

The BioComposites Centre **ANNUAL REPORT 2019**



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BEACON
From plants to products
O blanhigion i gynhyrchion



Llywodraeth Cymru
Welsh Government



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Annual Report 2019

Welcome *Dr Rob Elias: Director*

Welcome to our annual report that celebrates our successes. I would like to thank all our team for their hard work and dedication in working with our project partners and sponsors in delivering on our R&D commitments, completing our commercial work to demanding timescales, and contributing to research impact here at Bangor University. Publishing an annual report is a great way to look back on the year and reflect on our achievements so I hope you find this year's report informative. Well done everyone!

As Centre director my focus is to look forward, try to identify the future opportunities for research to exploit our know-how and expertise into new and emerging areas within the biobased sector. Predicting the future is challenging and we face many unknowns in the UK funding landscape. However, the challenges faced by society remain the same; there is a need to develop sustainable biobased products that are easily recycled, or that have alternative end of life fates that are less damaging to the environment. The mandate from industry and society for cleaner technologies and materials is growing, and this is driving the demand for our expertise and capabilities that can help deliver cleaner technologies, processes and materials.

Some of the key successes this year include continued participation in new EU projects, the successful completion of NEWTON projects in Brazil and Malaysia, and the commercialisation of technologies in the agritech and packaging sectors. This year we have assisted in the development of new plastic compounds that will contribute to the UK Plastic Pact commitments, we have developed new pilot scale processing technologies for the food sector and have helped to shape future UK policy.

Using our funding we have helped early career researchers by providing new job opportunities through schemes such as the Knowledge Transfer Partnership (KTP). We have also offered funded industrial placements to recent Bangor graduates, allowing them to learn new analytical and scientific techniques whilst collaborating with industry.

As well as the research agenda we have also focused on growing the recognition of our Centre and of the impact we have at a regional, national and EU level. Our track record is being increasingly recognised by Welsh and UK Governments with numerous mentions of our activities



Dr Rob Elias: Director

in strategy documents and case studies, where we are cited as examples of best practice.

Building on this recognition we successfully completed a feasibility study and business plan to look at the creation of a new home for our pilot plant facilities. The plan is for co-locating the pilot scale equipment on the University's new Science Park Campus on Anglesey. A purpose-built state of the art building will provide a strong platform for our future, will help raise awareness of what we offer and facilitate new collaborative partnerships. This will maximise the economic impact we offer through better technology transfer to businesses. This in turn will lead to a stronger science and technology base with clear commercial potential that will increase R&D investment. Helping to embed a culture of innovation into companies by demonstrating the benefits of R&D is one of our many aims and the opportunity to do this from a new location is very exciting!

Table 1. Staff numbers for 2019

| Staff Category | |
|----------------------------------|----|
| Research Staff | 17 |
| Technicians and Research Support | 11 |
| Administration & Finance | 1 |
| PhD students | 1 |
| Embedded Staff | 1 |

National and International Funding

New bioplastic for coffee cup lids could bring royalties to Bangor University

A highly successful project came to an end in December 2019 and with it the signing of an agreement with the industrial partners to pay Bangor University a small fee for every kilogram of a new biopolymer developed during the HDTBioPol project.

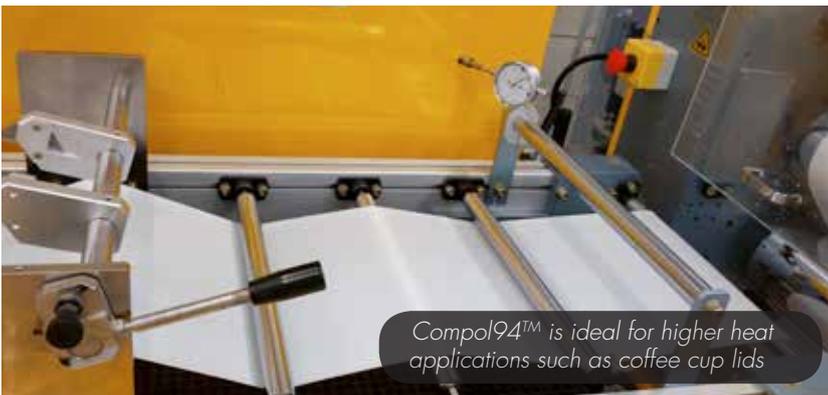
"We are delighted with the progress that has been made on the project" said Dr Gary Ogden from Wells Plastics who led the project. "Working with the BioComposites Centre and other partners to develop the new product and then get it through various types of certification has been an exciting process. We launched the product under its tradename Compol™ at the K-show in October in Dusseldorf". The K-show is one of the biggest trade shows for plastics, so it was a big achievement for the project to have a product ready to launch at such a high-profile event.

"Conventional polymers for coffee cup lids are actually not so simple to replace with biobased polymers" explained BC's Dr Qiuyun Liu. "Many biobased polymers

have low 'heat deflection' properties which makes them unsuitable for use in elevated heat applications like coffee cups. During this project we have successfully improved a number of properties, including the heat deflection temperature, so that the new range of products not only hold their shape at higher temperatures but also aren't brittle, making them suitable for a range of applications."

During the project the three partners (Wells Plastics, Dragon Packaging and BC) were co-funded by Innovate UK to collaborate over a 27-month period to develop the new product and bring it to market. The resulting Compol™ materials have now been tested, approved and certified to European compostability standard EN 13432 and conform to EC 10/2011 and FDA CFR21 food contact regulations.

"I look forward to the day when all coffee cup lids used here at Bangor University contain a biopolymer that was formulated right here in Bangor – that would be something to be really proud of" said Dr Rob Elias, director of BC. "Wells and Bangor are working together to prepare new proposals for the ISCF Smart Sustainable Plastic Packaging call to develop Compol™ further for other type food packaging products, and we are keen to work with Wells and Dragon again."



Compol™ 94



National and International Funding

Joint UK-Malaysia project finding alternatives to plastic food packaging

“It has been a fantastic project” said Dr Rob Elias, “at times it has been challenging but the effort put in by the BC team, particularly Dr Qiuyun Liu who managed it, and all the partners has really paid off. We have some great products and ideas to take forward and hopefully we will start to see some of them replacing plastic food packaging on supermarket shelves in the future.”

The aims of the SafeBioPack project were to improve the preservation of food during transport and storage between the producer and the consumer; reduce urban solid waste from plastics going to landfill; and improve health and well-being of the population by reducing risk of pathogenic diseases transmitted in meat or vegetables.

The project was a collaboration between Malaysia and the UK. It was co-funded by Innovate UK, MIGHT (Malaysian Industry Government Group for High Technology), EPSRC (Engineering and Physical Sciences Research Council) and by match funding from the commercial partners. The project ran from October 2016 to December 2019.

SafeBioPack looked at the use of cost-competitive, presently underutilised ‘waste’ raw materials, to make the base materials that are then made into pulp moulded trays. The Centre used its expertise and pilot-scale equipment at Mona to prepare a series of different pulps from various raw materials. One key achievement was to prove that atmospherically refined empty fruit bunch (EFB) fibre could successfully be manufactured into punnets. This was significant as previously pulps from EFB fibre in Malaysia have been prepared using a semi-chemical

approach. By removing the chemicals from the process this can reduce costs and environmental impacts of the whole process.

In addition to preparing the base raw materials and pulp moulded trays the project team looked at incorporating various active compounds from edible plants into the packaging to produce ‘active packaging’. Packaging films with antimicrobial properties were produced by SciTech Adhesives and the Malaysian partners and tested to both UK and Malaysian standards.

Three different types of packaging have been developed during the project: Type 1 is a pulp and paper tray for use with ‘dry’ fruit and vegetables such as tomatoes, grapes, and soft fruit. This Type 1 tray can be sealed either using a conventional plastic film or a compostable film. Type 2 is a pulp and paper tray suitable for meat applications, where a barrier coating is required to prevent leakage of the food out of the container and contamination of the food from air or contact sources. The third type of packaging is a bioplastic formulated by the partners during the project. Further formulation and optimisation work is still required, but one of the commercial partners is looking at registering a trademark for the formulation.

A meeting with the Malaysian Investment Development Authority (MIDA) in Kuala Lumpur in May 2019 looked at certification costs for the new products and commercialisation opportunities. Malaysia has a national biomass strategy and road map, and companies interested in developing value-added products using biomass in Malaysia can access a range of incentives. Partners are working to continue to develop exploitation opportunities after the end of the project.





Production trials at PolyComposite's factory in Malaysia. Dried oil palm fibre (from the empty fruit bunch) is milled and then thermoformed into formable sheets



Dr Khairul Zaman of PolyComposite and Dr Mohammad Jaiwad of Universiti Putra Malaysia



Final project meeting at Tesco's head office, UK

National and International Funding

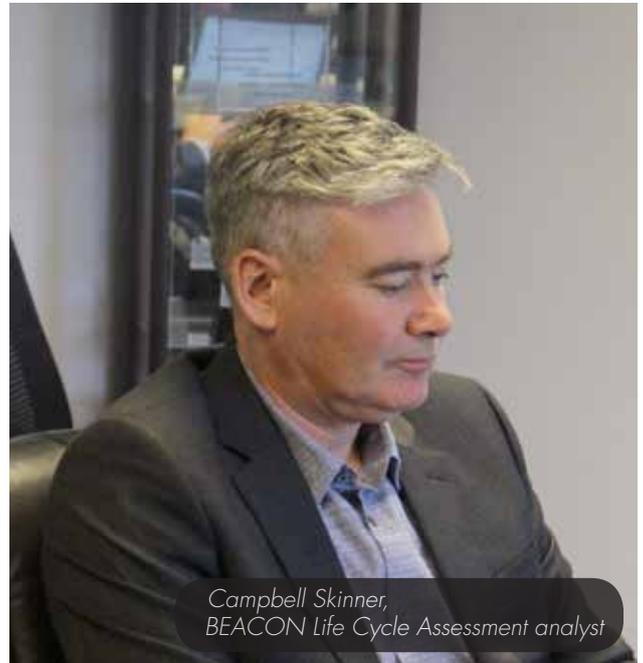
Approaching 10 years of Welsh biorefining research expertise

2020 will mark ten years of the very successful BEACON programme, a collaboration between Aberystwyth, Bangor and Swansea Universities, which is part-funded by the European Regional Development Fund (ERDF) through the Welsh Government.

Since 2010, BEACON has collaborated with over 300 companies across Wales and in 2014, was winner of the prestigious European Commission's Regiostars Award, in the category: 'Sustainable growth: Green growth and jobs through bioeconomy'. In 2019, further funding for the project was approved until 2022 and project activities have been extended into North East Wales, which is great news for building new collaborative links with companies there.

This year BEACON also welcomed a new project partner, University of South Wales, which further expands the expertise and capabilities within the project team. The USW team will bring wide-ranging expertise to BEACON, from bioplastics to anaerobic and aerobic processing and biological biogas upgrading.

To celebrate the first 10 years of BEACON we are planning an event that will take place in 2020 and will involve key stakeholders that we have collaborated with over the years.



*Campbell Skinner,
BEACON Life Cycle Assessment analyst*



BC's biorefining pilot-plant has been at the heart of many BEACON collaborations

Positive steps to cutting harmful plastics from entering our oceans and waterways

BC chemistry researcher Dr Ahmad Al-Dulayymi has led a team developing formulations for polymers containing graphene which could help reduce plastic pollution in our seas. These formulations eventually led to the production of prototype films which could be used in more environmentally friendly packaging.

Presently plastic films, many of which are used in food packaging, often end up polluting the environment. Even those materials designated recyclable are rarely recycled. This is due to both the lack of collection of plastic films by county councils and the difficulty in using recycled films back into the supply chain. Even if recycling schemes for plastic films are introduced, many are in fact laminates - several different layers, usually consisting of different materials stuck together - and as such are not recyclable.

The GraCoPack project was a year-long feasibility study co-funded by Innovate UK. The project was aimed at creating a single-layer recyclable or compostable material combined with a unique coating with high oxygen and water barrier properties. While there are several



sustainable, cellulose-based materials for food packaging that are both recyclable and compostable, they do not have inherent barrier properties that are required for the preservation and safety of food. Food can be adversely affected by the ingress of moisture and air, both of which have a negative effect on food safety and shelf life.

The project was a collaboration between industry and academia to develop technology that will assist in the reduction of plastics entering waterways, oceans and other undesirable disposal routes. The huge difference between the material developed in this project and existing plastic films is that this new packaging will be fully recyclable and / or compostable and thus will make a significant difference to environmental pollution.

Industrial project partners included Parkside Flexibles, an innovative packaging design company based in Yorkshire and Scitech Adhesives, a Welsh company specialising in industrial adhesives and coatings. The partners completed the work in 2019 and are already exploring opportunities to develop the research further.



Dr Ahmad Al-Dulayymi, with project partners from Parkside and Scitech

National and International Funding

Using seaweed to protect potato crops

Seaweed may seem like an unlikely candidate for protecting potatoes against the deadly infection 'blight'. Potato late blight, caused by the fungi *Phytophthora infestans*, is the main disease of potatoes in the world today, but lab tests at BC have identified natural extracts (plants, seaweeds and fish waste) and microbes that prevent infection of potato leaves.

Potato blight attacks all organs of the plant (leaves, stems and tubers) and can attack at any stage of crop development, provided that climatic conditions are right. Here in the UK and in Ireland, the mild temperatures and humidity are just right for the fungi to thrive. When this happens, potato late blight can cause very significant yield losses – 50%, or even 100% in cases of early and violent attacks or in conditions of production in organic farming. In case of late attacks, it is the quality of the tubers that are affected.

To control the disease the main method used is a weekly preventive application of fungicides. Mainstream farmers use synthetic pesticides, and organic farmers currently use copper salts. These salts have been used for centuries, but they are problematic because they are unselective and in the long-term they reduce soil fertility. Many

copper-based sprays have now been banned and many synthetic chemicals are likely to be banned in the near future, so alternatives are urgently required.

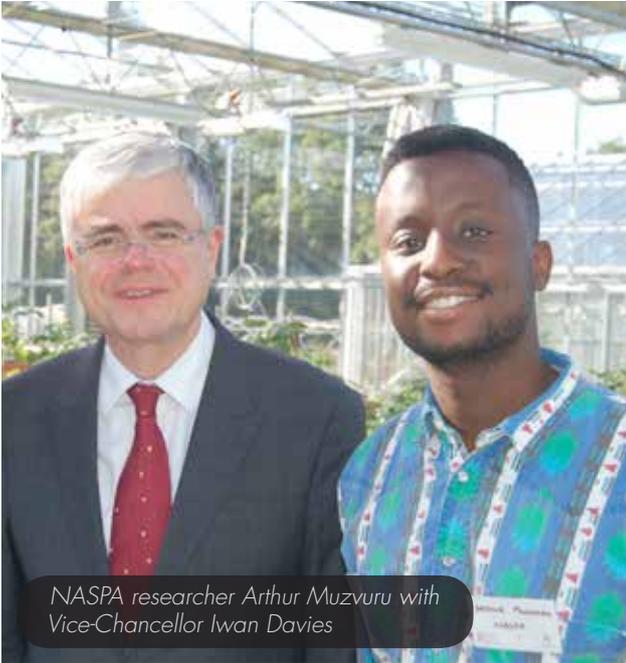
The NASPA project (2019-2021), coordinated by Bangor University and involving partners across Europe, aims to identify effective biocontrol products against *Phytophthora*, based on botanicals and / or natural antagonists. The first phase of the project consisted of evaluating the protective effectiveness of around forty biocontrol products (extracts of algae, extracts of plants, microorganisms, mineral elements and organic compounds) in controlled conditions. The most interesting products were then selected for field trials.

By better understanding the way the new products work (e.g. by stimulation of plant defences) and by studying their interaction with the genetics and architecture of plants in the fields, the project aims to evaluate the effectiveness of field protection in combination with a reduced rate of fungicide on a particular potato variety.

"The way ahead is to use integrated control" said Dr David Shaw from Sárvári Research Trust (SRT) based at Henfaes Research Farm, Bangor University. "Integrated control will require that we use new varieties of potatoes that are more resistant to late blight and fewer, less toxic sprays so that blight is totally suppressed."



Crop spraying bio-based disease controls at Henfaes Research Centre



NASPA researcher Arthur Muzvuru with Vice-Chancellor Iwan Davies

The Sarpao potato (a blight resistant potato developed by SRT) was one variety of potato used for the trials, which saw trial plots sprayed with the test products, then deliberately infected with blight. The development of rot on the potato foliage was charted. Foliage in unsprayed plots died off rapidly but some sprayed plots showed little or no disease. The weight of potatoes and their freedom from blight indicated that some products had the potential to suppress the infection.

The most promising products will be tested in more field trials in North Wales and at other sites in the UK and Western Europe during 2020 and 2021.



Creating sustainable packaging from maize stover in Uganda

Stoverpack is a joint project between the UK and Uganda funded by Innovate UK and the Department for

International Development. The project is led by BC's Dr Adam Charlton and the consortium consists of three Ugandan partners (Makerere University, Oribags Ltd and Musabody Ltd) and a UK company, NER Ltd.



Dr Adam Charlton with project partners and growers at the Kamuli Farmer Cooperative in Eastern Uganda

National and International Funding

The project aims to address issues around postharvest losses of fresh produce in Uganda, through the production of sustainable packaging manufactured in Uganda. The packaging will be produced from maize stover and will create a new market for this material, a large part of which is currently burnt in the field. Post-harvest losses have a huge impact on food security and farmer incomes in East Africa and are caused by fresh produce spoilage during transportation from farm to market, often resulting from the use of sub-optimal packaging materials.

The project will assess the feasibility of establishing a commercial facility for the production of pulp moulded packaging for eggs, tomatoes and oranges from maize stover in Uganda. Members of the project team have visited partners and growers in Uganda and a reciprocal visit to the UK is planned in 2020.



Dr Adam Charlton in discussion with Tefad who make textiles from banana fibres



A tour of the Kampala Industrial Business Park development with Joy Kabatsi, Minister of State for Animal Industry, and other delegates

Developing biodegradable mulch films for use in agriculture

The Centre's new collaborative project with China got off to a flying start with a meeting in Beijing in April 2019. The Newton funded project brings together industrial partners in the UK with a consortium of Chinese manufactures led by the Chinese Academy of Agricultural Sciences (CAAS). UK partners include Wells Plastics, a specialist compounder, Scitech Adhesives, and farm management company, Velcourt.

The official kick-off meeting was attended by VIP guests from the British Embassy, Beijing Welsh Office, the Chinese Ministry of Agriculture, Peking University and

Chinese business partners from Huasheng and Jintudi Plastics. UK industrial lead Gary Ogden of Wells Plastics attended along with Centre director Rob Elias and project manager Dr Qiuyun Liu.

"It was great to have some very senior guests" explained Qiuyun. "The kick-off meeting enabled us to raise the profile of our work and discuss the challenging issues faced by farmers. China is one of the largest end-users of plastic mulch films and over the last four decades Chinese agriculture has adopted this technique to dramatically improve crop yields. We can now see some of the issues regarding plastic waste and this is driving the team to develop a new range of biodegradable materials that can be adapted to the different soil and climatic conditions in China".



Dr Qiuyun Liu delivering the plenary address



Project partners at the kick-off meeting in Beijing

Professor Yan of CAAS is the Chinese project leader and he explained that that 0.3 - 1.4 million tonnes of plastic were used across nearly 19 million hectares of land in 2018. This is predicted to increase to 23 million hectares by 2025. However, investigations into plastic

residues in soil have identified contamination levels of 246 kg / hectare. This issue now needs to be tackled with alternative products that will biodegrade in the soil and won't contribute to microplastic contamination. To achieve this aim, the project will work with Chinese suppliers of

National and International Funding

biopolymers and the team will develop a range of new materials that will have enhanced soil biodegradation profiles.

Following the official meeting, the UK delegation visited industrial partner Huasheng in Nantog to look at their

facilities and agree the supply of different biopolymers for the research programme. The project runs to 2022.



UK partners visiting Chinese biopolymer manufacturer Huasheng in Nantog

Successful completion of KTP Associateship with Ligna Wood Co.

KTP Associate Dr Bronia Stefanowski recently celebrated the successful completion of her two-year KTP Associateship with Ligna Wood Company. During the placement Bronia successfully embedded knowledge and new technical methods into the company. At the closing meeting, her progress gained praise from both academic and company supervisors. Many of the achievements

made were additional, i.e. unexpected at the start of the project, and resulted from Bronia's skill in identifying a need and addressing it to provide a solution. Examples included the improvement of data reporting systems and the development of new tests to ensure feedstocks to the company were of the required quality.

Bronia was also responsible for coordinating a set of seminars with invited experts from BC and external sources to provide training to colleagues at Ligna. Data from the project was reported at conferences and is likely to be published in scientific journals during the coming year.



Dr Bronia Stefanowski, with BC's Graham Ormondroyd and Morwenna Spear

The KTP programme allows recent graduates and postgraduates to be placed with a company to address challenges or development opportunities identified by that company, with funding and support from Innovate UK. If you are interested in working with BC and securing a KTP Associate for your company, speak to one of our project managers to find out more.



Developing novel uses for rapeseed, olive, tomato and citrus waste streams

The Pro-Enrich project, supported by the Biobased Industries Joint Undertaking (BBIJU) through the H2020

programme, is investigating approaches to add value to currently underutilised agri-food processing residues, generated in large volumes across the European Union. The feedstocks being studied include rapeseed cake, olive processing residues and fruit and vegetable side streams (tomato and citrus). The aim of the project is to develop



new plant-based functional proteins for food and animal nutrition, along with new products for the cosmetics and biocomposites sectors.

The project is a collaboration between sixteen partners from seven EU member states and brings together a supply chain of feedstock suppliers, technology developers and industrial end-users. It includes two UK project partners: BC and Tate & Lyle, who have a large production facility at Mold in Flintshire.

In 2019 the first processed samples were supplied to the industrial partners for evaluation, and there were two very successful project meetings hosted by Tate & Lyle and Innorenew CoE. A promotional film about the project was made by the Welsh Government and shown at its annual Horizon 2020 meeting in Cardiff as a great example of the 'Stairway to Excellence' approach (used to maximise opportunities from EU regional funding initiatives). A case study about the Pro-Enrich project was also highlighted in the Welsh Government's Horizon 2020 annual report.

New Interreg project funded to develop willow-based biorefineries

Towards the end of 2019, the Centre learnt that a prestigious new project funded through the Interreg programme had been approved. Biowill is a €3.7 million, three-year project led by the University of Limerick and is a collaboration between ten partners across north west Europe, from Ireland, France, Belgium and the UK. Biowill will focus on using an integrated 'zero waste' cascade

biorefinery approach to fractionate and utilise willow to generate a range of products including biobased chemicals and materials, biomethane and natural fertilisers. The Centre will be using its expertise in the processing of agri-forestry residues and biobased packaging to support the project activities which will start in early 2020.



National and International Funding

Advanced monitoring to predict failures in building infrastructures

2019 saw the launch of the Smart Efficient Energy Centre (SEEC) at Bangor University. SEEC is a £7M research centre working across three low carbon energy sectors - ocean energy, nuclear energy, and energy efficient structures. Funded by the European Regional Development Fund and administered through the Welsh Government, the three themes are interconnected by a common cyber-infrastructure hub.

BC leads on one of the major themes, Energy Efficient Structures. The aim of this work package is to develop the capability of buildings to self-predict failures in

their infrastructure through advanced monitoring (using a network of super-accurate sensors), and to develop predictive models integrated into smart computer-based systems. These systems will also incorporate models that predict user well-being and increase environmental efficiency.

The project will develop capability and new research within these key areas and look to collaborate across the university, with other academics and with industry.



Team release new report on wood in UK construction

A team led by BC's Dr Graham Ormondroyd investigated the carbon abatement potential of wood in construction for the Committee on Climate Change (CCC). Their report, *Wood in Construction*, published in February 2019, had been commissioned to contribute data to underpin two CCC reports in this area. The first investigated the best use of biomass in the UK, and the second looked at methods to reduce the whole-life carbon footprint associated with new buildings.

Graham and BC wood expert Dr Morwenna Spear, worked with a team of experts in life cycle analysis (Dr Andrew Norton and Prof Callum Hill) and forest economics (Prof Colin Price) to deliver analysis of the UK forestry sector, UK current and future timber-framed sector, and the rapidly emerging use of cross-laminated timber (CLT).

The CCC's wider report, *Biomass in the Low Carbon Economy*, utilised data from the team's report on the quantities of timber required for different building systems, and the embodied carbon saved by switching from one material to another (e.g. from masonry to timber-framed, or from concrete to CLT-framed structures). This allowed a broader comparison of usage options for timber and other biomass within the UK economy.

In the second CCC report, *UK Housing: Fit for the Future*, data on the embodied carbon associated with timber-framed, masonry, concrete-framed, and CLT dwellings

was matched to similar dwellings in which increased thermal insulation, altered designs and novel energy-saving technologies were deployed. The costs and benefits of different systems and different measures to reduce operational carbon and embodied carbon were compared. This important exercise sought to identify options for further reduction in whole life carbon for the construction sector.

Both documents form part of a wide-ranging review by the CCC considering the UK's progress towards net zero carbon in 2050, and in identifying key issues and challenges to be addressed by future policies in order to achieve this goal.



Seeking sustainability in fast fashion

Sequins are hugely popular for use on clothing across the world and sustainability in the fashion industry has come under the spotlight recently, especially in relation to 'fast fashion'. Sequins are typically made from plastics and, when combined with textiles, add to the burden of unrecycled waste when clothing reaches the end of its useful life.

However, one company is hoping to change that. Rachel Clowes established The Sustainable Sequin Company a year ago to provide the fashion industry with a sustainable alternative. Rachel is currently using recycled plastic to provide off-the-shelf and custom-made sequins of various shapes and sizes. However, her recycled plastic sequins are only the first step towards her goal of developing a compostable sequin which, when used on a biodegradable material, could see the whole garment degrading naturally at end-of-life.

The Centre has been working with Rachel to make truly biodegradable sequins, manufactured from PLA, a biobased plastic, and using only environmentally friendly colouring. The work has led to new colour palettes and sequins that can withstand washing but that still degrade at the end of their fashionable lives.

See Dr Graham Ormondroyd speaking about the collaboration here: <https://youtu.be/PTaeuQqHo8E>



KTP launched to develop new products from fibreboard

The Centre has started a new Knowledge Transfer Project with Sundeala based in Cam near Gloucester. Sundeala make fibreboards which are used for a variety of products such as noticeboards and pinboards. The three-year

project involves a research associate from BC, based at Sundeala, working with company staff to investigate new and innovative products and processes. The project is at an early stage, but good progress has been made with training and testing and a start has been made in setting up a quality assurance and research lab at the company's factory.



People & Awards

Farewell to Gwenda Davies

From working in the pilot plant making MDF from rancid Tetra Pack waste to pulp moulding brewery wastes into new bio packaging materials, Gwenda has seen it all! If there was a tricky problem to solve, Gwenda would find a solution that, more often than not, involved the use and modification of some sort of household appliance such as an iron, a spin dryer or a set of hair straighteners, and all to get the job done. However, after many years Gwenda has opted for voluntary redundancy in a bid to follow her dreams of spending more time travelling with her family.

Gwenda first joined the Centre in 1991 to work in the labs on a range of commercial and research funded projects. Her first official contract specified that Gwenda had to have the skills and knowledge of Quattro Pro and Harvard Graphics. However, Gwenda quickly found her niche was not working with computers but more hands on, first in the pilot plant and then the pulp & paper lab. Here Gwenda's skills in organisation, work-load planning and her attention to detail were well suited to the fast pace of commercial work demanded by the pulp and paper sector. At the time, the Centre was working with major UK producers such as UPM and Kimberley Clark and providing a first-class service to help evaluate their pulps was critical. During this time the industry was switching feedstocks from virgin to recycled pulps and the Centre worked on the initial research that supported the development of de-inking processes using new surfactants and enzymes. Here Gwenda applied

her skills of fibre analysis, handsheet production and paper testing. Providing data on fibre width and length distributions was vital information for the mills to optimise their raw material mixes along with test data on handsheet strength. Working to international standards and ensuring the results were accurate and precise was critical to this role. Gwenda was able to consistently produce high levels of quality test data that the mills then confidently used in their development programmes.

The pulp and paper industry faced a downturn in the mid-2000s and the Centre looked at alternative fibre applications. Gwenda's experience was then put to use working on pulp moulding processes for packaging applications. Gwenda's knowledge and practical experience has helped the Centre develop a new range of packaging materials, from pizza discs to mushroom punnets working on an Innovate UK project linked to the Co-Op. Here the team successfully developed a replacement for expanded polystyrene (EPS) using waste straw that had better strength and improved environmental properties than that of EPS. This project helped to underpin the successful commercialisation of the grass fibre based packaging with the Duchy range of organic eggs for Waitrose.

Everyone would like to thank Gwenda for all her efforts over the years, her dedication to the Centre, her can-do attitude and her ability to come up with novel solutions to solve technical barriers when developing a new process. Thankyou Gwenda and we wish you well!



Laura Brandish – Project Management and Financial Support

I graduated from Bangor with a degree in Psychology and have been working here at BC for the past three and a half years after moving back to the area. I provide project management and financial support across the Centre. I enjoy my role as it is challenging juggling lots of different projects but also rewarding and interesting. It feels good to be working on projects that are helping to provide more environmentally sustainable solutions and networking events to help disseminate those findings. This year I particularly valued being part of the team that delivered the IPPS conference in Llandudno. The months of work beforehand paid off with a fantastic two-day event in October. I am looking forward to furthering my career at BC and appreciate being able to access staff training and Welsh courses within the University.



Amir Kia Ghazvini – Visiting Researcher

I studied for a BSc in Chemical Engineering at Sharif University of Technology in Iran and more recently graduated in Environmental Engineering with a Master's from the University of Bologna. After my MSc I was awarded a grant from the University of Bologna to spend six months working and gaining experience at BC. I have since returned to BC and am now developing my thesis further with the intention of publishing a research paper. My work concerns the exploitation of coffee waste as a potential material for use in green composites, in particular by combining it with PLA, a biobased plastic. During my time at BC I will be performing several new tests on the coffee waste and the finished composites, as well as modifying mechanical properties of the materials by finding the optimum matrix in a cost-effective way.



Arthur Muzvuru – Research Technician

My interests in organic chemistry began at Bangor University, where I worked closely with Dr Al-Dulayymi's group on the synthesis of mycolic acids. Following this, I was interested in how organic chemistry could be applied to issues outside of the lab and this led me to a project analysing microplastics in beach sediment across North Wales. Upon completing my Master's degree in Chemistry in 2019, I began working as a Research Technician at BC. In this role I am currently working on the NASPA project, in which the main goal is to develop a new generation of biofungicides and biostimulants. During this time, I have assisted with several other projects, including extracting keratin from sheep's wool and using supercritical CO₂ as a green chemistry tool. All in all, there is never a dull day at BC!



People & Awards

Bethan Brown – Research Technician

I joined BC as a Research Technician in August following my graduation from Bangor University, where I gained my Master's in Chemistry. I am currently working on a number of projects, but primarily the analysis of squill, a plant native to the Mediterranean, that is being trialled for growth here in Bangor. We aim to use the plant in several different ways, one of which would be a prebiotic component of animal feed.

I am thoroughly enjoying my time at BC. The wide breadth of projects has allowed me to gain a great deal of experience in areas that aren't all that common. The chance to familiarise myself with the use of supercritical CO₂ extraction has been particularly fun as it featured in part of my dissertation, but I never got the chance to experience it practically.



Chris Miles – Materials Research Technician

I joined BC at the beginning of 2019 as a research technician on the Lasercure project, where I provided technical support in the laboratory through to the conclusion of the project in July. The aim of the project was to discover how laser incisions in timber can be used to affect fluid uptake, primarily preservatives and resins. Beyond the Lasercure project I have been assisting in delivering various commercial contracts for BC's Materials group as well as performing other pieces of work such as timber weathering.

I have a degree in Biomedical Science from Brunel University and my employment history has so far been in Food Science and Food Forensics, so working at BC has been an entirely new experience for me. I have particularly enjoyed learning new methods and getting to grips with new pieces of equipment, as well as applying previously acquired skillsets, such as microscopy, to new materials and systems.



Daniel McBirney Hutchinson – Research Technician, Intern

I began working at BC as a Research Intern after graduating from Bangor University with a BSc in Biology with Biotechnology. During my time at the Centre I have been trained in the field of microbiology in order to conduct research into the antimicrobial properties of plant extracts, as part of the UK / Malaysia SafeBioPack project. This aims to create sustainable packaging for food with natural antimicrobial properties. I am currently testing the antimicrobial properties of sage extract and its abilities to inhibit the growth of *Staphylococcus aureus* and *Escherichia coli*. This area of research has been of significant interest to me, as a microbiologist and an environmentalist, and I look forward to continuing this research to create sustainable food packaging.



Sean Baxter – Materials Research Technician

I am currently working at BC as a materials research technician on the ZEWAMFI (Mulch Films) project, where we are developing new biodegradable mulch films alongside partners for the Chinese market. As part of this I attended the MPG 'Plastics and the Environment' conference. I have been lucky enough to receive training on a host of instruments and techniques which I have been able to make use of when fulfilling project tasks and helping with BC's commercial projects.

I have an MChem degree from the University of Wales, Bangor and a PGCE from Bangor University. I was previously working as a part time Senior Demonstrator, teaching within the undergraduate chemistry laboratories, whilst completing PhD research into the properties and uses of noble metal and metal alloy nanomaterials generated at the interface of oil and water. I am currently completing my doctoral thesis.



Plant fungi group recognised for extraordinary contribution to field mycology

BC technician Debbie Evans is part of a team of five amateur mycologists known as “The Welsh Rust Group”, who have been awarded the British Mycological Society’s Field Mycology Award “in recognition of an extraordinary contribution to the advancement of field mycology”. It is only the second time the award has been given and was presented to group members at a BMS event in Porth Talbot in October. The group have a passion for some of the plant-pathogenic fungi, which are mainly (but not solely) found on wild plants. They have written three books about these fungi in Wales, most recently “The Powdery Mildews of Wales: An identification guide and census catalogue” in 2019. They are currently preparing a book on the Downy Mildews and Albugos.

The main aim of the group is to increase the awareness of the importance of these fungi and encourage their identification and recording in Wales and beyond, by providing easily accessible, free or affordable books.

The books are also all available to download freely from <https://www.aber.ac.uk/waxcap/links/index.shtml> (listed under the first author, Woods, R.G.).

At the event, the group received certificates and a monetary prize of £500 which will be used towards future publishing costs.



Joint PhD student with the Department of Forest Production and Products, University of Ibadan, Nigeria

This year the Centre’s materials group welcomed Adewunmi Adenaiya as a joint PhD student funded by the Commonwealth Office. Wunmi is studying the effects of bio-incising on timbers native to his home country of Nigeria. The work has led to new developments in the treatment of timber that would be suited to a low-carbon economy.

Alongside his doctorate, Wunmi is an Assistant Lecturer at the University of Ibadan. His research interest is principally in the area of wood preservation, with a major focus on developing green and sustainable solutions to wood preservation. He holds a Master’s degree in Wood and Fibre Science from the University of Ibadan and a Master’s in Environmental Assessment and Management from the University of East Anglia. Wunmi will return to



Nigeria in 2020 to complete his studies but will still work as an active member of BC’s materials group.

People & Awards



Secondment of chemistry researcher to Centre for Environmental Biotechnology

BC Chemistry researcher Dr Olga Tverezovskaya has been seconded to the new Centre for Environmental Biotechnology (CEB) within Bangor University's School of Natural Sciences.

Olga obtained her PhD in Chemistry from Moscow State University and has been working at BC since 2002. She is a PRINCE2 Project Manager with a wealth of experience managing Innovate UK, EU and WEFO funded research projects. Past specializations include the development of biopolymers from waste biomass streams, investigations into antimicrobial efficacy, and the development of extraction processes and applications for chitosan and its derivatives. One of the outcomes of the chitosan work is currently under consideration for patenting in the agricultural sector.

"Throughout of my career at BC, I have been able to gain skills and valuable experience in project management and this has allowed me to be seconded as a project manager to the Centre for Environmental Biotechnology. This £7.8 million ERDF-WEFO and BU co-funded project is a leading research division within the School of Natural Sciences" explained Olga. "Working 50% of my time at BC and 50% at CEB helps me to facilitate joint research between different Schools" she added.

Networks & Committees

Head of Materials appointed as Chair of the Wood Technology Society

December 2018 saw Dr Graham Ormondroyd take over as the chair of the Wood Technology Society, formerly the Institute of Wood Science. The Society is a division of the Institute of Materials, Minerals and Mining and is the professional body for the timber and allied industries. It aims to promote and encourage a better understanding of timber, wood-based materials and associated timber processes.

Over the past year the WTS has co-hosted the Timber 2019 conference with BC and a number of other events, including seminars and school 'have a go' events. Graham said 'It is a great honour to follow so many memorable names from both industry and academia as Chair of the Wood Technology Society and it is great to have some of those names still sat on the board. It is the board that make the society function and I am privileged that they are so capable and willing to work towards our common goals of improving the understanding of timber and timber products'.

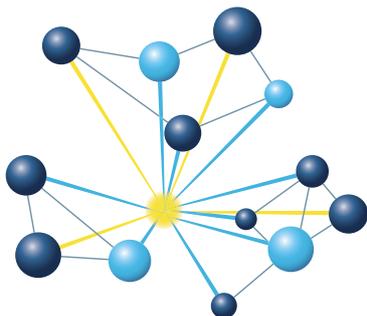
Graham is joined on the board by fellow BC members of staff Dr Morwenna Spear (as Vice-chair) and Dr Bronia Stefanowski (as Social Media champion).



The Wood Technology Society
A Division of the Institute of Materials, Minerals and Mining

Interregional cooperation on innovative use of non-food biomass

The Vanguard Initiative is a network of European regions that are dedicated to advancing industrial innovation in Europe. Based on the unique strengths of each region, the initiative encourages co-operation to create platforms for businesses, clusters and knowledge institutions that will join forces to find new innovative approaches. The initiative is currently focusing on inter-regional projects in five thematic areas and one of these is the bioeconomy.



VANGUARD INITIATIVE
New growth through smart specialisation

The initiative recognises that the bioeconomy is a huge opportunity, however market penetration of innovative biobased products is slow. A key issue for the sector is the scale-up of production processes and this barrier is hindering development. To help overcome this barrier, BC is playing a leading role in the co-ordination and development of demonstration projects linked to the bioeconomy that will bring benefits to Wales.

The bioeconomy initiative has identified six core areas of interest that are called demonstration cases. These are 1) bio-aromatics; 2) turning (waste) gas into value; 3) biogas beyond energy production; 4) bio-aviation fuel; 5) food & feed ingredients from agrofood waste; and 6) food & feed ingredients from algae.

"We are interested in three of these demonstration cases," explains BC's Dr Rob Elias, "these are lignocellulosic, aromatics and agrofood wastes. These three areas compliment projects here in Wales. Through the Vanguard Initiative we will be able to share and learn about best practice that can hopefully speed up closing the production gap and led to new investment opportunities".

Networks & Committees



BC's pilotscale processing equipment is key to the Initiative's development projects



The Vanguard Initiative is also co-operating with the Bio-Based Industry Joint Undertaking (BBI JU). The BBI JU supports industrial research and innovation by providing funding to bridge the gap from research to the marketplace – the so-called innovation ‘valley of death’. This is done by encouraging partnership with the private sector and bringing together resources that are needed to address the challenges of commercialising major society-changing disruptive technologies.

The Centre is already active with the BBI JU through a collaborative project called ProEnrich, managed by Dr Adam Charlton (see page 13). In that project we are scaling up protein fractionation using our pilot scale facilities. “This is a great example of a joined-up strategy working within our region” explained Rob.

Training and evaluating the next generation of European scientists

In addition to training and supervising our own Master's and PhD students, BC staff are also invited to evaluate and examine the work of students from both home and overseas institutions.

Dr Simon Curling was invited to the Norwegian University of Life Sciences in Ås, Norway to act as an opponent for Solrun Karlsen Lie in the defence of her PhD thesis, 'Surface mould growth as a contributor to visual changes of exterior wooden claddings'.

Similarly, Dr Graham Ormondroyd was invited to the Linnaeus University in Sweden to act as an opponent for Venla Hemmila in the defence of her thesis, 'Towards low-emitting and sustainable particle and fibreboards'. Graham was also invited to Sheffield University to examine Stella Manoli on her thesis, 'The effects of processing on performance and utility in plant fibre-based composites'.

We are pleased to say all three passed and we wish them every success in their future careers.

Back in Bangor, BC's Materials group hosted two undergraduate interns from the University of Paris in summer 2019. The internships act as part of their degree course and are evaluated as part of their studies. Working with researchers in this way is an excellent opportunity to help develop new scientists and get the sustainable materials message promoted.

Anh Van Nguyen was investigating in addition of miscanthus fibres to bioplastics to create a fibre-reinforced plastic composite for use in transport pallets. During her time in Bangor she was able to use the bioplastic extrusion facilities here at the Centre. Her work suggested



PhD's by Venla Hemmila and Solrun Karlsen Lie, evaluated by members of our materials team

that the fibre-reinforced plastic composites could be used in logistical applications.

Remi Roussel was also researching bioplastics but was looking at adding colour to the material. The aim was to formulate a brightly coloured but biodegradable material that could be used to produce the base for sequins – used widely in the fashion industry. This work linked in with another BC project, this time with the Sustainable Sequin Company, who are aiming to replace current sequins with a more sustainable alternative (see page 15).

Events

UK-Uganda workshops promote bioeconomy collaboration

In June the Centre hosted a UK-Uganda bioeconomy workshop in Bangor, with funding support from an ESRC Impact Acceleration Account. The event was attended by over fifty stakeholders from a range of organisations, including the Ugandan High Commission, the National Agricultural Research Organisation (NARO, Uganda), Ugandan Industrial Research Institute, Makerere University, UK Department for Trade and Industry, Welsh Government, Innovate UK, the United Nations, and academic colleagues from Bangor University.



BC's Dr Adam Charlton initiates the proceedings

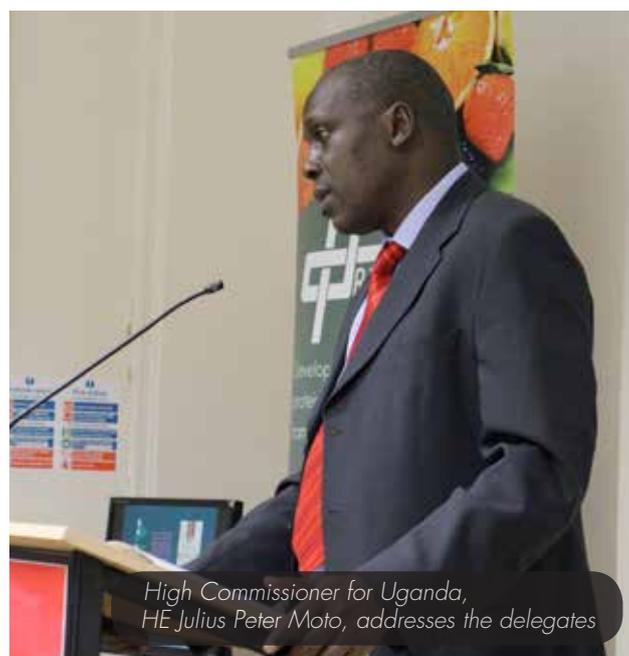
their time here. These included Henfaes Research Centre, Pontio Innovation, Treborth Botanic Garden, Menai Science Park (M-Sparc), and BC's pilot-scale processing facilities on Anglesey. In addition to this, several innovative local companies with strong research links to Bangor University, including Pennotec, Halen Môn and South Caernarfon Creameries, hosted the Ugandan delegation, which rounded off a very successful week.

A reciprocal workshop was hosted by Makerere University and NARO (at their National Crops Resources Research Institute, Namulonge) in July. This was an opportunity to showcase ongoing research linked to the bioeconomy, and the industrial collaboration taking

The aim of the day was to explore a number of themes linked to the bioeconomy, including:

- Understanding more about agricultural research and how it leads to economic development through industrial collaboration
- Technology transfer from the UK to Uganda to add value to agricultural wastes and co-products
- Approaches used by Ugandan, Welsh, and UK governments to provide support for research and innovation in this sector

Delegates from Uganda were hosted in the UK for five days and were able to visit a number of key sites during



High Commissioner for Uganda, HE Julius Peter Moto, addresses the delegates

place in Uganda that is linked to Bangor University. The remainder of the week involved a series of site visits to research organisations and companies, and meetings with a range of organisations (NARO, UIRI, DIT, UNIDO, Private Sector Foundation, and Makerere and Kyambogo Universities) in order to help provide focus for areas of future collaboration.

Following both workshops, a series of Memoranda of Understanding were signed by Bangor University and key Ugandan partner organisations and joint R&I projects are now being developed.



Delegates outside the University's Reichel venue



In Uganda, Adam with Dr Andy Goodman (Director of Pontio Innovation) with project partners and delegates

Events

IPPS marks Centre's 30th anniversary

October 2019 saw IPPS, an annual event organised by BC, return to The Imperial Hotel in Llandudno where the symposium was first held in 1997. The aim of that first conference was "to encourage the exchange of findings in both technological and fundamental research, to keep our industry as well informed and competitive as possible, and to ensure that fundamental research is industrially relevant". Over 20 years later this is still the key aim of the event today.

BC Director Dr Rob Elias opened the event with a very quick summary of the Centres' impressive achievements over the last 30 years in the area of panel products. These include helping to improve panel durability, decay and fire resistance and using our pilot plant to process alternative raw materials to wood. We have also worked closely with UK and EU governments to promote recycling in the sector, which led the way in early research on the use of waste co-products to manufacture particleboard – which is now the industry standard in the UK.

The keynote speech by Marcus Vroege looked at where future feedstocks for the global wood panels industry are going to come from. Forest resources worldwide are

under increasing pressure, with ever increasing demand from existing and emerging sectors. While increased forest cover is desirable, this has to be matched with other land use demands such as food provision. Existing industries will need to do more with their raw materials, reduce wastage during production, make products more durable and look carefully at recycling options. There are lots of challenges ahead for the industry and BC is well placed to support the transition to a more resource efficient future.

BC staff were well represented on the conference programme. Dr Dave Preskett gave a talk about extracting high value chemicals from Sitka spruce bark, which is usually destined for use as a low-value horticultural mulch or compost - and using them to make a plywood resin. Dr Morwenna Spear summarised a large piece of work looking at the embodied carbon of wood-based products in the construction sector (see page 14).

Important networking opportunities were provided for symposium delegates, with posters as well as company trade stands on show over the two days. The gala dinner was an opportunity to celebrate the Centre's 30th anniversary and also a chance to pay tribute to some of the people who have been part of IPPS' continuing success story over the years.



BC's IPPS organising team



WoodBUILD 2019 focus of forestry and timber expertise at Bangor

Closer collaboration with Woodknowledge Wales (WKW), forged via BC staff member Ceri Loxton who has been on secondment there since 2016, took another step forward when WKW held their annual conference here in Bangor.

The WoodBUILD 2019 conference took place at the Reichel conference centre in June. “I organise events all over Wales but love working with the conference team here at Bangor University” said Ceri. “The service is very professional, the food is great, there is ample parking for delegates, staff are friendly and there was fantastic IT support.”

The event attracted over 100 delegates from Wales and the UK to debate how Wales can become a high value forest nation. Professor John Healey from the University’s School of Natural Sciences gave an overview of Welsh forestry and its potential for expansion, highlighting land as Wales’ greatest asset. BC’s Graham Ormondroyd went on to highlight a number of recent Welsh-based research projects, covering a wide range of subjects including the heat treatment of timber, resin modification, the conversion of Sitka spruce into blanks for CLT (cross laminated timber) production, and the use of lasers to increase permeability of timber as an aid to treatment options.

Eilidh Forster, a PhD student at Bangor who is supervised by Professor Healey and part funded by WKW, showcased the first version of an infographic she is developing to visualise carbon capture in trees and its subsequent storage in houses. Her work has compared two different build types - a timber frame with a brick façade and a traditional brick and block build – and demonstrated a 20% reduction in the embedded carbon footprint of a typical semi-detached house built with a timber frame, versus that from brick and block.

Gary Newman, Chief Executive of WKW, said after the event “Next year the conference will return to south Wales but following the success of running it at Bangor University we plan to switch the conference annually between the north and south - so we look forward to being back in Bangor in 2021. Having Ceri on secondment from the University just made everything run that little bit smoother.”



Eilidh Forster, BU PhD student, showcases her work

Events

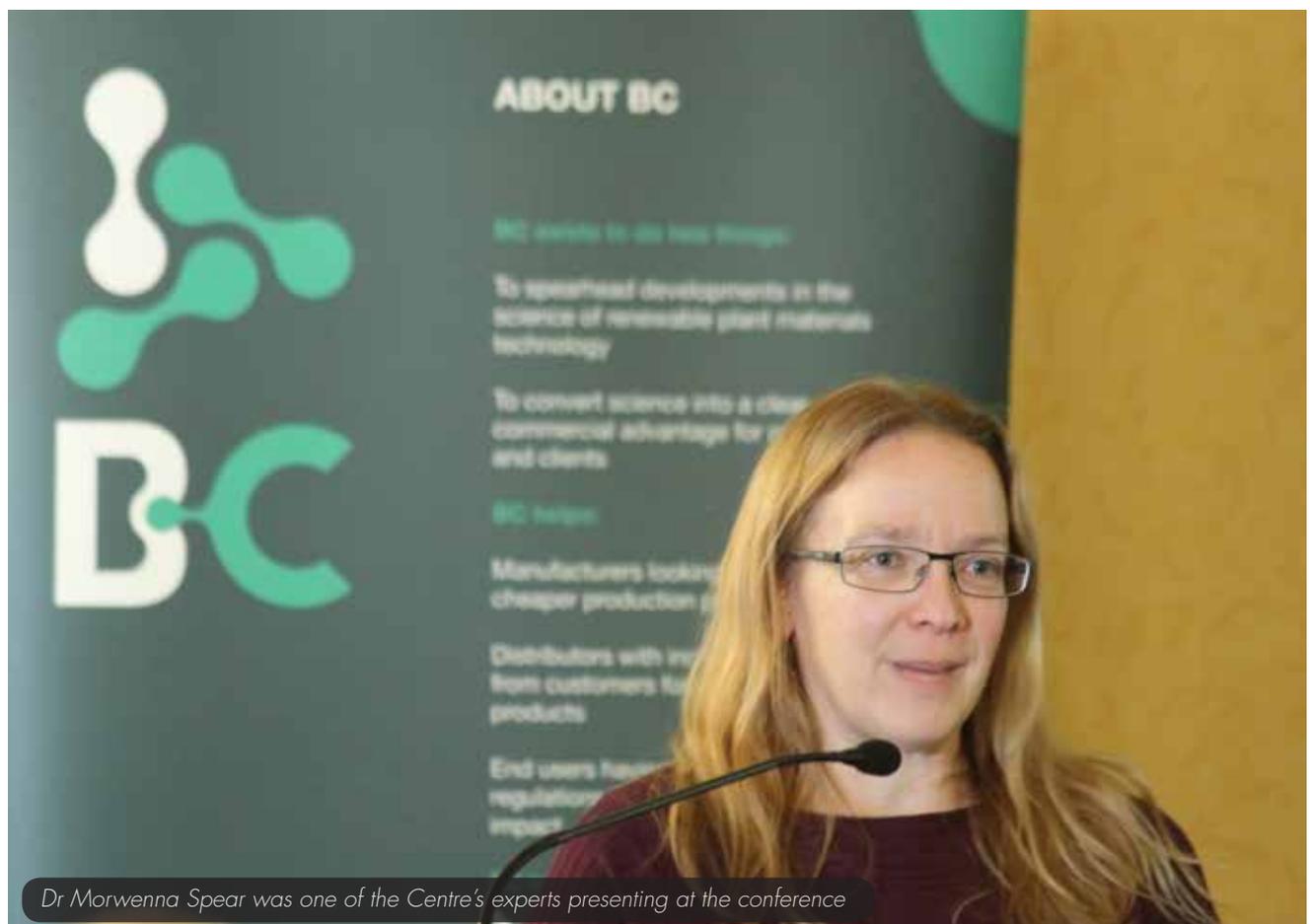
Strong presence for BC staff at Timber 2019

The Centre was well-represented at the Wood Technology Society's (WTS) annual Timber 2019 conference in London this July. Two presentations from the LaserCure project, one on thermally modified wood and a presentation on resin treatment by KTP Associate, Dr Bronia Stefanowski were all well received.

Dr Graham Ormondroyd, the chair of the WTS board, welcomed delegates to the event, and ensured a steady stream of social media vlogs during the event. Dr Martin Ansell (Bath University) gave an excellent keynote address highlighting a host of timber-related research to indicate the future trends and possibilities, whether in new modification systems or the use of artificial intelligence to detect wood boring insects. There was plenty of opportunity for questions and discussion with speakers during the event, giving a great atmosphere and plenty of food for thought.

Presentations by Graham and Dr Morwenna Spear covered the laser technology of incising timber; these reported novel experiments to investigate the fluid flow and drying rates within incised timber. Two further BC presentations addressed weathering. Morwenna reported on four years of service of thermally treated larch timber, and in the other Bronia presented data from exterior weathering trials on Lignia timber, a resin modified Radiata pine produced by Lignia Wood Company. The exterior exposed timber was compared with timber exposed to accelerated weathering, with both showing promising results.

Delegates had travelled from around the world to participate in the two-day event. The conference covered the latest research into wood composites, timber preservation, new analytical methods, and up to date challenges facing the industry, such as education and the role of timber in the circular economy.



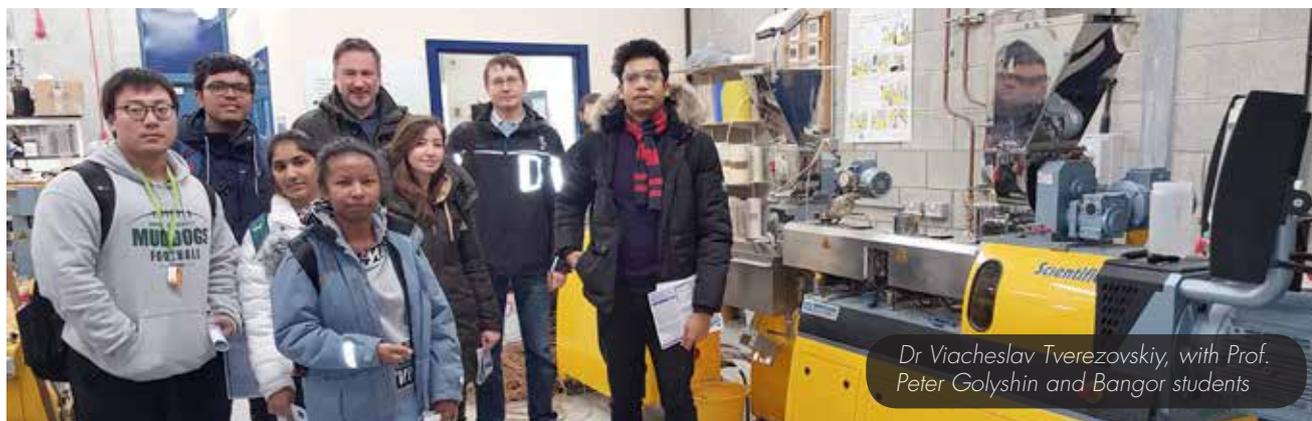
Dr Morwenna Spear was one of the Centre's experts presenting at the conference

Biotechnology students visit our Technology Transfer Centre on Anglesey

In November, Dr Viacheslav Tverezovskiy and Professor Peter Golyshin (Director of the Centre for Environmental Biotechnology at Bangor University) organised a field trip for biology students to BC's Technology Transfer Centre

on Anglesey. The students were introduced to the scale-up facilities by Viacheslav and the Centre's Senior Process Engineer, Llion Williams.

Learning about our pilot-scale equipment and its applicability to bio-transformations gives a great introduction to industrial practice for students interested in biotechnology.



Dr Viacheslav Tverezovskiy, with Prof. Peter Golyshin and Bangor students

Functional food tasting at Festival of Discovery, Wales

The Centre has been collaborating with Jonathan Hughes, Director of Pennotec (Pennog Ltd), and his team for a number of years. Located on the Lleyn Peninsula in North West Wales, the company provides advice and technology that helps business owners and operators convert manufacturing waste into marketable resources.



In collaboration with BC, Pennotec has successfully developed a new functional dietary fibre, derived from apple pomace, which is a co-product of the drinks sector. With the support of the Food Technology Centre, Coleg Menai and local food manufacturers, the apple derived functional fibre can be incorporated into a range of foods from sausages to cakes and desserts, in order to lower their fat and sugar content. This can hopefully help reduce obesity in Wales, which is an increasing problem for children from reception-class age.

In May 2019, Pennotec and BC had a stand at the Festival of Discovery, Wales. This was a three-day event

held at the Mona Show Ground on Anglesey, designed to showcase the latest in science, technology and engineering. The event hosted thousands of people and we were able to demonstrate the functional fibre product and the science behind it to members of the public, along with giving them a taste of foods containing it.

Pennotec was short-listed as an area finalist for Wales in the 2019 Federation of Small Businesses (FSB) awards (in the Business and Product Innovation category) for the work conducted on the development of the new functional food fibre.



Members of the public were able to sample functional fibre-containing foods at the Pennotec stand

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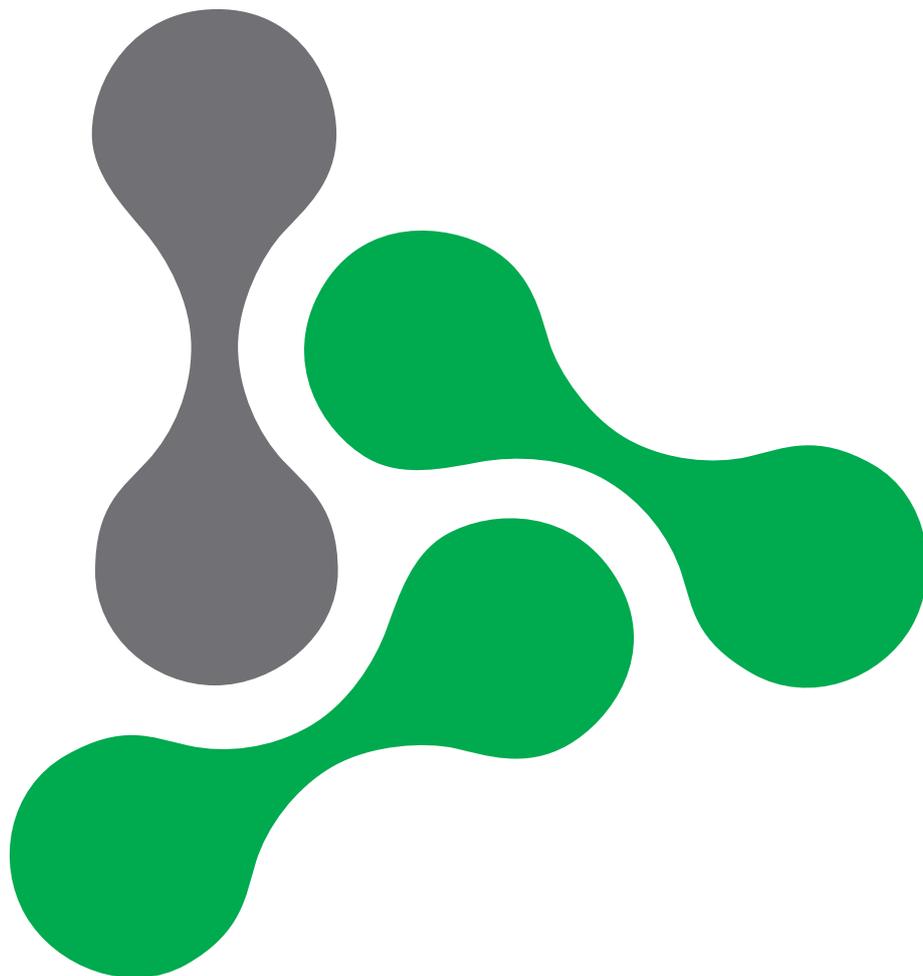
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