Materials for Sustainable Energy Technologies

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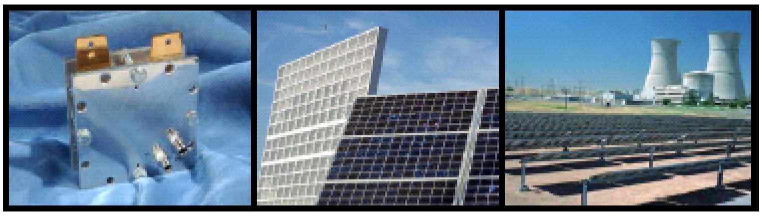
Royal Society of Chemistry



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Executive Summary

- Materials chemistry will underpin discoveries and breakthroughs in sustainable energy technologies.

- There are pockets of excellence in the UK in basic materials research, for example, developing new materials in photovoltaics, solid oxide fuel cell technologies, and batteries.

- Key weaknesses in materials chemistry research in the context of energy include a lack of (a) academics applying materials research to sustainable energy technologies (due to the rapid rise in significance of sustainable energy) (b) long-term funding (c) multidisciplinary research (d) funding to bridge the gap between fundamental research and technology development.

- Longer term goals in research and development will be the energy efficient electrochemical splitting of water, H_2 storage, advanced batteries, photovoltaics, nuclear fusion research and introducing design side efficiency for sustainable production of all materials.

Recommendations

Research Councils

- Significant long term funding (5 – 10 years) is required, in both responsive mode and targeted/managed programmes. The community would benefit from the streamlining of the various schemes presently available.

Government Bodies

- A more coherent strategy for sustainable energy research was called for which would compliment the UK's energy policy outlined in the government's Energy White Paper. More virtual research centres and collaborations between different institutions would facilitate access to European funding.
- Funding is required to support research as it moves from the laboratory into technology development. Tax breaks and other financial incentives should be offered to encourage industry to invest in sustainable energy technologies.

Learned Societies

- Greater interactions and collaborations are required between the various learned and professional societies to bring distinct academic communities together. Multidisciplinary research is effective but it could be greatly improved through mechanisms designed to bring the academic community together.

Introduction

The workshop – Materials for Sustainable Energy Technologies – was organised by the Royal Society of Chemistry and supported by the EPSRC. Materials chemistry is a cross-cutting theme which underpins discoveries and breakthroughs across a range of sustainable energy technologies. The aim of the workshop was to bring together materials chemists working on different sustainable energy technologies to assess present progress and discuss a future strategy for the UK in the support of sustainable energy research. This report summarises the discussion during the breakout sessions of the workshop.

Strengths

Fundamental research in materials chemistry is believed to be of a high quality in the UK.

There are pockets of excellence in several areas of research in materials for sustainable energy technologies. These are:

- synthesis of new functional polymers and nanomaterials for application in energy saving electronic devices, for example, in light emitting diodes for energy saving lighting.
- solid state electrochemistry, particularly in fuel cell research, batteries and photovoltaics, including the application of nanotechnology to these areas.
- Simulation and modelling of materials for developing a better understanding of materials used in fuel cells.

Key Challenges

1. Too few researchers

In the UK, there is a relatively small number of academics applying materials research to sustainable energy technologies in comparison to other technology applications. The number of researchers is also low in comparison to the proportion of mainland European researchers working in this area. Less than 1% of UK materials chemists are working in sustainable energy technologies.

2. Short term-ism in funding

Government funding mechanisms, and in particular the EPSRC's SUPERGEN initiative (Sustainable Power Generation and Supply Initiative) were discussed. The intent of SUPERGEN is highly valued in terms of the length of intended support (8 years) and the attempt to use innovative methods of consortium building. However, some found it difficult to reconcile the amount of effort which goes into securing the funding *versus* the level of funding received. There is also concern that the consortium building is too top-down.

The relatively short timescales (3 years) of normal research council funding was also seen as a major weakness in the context of the long-term challenge of sustainable energy research. It leads to a lack of continuity in academic research and a short term attitude. The short term-ism affects not only the continuity of research projects but the continuity of research personnel within research groups. All these factors have an effect on the type of research the UK is pursuing and the likelihood of technology development.

3. Targeted, long term funding for sustainable energy technologies
In terms of funding, responsive mode funding is viewed as being of vital importance to foster new discoveries and support high quality research. Such responsive mode funding needs to be long term 5 – 8 years rather than 2 – 3 years. However, responsive mode funding alone cannot address the strategic imperatives in research for sustainable energy technologies. It was felt that responsive mode funding must be complemented with more targeted, focussed funding and especially long term support to stimulate more materials research for sustainable energy technologies. This may help to increase overall numbers of researchers in this area which is underrepresented in chemistry and chemical engineering research in the UK. Any managed programmes must stem from bottom-up priorities, with the academic community itself driving the research agenda into new and exciting areas. This would also need to be integrated into the other existing managed funding initiatives.

4. A more coherent, streamlined, collaborative strategy
Delegates expressed a desire to see more coherency in energy research strategy and funding. A research strategy should be developed that would compliment UK energy policy.

It was suggested that research funding for materials chemistry in the context of sustainable energy technologies needs three streams, which run in parallel. All need equal support and funding. These are
1. Exploratory research
2. Incremental research
3. Step-change research.

The announcement of the UK Energy Research Centre was felt to be a good move in this direction although overall there was there was little support for a large centrally funded research centre or an IRC as past examples were not deemed to be successful; it was felt that centrally funded research centres limited resources available to others. The new UK Energy Research Centre (http://www.ukerc.ac.uk/), is funded until 2009 by the Research Councils. The interdisciplinary Centre will provide a focus for energy research in the UK. It is part of the Towards a Sustainable Energy Economy Programme (TSEC) – managed by the NERC on behalf of the EPSRC, ESRC and NERC who have jointly given £28 million funding to the whole programme. (TSEC sits alongside the ESPRC SUPERGEN and the Carbon Trust's Carbon Vision programme, collaboration between the Carbon Trust and the research councils). Some participants felt that funding the centre for only 4 years was a classic case of the UK's short term approach. Delegates would like to see the UK formulate a much longer term research strategy. There was a feeling that several of the schemes in existence should perhaps be pooled in one coherent managed programme.

Large-scale European funding favours large national institutions which are lacking in the UK – it was suggested that the establishment of more collaborative ‘virtual centres’ would bring academics into closer contact and foster multidisciplinary work. Virtual centres could also ease the difficulty experienced in securing funding from EU Framework VI and future EU programmes.

5. Not enough multidisciplinary thinking

Although UK materials research for application in sustainable energy technologies has some multidisciplinary element, there is still considerable room for improvement. Presently, there is little encouragement or incentive within the UK to carry out multidisciplinary research. In addition, the UK lacks a central mechanism to bring energy related research together and hence stimulate multidisciplinary research (however the recently established UK Energy Research Centre will help to address this issue). National barriers such as the RAE exercise were highlighted as factors that can act against multidisciplinary research. In particular, a lack of communication between chemists and engineers in academic research in the context of sustainable energy was highlighted. A more collaborative approach between chemists and engineers would facilitate breakthroughs in sustainable energy technologies.

Greater interactions between learned and professional societies (for example, RSC, IOM^3 and IChemE) is required to facilitate the interaction of different academic disciplines and communities and hence stimulate more multidisciplinary research. A key role of learned societies is the ability to bring a broad base of people to bear upon a particular challenge. The RSC should also work together with the new UK Energy Research Centre to ensure that materials science and chemistry is recognised in its strategy or potential road maps. It was suggested that the RSC also take these discussions forward into Europe in the context of the new Sustainable Chemistry Platform. The platform aims to brings together European industry, research centres, the financial world and regulatory authorities to tailor a strategic research agenda for the sector.

Joint lobbying by the learned societies would also be particularly effective in terms of providing ‘one voice’ to represent the science community. The RSC was praised for organising this workshop as a step in the right direction.

6. The ‘development gap’ in funding and culture

Ultimately materials research must be scaled up and put into production by industry. In particular, it was noted that there are weaknesses in micro-structuring, fabrication and processing of materials. There is a real need to bridge the ‘development’ gap between academic research and prototyping. Large-scale collaboration is required to drive breakthroughs. As well as the cultural divide, the ‘development gap’ is linked to a lack of funding for development. Whilst the decline in large-scale corporate R&D investment reflects a global trend, this decline is felt particularly acutely in the UK where large-scale industrial research was previously very strong. Opportunities to collaborate with industry and the availability of additional industry funding are no longer as widely and readily available.

There is also a perceived gap between the research funded by research councils and that funded by the DTI. Research councils focus on fundamental research while the DTI concentrates on developed technology and demonstration projects. This leaves a gap in funding which is required to move a technology through the early development stage. An example of this ‘development gap’ can be seen in photovoltaics, where basic research in the UK is excellent. However, at present, final devices for commercialisation are being produced and developed overseas. This funding gap must be bridged and supported during the intermediate phase as research moves from the laboratory to development.

In response to this challenge, Scotland has established an Energy Intermediate Technology Institute with 10 year funding of £15m per annum to bridge the gap left by a lack of real industrial R&D.

`Tax breaks and other financial incentives should be offered to encourage industry to invest in sustainable energy technologies. This is particularly important in the early stages of development, for those companies who work on sustainable energy research. University spin-out companies and other new start-ups especially need financial support as they are quite likely to provide many of the breakthroughs in the area of sustainable energy. (To this end it is noted that in the recent 2004 pre-budget report the government removed the charge on income tax and national insurance for researchers when IP is transferred into a spin-out company by a university or research institution. This was introduced in Schedule 22 of the 2003 Finance Act to ‘prevent tax avoidance’ in employee share schemes but had the unintended effect of curtailing the creation of spin-out companies by universities and research institutions).

In other countries, such as Switzerland, government will invest in research that industry supports as potentially useful. More of this collaborative support between industry and government would help progress in the UK. Such support would help to stem the movement of companies, with emerging but fledging technologies, out of the UK in search of development funding.

Key Research Areas

When prioritising research areas in materials for sustainable energy technologies, it was felt that, the UK must carry out research underpinning several technologies where it has real strengths rather than focussing on just one or two particular technologies.

Areas that are considered a priority are:
Materials for hydrogen storage to enable the development of a hydrogen economy for transport and other uses. This was seen as a key research area of high strategic importance.

Developments in energy storage technologies such as battery materials and electrochemical systems were given a high priority.

Improving membrane exchange systems for fuel cells was considered a key technology which need to be addressed to reduce the cost and improve the durability of fuel cells.

Longer term challenges for materials scientists discussed are:

- Developing efficient technologies for the energy efficient electrochemical splitting of water to produce hydrogen for fuel cells.

- Nuclear fusion research

- Design side efficiency in areas such as lighting and materials production. This was highlighted as an important issue to contribute to a sustainable energy future. Designing all materials and devices with a view to their environmental impact and the energy needed for their manufacture will be of high importance. Some of the technologies that may come into play here are new nanocomposites and other nanomaterials, biomimetic materials, new catalysts and conducting polymers.

It was agreed that in the future, it will be imperative to take a ‘whole-systems’ approach to tackling sustainable energy technologies and to assess the ‘system’ cost rather than focus on individual materials cost.

It must also be remembered that technology is not the only barrier to progress in moving to a greater use for sustainable energy supplies. Developing the infrastructure for the use of such technologies such as hydrogen fuel cells may be a bigger barrier to the use of this technology than the development of the technology itself.

Appendix I

The discussion groups were posed four questions, namely:

1. What are the UK’s strengths and weaknesses in materials chemistry research in the context of sustainable energy?
2. What should we prioritise as key research areas in materials chemistry for sustainable energy technologies in the short, medium and long term?
3. Should there be a more coherent strategy for materials chemistry research in sustainable energy technologies in the UK?
4. What do you envisage being the ‘energy production landscape’ in 30 years time in the UK and rest of the world? Will any one type of sustainable energy production dominate?

Delegates List

Name	Institute
Dr Tim Abram	BNFL
Paolo Agnolucci	Policy Studies Institute
Dr Tariq Ali	Imperial College London
Yeni Astuti	Imperial College London
Dr Ross Barlow	The University of Birmingham
Dr Teresa Belmar	Unilever
Dr Colin Boxall	University of Central Lancashire
Dr Nigel Brandon	Imperial College London
Dr Rachel Brazil	RSC
Professor Peter Bruce	The University of St Andrews
Rob Burrows	BNFL
Dr Nick Coleman	Corus
Dr Eimear Cotter	RSC
Dr Ron Dell	Thames Valley Section RSC
Dr Nick Dartnell	Kodak Ltd
Dr Geoff Dutton	Rutherford Appleton Laboratory
Dr Helen Fletcher	University of Sheffield
Dr Marta Gonzalez-Mosquera	University of Alcala
Professor Michael Gratzel	Swiss Federal Institute of Technology
Professor Xiao Guo	Queen Mary, University of London
Professor John Harding	University of Sheffield
Russel Heathcote	MEL Chemicals
Dr Gareth Hinds	National Physical Laboratory
Professor John Irvine	The University of St Andrews
Dr M.Saiful Islam	University of Surrey
Dr Catherine Jewell	University of Nottingham
Rebecca Lavender	RSC
Dr Bill Macklin	AEA Technology
Dr Donald MacPhee	University of Aberdeen
Dr John McAleese	Beta Technology
Dr James Mason	University of Southampton
Dr Ahmed Mohameden	Royal School of Military Engineering
Dr John Owen	University of Southampton
Julian Perfect	University College London
Professor Laurie Peter	University of Bath
Dr Rob Potter	Johnson Matthey
Dr Paul Rutter	Imperial College London
Professor Nigel Sammes	University of Connecticut
Professor Ravi Silva	University of Surrey
Professor Jim Skea	UK-ERC
Dr Stephen Skinner	Imperial College London
Dr Yan Song	Queen Mary, University of London
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