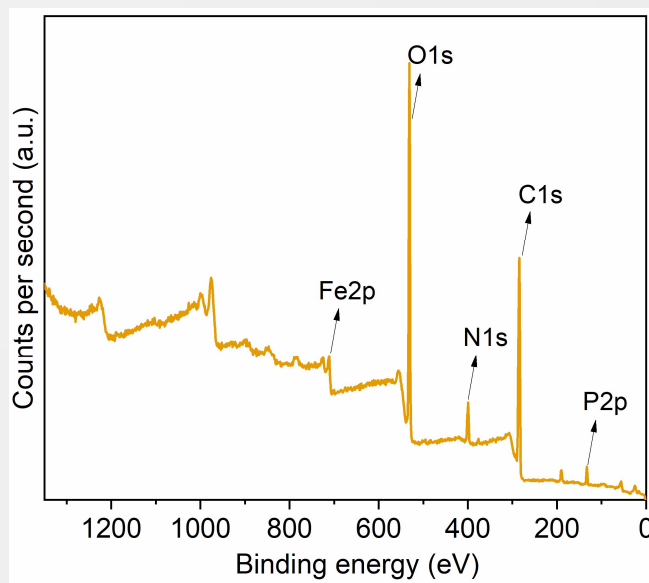


Raman analysis



Pulcherrimin characterisation

XPS analysis



BET Surface
area (m² g⁻¹)

29.05

Pore Volume
(cm³ g⁻¹)

0.153

Pore Size
(nm)

15.2

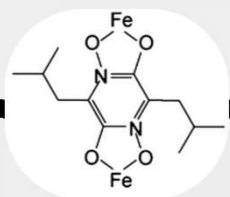


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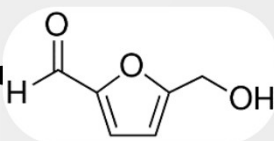
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5-HMF Oxidation experiments

50 mg
Pulcherrimin



40 mL of 500
ppm 5-HMF
in water



10 bar O₂



100 mL Parr reactor with
online liquid sampling

- 10 h total reaction time with intermediate liquid sampling
- 100 °C, 120 °C, 140 °C
- Reactions done in absence of base
- Compared against Fe₂O₃/C baseline catalyst

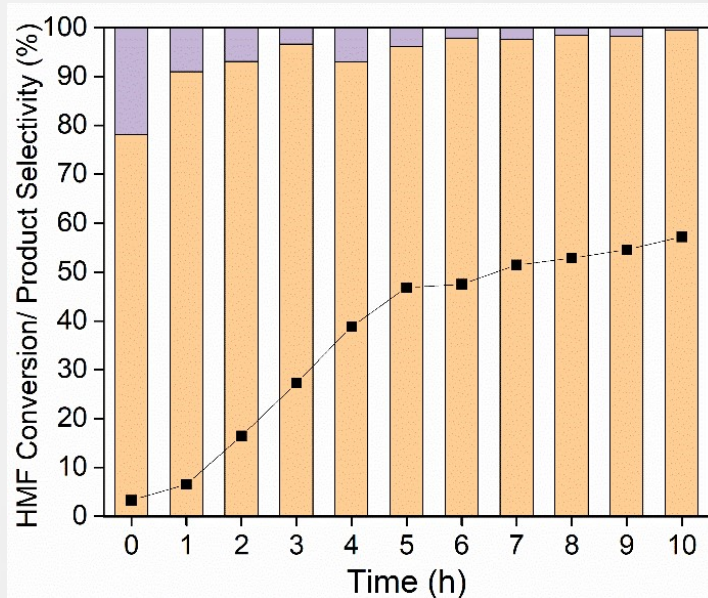


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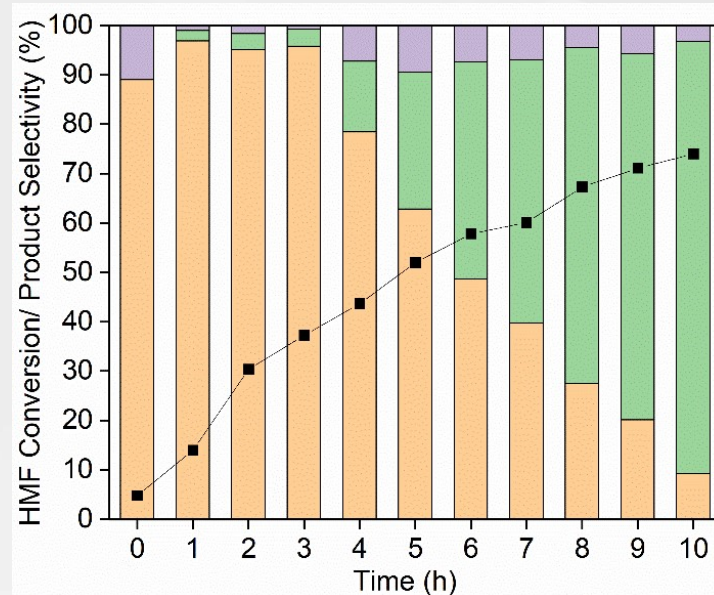
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Preliminary results

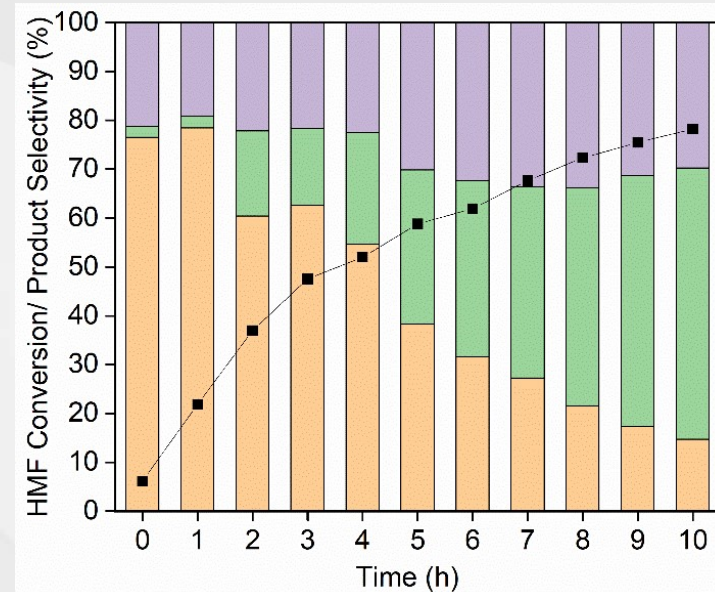
100 °C



120 °C



140 °C



DFF FDCA Others —■— HMF Conversion

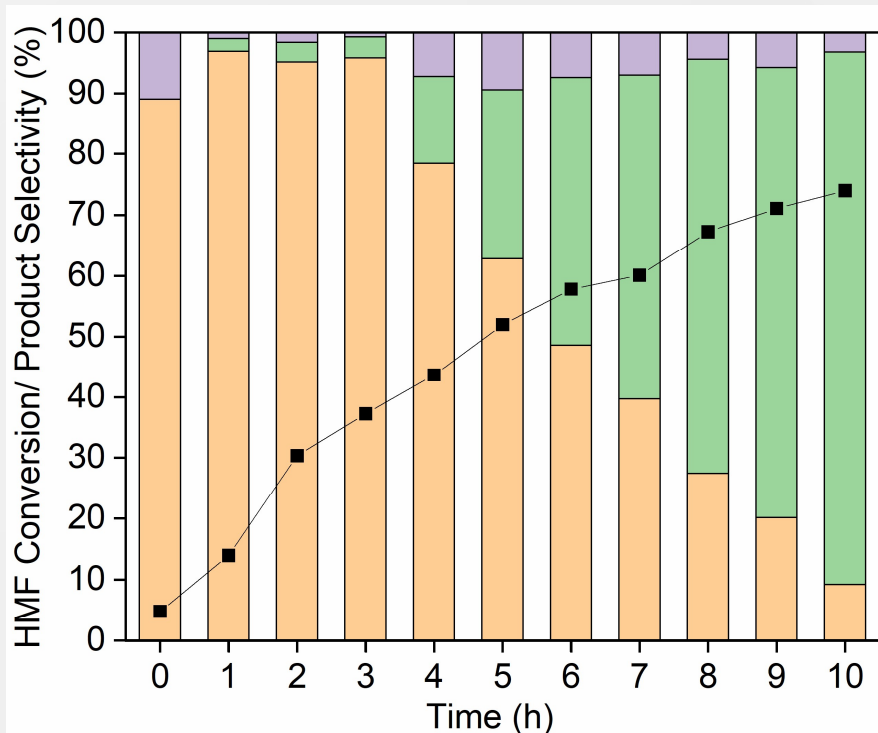


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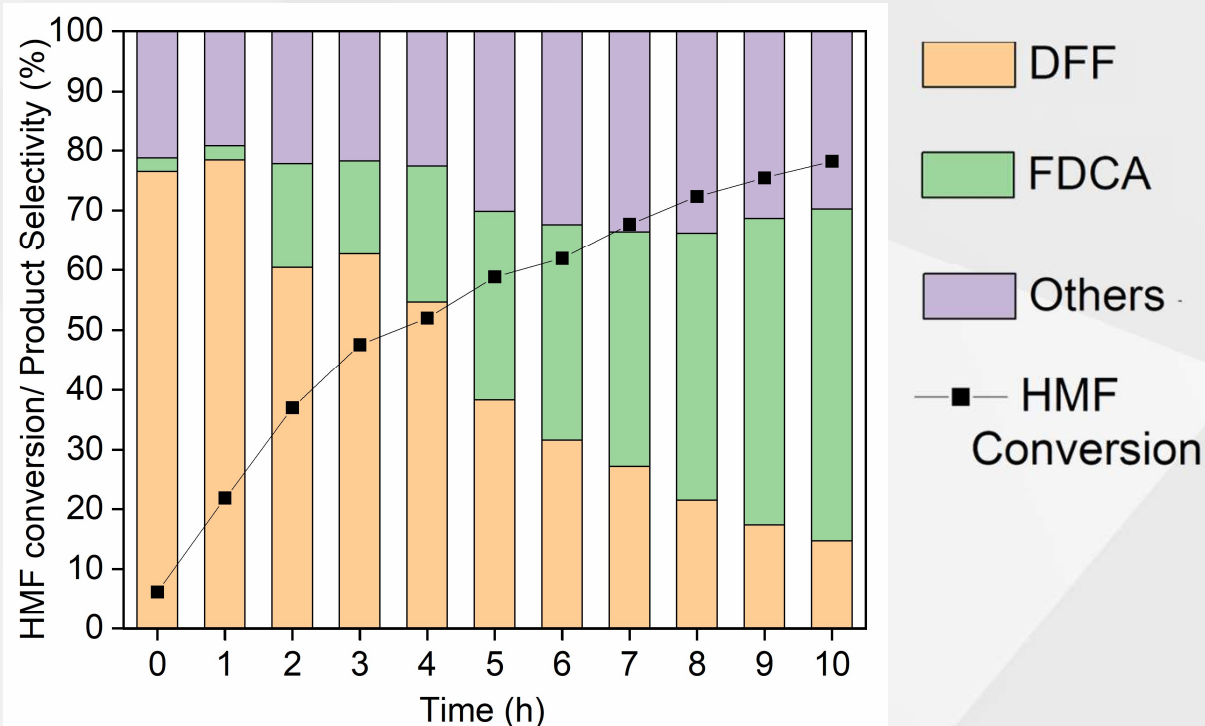
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Preliminary results

Pulcherrimin

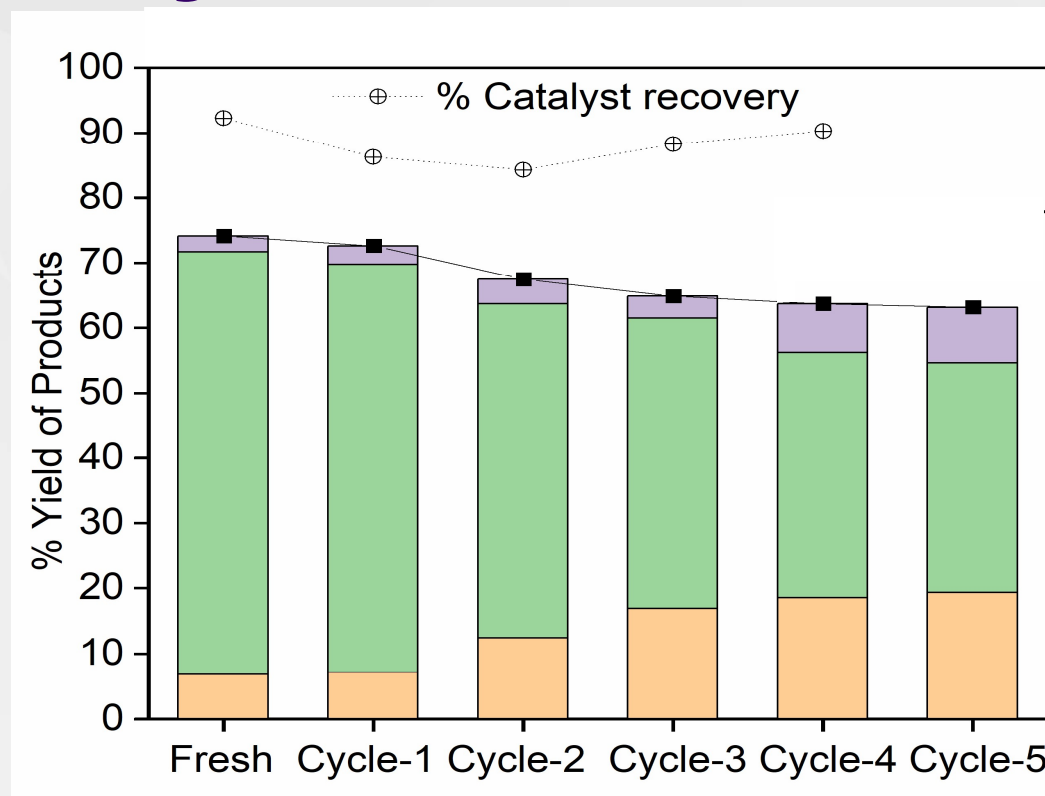


Fe₂O₃/C



Catalyst reusability

- High catalyst recovery
- Slight reduction in activity resulting in increase in DFF intermediate product



Conclusions

- Pulcherrimin produced with average yield of $3.24 \text{ mg g}^{-1}_{(\text{biomass})}$
- $\text{Fe}_3\text{O}_4/\text{C}$ mainly yielded DFF and range of by-products, while pulcherrimin gave high selectivity to FDCA without addition of base
- At 100°C , 5-HMF selectively produced DFF
- Best 5-HMF conversion and FDCA yield obtained at 120°C
- Activity can be correlated to material acidity and surface nitrogen groups
- Material reusable up to 5 times with consistent conversion, but DFF to FDCA conversion affected
- Addition of NaOH (not shown) affected reaction pathway, producing HMFCA and DFF intermediates



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