Polymer Interdisciplinary Research Centre

Strategic Links with China

与中国的战略合作

2018
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Strategic Links with China
- the Science Bridges China/UK-China AMRI platform
The internationally recognised Polymer Interdisciplinary Research Centre (Polymer IRC) at the University of Bradford has a strong track record of warm co-operation in the UK and abroad, with academics, industry and clinicians across the area of advanced materials, especially polymers and polymer composites, and with an emphasis on healthcare technologies.

We celebrate some of the achievements to date, and our ongoing progress. A further extension of our capabilities in the healthcare technologies area is the EPSRC UK Centre for Innovative Manufacturing in Medical Devices, MeDe Innovation – a key grouping of five leading universities, which we introduce briefly here. We are also linking MeDe strongly with our Chinese partners.

In the Appendices origins of the Science Bridges China/UK-China AMRI platform are described. We also note briefly some further excellent international links, with leading groups in the pharmaceutical and polymer science and engineering areas in India. All of this exciting progress is only possible because of an excellent team of like-minded, dedicated people, who are developing the capability and capacity of our research laboratories, which continue to pursue an upward trajectory, with local through to international impact.

We are always open to new opportunities, and welcome academic, industrial and clinical collaborations, so please do contact us!

WELCOME

This booklet provides brief background information on ongoing developments in the world-class UK Polymer IRC, which was founded through an EPSRC grant in 1989. It then focusses on our extensive and warm collaborations in China for more than a decade, based on the Science Bridges China platform, where we have established the UK-China Advanced Materials Research Institute and have a vibrant, growing community of research leaders, researchers and early career researchers, with a highly productive programme of Research Workshops and researcher exchanges, and three Joint International Research Laboratories.

Prof Phil Coates FREng
Director, Polymer IRC
Director, Science Bridges China

International Science & Technology Co-operation Award of PR China (2017)
中国国际科学技术合作奖获得者
Famous Overseas Scholar, MoE China
中国教育部海外名师
Sichuan Province Foreign Expert
四川省外国专家局外国专家
Leading International Professor, Sichuan University
四川大学高端外籍教师
Honorary Professor, Sichuan University
四川大学名誉教授
Honorory Professor, Beijing University of Chemical Technology
北京化工大学名誉教授
Our Bradford RCUK Science Bridges China team

Prof Phil Coates FREng
Director Polymer IRC
Director, Science Bridges China
Co-Director AMRI Board

Xiaolei Wang
International Programme Manager,
AMRI Board Member

Dr Fin Caton-Rose
Manager Solid Phase Processing & Modelling
AMRI Board Member

Prof Anant Paradkar
Director, Pharmaceutical Engineering Science

Prof Ben Whiteside
Director, Polymer Micro & Nano Technology Centre
AMRI Board Member

Dr Pete Twigg
Reader, Medical Engineering

Prof Steve Rimmer
Head, Chemistry & Biology
Faculty of Life Sciences

Prof Adrian Kelly
Manager, Extrusion

Prof Tim Gough
Manager Polymer Characterisation

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For well over a decade we have developed extensive and warm collaborations in China.

After initial visits by Prof Coates to China (between 2000 and 2007), the EPSRC funded Virtual Institute for Polymer Process Structuring programme drew together some of the polymer research community in China, Japan, Taiwan and Korea (2008-9) led by Bradford but including Leeds University academics.

This was followed by the RCUK/ EPSRC – Bradford top-ranked grants for the Science Bridges China platform. From the Science Bridges China/ EPSRC Global Engagements programme, we established the UK-China Advanced Materials Research Institute and a vibrant, growing community of research leaders, researchers and early career researchers, with a highly productive programme of Research Workshops and researcher exchanges, and three Joint International Research Laboratories to date. This Science Bridges China/ UK-China AMRI platform has included an expanding range of leading UK and Chinese Universities, companies and clinicians.

The Science Bridges China £1.27m grant began in 2009 with three groups at the University of Bradford, led by Prof Coates (the Pro Vice Chancellor for Research & Knowledge Transfer) - the Polymer IRC, Institute for Pharmaceutical Innovation and Institute for Cancer Therapeutics, in collaboration with 11 Chinese academic institutions. It aimed at collaborative research, development and open innovation in pharmaceuticals and healthcare, and to bring together scientists and companies from the UK and China to develop new therapies, medical diagnostics, materials and devices.

Science and technology are primary production forces

An initial Board Meeting of leaders from the six founding research groups in Sichuan, BUCT, ICCAS, CIACCAS, SIMMCAAS and Bradford, was held on 19 April 2012, 5pm-6pm, Shangri-la Hotel, Chengdu.

**Purpose:** The leading researchers involved in UK-China collaborations in polymer-related materials, brought together by the RCUK Bradford Science Bridges China programme, agree to form the UK-China Advanced Materials Research Institute. This virtual institute will represent the growing UK-China research collaborations in a more coherent and substantial way, linking members together more visibly, for increased impact.

This will be valuable to all members, as it will:

- show a critical mass of leading Chinese and UK researchers who wish to collaborate in areas of research which are identified by our countries as strategic, and who show that they have a successful track record of collaboration, and
- help to increase our research co-operations and friendship, and create new opportunities for exchanges and funding,
- strengthen our joint approaches to UK and Chinese funding agencies.

**Initial Scientific Focus:** The Research Institute will aim to bring together leading UK and Chinese research groups with Advanced Materials research strengths, especially Polymer-related materials and processing. An initial focus will be on ‘advanced materials for healthcare’. This is an area identified by both the UK and China as a priority for research cooperation. This area also includes a range of materials interests, built strongly on our polymers and polymer-related materials expertise, and includes drug delivery and biomaterials aspects. Our approach is genuinely interdisciplinary, across materials science, engineering, physics, chemistry and biomaterials disciplines. Many materials advances offer potential application to healthcare, an initial focus, but the Institute will cover other advanced materials ‘themes’ which are also strategically important, such as advanced materials for Energy/ Resource Efficiency, and more general materials areas such as polymer nanocomposites.

**Research Institute proposed activities:**

- **Communications** – by regular emails, by conference call, web site and organised meetings.
- **Annual meeting:** this would involve (i) a technical meeting, reporting progress of collaborative research and aiming to discuss funding opportunities, develop new research and staff exchange opportunities, and (ii) a business/strategy discussion for the Institute and its research directions. Depending on funding streams, co-hosting, etc, it should be feasible to call an annual 2-day meeting in China or the UK. (Bradford currently has support for this for the next year).
- **Researcher exchanges** are encouraged, to develop research capacity and research training; similarly joint supervision of Research Students is encouraged.
- **Joint international laboratories:** Although the proposal is for a ‘virtual’ Research Institute, we aim to have joint international laboratories established or developed. Bradford and Sichuan University currently have such a joint laboratory for Polymer Micro Processing. An alternative is to identify clusters of research groups with at least one Chinese member and one UK member, with similar research interests.
- **Joint research projects and funding bids** (in China to MOST and NSFC, in the UK to EPSRC, and potentially in Joint Calls); industrially supported projects are welcome.

**Web site:** www.ukchina-amri.com
Research Declaration

Here is a ‘Research Declaration’ to describe ourselves as members of the new Research Institute.

UK-China Advanced Materials Research Institute – Research Declaration:

- We, the members of the UK-China Advanced Materials Research Institute, agree the following:
- **Research Quality**: We are committed to excellent basic research, and recognise the importance of knowledge generation and intellectual advancement,
- **Research applied**: We recognise the importance of the application of our knowledge, to benefit all.
- **Research vital for innovation**: We believe that research is vital for innovation, that there is a pipeline from research to innovation and eventual commercial exploitation.
- **Academic Research Collaboration**: We value highly collaboration in our research and innovation. We recognise that such collaboration needs to be of mutual benefit, for example with joint publication and joint intellectual property, and it is highly preferred that collaborations should be long term to build up the advantages and develop teams of researchers.
- **Collaboration with industry**: We also recognise the high value of collaboration with industry in our research programmes, to help direct aspects of our research and knowledge transfer more effectively.
- **Social value**: We are responsible researchers, with a commitment and passion for our countries and our subject areas. We pursue excellence, and seek to benefit our academic community and our collaborators. Our funded programmes should be good value for money, and have clear targets.
- **International ‘people bridges’**: We are committed to international collaboration and to each other personally as we build ‘people bridges’, and help to combine our skills in research, knowledge transfer and innovation.

Science Bridges is an opportunity to take the University’s warmth of relationship with China to a new level. Science Bridges, for us, has become ‘People Bridges’ – it really is a celebration of friendship

Professor Phil Coates
UK Core members:

Universities of Leeds, Bradford, Durham and Sheffield

We build too many walls and not enough bridges

Isaac Newton, ‘Father of Modern Science’

Chinese Core members (& leaders):

Sichuan University: SKLPME, NERCB

Prof Guangxian Li
Prof Qi Wang
Prof Hesheng Xia
Prof Lin Ye

Beijing University of Chemical Technology

Prof Liqun Zhang
Prof Daming Wu

Changchun Institute of Applied Chemistry,
Chinese Academy of Sciences

Prof Yongfeng Men

Institute of Chemistry, Chinese Academy of Sciences, Beijing

Prof Dujin Wang

Shanghai Institute Materia Medica
Chinese Academy of Sciences

Prof Dong Qiu

Prof Jiwen Zhang
Delivery: Growing the community platform

Outputs
- Papers, Exchanges, Projects, Innovation, KT, Joint IP;
- Building Research Capacity & Capability


- EPSRC: People Collaboration, £0.23m
- RCUK: Science Bridges - China, £7.25m
- EPSRC: Global Engagements, £0.5m
- MRC-MOST joint grant
- Royal Society Newton Advanced Fellowship

Workshops (open innovation; Research & KT)
Joint Lab Sichuan launched
Royal Society Newton Advanced Fellowship
NSFC Research Workshop 6-8 Dec, Chengdu
MRC-MOST joint grant
PPE'17/AMRI 9 Bradford July 2017
Royal Society Newton Advanced Fellowship

In China: Sinopec, DePuy/J&J, Paragon, Molex, AZ +…
In UK: Smith & Nephew, Autodesk, Sabic, +…
+ Clinicians from Beijing, Sichuan, Bradford,

In China: Sinopec, DePuy/J&J, Paragon, Molex, AZ +…
In UK: Smith & Nephew, Autodesk, Sabic, +…
+ Clinicians from Beijing, Sichuan, Bradford,
We have built strongly on success. Following the **EPSRC Science Bridges China** and **Global Engagements** grants, ongoing collaborations include externally funded programmes awarded to our teams:

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<td>Introducing Talents from leading institutions or groups to Chinese Universities; Sichuan University, announced September 2012 (to 2017)</td>
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<td><strong>RCUK – MOST Joint Call</strong></td>
<td>Of April 2012, project announced December 2012: Biomaterials for Joint Soft Tissue Repair - Improving Health in Older Age; - Bradford, Sheffield, Durham, Sichuan, ICCAS;</td>
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<td><strong>EPSRC Centre for Innovative Manufacturing in Medical Devices</strong></td>
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<td><strong>EPSRC Capital for Great Technologies</strong></td>
<td>Award (total value £6.5m, including industry and University support) for Advanced Materials in Healthcare for facilities providing opportunities for international co-operation, 2014-17</td>
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**111 Programme - Introducing Talents**

A Programme for Introducing Talents from leading institutions or groups to Chinese Universities

1,000 leading scholars from top 100 Institutions in the world: To help to build 100 leading research bases in Chinese universities. Announced 12 September 2012:

**Sichuan University team:**
- Leader – Prof Guangxian Li
- Prof Qi Wang, Prof Q Fu, Prof Y Z Wang Prof LY Chu, Prof Z M Li, Prof C H Zhang, Prof S Y Guo, Prof. C.S. Zhao, Prof H.S. Xia, Prof Q. Yang, Prof J. Zhang, Prof Y.H. Chen

**International Team:**
- Leader Prof. P.D. Coates, Bradford University
- Prof. A. Bismarck, Imperial College London
- Prof. B. Hsiao, Stonybrook University
- Prof. L. Ambrosio, CNR-IMCB, Italy
- Prof. DA. Schiraldi, Case Western Reserve University
- Prof. P. Ducheyne, Univ of Pennsylania
- Professor S. Rimmer, Sheffield University (now Bradford)
- Dr B. Whiteside, Dr P. Caton-Rose, Dr P. Twigg

**UK team:**
- Our research focus is to fabricate a cell-conducting osteochondral implant scaffold; the material is a polyvinyl alcohol-based hydrogel nanocomposite. Initially the thrust of the research was to optimise the use of established experimental freeze-thaw techniques utilising Poly(vinyl alcohol) (PVA) and β-Tricalcium Phosphate (β-TCP). The objective is to produce a modified protocol to facilitate a robust testing of the dynamic, mechanical and biocompatibility of the scaffold material. Process variables have included a range of weight % (15-30) and low to high molecular weight (89-98 & 146-186) of the PVA.

**RCUK – MOST Joint Call, April 2012**

**Biomaterials for Joint Soft Tissue Repair**
**Improving Health in Older Age**

the only project funded from 37 applications, announced December 2012:
- Led by Dr Pete Twigg (University of Bradford) and Dr Chuhong Zhang (Sichuan University).
- University of Bradford: Dr Pete Twigg, Prof Phil Coates, Dr Colin Grant, Dr Fin Caton-Rose, Dr Leigh Mulvaney-Johnson, Dr Ben Whiteside;
- State Key Laboratory of Polymer Materials Engineering, Sichuan University: Dr Chuhong Zhang, Prof Qi Wang, Li Li, Ning Chen, Xi Wang, Xiao Chen, Yujun Yang, Jun Zhu, Huan Wang, Jia Wan;

**University of Bradford:**
- Dr Aileen Crawford
- Dr Aileen Crawford

**China:**
- Dr Junjie Wu
- Dr Xiaofang Wang

**Budget:**
- Total: 9 million RMB in 5 years (renewable) - National Budget: 450m RMB; SCU supporting fund: 450m RMB

**Research co-operation areas:**
- 1. New theories and technologies in polymer processing
  - Evolution and controlling of multi-level-structures in polymeric materials during processing
  - New theory and technology for micro-processing
- 2. High performance and functional polymeric materials
  - High-performance materials based on common polymers’ environment friendly polymer materials
  - Environment friendly polymer materials

**Osteoarthritis** is a currently incurable condition and a leading cause of functional disability and loss of independence in older adults globally, causing significant economic impact (1-2% GDP). This project proposes a novel cell-conducting osteochondral implant for the treatment of osteoarthritis and traumatic lesions of articular cartilage, which have a similar prevalence in Chinese and Caucasian populations. The implant is a polyvinyl alcohol-based hydrogel nanocomposite, which exhibits compositional/structural regions that mimic the appropriate biomechanical properties of the different regions of native tissue (i.e. subchondral bone, mineralised cartilage and cartilage) and support regeneration of cartilage tissue in situ. This implant should extend the pain-free function of osteoarthritic joints, thereby enhancing patient quality of life and mobility while reducing patient demands on health and social support services. In addition, the need for total joint replacement, with its potential problems of prosthesis loosening and limited lifespan, would be delayed.

This collaboration brings together the requisite multidisciplinary and complementary strands of research, and essential scientific expertise, from the partner institutions into a world class team to conduct the project. The proposal builds on links made through the existing RCUK Science Bridges China programme and will receive additional support through the RCUK Global Exchanges programme.

**UK team:**
- Our research focus is to fabricate a cell-conducting osteochondral implant scaffold; the material is a polyvinyl alcohol-based hydrogel nanocomposite. Initially the thrust of the research was to optimise the use of established experimental freeze-thaw techniques utilising Poly(vinyl alcohol) (PVA) and β-Tricalcium Phosphate (β-TCP). The objective is to produce a modified protocol to facilitate a robust testing of the dynamic, mechanical and biocompatibility of the scaffold material. Process variables have included a range of weight % (15-30) and low to high molecular weight (89-98 & 146-186) of the PVA.

Varying the composition of the hydrogel and also the cross-linking is attributable to a change in the functionality of a polymer that can alter the results obtained from Dynamic Mechanical Analysis (DMA). The hydrogel is a viscoelastic substance; to investigate the viscous and elastic characteristics when undergoing deformation both storage modulus (E’),elasticity and loss modulus (E”) viscosity are to be investigated from the Macro (dynamic compression & torsion), Micro (nanoindentation) and nano (AFM) DMA perspective. A Bose Electro Force 3200 was the apparatus utilised to produce DMA data from the hydrogel. The sinusoidal stress was pre-set to represents a physiological frequency range 0.1-10Hz (walking mode = 1Hz). The recent delivery of a Biomomentum Mach-1 will facilitate additional torsion tests of the hydrogel. The significance of this new apparatus will be to apply a torsional stress that should allow the study of the intrinsic material properties with reduced fluid exudation from the material. This new data will be compared to the previous compression testing.

Future work includes the fabrication of a functionally graded material with a modulus range of approximately 1000X between the extremes of the material. This is necessary to mimic the properties of both cartilage and subchondral bone.

**Sichuan** are researching material combinations, including...
PVA / Bioceramics Composites Prepared by Solid state shear milling (S3M) & Thermal Processing; PVA / Gel / Bioceramics Composites Prepared by S3M & Thermal Processing and Thermal Foaming of PVA / Bioceramics Composites. By combining our two developed technologies, thermal processing of PVA and S3M, PVA/bioactive particle composites have been successfully prepared, particle content can reach to 40wt%. The in-situ degradation of collagen fibers to gelatin during thermal processing has been achieved, greatly improving the thermal processability of PVA/bioactive particle composites; Using water as physical blowing agent and bioactive particles as nucleating agent, PVA foams with uniform porous structure have been prepared. These materials have potential applications in the biomedical field, e.g. soft tissue repair.

ICCAS are researching bioactive nanoparticles with well controlled structure, particularly exploring gradient biomaterials for cartilage repair with bioactive glass particles, and polymer-particle interactions.

Deformation and Fracture Behavior of Polymer Materials
Dr Zhiyong Jiang of Changchun CIACAS, March 2014

Research undertaken: the research focuses on the relationships between nanostructure and macroscopic mechanical properties in polymeric materials, in particular with respect to the effects of processing length scales from micro to macroscopic moulding.

Original objectives of the award and subsequent main achievements: our original objectives are to explore the role of tie molecules in the tensile deformation and fracture behavior of polymer materials and provide a whole picture of the mechanisms and laws controlling deformation and fracture in the solid polymeric products. The main achievements of the project include:
(a) A series of samples were fabricated via processing at different length scales from micro to macroscopic injection moulding under various moulding conditions (varying injection velocity, melt temperature, and mold temperature), including poly(ε-caprolactone) (PCL) and its miscible blends with noncrystallizable poly(styrene-co-acrylonitrile) (SAN) in different proportions, polyethylene, and polypropylene.
(b) The structural evolution of macroscopic moulded PCL was investigated as a function of deformation ratio and crystallization temperature using an in situ synchrotron small-angle X-ray scattering (SAXS) technique. The correlation between the cavitation and the plastic deformation of lamellar crystals as well as their influence on the deformation behaviour of PCL were elucidated based on the SAXS observations. At small deformations, intralamellar crystalline block slips and fragmentation of lamellae greatly stimulated the generation of cavities with their normal perpendicular to the stretching direction, which in turn promoted crystallite shearing quite remarkably during stretching. The oriented cavities with a major axis dimension of several hundreds of nanometers were found to assemble in the interfibrillar regions even at moderate strains where the stress-induced fragmentation and recrystallization just sets in. Accordingly, the long spacing of the newly developed lamellae remained essentially constant after the lamellar-to-fibrillar transition, regardless of the degree of cavitation which occurred in the samples. Upon further deformation the cooperative deformational behavior mediated via slippage of fibrils (stacks of lamellae with their normal parallel to the stretching direction) was evidenced. The extent of this slippage depended on the crystallization temperature, which could be traced back to the significantly different coupling forces imposed by chains connecting adjacent fibrils. The interaction between fibrils decreased with increasing crystallization temperature due to cavities acting as an effective diluent of the interfibrillar entanglements thus increasingly facilitating further sliding of the fibrils leading finally to more shrinkage of the stretched interlamellar amorphous layers during stretching.
(c) The microstructure and deformation behavior of micro-molded PCL/SAN blends were studied as a function of blend composition and melt temperature. It was found that the melt temperature during injection moulding plays a dominant role in determining the mechanical property of the blends. As it appears, the mixtures molded at a melt temperature of 100 oC show brittle fracture under tensile deformation, whereas the samples molded at a melt temperature of 180 oC exhibit ductile behavior apparently. Subsequently, a structural characterization of the different blends was carried out by SAXS. As was found, an injection moulding-induced phase separation between PCL and SAN occurs in the blends molded at a melt temperature of 180 oC. Moreover, the crystalline lamellae of the blends molded at a melt temperature of 100 oC display a higher degree of orientation as compared to those processed at a melt temperature of 180 oC thus leading to a smaller elongation at break. The discrepancy between the degrees of orientation derived from the two sets of blends is due to the fact that the incorporation of SAN practically affects the state of the PCL amorphous phase. In the case of samples molded at a melt temperature of 100 oC, the interactions between lamellae become weaker because of a significant decrease of concentration of tie molecules and an increase in the concentration of chain ends that may easily be freed during deformation, and thus resulting in a less extent of relaxation of lamellar crystals upon solidification from the melt.

In summary, a major part of the original work programme submitted in the application form has been completed during the visit. For example, samples with different crystalline morphology and aggregation structure were obtained through controlled shaping operations. Extensive investigations on the mechanical properties of the as-received products have been carried out utilizing true stress-strain measurements. Additionally, the influence of processing conditions and tie molecule density on the deformation behavior has been unraveled by SAXS.
The focus of the proposed research is understanding and control of polymer morphology via melt and solid phase orientation processing routes to obtain enhanced product properties. We focus on commercially available polylactic acids (PLA) and polyolefins, which are of interest for their biomedical and mechanical applications.

**Objectives**

(i) to understand hierarchical process structuring during micro moulding and die drawing of typical semi-crystalline polymers;

(ii) to build relationships between morphology and mechanical properties of specially structured polymer products;

(iii) to establish inter-linkages among polymer molecular parameters, processing conditions and mechanical properties for tailor-making smart polymeric products out of ordinary materials using the advanced processing technologies.

**Programme:** September 2015- September 2018.

**Budget:** £111k from the Royal Society Newton Fund.

**Expert Support** includes Fin Caton-Rose, Ben Whiteside, Tim Gough and Glen Thompson; Yuqing Lai, Zhiyong Zhang, Jidong Zhang.

Bradford die-drawing equipment installed in the X-ray beam line at Changchun CIACAS, with world-first in-situ SAXS and WAXS measurements of structure changes (below); also our micromoulding machine for in-situ beam experiments (with high speed thermal imaging) commissioned at Bradford.
Research Workshops have proven to be a major vehicle for development of our community, along with Researcher Exchanges.

At the Workshops, technical information is presented by senior and early career researchers, and collaboration plans and bids are discussed. These began under the Science Bridges China grant, but have continued outside of that funding, which is a testimony to the strength of our ‘People Bridges’

1. Beijing, 14-15 November 2011 co-hosted by BUCT and Bradford
2. Chengdu, 19-21 April 2012 co-hosted by Sichuan and Bradford
4. Chengdu, 25-26 March 2013 co-hosted by Sichuan and Bradford
6. Beijing, 5-6 May 2014 co-hosted by ICCAS, BUCT and Bradford
7. Bradford, 8-10 September 2015, co-hosted by UKIERI
8. Chengdu, 6-8 December 2016, Newton Researcher Links/Sichuan-Bradford

These were preceded by our People Collaboration Programmes in 2008-9, with:
• EPSRC Virtual Institute for Polymer Process Structuring (VIPPS) meeting at Bradford, 15-20 September 2008
• EPSRC VIPPS meeting in Chengdu, 23-25 March 2009 and special events:
• Science Bridges China Launch, Royal Society London, 2 February 2010
• Shanghai Expo ‘Celebrating Friendship with China’, UK Pavilion, 23 Sept 2010

By bridging the excellence we have, and the excellence in China, we can actually add value to both nations’ future potential.

Professor Peter York

with Sunan Jiang, Chinese UK Embassy Minster Counsellor for Science, at PPE‘15/AMRI 7, Bradford September 2015:
We had a most enthusiastic input to our Researcher Links Workshop ‘Healthcare Technologies for Aging Populations’ in Chengdu (see www.ukchina-amri.com), with 35 early career researchers (ECR) from 11 UK universities and 7 Chinese institutions, supported by 6 Sichuan and Bradford mentors. These were complemented by 7 (six Chinese, one UK) research leaders supporting this workshop, plus 2 Sichuan Province and 4 UK government representatives.

Building on our Science Bridges China platform’s 9 previous Workshops, it was particularly exciting to see the energy and commitment from all attendees with the focus on ECRs. They all shared expertise and looked enthusiastically for new research collaborations via:

- technical presentations in themes of biomedical materials for tissue repair, biomechanical/medical technology, incorporating actives and generic issues, each with 2 keynotes from research leaders/mentors;
- group activities on healthcare context and Early Career Researcher career needs, and
- a workshop session on Creating and Taking Opportunities, including funding routes and a Mentor Panel for advice.

This led to 25 excellent bids for 8 Researcher Exchanges we had secured as a very distinct output from the Workshop - supported by the Polymer IRC Bradford and our EPSRC MeDe Centre of Innovative Manufacturing in Medical Devices. This has been expanded by support from our 5 core Chinese institutions, so at least 13 research exchanges will occur. Prof Xia wrote they “shared with each other their excellent work to create innovative ideas based on their research strength. Phil carried a bag of ideas to UK. Those ideas are our future!” That is so true — and we are strongly committed to the next generations of researchers and leaders, and the Workshop. Excellent visits to the Sichuan host laboratories, a medical device company, and the panda research station added much value. The warmth of Sichuan hospitality and its wonderful food made a great impact!

The Science Bridges China (led by Bradford) and MeDe Innovation (co-directed by Bradford) networks has been constructively expanded in terms of the range of UK universities involved. It was a very harmonious team effort, built on the warmth of previous collaborations, to mutual benefit. It added further opportunities for co-operation for us in China, through the involvement (keynote, plus lab visit) of the National Engineering Research Centre in Biomaterials, Sichuan University.

Senior mentors from 4 leading Chinese groups (ICCAS, Changchun CIACCAS, SIMMCAS and BUCT, +1 extra from Bradford), came at their own expense, adding much extra value to the mentors, and the ECR attendees. We appreciate greatly and will build on this warm expression of co-operation. A range of other outcomes (including joint grant bids and other co-operations such as sharing materials and facilities) are being pursued. Also, support for other visits will come via other routes, e.g. our Royal Society Newton programme, and some Chinese institution schemes.

Professor Hesheng Xia
British Council Newton/NSFC Researcher Links Workshop
for Early Career Researchers

2016 China-UK Researcher Links Workshop on Healthcare Technologies for Aging Populations
December 5–8, 2016, Chengdu

Organized by
State Key Laboratory of Polymer Materials Engineering
Polymer Research Institute of Xi’an Jiaotong University, China
department of polymer

[Image of workshop participants]
Bradford Polymer IRC - China Joint Research Laboratories

Joint International Laboratory for Polymer Micro Processing, with SKLPME, Sichuan University, 2010:

Prof Wang, Prof Guangxian Li, Prof Phil Coates and Prof Qi Wang unveiling the plaque

This Joint Laboratory received MOST approval in 2014 as a top level laboratory for international co-operation in China
Joint International Laboratory for Polymer Process Physics, with Changchun Institute of Applied Chemistry, CAS – September 2015:

Prof Coates & Prof Xianiu Yang, Bradford & Changchun teams at the 7th UK-China AMRI Research Workshop, Bradford, Sept 2015

Joint International Laboratory for Soft Matter Technologies with Beijing University of Chemical Technology, December 2016

Prof Phil Coates and Prof Liqun Zhang at the British Council Newton Researcher Links/ UK-China AMRI 8th Research Workshop, Chengdu December 2016
An excellent range of high quality journal papers – a growing pipeline – in strategic topics have arisen from the Science Bridges China/ UK-China AMRI platform, particularly through Researcher Exchanges and joint research programmes.

### 2018


### 2017

- X Lin, L Fan, D Ren, Z Jiao, P Coates, We Yang Enhanced dielectric properties of immiscible poly (vinyliden fluoride)/low density polyethylene blends by inducing multilayered and orientated structures Composites B Eng. DOI: 10.1016/j.compositesb.2017.01.065 2017


### 2016


- Li, Z ; Zhao, X ; Ye, L ; Coates, P D ; Caton-Rose, P ; Martyn, M, Structure and blood compatibility of highly oriented poly(lactic acid) chain extended by ethylene glycol diglycidyl ether Polymer 56; 523-534 DOI: 10.1016/j.polymer.2014.11.035, 2015

### 2015


- Li, Z ; Zhao, X ; Ye, L ; Coates, P D ; Caton-Rose, P ; Martyn, M, Fibrillation of Chain branched Poly (lactic acid) with Improved Blood Compatibility and Bionic Structure, Chem Eng J, 279 767–776, DOI: 10.1016/j.cej.2015.05.082 2015

- Y Gao, X Dong, L Wang, G Liu, X Liu, C Tuineba-Bobe, B Whiteside, P Coates, D Wang, C C, Han  Flow-induced crystallization of long chain aliphatic polyamides under a complex flow field: Inverted anisotropic structure and formation mechanism, Polymer; 73, 91-101; 2015 DOI: 10.1016/j.polymer.2015.07.029


- J Xue, M He, H Liu, Y Niu, A Crawford, P D Coates, D Chen, R Shi, L Zhang, Drug loaded homogeneous electrospray PCL/gelatin hybrid nanofibers for anti-infective tissue regeneration membranes, Biomaterials. 08/2014; 35(34):9395-9405. DOI: 10.1016/j.biomaterials.2014.07.060, 2014


- Chen Zhang, Xiujian Jiang, Zhiyuan Zhao, Lixin Mao, Ligun Zhang, Phil Coates Effects of wide-range gamma-irradiation doses on the structures and properties of 4,4'-dicyclohexyl methane disiocyanate based poly(carbonate urethane)
Journal Publications associated with the Science Bridges China/UK-China AMRI platform

**Journal of Applied Polymer Science (Impact Factor: 1.4).**


**2013**

H Kang, B Qiao, R Qang, Z W Qang, L Zhang, J Ma, P D Coates. Employing a novel bioelastomer to toughen polylactide. Polymer, doi: http://dx.doi.org/10.10.16/j.polymer.2013.02.053 (2013)


**2012**


## Researcher Exchanges

### China to UK – Science Bridges China supported

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<td>Dr Chen Ning</td>
<td>Sichuan University</td>
<td>UoB</td>
<td>Poly(vinyl alcohol)-based composite products for drug delivery</td>
<td>29/06/2011</td>
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<td>Dr Fei Guoxia</td>
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<td>Solid phase processing of PLA based blends and composites for blood-contacting medical devices</td>
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<td>Effects of ultrasound on molecular structure development and drug release behaviors of PLA</td>
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<td>Dr Zhao Xiaowen</td>
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<td>Electrically Conductive Polyurethane/Carbon Nanotubes Composites for Medical Microdevices</td>
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<td>Dr Dong Xia</td>
<td>ICCAS</td>
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<td>Orientation Study of PA1012 Material by Microinjeect Preparation</td>
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<td>Characterization of the spatial distribution of microinjection parts by micro-beam X-ray scattering</td>
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<td>Structure and Properties of Micro-Molded Poly(β-caprolactone) and Its Miscible Blends</td>
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<td>Dr Gao Ying</td>
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<td>Correlation between Thermal Analysis and X-ray Diffraction of Micro Moulding Polypropylene</td>
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<td>Dr Lin Xiang</td>
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<td>Geometrical dependence of shear viscosity in capillary flowing: slip behaviour and pressure sensitivity</td>
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<td>Dr Bai Shibing</td>
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<td>Preparation of Waster PP/PE Material with High Performance by Pan-milling and Biaxial Stretching</td>
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<td>taste masking, architecture of DDS and extrusion materials</td>
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<td>Ms Guan Yinyan</td>
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<td>Highly Branched Poly(N-isopropyl acrylamide) Copolymers with Imidazole End Group</td>
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<td>Rheology of polymers for extrusion based micro-channel production</td>
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<td>Electros spun Anti-inflammation Drug-loaded Guided Tissue Regeneration Membrane</td>
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<td>Establishment of Evaluation and Prediction Models for Properties of Compounds based on QSPR</td>
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<td>Capillary Rheology, Die drawing (biaxial), Rotational Rheology, and actuator and micro sensors with dielectric materials in seeking potential application of microinjection for the constructions of micro sensors</td>
<td>08/03/2015</td>
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Ms Wang Lili ICCAS UoB investigation of the microstructure distribution and crystallization transition of micro-injection long chain polyamide alloys 06/04/2015 26/04/2015

Mr Yin Xianzhen SIMM UoB micro-needles array preparation 09/09/2015 19/09/2015

Ms Cui Yang ICCAS Nottingham University* Manufacture, Characterisation, and Investigation of Particles on a Precisely Defined Scale 31/05/2016 30/06/2016

Ms Ren Huihui ICCAS Newcastle University* Development and characterisation of a hybrid composite structure April 2017

Miss Pu Wuli Sichuan University University of Sheffield* Utilising 3D printed conductive polyurethane/carbon nano-tube composite as a template for patterned electrospinning 03/07/2017 03/08/2017

Mr Fu Dahuia Sichuan University UoB/Southampton The Polymer Graphene Nano Composite Electrode for Wearable Stroke Rehabilitation 06/07/2017 04/08/2017

Mr Liu Yalong Sichuan University UoB Preparation of PLA bone fixation material through solid hot stretching microfibrillation and its biological properties 13/07/2017 11/08/2017

Mr Meng Yeqiao Sichuan University UoB/Leeds High strength PVA composites for osteochondral implantation 13/07/2017 11/08/2017

Miss Chen Rong Sichuan University UoB High strength PVA composites for osteochondral implantation August 2017

*Partially supported by EPSRC MeDe Centre for Innovative Manufacture of Medical Devices

Chinese Scholarship Council Awards

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<td>Structure-Property Relationship of Polymer Nanocomposite under Micro-Processing Conditions</td>
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<td>Prof Yang Qi</td>
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<td>Study on HDPE/UHMWPE blends through Die drawing method</td>
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<td>Functional polymer devices</td>
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<td>Dr Lin Xiang</td>
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<td>Processing and Characterisation of Multi-Functional Polymer Composites</td>
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Royal Academy of Engineering Research Award

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### Sichuan Province International Scientific and Technological Cooperation and Exchange Project
(Prof Lin Ye and Dr Fin Caton-Rose)

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<td>High microfibrillation of PLA bone fixation material and its biological properties</td>
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### Royal Society Newton Advanced Fellowship
(Prof Yongfeng Men of CIACCAS and Prof Phil Coates of UoB, 09/2015-09/2018)

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<td>Advanced processing physics of micro molding and die drawing of polymers for control of properties</td>
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<td>Dr</td>
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Science Bridges China is very visible with UK and Chinese central and local governments.

Our meetings include:

Ministry of Science & Technology:
Regular meetings with Dr Longchao Zhou, Director for Europe, MOST Beijing (accompanied by Prof Liqun Zhang); and with

Chinese Embassy UK, Minister Counsellors for Science, Dr Futao Chen and Dr Sunan Jiang

RCUK and Science & Innovation Network
Regular meetings with Grace Lang, Holly White, Karen Maddocks and team, in the UK Embassy, Beijing

December 2013 UK Government visit to China
– Science Bridges China/ UK-China AMRI feature strongly.

UK Science Minister, David Willetts had a meeting on Innovation in Shanghai on 3 December 2013. Prof Jiwen Zhang of SIMM CAS was a member of the discussion panel at this event.

On 4 December the UK Science Minister visited Sichuan University, hosted by Prof Guangxian Li. Prof Li and Prof Phil Coates gave a joint presentation on the strong cooperation between Bradford and Sichuan, emphasising the value of the Science Bridges China platform, and UK-China AMRI. The visit coincided with the launch of the Newton Fund.

On both occasions, the Minister was accompanied by a group of UK Vice Chancellors and government officials.
The internationally leading nature of the Polymer IRC and our UK-China AMRI is reflected in a range of prestigious international and national awards.

**International Awards (Prof Coates)**

2015  Tian Fu Friendship Award, of the People’s Government of Sichuan Province (first ever awarded)


2017  James L White Innovation Award of the International Polymer Processing Society, the top award of the PPS for leading achievement in polymer innovation

2018  Society of Plastics Engineers International Award, the top award of the Society, for lifetime achievement in polymer engineering
2018 International Science & Technology Cooperation Award of the People’s Republic of China, presented by President Xi Jinping

The award; pre-meeting of awardees with President Xi Jinping and the full leadership team of the PR China

Award Ceremony in the Great Hall of the People

Outside the Great Hall - with great support from Chinese colleagues, Prof Hesheng Xia, Prof Guangxian Li, Prof Liqun Zhang and Prof Yongfeng Men

Medal presentation by Vice President, Madam Liu
Relevant Personal Awards

Prof Phil Coates:
• 2008 Honorary Professor Sichuan University
• 2008 Molecular Sciences Forum Professor, Chinese Academy of Sciences, Institute of Chemistry, Beijing
• 2009 Honorary Professor Beijing University of Chemical Technology
• 2010 Famous Overseas Scholar, Ministry of Education, China / Sichuan University
• 2011 Top Foreign Expert of the State Foreign Experts Bureau
• 2012 Changchun Institute of Applied Chemistry, Chinese Academy of Sciences honorary lecturer

Prof Qi Wang:
• 1999 Cheung Kong Scholar, MoE China
• 2012 Honorary Professor, University of Bradford, 2012
• 2016 18th WIPO and SIPO golden award for Chinese outstanding patented invention
• 2017 Academician of the Chinese Academy of Engineering

Prof Liqun Zhang:
• 2005 Cheung Kong Scholar, MoE China
• 2012 Spark-Thomas Award, ACS Rubber Division
• 2012 Asia Research Award, Society of Chemical Engineering Japan
• 2014 Morand Lambla Award, Polymer Processing Society

Prof Dujin Wang:
• 2007 PetroChina Technology Innovation Award
• 2009 Science and Technology Progress Award of Beijing Municipal
• 2012 Science and Technology Progress Award of Beijing Municipal

Alan Glanville Award of the Institute of Materials, Minerals & Mining
• 2008 – Qi Wang et al, Sichuan
• 2012 – Liqun Zhang et al, BUCT
• 2014– Yongfeng Men et al, Changchun
• 2016 – Hesheng Xia et al, Sichuan

Science Bridges China team awards

• 2008 RCUK Bradford Science Bridges China top ranked bid
• 2008 UKTI/Y&H China Business Award – Best Education
• 2011 Interdisciplinary Working Award, Bradford University
• 2014 Vice Chancellor’s Award for Outstanding Achievement, University of Bradford

Funding awards

Some key awards include:

• 1989-2000 IRC in Polymer Science & Technology original award (£23m)
• 2007-9 EPSRC Virtual Institute - Polymer Process Structuring, with China (£0.23m)
• 2008 -12 RCUK Science Bridges China - top ranked award (£1.25m)
• 2012 EPSRC Global Engagements: China (£0.5m)
• RCUK-MOST 2013-15 (Bradford, Sheffield, Durham, Sichuan, ICCAS) (£0.2m)
• 2013-2017 111 programme (Sichuan/ Bradford, + international team (USA, Europe, led by Bradford; (9m RMB)
• 2013- 2018 EPSRC MeDe: UK Centre of Innovative Manufacturing in Medical Devices (Leeds, Bradford, Newcastle, Nottingham, Sheffield Universities; (£5.7m)
• 2013 - 2021 Sinopec BRICI polymer orientation (£0.68m)
• 2014-2024 EPSRC Capital Grant: Advanced Materials for Healthcare (£5.42m including £2m UoB)
• 2015-18 Royal Society Newton Advanced Fellowship with Prof Men, Changchun; (£0.11m)
• 2018-21 EPSRC Healthcare Innovation Partnership (£1.1m)
• 2009-12 Design, Preparation and Micromolding of Polymer Nanocomposites for Medical Application” International S & T Cooperation project of MoST, China (0.95m RMB)
• 2010-2013 Preparation and application of high performance biodegradable polymer nanomaterials, International S & T Cooperation project of MoST, China (0.9m RMB)
• 2013-2017 Study on the structure controlling and properties of block copolymers, Major International (Regional) Joint Research Project of NSFC, China 51210005, (2.8m RMB)
• 2012-2016 Fundamental research on crystallization of polylactic acid under external processing using synchrotron radiation Major International (Regional) Joint Research Project of NSFC, China, Sichuan Province (0.5m RMB)
• 2016 China-UK Bilateral Conference in Healthcare technologies for aging populations NNSFC (5151101507) (0.2 m RMB)
The Polymer Interdisciplinary Research Centre at Bradford offers internationally leading Polymer Research; genuinely interdisciplinary, with major academic collaborations worldwide, and strong industrial involvement in our research.

The Polymer Interdisciplinary Research Centre was founded in 1989 as a focal point for UK polymer science & engineering, supported by an EPSRC grant of £23m to the Universities of Leeds, Bradford and Durham, over its first 11 years. It formed a critical mass network of leading polymer scientists and engineers, with research interests across advanced materials including soft matter, nanocomposites, biomaterials, with strong UK and International links.

The world-class Polymer IRC research centre at Bradford has 16 processing laboratories (including a suite of 3 clean rooms), 6 materials preparation and characterisation laboratories, a computer modelling centre and large conference room. Processing capabilities include 10 injection moulding machines – emphasising ultraprecision moulding - over 20 extrusion lines, and 10 unique solid phase orientation processing lines; 10 3-d printers; electrospinning and cell culture. Materials characterisation includes TEM, AFM, X-ray, spectroscopy, rheometry, thermal and chemical techniques; product characterisation across the length scales includes surfaces via AFM, confocal laser microscopy, WLI, Raman surface mapping, and energy; physical properties from micro to macro scale – nanoindentation, micromechanical, micro CT, wear. In-process metrology features strongly, with many techniques pioneered in our laboratories, and includes precision optical and thermal imaging (both to ultra high speed).

Professor Phil Coates FREng is the overall Director of the Polymer IRC, based at Bradford in the Faculty of Engineering & Informatics, and Director of the Advanced Materials Engineering RKT Centre. Professor Ben Whiteside is Director of the Polymer Micro & Nano Technology RKT Centre, and Professor Anant Paradkar is Director of the Pharmaceutical Engineering Sciences RKT Centre (hosted in the Faculty of Life Sciences). Over 50 research staff at Bradford are involved in our programmes.

We are delighted to have taken the following major steps since 2014:

1. The EPSRC Capital grant (£3.42m, with a further £3.1m from industry and the University) for new processing and characterisation facilities for advanced materials for healthcare, early 2014.
2. Recladding and re-roofing of the laboratories, around £3m in 2014-15.
3. Materials Chemistry adding to the strength of the Polymer IRC in Bradford, summer 2015;
4. A Joint International Laboratory for Polymer Process Physics was formed in September 2015 between Changchun Institute of Applied Chemistry CAS and the Polymer IRC;
5. Xplore have placed a PMS specialist compounding and film processing line in our laboratories, particularly for pharmaceuticals processing, in 2016
6. A significant donation of biomedical polymer equipment was made to our laboratory by Smith & Nephew Ltd, 2016
7. A Joint International Laboratory for Soft Matter Technologies between Beijing University of Chemical Technology and the Polymer IRC at the University of Bradford, was announced in December 2016
8. 3 major International Awards in 2017 and 2018.
A coherent, internationally leading Polymer Research Laboratory; genuinely interdisciplinary, with major academic collaborations worldwide, and major industrial involvement in our research

Polymer IRC science structure and some collaborative links
Polymer IRC

Polymer IRC continues as a network of the core Universities, with other associated UK and international universities

www.polymerirc.org  www.polyeng.com
Research philosophy:

We structure polymers in a controlled way via the manufacturing process, to control and enhance final product properties or functionalities (‘process structuring’ - see below). The Polymer IRC laboratories at Bradford have been built on pioneering in-process measurements, which are vital for developing understanding of the way in which polymers behave during processing in relation to their molecular structure and the associated kinetics of long chain molecules as they reptate in the melt, then change on cooling to the solid state to particular crystalline or amorphous morphologies in extruded or moulded products - but having been subjected to imposed process variables such as stresses, strains, heat fluxes, with their own dynamics. The interaction of material kinetics and process dynamics produces the final product properties.

In-process measurements are vital to our understanding and control of polymer processing operations. We have pioneered in-situ measurements including pressure, IR temperature, thermocouple grids, ultrasonic velocity and transit time for bulk melt flows, visualisation of melt free surfaces, rheo-optical and thermal imaging of process flows, in-situ IR, MIR and UV-vis spectroscopy and in-situ SAXS and WAXS; imaging metrology for polymer deformation and solid phase processing and surface feature assessments.
The Polymer IRC hosts three University RKT Centres. Advanced Materials Engineering, Polymer Micro & Nano Technology and Pharmaceutical Engineering Science. These deliver into focussed areas, but have coherent research activities across discipline boundaries. All pursue the controlled structuring of polymers and polymer-related materials through processing, to achieve enhanced property products.

**Advanced Materials Engineering**  
*(director Prof Phil Coates)*  
Research focusses on structuring advanced polymeric and biomedical materials via processing, and modelling, for:
- high added-value products and methodologies and therapies aimed primarily at health and wellbeing, and
- resource efficient materials, enhancing the value of feedstocks.

The AME Centre builds on ‘smart materials’ expertise associated with the Polymer IRC and beyond, into the growth areas of medical and biomedical products and advanced materials for other high added value applications, and the developing area of sustainable materials. Unique, world-leading capabilities include precision solid phase orientation processing of polymers in a variety of profiles, from high precision oriented tubes for arterial stents to structural building products. Typical medical/biomedical products include bioresorbable or non-resorbable shape memory polymer orthopaedic components for joint repair or replacement, stents for vascular repair, spinal braces, structured films for wound dressing, precision tubing, medical devices and components, and medical packaging. These may also include active pharmaceutical ingredients, e.g. aimed at drug eluting implants. Sustainable material products include novel acoustic materials made from recycled polymers, and smart incorporation of recyclates into conventional products for lower carbon footprint.

See [https://www.bradford.ac.uk/research/kt-centres/advanced-materials-engineering](https://www.bradford.ac.uk/research/kt-centres/advanced-materials-engineering) for more details.

**Polymer Micro & Nano Technology**  
*(director Prof Ben Whiteside)*  
Polymer Micro & Nano Technology (MNT) is a world-class facility within the Polymer IRC laboratories at the University of Bradford, with research in ultraprecision polymer processing, especially micro injection moulding (micromoulding), simulation, in-situ characterisation and measurement techniques. Micromoulding has developed rapidly for micro-component manufacture or surface feature moulding, offering high production capacity at low marginal cost, with wide applications in healthcare, telecommunications, energy and consumer goods. Extensive in-process measurement techniques include high speed thermal and optical imaging in-situ in micromoulds, optical and mechanical product metrology, including bespoke product characterisation. Key areas of expertise are in: moulding of microscale features; nano-structured surfaces; nano-fillers compounding and processing; metal/ceramic powders; materials characterisation, product measurement; and inspection systems. Applications include: Medical devices, including dental obturation points, eye surgery devices, implants, microneedles; micro-optics; and integrated micro devices.

Polymer MNT helps develop new and improved micro and nano-components in a range of materials via process optimisation, tool design, proof of concept and low volume manufacture. The Polymer MNT collaborative network is an interdisciplinary partnership with colleagues from academia and industry. See [https://www.bradford.ac.uk/research/kt-centres/polymer-mnt](https://www.bradford.ac.uk/research/kt-centres/polymer-mnt) for more details.

**Pharmaceutical Engineering Science**  
*(director Prof Anant Paradkar)*. The Centre for Pharmaceutical Engineering Science (CPES) is an interdisciplinary research and industrial collaboration centre, with expertise across the pharmaceutical sciences, chemistry and polymer engineering disciplines. The Centre has core capabilities in the areas of preformulation analysis including solid state screening, pharmaceutical and healthcare formulation development, drug delivery systems, enabling process technologies including melt processing, proprietary innovative technologies and Process Analytical Technology (PAT) and Quality by Design (QbD) approaches to pharmaceutical and healthcare product development.

Research activity is focused on design of novel formulation technologies for the development of enhanced pharmaceutical and related products, together with process optimisation in the niche areas related to advanced pharmaceutical materials. We offer expertise and access to a range of proprietary and enabling technologies to a range of industrial sectors including nutraceuticals, health and personal care, foodstuffs and medical devices. The centre also has a focus on developing innovative green technologies specialising in waste and solvent reduction, energy efficiency and optimisation of processes.

The CPES has established links with research laboratories within the UK, Europe, USA and Canada as well as China and India. See [https://www.bradford.ac.uk/research/kt-centres/pharmaceutical-engineering](https://www.bradford.ac.uk/research/kt-centres/pharmaceutical-engineering) for more details.

**Materials Chemistry**, led by Professor Stephen Rimmer, became a fourth research centre in the Polymer Interdisciplinary Research Centre at Bradford, in 2015. Prof Rimmer (previously at Sheffield University) is a long-standing collaborator, having been involved in all of our Science
Bridges China/ UK-China AMRI Research Workshops. He is a Board member of the UK China AMRI. Aspects of Steve’s work and that of his team can be found at [http://www.brad.ac.uk/life-sciences/chemistry-and-forensic-sciences/research/](http://www.brad.ac.uk/life-sciences/chemistry-and-forensic-sciences/research/).

The Polymer Science activity is focused on the synthesis and properties of functional polymers. Research in Chemistry includes:

- Nanoscience
- Medicinal Chemistry (our Institute of Cancer Therapeutics, is heavily involved in the Science Bridges China/ AMRI platforms)
- Polymer Science
- Functional Materials
- Crystal Engineering and
- Analytical Chemistry.

Functional polymers are produced using a variety of methods including radical, cationic and ring-opening polymerisations as well as step-growth techniques such as polyurethane synthesis. We also make extensive use of polymerisations in disperse media; such as emulsion polymerisations. Recently, one of our focuses has been on producing functional hydrogels to support cells for applications in tissue engineering.

Here our aim is to control cells as they develop and grow and to examine how the structure of the materials affects performance and cell compatibility. Another strong theme is to use functional polymers to detect pathogens in infective diseases and here we are developing unique medical devices for use at the point of care.

The Polymer IRC world class facilities were further enhanced by a major EPSRC Capital award which has seen extensive processing and characterisation facilities installed in our laboratory which promote the interdisciplinary working across Engineering and Life Sciences. Also, industrial donations including extensive biomedical materials extrusion and drawing facilities from Smith & Nephew Ltd (FET fibre line and Rondol fibre drawing frame, Prism extruder) and an Xplore PMS stainless steel conical twin screw extruder and film line, aimed primarily at pharmaceuticals processing.

A key feature of the Polymer IRC at Bradford is our extensive international presence, collaborating with many leading overseas partners in Europe, India, the USA and especially China. The Science Bridges China platform led to the formation of the UK-China Advanced Materials Research Institute, and we have over 300 leading UK and Chinese academics actively involved in joint research projects, research exchanges, and Joint Laboratories.

The Polymer IRC at Bradford has three Joint International Research Laboratories in China.

The first of these was formed with Sichuan SKLPME for Polymer Micro Processing in 2010, and was formally approved by MOST in 2014. It is directed by Prof Coates and Prof Qi Wang, with Prof Xia and Prof Whiteside), and we have achieved a range of joint research grants, high level publications, patents, awards and many researcher exchanges, including Chinese Scholarship Council awards. Prof Coates is an Honorary Professor of Sichuan and Prof Wang is an Honorary Professor of Bradford.

The second Joint Laboratory was formed with Changchun CIACCAS for Polymer Process Physics in September 2015, directed by Prof Coates and Prof Xianiu Yang and Prof Yongfeng Men, with Dr Caton-Rose and Prof Whiteside. We have excellent joint programmes, especially Royal Society Advanced Fellowship funding, and high level publications.

These were complemented in December 2016 by the new Joint International Laboratory for Soft Matter Technologies with BUCT – directed by Prof Liqun Zhang and Prof Phil Coates. We already have research exchanges, and excellent joint publications with Prof Zhang’s team and Prof Coates is an Honorary Professor of BUCT. We look forward to joint programmes!

These laboratories are promoting our research collaborations and joint publications of leading research. They continue to provide a major platform for collaborative ventures and joint funding, and promote our international visibility.

### Web sites

- [www.polyeng.com](http://www.polyeng.com) - our main site, with full information and links
- [www.polymerirc.org](http://www.polymerirc.org) - includes the original Polymer IRC web site
- [www.ukchina-amri.com](http://www.ukchina-amri.com) - our UK China Advanced Materials Institute
- [www.sciencebridgeschina.com](http://www.sciencebridgeschina.com)

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**International**

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**Science Bridges China**

[www.sciencebridgeschina.com](http://www.sciencebridgeschina.com)

**GLOBAL ENGAGEMENTS**

**UK-CHINA AMRI**

Advanced Materials Research Institute

**Joint International Laboratories**

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- [www.polymerirc.org](http://www.polymerirc.org) - includes the original Polymer IRC web site
- [www.ukchina-amri.com](http://www.ukchina-amri.com) - our UK China Advanced Materials Institute
- [www.sciencebridgeschina.com](http://www.sciencebridgeschina.com)
www.polyeng.com is the ‘gateway’ website to all of our sites, and contains much information about our laboratory and capabilities.

www.ukchina-amri.com is the web site dedicated to the UK-China AMRI, and includes all of the Researcher Profiles and other useful information about the extensive UK-China collaborations.
www.sciencebridgeschina.com is the University of Bradford hosted web site reflecting our UK-China collaborations, and the two Faculties (Engineering & Informatics and Life Sciences) involved at Bradford.

www.polyeng.com/ukieri provides brief information about our links particularly with the Institute of Chemical Technology Mumbai and the CSIR National Chemical Laboratory, Pune.
www.mede-innovation.ac.uk is the web site of the UK's EPSRC Centre for Innovative Manufacturing in Medical Devices, a 5-university consortium for leading edge research.

www.short-term4china.org.uk is a web site operated for an Amity Foundation Summer English Programme (Jane Coates) which we support – aimed at teaching English curacy to Chinese schoolteachers of English, in areas away
1. Some links with China 2008-9
A brief indication of the foundational programme which began to build the community which became the Science Bridges China/UK-China AMRI.
People Collaboration: EPSRC Virtual Institute for Polymer Process Structuring (VIPps) 2008-9. This is followed by a pictorial booklet produced to capture the early days of the development of our UK-China community. Early involvement with China in Life Sciences and Advanced Materials Engineering led to the major Science Bridges China project and our ongoing successes.

2 RCUK Bradford Science Bridges China Background - 2009 – 13
The booklet captured our major programme, funded by RCUK via EPSRC, for our RCUK Bradford Science Bridges China programme. Note that the Open Innovation programme, which was effectively supported through the Science Bridges China has continued in an independent way, particularly with Guangzhou – each workshop has stood alone, so is not reported further here. Our mainstream Science Bridges China platform has achieved a substantial research community and an ongoing, growing connections with core groups and new collaborators.
1. SOME LINKS WITH CHINA, 2008-9

VIPps
Virtual Institute - Polymer Process Structuring
www.polymervip.com

WHAT IS VIPps?

The Virtual Institute for Polymer Process Structuring (VIPps) is a Polymer IRC Polymer Engineering project at the Universities of Bradford and Leeds, funded by the Engineering & Physical Science Research Council (EPSRC). It forms part of the EPSRC programme on ‘People Collaboration’ and runs from 1 October 2004 to 31 March 2008.

VIPps is a platform to develop new collaborations, particularly with Pacific Rim countries, focusing on the Polymer Engineering aspect of our IRC research portfolio, and the increasingly important issue of the interaction between processing and structuring of polymers (linking polymer engineering and polymer physics, and with appropriate polymer chemistry links, for example in reactive processing blending).

VIPps travel and meetings

- for Polymer IRC staff at Bradford & Leeds academics in China, Japan, Taiwan, China & Korea.
- for Chinese & Japanese academics to come to the UK to present their work and meet with us.
- The meetings include ‘one to one’ or one to a few) visits to the Far East by IRC staff, and larger joint meetings held in China and Japan respectively, repeated in the UK.

The VIPps meetings are for:
- sharing of research topics from each laboratory, for awareness and information gathering
- stimulation of possible co-operative projects
- visits to key laboratories, for particular personnel including development of inter-institutional relationships which are vital to ongoing success - sowing seeds for the future.

Polymer IRC staff form the core, but we include (a) the wider Polymer IRC staff and (b) associated groups in the UK polymer community - as we do, for example, in the UK Polymer Showcase, which also formed a focal point for VIPps in September 2008, together with relevant overseas groups. This helps to bring researchers together from a selection of groups and research areas in the polymer engineering-polymer physics arena, for mutual benefit.

COLLABORATIONS

Proposed collaborations to be developed through this initiative focus on the vital area of structuring of polymers by processing - increasingly recognised by academics and industry as being in particular need of enhanced understanding, in order to exploit the possibilities for obtaining novel properties or property distributions from polymers and associated materials (including biomaterials, fine chemicals and foodstuffs). The various groups involved have strong experimental and some theoretical research records in processing and morphology of polymer. Current collaborators include:

UK
- University of Bradford
- University of Leeds
- University of Leeds
- University of Sheffield
- University of Huddersfield
- Sheffield Hallam University
- University of Hull
- University of York
- University of Liverpool
- University of Leeds

CHINA
- Beijing Laboratory of Polymer Microscale Engineering, Beijing University
- Beijing Institute of Chemical Technology, Beijing University
- Guangzhou University
- Xiamen University
- Shanghai Jiao Tong University
- Dalian University

TAIWAN, CHINA
- National Taiwan University
- National Taiwan University

JAPAN
- Kyushu Institute of Technology
- Osaka University
- Yamagata University
- Kyushu University
- Kyushu University

KOREA
- Korea University of Science & Technology

Poster for our EPSRC Virtual Institute for Polymer Process Engineering
Hosted by the Polymer IRC (see www.polyeng.com), the background is the Micro & Nano Technology Laboratory of the Polymer IRC
1. EPSRC People Collaboration Programme: Virtual Institute for Polymer Process Structuring (VIPps)

The EPSRC-funded (£227k) People Collaboration programme, focuses on polymer engineering and aims to develop co-operations with academics in China, Japan, Taiwan and Korea. It is led by Prof Phil Coates and has provided an excellent platform of cooperative meetings to date. These started with Prof Coates’ strategy plus technical meetings with Chinese academics in Shanghai in July 2007, in association with the Polymer Processing Society conference (where Prof Coates gave a plenary address), which allowed a survey of leading polymer engineering-related groups in China to be conducted, followed by meetings in Chengdu (State Key Laboratory for Polymer Materials Engineering, SKLPMME), Beijing (Institute of Chemistry, Chinese Academy of Sciences, ICCAS) and Tokyo (associated with the major Japan Society for Polymer Processing meeting) in May 2008.

The time in Chengdu was particularly moving, coming just 2 weeks after the disastrous earthquake there, and our visit was much appreciated. Prof Coates was appointed an Honorary Professor of Sichuan University. In Salerno, again associated with the PPS-24 international meeting in June 2008, there was opportunity to meet with colleagues from all of the participating Far East countries, to share information and discuss collaboration in such areas as micromoulding, nanocomposite structuring and processing of modified polymers. This was complemented Prof Coates visit to Taiwan (in conjunction with IUPAC Macrow2008, Prof Coates being an invited speaker) – including a laboratory visit to fluid-assisted moulding centre of Prof Liu.

On to Beijing, July 2008, to visit four institutions, presenting science and discussing strategy. First, Beijing University of Chemical Technology (BUCT), then ICCAS where Prof Coates was honoured to be a Molecular Sciences Forum Professor, then Sinopec Beijing Research Institute, and finally Tsinghua University.

In addition, Leeds colleagues have been involved in cooperative visits to Japan - Dr Easan Savaniah, Frederico Roschitztardtz (on a 6 month placement with Prof H Watanabe, Kyoto University), and China - Prof Peter Olmsted, Dr Xiaosong Wang.

An exciting outcome was the VIPps UK meeting held during the week of 15th September 2008, including participation in the UK Polymer Showcase, with 27 Chinese academics being brought to the UK under the VIPps programme, from Sichuan University, ICCAS, and Shanghai Jiao Tong University. VIPps technical meetings, with presentations by invited Chinese and IRC academics together with posters from each participant, were in Bradford on Monday and Friday, and the posters were also exhibited at the UK Polymer Showcase, which also included a lecture from Prof Q Wang, Director of SKLPM Chengdu on polyolefin developments.

Three of the Chinese academics from Sichuan came to Bradford for 2 weeks for cooperative research studies in our laboratory, with a view to building more substantial programmes, 1-14 Feb, 2009.

We also hosted a visit to Bradford by Prof Koyama (Yamagata University) later in February 2009. Further international contacts were developed at PPS-25 in India in early March 2009.

The VIPps UK technical meeting was mirrored by one in China, March 23-25, 2009. At that meeting, 17 UK attendees and over 50 Chinese academics are presenting their research. We were greatly assisted by Prof Wang and colleagues at Sichuan University in the organisation of this meeting. Prof Coates was then made an Honorary Professor at Beijing University of Chemical Technology, 27 March 2009, during a visit to BUCT by a seven colleagues from Bradford.

Prof Coates wrote in 2009 “Academic activity in China is developing rapidly, so it is a privilege, timely and strategic to be involved in this cooperative venture. It is also a significant time in relation to the development of R&D in the industry there. In general the polymer industry has a limited experience of R&D, although the trend in Sinopec, to establish a new processing laboratory to complement its excellent characterisation facilities in Beijing, reflects that of Sabic and other major developing polymer manufacturers (against the trend to diminish R&D centres in the West). The Japanese polymer groups in particular are strong, with a very strong industry base, so the nature of our interaction is different – more ‘one to one’. In all cases, the VIPps programme has received an extremely warm welcome, and has generated many new opportunities, which we aim to build upon. We are grateful for the very strong support for VIPps in each of the collaborating institutions.”

In December 2008 EPSRC announced that the University of Bradford Polymer IRC, Institute for Pharmaceutical Innovation and Institute for Cancer Therapeutics groups’ bid for a Science Bridges China three year project was successful – and was the top ranked bid in this very competitive programme call. An award of £1.27m was announced to develop knowledge transfer, training and assist with commercialisation of healthcare-related products, in collaboration with 11 Chinese academic institutions. The programme is also supported by Medlink (Y&H) Ltd, the Healthcare Technologies Knowledge Transfer Network and the UKTI.

The following picture album capture some – but not all – of the active research and knowledge transfer links which the University of Bradford developed with China, from 2008-9, which was a very formative time for our relationship. It consists largely of pictures and some brief commentary covering:

• our Engineering and Physical Sciences Research Council/ Research Councils UK (EPSRC and RCUK) -funded programmes;
• Honorary and Visiting Professor appointments;
• an RCUK Summer School in Shanghai;
• English teaching in China (in conjunction with the Amity Foundation);
• special editions of an international journal;
The VIPps People Collaboration programme (2008-9) was mainly in the polymer area, developing links between researchers and teachers in the UK and China, at both senior academic and student levels, plus links to school teachers.

*Prof Phil Coates is made an Honorary Professor of Sichuan University by Senior Vice President Professor Li, May 2008; Academician Prof Xu Xi is on the right of the picture.*

*Prof Wan, Director of ICCAS Beijing, welcomes Prof Coates as Molecular Sciences Forum Professor, July 2008; below with Prof Dujin Wang.*

Sichuan University, May 2008:
Prof Coates, & Mrs Jane Coates, (Honorary People Collaboration Assistant) who provided an English workshop for the Sichuan University Foreign languages department (below).

*Jane also leads Amity Foundation teams each July in China, helping Chinese teachers of English to develop their English accuracy (listening, language and teaching skills) –typically around 100 teachers each year.*
Meeting with Sichuan University and ICCAS Beijing senior (inc Prof Qi Wang, centre) and junior academics at the PPS-24 international meeting, Salerno, Italy, June 2008

Meeting with the Dean, Prof Wan, and key Polymer researchers at Beijing University of Chemical Technology, Beijing July 2008
At Sinopec, a major international oil company (hosted by Prof Jingliang Qiao, centre), who link strongly with various Chinese academics; Beijing July 2008

Meeting with the (then) youngest Chinese Academician, Prof Xi Zhang, Tsinghua University, Beijing to develop People Collaboration links, July 2008

EPSRC VIPps technical meeting held in Bradford, 15-20 September 2008; 27 Chinese academics came to this week of technical meetings.

Prof Qi Wang, Director of the State Key Laboratory for Polymer Materials Engineering, addresses the Polymer IRC’s UK Polymer Showcase meeting in York, Sept 2008; chaired by Prof Coates
27 Chinese academics from Sichuan, Beijing and Shanghai meet with the Vice Chancellor, senior management, and polymer-related academics, Bradford University, September 2008.

China Business Awards, UKTI/ Yorkshire & Humberside at the Queen’s Hotel, Leeds: the Bradford team were first winners of the Best Education – China award, January 2009.
Prof Qi Yang, Dr Li Li and Prof Hesheng Xia of Sichuan University, working with colleagues in the Bradford Polymer IRC laboratories on short VIPps projects, 2-14 February, 2009.

Prof Jinhua Dong (Director, NSFC) sits between Prof Qi Wang and Prof Guangxian Li (Vice President, Sichuan University) at the VIPps China-UK meeting, Chengdu, March 2009.

Prof Xu Xi, Academician (seated), gave the introductory technical presentation.
A view of the VIPps conference stage and audience – with over 50 Chinese delegates, including local and regional government, and 17 UK academics.

Over 60 technical posters were on show outside the Conference room.

The VIPps China-UK Technical Meeting was held in Chengdu, 23-25 March 2009; 17 UK academics from Bradford, Leeds and Durham, and over 50 Chinese academics from 8 universities and institutions participated. The event was held in the Shangri-la hotel, and included a laboratory visit to the State Key Laboratory for Polymer Materials Engineering, Sichuan University.
Prof Coates meets the Mayor of Chengdu, Ge Honglin, at City Hall, Chengdu, March 2009, to pass on a letter of friendship from the Lord Mayor of Bradford. Xiao Lei Wang (left) acted as translator for the formal welcome ceremony.

Prof Coates receives his Honorary Professorship from the Vice President Li of Beijing University of Chemical Technology.

At Beijing University of Chemical Technology, March 2009
Dr. Futao Chen, Minister Counsellor of the Science & Technology Section meets Prof Coates in the Polymer IRC Micro & Nano Technology laboratory, March 2009

Chinese Embassy visitors to the University, March 2009

Pharmaceutical and Cancer Therapeutics related activities

Over 60 young researchers attend RCUK-supported Summer School on drug delivery research 28 Oct. 2008
Prof Peter York, Dr Qun Shao, IPI, University of Bradford.

RCUK Summer School attendees, Shanghai 2008
The CAS Shanghai Institute of Materia Medica (SIMM) and the Institute of Pharmaceutical Innovation (IPI) at the University of Bradford in the UK on 27 Oct. 2008 launched a week-long Summer School in Shanghai to introduce young researchers to new techniques for drug discovery and drug delivery.

The Summer School is being taught by distinguished professors from SIMM, Bradford University, Fudan University, Shanghai University of Traditional Chinese Medicine, and Shanghai Jiaotong University. Over 60 young researchers from Shanghai and as far away as Wuhan have signed on. This event is supported by RCUK China following the first annual UK-China Summer School competition.

The Summer School takes place just as China has announced major new investments in pharmaceutical research and development. A total of RMB6600 million is being allocated to institutes around China. SIMM is looking forward to a major boost in its activities from this budget.

In his opening remarks, Professor Peter York of IPI highlighted the key role of the UK in world biotechnology and pharmaceutical research. The UK’s biotechnology sector is second only to the USA, and the UK accounts for 27% of all European pharmaceutical investment.

Chris Godwin, Director of RCUK in China, pointed out that the UK is already China’s main research partner among European countries, and China is the UK’s fastest-growing partner. The UK is the world’s most productive research nation, while China is the fastest-growing research nation in history. These facts make China and the UK perfect partners in research.

Prof. Peter York and Prof. Jamshed Anwar were appointed as Honorary Professors by Shanghai Institute of Materia Medica, Chinese Academy of Science, 2008.

Prof. Laurence Patterson, Director of the Institute for Cancer Therapeutics, is made a Visiting Professor of the 3rd Medical Military Hospital, Chongqing, January 2008; below -with Pharmacy staff at HMMU, Wuhan January 2008
SCIENTIFIC JOURNALS: a landmark for a Chinese group

A special double edition of the journal Plastics Rubber and Composites: Macromolecular Engineering, an international polymer journal of the Institute of Materials, Minerals and Mining, has research papers in English from the Sichuan University State Key Laboratory of Polymer Materials Engineering, Directed by Professor Qi Wang. This high quality landmark special edition Vol 36, Numbers 7-8, October 2007 was the first to be published in English in an international journal by a Chinese laboratory.

The State Key Laboratory for Polymer Materials Engineering, Sichuan University

The Institute of Materials, Minerals and Mining’s 2008 Alan Glanvill Award for a paper published by the Institute of particular merit in the field of polymers was awarded to N Chen, L Li and Q Wang, (Sichuan University) for the paper "New technology for thermal processing of poly (vinyl alcohol)". Plastics, Rubber and Composites No 7/8 2007 Vol 36, No7/8, pp283-290. – this is one of the papers from the special edition.
2. RCUK Bradford Science Bridges China Background - 2009 – 13

RCUK Bradford Science Bridges China

EPSRC Global Engagements Programme

‘People Bridges’ (人与人的桥梁)
for Healthcare Technologies

a Strategic Platform creating Research and Innovation opportunities with China, advancing Science & Innovation in Pharmaceutical Sciences & Advanced Materials for drug discovery, drug delivery and medical technology
INTRODUCTION

This booklet provides an outline, with some detailed information, of activities in our RCUK Science Bridges China Platform, including the EPSRC Global Engagements programme, which focuses on Advancing Science & Innovation in Pharmaceutical Sciences & Advanced Materials, for drug discovery, drug delivery and medical technology. This is a strategic priority area for UK-China cooperation. We have developed a successful, growing platform, extending collaborations to other UK & Chinese partners - universities, companies, hospitals and government agencies.

OUR APPROACH:

Investing in People
People are the key - we have established ‘People Bridges’ – working collaborations, developed trust and formed excellent research teams - with Research & Innovation Leaders and Young Researchers in 28 leading Chinese institutions and 6 UK universities (Bradford, Durham, Sheffield, Leeds, Nottingham and York).

Growing the platform
Our original RCUK Science Bridges China £1.25m programme has achieved total cash support to date of £7.54m, and £1.5m in-kind support in the UK and China, which covers 44 research or innovation projects. This represents a six-fold cash leverage in £ sterling (7.54/1.25). In terms of value (taking into account the relative cost of R&D in China, the leverage is ~ 32.5/1.25 = 26 fold. (see next page)

Creating a Community
We have established close working relationships, which has led to the formation of the UK-China Advanced Materials Research Institute (www.ukchina-amri.com) - a Community for Research Excellence!

This represents a virtual institute of over 200 UK and Chinese researchers to date, with:
- Researcher profiles
- Joint publication
- Joint international laboratories being formed – the first is the Bradford-Sichuan Joint International Laboratory in Polymer Micro Processing

Encouraging Outputs
25 collaborative research projects include:
- Drug development & delivery for diabetes, cancer, malaria, Traditional Chinese Medicines and Advanced materials - Polymer biomaterials, bioreosorables, nanocomposites and micro-processing for medical devices and drug delivery
- 3 Research Workshops to date (Beijing (2011), Chengdu (2012), Bradford (2012) have been held, co-hosted with partners, to develop research programmes
- 19 open innovation ‘proof of concept’ projects, have been formed from 4 Open Innovation Workshops to date, co-hosted with Changzhou (2009, 2011) and Guangzhou (2011, 2012) Science & Technology Bureaus, including drug delivery, biomarkers, stem cells, wound treatment, diagnostics.
Programme outputs to date include:

- 13 joint publications
- >120 international conference presentations
- 3 joint international patents filed
- Participation in high level political & trade events
- Joint International Laboratory founded
- UK-China Advanced Materials Research Institute founded

EPSRC Global Engagements supports and further builds:

- Collaborative Research Programmes,
- Researcher Exchanges, - a major emphasis
- Joint research students,
- high level Research Workshops

Growing the platform (to 2013):

<table>
<thead>
<tr>
<th>Source</th>
<th>Funding Won £</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPSRC Global Engagements</td>
<td>£500,000</td>
</tr>
<tr>
<td>RCUK MOST Joint call</td>
<td>£250,000</td>
</tr>
<tr>
<td>Chinese central government (MOST, NSFC, MoD)</td>
<td>£1,000,000</td>
</tr>
<tr>
<td>Chinese local government (S&amp;T Bureaus)</td>
<td>£3,370,000</td>
</tr>
<tr>
<td>Chinese industry (project match)</td>
<td>£870,000</td>
</tr>
<tr>
<td>UK Other (White Rose, YCR)</td>
<td>£300,000</td>
</tr>
</tbody>
</table>

- additional
- RCUK Science Bridges China £1,250,000
- £500,000
- £250,000
- £1,000,000
- £3,370,000
- £870,000
- £300,000

2 grants 1 project 8 projects 19 projects 6 projects support

16 projects
RCUK Bradford Science Bridges China – Outline of Activities in the grant period + EPSRC Global Engagements Programme

RCUK Bradford Science Bridges China - Scope

The Bradford RCUK Science Bridges China (SBC) programme consists of collaborative research, development and open innovation in pharmaceuticals and healthcare. It brings together scientists and companies from the UK and China to develop new therapies, medical diagnostics, materials and devices.

The 3 year £1.25m RCUK-funded programme commenced on 30 June 2009. It builds upon a successful range of activities by members of the Bradford team in China over more than a decade, has an advisory board consisting of UK and Chinese members and links strongly with funding bodies and government agencies or Ministries in the UK and China. Our EPSRC Global Engagements programme (April 2012-March 2013) builds on this excellent foundation, building a Research Community.

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Science Bridges China — a Strategic Platform

Science Bridges China provides a strategic platform for the University, and for the UK by creating Opportunities with China by high level RKT people links. EPSRC Global Engagements further provides Research Programmes, Researcher Exchanges, Joint research students, & high level Research Workshops.

Science Bridges Chinese Collaborators & People Bridges (人与人的桥梁)

- Tsinghua University
- Beijing University of Chemical Technology
- Institute of Chemistry, Chinese Academy of Science
- Institute of Materia Medica, Chinese Academy of Medical Science
- NanJing University
- TianJin University
- The 6th Military Institute, Chinese Military Science
- Beijing Institute of Chemical Industry
- MoST, MSC, Mf
- Jilin University
- Changchun University of Applied Chemistry, Chinese Academy of Sciences
- Shenyang Pharmaceutical University
- Sichuan University
- HuaNan Medical University
- The Third Military University
- Chengdu Science & Technology Bureau
- Hong Kong University of Science & Technology (HKUST)
- Hong Kong Chinese University
- Guangzhou Science & Technology Bureau
- Kangaroo Pharmaceutical Group
- Jilin University
- Changchun Institute of Applied Chemistry, Chinese Academy of Sciences
- Shanghai Institute of Materia Medica, Chinese Academy of Science
- China Pharmaceutical University
- Fudan University
- Jiaotong University
- Shanghai TCM University
- Zhejiang TCM University
- China Medical City
- Suzhou Biosky
- Changzhou Science & Technology Bureau

We gratefully acknowledge the support of:

EPSRC
ipi
MRC
Science Bridges China
UK-China
amri
University of Bradford RKT Centres in Advanced Materials Engineering, Polymer Micro & Nanotechnology, Pharmaceutical Engineering Science, Visual Computing, Skin Sciences

+ University of Bradford RKT Centres in Advanced Materials Engineering, Polymer Micro & Nanotechnology, Pharmaceutical Engineering Science, Visual Computing, Skin Sciences

Founder members:
Polymer IRC, led by Bradford, with Durham, Leeds, Sheffield; Sichuan University, BCST, ECNU, ZJUA, WRFG C55 ~ 230 academic members.
1. Translational Research Projects to 2012

1.1 RCUK-funded ‘core’ translational research projects

<table>
<thead>
<tr>
<th>Project Title</th>
<th>UoB</th>
<th>Partner</th>
<th>Running Period</th>
<th>Amount from grant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of Key Ingredients in Complex Chinese Medicines, to Develop New Therapies for Global Markets</td>
<td>Dr Qun Shao</td>
<td>Prof Guan Luo and Dr. Liangqiong Lin, Tsinghua University</td>
<td>Oct 2009 – June 2012</td>
<td>~£50k</td>
</tr>
<tr>
<td>A Mechanistic Investigation of TCM Therapies for Type 2 Diabetes</td>
<td>Dr Qun Shao</td>
<td>Prof Jiwen Zhang, Shanghai Institute of Material Medica, CAS</td>
<td>Oct 2010 – June 2012</td>
<td>~£50k</td>
</tr>
<tr>
<td>Seeding of plug flow crystalliser using a micro channel reactor</td>
<td>Dr Nicholas Blagden, Dr Qun Shao</td>
<td>Prof David Wei, Tianjin University</td>
<td>Aug 2011 – July 2012</td>
<td>~£20k</td>
</tr>
<tr>
<td>The Development of Agents Targeting the Hypoxic Tumour Cell Phenotype</td>
<td>Prof Laurence Patterson, Dr Klaus Pors</td>
<td>Prof Weishou Fang, Institute of Material Medica, Chinese Academy of Medical Sciences &amp; Beijing Union Medical College</td>
<td>Nov 2010 – Oct 2012</td>
<td>~£50k</td>
</tr>
<tr>
<td>The development of FormylPeptide Receptor antagonists as a New Class of Antiproliferative Agents</td>
<td>Prof Laurence Patterson, Dr kamyar Afarinkia, Dr Viqui Vinader, Dr Rob Falconer</td>
<td>Prof Xiuxiu Bian, Southwest Hospital, Third Military Medical</td>
<td>Nov 2010 – Oct 2012</td>
<td>~£50k</td>
</tr>
<tr>
<td>Improved Anti-Malarial Treatment through Enhanced Bioavailability of Artemisinin</td>
<td>Prof Laurence Patterson, Dr Wendy Hulse</td>
<td>Jiwen Zhang, Shanghai Institute of Material Medica, CAS</td>
<td>Dec 2010 – June 2012</td>
<td>~£75k</td>
</tr>
</tbody>
</table>

1.2 RCUK-funded mini-core projects to 2012

<table>
<thead>
<tr>
<th>Project Title</th>
<th>UoB</th>
<th>Partner</th>
<th>Running Period</th>
<th>Amount from grant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound-assisted Physical or Chemical Interaction from Melts</td>
<td>Prof Anant Paradkar, Dr Adrian Kelly, Dr Elaine Brown and Prof Phil Coates</td>
<td>Dr Hong Wu, Prof Shaoyun Guo, Sichuan University</td>
<td>Oct 2010 – June 2012</td>
<td>50k RMB (~£8k)</td>
</tr>
<tr>
<td>Electrically Conductive Polyurethane/Carbon Nanotubes Composites for Medical Microdevices</td>
<td>Prof Phil Coates, Prof Hadj Benkreira, Dr Raj Patel, Dr Ben Whiteside, Dr Fin Caton-Rose</td>
<td>Prof Hesheng Xia, Dr Guoxia Fei, Sichuan University</td>
<td>Oct 2010 – June 2012</td>
<td>80k RMB (~£12k)</td>
</tr>
<tr>
<td>Poly(vinyl alcohol)-based Composite Products for Drug Delivery</td>
<td>Prof Phil Coates, Dr Leigh Mulvaney-Johnson, Dr Ben Whiteside</td>
<td>Prof Qi Wang, Dr Ning Chen, Dr Li Li and Prof Jie Zhang, Sichuan University</td>
<td>Oct 2010 – June 2012</td>
<td>60k RMB (~£9k)</td>
</tr>
<tr>
<td>Solid Phase Processing of Polymer Blends and Nanocomposites</td>
<td>Prof Phil Coates, Dr Fin Caton-Rose, Dr Michael Martyn</td>
<td>Dr Xiaowen Zhao, Prof Lin Ye, Sichuan University</td>
<td>Oct 2010 – June 2012</td>
<td>80k RMB (~£12k)</td>
</tr>
<tr>
<td>Targeted polymetric micelles for anti-cancer drug delivery</td>
<td>Dr Kamyar Afarinkia, Prof L Patterson, Prof Phil Coates</td>
<td>Prof Zhongwei Gu, Dr. Yu Nie, Sichuan University</td>
<td>June 2011 – June 2012</td>
<td>50k RMB (~£8k)</td>
</tr>
<tr>
<td>Investigation of polymer micro-needles by micro-injection molding</td>
<td>Dr Ben Whiteside, Prof Anant Paradkar, Dr Adrian Kelly, Prof Phil Coates</td>
<td>Prof Dongyuan Ren, Prof Yaqun Zhang, Mr Xiang Lin, Mr Ling Xue, Beijing University of Chemical Technology</td>
<td>Aug 2011 – Aug 2012</td>
<td>50k RMB (~£8k)</td>
</tr>
<tr>
<td>Precise Microfabrication and Nano-Nanoscale Combination of Polymeric Microspheres for Promoting Cell Growth</td>
<td>Prof Phil Coates, Dr Colin Grant, Dr Ben Whiteside</td>
<td>Prof Zhuhua Gan, Dr Xudong Shi, Institute of Chemistry, CAS</td>
<td>Aug 2011 – Aug 2012</td>
<td>50k RMB (~£8k)</td>
</tr>
<tr>
<td>Structure and Properties of Micro-moulded Poly(ε-caprolactone) and its miscible blends</td>
<td>Dr Tim Gough, Dr Ben Whiteside, Prof Phil Coates</td>
<td>Prof Yongfeng Men, Dr Ying Gao, Dr Yuqin Li, Dr Zhongyong Jiang, Dr Lingshi Liu, Changchun Institute of Applied Chemistry, CAS</td>
<td>Aug 2011 – Aug 2012</td>
<td>50k RMB (~£8k)</td>
</tr>
<tr>
<td>Toughening of Polyolactide with Bioelastomer for Biomedical Application Research Team</td>
<td>Dr Mike Martyn, Dr Tim Gough, Prof Phil Coates</td>
<td>Prof Liqun Zhang, Haiyan Kang, Prof Dongmei Yue, Beijing University of Chemical Technology</td>
<td>Aug 2011 – Aug 2012</td>
<td>50k RMB (~£8k)</td>
</tr>
<tr>
<td>Epigenetic Mechanisms of Tissue Development and Regeneration</td>
<td>Prof Vladimir Botchkarev</td>
<td>Dr. Guo-Liang Xu, The State Key Laboratory of Molecular Biology, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences</td>
<td>Nov 2011 - Jun 2012</td>
<td>50k RMB (~£8k)</td>
</tr>
</tbody>
</table>
1.3 Chinese government-funded internationally collaborative projects to 2012

- successful joint bids to MOST & NSFC international programmes, run in China; - successful bids to MOE, run in the UK and China:

| Science Bridges China: Chinese Research Councils Funded Projects/Awards |
|-----------------------------|-----------------|------------------|--------------------|
| **Project Title** | **UoB** | **Partner** | **Running Period** | **Funding Body** | **Amount** |
| Enhance the Bioavailability of Artemisinin by Combined Drug Delivery Techniques to Limit the Emergence of Malaria Resistance | Prof Laurence Patterson | Jiwen Zhang, Shanghai Institute of Materia Medica, CAS | May 2010 – Dec 2012 | MOST | 1m RMB |
| Development of methods for the assessment of TCM's disease/syndrome and efficacy as well as data mining | Dr Gun Shao | Prof Guoan Luo, Tsinghua University | May 2010 – Dec 2012 | MOST | 1m RMB |
| Preparation and Micromolding of Polymer Nanocomposites for Medical Applications | Prof Phil Coates | Qi Wang, Sichuan University | May 2011 – Dec 2013 | MOST | 1m RMB |
| Fundamental studies on the preparation and micro-processing of polymer functional micro-devices | Prof Phil Coates, Prof Hadj Benkreira, Dr Ben Whiteside, Dr Michael Martyn, Dr Adrian Kelly, Dr Tim Gough | Prof Qi Wang, Prof Hesheng Xia, Prof Jie Zhang, Dr Yan Liu, Dr Ning Chen, Dr Shibing Bai, Dr Guoxia Fei, Ms Zhengkun Hua, Sichuan University | Jan 2011 – Dec 2013 | NSFC | 1.6m RMB |
| Overseas Famous Scholar | Prof Phil Coates | Sichuan University | 2010 - 2015 | MOE | 1m RMB |
| High-End Foreign Professor awards | Prof Phil Coates | Sichuan University | 1 July 2010 – 30 June 2013 | Sichuan University | 100k RMB |
| China Scholarship Council awards | Prof Phil Coates | Prof Yinghong Chen, Sichuan University | Jan 2011- Jan2012 | MOE | ~150k RMB |
| China Scholarship Council awards | Prof Phil Coates | Prof Qi Yang, Sichuan University | March 2011-March2012 | MOE | ~150k RMB |

Research Workshops in Advanced Materials for Healthcare have been run by the Bradford team in Beijing (Nov 2011) and Chengdu (April 2012) aimed at joint bids to MOST or NSFC international programmes – as a result in April 2012, 3 bids were submitted the 2012 RCUK-MOST Joint Call for Healthy Ageing Populations:

- **Biomaterials for Joint Soft Tissue Repair - Improving Health in Older Age:** University of Bradford/ Sheffield University/ Durham University- FUNDED
- Elderly specific transdermal patch design to improve patient compliance in dementia patients: University of Bradford/ Shanghai Institute of Materia Medica, Chinese Academy of Sciences/ Jilin University/ Peking University First Hospital/ The First People’s Hospital of Changzhou.
- An exploration of chemopreventive TCM and tumour targeted novel ultrapotent chemotherapeutic agents in tissues from UK and China cancer patients: University of Bradford/ Southwest University Chongqing / Southwest Hospital, Third Military Medical University, Chongqing/ Huaxi Hospital, Sichuan University, Chengdu, St James’ Hospital, Leeds University/ Bradford Royal Infirmary.

2. Chinese local government-funded ‘open innovation’ (OI) workshops run by the Bradford team in China, leading to projects for proof of concept applications, are based mainly in China. Projects are typically 2 year duration, with expectation of particular commercial milestones being met.

2.1 Changzhou Science & Technology Bureau hosted two OI workshops, with ~£1.2m funding in China.

| Science Bridges China Open Innovation Projects |
|-----------------------------|-----------------|------------------|--------------------|
| **Project Title** | **UoB** | **UK partners** | **Chinese Partner 1** | **Other Chinese Partners** | **Amount** | **Funding to UK** |
| Repair of Oral and Peridontal Defects using Regenerative and Antimicrobial Strategies Delivered by Novel Tissue Scaffold | Dr Richard Telford, Dr Qun Shao | University of Leeds, Notherix Ltd | Prof Jiwen Zhang, Shanghai Institute of Materia Medica, CAS | Dr Juan Du, Changzhou Sanwei Industry Institute Prof Jingkai Gu, Jilin University | ~£200k | £31.4k (J00132) |
| The Development of Nanoparticulate Curcumin with Enhancers from TCM for Treatment of Cancer and Alzheimer’s Disease | Prof Anant Paradkar | Prof Yihu Qiao, Nanjing University | Dr Zhifei, Changzhou City Hospital | ~£200k | £7.9k (J00117) |
| A Suite of Platform Technologies for Masking the Undesirable Taste of TCM and Western | Prof Laurence Patterson, Dr Stefan Ogorzlozinski, Biostatutes | Prof Yi Peng, Shanghai University | Changzhou Yabang Pharmaceutical s Co Ltd | ~£200k | £6.0k (J001172) |
2.2 Guangzhou I – November 2011 (awards announced April 2012) – Guangzhou Science & Technology Bureau (BioIsland) have hosted one workshop in the grant period, led by our team. This has provided £1.1m across 7 projects, with match funding required from Chinese industrial collaborators.

<table>
<thead>
<tr>
<th>Project title</th>
<th>UK partners</th>
<th>Chinese Partner</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of Candidate Vaccines Against Viral Disease using Advanced Adjuvant Technology</td>
<td>Jon Sayers, University of Sheffield</td>
<td>South China United Vaccine Institute</td>
<td>1.8m RMB</td>
</tr>
<tr>
<td>Development of cancer biomarker immunocassay using novel antibody mimetics</td>
<td>Darren Tomlinson, Leeds University</td>
<td>Raybiotech, Inc. Guangzhou</td>
<td>2m RMB</td>
</tr>
<tr>
<td>Multi-Analyte-Virus-Chip (MAVIC)</td>
<td>Tom Gibson, ELISHA Systems Ltd</td>
<td>Guangzhou IRD Medicine Co., Ltd</td>
<td>2m RMB</td>
</tr>
<tr>
<td>Biosensor Systems for Cancer Biomarkers and Bacteria</td>
<td>Tom Gibson, ELISHA Systems Ltd</td>
<td>Guangzhou Wondfo Biotech Co., Ltd</td>
<td>1.5m RMB</td>
</tr>
<tr>
<td>Development of Novel Reagents for Virus Detection and Antiviral Therapeutics</td>
<td>Darren Tomlinson, Leeds University</td>
<td>Guangzhou Institutes of Biomedicine and Health</td>
<td>1.3m RMB</td>
</tr>
<tr>
<td>Automatic System for Measurement of Neural Respiratory Drive and Muscle Function</td>
<td>Mohammed Benaissa, Sheffield University</td>
<td>Guangzhou Respiratory Medical Science Ltd. Co</td>
<td>1.2m RMB</td>
</tr>
<tr>
<td>Clinical Trial and Evaluation of a Computer Aided Diagnostic System for Breast Cancer Screening</td>
<td>Hassan Ugail</td>
<td>Guangzhou Huayin Medical Laboratory Centre, China</td>
<td>1.2m RMB</td>
</tr>
</tbody>
</table>

Note that the Open Innovation projects may be set up without Bradford University being a collaboration partner, to help develop the range of collaborators. White Rose University members are supported by the White Rose University Consortium for Open Innovation workshop costs.

2.3 Guangzhou II – this Workshop was Yorkshire Cancer Research funded – ran in July 2012:

<table>
<thead>
<tr>
<th>Project title</th>
<th>UK/China collaborators</th>
<th>Awarded amount from GDD</th>
<th>Guangzhou company match funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Swept laser source for ultra-high resolution optical coherence technology</td>
<td>Guangzhou FemtoView Optoelectronics Technology Co. Ltd./Sheffield University</td>
<td>£200K</td>
<td>£200K</td>
</tr>
<tr>
<td>2 Development of an MMP-based diagnostic system for cancer</td>
<td>Guangzhou Zhongke Kaisheng Medical Technology Co. Ltd, Sun Yat-sen University/University of Bradford</td>
<td>£200K</td>
<td>£200K</td>
</tr>
<tr>
<td>3 Development of automated detection system of multi-cancer markers protein chip</td>
<td>Guangzhou Raybiotech Inc., Guangzhou South China biochip research institute, Leeds University</td>
<td>£150K</td>
<td>£150K</td>
</tr>
<tr>
<td>4 Development of an Immune colloidal gold kit for testing for malaria based on a non antibody binding protein</td>
<td>Guangzhou Hexin Biotechnology Co. Ltd./Leeds University</td>
<td>£120K</td>
<td>£120K</td>
</tr>
<tr>
<td>5 Developing tumour marker detection kits using novel nABP materials</td>
<td>Daan Gene/Leeds University</td>
<td>£100K</td>
<td>£100K</td>
</tr>
<tr>
<td>6 Kit for mobilisation and isolation of haematopoietic stem cells (HSC) for use in therapy</td>
<td>Sun Yat-sen University/University of Hull</td>
<td>£100K</td>
<td>£100K</td>
</tr>
</tbody>
</table>

2.4 Guangzhou III - a third Guangzhou Workshop is being supported by Yorkshire Cancer Research (2013).
3 International Conferences & Meetings to 2012

We have over 120 international conference presentations associated with the Science Bridges China programme in the grant period, including plenaries, keynotes, invited papers; the international meetings include the following:

- 103rd AACR Annual Meeting 2012, Chicago
- AAPS, Los Angeles, 2009
- AAPS, Washington, 2011
- Academy of Pharmaceutical Science Annual Conference (Pharmsci UK), Nottingham, 2011
- Canadian Society of Rheology, Montreal, 2011
- Drug Delivery and Formulation Asia Summit, 2011
- 20th ICCE, Beijing 2012
- 2nd International Conference on Nanomechanics and Nanocomposites, Beijing, 2010
- 8th International Congress of Pharmaceutical Sciences, Brasil, 2011
- 6th International Conference on Micro Manufacturing (ICOMM), Tokyo, 2011
- IUPAC Macro World Polymer Congress, Virginia Tech, 2012
- NexGen China Conference, Shanghai, 2012
- Polymer Process Engineering’09, Bradford, 2009
- Polymer Process Engineering’11, Bradford, 2011
- Polymer Processing Society International, Banff, 2010
- Polymer Processing Society International, Marrakesh, 2011
- Polymer Processing Society International, Niagara, 2012
- Polymer Processing Society International, Pattaya, 2012
- Science Bridges China Research Workshop, Beijing, 2011
- Science Bridges China Research Workshop, Chengdu, 2012
- Society of Plastics Engineers, ANTEC, Chicago, 2009

We have participated in a wide variety of international meetings, in addition to those indicated above, including:

- Academy of Pharmaceutical Science Annual Conference, Nottingham, UK 2010
- Academy of Pharmaceutical Science Annual Conference, Nottingham, UK, 2009
- Academy of Pharmaceutical Sciences China-India Event (Joint event with Nottingham), 2009
- Annual Conference of Consortium of Globalisation of Chinese Medicine, Hongkong, 2010
- Annual Meeting of the European Society for Dermatological Research, Venice 2012
- Beijing Health Innovation Forum (Chinese Medicine), 2009
- Beijing Health Innovation Forum (East-West convergence), 2010
- Beijing Health Innovation Forum (International co-operation) 2011
- Beijing Health Innovation Forum (Technology Transfer Case Studies) 2012
- Beijing HIP annual conference, Beijing , 2010
- Chinese Association of Medical Device Industries (CAMDI) International conference, 2009
- CCCMHPIE Healthcare Industries Forum2011
- CMFE Woundcare Forum, Shenzhen, 2010
- Globalisation for Chinese Medicine Annual Conference, Hongkong, China, 2011
- ICONTOX, Lucknow India, 2010
- International Translational Medicine Symposia, Chongqing, 2010
- JETC Healthcare Working Group, 2009
- JETC Healthcare Working Group, 2010
- Ministerial Briefing Event, Beijing2011
- MOST open innovation briefing event2011
- Nanotechnology convention, Beijing, 2009
- Shanghai BioForum, 2011
- UK Life Sciences day, Shanghai Expo, Shanghai 2010
- UKTI China Sector briefing event
- UKTI innovation with China event2011
- UKTI R2D BioBridge International Conferences in Beijing, Suzhou, Shanghai) 2011
- UKTI R2D BioBridge International Conferences in Shanghai, 2011
- UKTI R2D healthcare innovation forum, 2010
- UKTI/Medilink Woundcare mission (Beijing, Shanghai, Guangzhou), 2010
- 7th World Meeting on Pharmaceutics, Biopharmaceutics and Pharmaceutical Technology, Malta, 2009

We have shared IP agreements for all of the above projects (open innovation and research); plus separate IP with:

- Sichuan University/Bradford - High conducting polymer carbon nanotube composites
- Neotherix/University of Leeds - Tissue Engineering – Photodynamic Therapy
- A Paradkar - hot melt extrusion - patent filed
- P York, Bradford / SIMM - artesimin anti-malarial treatment using supercritical fluids - patent being developed.
- synchrotron studies of drug elution (Jiwen Zhang, SIMM/CAS)
4 SHARED INTELLECTUAL PROPERTY to 2013

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Some views of our activities, 2009-12:

- Working together at Bradford
- Discussions in Chengdu High Technology Zone
- Changzhou team signing at Shanghai Expo
- Dr Futao Chen (centre) Chinese Embassy visits our Polymer Micro & Nano Technology Centre
- Science Bridges Launch, Royal Society London, with Chinese Embassy & Sophie Laurie, RCUK
- Prof Peter York addresses the Changzhou Open Innovation Workshop, Dec 2009
- President Xie of Sichuan University, appoints Prof Coates to the highest level foreign professor post, 2010
- UK-China-India Pharma Meeting, Nottingham
- Bradford-SIMMCAS sign agreement
some of the many meetings with Academician Professor Xu Xi of SKLME, Sichuan University
Science Bridges China Life Sciences
Event at the UK Pavilion, Shanghai Expo,
23 Sept 2010: fifty Chinese leaders meet
with the Bradford team (14 staff plus
clinician Peter O’Donovan)
The UK Polymer Interdisciplinary Research Centre

A simple philosophy:

Aim to be the best at what we do
Build bridges - science, technology and people
Cross the bridges!

Delivering 21st century polymer-related research and knowledge transfer aligned with UKRI strategic aims, we provide researchers with an environment in which ideas and innovations can flourish. We build locally, nationally and globally (with 3 Joint laboratories in China), to help develop fundamental understanding, meet societal needs and benefit our industry sector. We work with over 100 companies, and have an excellent track record of delivery.

Early career ‘rising star’ researchers are particularly important to us – we have in the past few years run over 60 Researcher Exchanges with overseas partners, including our collaborators in other UK universities, to help develop longer term research strengths and international relationships.

Our ‘process structuring’ research addresses a wide range of sectors, including advanced healthcare, precision engineering devices, electronics, transport, construction products and consumer goods. We are at the leading edge of advanced manufacturing technologies, including process instrumentation, process modelling and control. We uniquely reach across polymer synthesis, polymer physics and engineering and pharmaceuticals processing. Polymers are vital materials - too good to waste - they are chemically rich, made from the amazingly rich oil (only a small fraction of which is turned into polymers, which contain the same calorific value as the oil they are derived from); it makes no sense to scrap polymers having invested in making these important and highly useful materials. We are consequently much involved in ‘green processing’ and in promoting the Circular Economy approach which aims to promote recycling, re-use, and to move away and from the traditional make-use-dispose economic model.

We strongly welcome interdisciplinary collaborations in the UK and worldwide.

Professor Phil Coates FREng
Director, Polymer IRC

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