

UK Catalysis Hub

Professor Graham Hutchings and **Dr Josie Goodall** explain the function of the UK Catalysis Hub and how it is working to maintain the UK's position as a global scientific and industrial leader



Harwell Science and Innovation Campus, Oxfordshire, that provides the physical hub for the new national programme whose total funding is around £13 million. This funds 120 years of research associate time spread across the four main themes and the partner institutions over five years.

What are the Hub's goals?

The UK Catalysis Hub aims to interact, network and build the UK catalysis and wider international catalysis community through collaborative projects, meetings, conferences and research outputs, including publications. The Hub also plans to build catalysis facilities at the research complex in Harwell. Furthermore, the Hub endeavours to develop a broad scientific programme, from fundamentals for tackling big challenges to allowing extensive collaboration to develop new catalysts, reactions and process. In turn, this provides fundamental understanding, benefiting industry, the economy and scientific understanding. The UK Catalysis Hub also aims to develop the next generation of students, through courses, conferences, PhD programmes, summer schools and outreach activities.

Have your studies unveiled novel insights into the impacts of catalysis studies on the UK's economy and society?

The impact of catalysis on the economy and society is huge, and as our need for new chemical feedstocks and new energy sources grows, this impact is only increasing. There are four key challenges for any catalyst or catalytic process: durability, activity, selectivity and cost. Multidisciplinary research

is essential to meet these challenges, and through close links with industrial partners and advisers the UK Catalysis Hub is focused on the needs of industry. These requirements mean that research should be planned to involve cost effectiveness, functionality and operational needs. Many of the projects funded as part of the Hub focus on underpinning research that is not feasible to be undertaken by industry but is necessary to make critical advances. The Hub is also involved in the training of future researchers, which in turn allows the UK to maintain its leading position in the field of catalysis.

What have been the principal advantages of working alongside co-investigators and project leaders from several institutions across the country?

One of the criteria of the projects funded by the Hub is that any research undertaken should be done by one group or institution. The collaborative projects enable new research to be accessed by facilitating teams of researchers at multiple institutions to work together and link expertise. The main advantage of the approach is to generate new ideas and research that may not be possible through other routes or explore new ideas arising from links.

Do you have further plans for expansion?

The UK Catalysis Hub plans to evolve to reflect the key challenges in the field and maintain a relevant and strategic research profile. Part of this is the call for projects that opened in November 2014 and will close in March 2015 to address new challenges and develop fresh collaborations.

Can you describe your current research centred on catalytic science?

Catalysis is a core area of current science, engineering and technology that has the potential to provide substantial economic and societal impact. Although rooted in chemistry and chemical engineering, catalytic science is now strongly multidisciplinary drawing heavily from materials and biosciences. The importance of the field is recognised by the Engineering and Physical Sciences Research Council (EPSRC), which has identified catalysis as a growth area. Furthermore, it has been acknowledged that there is a need for increased coordination of UK science in the field and to assist and promote its engagement with the country's industry. This is the driving force behind the recently formed UK Catalysis Hub, which comprises leading groups in catalytic science.

How did the UK Catalysis Hub start?

The Hub was established following the call in 2012 from EPSRC for the Catalysis Hub project. The initial team of four lead investigators together with over 20 principal investigators and 80 co-investigators from institutions throughout the UK formulated a joint proposal for a national programme of catalytic science. We have a centre at the

A catalyst for change

Catalysis is widely used in industry and science, and it drives biotechnological advances. The **UK Catalysis Hub** leads the country's research on catalysis and fosters collaboration across a variety of institutions

CATALYSTS HAVE BEEN used for decades in an extensive range of processes with over 80 per cent of products having used catalysis at some stage in their production. Catalysis mobilises reactions that would otherwise be impossible or excessively time consuming and subsequently economically unviable. In fact, it is thought that catalysis generates in excess of £50 billion per annum for the UK economy. Despite the immense success, the list of potential uses is far from exhausted. With a reactive infusion of new biotechnologies and increased understanding of the chemical processes involved, catalysts are becoming a stimulant for a generation of new technologies with a global significance.

The Catalyst Hub is a project designed to take the UK to the cutting-edge of the science and it includes an impressive host of researchers from several universities, including the University of Bath, University College London, Queen's University in Belfast, Cardiff University and the University of Manchester. Dr Josie Goodall of the UK Catalyst Hub is based at the Harwell Science and Innovation Campus, the centre point of the project. She explains the ideas behind unifying the institutions: "A collaborative multidisciplinary approach to these projects will draw together a disparate community and enable cross-disciplinary research, responding to a need to coherently address key challenges in the field". This association is driven by the mutual aim of using this contemporary science to solve some of the problems at the heart of society while retaining the UK's elevated status

among global industrial and scientific leaders. The project has been dissected into smaller subprojects each of which falls under one of four key themes. These themes have shaped the direction of the venture and have allowed it to be structured so as to address crucial areas in the development of the science.

DESIGNING IMPROVED CATALYSTS

The first of these four themes is led by Professor Richard Catlow of University College London. Entitled 'Catalyst by Design', it aims to explore the complexities of a catalyst's structure to discern more about the mechanisms involved in catalysis. The overarching objective is partitioned into individually funded projects that incorporate numerous innovative computational and experimental technologies, including the use of synchrotrons and laser facilities. In addition, the teams are working to understand the processes from the nanoscale up to the macroscale in order to boost the depth of understanding. This initial design stage is a vital first step towards developing specific technologies to solve real-world problems with palpable results.

ENERGISING SOCIETY

Since 1965, the world's daily demand for oil has nearly doubled. It currently sits at 86,753 thousand barrels per day, and demand for energy to fuel national and international needs only appears to be increasing. Hub's

second theme, 'Catalysis for Energy', addresses a sizable slice of this energy supply pie, as it aims to transform society from its reliance on hydrocarbons to using biofuels. Headed up by Professor Christopher Hardacre of Queen's University in Belfast, it encompasses several projects including the use of algal cells for energy production, new energy storage methods and photocatalytic water splitting, which is involved in the production of hydrogen fuel; an environmentally friendly energy source that has previously been held back due to costly production. The use of an effective catalyst could speed up the process of splitting water into oxygen and hydrogen, propelling hydrogen fuel into the realms of economic sense and producing a viable green fuel.

ELIMINATING ENVIRONMENTAL ISSUES

Across the globe, countries are joining hands and passing legislation that is calling for carbon emission reduction. For example, the EU passed the 20-20-20 plan, which aims to reduce greenhouse gas emissions by 20 per cent while simultaneously increasing renewable energy usage and energy efficiency both by 20 per cent. This drive is fuelling a vast amount of research into environmental remediation and preservation, and is reflected in 'Environmental Catalysis', the third part of the Hub's project outline. This theme aims to use catalysis to confront the world's most prominent environmental problems by refining and building on existing techniques, and generating

UK CATALYSIS HUB

OBJECTIVES

- To establish a world-leading, comprehensive and coordinated programme of catalytic science in the UK
- To develop new knowledge and promote innovation in and translation of catalytic science and technology. To facilitate this, the UK Catalysis Hub is an inclusive community across UK catalysis and the wider international catalysis community interacting and networking through collaborative projects, meetings, conferences and research outputs including publications

KEY COLLABORATORS

Professor Graham Hutchings, Cardiff University, UK • **Professor Chris Hardacre**, Queens University Belfast, UK • **Professor Richard Catlow**, University College London, UK • **Professor Mathew Davison**, University of Bath, UK • **Professor Nicholas Turner**, University of Manchester, UK • **Dr Josie Goodall**, Research Complex at Harwell Science and Innovation Campus, UK

FUNDING

Engineering and Physical Sciences Research Council

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GRAHAM JOHN HUTCHINGS is a British chemist, professor and Pro Vice-Chancellor for Research at Cardiff University. He gained his BSc in 1972 at University College London, a PhD from the university in 1975 in Biological Chemistry and a DSc from the University of London in 2002 for his work on heterogeneous catalysis. He is currently Director of the UK Catalysis Hub.

JOSIE GOODALL completed a PhD in Materials Chemistry at Queen Mary University of London (2006) investigating the properties of nano-ceramic materials for sunscreens and photocatalytic materials. She is currently based at the Research Complex at Harwell Science and Innovation Campus as part of the UK Catalysis Hub.

entirely new green appliances and specialised renewable energy sources. This ambition – being realised by Professor Graham Hutchings of Cardiff University – comprises a range of smaller, but equally important projects, such as water treatment, which aspires to create quicker and more effective methods for removing hydrocarbons and nitrates from water systems.

TRANSFORMING INDUSTRY WITH CHEMICALS

While the study of catalysis has contributed positively to the struggle against global warming, it is still, essentially, a product of industry. The fourth theme in the Hub's project is being explored by Professor Matthew Davidson of the University of Bath and is termed 'Chemical Transformations'. This topic involves the use of catalysis within UK industry, particularly in pharmaceuticals. "This theme aims to promote the prosperity of the UK manufacturing base in fine and bulk chemicals, polymers and pharmaceutical areas of research," Goodall explains. This theme draws information from all areas of the science, generating cutting-edge biotechnologies at the forefront of global research. It also includes a variety of specialist topics and challenges, including synthesis gas conversion, generation of renewable polymers and use of catalysis in a confined environment.

ONE MORE FOR GOOD MEASURE

With these initial four themes well underway, a fifth has recently been added to contribute further direction to the informative project. 'Biocatalysis and Biotransformations'. "The purpose of this theme is to lead to the development and

implementation of new catalytic solutions in sustainable manufacture based on the integration of biocatalytic processes," Goodall describes. As with the other themes, the concept is being subdivided into more specific aims such as developing the next generation of biocatalysts and the study of flow biocatalysis. A further consequence of this branch of the Hub is to distribute information learnt from biocatalysis across all of its sectors. The advantages of integrating Biocatalysis and Biotransformations with the existing themes are far reaching, and will exert influence on the entirety of chemical sciences, while also impacting many regions of commerce from home supplies to agriculture.

With the fifth theme contributing vast improvements in the understanding of biocatalysis, the Hub's next step is to amalgamate it with chemocatalysis to produce a new blend of catalysis. The group's intention is to achieve new discoveries in this area that will generate the potential for further investigation.

With so much still to learn, Goodall reveals her plans for the Hub: "The network of Hub affiliated academics and industrial groups can exploit the advances already made to fund new catalysis developments, growing the Hub's biocatalysis capability along with the UK catalysis research base as a whole". With energy prices rocketing across all sectors, landfill sites filling up and a growing global population exerting increased industrial demand, it seems catalysis could be the answer to many of the world's problems. Furthermore, the work of the Hub is ensuring UK-based research is leading the way in devising the solution to a better global future.

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A call to action

The UK Catalysis Hub has an open call for projects, running until 31 March 2015. This call is for up to two years of postdoctoral research to work on collaborative multidisciplinary, multi-institution projects that coordinate, promote and advance the UK catalysis research portfolio within the areas of catalysis, as represented by its four themes and/or in three catalysis areas. For more information on the Hub and how to apply, visit www.rc-harwell.ac.uk/UKCatalysisHub for more information.

