

The BioComposites Centre **ANNUAL REPORT 2023**



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BEACON
From plants to products
O blanhigion i gynhyrchion



Llywodraeth Cymru
Welsh Government



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BC Annual Report 2023

Welcome

In 2023 we continued to increase our research profile winning new projects with funds from InnovateUK to support the decarbonisation of the construction, packaging and most notably in the agritech sectors.

This year we won one of the largest collaborative funded projects from DEFRA (the Department for Environment, Food and Rural Affairs) to help look at reducing the emissions from livestock. Our Dancing with Daffodils project led by Rumenco, a leading supplier of high-quality ruminant feeds, aims to reduce methane production through the addition of bioactive compounds into animal rations (see "Livestock innovation project awarded to transform sustainability of ruminant farming").

This year we held our International Panel Product Symposium (IPPS). This was a welcomed return of our wood-based panels conference held every two years in October. The event drew an audience of academic and industrial colleagues from across Europe who all work in this important sector. The conference was a great success with lots of positive feedback and we were delighted to be able to award two Harry Earl Memorial Scholarships. This funding was set up by Kronospan Ltd, CRC Chemicals and the Centre to help support early career researchers to attend and present their work.

In 2023 we also saw the end of the European Regional Development Funds (ERDF). This funding has been extremely useful in helping us build capacity and reach regional businesses. A great number of successes were achieved. As an example, the ERDF funded BEACON project delivered over 635 collaborative projects, created over 100 new jobs and drove an additional £14.5M of private sector investment. With the loss of this type of funding there is now a focus on developing links to regionally important enterprises such as the local housing association ADRA and attracting funds through UK initiatives like the Freeport opportunity in Holyhead.

Our commercial work is also an important part of our research income. It is often our first step in forging a connection with a new industrial partner. Through these commercial partnerships we can develop our relationship with companies and gain a better understanding of their needs and future R&D challenges. These early insights enable us to better target research projects and increase our success in applying for research funding.

Much of this commercial work is undertaken using our pilot scale facilities at Mona. In 2023 we benefitted from additional capital funds from Welsh Government that brought new investment to equipment in Mona and Bangor; improving and upgrading the capacity we can offer to industry.

However, the delays from the relocation of our labs from the demolition of the Alan Roberts Tower put pressure and extra demands for space at our Mona facilities. I would therefore like to thank staff for being very accommodating, helping to work around various projects and getting projects completed to tight deadlines. Well done everyone!

This year our efforts have also strengthened the research impact here at Bangor University. Our activities account for something like 30% of the total industry targets for the whole University. I am therefore very pleased with this achievement. Given our limited resources and lack of core funding this is a significant contribution.

Looking forward, in 2024 we will be operational in our new labs and now that we are Associated Members of Horizon, we will have a strong pipeline of new projects working with our European colleagues. I am look forward to continuing our successes in helping industry to decarbonise their operations.



Rob Elias helping out on the pilot plant.

National and Internationally Funded Projects

Transforming Potatoes – Dyson Farming and Bangor University collaborate on Innovate UK Farming Innovation Programme Project

Most of us enjoy crisps, chips and baked potatoes, yet few of us realise that growing potatoes uses intensive soil cultivation and very large inputs of inorganic nutrients, herbicides, fungicides and insecticides. It leads to continuous degradation of farm soil and large emissions of two major greenhouse gases, carbon dioxide (CO₂) and nitrous oxide (N₂O).

The new project, Transformative Reduced Input Potatoes (TRIP), brings together Dyson Farming Ltd., The James Hutton Institute, Emerald Research, Light Science Technologies, The Sarvari Research Trust and scientists from Bangor University's School of Environmental and Natural Science including the BioComposites Centre. The partners will test out a range of regenerative cultivation methods that could reduce the environmental damage caused by producing potatoes. The project consortium includes a range of commercial potato growers across England - from Lincolnshire to Cornwall - and includes farms owned and managed by Dyson Farming.

The three-year TRIP project is funded by the Department for Environment, Food & Rural Affairs (DEFRA) through

Innovate UK's Farming Innovation Programme. It will investigate new breeds of disease resistant potato, new nutrient treatments for use on leaves not soil, reduced tillage methods including use of mulches as a growing medium and new methods to monitor greenhouse gas emissions from farmers' fields.

Dr Radek Braganca, lead for the project, said *"This is a great example of how we have used know-how developed by a past EU Interreg project called NASPA. NASPA allowed us to develop our expertise in potatoes working with experts like Dr David Shaw of the Sarvari Research Trust. The new TRIP project develops this approach as we are now working with other colleagues in Bangor like Dr Katherine Steele and Prof David Chadwick"* added Radek.

The Centre's research technician Josh Davies will be helping to do all the practical work. *"As an early career researcher, I am extremely interested in science approaches that will help reduce greenhouse gas emissions especially in the agriculture sector. The TRIP project is therefore a wonderful opportunity for me to further my experiences. My role will be helping to develop the processes used to monitor and determine green-house gas emissions and measure the nitrogen content in soil throughout the project,"* explained Josh



Transforming Potatoes Josh Davies showing project partners the field trials.

National and Internationally Funded Projects

New KTP project launched with Lyan Packaging to develop more sustainable packaging.

In January we embarked on a new two-year Knowledge Transfer Partnership (KTP) with Wrexham-based packaging business, Lyan Packaging. This dynamic family-run business manufactures and supplies a range of packaging formats, including temperature-controlled solutions for shipping chilled goods.

Adam Jones, MD of Lyan Packaging is pleased with progress so far, *"The KTP has kickstarted our journey to become sustainable leaders within our industry for cold chain deliveries. Already, within 12 months, we have a much clearer direction of the longer-term company objectives, and the work from the KTP has helped us to develop a new and innovative product range, with a patent pending application filed, that will hopefully see a huge increase in the number of customers we sell 100% kerbside recyclable packaging too"*.

The project aims to enable Lyan Packaging to position themselves as market leaders in the development of sustainable packaging solutions within the direct-to-consumer food and drink industry through their trading division, Icertech.

Life cycle assessment (LCA) will be used in one key workstream to fully model the environmental footprints of the company's existing product range and to use insights gained from this to inform new product design. Primary production data has been collected on-site, using the Centres' real-time factory-scale energy monitoring equipment.



Examples of packaging for cold chain deliveries being developed during the KTP with Lyan Packaging Ltd in Wrexham.



Members of Lyan Packaging Ltd Team and Campbell Skinner who are involved with the sustainable packaging project.

Another work stream uses the BioComposites Centre's (BC) suite of technical testing equipment to further define the physical performance characteristics of different packaging design options. Key measures here are material strength and, for the cold chain formats, insulative capability. This combined approach will allow for the development of innovative, high-performance solutions that minimise material use and waste and ensure preferable post-consumer disposal options.

KTP Associate, Simon Morris said *"Sustainable packaging development is a crucial area of focus for Lyan Packaging. As we all become increasingly aware of the environmental impact of packaging waste, we are taking proactive steps to reduce our carbon footprint and ensure that our packaging is sustainable."*

"This is a great project that will bring about genuine change in the company's product offering, enhancing the sustainability of packaging used in this sector, as well as developing the academic knowledge base for us here in the Centre", said Campbell Skinner, the Centre's LCA lead and academic supervisor for the work.

National and Internationally Funded Projects

Could a chlorophyll by-product be a sustainable answer to the £50million problem of potato blight?

The Centre is collaborating on a project led by Western Europe's largest producer of chlorophyll, Blankney Estates Ltd, to investigate whether the large amount of grass wax it produces as part of its chlorophyll production process could be used as a more sustainable alternative to current fungicide controls for late potato blight.

The 12-month project is funded by the Department for Environment, Food and Rural Affairs' (DEFRA) through the Farming Innovation Programme, delivered in partnership with Innovate UK.

Late potato blight results in up to £50million of annual losses for UK farmers and is caused by a fungus-like organism (*Phytophthora infestans*) that results in leaf and stem damage and eventual rotting of the potato.

Project Lead Blankney Estates, based in Lincolnshire in the North of England, farms 14,000 acres of land, and grows a wide range of arable crops for human consumption,

animal feed and energy production. 1,500 acres of this land is dedicated to growing a type of grass called tall fescue for chlorophyll extraction, which is used in a range of food, pharmaceutical and cosmetic applications, mainly as a natural green colourant. During the process of chlorophyll pigment extraction, large residual volumes of natural grass wax are produced and subsequently discarded as waste.

As experts in research and innovation around biobased technologies, this is where the BioComposites Centre stepped in:

"We've worked with the Blankney Estates since 2007 on various projects related to how we can add value to the grass they grow" explains Dr Adam Chalton. "We are now very pleased to be extending this relationship thanks to funding from DEFRA through Innovate UK's Farming Innovation Programme, to assess the functionality of the grass wax as a novel biocontrol system using a combination of greenhouse and field trials."

The main treatment and control option for late potato blight involves regular application of antifungal chemicals, but the *Phytophthora infestans* organism is now resistant to



National and Internationally Funded Projects

most synthetic fungicides, and there are currently very few options to replace these, many of which are being phased out from use because of environmental considerations.

The other challenge is that when used in excess, synthetic fungicides are a hazard to plant, animal and human health and can have a negative impact on ecosystems through their accumulation in soils and watercourses.

It has been reported that up to 20% of greenhouse gas emissions linked to potato production results from energy outputs associated with the production and use of fertilisers and synthetic fungicides.

Dr Charlton adds, *"Biocontrol agents are an alternative and potentially, a more sustainable alternative, to the synthetic fungicides used to combat plant pathogens."*

This project could also contribute towards the commitment to reach net zero emissions by 2050 by reducing input costs for new biobased potato blight treatments using the circular economy approach by making use of this otherwise wasted product."

"We are delighted to be partnering with Bangor University's BioComposites Centre on an exciting project exploring" a potentially valuable application for our 'waste' grass wax stream, which is produced as a by-product of our chlorophyll extraction process" said Stuart Parr, General Manager, Blankney Estates. "As the largest commercial producer of chlorophyll in Western Europe, we are committed to farming in the most environmentally responsible way, unlocking the full potential of our grass crops and processes."

Livestock innovation project awarded funding to transform sustainability of ruminant farming

The Centre is part of a team that has been awarded £2.8 million to fund a project which will look at ruminant efficiency, sustainable farming, and on-farm methane monitoring.

Following a Farming Innovation Competition hosted by the Department for Environmental Food and Rural Affairs (DEFRA) in partnership with Innovate UK, The Dancing with Daffodils project will look at transforming the efficiency and sustainability of ruminant farming.

The partnership organisations which include Rumenco, Agroceutical Products Ltd, Analox Group, Beneve Ltd, Bioextraction Ltd, Bangor University, CIEL (Centre for Innovation Excellence in Livestock), Grampian Growers Ltd, Scotland's Rural College and Wynnstay, will combine their expertise during the project to address challenges relating to the sustainability of livestock farming.

The project's principal investigator, Dr Radek Braganca explains *"We are delighted to be bringing our extensive research experience to this project. For some years, we have been investigating ways of extracting high value compounds from daffodils with our collaborators and the application of this research to develop a methane-reducing feed additive for livestock represents an exciting opportunity to help lower green-house gas emissions. I am look forward to working with industry partners on a*

project which has the potential to make a real difference both in terms of supporting farming communities and contributing to global sustainability goals".

The consortium will work closely with farmers, industry stakeholders, and policymakers throughout the project's lifecycle to ensure alignment with the sector's needs and priorities. By fostering collaboration and knowledge exchange, the consortium aims to bring tangible benefits to the farming community while contributing to national and global sustainability goals.



PI Radek Braganca and Adam Charlton.

National and Internationally Funded Projects

Testing an 'Appelling', Solution to the UK Obesity Crisis

Summer 2023 saw the culmination of five years of joint development between the BioComposites Centre and Gwynedd-based green technology company Pennotec (Pennog Ltd) in their efforts to use apples to replace unhealthy ingredients such as saturated fats and 'invert' sugars in the foods we all enjoy.

BC and Pennotec are collaborating with a Flintshire-based company, The Pudding Compartment. The Pudding Compartment are the first company in the UK to produce a healthier version of the humble flapjack using functional food ingredients prepared from apples. The 'All-Natural Apple Flapjack', one of the first products to be developed as part of this collaboration between Bangor University and industry partners, caused quite a stir at The Royal Welsh Show, the Urdd Eisteddfod and the National Eisteddfod this summer.

"These new apple ingredients developed as part of this R&D project with Bangor University and Pennotec have been a revelation!", says The Pudding Compartment

owner and MD, Steve West. "For the first time we've been able to replace palm oil and invert sugar syrup in our recipes with much healthier alternatives. And the bonus is our products now have a delicious apple flavour that consumers really seem to enjoy."

This summer, 2,400 visitors to The Royal Welsh Show and the Urdd Eisteddfod and National Eisteddfod – including opera star Bryn Terfel - participated in blind tastings organised by Bangor University. And guess what? The All-Natural Apple Flapjack come out on top!

"Earlier this year we'd conducted consumer tasting trials with reduced calorie versions of our flapjacks, chocolate brownies, Welsh cakes and biscuits and we were surprised and delighted to find that not only did consumers prefer the healthier apple ingredient versions, they also loved the tangy, sweet apple flavour," explains Steve. "So, for the big events of the Welsh summer, we wanted to conduct a truly blind trial – we added apple flavour to our standard flapjack recipe. And what do you know? The reduced calories versions came out on top again – almost 1,300 preferred the All-Natural Apple Flapjack".



Sir Bryn Terfel (left) tests the All-Natural Apple Flapjack on the Bangor University's stand at the Urdd Eisteddfod, Summer 2023.

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So what is the secret?

Bangor University's lead Dr Adam Charlton says, "By mechanically breaking up healthy dietary fibre in apple pomace—the solid left after extracting the juice, we can produce an ingredient that binds up to 20 times its weight in water. This dietary fibre 'sponge' we've created, is tasteless but has the same mouthfeel as fat and the same thickness as starch and so can be used to replace these kinds of ingredients in a whole range of foods, with practically zero calories."

But what about the apple flavour?

Dr Jonathan Hughes of Pennotec explains, "With the support from the Welsh Government's Decarbonisation and Covid Recovery programme, we began to look at reducing the carbon footprint of our manufacturing processes. We realised that to produce the fat-replacing fibre from apple pomace – pressings comprising apple pulp and peel - we had to wash away a lot of really healthy fruit sugars and flavours. We spent a year investigating ways to recover and convert pomace sugars, complex carbohydrates, vitamins and anti-oxidants into a new 'fruit syrup' replacement for invert syrups used by everyone in the food industry. Not only are we saving money by reducing waste, we've also created a new, delicious and healthy fruit syrup!"

"Reformulating recipes to replace 'dry' ingredients margarine, vegetable oils, caster sugar and golden syrup with water-based apple ingredients has been enormously challenging. However, The Pudding Compartment worked tirelessly, testing recipes and balancing the fat, sugar, salt and fibre content to hit the 'sweet spot' of the best possible nutritional profile and the best possible taste and texture. And the proof is in the pudding as almost 1,500 happy consumers will attest."

"This summer we've proven that there is genuine consumer demand for healthier bakes and consumers genuinely love the apple flavour," says Steve.

"Our healthy apple syrup is currently more expensive than mass golden syrup and we are investigating how to make it cheaper as we look for investment to scale-up manufacture", said Dr Hughes. "But in market testing, consumers expressed a willingness to pay up to 40% more for healthier versions of baked goods that companies like The Pudding Compartment produces. Especially once



Photo: The Pudding Compartment.

they were informed of how healthy the apple ingredients were and how environmentally friendly our sourcing and production methods were."

This has very much been a North Wales team effort, working with commercial partners in food technology and production and other Bangor University researchers. The Psychology and Geography departments have been involved, developing tasting trials and understanding how the 'green' credentials of apple ingredients could influence consumers and food service outlets to buy the product.

"We're trying to help with important societal challenges, including the high levels of obesity in Wales and the need to improve the health and wellbeing of present and future generations, as identified by the Welsh Government", said Adam Charlton. "We've also developed an innovative approach to sustainable manufacturing by adding economic value to apple pomace."

It's important that health innovations like these, which can really help Wales and the UK overcome the obesity crisis and recover from Covid, go beyond the laboratory. That is why working with Welsh food innovators like The Pudding Compartment has been so important.

The three organisations are now committed to continue working together to scale-up manufacture and bring this amazing food innovation to market within the next two years. They're going to need a lot of apples!

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Size of Wales, degradable tree planting pots help reduce pollution.

The Centre, in collaboration with NARO METGE in Uganda and supported by the Welsh Government has developed a biodegradable potting sleeve made from Ugandan agricultural residues known as a biopot.

The biopot protects the seedlings from sun and water for several months while they grow and then degrades harmlessly in the soil once planted.

Welsh charity, the size of Wales and their partners the Mount Elgon Tree Growing Enterprise (METGE) supported by the Welsh government through its Wales and Africa programme is aiming to distribute 50 million trees in eastern Uganda by 2030.

BioComposites Staff attend stakeholder meeting in Uganda.

METGE has run a series of workshops with local farmers, growers and nursery operators in the Mt. Elgon Region of Eastern Uganda, in order to promote the benefits of transitioning from single use plastics to biodegradable alternatives to package and grow tree seedlings. This has included briefing sessions on the issues with environmental damage caused by single use plastics in the agroforestry sector in Uganda. In total 255 people (108 female, 147 male) attended these workshops in March 2023 and stakeholders included farmers, nursery operators, local community and religious leaders, local/regional Ugandan Government representatives and school children.

In addition, two separate workshops took place in Uganda and hosted by the project team in Kampala (27.3.23) and Mbale (30.3.23). These were attended by 84 people, including representatives from the Ugandan Government and the British High Commission. These workshops promoted the project to key stakeholders, highlighted the current status of the research and discussed the next steps, with the ultimate aim of establishing a manufacturing facility in Mbale to produce the tree seedling film wrap.

The project team were invited to participate in two separate radio interviews on a popular farming programme in Mbale (March 2023) to promote the

METGE is currently supporting 50 community-based tree nurseries in the Mbale region of eastern Uganda in a bid to increase community resilience to the impacts of climate change. The trees help provide shade to improve crop yields, help prevent landslides and improve the soil. The trees also absorb carbon to help slow down climate change.

However, each tree seedling is contained in a single use of plastic sleeve which is made from fossil fuel derived materials. Efforts are being made to reduce the plastic waste problem associated with disposal of these by farmers once the trees are planted, but that are no cost-effective solutions to the problem.



Dr. Adam Charlton presenting at project workshop in Mbale, Eastern Uganda (March 2023).



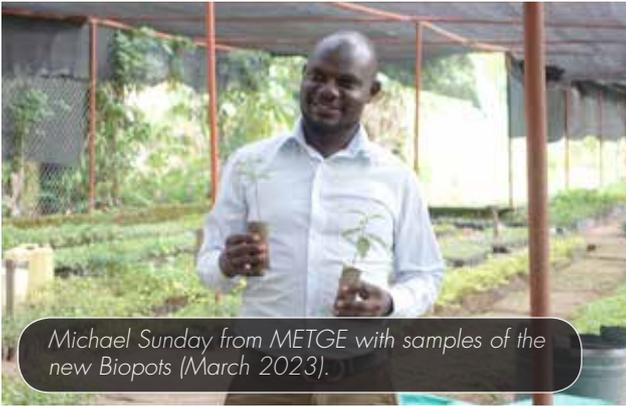
The project team visiting a METGE tree nursery site in Mbale to look at field trials using the new Biopots (March 2023).

project. TV interviews were also given by the project team to regional and national channels (March 2023) and two newspaper articles highlighting the project were published in Uganda (March 2023).

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The project is technically difficult but once the final formulation is perfected production can begin.

The hope is that eventually the potting sleeves will be used



Michael Sunday from METGE with samples of the new Biopots (March 2023).

by the hundreds of tree planting projects in Equatorial Africa to help reduce the environmental impacts of single use plastic waste.



Uganda Trip / Project partners showing biodegradable biopots

A Helping Hand to Female Farmers in Ethiopia

In 2020 Ethiopia's government took the bold step of banning single-use plastics, in a bid to tackle the country's levels of plastic pollution. But implementing the new policy has been a challenge, since there is a lack of suitable alternatives. Half a million tonnes of plastic is still dumped, buried or burned in the country every year.

Now, scientists at BC are hoping that they can transform organic waste from Ethiopian crop residues including banana leaves into an alternative to plastic packaging, in a project that could also offer a much-needed revenue stream to the country's female farmers.

Bangor specialists are working with two collaborators in Ethiopia, the Ethiopian Pulp and Paper SC and the Bio & Emerging Technology Institute, to investigate whether the



Farmers in the Yirgalem region of Southern Ethiopia harvesting and processing banana.

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fibrous leaves of the plant, usually discarded during food processing, could form a new type of packaging material. The research project is funded by Innovate UK's GCRF AgriFood Africa Innovation Awards.

The leaves will be shipped from Ethiopia to the BC team's unique facility in Anglesey to see if their larger-scale processing equipment can break down the material to a pulp that can then form cardboard-like moulded packaging prototypes.

The project will provide valuable knowledge as to whether Ensete and banana leaf more generally is suitable for industrial processing back in Ethiopia.

Senior Research Fellow Dr Adam Charlton explains: *"If the leaf and stem material prove suitable, we'll produce a variety of prototype products that we can bring to a workshop with the company, inviting representatives of the government and the private sector, so they can see the rationale for moving beyond the feasibility study."*

The project has another dimension too; if larger-scale production is approved, it will benefit the country's female-led farming groups who could supply the necessary biomass.

Although women make up half of Ethiopia's rural labour force, their productivity is lower than male farmers, due to a lack of access to land and seed. Providing the crops for industrial processing could be an additional revenue stream for these women.

Bangor has decades of knowledge and know-how on processing a wide range of agricultural, forestry and food processing residues, and at the Centre's pilot scale processing facility on Anglesey, the team have produced a series of food trays made from the pulped banana leaf. These were shown to a range of stakeholders, including female farmers, at two workshops held in Addis Ababa and in Southern Ethiopia, in November 2023.

The potential supply chain infrastructure is already in place, since the Ethiopian Government and the United Nations Industrial Development Organisation (UNDO) have set up special agro-industrial parks, where local farmers bring their different types of produce to be processed.

So, if the prototypes are successful, and we can tap into local expertise, this could work for everyone and create a sustainable alternative to plastic packaging.

PlantSea Pack - Second Phase

The cooperation with PlantSea and Olew builds on the feasibility study backed by the Industrial Strategy Challenge Fund to develop an innovative packaging solution. The unique seaweed-based film packaging is being created for single-use or refill-use of water-soluble pods. It can hold personal care products such as shampoos, conditioners, balms, oils and creams as well as laundry and dishwasher cleaning detergents.



The Plantsea-Pack project team meeting in St Asaph.



Dr Gianmarco Sanfratello, PlantSea CTO, explains, *"The adoption of PlantSea pods will foster packaging reuse by applying the concept of a reusable bottle-for-life and promoting the usage of refills of personal care goods."*

Dr Viacheslav Tverezovskiy, BC's project lead scientist, adds, *"PlantSea-Pack packaging applied at scale will deliver multiple objectives of the Plastic Pact, as it will provide a new non-plastic waste-free product design and will enable the elimination of millions of non-recyclable plastic containers."*

National and Internationally Funded Projects

Biotwin project –building new biomaterials for construction

As part of UKRI funded feasibility project, the Centre is working with the Biotwin company, an innovative company in construction using biomaterials.

Dr Robert Elias and Dr Simon Curling lead a team utilising

the skills and knowledge of the production team at the BC Technology Transfer Centre in Mona, and the analytical team based in Bangor. The aim is to develop biobased, low carbon construction elements for the UK market using low cost carbon sequestering plant materials combined with state of the art low formaldehyde binders to produce complex shapes and structures.

A unique seaweed-based mulch film, from lab to field

The project assesses the feasibility of a low-carbon, innovative seaweed-based mulch film to replace conventional and unrecyclable films. It will significantly improve over existing biodegradable polymer solutions, often made using petroleum-based materials. The agricultural film in development will be suitable for organic farming and help support crop production,

increase yield, and improve soil health.

BC's Head of Chemistry Research, Dr Viacheslav Tverezovskiy, explains *"PlantSea leads this project in collaboration with BioComposites Centre and G's Fresh farms. We assess the technological challenges, environmental impacts, and market needs in developing seaweed-based mulch film. The consortium expands on novel methodologies for the processing and production of seaweed-derived biomaterials."*



Project partners at Henfaes Farm research facility of Bangor University.

Transfire – helping UK industries become more efficient

Prof Graham Ormondroyd and Dr Simon Curling are the leads for the paper thematic working group of the Transfire project. Transfire is part of the Transforming Foundation Industries theme and covers the six major industries in the UK; Cement, ceramics, chemicals, glass, metals and paper.

BC are working with a range of companies within the pulp and paper sector to help develop zero carbon efficiencies within manufacturing processes, investigate biobased coatings and repulpability and recycling strategies for the industry.



Clay and wood bricks which will be used in an experimental house being constructed from a variety of natural building materials including clay with straw, wood and other fibres.

National and Internationally Funded Projects



Researchers on the Transfire project gather in Crete for an intensive week of work. Prof Graham Ormondroyd and Dr Simon Curling can be seen on the far-right hand side of the image

Combined with the recent investment in state of the art paper testing equipment at our Technology Transfer Centre BC are ideally placed to help the switch from fossil based packaging products to paper and fibre based products. Recent highlights of the Transfire project include working closely with Zentia Ltd, a leading ceiling tile manufacturer to help assess their manufacturing system and visits for discussions with major paper mills such as Saica Ltd in Manchester.

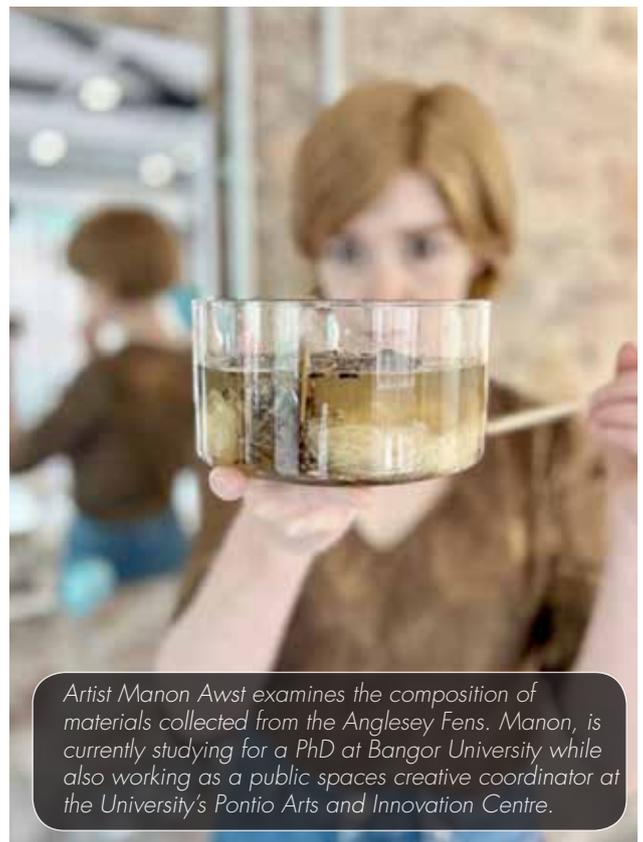
In early spring 2022 Graham and Simon joined others from the project on an intensive and thorough fact-finding visit to Crete. Hosted by the European Sustainability Academy, several study visits were organised including; one to innovative local manufacturers of glass and ceramics, another to different agricultural producers to assess potential by-products, and a third to the islands main recycling and refuse centre. Coupled with extensive training and discussions the week was tiring but worthwhile.

Collaboration with international artist to develop sustainable materials which tell their own story of the land

A North Wales artist worked closely with Dr Simon Curling in 2023 to create new composites derived from natural materials which can be used to create artworks. The project also highlighted the need to care for our natural environment.

Manon Awst, who was brought up on Anglesey and exhibits her work internationally, has been undertaking site-specific research at the Anglesey Fens and Llŷn Fens Special Areas of Conservation. The research is in collaboration with experts from Natural Resources Wales' National Peatland Action Programme, a five-year plan of peatland restoration in Wales.

These areas are home to the most significant and extensive concentration of rich fen habitat in Wales and western Britain. They play an important role in capturing and storing carbon, regulating greenhouse gases, maintaining biodiversity and regulating water.



Artist Manon Awst examines the composition of materials collected from the Anglesey Fens. Manon, is currently studying for a PhD at Bangor University while also working as a public spaces creative coordinator at the University's Pontio Arts and Innovation Centre.

As part of the research process Manon has been working with materials specialist Dr Simon Curling here at the BioComposites Centre to bring together various materials to develop new sculptural composites for her current body of work and beyond.

Manon said, *"The material that defines the fens is peat, and I've been exploring it from various perspectives and at different times of the year through site visits with local ecologists, peat specialists, fellow creatives and school pupils.*

"Peat has its own timescale – it forms very slowly: each year, just one mm of new peat forms in active and healthy peatland. It reminds me that materials take their own time, and that I have a responsibility as an artist when I choose which materials to work with."

Although Manon's project is exploring the unique and vibrant peatlands, using peat was out of the question as

it must stay in the ground to perform its valuable functions in terms of carbon storage, biodiversity and water regulation. Nevertheless, its texture when viewed under a microscope provided a point of departure for the artist:

"Dr Curling has supported me whilst I've explored various methods of bringing together waste grasses from Cors Erddreiniog, powdered mussel shells, lime, wool and biochar - which is produced from the grass" said Manon Awst. "It's an ongoing process of trial and error, and many material samples have gathered in my studio! One of my favourites is made from pulped grass, mussel shells and a wool base, bound together with alginate, a derivative of seaweed."

"As researchers, we are used to looking at natural materials from the scientific or product development point of view" commented Simon. "Working with Manon, with her artistic outlook, is a novel and exciting approach for us and is helping us look at materials in new ways."

Other Activity

Successful completion of joint CEB and SEEC projects

In early 2023, two of Bangor's European Regional Development Funded (ERDF) projects came to close. The Bangor led projects were the Centre for Environmental Biotechnology (CEB), a 5-year £8.6M Structural funds Operation and the Smart Efficient Energy Centre (SEEC), a £7M multidisciplinary operation.

"Both projects were important to the Centre", explained Rob Elias, "as they helped us to develop collaborative links within Bangor with increased capacity and additional resources. For example, the SEEC funding helped us win bids to look at improving insulation materials for construction and we were able to use this to help secure a new link to local housing association ADRA. ERDF projects have key performance targets to meet, and I would like to thank Dr Olga Tverezovskaya for her help as project manager during her secondment to CEB and SEEC. Her work helped to ensure that the projects were well managed, and that Bangor achieved the metrics for the funding partners" added Rob.



Other Activity

The BEACON Journey: Past Impact and Future Direction.

BEACON project partners gathered together to celebrate ten years of their achievements in supporting the bioeconomy in Wales. The final ERDF funded project event was held on the 28th of March 2023, at the new AberInnovation building on the Plas Gogerddan campus of Aberystwyth University. The meeting was chaired by Prof Sandra Esteves of the University of South Wales and the day celebrated the outcomes and achievements of the project with a series of talks from industry.

The audience heard how the award-winning project had resulted in over 1100 cross sector interactions, delivering over 635 collaborative projects with regional businesses that lead to the creation of over 100 highly skilled jobs within Wales.



BEACON has also had impact in the UK, EU and overseas. It has helped to support over 100 national projects in the UK and over 30 international projects working with partners in locations across the globe with links to India, Malaysia and China.

To mark the event industry partners explained how their interactions with BEACON had helped them developed their businesses and achieve their scientific aims. Dr Rob Elias Deputy Director for BEACON explained "We heard today from our industrial partners that there are lots of examples where access to the wide range of scale up equipment has really helped companies develop their businesses. Through the BEACON partnership we could help them out using the expertise and facilities at Aberystwyth, Bangor, Swansea or USW" added Rob.

The event concluded with a tour of the BEACON biorefining facility. Guests had a chance to look at the equipment and meet with technical staff in their new home in the AberInnovation Centre.

Following the meeting project partners discussed how further impact will be developed working together in a collaborative approach to attract further funding for this important regional sector within the economy.

Conferences & Events

Malaysian SafeBioPack Impact workshop

The final SafebioPack project meeting was held back in Jan 2020 just before the Pandemic struck at Tesco's HQ in Welwyn Garden City and plans were put into place to spin out some new enterprises.

However, with the impact of COVID project partners were unable to travel and actions to progress these ideas were delayed. In early 2023 Project leader Dr Rob Elias was able to successfully bid for some additional funds to help accelerate the impact of the project. These funds enabled the project partners to take part in a series of weeklong activities that consisted of workshops and site visits in Malaysia from the 13th until 17th of Feb 2023.

One focus area for SafeBioPack was the development of a fibre based pulp moulded punnet that was 100% biodegradable. This prototype was successfully evaluated by Tesco and achieved the functionality needed by their consumers, but work had stalled since 2020. The Accelerator Fund allowed the project partners to return to Malaysia and host a series of events with joint partner Universiti Putra Malaysia (UPM) to get back on track.

Dr Qiuyun Liu and Campbell Skinner hosted a series of international workshops over two days that were attended by over 200 people covering topics on life cycle assessment (LCA) with talks by industry and academics highlighting the opportunities and challenges if developing alternative biobased packaging materials.

The team also visited Parkside's Kula Lumpur factory where they learnt about the increased and growing compostable market now being developed in Australia with technology spun out from the SafebioPack project partner SciTech Adhesives Ltd.

The busy week helped the project team to look at key issues that are faced by industry developing alternative biobased packaging materials such as how to increase R&D investment, develop strategies to reduce the costs, manage the risks of developing disruptive technologies and support skills development. A key action of these meetings was to look at the opportunity of establishing a new trade organization in Malaysia for the fibre-based packaging sector as this would help grow the industry and provide a focus for the sector.



Malaysian Impact Workshop - Dr Qiuyun Liu.



Malaysian Impact Workshop - Site visit to Parkside.

Conferences & Events

HIBARFilm at GRIPS 2023 (May 2023)

The Global Research and Innovation in Plastics Sustainability (GRIPS) conference was held on the 10th and 11th of May in Coventry. The event organised by InnovateUK brings together leading companies and researchers on technologies and approaches that will help reduce the impact of plastics on our planet by reducing landfill, incineration and littering.

The two-day event included an exhibition and a series of parallel talks highlighting current research. Dr Rob Elias was invited to give an update on an InnovateUK funded project, HiBarFilm to the InnovateUK Sustainable Plastic Packaging team. The HiBarFilm project leader is Haydale Composite Solutions Ltd and the consortium has seven other enterprises – BASF, Cambridge Nanomaterials Technologies, Dunbia, Fre-Energy, Parkside Flexibles and Wells Plastics. The project aim is to develop the next generation of high barrier films for food packaging using functionalised nanomaterials.

“The conference was a great opportunity to talk about the approach we have adopted in HiBarFilm” explained Rob. “We have a very ambitious objective to achieve the same barrier performance using a mono-material compared to the current multilayer barrier structures that make the films

Impossible to recycle. Here the challenge is to eliminate problematic or unnecessary single-use packaging through redesign, innovation or alternative (reuse). However, many films just end up in landfill and this needs to be avoided. Our research is aimed at reformulating the films so that they can be easily recycled at end of life”

Rob was joined by the Centre’s LCA expert Campbell Skinner and Simon Morris, the KTP Associate for Lyan Packaging. The day offered the opportunity for the team to look at the exhibition, catch up with existing partners and learn about the next developments in packaging.



Open Workshop for HighBar in Cambridge June 2023

The HiBarFilm2 Project is an Innovate UK funded project started in March 2022 and is expected to run for 30 months. Haydale Composite Solutions Ltd is leading the consortium of eight companies to develop the next generation of high barrier films for food packaging using functionalised nanomaterials.

HiBarFilm2 has an ambitious objective to achieve the same barrier performance using a mono-materials polyolefin film as the currently used multilayer barrier films.

The consortium aims to accomplish this using plasma functionalised nanomaterials to increase the barrier performance of the film. There are two main areas of focus: firstly, by mixing the nanomaterials directly into the polymer prior to filming (this adds barrier properties to the film itself) and secondly, by dispersing the nanomaterials onto the surface of the film to form a barrier coating.

The consortium is assessing both polyolefin films and compostable plastics, the latter having the potential benefit of reducing plastic contamination when included in food waste collection streams.

As part of the project the partners organised an open workshop that was well attended with most delegates drawn from industry. The open workshop consisted of keynote talks from all the project partners and was an opportunity for delegates to get an update and a fast track on the issues around plastics and packaging.

The first open day was held in Cambridge, on the 29th of June 2023. A total of 35 delegates registered to participate in the event in person and online. They came from the following leading organisations University of Cambridge, Novartis Pharma (CH), The Co-op, University of Strathclyde, Queen Mary University of London with international representatives from Bimbo Bakeries USA and Yiotis SA, among others.

Dr Rob Elias explained *“Having the open day is very*

Conferences & Events

useful. We get to engage with other enterprises interested in our technology and our approach to improving barrier performance. This is an area of great interest in the packaging sector. The workshop offers the opportunity for other people to learn about the challenges faced in developing barrier performance for end-users such as Dunbia, one of our project partners. Dunbia pack very high-quality red meat products such as fillet steaks and age

them to improve their taste, so barrier performance and strength of the films is very important to their applications," added Rob.

For further information and project updates please contact the project using the dedicated website <https://hibarfilm.co.uk/> and email info@hibarfilm2.co.uk to learn more.

IPPS 2023 back after four years! (Oct 2023)

Nearly eighty delegates attended the two-day International Panel Products Symposium (IPPS) which was held in Llandudno following a four-year break due to the covid pandemic. This normally bi-annual event has been organised by the BioComposites Centre since 1997 and has become one of the leading conferences for the (predominantly) wood-based panels sector.

A comprehensive write up about the conference, 'IPPS innovation focus' can be found in Wood Based Panels International <https://www.wbponline.com/features/ipps-innovation-focus-11402024/>

The event aims to bring together leading academics working in the sector with industry. This is becoming increasingly important as Dr Rob Elias highlighted in his opening address on how the sector can help achieve net zero through innovation. But there was caution and a call to increase the speed of innovation and to "draw on the capacity of researchers across Europe; and we must work in more multi-disciplinary teams alongside industry."



Delegates listening to keynote address given by Alister Kerr – Wood Panels Industry Federation

Key themes of the conference this year were how the sector can decarbonise and opportunities for a circular economy. Technologies like MDF Recovery, who BioComposites Centre have been working with for many years, have now moved from lab to pilot to full scale reality offering ways to prevent 'waste' MDF panels from going to land fill or being incinerated and instead the fibre, and associated carbon, being incorporated into other products and so contributing to a circular economy.



Harry Earl Award Winners - From left to right: Dr Rob Elias, Mark Jones, Sofia Gonçalves, Gulsah Balamut and Keith Godber.

Conferences & Events

There is no denying that the sector is energy intensive, but innovation is constantly chipping away at making the process less energy intensive, driving down waste, increasing on site power generation – including by processing inhouse by products. And now attention is turning once again to the resins that are used to bind wood particles together – how can they be formulated to cure at lower temperatures and provide the same bond quality?

Two Harry Earl Memorial Prizes were awarded this year

one to Gulsah Balamut Arslan (Kastamonu Integrated Wood Industry) and the other to Sofia Gonçalves (Faculty of Engineering of the University of Porto).

Harry had a successful career in the wood panel product sector, including many years as a researcher in Bangor and culminating with the position of technical manager at Kronospan's mill in Chirk. In 2015 BC and Kronospan, together with CRC Chemical Release Company Ltd., launched a new scholarship fund to commemorate the life of Dr Harry Earl.

Timber 2023 for the latest developments in UK timber research

The Timber 2023 conference, organised by the Wood Technology Group of the IOM3, was held in London on 29th November. As the new Chair of the Wood Technology Group, Dr Morwenna Spear opened the event and chaired various sessions. The event in 2023 was the fifth event since it started.

The primary aim of the event is to showcase the latest developments in timber research in the UK and beyond, and to prompt discussion of new products, processes and concepts and their potential within the UK. The event speeds up transfer of knowledge between academia and businesses, and between specialists in the many areas of timber and wood science, which will strengthen our industry.

This year featured presentations from Carlo Kupfernagel, now a final year PhD student at BC, and Stefan Rijnbeek, a recently graduated MSc student who completed his dissertation project in the BC labs during the summer. Stefan's talk focused on strip barking, a natural method for enhancing the durability of pine timber, traditionally used in Nordic countries, and lab analysis to investigate the

changes in the timber which it causes. Carlo spoke about resin treatment of wood – proposing some challenging and thought-provoking research about the mechanisms of cell wall changes during the modification process.

Another highlight was a very entertaining talk by John Williams, reporting his exploits as a timber consultant interacting with architects and developer on historic buildings and guiding intelligent use of wood during restoration. It was also great to hear about ongoing project to increase the use of homegrown timber and to promote timber in new structures. Prof Callum Hill reported some keen insights based on environmental product declarations and Scope 1,2,3 emissions calculations he had done for Vastern timber. It is encouraging to see the industry taking such steps to understand their environmental footprint and to look to the future.

The one-day conference provides plenty of opportunities for networking, while allowing delegates to present and discuss their work from a wide range of backgrounds. The new connections and context given by talking with wood experts from other fields is really appreciated by all who attend. The WTG is pleased to participate in strengthening and creating these active UK-based research networks, and stimulating new ideas to benefit the industry in years to come.

WoodBUILD 2023 – Trees, timber & the transition to zero carbon construction

IBC staff got to showcase their capabilities in timber-based research at WoodBUILD 2023. The event has become the premium wood industry and low carbon housing event in Wales. The two-day event held this year at UWTSU in Lampeter was packed with speakers and included workshops and forest walks to complement networking opportunities. The BC team (Morwenna Spear, Graham

Ormondroyd and Athanasios Dimitriou) took an exhibit along to the trade show area, and as always, the samples and pictures on the table meant that plenty of interesting new avenues for research were discussed.

Dr Morwenna Spear also took part in a hands-on showcase of timber samples led by Dainis Dauksta of WoodKnowledge Wales. The session was intended to familiarise a wide range of professionals about species of timber, growth rates, silviculture and properties. The discussion took a useful look at how grading works, and the reasons appearances can be deceiving. After the event Dr Spear said *"It is always great*

Conferences & Events



Dr Athanasios Dimitriou with the BioComposites Centre display at WoodBUILD2023.

to talk to people about homegrown timber and increase understanding. It's also great when the conversation evolves to meet the questions raised by the audience – for example we ended up discussing treatments for timber in the structure of the building, and had some very handy large timber frame wall exhibits close by to use as examples”.

WoodKnowledge Wales, who organise WoodBUILD, aim for the event to inspire, create new business opportunities



Dr Morwenna Spear pointing out features and discussing wood properties at WoodBUILD 2023.

and offer a collaborative platform for all participants to share information. “The event did not disappoint” said Dr Graham Ormondroyd “with interesting presentations and discussions. It was a great networking opportunity and as a result of it we have been able to secure some new commercial work. It was also an excellent example of working across the supply chain with colleagues from the forestry department at Bangor university also participating.”

The benefits of growing willow highlighted at Agroforestry Show 2023

The “UK’s First Agroforestry Show” was held over two days of unseasonably high temperatures and blistering sunshine on a Wiltshire farm in September 2023. The show saw farmers, foresters, researchers, environmentalists and policy makers sharing insights and advice on how to help farm businesses benefit from trees.

“It was very interesting to be at an event with both foresters and farmers present” said Ceri Loxton who attend as part of her secondment with Woodknowledge Wales (WKW). “It was a great way to network and attend workshops and talks from pioneers in the sector. There is so much to learn, not only about planting trees on farms but also about the range of products that can be manufactured, issues around scaling up production as well as how to distribute and market those products.”

Ceri is on secondment with Woodknowledge Wales working on Phase 2 of the Home-Grown Homes Project.



Part of the project includes developing a picture of the current timber supply chain, including the value of farm forestry and engagement with farmers.

“The BioComposites Centre works on a variety of different projects linked to the farming sector. The Agitech sector is a high priority for the UK,” explains Dr Rob Elias, “as farmers need to reduce their greenhouse gas emissions. We are working with them to help decarbonise their farms by replacing synthetic fungicides/herbicides with novel biobased compounds and we are developing functional feed additives designed to reduce CO2 emissions in their cattle.”

Conferences & Events

BC are one of 10 partners in an Interreg project which could be rolled out to farmers soon. *“The BioWill project aims to use biorefinery techniques to extract high value salicylates from willow bark for medical applications”* said Dr Adam Charlton the BC project lead on BioWill. *“The bark residue and bark-free willow pulp will be converted into safe food quality packaging materials, and though links developed with WKW we have been exploring the possibility of using willow fibre as an insulation material in construction.”*

“Attending the two-day event was a perfect opportunity for me to get a quick introduction to agroforestry. The benefits of growing willow on farms were mentioned numerous times during the show” said Ceri. From using willow species as hedging and shelterbelts, to a fodder crop for animals and the worming and medical benefits that farmers had observed for animals feeding on the leaves and bark. Through to biomass, biodiversity and the importance of shading for livestock. The importance of shading was starkly brought to all the delegates attention during the sweltering two-day event.

“WKW are currently funding three MRes students in the forestry department to work on the value of farm forestry. We have had some introductory meetings with them to see where BC can support their various projects, particularly in developing LCAs around farm trees” said Campbell Skinner *“we look forward to seeing how their projects develop and offering support where we can.”*



Timber Alleys, benefits of grazing stock on willow, benefits of chipping and using young willow as a mulch.

The Power of Microbes and the Development of Circular Bioeconomy - BBIA Spring Event 2023

Dr Athanasios Dimitriou delivered a comprehensive presentation showcasing the Centre's notable contributions in the realm of biobased packaging, barrier coatings, paper recycling, and testing to the BioBased and Biodegradable Industries Association (BBIA) event in London.

The conference took place at the Society of Chemical Industry in May and brought together a dynamic assembly of innovators, entrepreneurs, policy makers, and legislators, all engaged with the burgeoning advancements within the UK's emerging biotechnology sectors. This collaborative forum served as a hub for discussions on cutting-edge developments and strategic initiatives in the field.

The conference boasted an impressive line-up of distinguished delegates, offering diverse expertise and perspectives in the

field of biotechnology. Anaerobic Digestion (AD) emerged as a compelling sustainable energy solution. Challenges in securing feedstocks through waste streams were discussed, underlining the crucial role of efficient waste utilization in fostering innovation. And critical issues ranging from industrial biotechnology leadership to policies for healthy soils were also covered.

Opportunities for funding through The Clean Growth Fund were highlighted. This £101 million climate venture capital fund is aimed at empowering UK clean tech entrepreneurs to combat climate change. This fund not only provides substantial financial backing but also opens avenues for collaboration in the clean tech sector.

The collective expertise and diverse perspectives of the delegates enriched the conference, offering a multifaceted exploration of the UK's emerging biotechnology industries. The encompassing body of work presented by Dr Dimitriou at the event underscores the Center's commitment to advancing sustainable solutions in this critical area.

Trips & Visits

NMITE Visit and Hardwoods CPD event

In February, Graham Ormondroyd and Morwenna Spear dropped in on the Timber TED course, being run by the Centre for Advanced Timber Technology (CATT) at NMITE in Hereford. It was exciting to see the students engaging with different aspects of sustainable timber growing, and gaining awareness of many topics. A variety of guest speakers had been brought in to cover everything from sawmilling to cross laminated timber (CLT). The visit allowed several meetings, as well as a tour of the newly finished CLT and steel frame building, which houses CATT on the new campus at Hereford.

Morwenna Spear stayed on in NMITE to participate in a two-day CPD event on hardwood characterisation provided

by the Building from England's Woodlands project. The event was held at NMITE, but led by Dr Dan Ridley-Ellis of Edinburgh Napier University, with contributions from Marlene Cramer, Phil O Leary and others.

One aspect of the first day was the link between wood anatomy and wood properties, moving right up to timber grading. While the event focused on UK softwood mechanical and visual grading methods, some of this has extension to understanding hardwood grading for the future. Obviously, this forms a large component of the Building From England's Woodlands project – watch this space.

Throughout the event there was plenty of opportunity for knowledge sharing and some very interesting discussions about future forestry, and how to make the best use of homegrown hardwood timber.

Environmental Microbiology and Biotechnology course

In February, Dr Viacheslav Tverezovskiy and Professor Peter Golyshin organised a field trip for biology students to BC's Technology Transfer Centre on Anglesey. Viacheslav and the Centre's Senior Process Engineer, Llion Williams, introduced

the students to the scale-up facilities.

Learning about our pilot-scale equipment and its applicability to bio-transformations gives a great introduction to industrial practice for students interested in biotechnology. Students from the "Environmental Microbiology and Biotechnology" course have been visiting BC's Mona scale-up facilities as part of the module 'Industrial Practice' since 2017.

ISO TC287 in Brazil

In May Morwenna Spear attended an ISO meeting to discuss development of a new standard for carbon calculations on wood. Many of the meetings have been held online, however this event brought together all three working groups for a higher-level meeting and broader discussions, as well as allowing a concentrated dive into the writing and editing process for the new standard.

One of the exciting aspects was a pre-event trip, organised

by hosts Suzano, to a forest reserve a short drive outside of São Paulo, where forest is being restored from eucalyptus plantation into native Atlantic Rainforest. *'It was wonderful to take a hiking trail through the reserve, hear about eco-tourism, community projects and habitat restoration'* said Dr Spear. *'The efforts to restore native Atlantic rainforests have worked really well. We also got to try jams and liqueurs made from forest fruits that are being harvested by local people to encourage them to value the forest in its new mix of species'*.

Kronospan, circularity in the wood-based panels sector

The Kronospan factory at Chirk are upgrading and installing new equipment to extend the product range made on site and improve their energy security. BioComposites Center (BC) staff member Ceri Loxton had the opportunity to join a Woodknowledge Wales Community of Practice (COP) visit to the company on 15 September 2023.

The Kronospan group are one of the global leaders in manufacturing wood-based panels. *"Bangor University, and particularly BC have had a long history of interaction with Kronospan in Chirk. When I was a student at Bangor University we visited the site on field trips. And since working with BC, we have worked on numerous commercial research projects with the company over the years. Kronospan have also generously supported us with supplying wood chips and resins for our own MDF and chipboard pilot plant at Mona"* said Ceri.

Trips & Visits

During the visit in September the group heard about the huge new wood recycling facilities that have been installed. These state-of-the-art facilities allow 'waste' wood in the form of kitchen work tops, furniture, fixtures and fittings to be chipped, cleaned, graded and then used to manufacture chipboard on site. Thus, helping to contribute to a more circular economy.

The company is also installing its own electricity substation to meet the needs of a new orientated strand board (OSB) line that is planned. The upgrades will include the addition of solar panels over the extensive roof area and through this and via the new substation the company hope to be able to supply electricity back into the local grid.

"One of the benefits of having Ceri on secondment with Woodknowledge Wales" said Dr Rob Elias "is that she can attend these networking opportunities and invite along other people who may be interested. In this case Lauren Bate (Senior Commercial Development at Bangor University) and Martin Burger (Materials Framework Manager, Adra)."

"It was a very interesting and productive visit" said Lauren "and as a result Rob and I were able to invite a Kronospan representative to visit both Bangor University and the new Adra Decarbonisation Hub in Penygroes. We discussed possible ways to work together, including by providing student placements, research projects and potential pathways to recycle wood-based materials from renovation of Adra housing stock back into wood-based panels."

Awards

Decontaminating post-consumer food films

COtooCLEAN is an Innovate UK funded project, led by Nextek, formed with six industrial and two academic partners (Bangor and Nottingham University). The project is to develop a unique supercritical carbon dioxide (ScCO₂) cleaning process that can efficiently and effectively clean and decontaminate post-consumer polyolefin films to a food-grade status. Our role is to provide technical support for developing the ScCO₂ cleaning method.

"We are very proud to be part of the COtooCLEAN team" said Dr Qiuyun Liu the BC lead on the project, "and to make a major contribution to the circularity of films, keeping waste out of landfills and prevent downcycling."

ScCO₂ is a non-toxic, non-flammable and non-corrosive solvent that can selectively remove contaminants through the use of co-solvents.

Existing processes use a mixture of aqueous or organic solvent washing, drying and thermal desorption to recycle plastic films. These processes are unable to reach food-grade compliance, yet are energy intensive and have a high environmental impact.

COtooCLEAN, a proprietary waterless cleaning process for polyolefin films, uses low-pressure super-critical CO₂ (ScCO₂) to deal with contamination – one of the biggest challenges in recycling flexible films found in household waste – by removing oils, fats and printing inks from the film.

The vision of COtooCLEAN is to achieve circularity for food-grade films to reduce demand for virgin resin and improve recycling rates of flexible films. The innovation provides a solution to enable better processing and recycling of one of the largest plastic waste streams.

The project won the following prizes:

- Alliance Prize Winner
COtooCLEAN – the innovative multi-participant project by Nextek Limited – has won the Alliance Prize in Circular Solutions for Flexibles.
- Circular Economy Winner,
The IOM3 Sustainable Future Awards 2023



Edward Kosior of Nextek Ltd with one of the judges Sarah Connolly from the awards' headline sponsor Innovate UK (left) and IOM3 President Kate Thornton (right)

Other

- Pre-Commercialized Driving the Circular Economy Winner, the Sustainability Awards 2023 (the most prestigious global competition for sustainable packaging innovation).

"We appreciate there is a significant challenge ahead for the recycling of plastic films and believe that COtooCLEAN will be able to make a major contribution by decontaminating post-consumer films back to food-grade quality, thereby creating a circular destination back to food applications," said Professor Edward Kosior, CEO and Founder of Nextek.

Academic

In June Dr Morwenna Spear served on the examination panel for the PhD viva exam of Dr Nicolas Neitzel, at

Linnaeus University in Växjö, Sweden. The thesis on agro-industry feedstocks for the panels industry covered some innovative ideas, including tubular boards and bio-based adhesives. *"We are happy to support the new generation of researchers in the panel products sector"* said Dr Spear.

From theory to reality. Recycling waste fibreboard now a commercial option

MDF Recovery Ltd (MDFR), a long-term collaborative research partner of the Centre, made two significant announcements in 2023 on their pathway from prototype to commercial reality.

MDFR's technology has been promoted as the world's first low energy, low water solution for the effective recycling of waste medium density fibreboard (MDF).

Over 75 million tonnes of MDF are produced each year around the world. Significant volumes of waste are generated as new MDF boards are converted into products such as furniture and shop fittings and as more MDF material enters the waste stream at the end of its first user life. Until the advent of MDFR's patented and cost-effective technology, much of this waste has been sent to landfill or incinerated.

MDFR announced at the end of 2023 a new partnership with PAL, part of the international wood manufacturing technology IMAL PAL GROUP.

The partnership will provide PAL with exclusive rights to integrate the MDFR process with its own market leading wood cleaning and recycling technologies.

The partners say that by incorporating MDFR's patented technology with PAL's extensive recycling expertise and experience, MDF manufacturers, processors and retailers will be able to reduce costs, enhance both product and corporate sustainability and address the needs of the circular economy.

The partnership between MDFR and PAL offers an integrated solution to challenges including rising raw material and



Rob Elias and Craig Bartlett.

energy costs, security of supply, and pressure to adopt the principles of the circular economy, that are impacting the industry around the world.

"We are delighted to be able to offer our customers around the world the integration of MDFR's unique process with PAL's market leading recycling technology" commented Antonio Dal Ben, PAL's Vice President and CEO.

"This exciting development is a huge step forward for MDFR and the environment" says Craig Bartlett, MDFR's CEO. *"Our technology and process offer MDF processors and users a way to benefit both the planet and their businesses' bottom line."*

MDF Recovery's process recovers wood fibre which can be re-integrated into the manufacture of panel boards or used as a natural, wood-based alternative to glass fibre and mineral wool insulation products.

Other

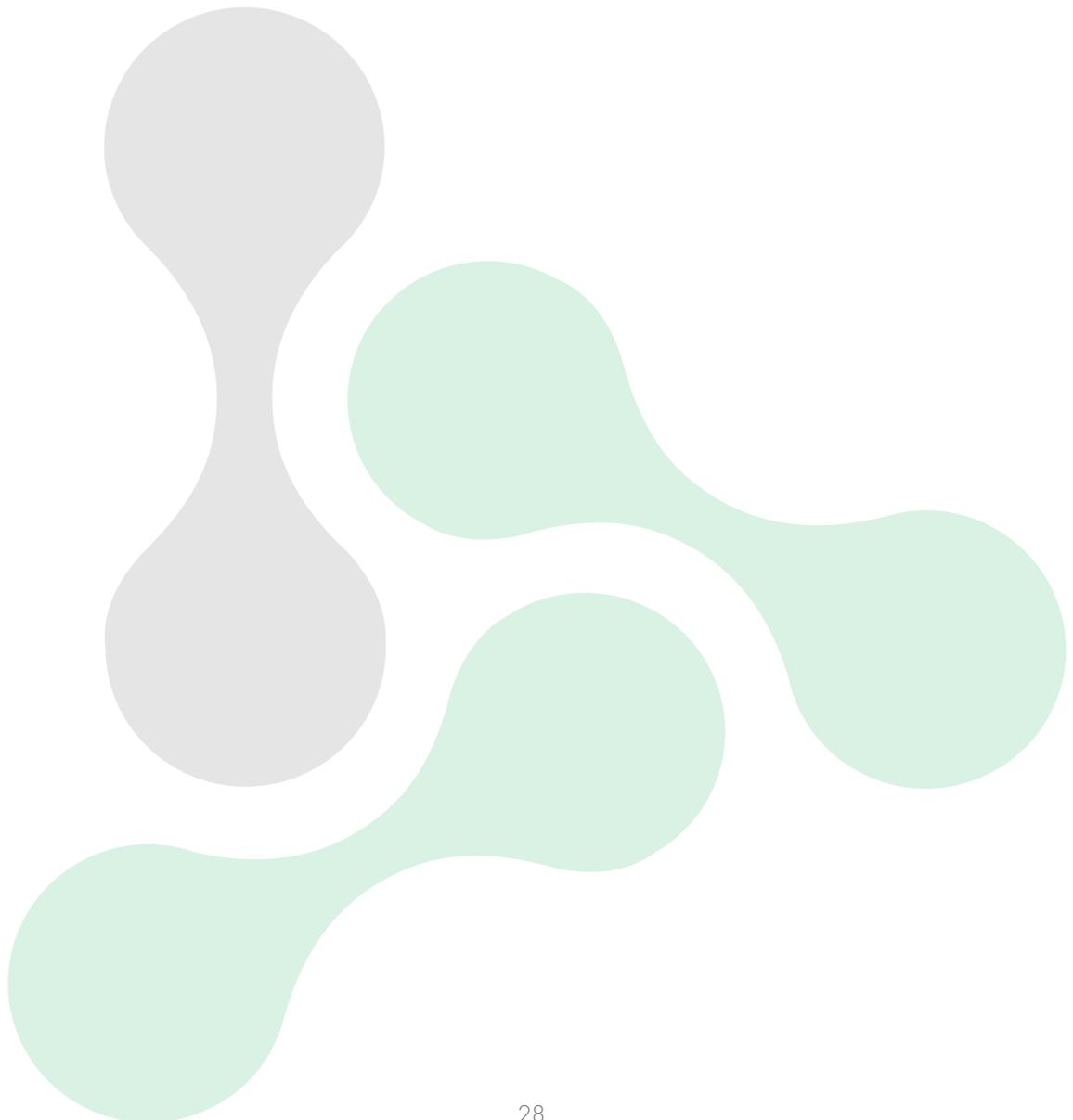
Polyco, a subsidiary of W Howard Ltd, is the first company to take advantage of the technology and has agreed a multi-year licence for the use of MDF Recovery's unique MDF recycling technology to produce loose-fill wood fibre insulation in the UK and Ireland.

Work on a new manufacturing facility in Newtown Powys has started and the first production of natural wood fibre insulation is expected in 2024.

Natural insulation is one of the fastest growing market sectors in Europe. In a growing market for natural construction materials, wood fibre has many benefits including ease of use, thermal mass, durability and appeal to increasingly CO2 conscious housebuilder and consumers.

"MDF Recovery's technology is unique" comments Jonathan Grant, Group Chief Executive of W Howard. "As a company, we are always seeking new and innovative products. The demand for natural building materials is only going to increase and the addition of recycled MDF wood fibres and loose-fill insulation is an exciting addition to our product portfolio".

"W Howards' commitment and investment in the first production plant using our technology is a significant step forward for MDF Recovery" adds Craig Bartlett, the company's CEO. "The market, governments and consumers are all keen to encourage re-use of materials and the circular economy. Waste MDF - either during processing or at end of life - is no longer a problem that has to be dealt with, but a valuable resource of high-quality wood fibres".



Bangor Linked Events and Projects

At Eich Coed / Tree Sense (Morwenna)

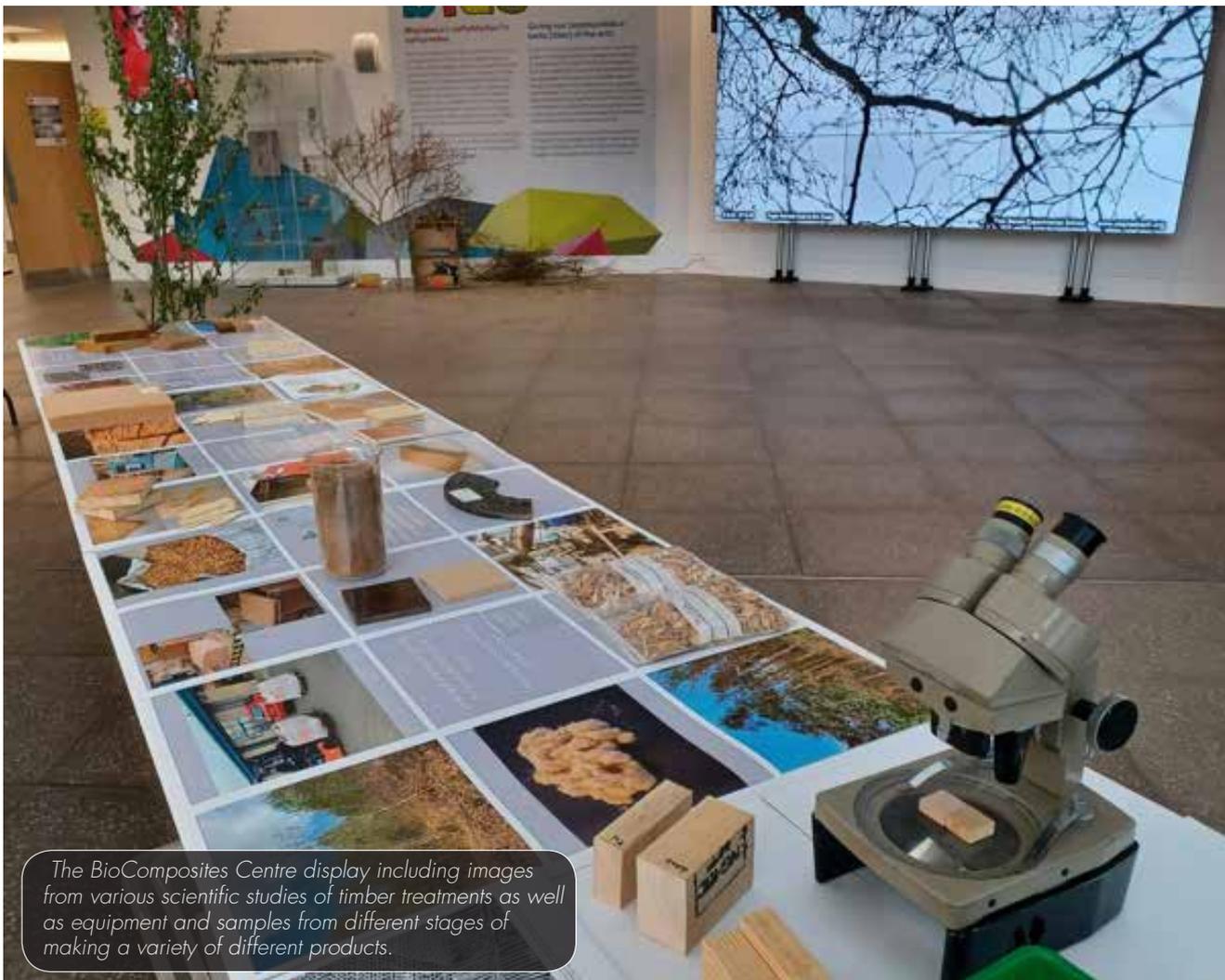
Tree Sense was a series of cultural events that brought artists and staff from a wide range of Bangor University departments together. It drew on Bangor University's position as the UK's leading centre for research and education on trees, their conservation and management. Resident artists and art commissions were a key element of the project, combining art and science to explore many perceptions of trees through a series of creative installations, discussions, workshops and performances.

Researchers from the Centre showcased their work at the Tree Sense exhibition in Pontio, Bangor, which ran from March to May. The installation included images from scientific studies of timber treatments, properties and chemistry, alongside the natural world and explored links between the bio-inspiration for technological developments. Other exhibits explored

research from the University, creative writing and artworks commissioned specially for the event, with plenty to see and explore.

The opening night, on Friday 3rd March, was a great success, featuring multi-disciplinary contributions from artists, scientists, poets, musicians, ecologists and tree enthusiasts. At the end of the project, a community and sharing day gave a second opportunity for hand-on exhibits, so BC took a table-top display along to Pontio to interact with students and the public, generating some interesting conversations and discussions about the important role of bio-based materials for the future.

The exhibition ran until 27th May, including various in-person workshops and performances. The Tree Sense exhibition and project received funding and support from HEFCW, UKCEH, Arts Council for Wales, The National Lottery, Welsh Government, Coed Lleol and the University.



The BioComposites Centre display including images from various scientific studies of timber treatments as well as equipment and samples from different stages of making a variety of different products.

Bangor Linked Events and Projects

Bangor University Community Day

In September Bangor University held its first Community Day where different departments presented their work and research to the public, taking over the Main Arts building for the day. The BioCompositec Centre had an informative and very well received display where we detailed one specific area of our work into replacing plastic packaging with renewable alternatives.

The display featured; the work on paper being performed under the Transfire project, details of PhD student Jenny Woods project on biobased coatings for paper and work on innovative seaweed based packaging being carried out by Dr Slava Tverezovskiy and team working with local company Plant Sea Ltd. It was good to see how knowledgeable and engaged our young (future scientists and leaders) were.



Dr Viacheslav Tverezovskiy and Dr Simon Curling demonstrating how to make paper and that seaweed can be used to make packaging.



Ceri Loxton demonstrating paper making to some very engaged youngsters from a local school.

Bangor Linked Events and Projects

Hyperspectral imaging of the Bangor University Archival Wood library

Bangor University have a very extensive wood library of 5000 samples gathered from around the world, including a large number of tropical specials. This is an extremely valuable resource and one that BioComposites Centre (BC) is helping to utilise and analyse.

This year Dr Simon Curling and Dr Athanasios Dimitriou were allocated an internship under the Bangor Employability scheme. This funding was used to employ Kim Diefenthal to help scan some of the samples using BC'S hyperspectral camera.

The aim of this project was to develop multispectral analysis of the samples to determine whether species identification using the method would be possible. Our great intern Kim

Diefenthal, spent many hours scanning a large number of samples and also highlighting a few discrepancies in the current catalogue. We are now hoping to recruit a second intern to help analyse the large amount of data that was produced.



Hyperspectral imaging.

COVID-19: Media failed to highlight the negative impact of single-use facemasks on the environment

How facemasks were referred to and reported on in the print media may have inadvertently encouraged more people to use disposable face coverings over cloth ones, according to new research. Writing in *Frontiers in Communication*, a multidisciplinary team from Bangor has shown how media messaging could have determined people's mask-wearing choices during the pandemic. This was based on a qualitative and quantitative review of British and Irish press

coverage mentioning masks and face coverings between March 2020 and December 2021.

The results demonstrate how newspaper journalism favoured single-use surgical masks but overwhelmingly failed to report on their environmental impact and lack of waste management. The paper discusses how the environmental impact of single-use masks or face coverings is an under-considered effect associated with the COVID-19 pandemic.

"It's not just what's reported that has an effect, but the way in which it is reported," explained first author, Dr Anaïs Augé.

"What we found was that the word 'masks' was used predominantly to mean disposable face masks, while the media used 'face-coverings' to refer to homemade or shop-bought material masks. They also predominantly used the word 'mask' while discussing mandatory wearing of face coverings, and the term 'face-covering' where there was an element of option. This was despite the UK government predominantly using masks to refer to masks used by health professionals and face-coverings as a term used for what everyone else should be wearing to reduce the spread of COVID-19."

Materials scientist Dr Morwenna Spear added, *"Despite scientific discussion of the safety provided by reusable face-coverings, and the waste associated with single-use masks already in the early stages of the COVID-19 pandemic, little of this was presented in newspapers."*



Example of a clinical disposable face mask.

Bangor Linked Events and Projects

Prof. Thora Tenbrink concluded, *"The increase in waste can be related to prevailing representations of single-use surgical masks and limited attention paid to environmental concerns. We think our work casts further doubt on the role of newspapers in effectively conveying the information needed to enable the public to make informed choices."*

The research paper is one output from the £426,513 Arts and Humanities Research Council project *Between environmental concerns and compliance: How does media messaging affect motivation and choice between disposable versus reusable facemasks?*, led by Prof. Nathan Abrams, with BC staff members Morwenna Spear and George Roberts working with social scientists, linguists, media experts and psychologists to investigate the topic from an interdisciplinary perspective. They explored the complex factors underpinning consumer choice of masks and the adoption or rejection of facemask wearing, including the responsible disposal of masks.



Example of a reusable face covering.

Welsh Innovation week in London, 9-14 September

The Centre took part in the Welsh Innovation #OnTour event organised by M-Sparc. Dr. Viacheslav Tverezovskiy exhibited our research on natural biodegradable packaging materials. He highlighted our projects with Plantsea Ltd and Pulpex to universities, industry and the finance sector at the House of Lords.



Presentation of the BioComposites Center's research to Cheryl Dennis, Welsh Government, Head of London Office; Dr Daniel Dickson, Private Secretary to Professor Dame Ottoline; and Andrew Gwatkin, Director of the Department of International Relations and Trade.



Keynote Speech by Rt Hon Lord Wigley.

Bangor Linked Events and Projects

KESS 2 updates - sustainability

The team have continued to deliver the KESS 2 sustainability agenda through a series of workshops and on-line seminars based on the UN Sustainable Development goals. The

year was highlighted by the annual awards dinner that took place in Cardiff and this year showcased how the work undertaken through the KESS project has influenced our planet. The year was rounded out with an on-line quiz mixing sustainability questions with Christmas cheer.

KESS 2 updates - Re-thinking Packaging for Food Supply Chains of the Future

PhD researcher Jenny Woods travelled to Madrid in September 2023 to present her research for the first time at a conference. The 3rd Circul-A-Bility conference was for members of the COST action community (CA191249) to share results, debate ideas and facilitate solutions for a greener transition to more sustainable food packaging.

Jenny presented her research on novel bio-based coating alternatives for paper food packaging. The focus of the talk was on the lab scale application technique she has been using and a discussion of her preliminary barrier testing results. The presentation summarised Jenny's first year as a masters student at the BioComposites Centre and gave an overview of future prospects as she progresses into what will now be the second year of her PhD.

The conference presented many opportunities to network and learn from other scientists and professionals and gave a great chance to develop new ideas and collaborations that could feed into future research topics. "This was a great experience and one that wouldn't be possible without the funding and support from KESS 2" said Jenny.



Jenny Woods presenting her work on novel bio-based coatings at a COST action conference in Madrid, September 2023.

People

Early Retirement Dr Ahmad Al-Dulayymi

In October 2023, the Centre wished Dr Ahmad Al-Dulayymi farewell with his early retirement on medical grounds.

In late 2022, Dr Ahmad was taken seriously ill and rushed to hospital in Liverpool for surgery to repair a bleed on his brain. After a period of hospital convalescence, Ahmad returned to his Bangor home in June 23, where he continued his impressive recovery. In September 23, working with Bangor Occupational Health team, the plan was for a phased approach back to work. However, in October, Ahmad decided to take up the option of early retirement and all his work colleagues wish him well with his continued recovery.

Leaving his job as a synthetic chemist in Canada, Ahmad moved his family back to Wales to join the Centre in June 2014. His first role was to support a new EU FP7 project called High value-added chemicals and Bioresins from algae biorefineries produced from CO₂ provided by industrial emissions (BISIGODOS).

This project involved 15 EU partners from Germany, France, and Spain. The lead partner had developed strains of microalgae that were grown to efficiently convert CO₂ and sunlight into kilograms of biomass. The lipids were then extracted from this biomass and converted into fatty acids. *"The challenge was to convert these feedstocks into a range of bio-based products for applications such as adhesives, resins and for flexible and sustainable packaging"* explained Dr Radek Braganca, project manager.

Ahmad's role was to take fractions of algae-derived chemicals functionalise them for use as anti-corrosive paints, bio-based resins for inks and compounds for the hair care industry. Ahmad worked with key partners in the United Kingdom (UK) and undertook trials with Croda, Sun Chemicals and Becker paints.

Colleagues were quickly impressed with his chemistry skills, and Ahmad worked on a wide range of projects and just got on with it. UK funded projects included the development of novel biobased polyesters that interior coatings of tin cans working with PPG's main UK research centre.

Ahmad also used his excellent organic chemistry skills to work in the fine chemical sector helping to synthesise intermediate chemical compounds on a commercial basis for some of the Centre's customers. Other projects took Ahmad into some new and unknown areas of research,

notably in agriculture. Here Ahmad's skills were used to formulate new bioactive compounds and trials took Ahmad out to work in the fields growing potatoes.

Whatever the project, Ahmad was always quick to help, lending a hand to get the job done. His amazing skills as a chemist will be sorely missed but most of all we will miss his friendly and enthusiastic approach. We all wish you the absolute best in your retirement.



Ahmad with David Shaw and Debbie Evans helping with harvest.

People

Dr Paddy Murphy

Paddy Murphy has been recognised by Bangor University's Senate for his significant contribution to work in The BioComposite Centre. Paddy and has been given the title of 'Honorary Professor of Industrial BioTechnology'. The appointment is for a period of three years.

Paddy helped to pave the way for the recently funded Dancing with Daffodils project. This project funded in 2023 by the Department for Environmental Food and Rural Affairs (DEFRA) has a total award of £2.8 million to look at ruminant efficiency, sustainable farming, and on-farm methane monitoring. Early work with Paddy and Dr Radek Braganca with colleagues from Scotland's Rural College (SRUC) in Edinburgh identified the target molecule. This

work was summarised in a paper "*Slight changes in the chemical structure of haemanthamine greatly influence the effect of the derivatives on rumen fermentation in vitro*" and was published back in 2019.

"This publication helped the successful funding of the project" explained Dr Radek Braganca "and in his new honorary position it is nice to have Paddy helping to oversee our research and work with Dr Sean Baxter, Dr Adam Charlton and the rest of the project team".

Ramos-Morales E., Tibble-Howlings J., Lyons L., Ogbu M.O., Murphy P.J., Braganca R., Newbold C.J. (2019) Slight changes in the chemical structure of haemanthamine greatly influence the effect of the derivatives on rumen fermentation in vitro, *Scientific Reports*, 9, 2440.



People

Carlo Kupfernagel

– Goodbye and Good Luck

Final year PhD student Carlo left Bangor in November 2023 by bicycle to cycle back to Germany! He will now complete the final stages of writing up his PhD and prepare for the next phase of his working life.

“Carlo is an excellent PhD student and has thrived in the research environment here in Bangor. His work has been of very high quality, despite the challenges of starting under pandemic conditions (with enforced remote study and no laboratory work) and later the sudden loss of lab space and demolition of the Alun Roberts Building where the BioComposites Centre was previously housed.” said Dr Morwenna Spear, Carlo’s supervisor.

Prof Graham Ormondroyd, who also supervised the PhD, commented *“Carlo has made great use of opportunities to*

prepare presentations, give talks, attend workshops and conferences, and has always been a great ambassador for the Centre. We wish him every success for the final phases of his writing up and viva examination.”

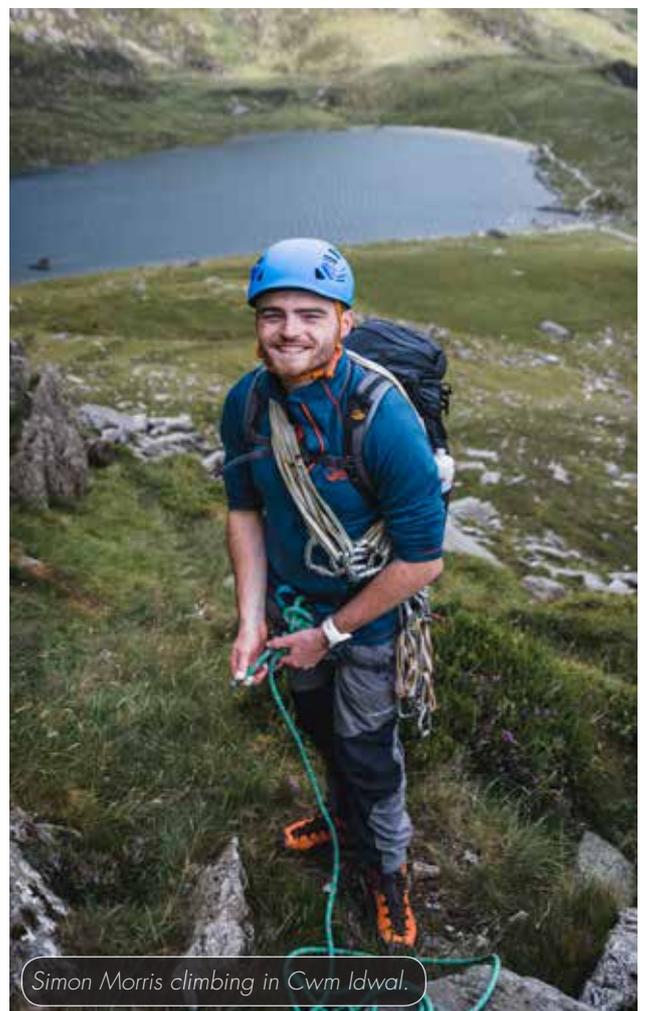


Image of Carlo at IPPS.

Simon Morris

I joined the BioComposites Centre in January 2023 following graduation from Lancaster University with a masters in Earth and Environmental Science. I am a KTP associate, on a project between Bangor and Lyan Packaging in Wrexham; a company that specialises in the provision of temperature-controlled packaging through their Icertech trading division.

I am embedded within Lyan Packaging and primarily operate from their base in Wrexham. The KTP project aims to use LCA to inform new sustainable product development, with the aim for Lyan Packaging to become the sustainability leaders within the market. My personal interests lie in identifying environmental impact, sustainable development of products and business practices and communicating environmental issues to a wide audience in the hope to stimulate change. Outside of work I do a lot of sport, coaching water polo with the local Wrexham team, and the Welsh Junior boys’ team.



Simon Morris climbing in Cwm Idwal.

Publications & Publicity

Papers Published

Auge A.C., Tenbrink T., **Spear M.** and Abrams N. (2023) British and Irish newspapers implicitly support single-use masks over reusable face coverings. *Frontiers in Communication*, section Science and Environmental Communication 8: 1256349 <https://doi.org/10.3389/fcomm.2023.1256349>

P. Baker, A. Miklavčič Višnjevec, K. Peeters, M. Schwarzkopf and **A. Charlton** (2023) Valorisation of waste olive pomace: Laboratory and pilot scale processing to extract dietary fibre, *Cleaner and Circular Bioeconomy*, 5, 100045; <https://doi.org/10.1016/j.clcb.2023.100045>

P. Baker and A. Charlton (2023) Establishing conditions to produce lignin degrading enzyme on wheat bran by *Trametes versicolor* CM13 using solid state fermentation; *Waste*, 1(3),711-723; <https://doi.org/10.3390/waste1030042>

Ruiqi Fan, Bingru Li, Qi Liu, **Qiuyun Liu**, Jixiao Cui, Runhao Bai, Yang Wang, **Robert Elias**, Cheng Li, Wenqing He (2024) Comparative evaluation of soil accumulation of light stabilizers from biodegradable mulching films versus conventional polyethylene ones. *Journal of Hazardous Materials* Volume 465, 5 March 2024, 133302

Hu J, **Skinner C**, **Ormondroyd GA**, Thevenon M-F (2023) Life cycle assessment of a novel tannin-boron association for wood protection. *Science of the Total Environment*, 858(1), 159739. <https://doi.org/10.1016/j.scitotenv.2022.159739>

Kupfernagel C., **Spear M.J.**, Pitman A.J., **Ormondroyd G.A.** (2023) Wood modification with phenol urea formaldehyde (PUF) resin: The influence of wood species selection on the dimensional stability. *European Journal of Wood and Wood Products* 81: 5-19 <https://doi.org/10.1007/s00107-022-01893-5>

S. Lwasa, **A. Charlton**, A. S Ayor, J. B. Kirabira, N. Khairallah, F. Miremadi, D. Bariho, E. Mugambe, L. Katiiti, and R. Orikiriza (2023) A New Value Proposition for Uganda's Maize Stover to Manufacture Moulded Pulp Packaging Material for Fruit and Vegetables: *International Journal of Research and Innovation in Applied Science*, Volume 8, Issue 7; DOI: <https://doi.org/10.51584/IJRIAS.2023.8701>

Shi, Y., Li, X., **Liu, Q.**, Zhang, C., Guo, W., Tian, K., **Elias, R.** & Wang, H., (2023) High-yield carbon derived from commercial phenol-formaldehyde resin for broadband microwave absorption by balancing conductivity and polarization loss (E-pub ahead of print) In: *Journal of Materials Science*. 58, p. 7048-7059

Conference and workshop papers

Charlton, A., Bio & Emerging Technology Research Institute, Addis Ababa, Ethiopia (30 November 2023). Sustainable Industrial Materials: The Path towards Commercializing Research

Charlton, A., Yirgalem Integrated Agroindustrial Park, Sidama Region, Ethiopia (28 November 2023): Development of new food packaging from Ethiopian crop residues to reduce the impact of plastics pollution on agriculture

Charlton, A. (4 September 2023). Sustainability in the Horticultural Industry: Valorisation of agricultural, forestry and food waste- meeting of the Welsh Horticulture Cluster (on-line)

Charlton, A., Mt. Elgon Hotel, Mable, Uganda (30 March 2023): Seedling wrap: Development of biobased tree seedling film wrap to support agroforestry in Uganda

Charlton, A., National Crops Resources, Research Institute, Namulonge, Kampala, Uganda (27 March 2023): Seedling wrap: Development of biobased tree seedling film wrap to support agroforestry in Uganda

Charlton, A. Overview of the Seedling wrap project in Uganda. KTN Africa Agroforestry Meeting (On-line) *Agroforestry Innovation and Collaboration between the UK and Africa - Event round up - Innovate UK KTN* (ktn-uk.org)

Kupfernagel C., **Spear M.**, Pitman A. and **Ormondroyd G.** (2023) How drying conditions can affect resin modified wood. In: *Proceedings of the Northern European Network for Wood Science and Engineering (WSE) 2023*, Larnøy. E. (Ed.), 10-12th October 2023, Ås, Norway, pp.187-189.

Publications & Publicity

Kupfernagel C., Spear M., Pitman A. and **Ormondroyd G.** (2023) The curing reaction of phenol urea formaldehyde resin in the presence of different wood species. In: *Proceedings of the International Panel Products Symposium 2023*, 3-4th October 2023, Llandudno UK, pp. 69-76.

Spear M. (2023) The benefits of circular economy approaches in the wood panels industry on the magnitude of harvested wood products (HWP) carbon storage. In: *Proceedings of the International Panel Products Symposium 2023*, 3-4th October 2023, Llandudno UK, pp. 23-40.

Gonçalves S, **Curling SF, Ormondroyd G,** Paiva NT, Martins J, Magalhães FD and Carvalho LH (2023) VOC Emissions From Fast-Curing Particleboards Made With Lignosulphonate And pMDI Binders. In *Proceedings of the International Panel Products Symposium 2023 (IPPS)* Llandudno, Wales, October 2023.

Book Chapters and Reports

Agri-Food Wastes and Biomass Valorization, (2023) Editors: Vassilis Athanasiadis and Dimitris P. Makris. Chapter by **P. Baker** and **A. Charlton** 'Establishing conditions to produce lignin degrading enzyme on wheat bran by *Trametes versicolor* CM13 using solid state fermentation' ISBN 978-3-0365-9539-9 (hardback); ISBN 978-3-0365-9538-2 (PDF): <https://doi.org/10.3390/books978-3-0365-9538-2>;

Media Interviews

A radio interview involving members of the 'Seedling wrap project-reducing single use plastics in Uganda' took place on a popular radio station (Open Gate FM (103.2)) for farmers in the Mount Elgon region of Uganda called on 30.3.23. The interview involved METGE (Micheal Sunday), NARO (Ephraim Nuwamanya) and Bangor University/BioComposites Centre (**Adam Charlton**). The aim of the interview was to raise awareness about the project and the benefits of collaborating with local farmers to add value to agricultural crop residues by converting it into packaging. The interview involved a question and answer session between the project team and local farmers.

In addition, several TV interviews involving the project team and involving regional and national channels took place at the Mt. Elgon Hotel (30.3.23). The media channels involved were Next Media Services (NBS) and Uganda Broadcasting Corporation (UBC).

Magazine articles

Spear M. (January 2023) New orientations. Wood Based Panels International. <https://www.wbpionline.com/features/new-orientations-10631303/>

Spear (March 2023) Emerging species. Wood Based Panels International. <https://www.wbpionline.com/features/emerging-species-10719046/>

Spear M. (May 2023) Sensing what's happening. Wood Based Panels International [Sensing what's happening - Wood Based Panels \(wbpionline.com\)](https://www.wbpionline.com/features/sensing-what-s-happening-10719046/)

Kupfernagel C. (Sept 2023) Understanding resin chemistry. Wood Based Panels International. <https://www.wbpionline.com/features/understanding-resin-chemistry-11278132/>

Kupfernagel C. (Nov 2023) Making the nucleus dance with NMR. Wood Based Panels International. <https://www.wbpionline.com/features/making-the-nucleus-dance-with-nmr-11402137/>

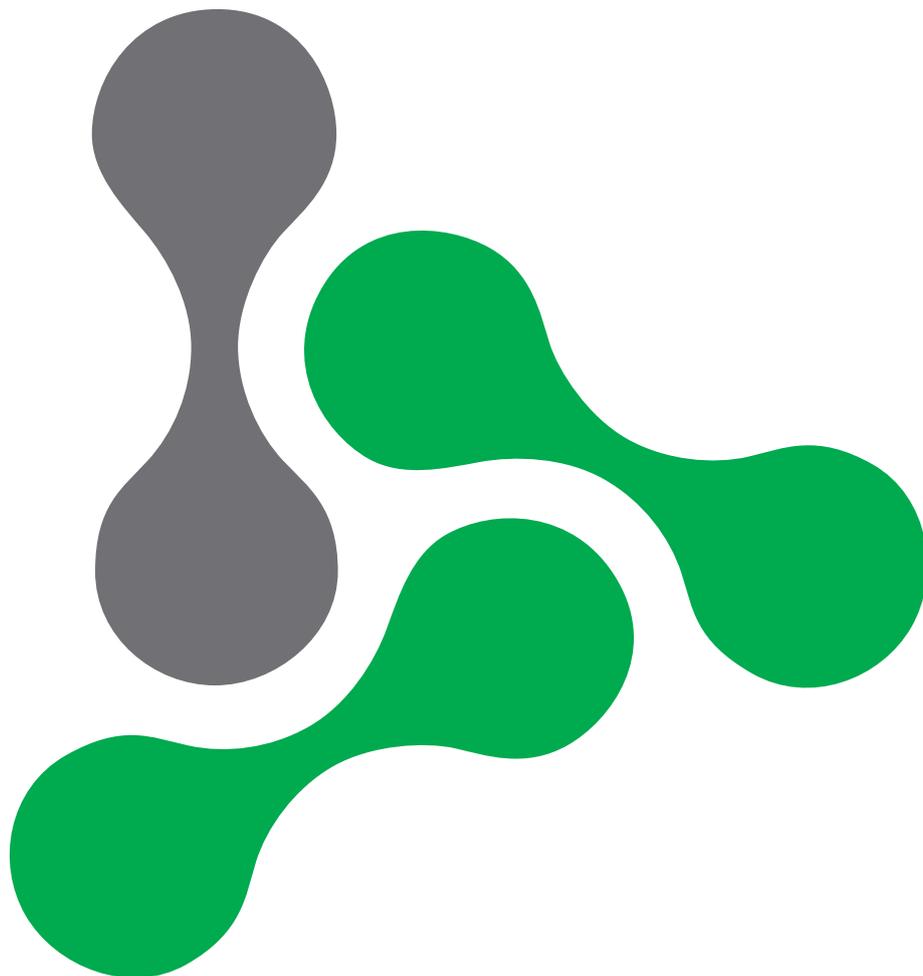
IPPS Innovation Focus. Wood Based Panels International. October/November 2023. [IPPS innovation focus - Wood Based Panels \(wbpionline.com\)](https://www.wbpionline.com/features/innovation-focus-10719046/)

Spear M. (2023) Appearance grading of Welsh Hardwoods. In: Growing Furniture in Wales. Coed Cymru, compiled by Dylan Glyn Jones and Lynne Elvins, pp. 38-41. <https://coed.cymru/images/user/Growing-Furniture-In-Wales-2023-new.pdf>

Staff List

BioComposites Centre Staff List 2023

| Staff Category | Name |
|---|-------------------------|
| Research Staff | Adam Charlton |
| | Ahmad Al-Dulayymi |
| | Athanasios Dimitriou |
| | Campbell Skinner |
| | Ceri Loxton |
| | Graham Ormondroyd |
| | Morwenna Spear |
| | Olga Tverezovskaya |
| | Paul Baker |
| | Qiuyun Liu |
| | Radak Braganca |
| | Robert Elias |
| | Simon Curling |
| | Viacheslav Tverezovskiy |
| Technicians and Research Support | Christopher Miles |
| | Debbie Evans |
| | Elisabetta Beltrami |
| | George Roberts |
| | Jacob Williams |
| | Jonathan Nicholls |
| | Joshua Davies |
| | Laura Bischoff |
| | Llion Williams |
| | Max Clarkson |
| Sean Baxter | |
| Administration and Finance | Anneli Hopkins |
| | Judith Burgess |
| Student | Carlo Kupfernagel |
| | Jenny Woods |
| | Josh Fielding |



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