The BioComposites Centre
ANNUAL REPORT 2016

PRIFYSGOL
BANGOR
UNIVERSITY

The BioComposites Centre
Alun Roberts Building, Bangor University,
Bangor, Gwynedd LL57 2UW

Tel: 01248 370588
E-mail: bc@bangor.ac.uk
Website: www.bc.bangor.ac.uk
Twitter: @bcbangor

BEACON
From plants to products
O blanhigion i gynhyrchion

Llywodraeth Cymru
Welsh Government

ERDF
Llywodraeth Cymru
Welsh Government
Ewrop & Chymru: Buddsoddi yn eich dyfodol
Cronfa Datblygu Rhanbarthol Ewrop
Europe & Wales: Investing in your future
European Regional Development Fund

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Annual Report 2016

Welcome

This 2015/2016 financial year has been defined by the uncertainty regarding the EU referendum. However, our strategic aim remains focused on building stronger partnerships with Europe and gaining H2020 funding. To achieve this we have raised awareness of our expertise and facilities in many EU networks. The Welsh Government 'Supporting Collaborative Research and innovation in Europe' (SCORE) fund has helped to support this activity. Using SCORE funding we have attended important information days and networking events. We have also worked closely with the Welsh Higher Education Brussels office to help raise our profile in Europe. As a result we have continued to submit bids and are being invited to join consortia because of our proven track record and specialist facilities.

This year we were nomination for an EU Life project award. The project looked at the conversion of bakery waste into lactic acid for bioplastic packaging (Bread4PLA). The BioComposites Centre (BC) undertook the scale up of the technology to multi kilo batches and as a result it was shortlisted as a best EU Life Environment Project.

This year research funding through Innovate UK is building on our work to develop natural compounds with antibacterial performance. The challenges faced by society to develop new antibacterial compounds is significant and we hope our research can develop some innovative solutions that can be applied in the food packaging sector.

Our backbone project BEACON+ continues to deliver company assists and research for Wales. The ERDF funded collaboration between Aberystwyth, Bangor and Swansea works closely with Welsh companies to develop innovative bio-based technologies. A key highlight this year for the Centre is the successful spin out of our CO_2 lab into the newly formed joint venture company called Suprex Ltd. This company formed in June, is based in Caernarfon and will contribute to our targets for creating new companies.

Dr Rob Elias: Director

Challenges in 2016/17 certainly lie ahead for us all, but great opportunities for the bio and circular economies are emerging to the forefront in a world facing increasing competition for resources. Working together using our excellent facilities and talented staff we will continue to collaborate with businesses to develop novel and innovative technologies in these sectors.

Table 1. Staff numbers for 2015/16

Staff Category	
Research Staff	18
Technicians	7
Administration & Finance	4
PhD Students	4

National and UK Funding

Pole position for novel wood lamination process

Project: Pollywood

Dr Simon Curling is helping develop a novel alternative to the solid wooden telegraph pole used for electricity distribution. Use of the traditional poles is coming under legal and environmental pressure because of the need to treat them with harmful chemical preservatives. One company, Pollywood Ltd, has developed a promising alternative using a laminated wood and a hollow design. Their solution has the added benefit of using less material and being much lighter to transport.

Simon's role is to test the strength and durability of test materials made by Pollywood. "Transmission poles have to have long lives in a wide range of conditions including extremes of heat/cold, rain and biological attack. I am looking at the adhesives used in the lamination process and testing the prototype products to assess their strength and durability to microbes. At the end of the project we hope to have an optimum idea of the best materials for the job," explains Simon.

This project is funded through an Innovate UK Feasibility Competition focusing on 'Materials for Demanding Environments'. Results will help underpin the future development of the product and hope to enable Pollywood to attract further investment.

Multifunctional coatings for packaging

Project: SAB-Coat

Innovate UK funded Synergetic AntiBacterial Coatings Solutions (SAB-Coat) project will improve the safety and shelf life of chicken meat products. The aim of the project is to develop new antimicrobial coatings for packaging solutions that will increase quality, shelf life and safety of chicken meat and chicken meat products.

Food poisoning in the UK represents a major challenge to the UK economy and the National Health Service. This project aims to reduce foodborne illness, which affects around 1 million people per year, costing the UK economy of over £1.5 bn.

The coating solution, developed in the SAB-Coat project, will have multiple activity against a wide microbial spectrum, even at low temperatures typical of the fresh meat sector. Innovative materials will be designed for use in Modified Atmosphere Packaging (MAP) trays, soaker pads or sealing foils in contact with poultry products.

Antibacterial packaging to improve food safety

Project: AC-Bit

A second Innovate UK funded project, Anti-Campylobacter Biofilm Technology (AC-Bit), is also related to antibacterial packaging. BC is working with partners to look at how natural compounds can be used to reduce the risk of disease associated with packaged raw food products, such a chicken.

Dr Radek Braganca explains, "Many of these pathogens generate biofilms as a protective coating. If we want to inhibit the growth of the pathogens, we must first target the biofilms in order to reach the pathogen itself. This is why some types of microbes are more difficult to control than others. We are looking at a range of natural compounds and assessing their ability to destroy these biofilms when we have coated them onto the surface of the packaging."

Coating performance is assessed using techniques like contact angle measurement. This gives us an idea of how well modified the surface is after treatment.

This work will help to underpin future research on the design of anti-biofilm products for the food packaging industry. The new packaging technology will be based on the use of the concept of active packaging (AP), recently approved by EU regulations. AP is a packaging that may interact with food, (in our case via a coating) to improve shelf life, maintaining or improving quality of food and therefore reducing spoilage and its pathogenic causative agents.

National and UK Funding

Developing healthy low carbon buildings

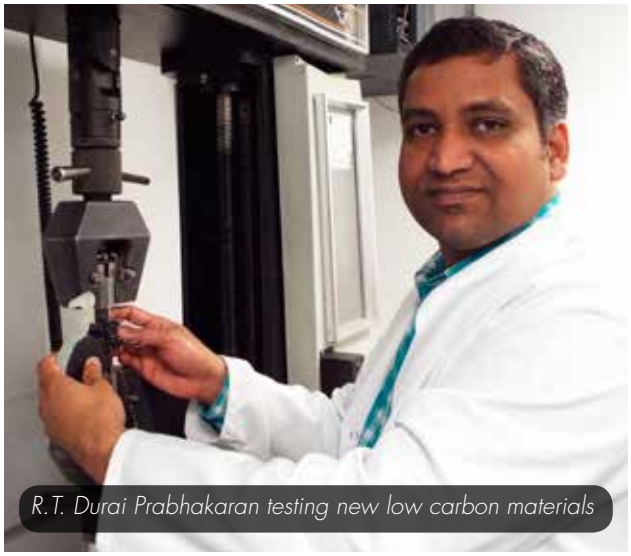
Project: NRN-LCEE cluster

The Sêr Cymru National Research Network for Low Carbon, Energy and the Environment (NRN-LCEE) Research Cluster 'Plants and Architecture' is an on-going collaboration between Bangor, Aberystwyth and Cardiff Universities.

The research cluster has identified five focus areas to work on over the course of the project. These areas are: Green Infrastructure, Urban Climate Modelling, Plant Form and Function, Bio-derived Materials and Urban Agriculture.

Research fellow Dr R.T. Durai Prabhakaran, based at BC, has been developing new panel systems using low carbon materials from plant fibres and polymers. These can be beneficial to the construction industry for use in improving indoor air quality and developing better insulation properties.

The cluster has led to new inter-university research between BC and the Institute of Biological, Environmental and Rural Studies (IBERS) at Aberystwyth University working jointly on 'Miscanthus plant fibres as building material'. This work aims to optimize plant physiology and develop miscanthus material as a high performance building product.



R.T. Durai Prabhakaran testing new low carbon materials

Dr Graham Ormondroyd explains, "The challenges faced by the cluster are not just technical. Whilst we can create a built environment that is both biobased and good for the well-being of the inhabitants, its acceptance in every day society is the key challenge faced by the cluster."

Work undertaken within the cluster, over the past year, has led to a number of publications. Grant proposals have been submitted to continue the work of cluster beyond the current funding period.

High value chemicals and bioresins from algae

Project: Bisigodos

This year has seen a lot of activity as the Framework 7 project BISIGODOS enters its final phase. The EU consortium aim is to develop value added applications from algae biomass grown in specialist reactors. In April Dr Rob Elias and Dr Ahmad Al-Dulayymi gathered with project partners in Orléans, France to review progress three years into this four year project.

Dr Ahmad Al-Dulayymi is leading the technical work to develop bio-based compounds for applications such as coatings, inks and cosmetics. Ahmad's role is to take the fractionated algae based pre-cursors from the bio oil and functionalise these compounds for industrial applications. "This year we have seen some major breakthroughs as some of the compounds developed are performing well in their tests. Work with our UK partner Becker, in Liverpool, on the development of compounds for anti-corrosive coatings is looking extremely promising," explains Ahmad.

At the meeting, a workshop with a focus on the technology and optimisation used to develop the photo reactors where the algae is grown, was held. The open workshop, hosted by French partners CASPEO, was well attended with guests from all over the EU. Presentations explained how biomass production could be optimised through the design and location of bioreactors. Of special interest were the mathematical models used to explain and predict biomass production in relation to sun direction.

BEACON+ Biorefining project overview

From plants to products
O blanhigion i gynhyrchion

BEACON + is led by Aberystwyth University in collaboration with partners at Bangor and Swansea Universities. It is backed with £10.6 million from the European Regional Development Fund (ERDF) through the Welsh Government. The Finance and Government Business Minister for Wales, Jane Hutt, announced that the successful project could continue into the second phase in December 2015.

The BEACON project facilitates collaborative research between industry and science in the development and commercialization of new sustainable green products. The scientific and technical expertise and facilities within BEACON helps Welsh businesses develop new ways of converting biomass crops such as rye grass, oats and Miscanthus (Asian elephant grass) into products. The project aims to create over 100 new products or processes in partnership with businesses over the next four years.

Companies can access pilot-scale equipment to undertake trials to de-risk the commercialisation and scale-up of innovative bio-based products and processes and also demonstrate their commercial viability. There are also opportunities to maximise value from waste and identify high value by-products for diversification into new income streams. Such products have the potential to feed into a wide range of commercial applications in the construction, health & food, nutraceutical, pharmaceutical, chemicals, fuel and cosmetic industries.

The Biorefining Technology Transfer Centre

The Biorefining Technology Transfer Centre (BTTC) at Bangor University's BioComposites Centre is a scale-up and product development facility where applied science is turned into market leading, innovative new products.

The BTTC focuses on aspects of biorefining (including biomass fractionation and extraction) and is staffed by specialists with a wealth of knowledge in the use of biomaterials in functional, practical applications. This purpose-built industrial unit on Anglesey operates as a proving ground for the commercial viability of new technologies before their final release to market. It is a dedicated facility for the promotion and development of novel materials and chemicals of benefit to the low carbon economy.

Launch of Beacon +

BEACON + *Show case company: Natural UK*

The Nappi-Cycle division of Natural UK uses an innovative hydro-recovery process to separate the plastics and cellulose material from used absorbent hygiene products (AHP) (e.g. nappies and adult incontinence pads). The absorbent part of the pads contain rayon made from wood pulp or cotton, a naturally occurring cellulose based raw material. The processing produces a clean and hygienic fibre fraction that can be used for new product development. This 'closed loop' offensive waste treatment and recovery system offers the potential for the company to achieve significant environmental benefits by moving towards zero landfill.

The company are currently processing several thousand tons of waste AHP material, resulting in a significant tonnage of recovered waste. They are expanding their nappy waste collection service in South Wales, to include East and North Wales and plan to develop a second processing line in Ammanford. In view of this expansion, BEACON + worked with Nappi-Cycle to scope opportunities for new markets and applications for the cellulose fibre waste stream and add value to the company.

Recycling absorbent hygiene products (AHP)

These included:

(i) Develop a prototype Medium-Density fibreboard (MDF) range of boards using the cellulose fibre fraction and undertake mechanical testing to evaluate the potential for construction applications

(ii) Develop a product to absorb industrial liquid spills – the cellulose fraction has "high absorbency" potential as a product to gather oil spills for instance.

(iii) Develop an acoustic/insulation board – suitability of cellulose fibre properties for these applications to be evaluated

(iv) Develop pulp moulded – single use products for the healthcare sector.

The first R&D project focused on the production and evaluation of MDF boards, using pilot facilities at BC. The initial response to the sample boards has been positive and potential development partners are showing interest. The feedback was that the boards looked more engineered and robust compared to the boards the company had made from another source. BEACON + will continue to support the company to develop products from their fibre waste stream.


Recycled AHP fibre mat before pressing


Recycled AHP fibre mat in the press

BEACON + ***Show case company: International Gums and Oils Ltd***

INTERNATIONAL GUMS & OILS LIMITED

BEACON + is working with International Gums and Oils Ltd (IGO) to identify high value extracts and formulate compounds for the health and beauty industry. IGO is a plant product company that supplies raw materials and their extracts to the nutraceutical, fragrance and cosmetics industries. The company currently imports premium botanical compounds, including frankincense, myrrh and sida/qasil from Asia, Somalia, Ethiopia and Oman.

It is well known that certain plants contain naturally occurring biochemical compounds with antiretroviral, antimalarial and anti-inflammatory properties. There are many still to be discovered. BEACON + initially assisted IGO by reviewing the literature surrounding a particular plant extract to better understand its benefits for the health and beauty industry. IGO are interested in extracting and formulating this extract and related compounds into facemasks and skin cleansers.

Following the initial assistance, work with BEACON + has progressed to a collaborative R&D project focusing on the compound extraction. This will focus initially on the extraction of saponins from leafy plant material supplied by the company. Ethanolic extraction and purification (crystallization or flash chromatography) at laboratory scale will be followed by scale-up using two 50 litre extraction vessels available at BC's BTTC on Anglesey. In parallel, accelerated solvent extraction (ASE) will be used to try to optimise the yield of the target chemical compound extracted to screen the leafy material for any other value added molecules.

Dr Ahmed Ali the CEO and cofounder of IGO is an honorary research fellow at Cardiff University's School of Biosciences. He has served for 12 years as an analytical /pharmaceutical chemist in the UK pharmaceutical industry and a further 15 years as the research director of a Welsh SME company. To-date he has co-authored five international patents based on African and Asian plants.

Ahmed said, "Working with BEACON + has enabled our company to use alternative techniques and larger scale equipment to extract the high value compounds we are interested in. We are keen to continue collaborating to investigate the presence of other high value biochemicals that can be extracted from other plant sources including fruits and seeds."

Frankincense trees growing in Africa

BEACON+ Showcase company: Pennotec

Pennotec is a Welsh SME and a long history of active collaboration with BC. The company develops technologies to convert manufacturing waste into marketable resources, using the concept of biorefining and biotechnology to develop the circular economy.

This year we carried out a number of collaborative research projects with the company. Biologically active polymers, produced by bacteria, were isolated and characterised as a part of BEACON+. We also investigated the use of marine waste (prawn and crab shells) to remove fine particles of phosphorus from waste water in a project funded by SBRI (Small Business Research Initiative).

Dr Jonathan Hughes, MD of Pennotec commented, "With access to BC's specialist facilities and expert support, Pennotec has been able to develop innovative processes that add value to waste and better understand the nature of the bio-materials we produce."

Pennotec and BC received funding from BBSRC network FoodWasteNet for another 'proof of concept' research project. "We have formed great cooperative research links with Pennotec. In this new project we aim to investigate applications of industrial biotechnology processes for extractions of antimicrobial polysaccharide from agricultural waste," explains BC Project Manager Dr Olga Tverezovskaya.

BioPilots UK: a new UK alliance of pilot scale biorefining facilities

BC, through the BEACON project, has been instrumental in helping to set up a new UK alliance of open-access biorefining centres called BioPilots UK. The alliance will work collaboratively with UK industry to help develop the biobased economy and will foster greater interactions between the different centres within the Alliance, through joint research projects. In order to be a member of the new group, potential partners need to be industry facing, open access and have pilot scale equipment that operates at a Technology Readiness Level of 4 or greater.

The alliance will be officially launched in October 2016 at the European Federation of Industrial Biotechnology annual conference in Glasgow. The current membership consists of the Industrial Biotechnology Innovation Centre (Scotland), Institute of Food Research (Norwich), Biorenewables Development Centre (York), Centre for Process Innovation (Wilton) and BEACON, which is an award-winning partnership between Aberystwyth, Bangor and Swansea Universities.

Novel fire resistant composite material for trains, tracks and buses.

In 2012, the BRIGIT project, funded by the European Commission within the Seventh Framework Programme, set out to develop high-tech fire resistant bioplastics for the passenger transport sector. The project was coordinated by The Technological Institute of Plastics (AIMPLAS) and involved a consortium of 16 partners. "The aim of the research was to produce a recyclable and lighter product that can be easily made using a high capacity production process," explains Project Manager Dr Olga Tverezovskaya.

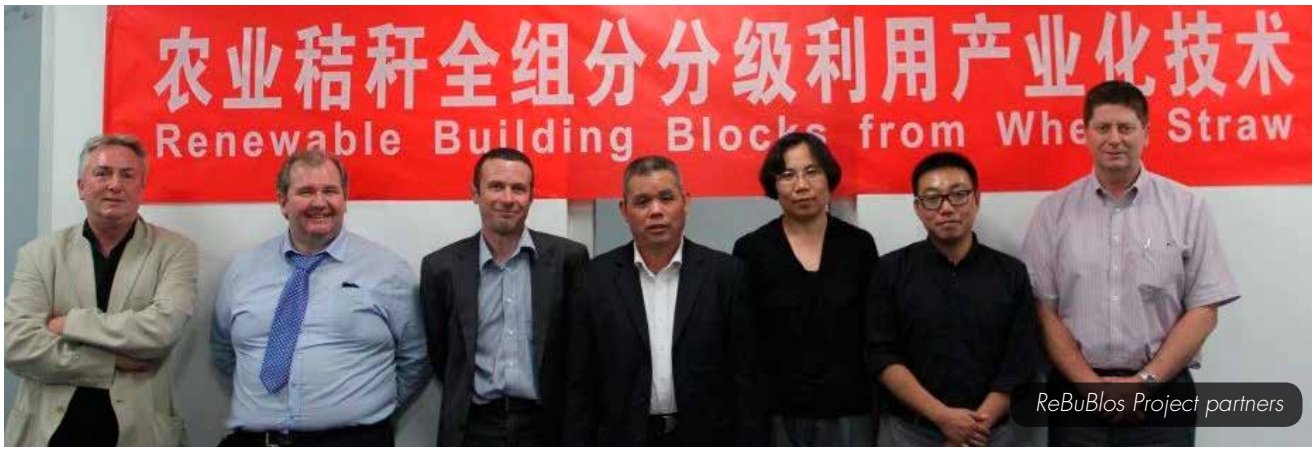
BC led work focusing on the production of polybutylene succinate (PBS) using a biobased succinic acid made from waste pulping chemicals. Olga's work was to synthesise the PBS based copolymers in the laboratory using enzymatic and chemical catalysis approaches. A series of polybutylene succinates (PBS) and polybutylene succinate-cobutylene adipate (PBSA) were prepared at Bangor University, through a two-step one batch polymerisation process. After optimising conditions, the process was scaled-up successfully.

BRIGIT showed that Bio-PBS, with properties comparable to those of commercially available materials, can be produced from bio-succinic acid derived from paper industry waste. The flame retardant PHB/PBS blends were fully compostable and panels were 100% biodegradable.

BRIGIT project panels in new bus, the Solaris Urbino 12

Multilayer composite panels, produced using the new technologies developed in BRIGIT, were tested by the bus and coach manufacturer, Solaris. The company were satisfied that the panels had equivalent properties to those currently in use. As a result, the new composite materials have been installed as side panels on their new bus model, the Solaris Urbino 12.

ReBluBlos - collaborative project with China



ReBuBlos Project partners

In October 2015, Dr Qiuyun Liu and Dr Adam Charlton visited China as part of the Renewable Building Blocks from Wheat Straw (ReBluBlos) project. They toured the National Centre of Excellence for Pulp and Paper Research at the State Key Laboratory of Pulp and Paper Engineering, South China University of Technology in Guangzhou. After presenting seminars about their research work at BC to staff and students at the institute, Qiuyun and Adam toured the facilities to see a wide range of pulp and paper laboratory and pilot scale equipment.

ReBluBlos is a UK:China collaborative project funded by Innovate UK, developing biomass fractionation technologies to produce fibres for the pulp and paper industry, and chemicals for the polymer and other industries.

Spinout and Research Impact

CO_2 Lab spins out to form Suprex Ltd

The Welsh Minister for Skills and Science, Julie James, will officially open Suprex Ltd in October 2016. Suprex Ltd is a contract research organisation based in Caernarfon, and is the only commercial organisation in the UK able to develop process applications for carbon dioxide (CO_2) up to pilot scale. The company is a spin-out of BC's CO_2 Lab and is a joint venture between Phytovation Ltd and Bangor University.

The CO_2 Lab, led by Professor Ray Marriott, became the preeminent centre for research into the use of supercritical CO_2 in the UK. In 2012, the Welsh Government supported laboratory expansion with a grant of £345,000, in recognition of the huge potential environmental benefits of the technology, which replaces traditional solvents with an environmentally benign alternative.

Suprex Ltd uses a cutting edge method of processing which is greener and more environmentally friendly than traditional methods. The process has applications across a wide range of industries including flavours, fragrances, cosmetics, personal care, nutraceuticals and pharmaceuticals. It is the only organisation in the UK capable of doing this type of research work.

The company currently works with a number of universities in the UK, as well as a broad range of blue chip businesses and SMEs and are actively working on new collaborative projects.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Waitrose supports research into eco-friendly Welsh ryegrass packaging
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Waitrose turns grass into egg boxes
12 October 2015, source edie newsroom
Waitrose has given the humble egg box a green makeover with the launch of a revolutionary new packaging material made from ryegrass and paper
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NNFCC
The Bioeconomy Consultants
Waitrose look to Ryegrass to make more sustainable packaging
Waitrose has partnered with two Welsh universities to deliver a research project aimed at using Welsh ryegrass to create sustainable products for the food packaging and cosmetics industries.
Date Posted
12 Mar 2013
Story Source
NNFCC
FARMING FUTURES
PROFITABLE BUSINESS IN A CHANGING CLIMATE
Waitrose look to Ryegrass to make more sustainable packaging

People and Awards

Smashing result for egg boxes

Significant impact was achieved following our work to produce sustainable packaging products from rye grass, on the Welsh Governments A4B (Academic Expertise for Business) programme funded STARS project. In October 2015, Waitrose our project partners, launched a new commercial egg box, using a grass fibre blend. The products developed from ryegrass packaging are 6 and 12 pack egg boxes and are exclusive to the Waitrose Duchy Original Range.

Within the first two weeks, tens of thousands of units sold in Waitrose stores across the UK. For example, sales for week commencing 12th October 2015 were 10,000 for the twelve pack and 42,000 for the six pack, equating to 68% of total weekly sales in this sector. For the three month period following launch (October-December 2015), total sales for six and twelve pack units were approximately 600,000. There is potential to increase volume to 76,000 per week across the four, six and twelve pack boxes. Waitrose will conduct a review of the product range during 2016, in order to discuss options for utilising the grass-based packaging in other product lines.

The new products have a range of advantages:

- Use of a 50:50 mixture of rye grass and recycled paper as a more sustainable option for packaging materials
- The move will save 77 tonnes of wood and recycled paper a year
- Plans to extend packaging to other ranges could save 405 tonnes of wood and recycled paper each year
- Production requires 60% less water and produces 10% less CO_2 than conventional packaging materials
- The products are 100% recyclable and can be recycled with newspapers and cardboard

We will be working on other projects using pulp moulding technology in conjunction with biobased films to continue our development of environmentally friendly packaging.

New Fellow for Royal Society of Chemistry

Dr Adam Charlton was accepted as Fellow of the Royal Society of Chemistry. Achieving Fellow status in the chemical profession requires a high level of accomplishment as a professional chemist. To be eligible, Members of the Royal Society of Chemistry (MRSC) must have a minimum of 5 years professional experience. They must also have made an outstanding contribution to the advancement of the chemical sciences; or to the advancement of the chemical sciences as a profession; or have been distinguished in the management of a chemical sciences organization.

Visiting Researchers

This year we have hosted a number of visiting researchers. They have come from as far as Slovenia and Switzerland and closer to home including Huddersfield University and even our own Chemistry department in Bangor University.

Three of the visitors, Matthew Schwarzkopf, Marion Noel and Lothar Clauder were funded through European COST actions (FP 1303 and FP 1407). Matthew worked with the Chemistry group to develop new resins for impregnation into timber, Marion worked with the Materials group focusing on wood modification and Lothar tested wood samples for VOC release. Raisa Teciu, funded by an Erasmus+ scholarship, joined us for 3 months and worked on the assessment of heat-treated timber for alternative applications.

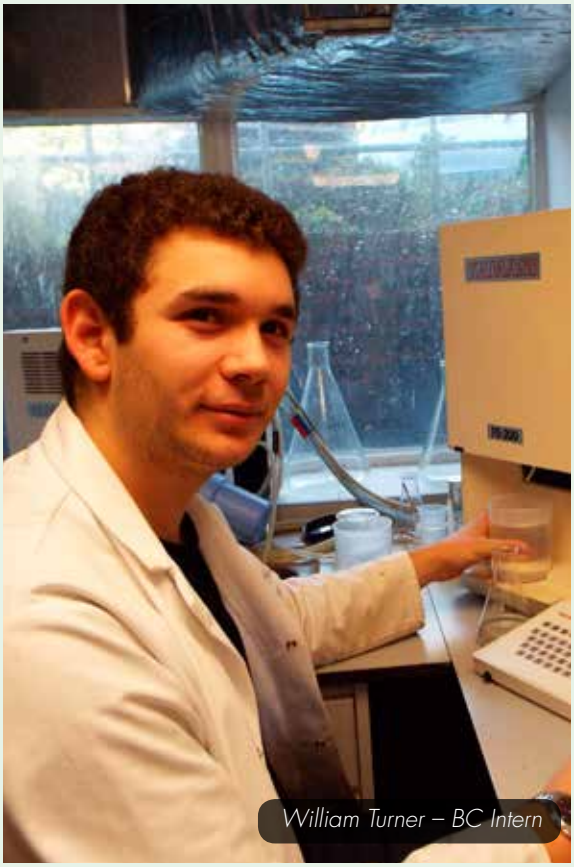
Antoine Stefan, Pierre La Floch and Benjamin Blake joined the Materials group to increase their experience of laboratory work. They worked on a variety of projects and gained valuable knowledge, both in the management of projects as well as the day-to-day bench work. Jesse Ross also joined us from a local school on work experience and teamed up with Bronia Stefanowski to assist with her final PhD experiments.

The Materials group has also extended a warm welcome to William Turner. William has recently joined the group on a yearlong internship and has already proved himself invaluable in the laboratory. We look forward to working with William for the next year.

People and Awards

People Focus: William Turner - Intern

I am a chemistry student in my third year of study at the University of Huddersfield. I am currently an intern at the BioComposites Centre as part of a placement year in research and industry. I am working in the BC Materials group under the supervision of Dr Morwenna Spear, primarily investigating the chemical properties of Miscanthus. During my internship, I will undertake a project that will contribute to the integrated masters (M.Chem) part of my course. The placement at BC gives me the opportunity to apply the chemistry and practical skills I have learnt at university and gain experience working in a research environment. After graduating, I plan to follow a career in green chemistry.



William Turner – BC Intern

People Focus: Steven Cenci - Research scientist CO_2 Lab

After graduating in Industrial Chemistry from the University of Bologna, I received my Master's Degree in Green Chemistry from the University of York, where I undertook a project studying biocatalytic reactions in supercritical carbon dioxide. With an opportunity arising to study for a PhD in Chemical Engineering at the University of Birmingham, I decided to pursue my interests in high pressure carbon dioxide processes. As a result, I successfully completed my research thesis with the title 'Acoustic agitation of dense carbon dioxide/water mixtures: emulsification, mass transfer, and reaction engineering'. Since then my research has become increasingly focused on organic synthesis, extractions, process optimisation and waste minimisation.

Steven Cenci - Research scientist CO_2 Lab

One of the BEST EU LIFE Environment Projects 2015

BREAD4PLA, a green science and technology project, in which BC's research played a significant role, was recognised as one of 25 Best LIFE Environment Projects delivered in 2015. The BEST projects were identified as those that, if widely applied, could have the most positive impact on the environment. LIFE is the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU.

Researchers at BC and School of Chemistry, Bangor University worked in collaboration with AIMPLAS, Technological Institute of Plastics and CETECE, the Cereals Technology Centre both based in Spain, and ATB, the Agricultural Engineering Institute, Germany. The consortium successfully developed a new biodegradable packaging for bakery products from bakery waste.

Dr Viacheslav Tverezovskiy explains: "Waste from sliced bread, crusts and sponge cakes underwent fermentation and enzymatic treatment to obtain lactic acid. Lactic acid was then polymerised to a biodegradable polymer called PLA. The PLA was then extruded to produce a packaging film which has excellent barrier properties, suitable for different products from the bakery sector, including pasta and sweets. The new packaging materials are fully biodegradable and compostable."

This project was also shortlisted for the Bangor University Impact and Innovation Award.

BC and WoolCool partnership recognition

The continuing partnership between BC's Materials group and WoolCool was recognized this year at two award ceremonies. The team were runners up in both the Business Insider Wales 'Business and Education Partnerships Awards' in the New Product category and the Bangor University Impact and Innovation Awards. Competition for both awards was tough with the awards going to innovations in the medical and food security arenas.

Woolcool take advantage of the natural insulation properties of wool to design and develop eco-friendly packaging products and offer novel packaging solutions. The partnership between BC and WoolCool goes from strength to strength with new collaborative projects developing this year.

Networks

BC teams up with the Ellen MacArthur Foundation

Bangor University, through BC, has been accepted as a 'network university' by the Ellen MacArthur Foundation, a charity dedicated to promoting the idea of a 'circular economy'.

Founded in 2010 by the record-breaking yachtswoman, the Ellen MacArthur Foundation sees our current industrial economy as being based on a 'take, make and dispose' model of production. A 'circular economy' is different as it produces no waste or pollution and resources are kept in use for as long as possible. Maximum value is obtained from the products whilst in use, then materials are recovered and regenerated at the end of the product life. The foundation seeks to establish a 'circular economy' on the agenda of decision makers across business, government and academia.

In addition to its global partners such as Google, Nike and Unilever, the foundation also has a global network of Universities. By show casing relevant academic work globally, the Foundation aims to enable collaborative ventures and knowledge exchange across policy makers, business and academia outside of its formal programmes. Joining a select group of institutions BC will now share some of its expertise in innovative business solutions with the Foundation, further cementing Bangor University's reputation as an international leader in the field of sustainability.

Dr Adam Charlton, from the BC said, "This represents an exciting opportunity for Bangor University to engage and collaborate with this high profile charity. It will showcase the industrial collaborative work carried out by the BioComposites Centre in the areas of waste minimisation, bio-based products, including food packaging and the application of low carbon technologies."

COST Action participation

BC values the chance to collaborate with colleagues around the world. We have been a keen participant in the European COST (Cooperation in Science and Technology) scheme and have been active in the following COST actions:

FP1205 - Innovative applications of regenerated wood cellulose fibres. Dr Graham Ormondroyd and Dr Simon Curling are members of the management committee of this action and Simon attended conferences in Boras, Sweden and Budapest, Hungary.

FP1303 - Performance of Biobased building materials. BC materials staff are active in this project with Dr Simon Curling collating a chapter for a forthcoming book on biomaterial properties. Other members of BC have also contributed heavily to the book. Simon presented two papers at a FP1303 conference in Poznan, Poland. At the same conference, Matthew Schwarzkopf presented his work carried out on a Short Term Scientific Mission (STSM) at BC in Bangor.

FP 1407 - Understanding wood modification through an integrated scientific and environmental impact approach. Dr Graham Ormondroyd undertook an STSM to the Norwegian Institute of BioEconomy Research (see next section).

Staff benefit from training programmes

This year two members of BC staff undertook Short Term Scientific Missions (STSM). STSMs, supported through the EU COST programme, allow scientists to learn from an institution or laboratory in another COST country.

Dr Graham Ormondroyd travelled to the Norwegian Institute of Bioeconomy Research (NIBIO), Norway to undertake fungal DNA quantification on samples of timber that had been subjected to a short period of decay. Graham spend a week learning new analytical techniques and developing an understanding of the complexities of DNA analysis. The work has established new links between Bangor University and NIBIO and will lead to a journal paper. This STSM was funded by COST Action FP1407 'Understanding wood modification through an integrated scientific and environmental impact approach (ModWoodLife)'.

Dr Athanasios Dimitriou spent three months in CNR-IVALSA Trees and Timber Research Institute in San Michelle all'Adige, (Trento) Italy on a STSM funded by COST Action FP1303 *"Performance of biobased building materials"*. He investigated the effect of different climatic conditions on the natural weathering of wood in collaboration with Dr. Jakub Sandak and Dr. Anna Sandak (See next section).

Dr Luis Martin, from the CO_2 Lab, BC, was awarded £500 to fund a short scientific exchange with the Università degli Studi di Salerno in Italy to study the fractionation of glycolipids using a counter current technique with supercritical CO_2. The award, funded by BioProNET, is presented to early career scientific researchers who have spent less than 10 years in active postgraduate research. Luis spent three weeks learning about the techniques of supercritical counter current fractionation and studying the possibility of moving from a batch process to a continuous one using a counter current supercritical column. "I was delighted to be awarded the scientific exchange funding," said Luis, "I was able to experience work in another lab and see the potential applications of the equipment that I was able to use."

Luis Martin on a BioProNET short scientific exchange

Focus on COST Action FP1303 STSM

Weathering is a process where different atmospheric conditions (solar radiation, temperature and moisture) cause degradation of fibres in biobased materials. Weathering leads to surface degradation, through fibre damage which results in an increase of the surface roughness and changes in colour and glossiness which reduces the aesthetic value of the material. The increased surface roughness allows for further exposure to weathering penetrating deeper into sub-surface layers. The rate of weathering is affected by the fibre species, the climatic conditions that the material is exposed to and the pre-treatment of the material.

In order to promote the use of wood in outdoor construction it is essential to understand the effect of weathering to design more effective preservation techniques. By studying weathering mechanisms and kinetics we aim to develop a predictive model for changes that occur naturally in wood over time.

In this project, wood samples were exposed to natural weathering at 28 sites across Europe for a duration of 12 months. Dr Athanasios Dimitriou investigated the aesthetic, chemical and the morphological properties of the weathered samples using various techniques. The efficiency of each surface characterisation method was also assessed. Methods used for the surface aesthetic characterisation were CIE Lab colour, VIS hyperspectral image, VIS integrated sphere, Hamamatsu VIS-NIR and glossiness. Chemical changes were determined using MIR, NIR, UV-VIS-NIR, Micro NIR and XRF. Finally the surface morphology was investigated by laser displacement sensor, laser line and focus depth measurement. Part of the results of this successful STSM were presented by Athanasios in the *2nd Workshop on application of NIR spectroscopy for wood science and technology research*, which was held by CNR-IVALSA on 19th to 21st of April 2016. The results of this STSM will be presented in forthcoming scientific papers.

Athanasios Dimitriou on a COST Action FP1303STSM

EVENTS

NRN-LCEE fact finding mission to Brazil

In March 2016, funding from the Sêr Cymru National Research Network for Low Carbon, Energy and Environment (NRN-LCEE) Plants and Architecture cluster allowed Dr Morwenna Spear to attend a conference and other events in Curitiba, Brazil. During her visit, Morwenna presented a paper at the Society of Wood Science and Technology (SWST) International Convention, attended Lignum Expo and explored future transatlantic links.

Curitiba is well known for its environmental awareness in urban planning, and has some great examples of green infrastructure. The city has the greatest quantity of green space per resident in the world, and planted an extra 2.5 million square metres during 20 years to 2013. This is valued for environmental protection, leisure and social integration, as well as alleviating flood risk. "During my trip I visited São Paulo and Curitiba and saw great examples of timber structures, green façades, planting to reduce urban heat islands and sustainable architecture. These examples all link in to the work we are doing with Cardiff School of Architecture and Aberystwyth University."

While at the SWST International Convention Morwenna spoke about her work with thermally modified wood and heard a wide range of presentations on timber, wood based composites and timber protection. The SWST conference had joint sessions with EBRAMEM, a Brazilian conference on timber structures. This provided great opportunities to gain insights into the technology and use of timber in Brazil, with excellent presentations by representatives of local companies on topics ranging from tropical hardwoods, glulam, affordable housing and architecture. Morwenna recounts, "There were some great talks – a lot of new companies reporting the use of glulam and CLT, or modular housing. Architects seem really excited about the potential of timber structures here."

Hidden Worlds Exhibition

On March 12th Bangor University hosted its Hidden World exhibition as part of Bangor Science week. A range of displays and demonstrations introduce the public to research carried out at the University. The BioComposites Centre, as part of our research dissemination and S.T.E.M. education commitments presented two aspects of our work.

The first, a display of the wide range of uses and properties of wood, proved fascinating for young and old alike. The most eye catching part of this display was a 3.5 meter high tower of wood (kindly lent to us by the Wood Technology Society) emerging from a photograph of Wembley stadium as a scale representation of the amount of wood products used in the UK in one year.

The second display featured BC's work on indoor air quality as part of the ECOSEE and NRN-LCEE projects. This topic has been in the media recently and BC's novel approach using natural materials to improve indoor air quality attracted a lot of attention. Following BC's commitment to working with local companies the display utilised sensor technology provided by Caernarfon based PPM Technology, to monitor temperature, humidity and formaldehyde (a common volatile organic compound (VOC)) in the room. This proved very useful as a hands-on method of demonstrating the air quality issues raised, especially as the day progressed and the room warmed up due to all the visitors!

Ceri Loxton demonstrating the versatility of wood

Wild Forest Products Fair

Researchers Dr Morwenna Spear and Dr Simon Curling demonstrated BC's work at the Wild Forest Products Fair at Glynllifon, North Wales in May. The fair was a knowledge exchange event organised by the European funded StarTree project aimed at educating and informing communities about the resources, both timber and non-timber, found in woodland and forest areas.

The BC exhibit focused on how different timber types and products are suited for differing uses based on their material properties. An interesting demonstration on the tensile strength of wood (kindly loaned by the Wood Technology Society) proved popular with both the younger (and slightly older) visitors! The exhibit also demonstrated how advancements in understanding wood properties and the development of engineered wood products is leading to a resurgence in building with wood, including new tall wood structures.

Information on other biomaterials, such as plant and animal derived fibres (e.g. hemp and wool) and how they can be used in modern buildings (such as the insulation materials being developed in BC's ECOSEE project) were also highlighted. The incorporation of biomaterials and engineered timber in buildings, and use of plants in urban greening options such as vertical gardens and green roofs were also demonstrated. This area of BC's research under the NRN-LCEE Plants and Architecture cluster proved especially topical with many visitors discussing their own experiences and buildings.

Morwenna Spear demonstrating the strength of wood

Back to Basics: IPPS Masterclass 2016

BC hosted its biennial International Panel Products Symposium (IPPS) Masterclass 2016 in the laboratories of Bangor University. The 'Back to Basics' Masterclass attracted a number of representatives from the industrial sector for a range of talks, discussions and practical sessions. Topics covered ranged from particle size determination, wood anatomy and its affect on panel properties, wood biodeterioration and basic resin and adhesive considerations.

Dr Martin Ohlmeyer, from the Thünen Institute of Wood Research in Germany, spoke about the current and past methods of fibre particle measurements and introduced the novel Fibre Cube equipment that he has developed.

Dr Morwenna Spear, from BC, delivered a presentation and practical session on wood anatomy. This included microscopic examination of a number of wood samples to recognise differing wood cell types. Participants gained an understanding of the role these parts play in wood structure and how they affect panel properties when using fibres, chips or flakes and veneers.

Microscopy session at IPPS Masterclass 2016

Dr Lone Ross Gobakken, from the Norwegian Institute of Bioeconomy Research (NIBIO), a specialist in wood biodegradation, discussed all aspects of wood moulds, stains and decay. Following this there was a practical microscopy session, led by Dr Gobakken and Dr Simon Curling, for the class to examine a wide range of examples of decayed wood and panel products that had previously been subjected to different types of fungal attack.

The last session of the Masterclass led by Dr Rob Elias, director of BC, addressed resin and adhesives and included a short, fun practical session using an improvised testing system for determining the strength of adhesive bonds. Teams of delegates compared different hardener addition rates and cure times.

Discovering resins & adhesives at IPPS Masterclass 2016

Attendees of the IPPS Masterclass 2016

Publications

Book Chapters

1. Ormondroyd G.A. (2015) Adhesives for wood composites, *Wood Composites*, Ed: M.P. Ansell Woodhead Publishing Cambridge, UK. pp. 47-66ISBN 978-178-24-2454-3
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3. Ormondroyd, G.A., Spear, M.J. and Skinner, C. (2016) The Opportunities and Challenges for Re-use and Recycling of Timer and Wood Products within the Construction Industry, *Environmental Impacts of Traditional and Innovative Forest-based Bioproducts,* Eds: Kutnar, A., Muthu S.S. Springer, Singapore.
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5. Spear M.J., Eder A. and Carus M. (2015) Wood polymer composites. Chapter 10 in *Wood Composites – from nanocellulose to superstructures.* M.P. Ansell (Ed.), Woodhead Publishing, Cambridge, UK, pp. 195-249. ISBN 978-178-24-2454-3

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1. Dimitriou A., Spear M.J. and Hale M.D. (2016) The effect of four methods of surface activation for improved adhesion of wood polymer composites (WPCs). *International Journal of Adhesion and Adhesives* 68:188-194. (DOI 10.1016/j.ijadhadh.2016.03.003)

2. Mansour, E. Curling, S., Stephan, A., Ormondroyd, G. (2016) Absorption of Volatile Organic Compounds by Different Wool Types *ICE Green Materials* DOI: http://dx.doi.org/10.1680/jgrma.15.00031

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5. Skinner, C. Stefanowski, B. Heathcote, D. Charlton, A. Ormondroyd, G.A. (2016) Life Cycle Assessment of pilot scale wood fibre production using mechanical disc refining at different pressures. *International Wood Products Journal* (In Press)

6. Stefanowski, B., Curling S., Ormondroyd, G. (2016) The sorption of volatile organic compounds (VOCs) by modified MDF panels and the effects on mould colonisation and growth *International Journal of Wood Products* (In Press)

7. Lahmer, R.A., Morris, A. Curling, S. Ormondroyd, G.A. Jones, D.L. Williams, P.A. (2016) Effectiveness of a Wool Based Packaging System on the Abundance of Surface Spoilage Microorganisms on Meat Products *American Journal of Food Science and Nutrition* (In Press)

8. Belanche, A., Pinloche, E., Preskett, D. and Newbold, C.J. (2016) Effects and mode of action of chitosan and ivy fruit saponins on the microbiome, fermentation and methanogenesis in the rumen simulation technique. FEMS Microbiology Ecolog. Vol92(1) pp 1-13.

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Conference Proceedings

1. Hu, J-B., Skinner, C., Ormondroyd, G., Tondi, G., Pizzi, A., Thevenon, M-F. (2015) Life cycle assessment of a novel tannin-boron association for wood protection In *the Proceedings of COST Action FP 1407 Life Cycle Assessment, EPDs and modified wood* Koper, Slovenia 25-26 August 2015

2. Spear M., Binding T., Nicholls J., Jenkins D., Ormondroyd G. (2015) Physical properties of UK grown larch subjected to a mild and moderate thermal treatment process In: *Proceedings of The 11th Northern European Wood Science and Engineering 2015*, Poznan, Poland. pp. 98-104.

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4. Prabhakaran, R.T.D., Ormondroyd G.A., Curling, S., Spear, M. (2015) Bio-based and Bio-inspired materials for a modern Building Design – A Research Perspective In: *Proceedings of the International Panel Products Symposium 2015*, Llandudno, UK 7-8th October 2015, pp. 293-296.

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7. Segerholm K. Jones, D. Rautkari, L. Olsson, S. Ormondroyd, G. Mansour, E. Leung, G-S. Wilems, W. (2015) Evaluation of different in thermal modification as a result of depth profiling. Preliminary investigations into material treated using the Firmolin process. In: *Proceedings of the European Conference on Wood Modification 2015* Helsinki, Finland 26/27th October 2015

8. Noel, M. Ormondroyd, G. Spear, M. Grigsby, W. Volkmer, T. (2015) Evaluating the optimization of wood modification with polybutylene succinate bio-polyester In: *Proceedings of the European Conference on Wood Modification 2015* Helsinki, Finland 26/27th October 2015

9. Clauder, L. Mansour, E. Ormondroyd, G. Pfriem, A. (2015) Emissions from bio-based building products In: *Proceedings of the European Conference on Wood Modification 2015* Helsinki, Finland 26/27th October 2015

10. Spear, M. Binding, T. Dimitriou, A. Cowley, C. Ormondroyd, G. (2015) Chemical changes in mild thermal treatment of larch: to what extent to they differ from full thermal modification? In: *Proceedings of the European Conference on Wood Modification 2015* Helsinki, Finland 26/27th October 2015

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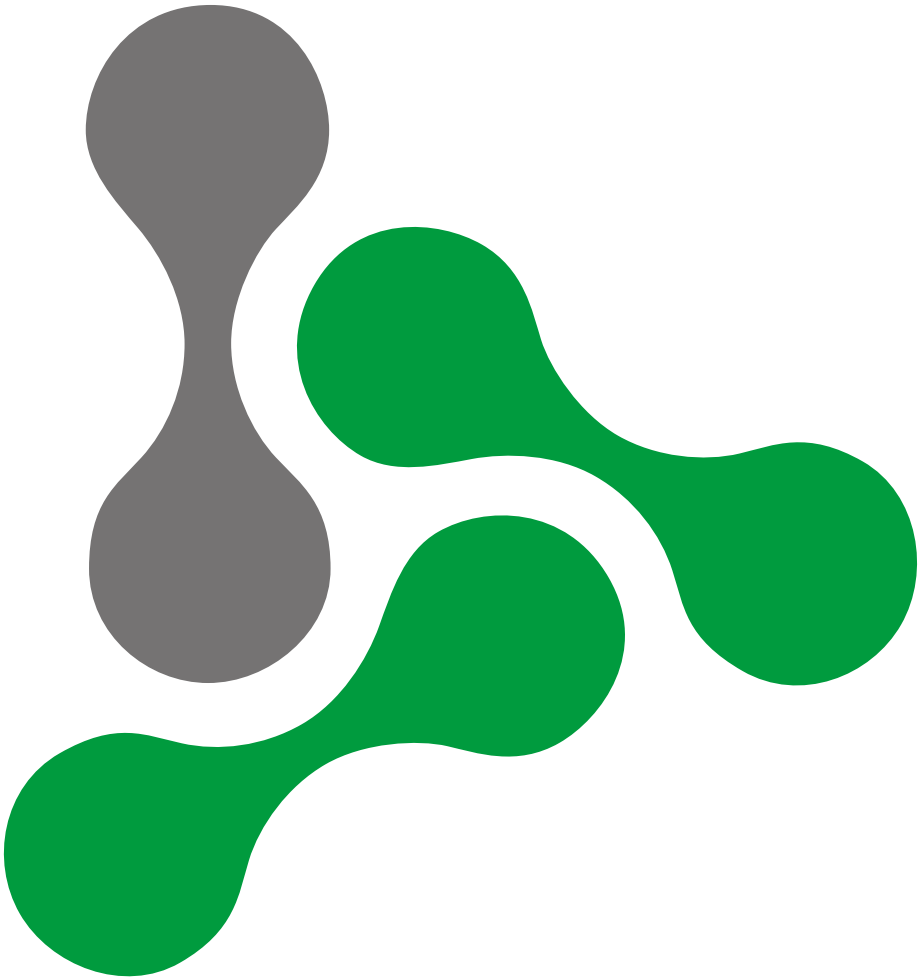
Staff List

Staff Category	Name
Research Staff	Adam Charlton
	Ahmed Al-Dulayymi
	Campbell Skinner
	Ceri Loxton
	Courtney Williamson
	Dave Preskett
	Graham Ormondroyd
	Luis Martin Navarro
	Morwenna Spear
	Olga Tverezovskaya
	Paul Baker
	Quiyun Liu
	Radek Braganca
	Ray Marriott
	Rebecca Snell
	Rob Elias
	Simon Curling
	Viacheslav Tverezovskiy
Technicians	Derek Heathcote
	Gee-Sian Leung
	Gwenda Davies
	Jon Nicholls
	Nick Laflin
	Shon Jones
	Thanasis Dimitriu
Administration and Finance	Dominic Breslin
	Judith Burgess
	Nicola Sturrs
	Raine Williams
PhD students	Bronia Stefanowski
	Elie Mansour
	Sam Wright
	Sayma Akhter (Joint with CNS)



The BioComposites Centre
Alun Roberts Building, Bangor University,
Bangor, Gwynedd LL57 2UW

Tel: 01248 370588
E-mail: bc@bangor.ac.uk
Website: www.bc.bangor.ac.uk
Twitter: @bcbangor