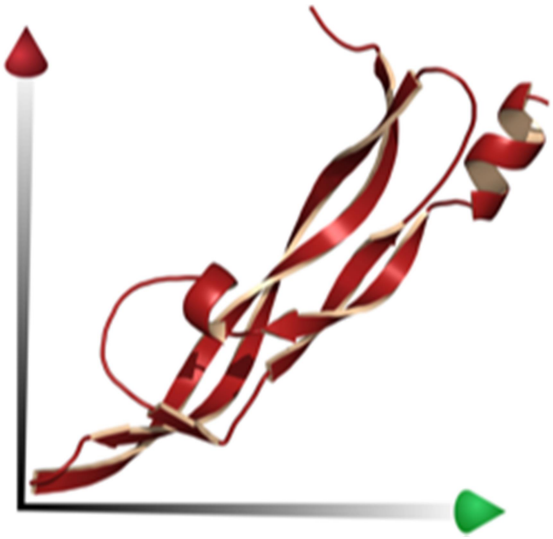
RSC INTEREST GROUP
PROCESS CHEMISTRY AND TECHNOLOGY

One-day Symposium – "Making it small: Energising entrepreneurship in the chemical sector"

Friday 15 Nov 2019

The Royal Society of Chemistry, Burlington House, Piccadilly, London, W1J 0BA, United Kingdom



Programme

09:00-09:30 Registration and refreshments

09:30 **Welcome:** Mukund Chorghade

Session 1: Chair Mukund Chorghade

09:45 **Plenary**: Prof Graham Richards CBE FRS, Oxford Drug Design Ltd

Commercialising Academic Research

10:30 Dr Elizabeth Farrant, New Path Molecular Research Ltd

11:00 Break

Session 2: Chair Richard Hart

11:15 Dr Ross Burn, CatSci Traversing the Entrepreneurial 'Valley of Death' to a high growth SME- a CatSci perspective

11:45 Professor Colin J Suckling OBE, DSc, FRSE, University of Strathclyde
'Useful Learning' makes things possible but not necessarily available

12:15 Lunch

Session 3: Chair Charles Gordon

13:15 Dr Olga Shvarova, McGrigor Group
Technology Transfer as Knowledge Creation

13.45 Professor John Blacker University of Leeds
Benefitting society with good product and process design

14:15 break

Session 4: Chair Mukund Chorghade

14:30 Prof Will Zimmerman, University of Sheffield
Anatomy of a spinning out a company for microbubbles and more

15:00 Siddharth V. Patwardhan, University of Sheffield Green nanomaterials: Journey from lab to manufacturing

15:30 Pam Randhawa, Empiriko
From BlackJack to Entrepreneurship

16:00 final remarks Professor Steve Ley

16:15 close

Biographies and Abstracts

Prof Graham Richards CBE FRS, Oxford Drug Design Ltd

BIOGRAPHY
Graham Richards was Head of Chemistry at Oxford and founder of a number of companies, including Oxford Molecular Plc and Oxford Drug Design Ltd. The deal which he did to fund the new Chemical Research Laboratory at Oxford grew to become IP Group Plc, which has been responsible for supporting some hundreds of start-up companies.

'Commercialising Academic Research'

The commercialisation of academic research will be described, with particular emphasis on the importance of intellectual property. The topic will be illustrated by reference to the some thirty companies derived from the Oxford Chemistry Department of which several have had IPOs and includes Oxford Nanopore Technology, one of the rare British unicorns.

Dr Elizabeth Farrant, New Path Molecular Research Ltd

Elizabeth has a degree in chemistry and a PhD in natural product synthesis. She started her career as a chemist in discovery research at SmithKline Beecham and since then she has worked in scientific and leadership roles in GSK and Pfizer. In 2011 she switched tracks to become Chief Business Officer at a Pfizer spin out and in 2015 became one of the founders of start-up New Path Molecular, a spin out from the laboratory of Prof Seven Ley. She brings a 20-year track record of technology development and commercialisation in the pharmaceutical industry and has also published in chemical technologies, flow chemistry and lead diversification.

Presentation:
New Path Molecular Research

New Path Molecular Research is a spin out founded by Prof. Steve Ley (University of Cambridge). We specialise in machine assisted chemistry, including flow chemistry, natural product synthesis and automation and run a hybrid research collaboration and drug discovery business model. The presentation will discuss New Path's story so far and what we have learnt about the ups and downs of making it small!

Dr Ross Burn, CatSci

Biography
After completing his PhD in 2007, Ross joined AstraZeneca to develop techniques to improve reaction understanding in process R&D. Ross' analytical expertise and entrepreneurial mindset was pivotal to the establishment of CatSci in 2011. Since his appointment as CEO in 2015 he has led the company's transition from a catalyst screening company to the award-winning process R&D CRO (Contract Research Organisation) that it is today. CatSci has achieved a Compound Annual Growth Rate of almost 40% over the last five years and has recently unveiled an ambitious growth plan to become the preferred partner for process R&D of small molecule therapeutics.

Traversing the Entrepreneurial 'Valley of Death' to a high growth SME- a CatSci perspective.

Professor Colin J Suckling OBE, DSc, FRSE, University of Strathclyde

Colin Suckling is a graduate of the University of Liverpool (BSc 1967, PhD 1970, DSc 1989) and has spent most of the rest of his academic career at the University of Strathclyde where he was Freeland Professor of Chemistry from 1989 to 2012. During the 1990s until 2002, was Dean of the Faculty of Science, Deputy Principal, and Vice Principal of the University.
Current research interests focus on the synthesis and properties of heterocyclic compounds designed as molecular probes for biological systems or as drugs, principally for treating infectious diseases. The most advanced antibacterial compound, a DNA Minor Groove Binder (MGB), is about to begin a phase 2 clinical trial for the treatment of Clostridium difficile infections. Other compounds in the Strathclyde collection of MGBs are nearing candidate selection status as treatments for African Animal Trypanosomiasis and also as antifungal compounds. A further advanced project in medicinal chemistry entering the commercial phase concerns immunomodulatory compounds based upon the structures of protein secretions of parasitic worms. The small molecule analogues of the parasite protein show great promise as treatments for inflammatory diseases such as rheumatoid arthritis, asthma, and lupus.

Colin has published over 250 papers and books. He was the Adrien Albert Lecturer of the Royal Society of Chemistry (2009-10), Chairman of the 2011 International Congress of Heterocyclic Chemistry held in Glasgow, recipient of the Nexxus Lifetime Achievement Award (2011), and elected an Honorary Life Fellow of the Indian Society of Chemists and

Biologists (2011). Colin is a Fellow of many learned societies and Royal Colleges including the Royal Society of Chemistry, the Royal Society of Edinburgh, the Royal College of Surgeons of Edinburgh and the Royal College of Physicians and Surgeons of Glasgow.

Selected recent publications

1. An Evaluation of Minor Groove Binders as Anti-Lung Cancer Therapeutics,
F.J. Scott, M. Puig-Sellart, A.I. Khalaf, C.J. Henderson, G. Westrop, D.G. Watson, K. Carter, H.M. Grant, C.J. Suckling. *Bioorg. Med. Chem. Lett.* **2016** doi: http://dx.doi.org/10.1016/j.bmcl.2016.06.040

2. An evaluation of Minor Groove Binders as anti-*Trypanosoma brucei brucei* therapeutics.
F.J. Scott, A.I. Khalaf, F. Giordani, P.E. Wong, S. Duffy, M.P. Barrett, V.M. Avery, C.J. Suckling, *Eur. J. Med. Chem*. **2016**, 116, 116-125

3. Designing Anti-inflammatory Drugs from Parasitic Worms: A Synthetic Small Molecule Analogue of the *Acanthocheilonema viteae* Product ES-62 Prevents Development of Collagen-Induced Arthritis.
L. Al-Riyami, M.A. Pineda,J. Rzepecka, J.K. Huggan, A.I. Khalaf, C.J. Suckling, F.J. Scott, D.T. Rodgers, M.M. Harnett, and W. Harnett. *J. Med. Chem.* **2013**, *56*, 9982-10002. dx.doi.org/10.1021/jm401251p

4. Small Molecule Analogues of the parasitic worm product ES-62 interact with the TIR domain of MyD88 to inhibit pro-inflammatory signalling,
C.J. Suckling, S. Alam, M.A. Olson, K. U. Saikh, M. M. Harnett & W.Harnett. *Scientific Reports*, **2018**, 8, 2123 DOI:10.1038/s41598-018-20388-z.

5. Novel Minor Groove Binders cure animal African trypanosomiasis in an in vivo mouse model
F. Giordani, A.I. Khalaf, K. Gillingwater, J. Munday, H. de Koning, C.J. Suckling, M.P. Barrett, F.J. Scott, *J.Med.Chem.* **2019**, DOI: 10.1021/acs.jmedchem.8b01847

'Useful Learning' makes things possible but not necessarily available

The founding of the University of Strathclyde in 1796 by John Anderson at the time of the Scottish Enlightenment stipulated that it should be an Institution for Useful Learning for the benefit of mankind. There can be few fields of activity with greater potential to satisfy our founder's stipulations than that of medicinal chemistry. There have been several exploits in the drug discovery field at Strathclyde, each with its own characteristics in terms of both background science and commercialisation pathway. This presentation draws on the past cases of Atracurium and Leucovorin, and current commercial ventures associated with the University of Strathclyde including MGB Biopharma in anti-infective compounds and Mironid in anti-inflammatory compounds together with a new venture in immunomodulatory compounds. Whereas Atracurium, Leucovorin, and Mironid's PDE inhibitors all have fully validated molecular targets consistent with the idealised standard industry drug discovery paradigm of single molecule, single target, single effect, our anti-infectives and

immunomodulatory compounds have non-conventional origins; they are in different senses multi-targeted. Whilst this property can be argued to be realistic in the case of most drugs despite their design and discovery philosophy, it presents challenges for the commercialisation and development even of demonstrably effective compounds. In the case of anti-infective compounds to tackle antimicrobial resistance, combining potency with resilience is unlikely to be met using the standard paradigm. In the case of immunomodulatory compounds, the complex interactions between signalling pathways make it difficult for a single target to lead to a balanced therapeutic response. For these reasons our approach from the academic environment has deviated from the standard paradigm. The scientific and developmental interactions in these cases will be described and discussed.

Dr Olga Shvarova, McGrigor Group

Olga is an Expert in Technology Transfer at the European Commission's Joint Research Centre and is an Advisor to APEC Centre of Technology Transfer. Olga works with Oxentia as the Senior Consultant and was involved in numerous technology transfer projects e.g. the Leaders in Innovation Fellowship Programme of the Royal Academy of Engineering, scouting technologies for Phillips, Siemens, Panasonic, Mitsui and Kawasaki Heavy Industry, Gates Foundation projects assessments, etc. Olga has a total of 15 years' experience of Intellectual Property consulting, innovation project management, technology translation and corporate finance, and is an Operations Director with New Medicine Partners, an advisory firm specialising in precision medicine, a Senior Consultant at McGrigor Group, a global strategy and M&A advisory firm in health insurance and medical products and services, and an Associate Partner at Ruffena Capital, a London-based corporate finance advisory firm specialising in private equity investments in SMEs. Olga holds a doctorate degree in Materials from the University of Oxford, and a summa cum laude Masters/Bachelor of Science degree in Geology from Moscow State University (Lomonosov). In the past Olga held a few short-term post-doc positions at the Department of Materials, University of Oxford.

Technology Transfer as Knowledge Creation

Despite the usual perception of technology transfer as a lateral from of knowledge from point A to point B, it is much better described as a knowledge creation process. This is especially true for the areas of knowledge where the knowledge is generated not for a single

purpose but to be used for a multitude of applications, e.g. process chemistry, biotechnology, or digital data manipulation. The technologies need to function in relation to their context of application, whether it is a biological production method or a water recovery. Thus, technology transfer becomes an active process of adapting and modifying the original invention to create a new product. In process chemistry commercial development is slow despite the fact that it has the potential to affect many spheres, from pharmaceuticals, to pollution control, to materials. Can this process be encouraged?

Professor John Blacker University of Leeds

Professor John Blacker is Chair of Process Chemistry and Technical Director of the Institute of Process Research and Development (www.iprd.leeds.ac.uk) appointed to both the Schools of Chemistry and of Chemical and Process Engineering at the University of Leeds. Prior to this he spent 18 years in the Fine Chemical industry as Technical Director working on catalysis and process development. In 2007 John transitioned to academia to help found the Institute for Process Research and Development, and was appointed a Full Professor in 2009. Blacker has 120 publications, around 40 patents, an H-index of 31 and over £15m of grant income. Research focus involves bio- and chemocatalysis in process development, industrial biotechnology, multi-phasic continuous flow, hydrogen transfer catalysis & manufacturability. Blacker has delivered and currently leads a number of large projects and collaborates extensively with industry. He is the recipient of RSC Process Development Award and SCI Chemistry for Industry Award.

Benefitting society with good product and process design

Abstract: Once a market need has been identified, and a project has delivered a prototype product design, there are many considerations for it to be successful in it reaching the consumer. Focusing on chemical process development, this presentation will discuss the essentials, the options, the difficulties and the joy in getting the product in to manufacture and to the people who need it. Considering costs, productivity, sustainability, safety, compliance and quality, the talk will use examples from bioplastics, industrial biotechnology, pharma and agrochemicals to illustrate how the efforts required in entrepreneurship can be successfully deployed.

Prof Will Zimmerman, University of Sheffield

Anatomy of a spinning out a company for microbubbles and more Prof Will Zimmerman (WZ), Chemical and Biological Engineering, University of Sheffield Chairman and Founder, Perlemax Ltd.

ABSTRACT Perlemax (PMX) was created from negotiations with fusionIP (now part of IP Group) over 2008-10, founded on two patent filings (energy efficient microbubbles and plasma activated microbubbles) which were eventually transferred to PMX. PMX was only created because the R&D needed to bring it to market required rare technical expertise (fluidics). Furthermore, the first commercialisation partner would only engage if WZ were "pledged". The negotiations were deadlocked until the award of the 2010 Royal Society "Labs to Riches" Innovation Award (£250k + prestige of the sole awardee) was revealed to WZ. These factors facilitated the founding of PMX with WZ holding the majority shareholding and control. With over 50 potential applications envisaged at the time (more than 500 now), it was essential that the IP not be fragmented nor WZ lose control. Hence the major commercial strategy has been licensing to commercialisation / enduser partners while PMX itself maintains a small cadre of R&D engineers, scientists, and technical support for the early applications and launching new. Perlemax has avoided dilution of the original shareholding by the strategy of following "market pull" for R&D and grants-in-aid for "technology push", as well as reinvesting its surplus into IP. PMX success, however, is really due to the capabilities of its cadre of developers, and in recent years, WZ's successor as CEO, Dr Pratik Desai (co-inventor of PMX's most recent patent – a new fluidic oscillator -- and sole inventor of its next – micronano droplet spray).

Mini-Bio A graduate of Princeton and Stanford Universities, WZ has held five prestigious research fellowships from NSF, NATO, RAEng (2) and EPSRC. He is creative inventor of seven patent families. Supervised over 40 doctoral students. Investigator on over £19m of academic grants. Author of over 180 scientific works including 140 scientific journal articles. Published a monograph Multiphysics Modelling with Finite Element Methods, World Scientific (which has been on the publisher's bestseller list), and served as author/editor for a multi-author volume Microfluidics: History,Theory, and Applications with Springer-Verlag-Wien, 2005. Winner of several awards, including the UK CleanTech Open (2010). Most recently recognized by the Anaerobic Digestion and Bioresource Association for Best R&D Innovation (2019) for the Desai-Zimmerman Anaerobic Digester. In REF 2014, author of two of Chemical and Biological Engineering's four impact case studies – monitoring systems for liquefied natural gas storage to avoid rollover explosions (software exploited by SME MHT Technology) and energy efficient microbubbles for wastewater aeration (implemented by SME Perlemax).

Prof Siddharth V. Patwardhan, University of Sheffield.

Siddharth is educated in chemical engineering and materials science, followed by post-doctoral experience in inorganic chemistry (Delaware and Nottingham). After taking up a short-term lectureship in Chemistry (Nottingham Trent University), he became a Lecturer in Chemical Engineering (Strathclyde). He then moved to Sheffield to take up a position of Senior Lecturer, where he was recently promoted to a Professor of *Sustainable Chemical and Materials Engineering*.

He is an EPSRC Fellow in Manufacturing and a Fellow of the RSC. Siddharth leads the *Green Nanomaterials Research Group* with a vision to develop sustainable routes to functional nanomaterials. His group focusses on the discovery of bioinspired nanomaterials, assessing their scalability and developing manufacturing technologies for energy, environmental, biomedical and engineering applications. This research has produced 70+ publications (*h* index of 33, over 3400 total citations), 50+ presentations at conferences and a number of inventions.

Siddharth has played a key role in a number of national and international networks as well as conference organisation, e.g. EPSRC's *Early Career Forum for Manufacturing Research*, RSC's *Materials Chemistry Division*, EPSRC's *Directed Assembly Grand Challenge Network* and ACS *Green Chemistry and Engineering conference*.

Along with various funding awards, he received the *Dedicated Outstanding Mentor* award four-times in recognition of his mentoring skills that helped mentees "make a significant transition in knowledge, work, or thinking". He also received *Teaching Excellence Award* twice and nominated as a *SuperVisionary* 'recognising good all-round supervision that has really made a difference to doctoral students'.

Abstract:

Global production of all types of nanomaterials is of the order of several million tons per annum, with value $3.4 billion, and enjoying continuous growth. However, nanomaterials have not received much attention in terms of making their production sustainable and green. Traditional methods for nanomaterials production can produce 1000s of kg waste per kg of product. We invented green routes to functional nanomaterials that are suitable for a range of applications (see patent WO2017037460). This enables the production of monodisperse silica nanoparticles and mesoporous silica, at room temperature, neutral pH

in water, and within 5 minutes. Green nanomaterials synthesis is based on learning from biology (biomineralisation), which produces large quantities of sophisticated and hierarchically organised nanostructured biominerals under mild conditions. Our fully synthetic approach uses inexpensive synthetic molecules inspired from biology (called "additives").

In order to make this new method accessible and impactful, we have started designing scale-up strategies. Taking a systematic approach in terms of both process scale-up and process intensification. We performed a techno-economic analysis of our method in order to assess the economic feasibility and followed by a number of experimental scalability assessments (up to 40L scales) that work in both batch and continuous mode in tank and tubular reactors. We have also focused on downstream processing, in particular, purification of the products, allowing a complete removal of organic impurities, with an added possibility of composition and porosity control. More than 90% of the water and additive can be recycled. We have demonstrated the potential of green methods by applying them to the synthesis of a range of nanomaterials, as well as testing them in real-life applications. Our focus is on increasing technology readiness level and delivering technologies that are ready for commercialisation.

Relevant publications:

1. Patwardhan, Manning and Chiacchia, *Curr. Opin. Green. Sus. Chem.*, 2018, **12**, 110. **URL**

2. Drummond, McCann and Patwardhan, *Chem. Eng. J.*, 2014, **244**, 483. **URL**

3. Patwardhan and Manning, WO2017037460. **URL**

4. Manning, Yip, Centi, Jorge and Patwardhan, *ChemSusChem*, 2017, **10**, 1683. **URL**

5. Entwistle, Rennie and Patwardhan, *J. Mater. Chem. A*, 2018, **6**, 18344. **URL**

6. Forsyth, Yip and Patwardhan, *Chem. Commun.*, 2013, **49**, 3191. **URL**

7. Alotaibi, *et al.*, *Chem. Sci.*, 2017, **8**, 567. **URL**

8. Forsyth and Patwardhan, *J. Mater. Chem. B*, 2013, **1**, 1164. **URL**

9. Davidson, *et al.*, *ACS Biomater. Sci. Eng.*, 2016, **2**, 1493. **URL**

Pam Randhawa, Empirika

From blackjack to entrepreneurship