UCL

100

UCL Chemical Engineering since 1923

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Foreword by Head of Department

It is my very great pleasure to present to you this Centenary publication, giving you an overview of our department in our Centenary year 2023-24.

We trace our history back to 1923 when the Ramsay Memorial Department of Chemical Engineering was established at UCL. The objective then was to enable young graduates in chemistry and engineering, who had already obtained good training in the fundamental sciences, to direct their studies towards the application of these sciences to the design and operation of chemical engineering units and processes.

Whilst the initial focus of the department was to provide postgraduate level education and conduct research particularly related to scale-up and design of chemical processes, we now provide a broad educational programme based on an extensive research portfolio across a wealth of areas, from the molecular level to the scale-up of large processing plants, developing innovative and impactful technological solutions that leverage advances in basic sciences addressing global grand challenges in domains such as advanced manufacturing, functional materials, health, energy, environment and sustainability.

From a humble beginning of three students and two members of staff in 1923, in 2022-23 we counted over 800 students and over 150 staff members of which 47 academics. Our students, now nearly 40% female, come from all corners of the world and the department's alumni reach is therefore extensive, spanning many different industries, organisations and academic departments and counting several CEOs and Heads of Departments.

We currently offer two undergraduate degrees, BEng and MEng, with the latter having five different routes with different specialisations. We also offer two MSc programmes at our main campus in Bloomsbury and will in our Centenary year launch three new MSc programmes at our new campus at UCL East in Stratford. This campus is the next chapter in UCL's disruptive thinking and the biggest development in UCL's nearly 200-year history. The development will provide facilities for cross-disciplinary research and open innovation, new approaches to practical learning and opportunities for public engagement, and the department is playing a key role in this vision.

Our research programme counts over 160 PhD students who work alongside nearly 70 postdoctoral researchers. Our research activity remains very strong, as do our educational offerings, and we are consistently recognised amongst the top 20 chemical engineering departments in the world according to QS World University rankings. This publication will briefly outline our research themes and main application areas and will show that we are contributing, and leading, at the forefront of science in solving many of the challenges that the world is currently facing, including climate change, global health and transformative technology as illustrated by the research and impact highlights.

Within the department, we place great emphasis on looking after our staff and students, particularly related to equality, diversity and inclusion, and we are committed to a supportive culture for all. We were recently awarded a Gold Athena Swan award for our work in this regard, a recognition of which we are immensely proud. The work nevertheless continues, and we have clear action plans going forward.

It is difficult, if not impossible, to predict where we will be in 100 years' time. It is, however, clear that we will continue striving for excellence and that the problems we will be tackling will continue to increase in complexity and size. Our vision is to go even smaller in terms of considering behaviours at the molecular scale, as well as considering systems and processes that are far bigger than what we are currently able to investigate. Collaboration across disciplinary boundaries will become even more important, and our new facilities at UCL East are clearly a step in this direction. The advent of artificial intelligence offers both opportunities and challenges, for research and for education, and how to navigate this new paradigm will clearly be very important.

Happy reading!

Eva Sorensen MBE
MSc MA PhD CEng CSci FIChemE FHEA FSEFI

Professor in Chemical Engineering
and Head of Department

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Facts and Figures

837
Students in 2023-24

555
Undergraduates

122
Postgraduates

160
PhD

63%
International Students

39.5%
Female Students

19th

Ranked 19th in the world
QS World University Rankings 2023:
Chemical Engineering

Research Expenditure in 2022

£11,728,870

196
Degrees
Awarded in 2022

95
BEng & MEng

81
MSc

20
PhD

160
Staff members in 2023-24

33
Dual-track academics

40
Professional services staff

18
Teaching academics

69
Postdoctoral researches

28%
Female staff members

Staff originating from 25+ different countries

379
Publications in 2022

46
Conference papers

19
Book chapters

314
Journal articles

The world of UCL Chemical Engineering
(countries of origin of staff and students)

Departmental growth

	Students	Academic Staff	Professional Services Staff	PDRAs
1923/24	3	2	1	0
1973/74	109	17	33	8
2023/24	837	51	40	69

Academic Staff

Reza Abbasi
Lecturer (Teaching) in Digital Manufacturing of Advanced Materials

Panagiota Angeli
Professor in Chemical Engineering

Sakiru Badmos
Lecturer (Teaching) in Chemical Engineering

Diego Lopez Barreiro
Lecturer in Nature-Inspired Chemical Engineering

Sudeshna Basugupta
Associate Professor (Teaching) in Sustainable Resource Management (part-time)

Solomon Bawa
Lecturer (Teaching) in Digital Manufacturing of Advanced Materials

Maximilian Besenhard
Lecturer in Digital Manufacturing of Advanced Materials

David Bogle
Professor of Chemical Engineering, Pro-Vice-Provost (Doctoral School & ECR Staff)

Dan Brett
Professor of Electrochemical Engineering

Vasileios Charitopoulos
Lecturer in Product & Process Systems Engineering

Vicky Chen
Lecturer (Teaching) in Electrochemical Power Systems

Marc-Olivier Coppens
Ramsay Memorial Professor in Chemical Engineering, Vice-Dean

Vivek Dua
Professor of Chemical Engineering

Zahra Echresh Zadeh
Lecturer (Teaching) in Chemical Engineering

Eric Fraga
Professor of Process Systems Engineering

Federico Galvanin
Associate Professor of Chemical Engineering

Asterios Gavriilidis
Professor of Chemical Reaction Engineering

Stefan Guldin
Professor of Adaptive and Responsive Nanomaterials

Rhodri Jervis
Associate Professor in Electrochemical Engineering

Dina Kamel
Lecturer (Teaching) in Chemical Engineering

Yang Lan
Lecturer in Nature-Inspired Chemical Engineering

Lauren Lee
Lecturer in Data-Driven Chemical Process Systems Engineering

Paola Lettieri
Professor of Chemical Engineering, Pro-Provost (UCL East)

Isobel Mackay
Lecturer (Teaching) in Sustainable Resource Management

Haroun Mahgerefteh
Professor of Chemical Engineering

George Manos
Associate Professor in Chemical Engineering

Massimiliano Materazzi
Associate Professor in Chemical Engineering

Luca Mazzei
Professor of Chemical Engineering

Tom Miller
Associate Professor in Electrochemistry and Materials Science

Peyman Moghadam
Associate Professor of Data-driven Materials Engineering

Andrew Morrison
Lecturer (Teaching) in Electrochemical Power Systems (part-time)

Alexander Norori-McCormac
Associate Professor (Teaching) in Sustainable Resource Management

Ademola Odunsi
Lecturer (Teaching) in Chemical Engineering

Lazaros Papageorgiou
Professor of Chemical Engineering

Andrea Paulillo
Senior Research Fellow

Albie Pheasey
Lecturer (Teaching) in Sustainable Resource Management (part-time)

Michaela Pollock
Associate Professor (Teaching) in Chemical Engineering

Alex Rettie
Associate Professor in Electrochemical Energy Conversion and Storage

James Robinson
Lecturer in Advanced Propulsion

Elton Rodrias
Associate Professor (Teaching) in Chemical Engineering

Matteo Salvalaglio
Professor of Molecular Systems Engineering

Alex Sebastiani
Lecturer (Teaching) in Chemical Engineering

Marcello Sega
Associate Professor of Molecular Thermodynamics

Justin Siefker
Lecturer (Teaching) in Chemical Engineering

Eva Sorensen
Professor in Chemical Engineering,
Head of Department

Junwang Tang
Professor of Materials Chemistry and Engineering (part-time)

Aikaterini Tsatse
Lecturer (Teaching) in Chemical Engineering

Amita Ummadisingu
Lecturer in Nature-Inspired Chemical Engineering

Ryan Wang
Associate Professor of Chemical Engineering

Polina Yaseneva
Lecturer (Teaching) in Sustainability and Life Cycle Assessment (part-time)

Ozgur Yazaydin
Professor of Chemical Engineering

Professional Services Staff – Admin

David Alabaster Senior Finance Officer
Marietta Bamidi Learning Technologist
Mark Bernardes Communications and Marketing Officer
Lara Bogart Senior Research Finance Officer
Katie Bretherick Student Adviser
Paul Carter-Bowman Senior Research Finance Officer, EIL
Beth Hills Senior Teaching and Learning Administrator
John Hooper LiSTAR Project Manager
Lizzie Howie Outreach and Communications Officer
Melanie Ingle Facilities Administrator
Graham Knight CNIE Project Manager
Magdalena Knitter Finance Administrator
Katy Le Lion Departmental Manager
Lisa Pfaffenrath Inclusion Lead Public & Patient Involvement
Queenie Poon Teaching and Learning Administrator
Robin Ramphal EIL Project Integrator
Claire Saunders EIL Centre Manager
Rea Souida Senior Staffing Officer
Mark Tilse Doctoral Students Administrator
Melania Torok Executive Assistant (EA) to Head of Department
Pinkie Wong Teaching and Learning Administrator

Professional Services Staff – Technicians

Simon Barrass Facilities Manager
Mark Buckwell APL Lab Manager
Natalie Burnham Technical Safety Manager
Eileen Cheng MFL Lab Manager
George Christoforou Computing and Electronic Systems Technician
Albert Corredera Electronics Technician
Simon Dawes Workshop Technician
Dave Ellis Computing and Electronic Systems Technician
Francesco Iacoviello Experimental Manager (EIL Lab X-ray imaging facility)
Omid Nashrollahi Electronics Technician
Toby Neville Departmental Technical Operations Manager
Barry Reid Research Technician (CNIE)
Ami Shah Technician (EIL)
Nirav Shah Technical Lab Administrator
Nick Snead Instrument Technician
Mark Spurgeon Computing and Electronic Systems Technician
Martyn Vale Computing and Electronic Systems Manager
Sydney Wieckowski MFL Lab Technician (Chemical)
Han Wu Research Laboratories Manager

Our History

Heads of UCL Chemical Engineering Department 1923-2023

E. C. Williams
1923 – 1928

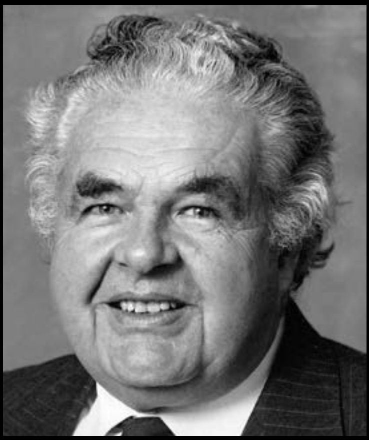
W. E. Gibbs
1928 – 1934

H. E. Watson
1934 – 1951

M. B. Donald
1951 – 1965

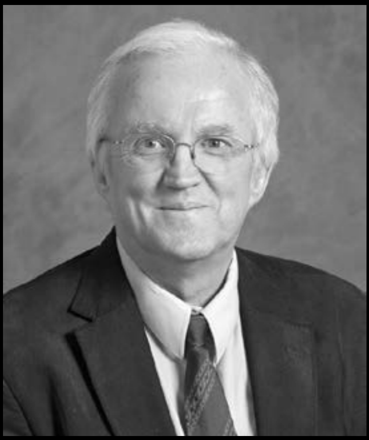
P. N. Rowe
1965 – 1985

J. W. Mullin
1985 – 1990



A. R. H. Cornish
1990 – 1996

J. G. Yates
1996 – 2003

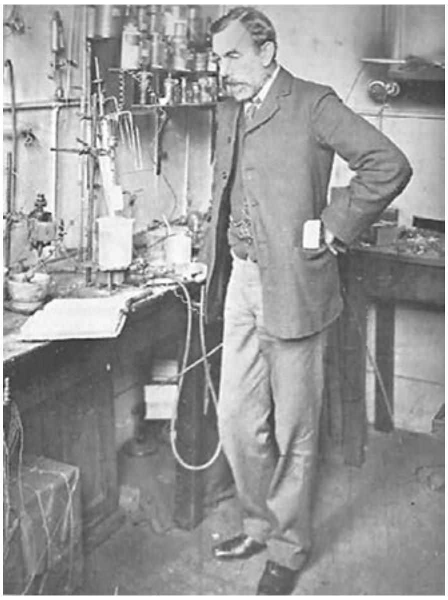


A. G. Jones
2003 – 2012

M. O. Coppens
2012 – 2020

E. Sorensen
2020 (interim) – present

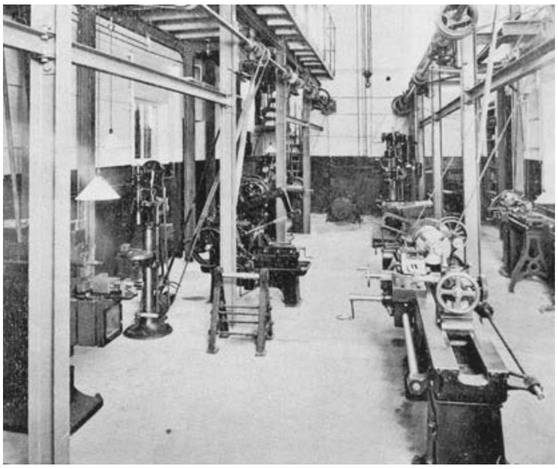
UCL Chemical Engineering at 100



Sir William Ramsay, Professor of Chemistry at University College London, 1887-1913

1922-1923 was a key time for our profession and the industry it supports following the end of the First World War. During the war, Lord Moulton, the Director General of Explosives Supply, had insisted on the necessity of training chemical engineers to improve chemical plant design and efficiency. The idea of forming a dedicated body for chemical engineering had taken root but for years faced resistance, including from existing bodies and institutions. Despite this opposition, clamour among practising engineers grew. There was a clear consensus that there was a need for a more scientific approach to the design, construction, and operation of chemical plants, a distinct place in the educational system, and for chemical engineering to have its own qualifying body. The establishment of the UCL Chemical Engineering Department was in response to the second of these points and the foundation of the IChemE to the last. UCL was not the first to give courses in Chemical Engineering: George Davis gave courses in the late 19th century at the Manchester Technical College and there were courses at Battersea College, but UCL was the first University to establish a dedicated Chemical Engineering Chair and Department, following the death of Nobel laureate and UCL Professor of Chemistry, Sir William Ramsay in 1916.

The department was founded in 1923 with Professor E. C. Williams as its first Chair (1923-1928). In spite of the significant fundraising drive, money was initially tight – as Mr Potter wrote in 1973: ‘I am amused when I think of the affluent conditions existing in the University when I retired and compare them with those in the early days of the department. Students had to pay for all the equipment they used, and, in the beginning, they even had to pay for the technician’s time.’

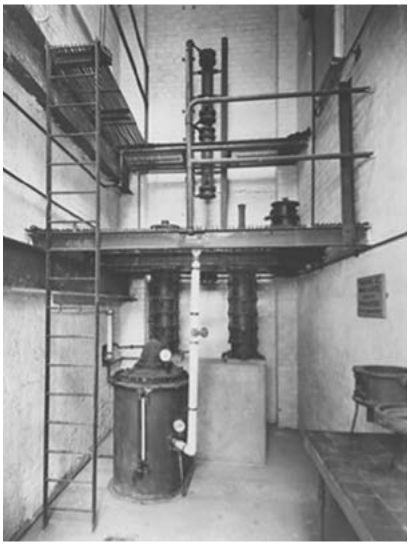


Workshop in the Ramsay Laboratory, 1931

Professor Williams was a man of tremendous enthusiasm, undaunted by inadequate premises or lack of plant and equipment. Initially a laboratory was constructed, lofty enough to take a small-scale distillation column and other items of equipment, while a basement room in the old St. Pancras Vestry Hall was fitted out as a workshop. […] For this novel venture many firms sent or donated plant and equipment which was used by students, some of whom came to take a postgraduate course and some to do research, but all helped to get the place organised so that after a lot of hard work the Ramsay Laboratory of Chemical Engineering was officially opened in 1931.

The Ramsay Lab – Early Days by H. W. Thorp, former member of staff, writing for the 50th anniversary Ramsay Society Journal

In its founding year, the department only had three students and two full-time staff members, Professor Williams and Mr Potter, the 'Chief Mechanic', which grew to three by 1924 with the addition of Dr Burrows Moore. Many alumni may also remember Mr Potter's daughter, Valerie, who joined the department as a secretary in 1957 and retired as Departmental Administrator in 1997. The first students were admitted in 1923, and a full (two-year postgraduate diploma) course started in 1924 followed by a four-year undergraduate B.Sc. (Eng.) degree course in 1937. The first temporary accommodation was opened in 1924 in the then St Pancras Vestry Hall, while the site of 21 and 23 Gordon Street next door was being used for the building of the new Ramsay Memorial Laboratory of Chemical Engineering. The department was arranged over two blocks, with a short corridor connecting the new four-storey laboratory with the old two-storey building (formerly the vestry rooms). One can still see the front of the building which now houses the Physics Department, but the inscription 'Ramsay Memorial Laboratory of Chemical Engineering' is covered. At its completion, the department provided space for approximately 50 students and researchers. Research has been carried out since the foundation of the department.



Bubble cap distillation column
in the Ramsay Laboratory, 1931

The Ramsay Laboratory of Chemical Engineering (completed in 1931)

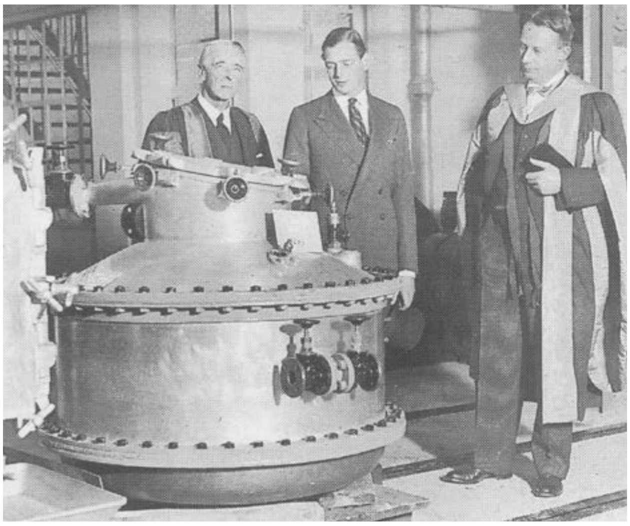
The industrial laboratory, in the Ramsay Laboratory, 1931

In 1935 my wife and I left Holland to come to London to study chemical engineering, England then being the only country in Europe where this was possible. Two most pleasant years were spent in the Ramsay Laboratory of Chemical Engineering. It was an interesting period in many ways – in 1936 there was the first Chemical Engineering World Congress. Quite a number of congress members visited our department and I was asked to take around Professor Eucken and Dr Damköhler.

Mr H. Verschoor (student, 1935 – 1937), writing for the 50th anniversary Ramsay Society Journal

While most of UCL was evacuated during the Second World War, the staff and students of the Chemical Engineering Department valiantly continued their work in London, because of the urgent need for trained chemical engineers. The older part of the department scored a direct hit during an air-raid in May 1941. Despite this, the course that year was completed using the premises of the School of Architecture.

Following the war, in 1946 in view of the rapid growth of the various branches of Engineering, the Engineering Faculty was reorganised into four departments: Civil and Municipal, Mechanical, Electrical, and Chemical Engineering. Prof M.B. Donald (Ramsay Memorial Professor, 1951-1965) became aware of the need for biochemical engineering and established the first British postgraduate course in 1959; an undergraduate degree course started in 1973. A new Engineering Faculty Building was erected in Torrington Place on the south of the College rectangle, which was completed in 1961, where the department was relocated.



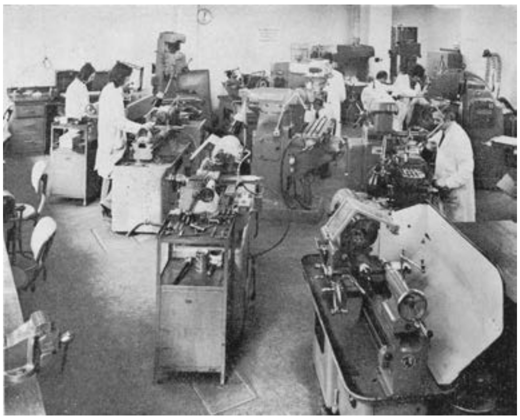
The formal opening of the Ramsay Laboratory of Chemical Engineering by HRH Prince George, Duke of Kent on 26 November 1931. Lord Chelmsford (left), the Chairman of the College Committee, and Professor W. E. Gibbs (right), the second Ramsay Memorial Professor, with the Duke, inspect an oil boiler used to manufacture components for paints and varnishes

The post-war growth of the oil industry was significant for UCL and the IChemE, with growth in numbers and a greater significance in becoming chartered. With a Chemical Engineering degree, the route was clear but those without had to take a written exam and what was called the ‘home paper’ to draw up plans for a complete unit. This was considered more stringent than the equivalent of other Engineering Institutions. Many from the UK and abroad took this route because of the excellent employment prospects.

In the mid-60s the first two female students joined the department: Maureen Rowley as an undergraduate student in 1964, and Iris Pape as a postgraduate student in 1966.

The 1970s saw the oil crisis caused by OPEC and this affected Chemical Engineering. In the 1973 Ramsay Journal (the department’s long-running annual publication) Peter Rowe, who was Ramsay Professor from 1965 to 1985 and IChemE President in 1981, talked about how the department had looked to spread its expertise well beyond oil and gas. The anniversary journal also has articles about electrochemical engineering, biochemical engineering, and fluidisation. Fluidisation research, which began when Peter Rowe joined the department from Harwell where it was being developed for the nuclear industry, continues strongly to this day. Biochemical Engineering flourished, with the department becoming the Department of Chemical and Biochemical Engineering in 1977, and the research group splitting off to become a separate department in 1997. Electrochemical Engineering waned but is now reborn and going strong.

The “new” Engineering Faculty building (completed in 1961)



Workshop in the Engineering Faculty Building (ca. 1973)

Our 50th anniversary is something in which we all take immense pride for we are one of the few departments of chemical engineering that can trace an unbroken history back so far. Naturally it is the present students and technical and academic staff that glow most warmly in this atmosphere of proud achievement, but the credit is really due to those who have gone before. […] In order to survive departments will have to develop some speciality and produce graduates suited to employment in areas outside the hitherto conventional ones. […] In a distinguished multi-faculty college, we can easily shift our emphasis to blend chemical engineering with other disciplines as the need suggests. With this combination of flexibility and opportunity we can be optimistic about the next 50 years and predict that a major trend will be towards a more liberal definition of a chemical engineer.

Professor P. N. Rowe's presidential foreword from the 50th anniversary Ramsay Society Journal

Chemical Engineers have a critical role to play in the next hundred years, particularly in tackling the climate emergency.

The 1973 'Golden Jubilee' Ramsay Society Journal celebrated 50 years of the department and included recollections from former staff and students, reflecting a small but willing department with a can-do spirit. Peter Rowe also commented in 1973 on the decreasing numbers of students choosing to study Chemical Engineering. The national intake figures were cyclical over many years with numbers fluctuating between 700 and 1,000. Since the year 2000, numbers have grown significantly, to a nationwide peak of 3,000. This is due to the success of IChemE's 'WhyNotChemEng?' campaign, as well as the recognition of the value of chemical engineering skills well beyond the traditional heartlands of the oil and gas industry. Student numbers at UCL have grown, with a current annual intake of around 800 across both undergraduate and postgraduate students. Staff numbers have grown too, with the department now boasting 156 staff members, including 69 Postdoctoral Research Associates.

There is much to celebrate in the past 100 years, both for the department and the IChemE. Chemical Engineers have a critical role to play in the next hundred years, particularly in tackling the climate emergency. Chemical Engineering is the 'Engineering of Chemicals': in the environment, in energy systems and infrastructure, in the development of cities and the countryside, and even in medicine where UCL is historically strong and where the department now has many collaborations, as well as in the traditional industrial heartlands, of course. The role of Chemical Engineers is more important today than it has ever been and UCL Chemical Engineering plays an internationally recognised role in their training and careers.

Contributed by Prof. David Bogle and Melania Torok

Excerpt from the 50th anniversary Ramsay Society Journal, describing the Golden Jubilee Dinner of 1974

‘The Golden Jubilee Dinner was held on St David’s Day, 1 March 1974. 70 past students and associates and 74 present students and staff attended, the largest total since 1968. After sherry in the Housman Room, dinner was served in the Old Refectory. After the meal, when the atmosphere had mellowed with coffee, port and tobacco fumes, the President began his speech. He noted that there were nine pre-war students present, welcomed many “old regulars” who come to the dinner every year and passed on messages from some who were unable to attend. […]

The President then informed us of some of the Golden Jubilee events. There would be an open day for those who wanted to see round the department, and a special edition of the Ramsay Society Journal would be published in April or May. The Chemical Engineer for May or June would contain many items from the department, as well as a very well-researched history of the department by Mr Thorp. […]

[Professor Rowe] finished by breaking with tradition and proposing a toast to the next fifty years of the Ramsay Society. […]

Wherever [Ramsay Society members] are, or whatever happens in the meantime, there can be no doubt that there will be a Centenary Dinner in early March 2024.’

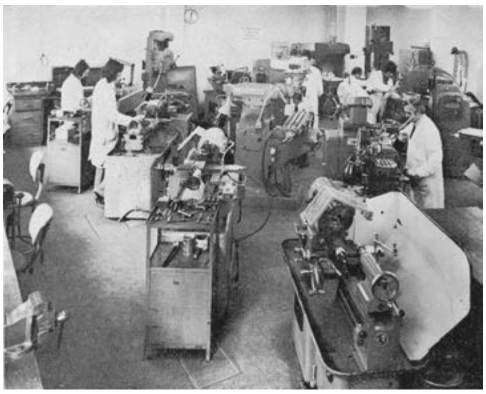
Ramsay Society Dinner, ca.1970s

Memories from Past Students and Members of Staff

When I joined UCL in 1964, UK universities were entering a period of expansion following the Robbins Report into higher education. The academic staff of the Chemical Engineering Department comprised four engineers, three chemists and two biochemists most of whom had had industrial experience. The first-year intake was around 30, the diploma course had about six students, and research student numbers were few. The undergraduate degree was a three-year London University BSc (Eng). The first and second year teaching contained a lot of chemistry; Maths was taught by the Maths Department and thermodynamics by the Mechanical Engineers. Chemical engineering teaching was slanted towards unit operations and relied heavily on Coulson and Richardson's text. There were no optional courses and engineering drawing had to be passed before the degree could be awarded. Lab work featured prominently; the basement lab being given over to fairly routine unit ops experiments, while the third floor was devoted to chemistry two afternoons a week during the second year. The design project dominated the third year. Students' extra-curricular needs/problems were catered for by the Departmental Tutor and it wasn't until the mid-70's that personal tutors were introduced. During the following 50 or so years the academic subject broadened to include new areas, again reflecting the expertise of the academic staff. Staff numbers increased, research across the board blossomed and undergraduate numbers expanded greatly. The quality of the student intake is now as high as ever, and over the years many of our graduates have gone on to stellar careers, one even becoming, albeit briefly, Chancellor of the Exchequer! The infant subject of biochemical engineering, nurtured in its early years in Chemical Engineering, has grown to maturity and now has its own UCL department. Prior to 2021, there had been 10 Ramsay Memorial Professors and Heads of Department (all male). We now have our first female Head, Eva Sorensen, who I took on to the staff as a young Lecturer in 1996. Eva and the department have prospered since then. Here's to the next 100 years.

John Yates, FREng – Ramsay Memorial Professor and Head of Department, 1996-2003

John G. Yates



Mechanical workshop in the "new" Engineering Faculty Building, ca. 1970s

John Garside

I applied for the 1960 entry to the undergraduate chemical engineering degree. At that time there was no UCAS, students made their applications to individual departments that were of interest. I was invited for an interview and, with some trepidation, found my way to the departmental office. The department was then located adjacent to the present Students' Union at the junction of Gordon Street and Gower Place. The first person I met was Valerie Potter, then early in her long career as Departmental Secretary. Shown into the Head of Department's office, I was faced with what I suspect was the entire teaching staff – Professor M. B. Donald, then Head of Department, John Mullin, John Barnard, Ken Ridgeway, Fife Webb, and Hubert Thorp (I may have forgotten one or two!). I can see them now, ready to interrogate me as suitable, or not, for their degree course. I must have said the 'right' things since I was accepted onto the course, 18 of us in total. After graduating I did a PhD with John Mullin and, after a few years with ICI, joined the department as a member of staff between 1969 and 1981. UCL and all it had to offer has meant something very special to me over the years.

John Garside, CBE, FREng – BSc (Eng) and PhD, 1960-1966; member of staff, 1969-1981

I joined the Chemical Engineering Department as it had just moved to the New Engineering Building in the last year of Professor Donald's tenure. It had only 16 students. I had studied 3 A levels in one year at a technical college and as a result I was offered an unconditional place although my results were not that good. I saw UCL as a friendly organisation offering opportunities to meet a wide range of students from other disciplines. London was also an attraction which at the time was affordable. Famous pop groups such as Gerry and The Pacemakers and the Moody Blues appeared at UCL events. I remember lectures from Professor Donald about Cornish mines, and the new approach to Fluid Dynamics from Alvin Nienow, which was not to everyone's liking. Dr Mullen was also an inspiration. The small numbers also meant we could have discussions with the lecturers over morning coffee. My time at UCL gave me a better outlook on the world in general and Chemical Engineering gave me the skills and confidence to tackle the problems of the rapidly developing petrochemical industry.

Tom Radford – BEng student, 1962-1965

Teaching laboratory in the "new" Engineering Faculty building, ca. 1970s

I attended UCL 1970-73. We had a class size of about 35: all male, about one fifth from Commonwealth countries. Many of the staff had worked in industry and introduced those practical experiences into their lectures. London was an enjoyable city to live in, especially with the UCL halls of residence being close to the heart of the city. I graduated with First Class Honors and was awarded the Goldsmid Medal & Prize for the most distinguished performance at the final examinations in all branches of Engineering at UCL. I was attracted to UCL (while living in Colombo, Sri Lanka), because of its reputation as a leading university in engineering, science, medicine & liberal arts. During the 3 years, I enjoyed my interactions with fellow students and the staff, especially at the Ramsey Society social events. I was inspired by many of the faculty, especially my tutor Dr. John Garside and Professors John Mullin and Peter Rowe (Head of Department). They urged me to pursue a PhD which I did at the California Institute of Technology and helped launch my academic career of 40 plus years. To this day, I fondly reminisce about my days at UCL.

Ajit P. Yoganathan – BSc (Hons), 1970-1973

Ajit P. Yoganathan

A small ChemEng department headed by some notable faculty – Peter Rowe, John Garside, Alvin Nienow, Victor Long, Walther McCready, Malcom Lilley, and support staff led by Valerie Potter to name just a few. Being an engineer inside the multi-cultural, cosmopolitan culture of UCL was the main attraction of the department and turned out to be a tremendous growth experience. The blistering genius of Vic Long's thermodynamics courses, the hidden basement fluidisation labs plus the standout Ramsay Dinners. What was inspiring were my fellow 'travel mates' on the course from all over the world, many of whom I still am in touch with today.

Kevin Baker – BSc (Hons), 1978-1981

In the early 90's the world was moving into the time of personal computers but the world-wide net was not yet born. I was attracted by the 5-Star award for the course – hence the high quality of the course. I remember the large lecture theatre downstairs where we joined with other engineering courses to learn maths. I also remember the practical experiments we carried out in the basement, as well as the approachable lecturers, and students from around the world.

Russell Smith – MEng (with study abroad), 1990-1994

My main memory [of the course] was that it was hard – much more difficult than business and finance that I later studied. Chemical Engineering was a difficult subject but prepared me very well for my career. It goes very deep but also provides breadth and understanding of how it all fits into the real world.

Mark C. Newman – MEng (with study abroad), 1992-1996

I was in the 1993 entry for Chemical Engineering. My decision was based on the facilities, location and (importantly) the friendly feeling that the department offered. I was not disappointed in my choice both from an academic and personal perspective (the friends I made at UCL are still friends today). Whilst still an undergraduate I remember David Bogle encouraging me to consider research. I was given the opportunity to start mathematical modelling on a 3rd year research project, which rolled into a summer project (1996) and resulted in me giving my first international conference talk (still as an undergraduate) in Trondheim (1997). This was a turning point in my career and I decided to pursue a PhD, where I focussed on reaction engineering with Professor Asterios Gavriilidis. The skills gained through undergraduate and postgraduate study have provided a firm foundation for my subsequent professional career. After graduating I spent a few years at Harwell as a Computational Fluid Dynamics engineer before embarking on a career in process development/engineering at several ex-ICI companies in the Northeast of England. Currently I am leading a large manufacturing research group for a FTSE 100 speciality chemical company, where I am pleased to report that I still have strong links with the department.

Darren Gobby – MEng and PhD, 1993-2000

After considering my options during the sixth form, I applied to all the usual Chemical Engineering Universities for my degree. However, it was whilst visiting UCL for interview that I really decided that this was my first choice. The relaxed and friendly atmosphere of the department, along with the location sold me. I spent the morning in the department for the interview and the afternoon exploring the West End and Covent Garden. I spent 4 happy years in the department, enjoying the course and making the most of the fantastic location. I made some lifelong friends and set myself up for a career in Chemical Engineering.

Michael Fildes – BEng, 1993-1998

Michael Fildes

During the late 90s, in my years at uni, I used to frequently visit friends living in London, jumping on the first not so cheap flight as soon as I had the opportunity. Probably, those were the days when I fell in love with the city. Soon after receiving my degree in Chemical Engineering in Italy, my work interests shifted onto academic research. My thesis supervisor, a former UCL alumni himself, encouraged me to look for PhD opportunities within the Chemical Engineering Department at UCL by describing the quality of research, its facilities, the vibrant life in the campus and the support provided to the foreign students. Given the times, the process was fairly quick; in a couple of months, I was interviewed and offered to join the department on an industry sponsored research project.
It was a steep learning curve in the early days, but I instantly felt a mutual and shared path of growth within the academic community; in fact, life at the department became a substantial part of my life in London. Travelling the world to attend international conferences and receiving acknowledgements for a piece of research work are among the most rewarding things that will stay with me forever. Equally important, it was the pulsating passion for solving scientific and technological challenges that is still inspiring and driving my professional career in R&D as a senior chemical engineer.

Paolo Pagliai – PhD, 2000-2005

I very much enjoyed the multicultural environment at UCL, which was quite different to university life in my home country of Austria, where I did my undergraduate degree. While doing my PhD in crystallisation, supervised by Professor Alan Jones, I felt humbled to meet Professor John Mullin, the godfather of crystallisation and former Head of the Department. This was definitely a highlight that I will never forget and I was able to get his book, the 'bible' of crystallisation, signed by him as well. Studying abroad was such a positive experience for me that I decided to start my professional career abroad, first in Germany at BASF and then in the USA. I spent almost ten years abroad altogether before returning to Austria, where I've worked in renewable energies and hydrogen. I believe that my days at UCL not only prepared me for an international career but also led me to become more open-minded and confident.

Rudi Zauner – PhD, 1996-1999

Rudi Zauner

I am thrilled to share my experiences and reflections as a graduate of the Department of Chemical Engineering at UCL, as well as the priceless opportunities and education I benefited from throughout my four years at the campus.

To put it mildly, my experience at UCL was transformational. I was immediately welcomed into a vibrant and intellectually fascinating community of researchers, professors, and chemical engineering students from the instant I arrived on campus in September 2002. I was exposed to a wide variety of ideas and cultures at UCL, which helped me prepare to function well in a multinational setting.

I am currently working as a Construction manager for Equinor's modification projects in the North Sea. I have also worked as process optimisation and process safety engineer for 10 years and applied the skills I acquired at UCL. Most importantly, this degree taught me critical thinking, problem solving and collaboration, something that is very vital in any field.

The benefits of a Chemical Engineering degree from UCL go far beyond a paycheck and a job title. You will get the ability to overcome any obstacle that life presents, you will make friends for life, and you will improve as a person.

Shaista Akhtar – BEng (with year in industry), 2002-2006

Shaista Akhtar

It was mid-April, I packed my luggage, a few books, and a bicycle. I left my parent's house in Rome. A few days after my arrival I was sitting by the columns of the UCL Main Building. A PhD badge was hanging from my neck. I remember thinking to myself: 'I'm sitting at the centre of what's happening in the world.' 'I can contribute.' I was right, my PhD at UCL Chemical Engineering Department was an extraordinary professional and personal experience. Professionally, a degree from UCL allowed me to choose the career I wanted. I work in R&D and Marketing developing products that are touching people's lives (FMCG and Medical Device industry). Cool, but technical expertise is not all I achieved! The PhD experience allowed me to develop the soft skills that make me successful as a human being and as a people and projects manager. I learned about myself, cultural differences, collaboration, public-speaking, research methodologies, project management. Spending days and nights in the lab with other students was an opportunity to establish friendships and to self-develop. Today my self-confidence at work comes also from the trust, respect, support, and challenges that the UCL staff and industrial sponsor offered me. At UCL I caught a contagious disease called passion for research which I'm using in different areas of my life. My research was awarded with the IChemE PTSG Young Researcher Award, and I was one of the founders of the UCL Enterprise Society. It is not only what you do, but how and with whom you do it.

Sarah Germanà – PhD, 2004-2008

Sarah Germanà

I recall the first day of my chemical engineering course where I got to meet my other classmates and saw that several of them were from the Year in Industry program that I participated in. Those classmates became my closest friends during the course as well as after I graduated and I still keep in touch with them today. My time at UCL moulded me to who I am today both in class with teachers such Dr Eva Sorensen (who is now the department head!) as well as having my first experience in leadership roles through activities with the clubs and societies and having the opportunity to be the Ramsay Society President. I really appreciated the opportunity I got to study abroad in New York as it gave me a chance to experience the education culture there and learn from academics working in different technologies. Ten years after graduating I got the chance to work with the UCL Chemical Engineering Department by joining the Industrial Advisory Board, which I saw as a way to give back to the department and also to see how much it has grown (and still growing) since I graduated. Thank you to everyone who was part of my journey when I was an undergraduate and am grateful for the ongoing relationship I have with the department today.

Neha Solanki – MEng (with study abroad), 2004-2008

Neha Solanki

Studying chemical engineering at UCL was a transformative experience that has shaped my life in countless ways. As we celebrate the department's centenary, I am honoured to reflect on the invaluable learnings and memories it has bestowed upon me.

One of the most profound aspects of my time at UCL was the emphasis on holistic thinking, something intrinsic to chemical engineering. I still vividly remember the words of Dr. Tim Elson during our very first lecture: "chemical engineers are global engineers", speaking to the essence of our discipline's versatility. Truly, the education I received not only honed my technical skills but instilled in me a sense of broader perspective, equipping me with the tools to excel in multiple career roles and take on grand and complex challenges.

UCL is more than an academic institution; It is a global community that opens doors to the world. The diverse department body and international outlook broadened my horizons and enriched my understanding of different cultures and perspectives. I am forever grateful for the exceptional quality of education and the inspiring professors who guided me. Their expertise, dedication, and passion for chemical engineering left an indelible mark on my academic and professional journey.

As we celebrate a century of excellence, I proudly carry the department's legacy with me, cherishing the education, values, and sense of community that have been integral to my growth as a "global" engineer and citizen.

Mohammed Buhassan – BEng, 2010-2013

Mohammed Buhassan

I studied in the department at the time that a lot of construction was happening on the UCL Campus and in the larger London area (as part of preparations for the 2012 Olympics). I decided on UCL because of its reputation and testimonials from friends who were alumni. I had many fun experiences ranging from juggling between grabbing coffee on the first floor of the Roberts building to making it to Prof Sorensen's Process Control class, which were always early in the morning (fun times!). Outside of the education and degree obtained from UCL, I had the chance to make friends with people from all over the world and I'm still friends with many of them today. Those are experiences and relationships I relish every day. I interacted with many students, staff, and faculty but Professor Alan Jones was quite an inspirational figure. His patience and simplicity despite his wealth of knowledge were qualities that stood out for me.

Olufemi (Femi) Kadri – MSc, 2010-2011

I was a PhD student in Professor Angeli's ThAMeS Multiphase group from 2015 to 2019. Afterwards, from 2019 to 2020 I was a teaching fellow in the process design modules for 3rd year undergrads and for MSc students. I really liked my time at the department because I was doing advanced research into multiphase flows with mass transfer but also because of the staff and other students. It was a very friendly and multicultural environment with incredible technical expertise. I was always learning from my peers and the academics. I was frequently involved in teaching in the labs to undergrads. The hours were long but it was a great experience to get to know other PhD students and the cohort of undergrads, some of whom would stay to do PhDs in the department. I remember the department as a place to work very hard on very complicated problems with a friendly environment.

Eduardo Garciadiego-Ortega – PhD, 2015-2020

One of the many reasons I chose to study in UCL Chemical Engineering, was the IEP (Integrated Engineering programme). From Year 1, we got involved in multi-disciplinary projects and attempted to tackle real world problems with students from electrical, mechanical, civil, biochemical, and computer science departments.

A standout moment was one of the one-week scenarios, when my team won a best video award related to water management and sustainability. During that week we were in the lab, assembling pumps and compressors in order to deepen our understanding of the operation and differences between each equipment. That same week, I had an interview, where at the start I was asked about my day. After I explained this unique and hands-on experience to the interviewer, he was impressed, and this gave me confidence to secure an internship at a global consultancy and construction firm in London.

After graduating from an MEng, I was attracted to stay for a PhD due to the interesting topics of microfluidics and surfactants that I was exposed to during my Masters, and of course my supervisor, Professor Panagiota Angeli. Being one of the leading forces as a woman in the Chemical Engineering Department was definitely an inspiration for me.

UCL also has a variety of extracurricular activities and endless opportunities that students can get involved in and gain valuable experience, either at the undergraduate or postgraduate level. Finally, as a London based university you get the chance to meet stimulating people from a wide variety of backgrounds and cultures, as well as build an important network that might follow you throughout your career.

Maria Kalli – MEng and PhD, 2014-2022

Maria Kalli

I enjoyed the challenge of my MEng Chemical Engineering degree at UCL, particularly the integrated projects which brought together the knowledge from all modules, such as process safety and economics, as well as the core chemical engineering modules of separation processes and chemical reaction engineering. This is reflective of real-world problems, which are complex and do not have prescribed answers.

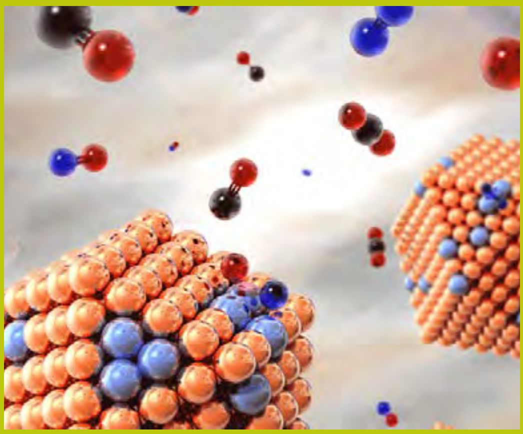
What was instilled in me at UCL was the vast scale of chemical production processes globally and the immense impact that chemical engineers can make, such as improving energy efficiency or engineering new ways to power chemical processes. For example, producing ammonia (a fertiliser, shipping fuel and hydrogen carrier) currently accounts for around 1% of the world's CO2 emissions – the hydrogen input is produced via natural gas. However, there is now a shift to electrifying ammonia production. If the energy input is renewable, the ammonia produced is called green ammonia. I'm currently reading for a DPhil (PhD.) in Engineering Science at the University of Oxford, on the topic of green ammonia. I am particularly grateful for the female academics at UCL, such as Professor Eva Sorensen, who were role models to me and encouraged me to pursue further education with a PhD.

Honora Driscoll – MEng, 2017-2021

Honora Driscoll

Research Themes, Applications and Centres

Research Themes

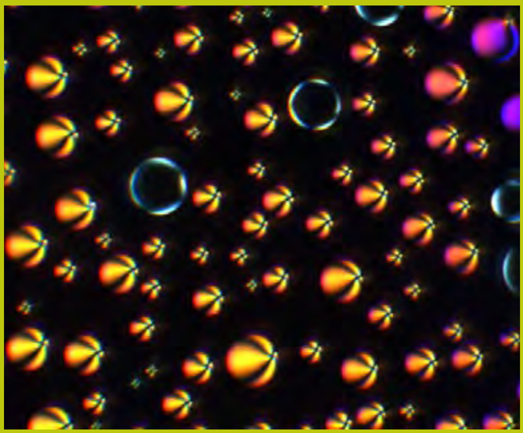


Catalysis and Reaction Engineering

Chemical reactions lie at the heart of processes where molecules are transformed from raw materials to useful products and energy. To make these reactions more efficient and sustainable, we create a variety of catalysts, novel reactor concepts and intensified processes. For this purpose, we develop and routinely employ modelling across length scales (from nano to macro), in conjunction with advanced experimental techniques.

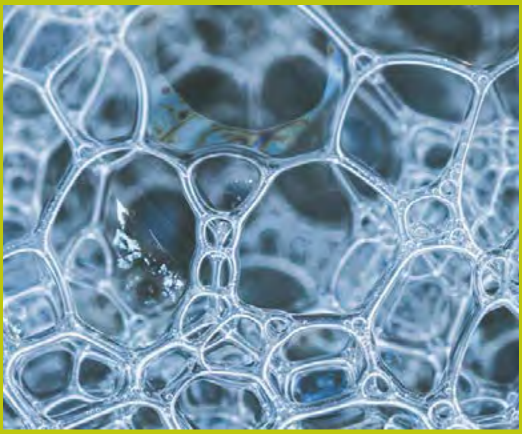
Electrochemical Engineering

Bridging the gap between electrochemistry and chemical engineering, electrochemical engineering aims to harness and optimise valuable electrochemical reactions for practical applications. This includes engineering effective power sources such as batteries, fuel cells and supercapacitors, as well as using electricity to drive chemical reactions, such as hydrogen and chlorine production.



Molecular and Engineering Thermodynamics

Thermodynamics underpins the fundamental laws that govern natural and anthropogenic processes, from energy storage and environmental remediation to controlled drug delivery. We use theory, simulations, and experiments to unravel the driving forces at the heart of these processes and lay the foundations of tomorrow's transformative technologies. Our work includes fundamental and applied aspects and both equilibrium and irreversible thermodynamics.



Multiphase Systems

Research in multiphase systems studies the flow and phase interactions of multiphase mixtures, from liquid/liquid systems such as emulsions, to solid/air systems like fluidised beds or air/liquid systems like foams. Through a combination of advanced experimental technologies, mechanistic modelling and numerical simulations, a fundamental understanding of the physical and transport properties of multicomponent mixtures is obtained from the micro to the pilot-plant scale, thus advancing the development of novel products, processes and decision support tools relevant to a variety of industrial sectors, from pharma and energy applications to CO_2 emission mitigation from diverse industrial sources through Carbon Capture Storage and Utilisation.

Nature-Inspired Chemical Engineering

We take inspiration from the materials, structures, patterns, and processes found in nature to engineer transformative solutions for sustainable development in areas including energy, manufacturing, healthcare, and the environment. Our research spans from the laboratory to the industrial scale, using both theory and simulation to drive experiments and prototype development.

Product and Process Systems Engineering

Computational tools are indispensable for optimising the transformation of raw materials into products in chemical manufacturing, environmental and biological systems. Our core competencies lie in modelling and model solution tools, process operations and control, product, and process design. Methodologies are being developed based on advanced modelling tools, optimisation techniques, non-linear analysis, data analysis and visualisation, aiming to innovate product and process design for safe, efficient, and sustainable development.

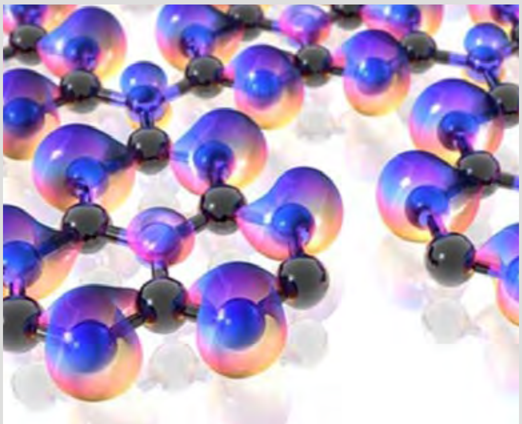
Applications Areas

Advanced Manufacturing

We develop innovative approaches and processes for sustainable manufacturing in the chemical, pharmaceutical, energy and healthcare sectors, encompassing digitisation and advanced experimentation. We use state-of-the-art modelling tools, novel methodologies, and sophisticated analytical and automation techniques.

CO_2 Emission Reduction, Energy and Sustainability

Meeting the critically important 2050 net-zero CO_2 emission target requires the decarbonisation of all sectors of our economy. This can be achieved through the development of new energy-efficient and sustainable processes and technologies for abating emissions (including carbon capture, storage and utilisation) and enhancing circularity.



Materials

We create new materials for the net-zero future. There is a range of research activities covering materials synthesis and design, advanced materials characterisation, and the applications of materials towards the UN's sustainable development goals, such as good health and well-being, clean water and sanitation, and affordable and clean energy.

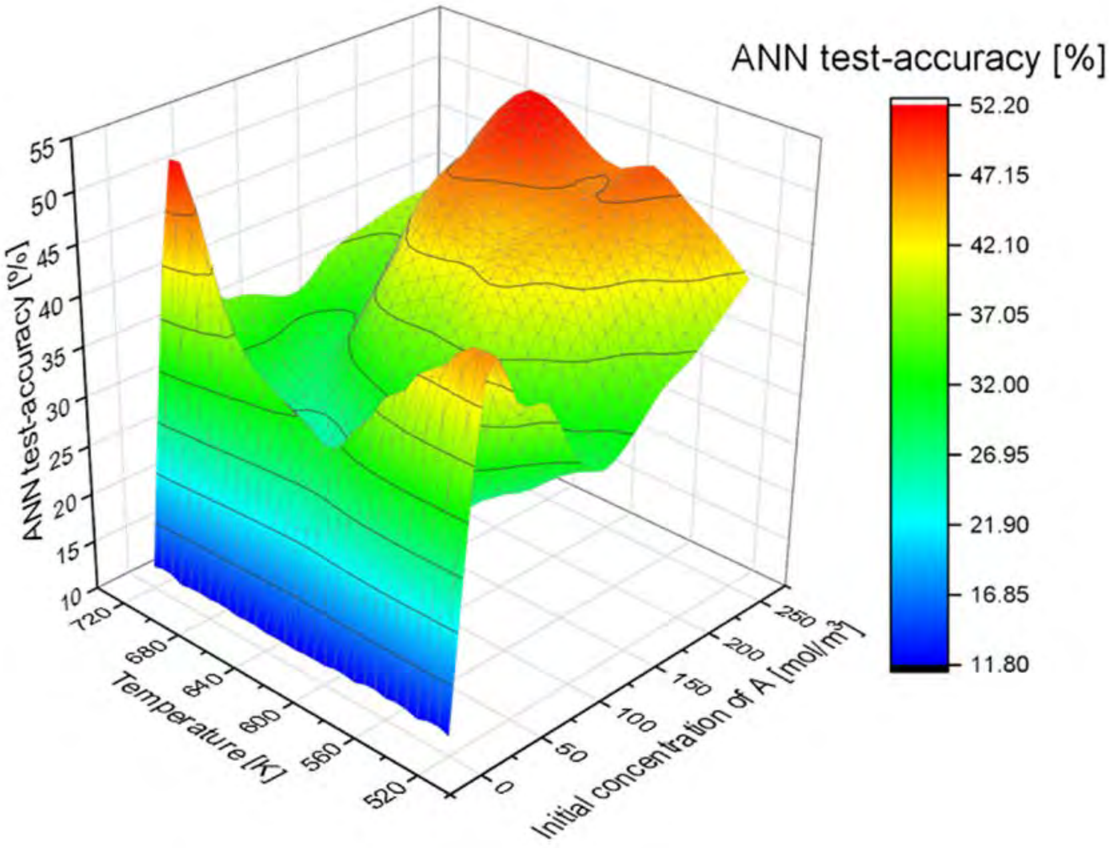
Health

Our work is highly relevant to various applications in healthcare, ranging from novel nanomaterials for assays and drug delivery to prototype development for diagnostic devices, to pharmaceutical manufacturing and the modelling of physiological systems and drug response, as well as systems approaches to support improved therapies.

Cross-disciplinary Research Centres

The Centre for Nature Inspired Engineering (CNIE) draws lessons from nature to engineer innovative solutions to the grand challenges in energy, water, materials, health and living space. Using theory and simulation-assisted rational design, complemented by experiments, synthesis and testing, the Centre unites a highly interdisciplinary team of researchers, from the physical sciences to chemical and materials engineering, computer science, architecture, and medicine. Collaborations with a wide range of industrial partners allow us to accelerate the translation of research findings into practice. Nucleated by the Nature Inspired Chemical Engineering (NICE) group at UCL and directed by Professor Marc-Olivier Coppens, the Centre received a £5M "Frontier Engineering" Award from the EPSRC, one of only five such Awards in the UK, as announced at the Global Grand Challenges summit at the Royal Academy of Engineering in London in March 2013.

The Sargent Centre for Process Systems Engineering is a multi-institutional research centre of world-class departments at Imperial College London and University College London. The Centre was inaugurated in 1989 by Professor Roger W.H. Sargent, the founding Director of the Centre from 1989 to his retirement in 1992; the UCL Department of Chemical Engineering was a founding member department. The Sargent Centre aims to address the sustainability grand challenges facing the process and allied industries and wider society, from the transition to net zero, to the reinvention of industry around renewable feedstocks, and the provision of affordable and effective healthcare. Systems thinking and systems engineering methods have a critical role to play in addressing these complex interconnected issues. Indeed, in parallel to deploying systems approaches on global challenges, the Sargent Centre community continues to advance the fundamentals of process systems engineering, finding new ways to model complex systems, developing the machine learning tools that can support decision-making in a context that is often data-poor, and enabling a more resilient approach to uncertainty and risk.



The Electrochemical Innovation Lab (EIL) is a cross-faculty mechanism for accelerating impact, innovation, enterprise and research in electrochemical science and engineering. The scope of activities in the EIL encompasses mechanistic understanding of fundamental processes; materials discovery; analytical diagnostics and advanced manufacture; device design and development; modelling, optimisation, and life cycle assessment; systems development and demonstration. The EIL is dedicated to excellence in research, teaching, and public engagement. Since its formation in 2010, the EIL has attracted over £50 million of funding and is currently home to over 80 researchers active in electrochemical science and technology. The EIL hosts the UCL Centre for Correlative X-Ray Microscopy and is the UCL arm of the National Centre for Grid Scale Energy Storage and EPSRC Centre for Doctoral Training in Fuel Cells and their Fuels. The EIL leads the STFC Global Challenge Network in Batteries and Electrochemical Energy Devices. It has also initiated several successful spin-out companies in the electrochemical space, e.g., Amalyst, Bramble Energy, Oort Energy, and Gaussion.

UCL East

From UCL Bloomsbury to UCL East

The London University and the playground of its associated junior school, illustrated by George Scharf in 1833 (Trustees of the British Museum, 1880,113.4738)

UCL traces its beginnings to a group of radical thinkers who wished to establish a secular, non-residential metropolitan university. The institution was to be the first university in the capital and the only one of its kind in England. The ideals on which UCL was founded in Bloomsbury in 1826 are reflected in the creation of UCL East, UCL's largest expansion to date. Parallels may be drawn with the aspirations of the university's founders in their endeavour to bring innovation and accessibility to higher education. Our UCL East campus brings together expertise from eight existing UCL faculties to form new schools and centres. From architectural design to robotics, media to art and technology, heritage to engineering, disability to advanced propulsion, UCL East continues UCL's unrestrained thinking and discovery across disciplines, to find solutions to the biggest local and global challenges for future living. The UCL East Pro-Provost is Paola Lettieri, a professor in our department, who has been leading the planning and construction of the UCL East campus from the conception stage.

UCL East leads the regeneration of Stratford, which was a centre for the capital's industries in the nineteenth and twentieth centuries. The site of the new campus was part of a large sweep of marshland in the Lower Lea Valley, bisected by canals lined by workshops, factories, and distilleries in the nineteenth century. The siting of UCL East with other major cultural institutions (including the Victoria & Albert Museum, Sadler's Wells, BBC, and UAL's London College of Fashion) is part of East Bank, a new education and cultural district creating a legacy from the 2012 Olympic and Paralympic Games. The first phase of UCL East has been designed as a new approach to developing a university campus for the twenty-first century, embedded in the local community and business. The buildings provide space and facilities for academic units working on significant issues for today's rapidly changing world, while participating in the regeneration of an urban area. In this sense, its aspirations and impact are not so far removed from UCL's founders and the first campus in Bloomsbury, offering a story of continuity and parallels against a backdrop of innovation and change over two hundred years. Within UCL East, two laboratories, the Advanced Propulsion Laboratory (APL) and the Manufacturing Futures Laboratory (MFL), represent extensions of the department's Bloomsbury activities.

Adapted from: A. Smith, "University College London: an architectural history, 1825–1939" Doctoral thesis (Ph.D.), 2021

"" The buildings provide space and facilities for academic units working on significant issues for today's rapidly changing world, while participating in the regeneration of an urban area.

Advanced Propulsion Laboratory (APL)

The Advanced Propulsion Lab (APL) at UCL East will be a global centre of excellence dedicated to the decarbonisation of the transport sector, specialising in battery and fuel cell electric vehicles. The APL will feature a vehicle propulsion research laboratory investigating advanced engines and alternative fuels, electrochemical power sources and storage (fuel cells, batteries, supercapacitors, and hydrogen storage), and an environmental laboratory – a live testing ground for automotive, marine, drone, mobility and (dis) ability technologies. New programmes will create innovative entry routes to the field including foundation programmes and a range of master's courses. The local community will benefit from the APL's engagement with UCL East's activities in outreach.

Core features

Taking up residence on the eighth floor of the campus' Marshgate building, and in a standalone facility, the APL will be equipped with state-of-the-art facilities and R&D space to tackle low – to mid-range technology readiness level challenges in the advanced propulsion sector. Together, these spaces provide: enhanced teaching and workspace provision for students and researchers; a vehicle propulsion research laboratory specialising in electrochemical power sources, energy storage and alternative fuels; a standalone testing facility for automotive-scale battery and fuel cell technology enabling the testing of component elements and whole systems – the UK's first integrated fuel cell and battery testing facility at a university; space for large-scale R&D activities, including environmental testing and rapid prototyping; an innovation lab to boost incubator potential and develop new intellectual property.

Applying engineering solutions to large automotive fuel cell stacks

Expanding the impact on cleaner, greener, future transport solutions

APL will tackle the grand challenge of zero-emission transport head-on, developing key technologies to clean our air and mitigate negative impacts on the environment. It will provide a unique combination of teaching, research, commercial innovation and outreach, a translational approach that means new research ideas can be developed and applied to real-world solutions to support a global reduction in the environmental impacts of transport. Building on the world-leading research and development activity of UCL's Electrochemical Innovation Lab, it will scale up the impact of Bloomsbury-based activities, in bigger cutting-edge facilities, in line with the scale of progress required to secure national and international vehicle electrification and emissions reduction targets. It will turn research excellence into impact: uniquely placed to develop hydrogen fuel cells, electromechanical propulsion and advanced battery technology, integrate them all, and apply these innovations to a wide range of mobility and transport options.

Masterplan for UCL East (LDA Design)

A living laboratory on Queen Elizabeth Olympic Park and beyond

Leveraging the Olympic Park as an environmental laboratory for new vehicle technologies where we can test innovations at scale, in real-world conditions, and working with industry, APL will provide the best environment for engaging the local community. Co-location with colleagues, such as peers at the Global Disability Innovation Hub (GDI Hub), will help to engineer new sustainable and inclusive transport solutions. It will provide a critical resource for academia and industry, and also supply data for policymakers shaping future manufacturing standards and promoting the take-up of new technology. The facilities will support collaboration with industry partners, taking innovative research concepts to the marketplace.

Manufacturing Futures Laboratory (MFL)

The Manufacturing Futures Laboratory (MFL) is a multi-disciplinary research and teaching hub, driving strategic research and fostering innovative industry collaborations to deliver the sustainable products and manufacturing processes of the future. Bringing together core expertise from the UCL Faculty of Engineering Sciences and the UCL Faculty of Mathematical & Physical Sciences, MFL focuses on knowledge-based and digitally enabled manufacturing. Technologies such as 3D printing, synthetic biology and intensified processing will be used to make future-proof products that are sustainable, cost-effective and with innovative functionalities. New educational programmes have been designed to inspire and train the next generation of engineers and scientists, emphasising hands-on, research-based learning.

Intensified Processing Pod at the Manufacturing Futures Lab

Core features

The MFL aims to be a unique, interdisciplinary research hub where researchers and students from biochemical, chemical and mechanical engineering, and chemistry can develop novel materials and chemicals manufactured via sustainable approaches and advanced therapies impacting a range of sectors. It is open to industry and the local community as a location for extra-curricular school activities, training, support for start-up ventures, summer residential courses, and events. Research-led teaching will form the basis to create a multi-skilled future workforce. The emphasis is on experiential learning, innovation, enterprise, and the wider regulatory environment. Programmes span from nanoscale and digital manufacturing, stem cell and gene therapy, to nature-inspired engineering, and they leverage wider UCL research strengths in 'big data' analytics, artificial intelligence, process monitoring and control technologies, and multi-scale modelling.

A trans-disciplinary environment for innovation

Working across traditional science and engineering disciplines and from the microscopic to the macroscale, research will push the frontiers of future energy technologies (e.g., clean hydrogen production), micro/nanoscale engineering, nature-inspired engineering, bio-molecular assembly, novel materials, digital and automated process technologies, and multi-scale modelling. It will support the development of completely new materials with exciting properties, and new products using digital manufacturing technologies, organic synthesis, and synthetic biology, and facilitate robust scale-up to deliver products which can be manufactured sustainably, with cost-effective technologies drawing on circular economy approaches facilitating the recycling and reuse of waste products and reducing the CO_2 footprint of (bio)chemical transformations.

Inside the MFL

MFL will drive research and development in diverse areas from healthcare to energy to consumer and specialty products and to future-proof manufacturing and train future industry leaders. It will leverage the potential of digitisation, artificial intelligence, robotics, and additive manufacturing to boost performance, shape new business models, and drive sustainable growth. This will be achieved by building agility and innovation into the manufacturing industry of the future, and responsiveness to real-world contexts, while innovating manufacturing for a carbon-constrained world. Drawing on rich expertise from Biochemical, Chemical, Mechanical Engineering and Chemistry, it provides an ideal foundation for creating future manufacturing solutions. A deep desire to understand underpins the conversion of scientific discoveries into commercially viable products, on a truly global scale, to meet real-world problems.

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Research Highlights

Advancing Battery Technologies

Lithium ion battery modules tested for hybridisation with other electrochemical technologies

The Electrochemical Innovation Lab (EIL) is one of the largest contributors to Faraday Institution research projects through activities targeting improved understanding of the degradation processes of Li-ion batteries, developing next generation battery technology, and improving the understanding of battery safety.

Faraday Institution and the Electrochemical Innovation Lab

The Faraday Institution, the UK's independent institute for electrochemical energy storage research, was established in 2017 with a mission to advance the UK's research capabilities in battery storage technology. The EIL played an important role in the formation of the Institution with researchers from the group forming the largest contribution from UCL as one of the seven founding universities. Over the subsequent six years the EIL's role has grown still further with research from the group supporting eight of the ten major research projects. This activity has focussed on improving the understanding of manufacturing and recycling techniques for batteries, developing next-generation electrode materials for Li-ion and solid-state battery technologies, and expanding on the modelling methods deployed in battery systems. Over the last year the EIL has also secured further research funding from the Faraday Institution in the form of a sprint project to investigate quasi-solid state lithium-sulphur batteries and several one-year seed projects researching advanced characterisation techniques, silicon-based anodes, and redox flow batteries. In addition to these activities, EIL group members acted in key leadership roles for three major projects:

Battery degradation

The Battery Degradation project, in which Dr Rhodri Jervis has acted as Project Lead since 2017, aims to understand the mechanisms of degradation of lithium-ion batteries containing high Ni-content NMC, cobalt-free cathodes and a range of anode chemistries. The EIL has contributed to the research efforts of this ten-university project by developing and applying advanced characterisation tools to investigate heterogeneities in electrode materials.

LiSTAR

The LiSTAR project, formed of ten university partners led by Prof. Paul Shearing (PI) and Drs James Robinson and Jennifer Hack (Project Leads), started in 2019 to develop lithium-sulphur batteries which are noted for their lightweight characteristics. Within this project, the EIL has developed new electrode materials capable of delivering long-lifetime and high-rate performance, a first-of-its-kind 3D model of the battery, and a range of diagnostic techniques to accelerate the commercial relevance of the batteries.

SAFEBATT

SAFEBATT, a project designed to improve the understanding of battery safety is led by Prof. Paul Shearing (PI) and EIL members Drs Julia Weaving (Project Lead) and Rhodri Jervis (WP Lead). This programme is a collaboration of six universities and has focussed on developing a science-led approach to improving the safety of Li-ion technology. UCL has contributed across the project with key highlights including the development of ultra-high speed tomographic techniques to explore failure nucleation and the design of diagnostic tools to provide advanced warning of battery failure.

For more information contact
Prof. Dan Brett: d.brett@ucl.ac.uk

Electrochemical Innovation in Chemical Engineering

Advanced diagnostics unravel the inner workings of hydrogen fuel cells

Since its founding in 2010, the Electrochemical Innovation Lab (EIL) has grown to now include 80 core members, including academics, technicians, administrators, postdoctoral researchers, and PhD students, as well as a broad array of academic and industrial honorary and visiting members. It has attracted major funding from research councils and industry and supported the founding of spin-out companies across the hydrogen, battery, materials, and characterisation sectors.

The Electrochemical Innovation Lab

From batteries to fuel cells, electrochemical technologies are set to define the future energy landscape. Yet for these technologies to replace fossil fuel alternatives, significant advances must still be made in their design, manufacture, and safety.

Based in the Department of Chemical Engineering, the Electrochemical Innovation Lab (EIL) is a world-leading facility for the development of electro-chemical energy materials and devices. The EIL hosts researchers working across a broad range of electrochemical interests, ranging from materials discovery to understanding electrochemical processes and analytical diagnostics, device design, development, modelling, and scale-up. Importantly these activities span from fundamental research through to demonstrator-scale device manufacture and testing, industrial consultation, and company spin-out. Throughout the EIL, scientific, engineering, and commercial thinking is embedded in the research phase, helping the research team to identify commercial opportunities early, consider the engineering and commercial implications of the science they do and build new research programmes to accelerate science towards real-world impact.

Advanced characterisation and diagnostics

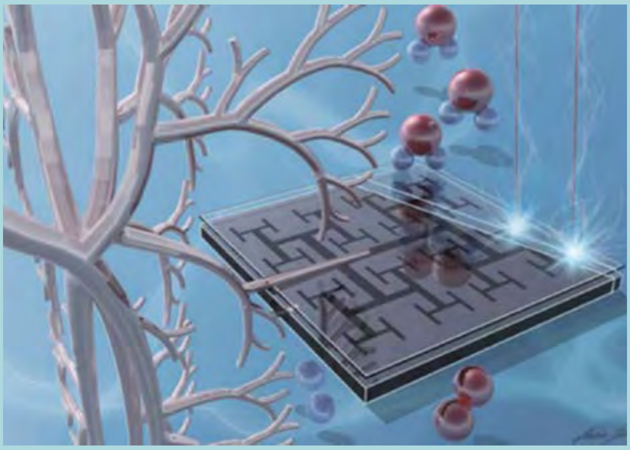
In particular, the EIL specialises in developing bespoke diagnostic techniques and characterisation tools to inform the optimisation and control of electrochemical systems, from bespoke experiments to in-line analysis. The performance of an electrochemical device is typically governed by the complex interplay of its constituent materials, device engineering and the conditions in which it is operating. The ability to 'see inside' electrochemical technologies as they operate allows the mechanisms driving their function, degradation, and failure to be examined. By combining techniques including X-ray computed tomography, electrochemical atomic force microscopy, spectroscopies, current mapping, off-gas analysis, high-speed photography, calorimetry, thermal imaging, a host of bespoke electro-chemical techniques, and multiscale computational modelling a 'whole cell' understanding of devices is developed.

Expanding the horizons of electrochemical technologies at UCL

With the founding of the Advanced Propulsion Lab (APL) at the UCL East campus in Stratford, which will be a global centre of excellence dedicated to the decarbonisation of the transport sector, the electrochemical engineering expertise developed in the EIL will be scaled up to even higher technology readiness levels, allowing us to work closely with industry to tackle global challenges, such as the future of mobility.

For more information contact
Dr Tom Miller: t.miller@ucl.ac.uk

Nature-Inspired Fuel Cell Technology



Nature-inspired fuel cell concept

Fuel cells that electrocatalytically convert hydrogen to produce electricity, are a key device in transitioning to sustainable energy. Inspired by the lung as a scalable, energetically efficient air distributor, and the remarkable abilities of desert lizards to channel water, nature-inspired fuel cell technology was developed that overcomes long-standing issues in scalability and operational stability, while providing exceptional power density.

Challenges of PEM fuel cells

Polymer electrolyte membrane (PEM) fuel cells are devices converting chemicals into electrical energy continuously, and are attractive in sustainable energy efforts, as they can use hydrogen potentially produced from renewable resources. However, ensuring uniform gas distribution across the catalyst layer remains one of the ongoing challenges impeding the broader commercialisation of PEM fuel cells.

Learning from lungs and lizards

Prof. Marc-Olivier Coppens's team at the UCL Centre for Nature-Inspired Engineering (CNIE), in collaboration with the UCL Electrochemical Innovation Laboratory (EIL), have created a fuel cell that draws lessons from the remarkably efficient architecture of the human lung to address many of the shortcomings of current fuel cells. The lung has self-similar, fractal scalability, with channels carefully proportioned to minimise loss of useful energy and reduce pressure drop. The lung-inspired fuel cell borrows these exceptional attributes from the lung to deliver robust, scalable performance in addition to increased power density. By homogenising transport and minimising diffusion limitations, the electrocatalyst is optimally used, which significantly reduces the requirement of costly noble metals, like platinum, and remarkably increases the power that the fuel cell can deliver.

The computationally assisted, nature-inspired design for the flow plates was first realised at the CNIE using additive manufacturing (3D printing) through selective laser sintering of metals, but it has now also been implemented using machine-cut, printed circuit boards (PCBs), facilitating scalable manufacturing and cutting the price by an order of magnitude. Such PCB-based, nature-inspired fuel cells are also easily stackable and adaptable. In addition, lessons are drawn from passive water transport in desert lizards through capillary action to control the fuel cell's humidity and manage the water that is produced at the cathode, for optimal performance without flooding – another issue hampering wider usage of current fuel cell designs.

A NICE approach to sustainability

Nature-inspired fuel cell technology is a prime example of nature-inspired chemical engineering (NICE), using the UCL CNIE's unique nature-inspired solutions (NIS) methodology, which is applied to accelerate innovation in areas ranging from sustainable chemical manufacturing to water treatment, smart materials, the built environment, and cancer immunotherapy. The success of the nature-inspired PEM fuel cell design has promoted further research on nature-inspired electrolysers for hydrogen production, as well as bio-inspired CO_2 electroreduction, all in the context of sustainable development to regain our balance with nature, by learning from nature.

For more information contact
Prof. Marc-Olivier Coppens:
m.coppens@ucl.ac.uk

The Route to Net Zero: Solutions for Transport, Reuse and Disposal of CO_2 Captured from European Industries

The Calcium Assisted Steel-mill Off-gas Hydrogen production (CASOH) pilot plant, at ArcelorMittal's Steelworks in Gijón, Spain developed as part of the C4U project

Within the context of a series of major research projects funded through the European Union's Horizon Programmes, a team of researchers, led by Prof. Haroun Mahgerefteh in collaboration with a range of academic and industrial partners, develop solutions for Europe's industrial CO_2 problem through carbon capture, transport, utilisation, and storage.

The CO_2 emissions challenge

Of the approximate 2.73 Gt CO_2 emitted annually by European countries, the hard-to-abate industrial sectors such as iron & steel, chemicals, and cement account for ~14%. Greenhouse gas emissions from these sectors must be reduced to net zero by 2050 for European countries to fulfil their decarbonisation commitments under the Paris Agreement and limit global warming to 1.5 °C. According to the International Energy Agency, achieving this will be virtually impossible without Carbon Capture, Utilisation and Storage (CCUS) technologies. As such, their development and deployment must be critically accelerated. Additionally, CO_2 transport from emission sources to geological storage sites through a variety of means (e.g., pipeline, ship, truck) faces several technical and economic challenges that range from capital and operating costs, network design, flow assurance, material issues, to health, safety, and environmental factors.

CCUS R&D for addressing the CO_2 challenge

Responding to the above challenges, the UCL research team leads and participates in a series of major EU Horizon projects for boosting innovation and reducing costs and risks of critical emerging CCUS technologies while coordinating the development of industrial hubs with shared CO_2 infrastructure. The C4U project spans the demonstration of two highly efficient solid-based CO_2 capture technologies for optimal integration into an iron & steel plant and detailed consideration of safety, environmental, societal, policy and business aspects for successful incorporation into an industrial cluster in Belgium and the Netherlands. Following C4U, the main goal of the CaLby2030 project is to act as an enabling tool to achieve, by 2030, commercial deployment of calcium looping technology using circulating fluidised bed reactors. Three pilot plants are used in Germany, Sweden, and Spain to demonstrate >99% CO_2 capture rates in hard-to-abate industrial sectors. Finally, the ENCASE project aims at the scientific and technological advancement of seven internationally leading research infrastructures for the capture and storage of CO_2, the development of new thermodynamic methods and models to support research in CCS, the generation of new experimental data and the training of specialised personnel in the sector.

Impact and outlook

As part of the quest in meeting the net-zero target, our work helps to accelerate the safe and economic deployment of CCUS industrial clusters, especially those incorporating hard-to-abate emissions industries such as iron & steel and cement, which make a major contribution to anthropogenic CO_2 emissions.

For more information contact Prof. Haroun Mahgerefteh:
h.mahgerefteh@ucl.ac.uk

Novel Technologies for Hydrogen Production and Carbon Capture

Biohydrogen plant in Swindon (UK)

New hydrogen production technologies with a low or even negative carbon footprint will be critical in deciding the roadmap and infrastructure required to reach the net-zero target. This research seeks to prove the technical, environmental and economic feasibility of biohydrogen, operating novel pilot and industrial-scale reactors and simulating commercial plants to convert waste biomass to pure hydrogen and CO_2*.*

The importance of hydrogen

As hydrogen is expected to play a key role in UK's legal target to reach net zero by 2050, new production technologies with low or even negative carbon footprint will be critical in deciding the exploitation roadmap and infrastructure that would require prioritisation. Biohydrogen can be generated from residual waste or biomass feedstock via gasification and subsequent syngas upgrading. When the CO_2 generated by the process is captured and sequestered, the entire process (known as BECCS, Bioenergy with Carbon Capture and Storage) qualifies as a greenhouse gas removal technology.

Advanced technology for waste-to-H_2

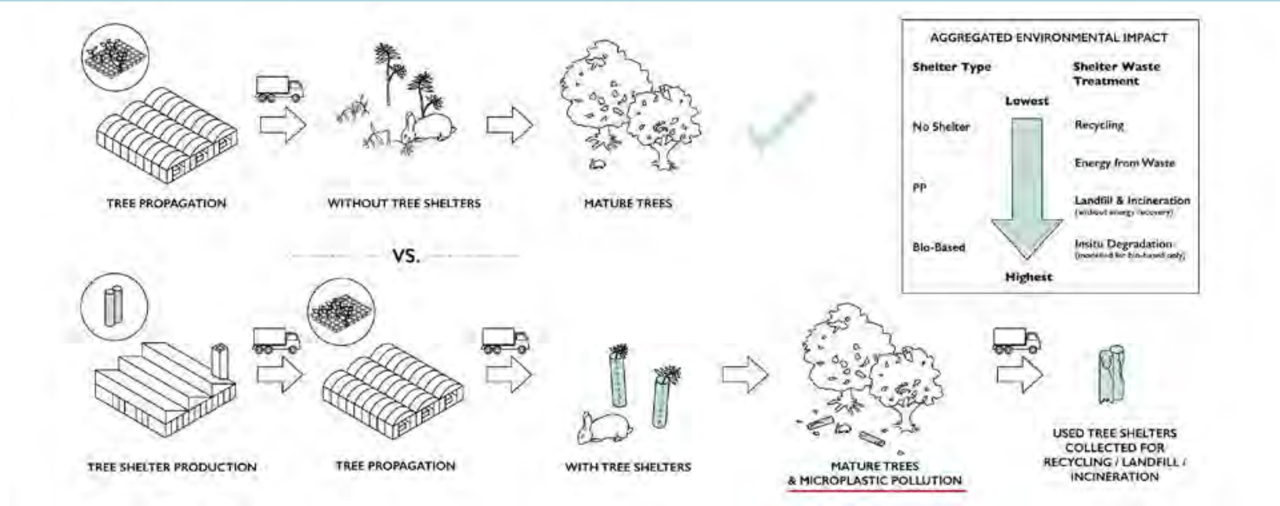
The UCL group and Bioenergy Technologies Research Lab led by Dr Materazzi have developed an innovative waste-to-H_2 process which is highly efficient and sustainable. The first breakthrough process is an advanced thermal conversion (ATC) technology which has been developed for the treatment of second-generation biomass and can also be successfully applied to treat household wastes. During the process, waste is converted into a clean, hydrogen-rich synthesis gas (syngas) and a vitrified, environmentally stable product each with multiple applications. The clean syngas is then converted to pure hydrogen and CO_2 with an innovative, highly intensified sorption enhanced water gas shift (SEWGS) process, designed and extensively tested with project partners on newly developed and commercially available catalysts. The process delivers high overall resource efficiency, high process flexibility, maximum landfill diversion, minimal generation of secondary residues and substantial negative carbon emissions. The combination of process efficiency and feedstock flexibility means that the process is a practical answer to de-carbonising energy and transport targets and can go a long way towards 'greening' future hydrogen networks.

Pilot fluidised bed facility

In 2022, the group received funding from the Department for Business, Energy, and Industrial Strategy (BEIS) to design, construct and build a pilot SEWGS facility to produce continuously up to 2 kg/h of transport grade hydrogen and ~30 kg/h of pure CO_2 from a slipstream of syngas, available from an industrial facility in Swindon (UK). In addition, a pilot fluidised bed SEWGS reactor, the first of its kind, will be constructed at the Manufacturing Futures Lab at UCL East for further process development and research. The build and operation of the plants, and the associated test programme, will inform the design and economics of subsequent commercial plants that could significantly increase the potential of BECCS in the UK.

For more information contact
Dr Massimiliano Materazzi:
massimiliano.materazzi.09@ucl.ac.uk

Designing-out Plastic Waste via Life Cycle Assessment



Schematic representation of the scope and result of the LCA study on seedling planting

Plastic waste is a failure of design that generates significant environmental impacts as well as economic burdens. Life Cycle Assessment (LCA) is a systematic and holistic tool that enables quantifying environmental impacts to support decision-making, including about design options. We show two practical applications of how LCA can be used to design-out plastic waste, covering face masks and plastic shelters. In both case studies we identify alternatives that do not use plastics and generate lower environmental impacts.

Plastic waste is a failure of design

Plastics production has increased twentyfold since 1964, but only a small portion is recycled globally, with the majority being incinerated, landfilled or, even worse, leaked to the oceans. Plastic waste is a failure of design at multiple levels: from developing better alternatives to plastics to designing plastics that are more reusable, recyclable or compostable, to devising better collection methods and more economically viable management technologies. Each level affects and compromises the whole system, leading to environmental impacts, including leakages of plastic into the environment, and creating economic burdens.

The "power" of LCA

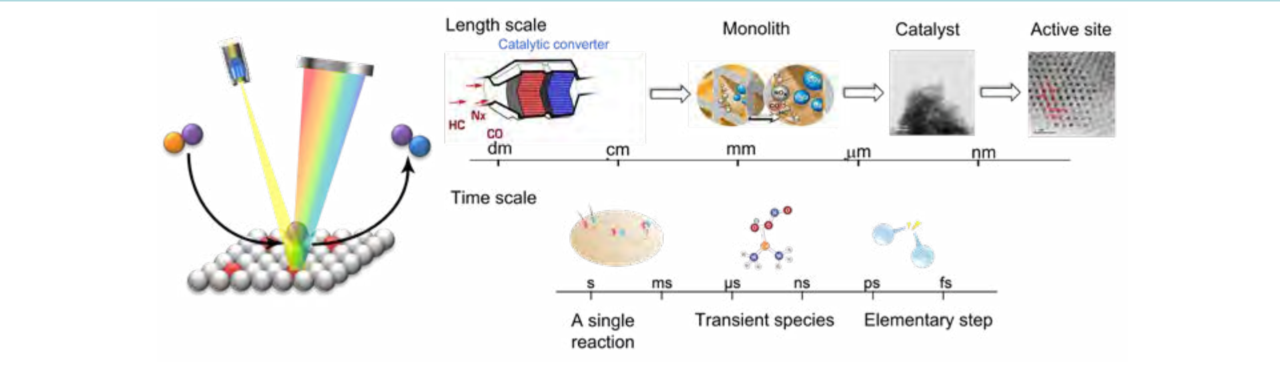
Life Cycle Assessment (LCA) is a standardised tool that enables quantifying the environmental impacts of products systematically and holistically, taking into consideration the whole life cycle of products and a wide range of environmental issues. LCA is thus the best tool to support decision-making, including which design options should be adopted.

Plant seedlings without plastic shelters

To meet net-zero targets, the Woodland Trust is embarking on a national reforestation effort to increase the UK's woodland cover by 6%. The most common strategy envisages planting seedlings with the use of plastic tree shelters which increase the growth and survival of trees. These plastic shelters are single-use and often left in-situ to degrade. With the use of LCA, we evaluated the environmental performance of current and prospective shelter options (including bio-plastic materials), compared with a base case where shelters are not employed. We demonstrated that planting seedling without shelters is the most environmentally preferable option and that, if shelters are to be used, polypropylene is to be preferred to current bio-based alternatives.

For more information contact
Dr Andrea Paulillo: andrea.paulillo@ucl.ac.uk

Catalysis Enabled by *Operando* Spectroscopy: from Fundamental Understanding to Innovative Materials



Understanding catalytic systems at multiple space and time scales

The Materials and Catalysis Laboratory (MCL) at UCL has developed new experimental methodologies to study catalytic processes in energy conversion, fuel production and emission control. MCL utilises the advanced synchrotron X-rays and X-ray free electron laser (XFEL) techniques to probe catalytic systems under working conditions in order to reveal reaction mechanisms and develop advanced catalytic systems.

Impact of heterogeneous catalysis

Heterogeneous catalysis is of prominent importance for modern society. For example, the Fe catalysed NH_3 synthesis process provides nitrogen fertilizers that lead to food production for at least half of the world's population. It is even more important in the circular economy, providing process solutions for future energy conversion, fuel production, and waste recycling. Yet the understanding of reaction mechanisms is still limited due to the complexity of surface catalytic systems and the lack of characterisation methods to directly observe surface processes under working conditions.

Operando spectroscopy

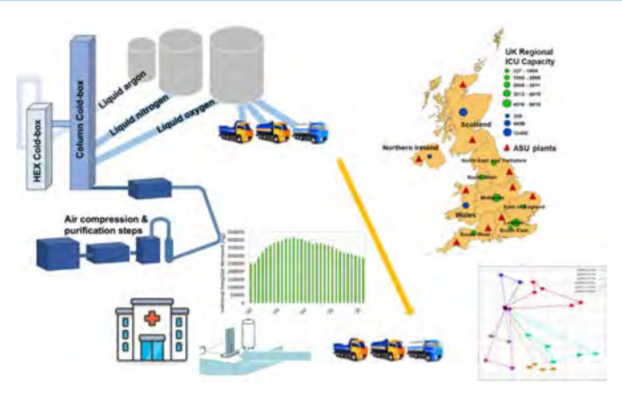
MCL has developed several methods to study catalytic processes at second (s), ms, μs, ns, and fs scales. At the s to ms scale, the rate of key reaction steps, such as the rate-limiting steps, are determined by measuring the dynamics of the catalysts during the reaction. At μs to ns scale, the intermediate species during the reaction are determined. At the ps to fs scale, the dynamics of individual elementary steps are investigated with advanced XFEL techniques. The *operando* studies at MCL have provided a few first-time observations of fast-dynamics processes in fuel production and emission control, gaining fundamental knowledge of complex catalytic systems.

Novel catalytic systems

With the understanding obtained from *operando* spectroscopy, MCL has developed and patented several catalytic systems in emission control, fuel production and energy conversion. Working with Johnson Matthey and Toyota Motors, MCL has developed new three-way catalysts for gasoline engine emission control and Cu-based catalysts for diesel engine emission control. Similar Cu systems are also applied to produce H_2 from green electricity, serving as new fuel feedstock for electric vehicles. Finally, MCL has developed low Pt content catalysts for fuel cell vehicles, boosting the energy conversion efficiency and stability significantly. The new *operando* X-ray methods at MCL have been used beyond catalysis and energy conversion systems with great potential in wide engineering applications.

For more information contact
Dr Ryan Wang: ryan.wang@ucl.ac.uk

Supply Chain Optimisation for Process and Energy Systems



Typical industrial gas supply chain

Contemporary supply chains are becoming increasingly complex in response to the ever-changing societal, economic and environmental demands. With unprecedented levels of market volatility, continually stringent environmental regulations and call for responsive and digital operations, new systems-based approaches become imperative. Research from the groups of Prof. Lazaros Papageorgiou and Dr Vassilis Charitopoulos focuses on novel techniques to address these challenges from a variety of sectors ranging from process industries to national energy infrastructure.

Managing medical oxygen supply chains during the COVID-19 pandemic

The recent pandemic confronted decision-makers with unprecedented challenges not only concerning the efficient containment of the virus but also for the major disruptions caused in supply chains. Through a UKRI COVID-19-funded project (INSIGHT), the effects and mitigation strategies for supply chain disruptions in the medical sector were examined. The team developed an optimisation-based decision-making framework for integrated production/distribution planning and routing for the UK medical oxygen supply chains, while similar systems-based approaches have been applied to other industrial gas systems.

Digital supply chain operations in process industries

The chemical industry in the UK plays a vital role in the nation's economy with a total annual turnover of £50 billion. To remain competitive, optimisation-based scheduling methods are often applied to achieve a significant increase in process profit, reduction in energy cost and improvement in the efficiency of inventory management. Work at UCL aims to develop the next-generation autonomous digital scheduling framework in response to different types of disruptions in chemical manufacturing, by integrating machine learning techniques with optimisation approaches through a UKRI project (AIOLOS).

Resilient future energy systems

With the power sector becoming increasingly reliant on intermittent renewable sources and the Government's commitment to net zero by 2050, the role of hydrogen towards heat decarbonisation and its related uncertainties need to be urgently explored. The project HUMAN aims to deliver systematic approaches to policymaking under uncertainty regarding hydrogen's role in the decarbonisation of the heat sector in the UK. Here, decision-making frameworks have been developed based on multi-period, spatial-explicit representation coupling long-term strategic planning decisions over 3-4 decades (e.g., production, storage facilities, H_2 and CO_2 pipelines) with hourly operation. Another project with industry focuses on decentralised energy networks such as microgrids under uncertainty that provide reliable, low-emission energy as well as flexibility to the power sector through energy trading schemes.

For more information contact Prof. Lazaros Papageorgiou:
l.papageorgiou@ucl.ac.uk

In-silico HPLC Method Development and Process Optimisation

Within the context of an EPSRC Prosperity Partnership on "Transforming synthetic drug manufacturing: novel processes, methods and tools", our team of researchers are developing a knowledge-driven systems engineering framework for analytical and preparative HPLC methods that will ease the experimental workload needed for process development.

Prosperity Partnership

The PharmaSEL-Prosperity Partnership is a business-driven research programme led by the global pharmaceuticals company Eli Lilly and Company and three London universities – UCL, Imperial College London and Queen Mary University of London – with part funding by EPSRC and significant support from the partner institutions. The road from the discovery of a drug molecule to a commercial product that benefits patients remains frustratingly long and arduous, with the total cost of development reaching $2.6bn and 10 years per new chemical entity (NCE). The Partnership aims to deliver novel systems-based engineering design methods for the rapid development of manufacturing processes for advanced synthetic drugs.

Synthetic drugs make up the largest part of the drug portfolios of pharmaceutical companies, peptides representing an increasingly important class of these drugs. The Partnership draws on expertise and advances in the manufacture of small molecules to enable radical progress in the synthetic manufacture of much larger peptide drugs, considering the entire chain from drug substance to drug product.

In-silico HPLC optimisation

At UCL, researchers are investigating innovative drug substance purification techniques based on high-performance liquid chromatography (HPLC). Our group is developing integrated HPLC systems and processes that will allow reducing the cost and time of performing advanced analytical chemistry

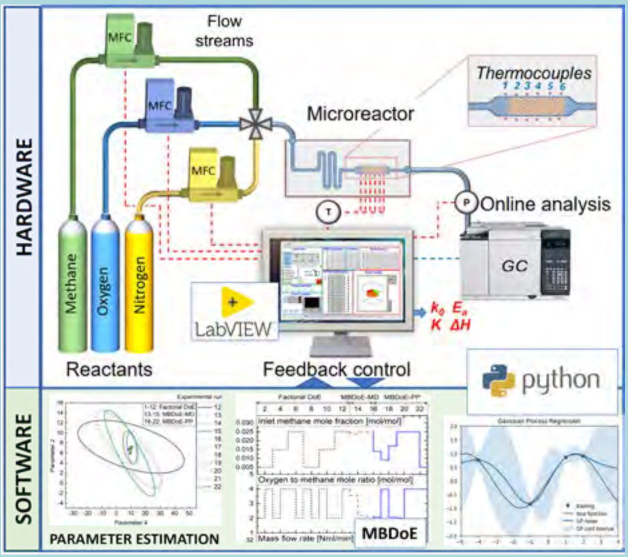
Pharmaceutical tablets

significantly, a step that is required for the effective purification of drug substances. To achieve this, we are developing a framework that identifies the optimal combination of separation techniques and configurations for attaining the required drug substance purification and isolation.

This research programme will deliver fundamental understanding, models, technologies, and design methodologies for accelerating the isolation and purification of synthetic drugs, from small molecules to peptides. This will improve the design, control and optimisation of medicine manufacturing processes, ultimately resulting in better and cheaper treatments for patients, thus positioning the UK at the leading edge of expertise and innovation in the manufacturing of high-value synthetic drugs, contributing to the growth of a value-creating innovation ecosystem.

For more information contact
Prof. Eva Sorensen: e.sorensen@ucl.ac.uk

Autonomous Systems for Digital Chemical Manufacturing



Hardware-software integration in an autonomous reaction platform

Within the context of digital chemical manufacturing, Dr Federico Galvanin, together with Prof. Asterios Gavriilidis and Prof. Richard Bourne (University of Leeds), is pioneering the use of integrated, computer-based systems comprised of simulation, analytics and advanced process optimisation tools to develop autonomous reaction systems. These systems are employed to identify kinetic models online for model-based reaction process optimisation and control in the course of unmanned experimental campaigns.

Digital twins

In the Industry 4.0 era, the rapid development of robust pharmaceutical and chemical processes is hampered by the time and effort required to obtain fast, highly predictive and reconfigurable mathematical models to be used in "digital twins", i.e., digital surrogates of the processes, for agile *in-silico* testing, design, optimisation and control of chemical processes. An accurate description of the reaction kinetics and heat and mass transfer phenomena occurring in the actual reaction processes is critical and requires extensive experimentation, time, and human and analytical resources.

Smart laboratory platforms

Smart laboratory platforms have been developed at UCL Chemical Engineering to drastically reduce the cost of experimentation for model development by integrating automated microreactor systems (hardware components), cloud-based computing, advanced model identification and optimisation algorithms (software components) to identify appropriate reaction models online. In these platforms, model-based design of experiments (MBDoE) methods are employed to i) discriminate among potential kinetic models; ii) estimate the set of model parameters precisely by designing optimal experiments that generate the data needed for rapid validation of kinetic models without human intervention. The computational framework of the platform was developed in Python programming language and was integrated into a LabVIEW program of the microreactor system. A new Pyomo-based parameter estimation module was employed in the framework for the efficient solution of online parameter estimation problems.

Cognitive chemical manufacturing

In the EPSRC project Cognitive Chemical Manufacturing, Galvanin's group has developed a software tool exploiting Gaussian Processes (GPs) as surrogate models to model reaction systems under uncertainty to design (from UCL computers) automated experiments run remotely at the University of Leeds using cloud-based services. The project combines automation, flow chemistry technology, machine learning (ML) and MBDoE to identify the best experimental conditions for model validation and move towards the development of an intelligent system for autonomous decision-making to facilitate the cost-effective continuous manufacturing of chemicals.

For more information contact
Dr Federico Galvanin: f.galvanin@ucl.ac.uk

Smart Manufacturing of Pharmaceutical Nanocrystals

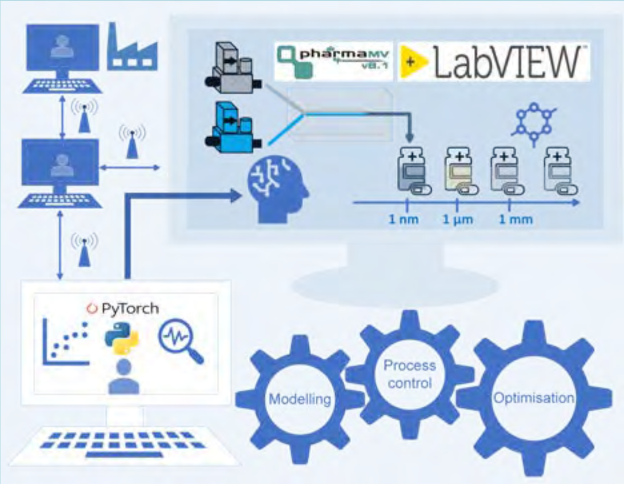
Integration of continuous flow processing, online process analytical technology, real-time process control, predictive modelling and artificial intelligence (AI) has the potential to deliver self-optimising platforms for screening and manufacturing nanocrystalline drugs. Using AI technologies to automatically identify the best processing conditions for the desired products, a software-hardware tool is being developed that will massively reduce the time scale to bring new nanocrystalline drugs to life.

Nanocrystalline pharmaceuticals

Nanocrystalline dosage forms have attracted substantial interest as a means of delivering poorly water-soluble drugs, a persistent and increasing problem for the pharmaceutical industry. Preparing drugs as nanosuspensions considerably increases their specific surface area, improving the dissolution rate of the drug and its bioavailability. However, manufacturing drugs in nanocrystalline form is challenging and requires long optimisation steps owing to issues related to particle size control, particle aggregation and undesired polymorph generation. These barriers have hindered adoption of this technology by the pharmaceutical industry.

Breaking the barriers

The EPSRC-funded NanoAPI project aims to overcome these barriers by delivering a fully automated, self-optimising continuous crystallisation platform to manufacture and simultaneously quality control drugs in the form of nanocrystals. To this end, the key enablers are continuous flow processing, online advanced process analytical technology, real-time process control, design of experiments, advanced data analysis and AI. This project combines all these technologies, using machine learning (ML) methods to automatically identify the best processing conditions for the desired products, thus facilitating the cost-effective continuous manufacture of reproducible and stable drug products.



An engineering solution for the autonomous synthesis of drug nanocrystals, combining flow crystallisation, online particle characterisation, design of experiments, machine learning, advanced data analysis and real-time process control & quality assurance

The manufacturing platform

A confined impinging jet reactor has been used as a robust antisolvent crystalliser, providing excellent mixing and resulting in consistent product quality. LabVIEW virtual instruments have been developed to control all the hardware in the platform. To reduce the experimental effort for identifying suitable conditions for targeting specific crystal sizes and navigating the multivariable design space efficiently, design of experiments is used. Python and PharmaMV (software developed by Perceptive Engineering Ltd.) have been used for real-time process control. The computational framework is formed by combining optimal experimental design methods and ML algorithms to develop uncertainty-aware predictive models to describe crystallisation data. The framework will be applied to real-time process control aiming to produce nanocrystals in the desired size range.

For more information contact
Prof. Luca Mazzei: l.mazzei@ucl.ac.uk

ChromaDose: Improving Chemotherapy for Children

Overview of the ChromaDose technology to aid precise pharmacokinetics-driven dosing, including an automated desktop unit, a consumable cartridge as well as analytical algorithms

Children receiving chemotherapy treatment each process the drugs differently, resulting in inconsistencies in drug concentrations in the blood (known as drug exposure). Patients may not receive enough of the drug or in some cases may experience delayed side effects, predominantly in the form of dose-related cardiotoxicity. Research in the Department of Chemical Engineering is leading to a novel point-of-care companion monitoring device to innovate the standard of care.

The dosing challenge

Chemotherapy dosing in childhood cancer is a clinical dilemma due to significant variability in drug metabolism and clearance, leading to either ineffective treatment or drastic side effects. As an example, anthracyclines, one of the most used therapeutics, cause heart problems in over 2/3 of cases. Therapeutic drug monitoring (TDM) provides data on how individuals process drugs to guide personalised methods of dosing. However, current TDM involves centralised analysis, leading to time delays, inaccuracies with sample handling and logistical complexities. Consequently, TDM is still not a standard of care.

A simple route to drug monitoring

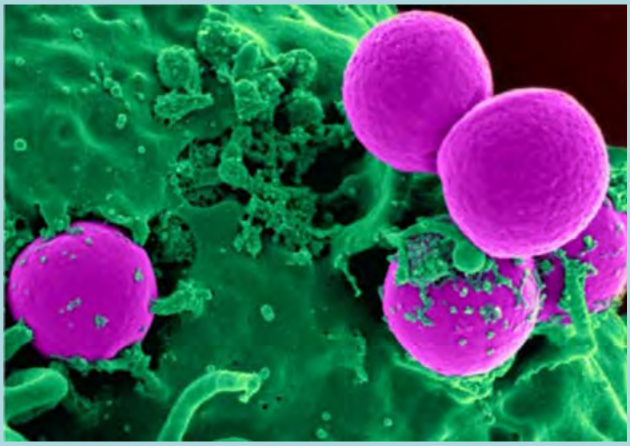
At University College London, we have established a novel way to determine drug concentrations with simple means, following chromatographic separation and quantification by fluorescence-based image analysis. As an offspring of our research, the underlying principle of quantitative thin-layer chromatography (qTLC) has been published as an educational platform, which allows end-users (from high school students to scientific researchers) to perform analytical chemistry with their smartphones. The accompanying web app qTLC.app has so far been accessed by users from 47 countries across six continents and received a UCL Education Award. Meanwhile, incorporation of the qTLC principle in the form of an IP-protected hermetically sealed cartridge enables translation into clinical workflows.

From proof-of-concept to clinical prototype

The lab-proven technology is currently being developed into a fully automated in-vitro diagnostic device as part of an Invention for Innovation Product Development Award by the National Institute for Health and Care Research. The project is co-led by Prof. Gareth Veal, who heads the 1st generation national TDM across 19 NHS specialist centres and involves a total of 11 partner organisations with the UCL start-up Vesynta serving as the commercial vehicle. Crucially, prototyping is conducted in close consultation with a variety of stakeholders, including consultants, nurses as well as patients and their families to ensure full adoption. The aim of the project is for all children receiving chemotherapy to benefit from the safety and effectiveness of personalised treatment. The bedside drug monitoring technology is in principle amenable to a wide range of therapies and is envisioned to be extended to additional patient groups in chemotherapy (including adults) and other drug classes (including antiarrhythmics, antibiotics, antiepileptics, antifungals and immunosuppressants).

For more information contact
Prof. Stefan Guldin: s.guldin@ucl.ac.uk

Continuous Flow Nanotechnology Aiding the Fight towards Antimicrobial Resistance



Staphylococcus aureus bacteria (purple artificially coloured)

Healthcare and nanomedicine present a major opportunity for nanotechnology and nano-enabled products. A significant roadblock in the use of nanoparticles (NPs) is the lack of large-scale availability of high quality NPs with tuneable size, morphology and surface functionalisation. Continuous flow processes, due to the better control they offer and minimisation of human intervention, have the potential to bridge the gap between synthesis and manufacturing.

Nanoparticles in healthcare

During the recent COVID-19 pandemic, almost everyone used nanotechnology: gold nanoparticles (NPs) are present in diagnostic lateral flow tests that have been used to detect the SARS-CoV-2 virus. NPs in medicine have many other uses such as drug carriers, labelling and tracking agents, vectors for gene therapy, hyperthermia treatment, and magnetic resonance imaging (MRI) agents. The size, monodispersity, shape, purity and functionalisation of the NPs are critically important for best clinical effect. However, batch-to-batch variations are highly problematic and a synthesis approach that gives uniform materials consistently is fundamental in allowing the applications to reach their full potential. A multidisciplinary team across UCL led by Prof. Gavriilidis has developed nanoparticles and scalable processes for healthcare applications.

Bacteria killed by nanoparticle-based light-activated coating

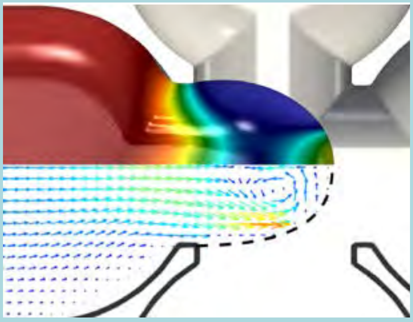
The emergence of antibiotic-resistant bacteria is a major threat to the practice of modern medicine. Photobactericidal agents are promising candidates to kill bacteria, and they have been extensively studied. However, to obtain photobactericidal activity, an intense white light source or UV-activation is usually required. The team developed a photobactericidal polymer containing crystal violet (CV) and thiolated gold nanoclusters ([$Au_{25}(Cys)_{18}$] activated at a low flux level of white light, 300 lux. Such low light is commonly found in healthcare facilities such as waiting rooms and general nursing care. Polymer swell-encapsulated with CV&[$Au_{25}(Cys)_{18}$] displayed potent bactericidal activity against S. aureus and E. coli, which are both associated with hospital-acquired infections. The coating kills bacteria by producing hydrogen peroxide – a relatively mild reagent used in contact lens cleaner solutions. It works by chemically attacking the cell membrane and therefore takes longer to work on bacteria with more layers of protection.

Intensified continuous synthesis of gold nanoclusters

Given that the gold clusters contain only 25 atoms of gold, very little of this precious metal is required compared to similar coatings, making the coating attractive for wider use. For the production of gold nanoclusters, a new continuous process was developed. It was based on carbon monoxide-mediated reduction in a millifluidic membrane reactor. The intensified system, operating at 80°C and 500 kPa took only 3 min for the synthesis of atomically precise nanoclusters, which is two orders of magnitudes faster than comparable batch processes. It led to a throughput of 0.9 gAu per day, paving the way for larger-scale production.

For more information contact
Prof. Asterios Gavriilidis: a.gavriilidis@ucl.ac.uk

Microfluidics for Controlled Droplet Generation



Drop formation in cross flow microfluidic junction. Top: Prediction of surfactant interfacial concentration Bottom: Velocity profile in the drop

With support from EPSRC Programme grants MEMPHIS and PREMIERE, Prof. Panagiota Angeli and colleagues across a number of UK universities have been developing tools for predicting multiphase flows. They combine physics-based predictions relying on experiments and computational fluid dynamics (CFD) simulations, with machine learning to address challenges in manufacturing, energy and healthcare. Microfluidic droplet generation underpins modern emulsion formulations.

Multiphase formulations

Multiphase systems are ubiquitous in industrial and environmental flows. They are central in manufacturing, energy and healthcare. Dispersions/emulsions of two immiscible liquids find numerous applications in pharmaceutical and healthcare formulations, food, agrochemicals and in inkjet printing. In recent years, microchannels have been extensively used to produce emulsions with small and uniform drop sizes. Surfactants and colloidal particles are commonly added to vary the interfacial properties, control the drop size, stabilise the emulsions and influence the final product rheology. Fast droplet generation rates are crucial for industrial translation. Understanding and predicting the properties of such systems and ultimately the drop size is very challenging. During fast droplet generation, the rates of the surfactant or particle transport and their adsorption/desorption to the interface can be competing. Models are often empirical, and thus have limited applicability, while experiments cannot capture the complex flow and surfactant/particle transport and absorption phenomena. The lack of detailed experiments limits further the development of predictive models.

Combining physics-based and data-driven modelling

With sustained funding from EPSRC via the Programme grants MEMPHIS and PREMIERE (over £11M) and in collaboration with Imperial College and the Universities of Birmingham and Cambridge, and support from global industries and healthcare partners, we are developing experimental and numerical methodologies to understand and predict multiphase flows. We have been combining the physics-based predictions relying on experiments and computational fluid dynamics (CFD) simulations, with machine learning approaches to inform the experiments (design of experiments), enhance the predictive capabilities of the models and quantify uncertainty to drive innovation and improve efficiencies.

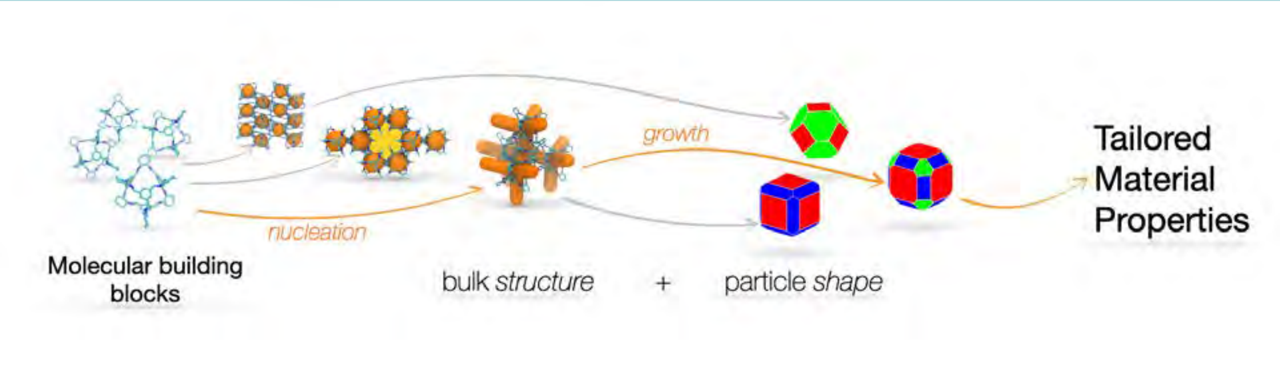
Predicting droplet generators

For the study of microfluidic droplet generation, we have developed novel experimental approaches. High-speed and high-resolution imaging and micro-particle image velocimetry have enabled us for the first time to observe all stages of the droplet formation and the velocity fields. We combined the experimental studies with physics-based numerical CFD simulations, which enable us to visualise the transport of surfactants. The experimental studies provided large data sets that we used to formulate data-driven models for predicting the drop size as a function of surfactant chemistry and concentration and of the flow rates of the two liquid phases. These tools allowed us to quantify the uncertainty of the predictions. To improve further the predictions, we developed synthetic data which share the same statistical properties as the experimental ones.

Our findings will support the development of microfluidic droplet generators and more widely of microfluidic systems where droplets are used for analysis or separations.

For more information contact
Prof. Panagiota Angeli: p.angeli@ucl.ac.uk

Zooming in on Crystals Assembly with a Computational Magnifying Glass



Predicting how molecular building blocks give rise to materials with specified properties requires to understand what crystal structures could form, and how such structures could evolve in realistic conditions

Achieving efficient and scalable production of materials with functional properties such as porosity, bioavailability, adsorption selectivity and therapeutic activity, is pivotal for developing innovative solutions across a broad range of rapidly evolving fields, from clean energy and manufacturing to healthcare. In the Molecular Modelling & Engineering (MME) group we apply molecular simulation techniques to learn how materials assemble at the molecular scale, advancing the fundamental understanding of crystallisation and enabling the development of rational workflows for the solid-form design of crystalline materials.

Understanding crystallisation

Molecular crystals are found in many everyday products, from food to pharmaceuticals. Like construction bricks, molecular crystals' building blocks can reversibly self-assemble into a plurality of structures. This characteristic opens endless possibilities in material design, with applications in pharmaceutical manufacturing, separations, catalysis and organic electronics. Despite their importance, the "blueprint" to assemble molecular building blocks into crystals with well-defined properties is often identified via trial-and-error, performing expensive and potentially limited experimental campaigns. In the Molecular Modelling and Engineering (MME) group we work to develop molecular simulation methods to overcome this limitation and achieve a rational understanding of crystallisation processes by answering questions such as: "What crystal structures are more likely to be assembled in a given set of conditions?" "How rapidly?", and "What molecular-scale mechanisms dominate the assembly process?" We attack these questions using a broad array of computational methods able to resolve the structure and dynamics of matter at the atomistic scale thus enabling us to probe the behaviour of crystals at the molecular scale, like a virtual, computational microscope.

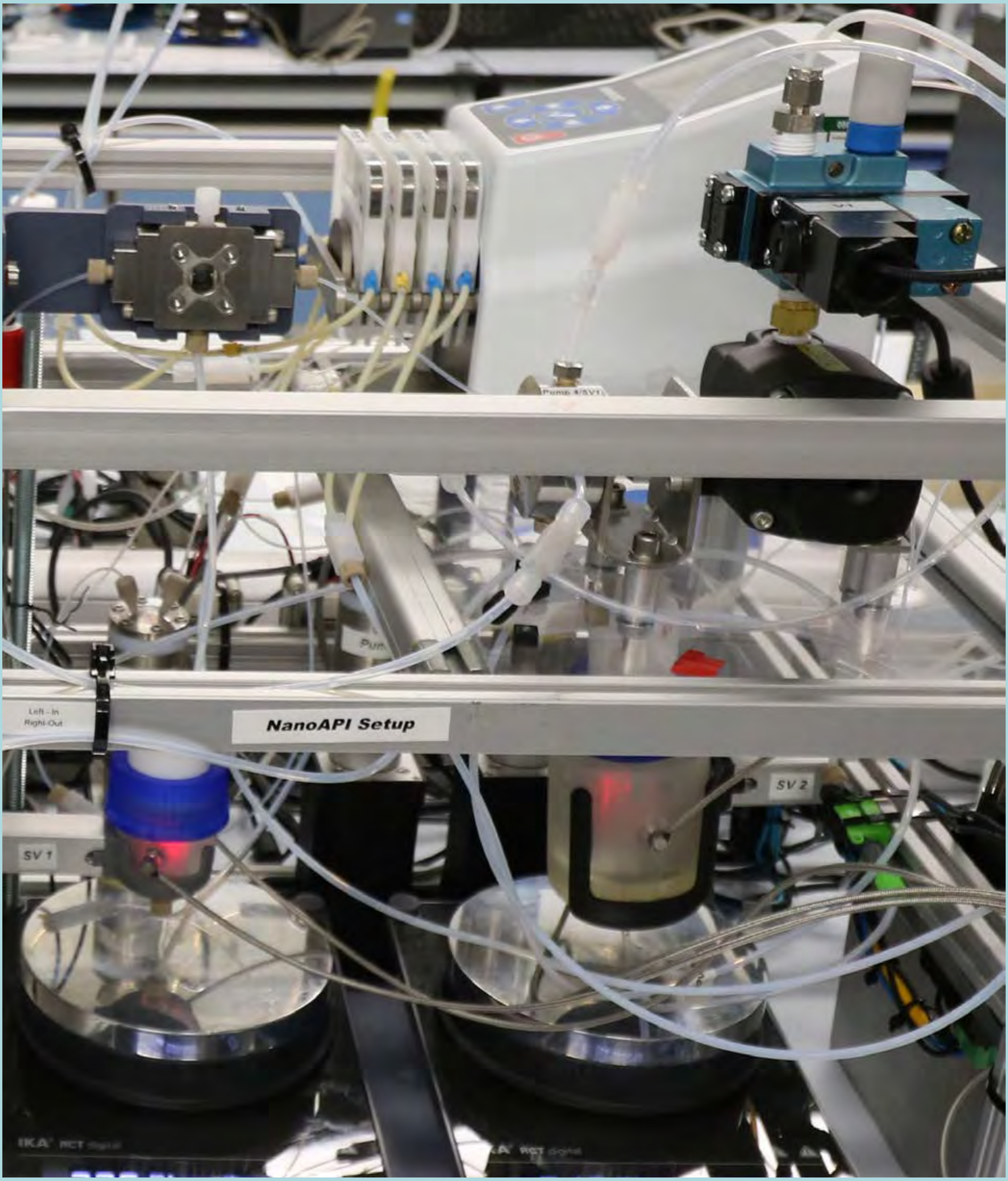
Large scale molecular dynamics to reduce polymorph overprediction

In collaboration with the UCL Department of Chemistry, we have recently proposed a workflow based on molecular dynamics aimed to systematically address the tendency of computational methods to predict more crystal structures than practically observed in experiments. This effort has been enabled by industrial funding and has culminated in participation in the 2022 CCDC Blind Test for crystal structure prediction and has enabled the MME group to establish new research directions.

Beyond thermodynamic stability

Despite the central role of thermodynamics, the experimental observation of crystal polymorphs depends crucially on the kinetics of nucleation. Due to its very small characteristic length scale, and stochastic nature, nucleation represents a challenge to computational scientists and experimentalists alike. With the award of the 2021 ERC Consolidator Grant ht-MATTER – *High-Throughput Modelling of Molecular Crystals Out of Equilibrium* (funded by UKRI via the Horizon Guarantee Program), the MME group is developing methods to explicitly consider out-of-equilibrium effects in the design of crystalline materials.

For more information contact
Prof. Matteo Salvalaglio: m.salvalaglio@ucl.ac.uk



Research Impact, Enterprise and Innovation

Fluidised Beds: From Lab to Full Scale

The department hosts the oldest fluidisation research group in the UK. Through research collaboration and consultancy, the group has enabled the development of new fluidised bed processes, resolved significant operational problems in complex industrial plants, and supported the design of sustainable processes. The core activities encompass experimental measurements on lab and pilot scale facilities, advanced imaging techniques based on X-ray and ultrasound, and fluid dynamics modelling.

Magnox thermal denitration reactor at Sellafield

The group worked with the National Nuclear Laboratories (NNL) and Sellafield to design and construct a scaled-down model of the TDN (thermal denitration) fluid-bed reactor for nuclear waste reprocessing operated at Sellafield. X-ray imaging was used to visualize the internal flow pattern inside the vessel, design new gas distribution systems, and improve the operation of the real facility.

Waste gasification plant in Swindon

The pioneering work of the group on the effect of process conditions on gas-fluidised beds contributed to understanding the role of interparticle forces on biomass treatment and produced gas quality and has been applied in the energy-from-waste sector, enabling the construction of the first Waste-to-Fuel facility in the UK. The plant, owned by the company Advanced Biofuel Solutions, processes approximately 10,000 tonnes per annum of waste-derived fuel or wood-based feedstock producing 22 GWh/a of renewable gas (methane or hydrogen), sufficient to heat around 1500 homes or power 75 HGVs. This is injected into the Swindon gas grid at a rate of up to 300 m^3/h.

For more information contact
Prof. Paola Lettieri: p.lettieri@ucl.ac.uk

Left: Waste-to-Fuel plant in Swindon (UK) Right: Scaled-down cold model of the TDN reactor at UCL

A Plastic-free Remembrance Poppy

The Royal British Legion's new paper Poppy.
Photograph: Royal British Legion

The iconic British Remembrance Poppy has been made of plastics and paper for over 30 years. This design has been problematic because it prevented widespread recycling. We collaborated with the Royal British Legion (RBL) to assess the environmental performance of alternative design options via Life Cycle Assessment. We found that a paper-based design generated 40% lower environmental impacts over its life cycle than the current design. Our results were instrumental in the decision of RBL to switch to a plastic-free design by 2023.

The iconic Remembrance Poppy

The Remembrance Poppy is an iconic artificial flower that is worn in the UK and other Commonwealth countries in the period preceding Remembrance Day to commemorate military personnel. The British Poppy has been unchanged for nearly 30 years, being based on a multi-material design made of fossil plastic (light-density polyethylene) and paper. This design prevented its widespread recycling and ascribed the Poppy to the realm of single-use plastics, which attract increasing public attention in the UK and elsewhere, particularly in relation to ocean pollution.

LCA, a holistic approach

In an effort to produce a more environment-friendly design, we collaborated with the Royal British Legion – the charity that sells the Poppy – to assess the environmental impacts of alternative design options via the use of Life Cycle Assessment. LCA is a standardised methodology that enables quantifying the environmental impacts of products or services in a holistic way. It considers a wide range of environmental issues, which include but are not limited to climate change and quantifies impacts that arise throughout the product life cycle, from the extraction of raw materials to the disposal of waste (i.e., from "cradle to grave"). This holistic approach enables identifying trade-offs amongst alternative scenarios, thus supporting a robust decision-making process.

A novel paper-based Poppy

We considered two alternative options for the Poppy: one envisaging an increased recycled content (30% for LDPE and 50% for paper) compared to the current design, and another based on a novel, mono-material, paper-based design with 50% recycled content; notably, being fully made of paper, the latter option can be widely recycled. In both cases, the recycled paper was obtained from the recycling of clean coffee cups (post-industrial waste). Our study indicated that the paper-based design is overall the environmentally preferable option, yielding environmental benefits ranging from 39% up to 54% compared to the current design, according to whether the Poppy is not or is recycled at the end of its life. Overall, our study highlighted the importance of using increasing percentages of recycled content, as well as that of designing products that are recyclable at the end of their life, which are both pillars of the Circular Economy paradigm. The Royal British Legion took on board our recommendations: from 2023 the British Poppy has been made entirely from paper.

For more information contact
Prof. Paola Lettieri: p.lettieri@ucl.ac.uk

Optimising Manufacture of Oral Healthcare Products using Rheological Modelling

Prof. Angeli and Prof. Mazzei led research efforts to understand the properties of complex mixtures used in toothpaste and gels, which led to the development of a rheological model and computational fluid dynamics simulations to improve manufacturing processes in industries from oral healthcare to petrochemicals and sustainable technologies.

Manufacturing challenges of modern formulations

Oral care products, such as toothpaste and gels, play an important part in maintaining good oral healthcare and preventing diseases. Great advances in the quality, function and effectiveness of these products have been made in recent years. However, the increased sophistication and complex rheological behaviour of the components pose new challenges for manufacturers, with time-consuming lab testing and extensive feasibility studies at pilot and production scales. Highly viscous, non-aqueous formulations have different rheological behaviour compared to their aqueous counterparts and often require longer mixing times, while they are temperature sensitive. Through an industrial partnership between Professors Panagiota Angeli and Luca Mazzei and a large oral healthcare product manufacturer, a systematic approach has been developed to characterise the complex rheology of non-aqueous oral formulations and to improve mixing for current formulations.

Rheological studies of complex mixtures underpin the development of predictive models

A rheological model has been implemented in a Computational Fluid Dynamics (CFD) code and has been successfully validated against experimental data. The model can be used to design more efficient manufacturing routes for complex fluids and has been extended to the mixing of solid suspensions. Understanding the relationship between temperature and viscosity has allowed manufacturers to improve the efficiency of the mixing process for oral care products and reduce batch cycle times.

Companies are now able to respond to consumers' higher demands for products that reduce tooth sensitivity in markets in the UK and worldwide in Romania, Saudi Arabia, the US, and South America. The research helped reduce manufacturing costs and CO_2 emissions and supported the increase in annual turnover of the industrial partner. The UCL team's work has contributed to a brand worth £270 million in book value and to a 7% growth in oral health product sales. The work has also led to reduced waste and transport of excess materials that will help companies' commitment to reduced carbon footprint.

Relevance of modelling methodology to other sectors

The modelling methodology has also been implemented by petrochemical and sustainable technology companies and is being used in other processes, for example, to predict the flow and separation of liquid dispersions relevant to the transport of multiphase mixtures and to pharmaceutical purifications. It is also used as a fast technical assessment tool for new non-aqueous formulations and has allowed accurate risk assessment when working in near-critical conditions, reducing the need for costly pilot-scale trials.

For more information contact
Prof. Panagiota Angeli: p.angeli@ucl.ac.uk

Rheological modelling and advanced experimentation help improve manufacturing of complex formulations such as toothpastes

CO_2 Utilisation

Carbon dioxide utilisation can play a productive role in achieving net-zero emissions by providing pathways for carbon storage in useful products in some cases and by enabling a circular carbon economy in others. Helping to accelerate this transition, Prof. Mahgerefteh is a committee member tasked with producing a two-part study report mandated by the U.S. Congress to guide the necessary government and public sector investment required to develop cost efficient, safe and environmentally benign carbon utilisation technologies and transport infrastructure across mainland U.S.A.

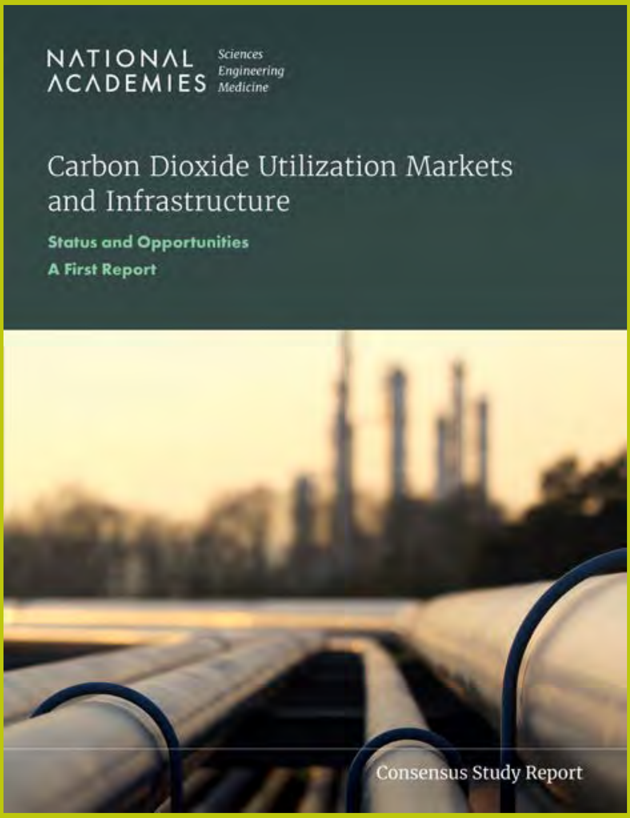
Importance of CO_2 Utilisation

A key component in achieving net-zero emissions is carbon management, which involves mitigating the vast majority of CO_2 emissions and ensuring that remaining flows of CO_2 to and from the atmosphere are balanced. CO_2 utilisation refers to a collection of applications in which CO_2 is put to use, either directly (i.e., not chemically converted such as in the case of a working fluid) or as a feedstock to a chemical process. Such approaches can be commercially attractive in cases where they generate a saleable product, as compared to a CO_2 disposal undertaking in the case of geological storage. Given the market size, CO_2 utilisation may however only make a minor contribution to the mitigation of current global CO_2 emissions as compared to geological storage. Nevertheless, it may in future offer a more sustainable and competitive alternative to the current fossil fuel fed means of chemical commodities production that could offer the potential of negative emissions in scenarios where the origin of CO_2 is biogenic and the lifetime in the product is long (e.g., >100 years). For the cases where CO_2 utilisation involves a chemical transformation, a number of pathways are considered which are based on mineralisation, anaerobic biological conversion, thermochemical conversion and electrochemical conversion (see figure below for a basic overview of some examples). These pathways could produce a wide range of products, comprising construction materials, chemicals and fuels, polymers and polymer precursors, elemental carbon and engineered products, or other niche products like vodka and diamonds.

U.S. National Academies of Sciences report

Working towards meeting the above challenge, Prof. Mahgerefteh is an elected committee member leading the transport infrastructure task group of the Carbon Utilization Markets and Infrastructure study report mandated by the U.S. Congress. The two-part report administered by the U.S. National Academies of Sciences is intended to inform the U.S. Department of Energy and private sector investments in research, demonstration and deployment for Carbon Utilization Infrastructure.

For more information contact Prof. Haroun Mahgerefteh: h.mahgerefteh@ucl.ac.uk



National Academies of Sciences, Engineering, and Medicine. 2023. Carbon Dioxide Utilization Markets and Infrastructure: Status and Opportunities: A First Report. Washington, DC: The National Academies Press.

Bramble Energy

Bramble Energy is a spin-out company from The Electrochemical Innovation Lab (EIL) and Imperial College London specialising in the development of advanced fuel cell stack technology. The company is based on research performed at Imperial College under Prof. Kucernak and the EIL, where Prof. Dan Brett led the engineering activities, and the EIL incubator labs were used to develop early prototypes. Having secured in excess of £43M funding from various sources, including their Series B funding round in 2022, they are now based in Crawley with an extensive R&D and manufacturing facility spanning 34,000 sq ft, employing over 70 people. Bramble Energy maintains strong links to UCL Chemical Engineering with ex-EIL PhD students Tom Mason (CEO and CTO), Vidal Bharath (CCO) and Erik Engebretsen (Chief Engineer – Fuel Cell Stacks) taking leading roles, as well as previous EIL post-doctoral researcher Simon Jones (Science Director) leading R&D efforts. Bramble is also involved in several Innovate UK grants with UCL Chemical Engineering and sponsors PhD students in the department, as well as Masters Research Project Theses awards.

Tackling decarbonisation of all sectors is a difficult task that will require a suite of high-tech solutions, including the use of green hydrogen in fuel cells to generate electricity in a flexible way at a range of scales for automotive, shipping and backup power supply applications. Current hydrogen fuel cell technologies are limited because of cost, inflexibility, manufacturing complexity and scaling issues. The company specifically uses printed circuit board (PCB) technology to form the structural parts of the fuel cell. This leads to substantial cost reduction and leverages the huge existing global infrastructure for manufacturing PCBs. The unique patented design also allows innovations never before possible with conventional fuel cells, to improve performance and durability.

Bramble hydrogen fuel cell demonstrator vehicle

Because of this, Bramble Energy can turn around bespoke fuel cell stacks from design concepts to physical units within days, saving up to a year in development time compared to other manufacturers. The ultimate target for the company is for Bramble Energy to be amongst the largest fuel cell manufacturers in the world and the go-to name in affordable, scalable electrochemical solutions to decarbonisation.


Bramble V500 Series 18 kW Banded PCBFC™ Stack

Gaussion

Gaussion is a UCL spin-out company founded by members of the Electrochemical Innovation Lab in the Chemical Engineering Department. Based on discoveries made by Dr Tom Heenan, Dr Chun Tan, Prof. Dan Brett, and Prof. Paul Shearing, it was found that magnetic fields can aid ion transport in electrochemical devices, and subsequently, a patent was filed in 2019. The invention was then catalysed by a Faraday Institution Entrepreneurial Fellowship for Dr Heenan, along with several awards that supported early commercialisation. In 2021 Gaussion was incorporated to commercialise the discovery and in 2022 a management team was established (Dr Heenan as CEO, and Dr Tan as COO) and formally spun out from the university, closing a seed investment round totalling £2.85M. Since receiving investment, the company has grown rapidly; a state-of-the-art research facility has been established in central London populated with a world-leading team and cutting-edge equipment. The company has further plans for rapid growth with a mission to disrupt the electric vehicle (EV) market through the development of its MagLiB™ ultra-rapid-charging technology. With this product range, they hope to deliver a week's driving range with 10 minutes charging or less, solving range anxiety and increasing EV adoption rates.

gaussion

Vesynta

Vesynta is a UCL-affiliated precision medicine company originating out of the Adaptive and Responsive Nanomaterials (AdReNa) Group, led by Prof. Stefan Guldin in the Department of Chemical Engineering. The company was co-founded by Prof. Guldin as CSO, Dr Alaric Taylor as CTO and Dr Jugal Suthar as CEO, following the successful completion of the KQ Labs Accelerator at the Francis Crick Institute in 2019. Their operations are based at the Innovation Gateway, part of The London Cancer Hub initiative in conjunction with the Institute of Cancer Research, Royal Marsden NHS Foundation Trust, and the London Borough of Sutton.

The Vesynta team

Vesynta is building a platform that helps personalise the dose selection for patients, maximising the therapeutic benefit of medicines. They combine machine learning with the data from their blood test and patient monitoring apps, to continuously deliver treatment recommendations at the point of care. They help drug developers and healthcare providers overcome the risks and costs of dose selection, by providing patient insight in their hands, overcoming the current challenges of "one size fits all dosing".

Vesynta has been backed by over £2M in grant funding, including as an SME co-investigator as part of the NIHR i4i funded ChromaDose project, and leads on the Innovate UK funded project Dosologic. This non-dilutive support is blended with private investment to establish a clinical-trial-ready hardware and software prototype by 2025, and U.S. market integration by 2026. Their mission is to democratise precision dosing and establish it as the standard of care by 2028, becoming the platform of choice for healthcare providers and drug developers, ensuring safe, effective and tailored dosing to every patient.

Zacros

Zacros is a Kinetic Monte Carlo (KMC) software package that performs accurate and efficient simulations of adsorption/desorption, diffusion, and reactions on surfaces of materials, with applications in heterogeneous catalysis, surface science and chemical reaction engineering. It implements the Graph-Theoretical KMC approach pioneered by Prof. Michail Stamatakis, which enables researchers to unravel complex catalytic phenomena, validate postulated reaction mechanisms against experiments, and guide the design of superior catalysts for applications relevant to, among others, energy conversion/storage and sustainable chemicals manufacturing.

Zacros and Zacros-post (the graphical user interface for post-processing simulation results) are the outcome of 10+ years of research and development efforts at UCL Chemical Engineering and the UCL Advanced Research Computing Centre, supported by over £1M of grant funding. The two software packages have been commercialised by UCL Business (UCLB), and are distributed via XIP, the express licensing portal of UCLB. Additionally, they have been incorporated into the AMS modelling suite developed and marketed by *Software for Chemistry and Materials* (SCM), a small-medium enterprise (SME) based in the Netherlands and specialising in scientific software. The latest major release, Zacros 3.01, incorporates cutting-edge acceleration approaches, notably the Time-Warp algorithm, for simulations harnessing massively parallel hardware architectures, which were previously extremely challenging.

Zacros and Zacros-post have already been licensed to more than 600 non-UCL users in more than 60 research groups in 31 countries (including commercial users, e.g., Johnson Matthey, a UK-based global science and chemicals company). As of June 2023, at least 50 external independent studies using Zacros have appeared in the literature (39 of which were published from 2019 onwards), spanning a broad range of topics, from the (electrochemical) conversion of CO_2 to methanol or electrocatalytic hydrogen evolution to bandgap engineering of InSe-based optoelectronic materials.

Industrial Advisory Board

Established in 2016, the Industrial Advisory Board (IAB) stands as an invaluable pillar of guidance and support for the Department of Chemical Engineering at UCL. Committed to fostering excellence and innovation within the field of Chemical Engineering, the IAB has been instrumental in shaping the department’s strategic planning, teaching methodologies and research impact. Composed of esteemed industrialists with vast expertise in various sectors of industries traditionally linked to Chemical Engineering, as well as consulting, software development and research institutions, the IAB represents a diverse and dynamic blend of knowledge and experience.

This amalgamation of perspectives, including several UCL Alumni and internationally affirmed professionals, ensures a comprehensive and forward-thinking approach to addressing the challenges and opportunities faced by a modern Chemical Engineering Department. The primary mission of the IAB is to bridge the gap between academia and industry, fostering a strong collaborative environment that facilitates the exchange of ideas and best practices and enables identifying emerging trends in industrial Research and Development. By maintaining a close relationship with industry, the Department of Chemical Engineering at UCL can stay in contact with the ever-evolving demands of the professional world and tailor its educational and research endeavours to meet those needs effectively.

Through regular meetings, workshops and engaging discussions, the IAB actively advises the department on a wide range of matters, including both curriculum development and research focus areas. This consultative process not only ensures that the department remains at the forefront of advancements but also equips students with the practical knowledge and skills that are in high demand within industries absorbing Chemical Engineering graduates.

Over the last seven years, the IAB's contributions have played a pivotal role in enhancing the overall quality of education and research within the Department of Chemical Engineering. By collaborating closely with industrial leaders, the department can effectively address real-world challenges, tackle emerging trends and seize exciting opportunities, all while empowering students to become future-ready professionals. As we advance, the Industrial Advisory Board remains an indispensable asset to the Department of Chemical Engineering at UCL, fostering its commitment to excellence in education, research and industry collaboration, enabling UCL Chemical Engineering to make a meaningful impact on society.

Our Current Industry Partners

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Zero Petroleum

Specialised Research Facilities

Specialised Research Facilities

High Precision Design and Fabrication Facility

Precision Fabrication Workshop

The High Precision Design and Fabrication Facility provides mechanical engineering support to research staff and students in the UCL Departments of Biochemical Engineering, Chemical Engineering, and Physics and Astronomy. It offers a complete design, development and manufacture of complex novel scientific equipment that cannot be bought commercially, utilising Computer Aided Design (CAD) systems to design, and state-of-the-art CNC machining to make the prototype. The workshop is equipped with six CNC milling machines, four CNC lathes, one 3D printer that prints ASA, ABS, PLA, TPU, one CNC water jet cutter, one manual mill and four manual lathes, welding and metal cutting facilities.

Nanoscribe Photonic Professional GT+ 3D

3D Nanoprinter

The Nanoscribe Photonic Professional GT+ 3D printer was funded by an EPSRC grant (Ioannis Papakonstantinou (EE) and Marc-Olivier Coppens (CE). It uses two-photon polymerisation technology to print complex 3D structures of nearly any shape with a resolution down to 100 nm. Applications include micro-optics, photonics, sensing, functional micro-devices and functional surface coatings. IP-dip, IP-S and IP-Visio photoresists allow the generation of biocompatible, non-cytotoxic print designs for bio-scaffolds, tissue engineering and biomedical applications. High-precision, high-resolution, millimetre-sized designs can be printed within hours. It has been applied to create nature-inspired multi-functional surfaces that were sent to the International Space Station (ISS), and for nature-inspired scaffolds to investigate cellular interactions in complex topologies (inspired by lymph nodes) and for cancer immunotherapy.

SAXSLAB Ganesha 300XL

Small/Wide Angle X-Ray Scattering (SAXS/WAXS)

The Centre for Nature Inspired Engineering (CNIE) at UCL has a unique in-house Small/Wide Angle X-Ray Scattering (SAXS/WAXS) instrument called Ganesha 300XL. This state-of-the-art SAXS/WAXS is developed by SAXSLAB for CNIE with full motorisation, extensive automation, large sample chamber and versatile sample area to provide a highly customised instrument. SAXS provides essential information on the structure and dynamics of large molecular assemblies (polymers, colloids and porous materials) in various environments. It is a useful complementary technique to study complex systems such as catalysts, adsorbents, membranes and interfaces.

Zeiss Xradia Versa Micro CT

Macro-Micro-Nano X-Ray Computed Tomography

The Electrochemical Innovation Lab hosts a world-leading suite of X-ray CT instruments, which produce high-quality 3D images at different scales. X-ray CT is uniquely non-destructive across a range of length scales, with resolution ranging from 10s nm to 10s mm, and sample sizes from 10s μm to 10s cm. Because of its non-destructive nature, it is possible to probe materials at various stages in their life cycle in response to a variety of processing or environmental conditions. So-called ‘4-D’ tomography (three dimensions in space, and one in time) enables characterisation of microstructure evolution processes. In turn, this facilitates an understanding of the influence of microscopic structural changes on material degradation. The combination of this suite of tools provides the opportunity for non-destructive characterisation across many length scales and is also supported by a suite of materials characterisation equipment including optical, electron and ion-beam microscopy.

Genvolt Pulsed X-Ray Generation (left) and Image Capturing System (right) in the UCL X-Ray room

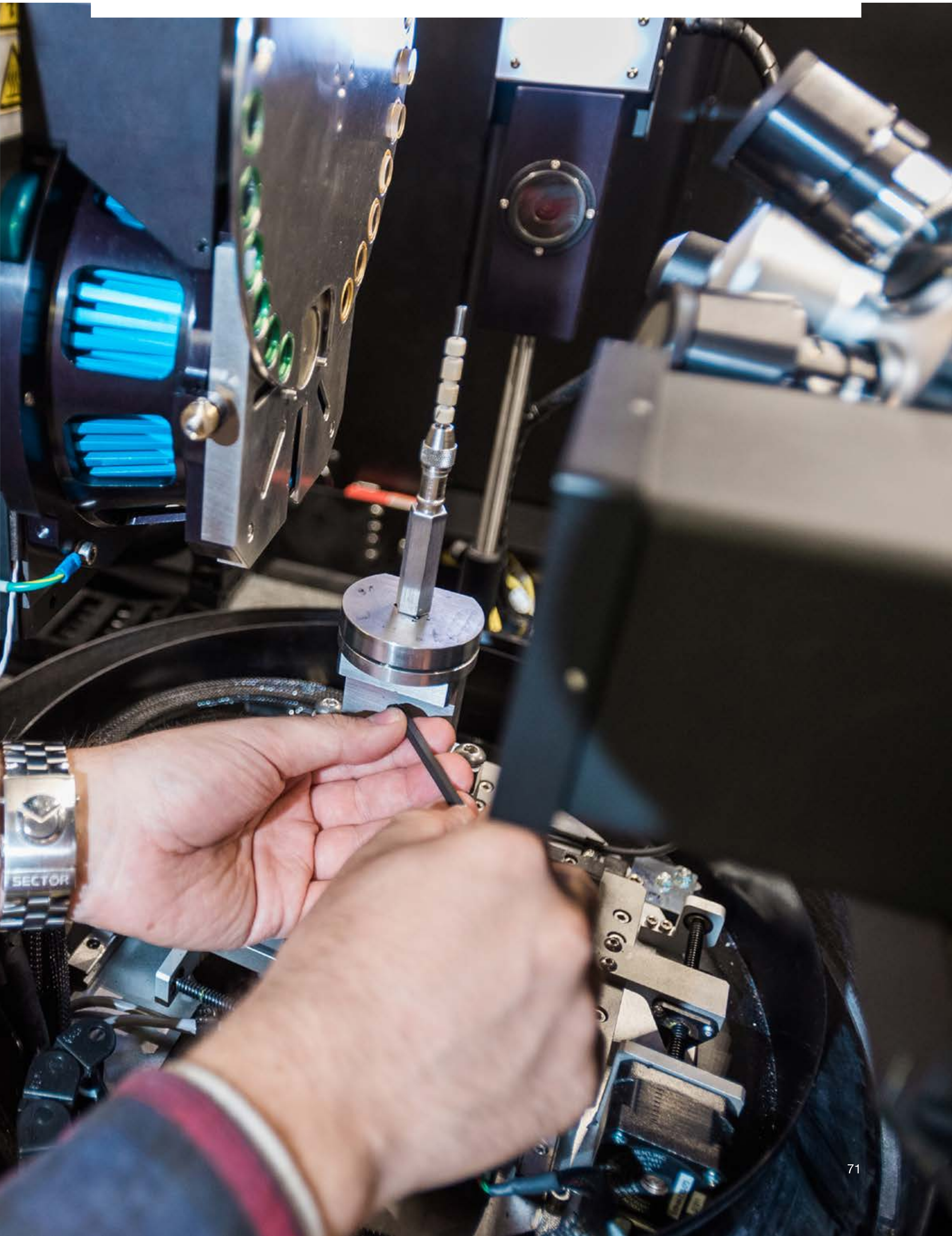
New Generation X-Ray Imaging for Multiphase Systems

Multiphase systems are employed in physical, chemical, pharmaceutical, petrochemical, electrochemical, biological and energy applications. Fluidised bed reactors are core technologies of the chemical process industries and are recognised as a key technology to optimise the potential of generating clean energy from renewable resources. Multiphase flows are often extremely complex and many of the relationships used to describe multiphase systems are essentially empirical of limited applicability, and reflect the poor physical understanding of many two-phase flow phenomena. Non-invasive experimental techniques, such as X-rays, are invaluable for providing a detailed insight into the flow patterns and general hydrodynamic characteristics of multiphase systems. This unique facility enables gas and solids flow patterns to be observed and quantified and can improve the design of internal structures such as gas distributors and heat exchangers in industrial fluid bed units.

LD60-532 laser for PIV

High-Speed Laser for Multiphase Flow Analysis

Particle Image Velocimetry (PIV) is a widely used non-invasive technique that allows measuring and visualising flow fields in fluids. By seeding the fluid with small particles and illuminating them with a laser sheet, the motion of the particles can be captured by a camera and analysed to determine fluid velocity. This technique has a variety of applications in fields such as aerodynamics, fluid mechanics, biomedical engineering and environmental science. Recent advancements in high-speed laser technology have enabled capturing ultra-fast phenomena often involved in multiphase flows, such as film breakage, coalescence and droplet formation. Currently, this technology is being used for microfluidic applications, particularly in the study of the effects of surface-active agents like surfactants or colloids on droplet transport.


SECTOR

Teaching Highlights

Our Degree Programmes

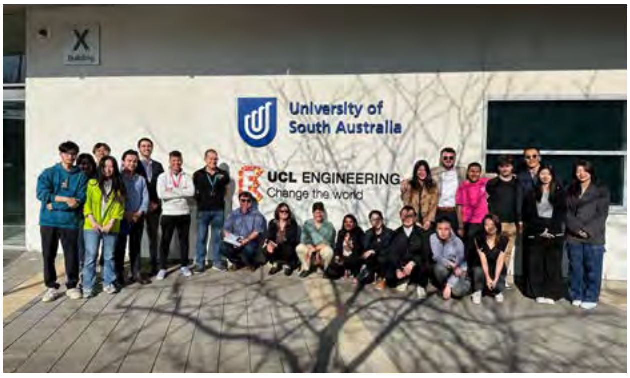
BEng and MEng in Chemical Engineering

We offer both BEng and MEng undergraduate programmes, which are accredited by the Institution of Chemical Engineers (IChemE). These broad-based, multidisciplinary programmes, with an emphasis on safety, sustainability and cost effectiveness, provide flexible training and a unique opportunity for our graduates to follow the widest possible range of careers, from design, construction and installation of processes, plants, and equipment to manufacturing and marketing of products, and from research and development to administration and management of people and resources. Students also have the possibility of undertaking a year abroad or a year in industry placement to further enhance their experience.

The BEng and MEng programmes are part of the Integrated Engineering Programme (IEP), a teaching framework that engages students in specialist and interdisciplinary activities designed to create well-rounded graduates with a strong grasp of the fundamentals of their discipline and a broad understanding of the complexity and context of engineering problems. Students register for a core discipline (chemical engineering), but also engage in activities that span other disciplines. The development of fundamental technical knowledge thereby takes place alongside specialist and interdisciplinary research-based projects and professional skills training. The programmes support the students' professional development, and challenge students to apply their knowledge to complex problems with an emphasis on sustainable design.

MSc in Global Management of Natural Resources

The MSc in Global Management of Natural Resources was developed and launched by the department in 2016, as a collaboration between UCL and the University of South Australia. Brought about by industry demand for upskilled professionals across the breadth of the natural resources industries, the programme has grown from 11 students to more than 50 in 2023, with numbers and interest continuing to grow. In a world demanding rapid change, facing a climate emergency, and transitioning towards more sustainable forms of energy and resources, there is an insatiable demand for professionals from all relevant academic backgrounds with a comprehensive understanding of the sector. Grounded in science and engineering, with awareness of the social, governance and environmental factors and a strong focus on sustainable practice, our graduates are at the heart of industry and academia, and the programme has been a fantastic success for interdisciplinary study in the department, and across UCL.



MSc in Chemical Process Engineering

Modern society relies on the work of chemical and process engineers to develop the expertise and technologies behind the products we depend on in everyday life such as clean, affordable and sustainable energy. The MSc in Chemical Process Engineering programme, which attracts 20 – 40 students annually, facilitates multidisciplinary collaboration between scientists and engineers with different backgrounds. Relying on an integrated approach to chemical engineering that encourages the application of core chemical engineering principles and allied subjects to problems of current and future industrial relevance, this programme aims to form engineers aware of the context of their work and able to have a positive impact on their future profession. Upon completion, our graduates can expect to play a major role in developing the technologies that make available most of the things that we use in everyday life and provide the expertise and technology to enhance our health and standard of living. These activities may involve the development of new materials, food processing, water treatment, pharmaceuticals, transport, and energy resources as well as being at the frontline, addressing present environmental issues such as climate change.

“”

The MSc in Chemical Process Engineering programme facilitates multidisciplinary collaboration between scientists and engineers with different backgrounds.

MSc in Digital Manufacturing of Advanced Materials

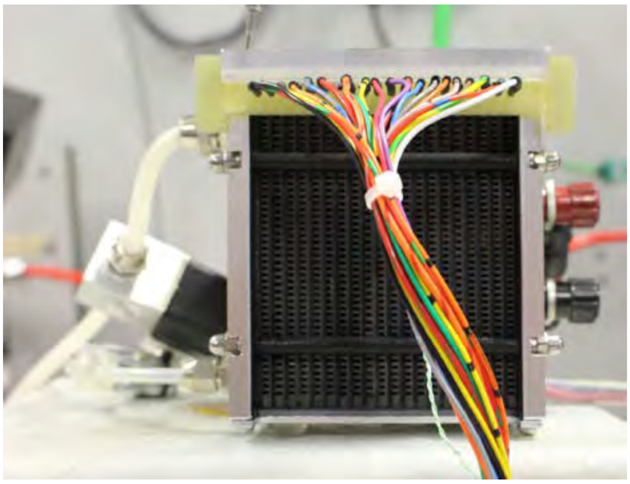
The MSc in Digital Manufacturing of Advanced Materials was co-developed with industry and launched in September 2023 at UCL East in the brand-new Manufacturing Futures Lab (MFL). To meet the new demands of the fourth industrial revolution, our students and engineers of the future learn to use smart technologies and digitalisation to develop and manufacture advanced materials needed for sectors such as pharmaceuticals & healthcare, electronics and automotive, green energy, food, and fine chemicals. Students learn about up-to-date material synthesis and characterisation techniques, high-throughput experimentation via robotics and flow chemistry, process automation for autonomous systems, as well as computational tools including data science and machine learning. This provides graduates with the experimental and computational skills that are in high demand in industry and academia alike. The MFL, with its high-end multidisciplinary research and teaching facilities, is a unique home to this new MSc, where students will experience future manufacturing in a vibrant research environment from day one.

MSc in Nature-Inspired Solutions

The MSc in Nature-Inspired Solutions at the Department of Chemical Engineering stems from the pioneering work and success for over a decade of the Centre for Nature-Inspired Engineering (CNIE). Hosted at the brand-new Manufacturing Futures Lab at the UCL East campus, this MSc is designed to empower students to draw inspiration from the materials, structures and dynamics found in nature, and translate those insights into disruptive technologies to tackle Grand Challenges in areas like climate change, healthcare, energy, infrastructure, or the environment. The MSc provides students with a unique competitive edge that is increasingly demanded in research and development, entrepreneurship, or industry in fields including manufacturing, engineering and design, biosciences, or the built environment. With a solid scientific and engineering foundation, this programme is designed to equip our graduates with the knowledge and skills needed to develop transformative solutions that will tackle some of the most pressing issues of our time.

MSc in Advanced Propulsion

The MSc in Advanced Propulsion will enable the “Clean Economy” by training the next generation of engineers and scientists specialising in batteries, fuel cells and electric machines on an industrial scale. This highly skilled workforce is critical to electrifying automotive, marine and air transport and achieving ambitious climate targets (UK’s Industrial Strategy (Net Zero 2021) and Road to Zero (2018) initiatives). This programme is situated at UCL East in the Advanced Propulsion Lab (APL), a dedicated world-class research facility, focusing on pack, stack and vehicle engineering and innovation. Importantly, the APL contains large-scale fabrication and testing equipment which will give students hands-on experience, in addition to taught content by world-leading academics and industry experts in the electric propulsion sector. This MSc programme addresses the national and global skills shortages and training priorities associated with the development and deployment of advanced propulsion technologies. Thus, it is central to establishing the UK as a leader in electric propulsion technology and ushering in a cleaner and more sustainable transport sector.



Accreditation

IChemE Accreditation

The department is committed to delivering education to the highest standards and hence ensuring that the students that we graduate have been through a sound educational programme that prepares them well for the challenges they would face at the workplace, now and also in the future as the needs of the society change. Accreditation of degree programmes provides an official certificate of the quality of our degree programmes by an external and professional body. The first accreditation of our department dates back to 1957 for the then-programme 'The college post-graduate diploma in chemical engineering'. In 2023, our undergraduate degree programmes and the MSc in Chemical Process Engineering (Advanced Route) programme were reaccredited by the Institution of Chemical Engineers (IChemE).

The accreditation process is quite comprehensive and requires departments to start planning about a year in advance of the submission of their accreditation application. IChemE provided detailed guidance on the documents and supporting evidence they need to evaluate the application; we submitted more than 700 files as part of our application. These files included documents highlighting the key features of our degree programmes, such as the specialist yet inter-disciplinarily outlook, research-based projects, design and professional skills, team-based activities, process safety, sustainability, ethics, communication skills, e-learning, a balanced and well-rounded knowledge of theoretical, computational and experimental techniques, industrial engagement, to name a few, as well as the documentary evidence to support these activities. The submission of documents was followed by its assessment by a discipline-specific peer review panel of three experienced professional chemical engineers from academia and industry, to benchmark it against high, internationally recognised standards of the IChemE. The assessment also included a panel member visiting the experimental facilities, while the students were doing the experiments in the department, and other facilities on the campus, such as lecture theatres and the Science Library. Finally, members of the teaching and professional services staff, senior staff members of the Faculty, and students were questioned by the panel members on aspects related to their respective roles.

With the accreditation of our programmes, employers can continue to recruit our graduates with confidence in their skills and professionalism, as they have gone through an academically rigorous and yet industrially relevant programme. Accreditation also underpins the registration for Chartered Engineer (CEng) for our graduates.

The department also holds an accreditation for the MSc in Global Management of Natural Resources with the Institute of Materials, Minerals and Mining (IOM3). This specialist programme provides a substantive overview of the resources sector, which is grounded in science and engineering as delivered by the department; it draws on experience from across UCL to complement this content to provide a holistic overview of the industry, as well as the expertise of the University of South Australia in Adelaide, Australia, where students complete their research project.

Equality, Diversity, Inclusion and Sustainability

Equality, Diversity and Inclusion

The Department of Chemical Engineering is committed to an inclusive and supportive culture for all its staff and students. It has the structures in place and is promoting activities to ensure that all members have equal access to opportunities, reach their full potential and maintain a work-life balance. It has consistently achieved Silver Athena Swan Awards, which recognise good practice in the department to advance gender equality, including representation, progression and success in 2009, 2012 and 2017, and Gold Athena Swan Award in 2023. Our department has been particularly commended for its recruitment process, mentoring schemes and Beacon activities to promote equality practices within UCL and externally. Ours was the first department in the Faculty of Engineering Science to appoint in 2019 a Deputy Head of Department for Equality, Diversity and Inclusion and to establish a departmental Equality, Diversity and Inclusion (EDI) Committee in 2016 with representation from all staff and students.

Highlights of EDI initiatives and achievements include:

- Our outreach and recruitment activities have resulted in increasing proportions of female students in our undergraduate (40%), postgraduate taught (40%) and postgraduate research (39%) categories, which are well above the sector averages.
- The performance of our female and male BAME students is continuously improving. Our staff have been awarded competitive funding to develop the Change Makers programme, for ethnic minority undergraduate students in collaboration with the Association for Black and Minority Ethnic Engineers. It aims to enhance the networking skills and career prospect of ethnic minority students. The programme has now been adopted by the Faculty of Engineering.
- We celebrate the work of our female researchers, by organising departmental workshops in

International Women in Engineering Day 2020

the International Women in Engineering and International Women's days.
- Half of our departmental seminar speakers are women. We have an EDI seminar series in addition to the academic one.
- We have introduced and trained Mental Health First Aiders every year, who continually provide important support to students and staff.
- We have developed resources such as information videos and quizzes to promote awareness and help staff and students become Allies for staff and students from marginalised groups.
- Our Research Fellow numbers have significantly increased in the last few years. To facilitate their integration into the department and support their career development, we have introduced significant initiatives. We have a dedicated staff member as Research Fellows Liaison, offer mentorships, organise workshops on promotions and CVs, and offer opportunities to network with academics and industrialists through our industrial days and the Industry Advisory Board.
- We have been promoting gender equality and EDI within UCL and in the wider academic community with a number of activities. These include workshops such as on EDI issues in academia and on best practices in Athena Swan in the national ChemEngDayUK conferences with participation from all UK Chemical Engineering Departments.

Sustainability

The Department of Chemical Engineering is committed to creating a sustainability culture within the department, which will be transferred from one generation to the next. To achieve this goal, as of May 2020, the department established a Sustainability Committee. The vision of the Sustainability Committee is to make the department a leader in sustainability and sustainable development among all universities in London by:

- Raising awareness about sustainability within our department.
- Empowering staff and students to champion sustainability by sparking debate and co-creating sustainability solutions.
- Introducing and developing the strategies which are most effective in improving the sustainable operation of the department.
- Sharing best practices with other departments and institutions.

Among other sustainable initiatives, it is worth mentioning:

- Sustainable transport initiatives such as the UCL Green Travel Plan and the UCL Cycle scheme help minimise the environmental impact of the department's core business activities.
- Energy-efficient practices to reduce the average amount of CO_2 produced for keeping the departmental buildings warm.
- The promotion of remote working by providing a home working setup and easy remote access to UCL's systems and services.
- The use of Ecosia as the default search engine for departmental laptops and computers. As a result, on average, 22 trees are planted each month.

The department's efforts towards sustainability were recognised when it was awarded the Green Impact Silver Award at the UCL Sustainability Awards Ceremony in 2021.

Honours & Awards

Recent Awards

2023

EFCE Recent Innovative Contribution Award

Professor David Bogle obtained the Recent Innovative Contribution Award from the EFCE Computer Aided Process Engineering Working Party (given every four years) in recognition of an outstanding innovative contribution to recent advances in CAPE ideas, methods and/or tools.

Member of the Order of the British Empire

Professor Eva Sorensen was awarded an MBE in the 2023 King's birthday honours for her contributions to education and chemical engineering.

RAEng Research Fellowship

Dr Andrea Paulillo received the Royal Academy of Engineering (RAEng) Research Fellowship for his research on "Absolute Environmental Sustainability for a Low-carbon Economy within Planetary Boundaries" which aims at combining Life Cycle Assessment (LCA) with the Planetary Boundaries concept to develop an innovative framework for decision and policy support.

Jacques Villermaux Medal

Professor David Bogle won the Jacques Villermaux Medal, presented every four years to recognise scientific achievements within the context of the Federation's science policy, working parties, conference programme or other related activities.

IChemE Warner Medal

Dr Massimiliano Materazzi won the IChemE's Warner Medal for showing exceptional promise in the field of sustainable chemical process technology, nuclear technology, combatting climate change, making chemical engineering more accessible to a wider scientific community, and working with organisations and the lay public to educate and inform via outreach activities.

RSC Materials Chemistry Horizon Prize: Stephanie L Kwolek Prize

Professor Stefan Guldin was part of a team, with colleagues from Imperial, Edinburgh, Liverpool and Cambridge, which received the 2023 RSC Materials Chemistry Horizon Prize for the development of ion-conducting polymers of intrinsic microporosity and applications as next-generation membranes in redox flow batteries for grid-scale energy storage.

2022

IChemE Oil and Gas Award

Professor Junwang Tang's Group was presented with the 2022 IChemE Oil and Gas Award due to the seminal contribution to converting methane into variable chemicals (C1-C2) and liquid fuels driven by abundant renewable solar energy.

IChemE Presidency

Professor David Bogle was elected President of IChemE for 2022-23 for its Centenary year of 2022. During his Presidency, he focused on Engineering Ethics and steering the development of a new strategy to strengthen IChemE's impact.

Clarivate Highly Cited Researcher

Professor Junwang Tang was presented with the title of Clarivate Highly Cited Researcher 2022 due to his novel contributions in both Chemistry and Materials Science.

Princess Royal Silver Medal

Professor Paul Shearing and Professor Dan Brett were awarded the Princess Royal Silver Medal from the Royal Academy of Engineering by the Princess Royal in person for their work commercialising scientific discoveries and supporting UK industry.

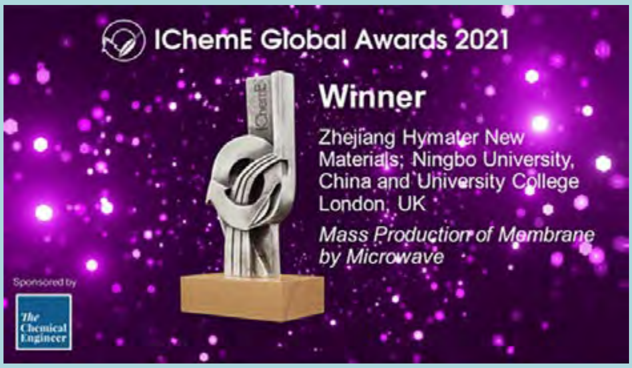
IChemE Young Researcher Award

Dr Thomas Heenan, then a part-time researcher in the Electrochemical Innovation Lab (EIL), and now CEO and Co-Founder at Gaussion, was presented with the IChemE Young Researcher Award 2022.

2021

IChemE Innovative Product Award

The project of Mass Production of Membrane by Microwave (3M) has been awarded the Innovative Product Award at the IChemE Global Awards 2021. This is a joint venture between Zhejiang Hymater New Materials, Co. Ltd, Ningbo University, China, and Professor Junwang Tang. The project is dedicated to providing an innovative solution to recycle the organic solvents used in the chemical industry so as to make these chemical processes sustainable, thus contributing to a circular economy.



IChemE Andrew Medal

Professor Junwang Tang won the IChemE's Andrew Medal for a major contribution to the science of the formulation of heterogeneous catalysts.

Corday-Morgan Prize

Professor Junwang Tang was awarded the Corday-Morgan Prize from the Royal Society of Chemistry for the discovery of efficient photocatalysts for clean and renewable fuel synthesis.

Freedom of the City of London

Professor Paola Lettieri became a Freeman of the City of London and a Liveryman for her work directing UCL East, which contributes to the regeneration of East London.

FREng

Professor Paola Lettieri was elected Royal Academy of Engineering Fellow, in recognition of her work on high temperature fluidisation and Life Cycle Assessment which have allowed resolving significant operational problems in complex industrial plants and influenced waste management strategies for energy recovery from waste, plastic waste reduction and nuclear waste reprocessing.

RAEng Research Chair

Professor Dan Brett was awarded a five-year Research Chair from the Royal Academy of Engineering co-sponsored by the National Physical Laboratory and HORIBA MIRA to develop and commercialise metrology solutions for the emerging electrochemical propulsion sector.

2019

IChemE Business Start-Up Award

Professor Junwang Tang's Group Business Start-Up Award was related to the project of continuous graphene manufacturing using microwaves. This project makes it commercially feasible to continuously exfoliate low-cost graphite into processable single-layer graphene flakes in large scale by microwave technology, whilst still maintaining the ideal atomic graphitic surface structure, promising a multi-million market and attracting the interest of many investors.

British Airways Sustainable Aviation Fuels Academic Challenge

Dr Massimiliano Materazzi and his team won first prize in the British Airways Sustainable Aviation Fuels Academic Challenge to develop an aviation fuel of the future.

2018

IChemE Outstanding Achievement in Chemical and Process Engineering Award, Sustainability Award, and Energy Award

The winner of the Global Award for Outstanding Achievement in Chemical and Process Engineering was a joint project by Advanced Plasma Power, the Department of Chemical Engineering at UCL (Dr Materazzi's group), Cadent Gas, and Progressive Energy, with the project "Converting Waste to BioSNG". The same group also won the Sustainability Award and the Energy Award in the same competition, being the first group to date to win three global awards in the same year. The technology uses a unique gasification and catalytic process to turn household waste into bio synthetic natural gas (BioSNG), a low-carbon, renewable gas. The team has launched the world's first commercial demonstration plant to produce the gas, which is used to heat homes across the UK and power heavy-duty vehicles and buses.

IChemE Young Researcher Award

Dr Donal Finegan, who completed his PhD in UCL Chemical Engineering, sponsored by the NPL in 2016, won the prestigious IChemE Global Young Researcher Award at the ceremony. Donal is now a Staff Scientist at the US Department of Energy, National Renewable Energy Laboratory but still retains a visiting position at UCL where he continues to collaborate closely.

IChemE Frank Morton Medal

Professor Eva Sorensen was presented with the IChemE Frank Morton medal, awarded to recognise excellence, and promoting best practice in chemical engineering education.

IPS Scientist award

Professor Junwang Tang received the IPS Scientist award at the 22nd International Conference on Photochemical Conversion and Storage of Solar Energy in recognition of his significant contribution in the field of photocatalysis.

Saxon Academy of Sciences

Professor Marc-Olivier Coppens was elected corresponding member of the Saxon Academy of Sciences (Sächsische Akademie der Wissenschaften), Germany, for his seminal work on the fundamentals of diffusion and on nature-inspired chemical engineering.

Engineering for Development Research Fellowship

Dr Massimiliano Materazzi won the prestigious 5-year Engineering for Development Research Fellowship (EDRF) from the Royal Academy of Engineering to develop future advanced thermal technologies for the production of hydrogen and biofuels from waste.

SEFI Fellowship

Professor Eva Sorensen was awarded a fellowship by the European Society for Engineering Education (SEFI) in recognition for meritorious service to engineering education in Europe.

Societies and Outreach

Societies

Ramsay Society of Chemical Engineers

The Ramsay Society, founded in 1933, is the undergraduate student-led society at the UCL Department of Chemical Engineering. It represents every chemical engineering student from UCL, past and present. The committee comprises seven members who have been elected by students. Together, they work towards planning and organising tailored academic, social and career-oriented events. The primary goal is to ensure equal access to opportunities and foster an environment that promotes professional development and work-life balance within the field of Chemical Engineering.

The pandemic made it incredibly challenging for the international and multicultural community of students to connect, posing an unprecedented challenge for first-year students who arrived to a fully online UCL experience. With students across 14 time zones, extending over every continent, the first edition of the Freshers Hackathon, held in September 2020, brought together over 60 first-year students to solve innovative engineering problems. In the following years, the event gained scale and influence; the society hosted distinguished guest speakers from the fields of Engineering, Business Management, and NGOs to brainstorm and solve pressing global issues revolving around the energy, food and water nexus. As of 2022, the event was held for the first time in person, following the highly positive feedback from past students.

Frank Morton Sports Day is a highly anticipated annual inter-institutional Chemical Engineering event. The event was last hosted on 20th February 2023 by the University of Birmingham, bringing together over 500 students from 14 distinguished universities across the UK and Ireland. The Ramsay Society coordinated a seamless 2-day trip to Birmingham, providing a fantastic opportunity for students to not only engage in a variety of sports and industry-specific career fairs but also to explore a new university environment. The event was a unifying force for the Chemical Engineering community, connecting and strengthening its members. The experience was enriching for all participants, with students having the opportunity to network, build new relationships, and showcase their sporting prowess.

The longest-running event organised by the Ramsay Society is the annual Ramsay Society Dinner, which brings together current and former students and staff, allowing them to catch up and mingle, hear the latest departmental updates, and honour those who have performed outstandingly with the awarding of annual student prizes. From its early days of dinner in the Refectory followed by brandy and cigars in the Housman Room, the Ramsay Dinner is now hosted yearly in the St Pancras Renaissance Hotel and consists of a drinks reception and three-course meal, followed by a live band and dancing into the night.

CheERS

The Chemical Engineering Researchers' Society (CheERS) is the first ever postgraduate-led society created in the Engineering Faculty at UCL. CheERS was founded in 2016, to encourage social networking amongst all PhDs and staff, both academic and non-academic, thereby improving knowledge transfer and facilitating a platform for multi-disciplinary engagement within the Department of Chemical Engineering at UCL.

As a committee, they organise career and social events across the calendar year. They work alongside the Ramsay Society to bridge the gap between students and staff/researchers, as well as the Industrial Advisory Board to give their members general advice about directions and trends in industry. Their scope is to responsibly plan and implement various events and conduct them by the regulations set by UCL and the Chemical Engineering Department.

Among the activities regularly organised by CheERS are the 3 Minute Thesis (3MT) and poster competitions, Christmas celebrations, the Engineering Cup, and the Summer BBQ. These have become a tradition for the community and are seen as a good chance for everyone to take a break from their work and connect with other people in the department in a friendly and welcoming environment.

CheERS also works to foster a culture of inclusivity, celebrating festivities such as the Lunar New Year, International Women's Day and many more. This is a great way to widen the range of researchers that could be reached, whilst giving them access to a network of peers with whom they could share their own experiences.

Finally, CheERS also works in collaboration with the departmental management to improve the experience of PhD students and post-doctoral research associates, by conducting annual surveys on themes such as well-being, satisfaction levels and potential improvements.

UCell

UCell is an outreach group made up of PhD students based in the Electrochemical Innovation Lab (EIL). It was founded with the mission of using education and demonstration to give the public first-hand experience of the green energy storage methods they work on in the lab, namely batteries and fuel cells, which are becoming increasingly relevant as we move towards net zero. UCell was born in 2011 and today consists of a large team armed with a 3 kW fuel cell stack and demo kits.

Since their first event at Glastonbury Festival, they have powered the Omni-Tent in the Einstein's Garden area of the Green Man festival for 12 years running. The Einstein's Garden is the festival's home for scientific engagement, hosting weird and wonderful science talks and demonstrations powered exclusively by the completely green energy produced from UCell's hydrogen fuel cell stack.

Alongside the stage, UCell runs a stall where festivalgoers can learn more about hydrogen power and interact with small versions of the fuel cell technology instrumental to the UK's dreams of clean energy.

The main work of UCell is its school visits. They go to schools across London to improve student understanding of batteries and fuel cells, energy technologies they will be seeing implemented more and more as they grow older, and as we move towards net zero. They also provide insight into the lives of real scientists and hope to inspire the next generation of budding scientific minds to take up science themselves.

They have also demonstrated at various science festivals and events around the UK, such as the Manchester Science Festival, where in the beautiful Manchester Central Library, UCell gave hands-on demonstrations on fuel cell and battery technologies, helping members of the public assemble their batteries using lemons, limes, and even a spooky Halloween pumpkin, all to power lights which decorated the stand. Reaching a record voltage of 15V with fruit only, they used the demonstrations to discuss the future of energy storage to the passing Mancunians.

At the four-day Bloomsbury Festival, UCell taught schools about the power of green energy by showing them how hydrogen can be used to make green popcorn – the most sustainable popcorn they may ever eat! Using the 3 kW stack and smaller fuel cell demonstrations, they showed how hydrogen can be used as a fuel to power a popcorn machine or a toy car, and crucially, how through electrolysis, hydrogen can be made in a green and sustainable way by splitting water using renewable energy.

UCell were invited to the 2022 British Science Festival 'Saturday City Centre Takeover' where the team used low-power demonstrator fuel cell kits to explain more about hydrogen generation from electrolysis to members of the public.

UCell was awarded the Royal Society of Chemistry Outreach fund in 2021, enabling the team to have more opportunities to go to schools and public engagement events throughout 2021/2022 including the UN Climate Change Conference in Glasgow. In 2022 UCell also successfully applied to the Access and Widening Participation Operation (AWPO) at UCL for funding in support of their school outreach project. Gaining this funding has allowed them to reach out and inspire more students from all over London about green energy production and storage!

In2ScienceUK

In2ScienceUK is an organisation dedicated to improving social mobility and diversity in STEM. Two of its key programmes, In2Science and In2Research, are designed to give young people from disadvantaged backgrounds an opportunity to further develop the knowledge, confidence and experience needed to access fulfilling careers in related disciplines. UCL is a regular participant in In2ScienceUK's activities, and the Department of Chemical Engineering now hosts students every year.

In2Science

Created for year 12 students (usually aged 16-17), this programme runs over the summer. It is free and open to STEM students who attend non-fee paying and non-selective state schools in the UK, and who also meet at least one of the following criteria:

- Be recipients of school meals, Education Maintenance Allowance (EMA), Pupil Premium or the 16-19 Bursary.
- Have parents who do not have a higher education.
- Be, or have been, in care.

One of the most important components of the In2Science programme is the week of hands-on work experience with leading academics and researchers in the field. Academics, post-docs and research groups from the Department of Chemical Engineering are pleased to have hosted around 10 In2Science participants each summer over the past few years, supporting young people in building a valuable skillset beneficial to accessing higher-level study and work related to chemical engineering.

In2Research

In2Research – aimed at final-year undergraduate students and MSc students – is a year-long programme where students receive mentoring and support including research skills workshops and an eight-week research placement funded with a stipend.

Programme participants must have been a recipient of Free School Meals at school or sixth form, recipients of funding such as EMA during their school year, or be from a low socioeconomic background.

For the past few years, research groups at the Department of Chemical Engineering have hosted around 1-2 placement students every year, together carrying out investigations relevant to their research and further developing the skills the young people need to embark on a career in research and academia. Academics have additionally acted as mentors outside of the placements. Students are encouraged and supported in evaluating their progress, concluding in a presentation and celebration day in autumn.

Summer Schools

EDT Insight into University Summer School

Formerly split into two summer schools known as Headstart and Insight, the Insight into University Residential Summer School usually lasts four days and follows a similar format to the Widening Participation Summer School, with similar academic components, including the ChemCar competition and the use of Aspen. We usually host around 30 students.

Prizes are given to those who make the coolest car, the car that travels the furthest, and those that deliver the best presentation. The department delivers this in collaboration with the Engineering Development Trust and plans the activities. Our learning materials are now used in the EDT's online learning activities, and over the lockdown, we delivered the summer school online.

Sutton Trust & UCL Widening Participation Summer School

This residential summer school for year 12 students runs over five days and is organised by the Sutton Trust and the UCL Widening Participation and Access Office. Departments from across the university deliver the teaching and learning activities in the summer school, with Widening Participation coordinating more general sessions such as fun trips out and support with writing their personal statements.

Attendees are from widening participation backgrounds – such as care-experienced young people or those with caring responsibilities, asylum seekers, those whose families are below a certain income, those eligible for free school meals or from areas with high levels of economic or social deprivation.

In the Chemical Engineering summer school, we usually host around 20 students, and we run sessions teaching practical and computational lab skills, research skills and academic presentation skills, supported by postgraduate teaching assistants, teaching academics and student ambassadors. The young people work in small teams to design and build small cars made from Lego powered by a chemical reaction in the ChemCar competition. They are challenged to experiment with the design and building of the car, and the balance of chemicals in the reaction, to maximise the distance their car travels.

EAST Summer School

As the Department of Chemical Engineering has a strong and increasing presence in UCL East, we are particularly involved with UCL's activities in the area. As a founding member of East Bank, based at Queen Elizabeth Olympic Park in Stratford, UCL engages in outreach work with the four boroughs surrounding the campus – Hackney, Newham, Tower Hamlets, and Waltham Forest – often working together with community partners such as London Legacy Development Corporation (LLDC), who coordinate the EAST Summer School.

Staff from UCell, the Advanced Propulsion Lab and the Manufacturing Futures Labs have run fun, practical workshops as part of the summer school, introducing around 15 participants from East London aged 12-17 to chemical engineering.

The MFL workshop involved an introduction to the chemistry of plastics and their impact on the environment along with the analytical methods scientists use to detect and identify plastics, such as IR spectroscopy. They were given a scenario where an unknown water company was found responsible for polluting natural water with unidentified plastic. Using state-of-the-art portable IR instruments, they had to find out which plastic – and therefore which water company – was responsible for the contamination, thus developing key scientific skills and a wider understanding of how plastic impacted the environment.

In UCell and APL's workshop, participants learned about battery and fuel cell research, hydrogen, clean technology and electricity storage, their importance and their impact on global challenges, obstacles their development faces and solutions they can provide. They enjoyed a demonstration of mini demo fuel cell cars, "lemon" batteries and battery Jenga, and in a tour of the area, learned about the local geography, transport, energy sources and culture. In groups, the young people then used this information to design and pitch a project to redesign the local area to run solely on renewable energy sources and storage.

Schools

The Department of Chemical Engineering has been involved with various events at primary, secondary, and sixth-form schools, mostly in East London, ranging from attending their careers fairs to our Chemical Engineer in the Classroom scheme, wherein researchers from the department run sessions, online and in person, introducing young people at schools to chemical engineering, their research and how they got where they are today. Researchers have hosted talks, Q&A sessions, and learning activities appropriate to the age group they are working with, which we hope will foster an interest in a future in STEM.

Other Outreach

This is not an exhaustive list – we have run other outreach activities over the years, for instance in the form of placements for schoolteachers to develop understanding and strategies useful in teaching the constituent skills of chemical engineering, neighbourhood talks and taster lectures to science and engineering fairs inside and outside of UCL. We work with the wider university and the Faculty of Engineering on a community engagement plan to offer new activities in the years to come. If you're interested in our outreach work, please contact us at chemeng.outreach@ucl.ac.uk

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Find us

Roberts Building
Bloomsbury Campus
Torrington Place
Bloomsbury
London
WC1E 7JE

Marshgate Building
UCL East Campus
7 Sidings Street
Stratford
London
E20 2AE

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