Centre for Doctoral Training in Fuel Cells and their Fuels

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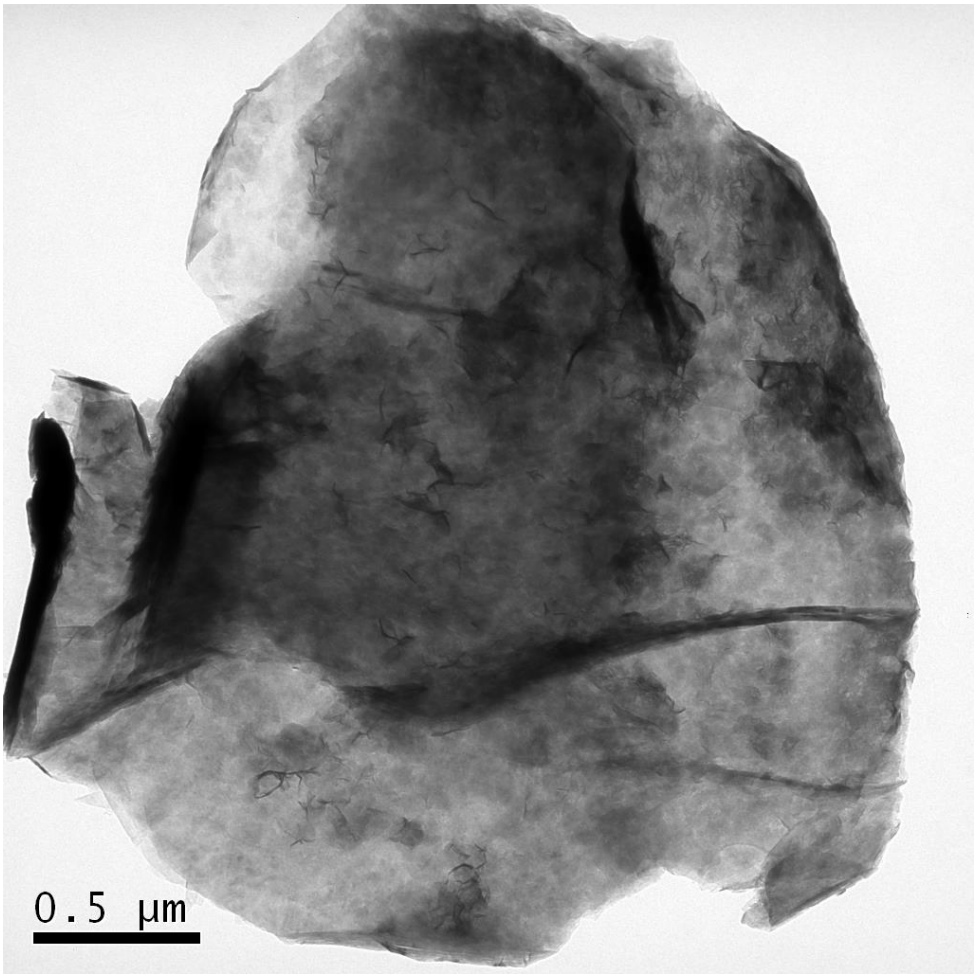

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CDT Fuel Cells and
their Fuels

UNIVERSITY OF BIRMINGHAM
Loughborough University
The University of Nottingham
Imperial College London
UCL

Welcome

Welcome to the April 2016 edition of the newsletter for the Engineering and Physical Sciences Research Council funded Centre for Doctoral Training in Fuel Cells and their Fuels which is a research partnership between the Universities of Birmingham, Nottingham, Loughborough, Imperial College London and University College London.

This newsletter was compiled by University of Birmingham Editors James Walker and Aimee Jackson with contributions from Site Editors Tom Heenan (UCL), Daniel Smith (Nottingham) and Ashkan Kavei (Imperial), as well as students from our partner universities. The editors are grateful to Project Officer John Hooper for his assistance. Readers can contact the editors with comments and contributions at:

hfc-cdt-editors@contacts.bham.ac.uk

Top: Aimee and James.

Bottom: Tom, Ashkan and Daniel.

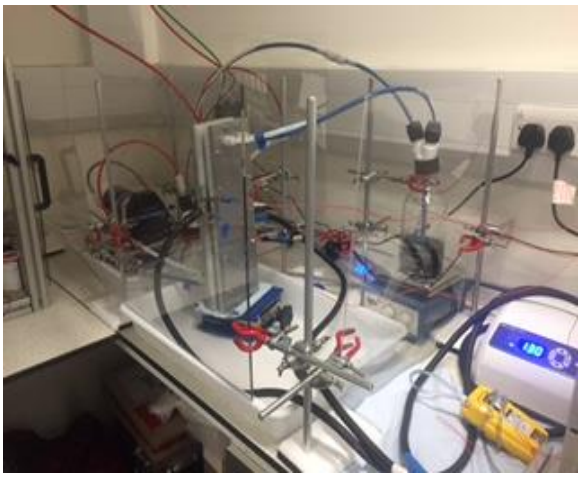
Thanks to Aimee for our cover image: a TEM image of graphene oxide – manganese oxide sheets. Highlights in this edition include an account of our recent annual meeting and snippets from recent conferences and events, as well as a round-up of public outreach activities from across our network.

Contents

Our Researchers: The Newbies

Ten new students started their PhDs within the CDT in 2015. We pinned down a couple more to introduce them in this edition.

Since beginning his PhD at Imperial College London, Ashkan Kavei has been working on a number of different projects carried on from his previous position as a research assistant. He has been continuing a feasibility study on the design of a Vanadium-Hydrogen Flow Battery system for applications in energy storage. Ashkan has been toiling away to design a suitably leak-proof cell system, since high concentrations of sulphuric acid are used in these devices.



Ashkan's flow cell.

Another of the first years, Derek Low, completed a B.Eng in Renewable Energy and Sustainable Technologies at Glyndwr University before moving onto study towards an MSc in Renewable Energy Systems Technology at Loughborough University. Continuing at Loughborough, Derek's PhD research will focus on the impact of operating conditions on the reliability of Polymer Electrolyte Fuel Cells. Derek will account for this impact using failure models which account for environmental parameters such as heat and humidity. These findings will feed into probabilistic models which can predict the modes of degradation affecting fuel cell components, in order to better predict stack lifetimes. Outside of his PhD, Derek enjoys a range of sports, including skiing, badminton, basketball and swimming.

What Have We Been Up To?

HydrogenDays 2016

A delegation from the University of Birmingham attended the annual HydrogenDays conference in Prague at the beginning of April. The programme combined talks and posters from technologists and researchers with practical demonstrations of fuel cell and hydrogen applications. The importance of identifying fuel cell added value was stressed. Our colleagues had a few lost-in-translation moments when touring the city, though, and were lost a few times. Maybe we'll have to plan some Czech courses before next year's event!

From left, Birmingham's Yousif, Robert, Sophie, Jong-Eun and Ahmad enjoying a break at HydrogenDays

Royal Society of Chemistry Energy Sector's Early Career Chemists' Symposium

In the historic setting of Burlington House, the Royal Society of Chemistry's London residence, PhD students and postdocs working on a broad range of energy-related chemistry research met in February to discuss their work.

Burlington House, right, set back from London's Picadilly.

From the CDT, Birmingham's James Walker and Loughborough's Jake Walls and Andrew McInnes went along for the day. Student flash presentations and a poster session sat alongside keynote speeches delivered by the University of Birmingham's Dr Jonathan Radcliffe, Imperial College's Professor Mary Ryan and the Chief Executive Officer of the Renewable Energy Agency Dr Nina Skorupska in the programme. Dr Skorupska and Professor Ryan were invited to reflect on their careers – and to offer some hints and tips for the next generation of researchers. Both gave uplifting and inspiring talks, with Dr Skorupska focussing on her take on how to avoid becoming bogged down by

organisational politics, and Professor Ryan highlighting the joys of interdisciplinarity in academia.

Graham Stevenson, author extraordinaire

First year CDT student Graham, who is based at Imperial College London, is currently likely to be found buried under a tonne of manuscripts as he's contributing to a book on solid oxide fuel cell power modules that Professor Nigel Brandon is due to publish in 2017. Graham is writing chapters on anode degradation measurement mechanisms and the state of affairs in the marketplace. We'd like to wish Graham all the best with the writing, and look forward to reading more when the book is published!

STFC ECRC 2016

The Science and Technology Facilities Council's Early Career Researchers' Conference is a event organised by early career researchers, for early career researchers. The topics at the ECRC all focused around electrochemical devices and the conference, now in its second year, was held between the 4th and 6th April at Coseners House, Oxford. This year the conference was run by Harini Hewa-Dewage of Imperial College, Rhodri Jervis of UCL and Thomas Heenan, who is our UCL CDT representative. There were attendees from 13 different institutions including two visitors from Tsinghua University in China. Talks covered a wide range of research areas, including lithium-ion batteries and liquid graphene applications. Feedback from the event was very positive and the organisers will now pass the reins on for ECRC 2017.

ECRC attendees sunning themselves on the grass outside Coseners House.

In-situ Electrode Potential Mapping

Birmingham's Laura and Ahmad recently visited the National Physical Laboratory (NPL) for some training on a technique that the team have been developing there. The technique permits in-situ mapping of electrode potentials across a polymer electrolyte fuel cell using through-plate reference electrodes

located in various positions. Potential measurements made across this network of electrodes permits the mapping of potentials and thus can be useful, for example, in degradation analysis. A further benefit of this approach is correction for IR drop effects. Laura and Ahmad are planning to aquire the relevant components to bring this technique to the University of Birmingham. For more information on the details of the technique, readers can consult ECS Transactions, 58, 2013, 1565-1587 with DOI of 10.1149/05801.1565.

The National Physical Laboratory, NPL.

The test stand, showing insertion of the electrodes through the end plate.

Opening of the Nottingham NMRC

The Nanoscale and Microscale Research Centre opened this month at the University of Nottingham. By way of opening ceremony, the School of Chemistry hosted a Low-Dimensional Materials Symposium, which brought together distinguished researchers in the field. There were talks from Sir Fraser Stoddart, FRS (Director of the Centre for Chemistry of Integrated Systems, Northwestern University), Ute Kaiser (Head of Electron Microscopy for Materials Science, University of Ulm) and Jeremy Baumberg, FRS (Director of NanoPhotonics Centre, University of Cambridge).

CDT students had a guided tour of the facility in the course of their recent annual meeting. Readers can find more information on the microscopy and spectroscopy facilities available, and means of gaining access to them, in our summary of the meeting which starts on Page 9.

The newly-opened Nanoscale and Microscale Research Centre at the University of Nottingham.

Outreach Activities

Rocket Seeds

The University of Birmingham's Aimee received a very exciting package this month. As part of a European Space Agency experiment and outreach project, Aimee and her brownie pack, 1st Berkswich Brownies, will be growing two sets of seeds under controlled conditions and measuring their growth. The excitement in this activity stems (Plant stems. STEM outreach. Geddit?) from the fact that while one pack are regular, run of the mill rocket (lettuce) seeds, the other pack has spent four months on the International Space Station! The experiment is designed to encourage STEM involvement, and also to gain an insight into the effects of space travel on food. We'll look forward to hearing about how Aimee's space seedlings are getting on!

The brownies' planted seeds.

UCell to Collaborate with Shell

In recent months, UCell from the UCL Chemical Engineering department, along with teams from Mechanical and Biochemical Engineering, have secured funding through a collaboration with the London Legacy Development Corporation for a project to develop entries for the Shell Bright Ideas Awards 2016. The project centres on the legacy of the Queen Elizabeth Olympic Park (QEOP) and will run throughout Spring, beginning with members from the public engagement teams at UCL delivering inspirational talks to 11-14 year olds at East London schools, discussing the need for cutting-edge research and its application. Following this, the UCell members will lead groups of students from the schools through interactive workshops developing innovative ideas to overcome energy problems at the QEOP, culminating in the creation of a prototype model demonstrating their ideas. The winning model will likely be placed on display at the park for all to see. UCell are very excited to be involved with such a large project and hope as a result to inspire many students to follow careers in STEM subjects.

FCH2 2016: Fuel Cell and Hydrogen Technical Conference

This year's FCH2 2016 Technical Conference is coming to Birmingham's Millenium Point in May. With speakers from industrial and academic backgrounds, the event promises to be an excellent opportunity to share knowledge and strike up new collaborations. Themes will cover a wide range of fuel cell and hydrogen-related topics including: materials and processes; hydrogen production and storage; socio-economics, marketing and strategy. Attendees should make sure to look out for the remote control electric vehicle circuit competition too! We hope to see many of you there.

More information including preliminary programming and registration can be found at www.fch2.co.uk or by tweeting @FCH2conference.

CDT Annual Meeting

In April, students from each of the Centre's partner universities came together at the University of Nottingham to showcase progress in their research and catch up on all the latest developments. Here we'd like to share some of the overwhelmingly positive feedback that we've had about the event, and to once again thank our always impressive student rep Lois Milner for all of her hardwork and dilligence in arranging the meeting.

Birmingham first year Oujen felt that the student presentations stimulated interesting discussions. He thoroughly enjoyed the group's post-dinner visit to Nottingham's iconic Ye Olde Trip to Jerusalem, which is England's oldest pub.

Thanks to Oujen for this picture of the Nottingham campus looking pretty.

Imperial student Ashkan appreciated the broad overview provided by hearing about everyone's research.

Birmingham student and much-praised meeting organiser Lois said that she particularly enjoyed learning about work underway in Nottingham on ionic liquids, as these were new to her. Lois also found the supportive atmosphere and enthusiasm for continual improvement of the CDT inspiring.

Scott, Birmingham fourth year, appreciated the opportunity for all of the various cohorts to get together to share their experiences. In particular Scott highlighted the usefulness for first and second year students to get feedback from more senior peers.

Graham, Imperial first year, also acknowledged the value in getting an overview of everyone's varied research projects. He enjoyed the informality of the evening meal and night out, and commented that events like these contribute to ensuring that each of the cohorts are integrated into one united CDT group. Finally, Graham praised the constructive nature of the feedback session which closed the event.

Birmingham student Sophie was surprised by how many questions there were after her talk. She enjoyed learning about fuzzy logic and had very positive feedback about the wedges at dinner. ☺

Rizki, Mélissa and Gulcan enjoying the meal.

First years Ashkan, Oujen and Graham.

Centre director Robert even showed off his pool skills.

Many thanks to Birmingham student Mélissa, who contributed these photos and had the following comments about the meeting:

I really enjoyed Scott's talk on consumer acceptance of fuel cell vehicles. It made me realise how much work we have to do to compete with electric cars! The mac 'n' cheese was great too.

The whole group thoroughly enjoyed their pizza, mac 'n' cheese and wedges buffet at Oscar and Rosie's in Nottingham.

After the meeting, attendees were conducted round the University of Nottingham School of Chemistry (SoC) on a tour kindly organised and ably lead by CDT students Daniel Smith and Sean Goodwin. Beginning in Professor Steve Howdle's polymer laboratory, PhD student Tom McAllister provided an overview of their thermogravimetric analysis, differential scanning calorimetry and dynamic mechanical

analysis instruments. Thereafter, Dr Mick Cooper and Dr William Lewis introduced the school's mass spectrometry facilities, and X-ray diffraction/crystallography instruments, respectively. Next, the group visited the nuclear magnetic resonance spectroscopy suite, where there are three 400 MHz instruments available for use.

Between lab tours, the group visited the school's atrium, which contains schematic diagrams of the new Carbon Neutral Laboratory to be opened later this year. The tour also included a pit-stop at the refectory run by Sue Bamford, who provides free hot drinks to PhD students daily. As readers might imagine this is a central part of PhD culture in the SoC!

Next, the group visited the Walsh Electrochemistry Group, where Daniel and Sean both work under the supervision of Associate Professor Darren Walsh. Here the tour group were shown a variety of potentiostats, a scanning electrochemical microscope, and high-vacuum electrochemical apparatus. As the electrochemistry of protic ionic liquids is a focus of the research group, the vising students were shown the elaborate glassware apparatus used to make and dry ionic liquids under vacuum.

Finally, the students were delighted by a pre-opening guided tour of the new Nanoscale & Microscale Research Centre (NMRC). Centre Director Andrei Khlobystov, Professor of Nanomaterials, has overseen the installation of a suite of scanning electron microscopes and transmission electron microscopes, as well as X-ray photoelectron spectrometers (overseen by Dr. Emily Smith), a Raman microscope and an ultramicrotome. The microscopes will provide extensive facility for energy dispersive X-ray spectroscopy, wavelength dispersive X-ray spectroscopy and electron energy loss spectroscopy measurements. NMRC Research and Business Manager Karen Alvey can be contacted for enquiries regarding access to the facility.

It's hoped that the tour will promote further collaboration between our CDT students and researchers local to the SoC/NMRC. Please get in touch if you have anything in the pipeline as a result as we'd be delighted to share these stories in future editions.

Thanks again to all those who made the meeting such a great success and here's to next year! No pressure for organisers Oujen and Graham then! ;)

Ask the Alumnus

In February, we caught up with Katie Howe, who completed her PhD within the then Doctoral Training Centre in Hydrogen, Fuel Cells and their Applications at the University of Birmingham in 2013. Katie hails from Sheffield, and prior to joining the DTC she studied for an MA in Natural Sciences (Physical) at the University of Cambridge. When she finished her PhD, Katie took up a trainee patent attorney position with Barker Brettell in Birmingham. For readers who are unsure what Katie's job might entail, she suggests that she could reasonably be described as a "science lawyer" and day-to-day, in between studying for professional exams, she meets with inventors to draft and file patent applications for their inventions. Katie described the intricacies of balancing the broad and encompassing with the novel and inventive when drafting the claims of a patent application, and highlighted the importance of pedantry due to the precise meanings of certain words in patent-speak. Katie's work generally covers the not at all diverse-sounding area of innovations in "physics/engineering/computer science" and she describes working on technologies as varied as pogo sticks and smartphones. We interviewed Katie to find out about her PhD experience, how the DTC journey shaped her skillset, and any wisdom she might have to share us.

JW: Thanks for talking to us Katie. First of all, what did you work on in your PhD and can you pinpoint any research highlights?

KH: My thesis title was 'Design improvements of micro-tubular solid oxide fuel cells for unmanned aircraft applications,' and a definite highlight would be the two months that I spent working with unmanned aircraft in France! I was also pleased to develop a water-based cathode ink which worked at least as well as the incumbent organic solvent-based ones.

JW: And more generally, any particular highs and lows of your PhD experience?

KH: Well the conferences in Mexico, Canada and Switzerland were all pretty good! Cocktails in the pool between the morning talks and the afternoon talks in Mexico were definitely a highlight. On the other

hand, the ten minutes that I spent waiting outside of the room in which I had my viva whilst the examiners deliberated before calling me back in to announce the result were the longest of my life!

JW: How have the non-research elements of the DTC training programme impacted your career? Were you involved in any particularly interesting mini-projects or collaborations?

KH: I was involved in filing a patent application (on water-based cathode inks), which got me thinking about patent law as a career, and the two months that I spent in France improved my French hugely. This is sometimes useful in my current role (although admittedly not as useful as German or Japanese would have been….). Additionally, working with EADS Innovation Works (project sponsors) and DuPont (on a mini-project) provided invaluable experience of working with different people, in different environments.

JW: Does your work now involve fuel cells or hydrogen?

KH: I have only been involved in drafting one fuel cell related patent application so far, but hope to get more in that area. By all means drop me a line if you are wondering whether or not something you have done could be patented!

JW: Great to talk to you Katie! One final question; if you could give one piece of advice to your PhD student self, what would that be?

KH: Make the most of what's on offer! There are lots of opportunities available, but you need to go looking for them. Keep an eye out for interesting conferences you might have something suitable to present at. Think about what you want to do after the PhD, and see if you can tie your mini-projects into something relevant and/or get teaching and lecturing experience. Investigate extra courses you can access (e.g. language classes, characterisation technique training, undergraduate teaching training).

Thanks again to Katie for her enthusiastic and insightful responses, and thanks to Scott Hardman for suggesting this feature! We're hoping to make this a regular newsletter item so if you know of any interesting alumni that you'd like to hear from, please get in touch with the editors.

Announcements & Closing Remarks

Don’t forget to let John Hooper (J.C.Hooper@bham.ac.uk) know about any conferences that you attend, along with your talk or poster title.

That’s all for this issue - thanks for reading! We look forward to seeing many of you at Millenium Point in Birmingham for FCH2! In the meantime, any comments, captions or contributions to the next edition can be sent to the editors at hfc-cdt-editors@contacts.bham.ac.uk or you can tweet us at @FuelCellsCDT. You’ll also find us on Facebook as ‘Fuel Cells and their Fuels CDT’.