

Annual Report 2016



Key numbers of 2016

The vision of DTU Chemical Engineering is to be acknowledged as a world-leading chemical and biochemical engineering department. Below we have listed a selection of our key results of 2016 to show how they support our strategic objectives.

| STRATEGIC AREA | VISION | RESULTS IN 2016 | | | | | | | | | | | | | | |
|----------------------------------|---|---|----------------------------------|----------------------------------|------------------|------------------|------------------|-----------------|------------------|-------------------|------------------|-----------------------|-----------------|-------------------------|-----------------|-------------------------|
| RESEARCH | Supports the development of sustainable solutions in the fields of chemistry, biotechnology, food, pharma, and energy through research and scientific advice. | 239 SCIENTIFIC ARTICLES IN WOS-INDEXED JOURNALS 3 BOOKS & MONOGRAPHS 12 CONTRIBUTIONS TO BOOKS 35 PHD THESES | | | | | | | | | | | | | | |
| INNOVATION | An attractive partner for university departments and research-based industry. | 16 ACCEPTED PATENT IDEAS & SPIN-OUTS 8 INDUSTRIAL PHDS 2 INDUSTRIAL POSTDOCS In cooperation with Haldor Topsøe, Hempel, Dupont, Novozymes, Vølund, Rockwool International, Unibio, PHX Innovation, and Grundfos | | | | | | | | | | | | | | |
| EDUCATION | Helps to retain, develop, and attract knowledge-based national working places, including companies with affiliates abroad. | 298 STUDENTS (STÅ**) 20 SINO-DANISH STUDENTS (STÅ**) 15 COMPLETED BENG PROJECTS 32 COMPLETED BSC PROJECTS 67 COMPLETED MSC PROJECTS | | | | | | | | | | | | | | |
| ORGANIZATION | Attractive place to work for ambitious and technology-passionate staff members. | 47 TECHNICAL/ADMINISTRATIVE EMPLOYEES 98 PHD STUDENTS 95 SCIENTIFIC EMPLOYEES—INCLUDING 33 FACULTY <hr/> 240 EMPLOYEES IN TOTAL * <hr/> <table border="0"> <tr> <td>STAFF DISTRIBUTED BY AGE:</td> <td>FOREIGN SCIENTIFIC STAFF:</td> </tr> <tr> <td>35% 20-29</td> <td>4% AFRICA</td> </tr> <tr> <td>29% 30-39</td> <td>34% ASIA</td> </tr> <tr> <td>14% 40-49</td> <td>53% EUROPE</td> </tr> <tr> <td>13% 50-59</td> <td>5% MIDDLE EAST</td> </tr> <tr> <td>8% 60-69</td> <td>1% NORTH AMERICA</td> </tr> <tr> <td>1% 70-79</td> <td>3% SOUTH AMERICA</td> </tr> </table> | STAFF DISTRIBUTED BY AGE: | FOREIGN SCIENTIFIC STAFF: | 35% 20-29 | 4% AFRICA | 29% 30-39 | 34% ASIA | 14% 40-49 | 53% EUROPE | 13% 50-59 | 5% MIDDLE EAST | 8% 60-69 | 1% NORTH AMERICA | 1% 70-79 | 3% SOUTH AMERICA |
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* 1 JANUARY - 1 DECEMBER 2016

** ONE STÅ IS THE EQUIVALENT OF ONE STUDENT STUDYING FULL TIME FOR A YEAR

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Front page photo:
Rolf H. Ringborg and Mafalda Costa Artur Dias working on a
experimental setup for the automated kinetic characterization of
enzymes. Photo by Thorkild Christensen



Behind the process

Frederico Montes and Carlos Eduardo Castelan behind a large stirred tank which they are using for process intensification of gas-liquid bioreactors—a core research area at the CAPEC-PROCESS Research Centre where they work as PhD-students.

Photo: Thorkild Christensen



Welcome to this Annual Report 2016 where we proudly present a small selection of our great many activities during this year within education, research, and innovation.

DTU's study programmes are becoming increasingly popular and in terms of student intake, 2016 was a year for the record books. One of the most popular branches of study was 'Chemistry and Technology', the qualifying main BSc for the MSc programmes which our department offers.

As a result, we are working hard to accommodate a reality where students not only have many different backgrounds, but also consume information in many different ways. This calls for innovative teaching methods, resulting this year in several e-learning videos that can be viewed on the digital platforms that our students use.

Innovation also goes hand in hand with research at our department. As the competition for research funds becomes fiercer, collaboration with our industrial partners accordingly becomes an important factor. Our research centres have extensive cooperation with both large global and small enterprises. It is from these relations that real innovation emerges. This year, we were proud to see that some of our innovative efforts were acknowledged with innovation awards from the Confederation of Danish Industry (DI) and at the international integrated water cycle show, iWater, in Barcelona.

Collaboration and through this, research, is further strengthened through the many conferences and annual discussion meetings that our researchers travel far to attend, as well as the ones we host ourselves. This year, we hosted 'PetroPhase 2016', the 17th International Conference on Petroleum Phase Behavior and Fouling, and we hosted the 6th international conference

on Electromechanically Active Polymer (EAP) transducers & artificial muscles. Both conferences were well-attended by industry and academia from all over the world. These meetings and conferences are important because they provide the opportunity for interchange of knowledge and thereby ensures that the research we conduct here at our department is useful to society. Adding to this, we also this year launched a cross-departmental 'KT Consortium' which we will grow to include many more relevant partners in the future. Furthermore, long-term agreements with Novozymes and Lundbeck have been extended this year, and we received the first generous grant to establish The Hempel Foundation Coatings Science and Technology Centre. Accordingly, we look forward to welcoming even more PhD students in the coming years.

The increasing number of students and research activities means that our department is growing. Just as 2016 was coming to an end, we reached an important milestone: The blueprint for our building expansion which will provide a better working environment, an improved study environment, and further development of research facilities.

I would like to close this preface by expressing my deepest gratitude to our many dedicated employees for their hard work and to thank our many national and international partners in industry and academia for sharing their knowledge and views with us. I hope you will enjoy reading about some of the many exciting results we have achieved together.

A handwritten signature in black ink, appearing to read 'Kim Dam-Johansen'. The signature is fluid and cursive, with a large, sweeping flourish at the end.

Kim Dam-Johansen
Professor, Head of Department





HIGHLIGHTS

The first graduates from the Sino-Danish programme

Graduation caps and dreams of the future were in the air when the very first graduates of the Sino-Danish programme in Chemical and Biochemical Engineering were celebrated at a festive ceremony in Beijing. Congratulations from DTU Chemical Engineering!

Photo: Yang Tian Peng



Photo: Ditte Valente ①



②



③

HIGHLIGHTS 2016

JANUARY

1 January

PROF. RAFIQU L GANI CONTINUES AS PRESIDENT OF EFCE

After two years as President of the European Federation of Chemical Engineering (EFCE), Professor Rafiqul Gani started his second term on 1 January 2016.

SELF-HEALING RUBBER GOES FOR COMMERCIALIZATION

The Danish Polymer Center (DPC) received a grant from the DTU Proof-of-Concept Fund which enables researchers to get new technology ready for the market and make it possible to test it in other products. DPC aims to expand the lifespan of many often expensive products by delivering the right recipe for self-healing silicone rubber.

FEBRUARY

10,000 FOR STUDENTS GOING TO CHINA

DTU's Teknisk Kemisk Fond has established a new grant of up to DKK 10,000 to cover travel and start-up costs for Danish students who are accepted into the Chemical and Biochemical Master's programme at the Sino-Danish Center in Beijing.

25 February

ELITEFORSK TRAVEL GRANT FOR PHD STUDENT ①

PhD Student Sofie Thage Morthensen from DTU Chemical Engineering was presented with the EliteForsk travel grant and honoured by HRH Crown Princess Mary and the (former) Danish Minister for Higher Education and Science, Esben Lunde Larsen. EliteForsk recognizes some of Denmark's most talented researchers who set the bar high and strive to be the best in their individual fields.

MARCH

31 March

MULTICULTURAL INSIGHTS FOR INTERNATIONAL WORK

The administrative group got to walk a day in their international colleagues' shoes in a course on 'cultural intelligence', providing insights that will strengthen the daily cooperation and understanding in the multicultural work environment that our department provides with more than 37 different nationalities.

APRIL

STUDENTS EXCEL AT PETROBOWL QUALIFIERS ②

Out of more than 20 teams from student chapters within the European region, Krystian Grzegorz Klepczyk, Adam Marczynski, Hadise Baghooee, Marton L. Szanyi, and Stefano Tafliaferri ranked among the top four elite teams in the Regional Petrobowl Contest—a great achievement and so far the best ranking in the history of DTU SPE Student Chapter.

26 April

DANISH SCIENCE FESTIVAL ③

DTU once again opened the doors to the public in order to showcase the best of science at the annual Danish Science Festival. Visitors were shown around the pilot plant, given a lecture on the history, future, and dynamics of volcanos and presented with laboratory examples of microfluidics.

26 April

HEMPEL-DTU AWARD FOR RYBNERS HIGHSCHOOL

The Hempel DTU award was given to Rybners high school for their dedication to and encouragement of science. The award was presented by DTU Dean, Martin Vigild as part of the 'Young Scientists' finals at the 'Science in Forum' event.



Photo: Thorkild Christensen



29 April

GOLD MEDAL, SAFETY PRIZE, AND SCIENTIFIC SPEECH ④ ⑤

Representation was strong at this year's DTU Commemoration Day. Professor Ole Hassager received the Julius Thomsen gold medal for excellent research throughout many years. Head of PILOT PLANT, Lars Kiørboe was honored with the Safety Prize for his long lasting dedication to help the students and employees get home safe. And, Professor Anne Meyer gave the evening's scientific speech on 'Biocatalysis for the future'.

MAY

1-7 May

PROF. KONTOGEOGRIS APPOINTED ADJUNCT PROFESSOR

Head of AT CERE and professor Georgios Kontogeorgis visited Xi'an Jiaotong University in Xianyang, China, where he had the honour of being appointed adjunct professor to the university.

27 May

RESEARCH DAY ⑥

This year's Research Day included poster presentations and a speech on innovation by DTU's Senior Vice President for Innovation and Entrepreneurship, Marianne Thellersen. PhD student Sara Wingstrand took home the Best Research Award for her work on optimizing polymeric fibre, while the Best Innovation Award went to PhD student Arne Gladis who has developed a kinetic model to predict the mass transfer of CO₂ in carbon capture technology.

JUNE

14-15 June

EAP CONFERENCE

Danish Polymer Center hosted the 6th international conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles. 110 researchers from all over the world as well as several companies and research groups exhibited their knowledge about dielectric elastomer based products.

19-23 June

PETROPHASE 2016

PetroPhase 2016—The 17th International Conference on Petroleum Phase Behavior and Fouling was held in Elsinore, Denmark. The international conference was aimed at researchers in industry and academia dedicated to the study of the properties and chemistry of petroleum fluids and their effect on producing, processing, and refining in the upstream, mid-stream, and downstream industries. 180 people from all over the world attended this year's conference.

29 June

FIRST GRADUATES FROM SINO-DANISH PROGRAMME

Graduation caps and dreams of the future were in the air when the very first graduates of the Sino-Danish programme in Chemical and Biochemical Engineering were celebrated at a festive ceremony in Beijing. Congratulations to the graduates!



HIGHLIGHTS 2016

JULY

1-30 July SUMMER UNIVERSITY ⑦

While most DTU students were enjoying their holiday, the campus grounds were kept alive and kicking by Summer University participants from all around the world. 69 students came from the US universities Auburn, Case Western Reserve University, Virginia Tech, University of Alabama, Texas A&M University, and John Hopkins University. Another 5 students participated from Denmark and Portugal. 14 students from the Sino-Danish Center (SDC) also participated in the summer university course.

17-25 August BIOPRO WORLD TALENT CAMPUS ⑧

Solutions, socializing, and Segways. The scene for student-industry networking was set in Sorø at the annual BIOPRO World Talent Campus event, bringing together talents from all parts of the biochemical world. The Novo Nordisk Foundation was of course present as the sponsor of WTC, but also Chr. Hansen, CP Kelco, and Novozymes took part as well as the University of Copenhagen (KU-FOOD).

SEPTEMBER

NEW H.C. ØRSTED POSTDOC

Marlène Vuillemin was granted a H.C. Ørsted COFUND postdoc fellowship enabled by the European Union's Marie Skłodowska-Curie actions. She will spend the next two years researching a 'Novel route to humanized glycoproteins by designed trans-sialidases (DESIGNGLYCO)'.

19-23 September RICHARD W. BRYERS AWARD

PhD student, Yashasvi Laxminarayan won the Richard W. Bryers award for the best student contribution at IFQ 2016 at the Czech Technical University in Prague.

27 September INNOVATION AWARD FOR DIGITAL WOOD STOVE

A digitally controlled wood stove with technology developed at DTU Chemical Engineering in collaboration with HWAM has won the very prestigious Confederation of Danish Industry Prize (DI Prisen).

30 September SCIENCE TALENTS EXPERIENCE LIFE AS SCIENTISTS

What is it like for a high school student to be a part of a high-quality technical university? The ScienceTalent Forsker camp offered 30 talented youngsters a working day in labs of DTU Chemical Engineering—encouraging them to choose the scientist's path.

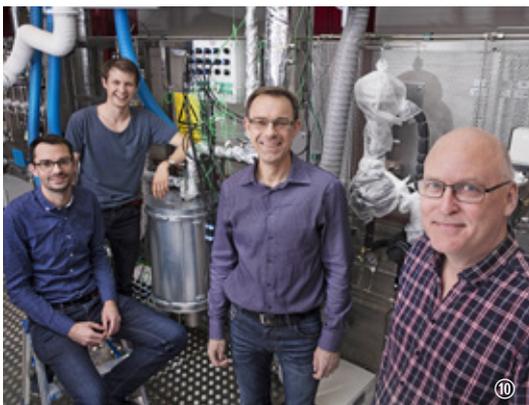
OCTOBER

4-7 October 2016 NEW COURSE FOR INDUSTRY

Professor Emeritus John Villadsen and Professor John Woodley gave the first course in 'Bio-process Engineering Applied to Analysis and Design of Bioprocesses'.

28 October ANNE LADEGAARD SKOV PHD SUPERVISOR OF THE YEAR ⑨

Champagne corks were popping at DTU's PhD reception for former students who submitted their PhD dissertation in 2016. At the celebration, Associate Professor and Head of the Danish Polymer Centre (DPC), Anne Ladegaard Skov, was presented with the honourable award PhD Supervisor of the year.



NOVEMBER

9 November

HIGH SCHOOL INVASION

Passing on knowledge to the younger generations was at heart on 9 November. At the Danish Polymer Centre, Associate Professor Anders Egede Daugaard welcomed high school teachers into the Hempel Lab to play with polymers. In the other buildings, 63 students from Odense Tekniske Gymnasium were enjoying part of their Hempel-DTU prize: A visit to Lyngby Campus.

INNOVATION AWARD FOR WATINTECH PROJECT

An innovation award was given at the International Integrated Water Cycle Show in Barcelona to the inter-disciplinary project WATINTECH which covers the whole value chain around wastewater and urban run-off. Senior Researcher Xavier Flores-Alsina from CAPEC-PROCESS is in charge of WP5 (modelling and system-wide optimization).

30 November

AWARD AT DTU SUSTAIN CONFERENCE ⑩

PhD student Magnus Stummann (photo: in the back on the left) from CHEC research centre won a poster award for his work with the H2CAP project which this year succeeded in developing a new process for producing high-quality bio-fuel from beech tree.

DECEMBER

4 December

MOVIE AWARD FOR SCIENCE CARTOONS

At the '2016 European Science TV and New Media Festival' in Lisbon the animated Microfluidics trilogy explaining the science of the two EU projects BIOINTENSE and EUROMBR won. The trilogy also won 'Best Animation Cartoon 2016' at the The Shortfest International in Malta and won silver in the Web/TV-Animation for Bleech.

4X25 YEARS IN SERVICE OF THE STATE ⑪

We wish to congratulate Associate Professor Flemming Jappe Frandsen (1 Feb), Professor Anker Degn Jensen (1 Aug), Associate Professor Peter Szabo (2 Oct), and Project Manager Michael Krosggaard Nielsen (12 Nov) on their 25-year anniversaries this year.

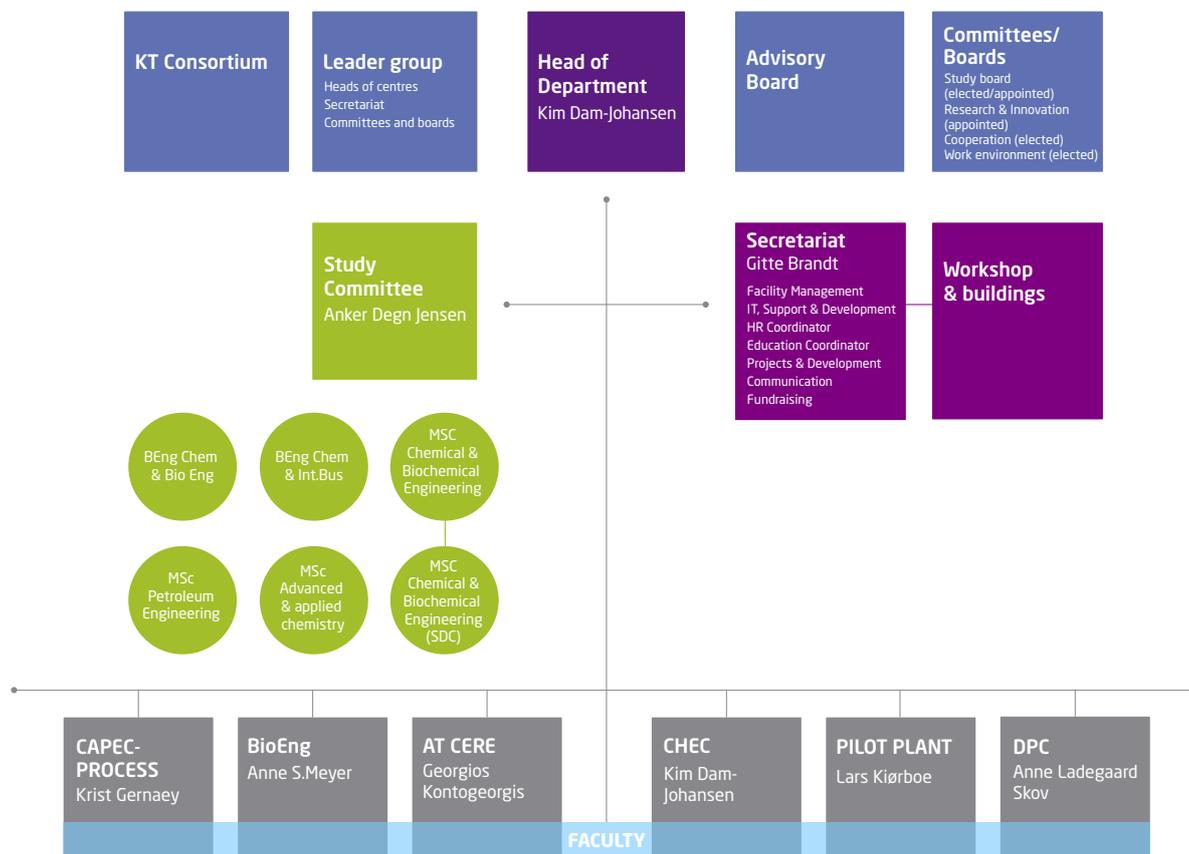
CONTRIBUTIONS TO OUR BOOKSHELVES THIS YEAR ⑫

This year, the book 'Fundamental Bio-Engineering'—edited by the prominent Professor Emeritus John Villadsen—finally found its way to our bookshelves. In addition, a new book on Applied Colloid and Surface Chemistry was written by Professor Georgios Kontogeorgis and Associate Professor Søren Kiil. The book is for use in our MSc course of the same name and is available on wiley.com. Professor Rafiqul Gani also co-authored the 4th Edition of the book 'Product and Process Design Principles' with professors Seider, Lewin, Widagdo and Ng. Several staff members have contributed to books which you can read about in page 47. For instance, Professor Krist Gernaey and Associate Professor Gürkan Sin contributed with a chapter on 'Data Handling and Parameter Estimation' to the book 'Experimental Methods in Wastewater Treatment'. The book has so far been downloaded more than 20,000 times—an amazing result for a technical book.

FIRST TWO INDUSTRIAL POSTDOCS

Innovation Fund Denmark has initiated an Industrial Postdoc programme—a collaboration between companies and research institutions about solving specific research and development tasks. This year, Seyednezamaddin Azizaddini was hired by PHX Innovation and Piotr Mazurek was hired by Grundfos.

ORGANIZATION



ADVISORY BOARD



LARS BANG

GROUP SENIOR VICE PRESIDENT, SUPPLY OPERATIONS & ENGINEERING, H. LUNDBECK A/S



BJERNE CLAUSEN

PRESIDENT AND CEO HALDOR TOPSØE A/S



KIM PANDRUP CHRISTENSEN

CHIEF TECHNICAL OFFICER AT ORECO A/S

"Scientific research at university level is a prerequisite for the development of Lundbeck's chemical activities in Denmark. We have had a beneficial partnership with DTU Chemical Engineering for several years, collaborating on PhD projects and recruiting several of the department's candidates. Furthermore, it has been a great advantage to be able to draw on the knowledge of DTU Chemical Engineering's scientific staff as advisors/consultants."

"Working closely with the best research groups within the fields of our core competences is of major importance to Haldor Topsoe A/S. Our cooperation with DTU Chemical Engineering enables us to resolve research challenges beyond our competences and resources and is an important source of inspiration and knowledge for employees at Haldor Topsoe, benefitting their own and the company's development."

"The close cooperation with DTU Chemical Engineering has ensured significant results in a lot of industries. Long-term focus on development and innovation is necessary to meet the ever-changing opportunities, rules, legislation, and profitability demands that all industries are faced with. DTU Chemical Engineering ensures a high level of education, motivated candidates, and industrial cooperation in important research projects that will lead to technologies of the future."

RESEARCH CENTRES

DTU Chemical and Biochemical Engineering is home to six research centres—each focusing on their area of expertise. Below you can get a quick overview of the centres and their respective research areas. To learn more about our research in details, recent results, or current projects, please visit www.kt.dtu.dk/research.

▶ CAPEC-PROCESS

Process Systems Engineering (PSE), Process Intensification and Integration (PII), process design and control, industrial fermentation technology, biocatalysis, microfluidics



Contact: Professor
Krist Gernaey
kvg@kt.dtu.dk
Phone: +45 4525 2970

▶ PILOT PLANT

Designing and building large-scale plants, Unit operations, Industrial chemical processes, Operational experience, Design of components, Plant safety, Good Manufacturing Practice



Contact:
Lars G. Kiørboe
lgk@kt.dtu.dk
Phone +45 4525 2857

▶ AT CERE

Applied Thermodynamics, Transport Processes and Properties, Mathematical modeling, Material science, Petroleum Technology, Enhanced Oil Recovery, CO₂ capture and gas hydrates, Energy resources



Contact: Professor
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gk@kt.dtu.dk
Phone: +45 4525 2859

▶ BIOENG

Enzyme engineering, Bioprocess enzyme technology, Biofuel production, Reactive separation technology, Biorefinery and sustainability



Contact: Professor
Anne S. Meyer
am@kt.dtu.dk
Phone: +45 4525 2800

▶ CHEC

Catalysis, Inorganic chemistry, Combustion and flue gas cleaning, Diagnostics, Gasification, Pretreatment of biomass, Coatings, Pharmaceuticals



Contact: Professor
Kim Dam-Johansen
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▶ DPC

Polymer technology, polymer chemistry, rheology, filament stretching rheology, surface modification, silicone polymers and elastomers



Contact: Associate Professor
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COOPERATING COMPANIES

A.P. Møller-Mærsk
Addifab
Agro Korn
Akzo Nobel
Alfa Laval
Aminord
Aquaporin
ARKEMA FRANCE
Arla Foods
ART photonics
AstraZeneca
At Sea Technologies
B&W Energy
Babcock & Wilcox Vølund
BASF AG
BAWAT
Bayer Technology Services
BiCT
Biofos
BioProduct
BP
Calsep
Carlsberg
Cargill
CelluComp
ChemStream
ChemProcessTechnologies
Chevron
Chr. Hansen

CLEA
c-LEcta
Coloplast
Conocophillips
CP Kelco
C-Tech
Dansk Gasteknisk Center
DHI
DONG Energy
DSM
DuPont
Esbjerg Farve- og Lakfabrik
eCoast Marine Research
Envidan
Evocatal
Evonik
ExxonMobil
FCC Aqualia
FiberVisions
Firmenich
Fermentationexperts
FLSmidth
Foss
FreeSense
GASSCO
GASSNOVA
GDF-SUEZ
GEA Process Engineering
Gelest

Genencor
Givaudan
GlaxoSmithKline
Grundfos
H. Lundbeck
Haldor Topsøe
Hempel
Hess
HOFOR
Hortimare
Hwam
Højmarks Group BHJ
IFP
Janssen Pharmaceutica
KBC
KMC
LEAP Technology
LEGO
Lentikats
Leo Pharma
LevOss
Lihme Protein Solutions
Linde
Lloyd's Register ODS
Lonza AG
Luxcel
Maersk Oil
MAN Diesel & Turbo

Melissa
Meneta
Microfluidic ChipShop
Micronit
Milliken
Mitsubishi
MOL
Morgenfruerne
NanomyP
National Oilwell Varco
Neste Jacobs Oy
Nordic Bioenergy
Nordic Sugar
Nordisk Tang
Novo Nordisk
Novozymes
OMV
Ocean Rainforest
Petrobras
PHX Innovation
PPG Industries
Processium
ProSim
Prozomix
Radiometer Medical
Rambøll
Rockwool
RWE
SBM Offshore

Schlumberger
Schneider Electric
Shell
Sigma Aldrich
Sika
Sinopec
Sintef
Solvionic
S-PACT
SpinChem
SQM
Statoil
Supren
Syngenta
Teknologisk Institut
Tetra Pak Packaging Solutions
Total
Trioplast
Unibio
UNILEVER
Union Engineering
Veolia Krüger
Wacker
Welltec
Xellia Pharmaceuticals





RESEARCH & INNOVATION

Chalk samples

A large part of the oil recovered in Denmark comes from underground chalk reservoirs in the Danish part of the North Sea. In the laboratories of DTU Chemical Engineering, researchers inject brines of different salinity into samples of chalk saturated with oil in order to push out the oil—a method known as ‘smart water flooding’. The progress is then monitored using X-ray computer tomography scanning.

Photo: Thorkild Christensen



Piotr Mazurek compares the sizes of two samples of the new material he has produced. The sample on the right has absorbed a lot of fluid due to its combination of silicone and glycerol. The new material could potentially be applied for many different functions in different industries—something which Mazurek is now researching as an industrial postdoc at Grundfos.

Photo: Thorkild Christensen

► Facts about the project

The project by Piotr Mazurek is entitled 'Glycerol-silicone elastomers as active membranes for wound dressings and beyond'.

Supervisors: Associate Professor Anne Ladegaard Skov (DTU) and Professor Michael A. Brook (McMaster University, Canada)

Objective: A list of features for an ideal chronic wound dressing has been proposed, which works as a guideline for our research. The list includes wound debridement, maintaining moist environment and gaseous exchange, absorption of blood and excess exudate, preventing infections, providing thermal insulation, low adherence, and cost-effectiveness. The aim was to create a material that would meet most (or all) these requirements and eventually create an attractive chronic wound care product.

A two-phase glycerol-silicone elastomer has been proposed as a novel membrane for wound dressings. It was discovered that this hybrid material is capable of releasing active substances when exposed to an aqueous medium. Various properties of the material (e.g. water permeability, water vapour transmission rate, water absorption, and ability to deliver active substances) were investigated and these were confronted with requirements of chronic wound treatment. Initial results are very optimistic and prove that it is possible to tune most of these properties.

Age. Obesity. Diabetes. Threats to our health that are both widespread and rising. They are also the most common causes for chronic wounds—not only painful to the patients, but often complex and expensive to treat. At DTU Chemical Engineering, a PhD project could make a difference.

Membrane can help patients with chronic wounds

Most of us take for granted the amazing ability of our skin to heal itself. Yet, the reality for the 6.5 million patients affected by chronic wounds in the US in 2008 was quite different. At that time, it was estimated that around USD 25 billion was spent annually on treating chronic wounds. And due to the ageing population and a sharp rise in widespread diseases such as diabetes and obesity, the numbers are growing rapidly.

By mixing silicone with glycerol, former PhD student, now postdoc at the Danish Polymer Centre (DPC) Piotr Mazurek, has developed a completely new material which may solve 7 out of 8 of the issues on a recent 'wish list' for the wound dressings of the future, providing a better and more cost-efficient solution.

Low price, high impact

Glycerol is abundant in the chemical industry and therefore very cheap. In addition to this, the methodology of mixing glycerol into silicone is quite simple and should be easy to upscale. This means that producing wound dressings in this way could be very cost-effective and therefore in high demand in a market where competition is intense.

Silicone and glycerol do not really mix; however, by spinning the ingredients at a certain rate and a certain temperature, Mazurek found that he could suspend glycerol as tiny droplets inside the silicone:

"The more droplets I supplied, the more soft and stretchable the material got. In the end, the large number of droplets assembled like raindrops on a window creating a new structure in the material. This turned out to be very interesting indeed," says Piotr Mazurek.

The market already offers multiple types of chronic wound dressings and it is no news that wound dressings can release substances such as antibiotics or anaesthesia. However, Mazurek's invention goes a bit further.

Extended treatment

According to Mazurek, the medicating dressings available in the market today, release most of the medicine rather rapidly and then the release slows down, which means a part of the medicine goes to waste and the dressing needs to be changed more often. The new material provides a longer period of medication,

which could mean more time for other care assignments for nurses and that wounds are allowed a little more time to rest. The extended release of medicine is provided by taking advantage of glycerol's ability to absorb. When the wound secretes fluids, the fluids are absorbed into the droplets of glycerol, which at the same time pushes out the medicine, creating this constant treatment effect.

Great potential

According to Mazurek, the combination with silicone adds some more important features from the 'wish list'. Silicone has low adhesion which most people recognize from, for instance, baking moulds. It also insulates very well and protects the wound from temperature changes. Furthermore, silicone allows for gaseous exchange so that the skin to breathe while keeping a moist environment around the wound which is key to the healing process.

"All of these properties combined in this new material gives it great potential. Not only as a wound dressing, but also for other applications. It seems like the sky's the limit and I'm excited to see what the future will bring," says Piotr Mazurek.



Straw is at the heart of a PhD project which earned Sofie Thage Morthensen a visit to Belgium and a rare opportunity to synthesize her own membranes.

Photo: Christian Ove Carlsson

► Facts

Sofie Thage Morthensen's PhD project is entitled 'Integration between enzyme technology and membrane separation in biorefinery processes', and is supervised by Associate Professor Manuel Pinelo.

The project is part of the BIOVALUE SPIR strategic platform for innovation and research on value-added products from biomass.

The objective of BIOVALUE SPIR is to ensure that Denmark is a world leader in sustainable biorefining technologies and solutions for tomorrow's bio-based society.

The Department of Chemical Engineering's Center for BioProcess Engineering leads the competences centre within Separation for BIOVALUE.

Glucose from straw may play a big role in the future production of many everyday products such as pharmaceuticals and clothes. An EliteForsk travel grant winning PhD project from DTU Chemical Engineering aims to uncover how new processes can help increase the value of straw and make it an effective and profitable business.

Getting the best out of straw

As the world population continues to grow and the search for alternative resources intensifies, researchers are looking at different and more efficient ways to use the materials at our disposal.

Straw—a residual product from agriculture—can be used as raw material for production of, for instance, pharmaceutical products, cosmetics, and textiles. Yet, as is the case with many concepts, finances have great influence on whether or not it will become a success. Therefore, development of cost-effective processes with maximum yield and efficiency is needed. If a PhD project at DTU Chemical Engineering goes as planned, we may be one step closer to perfecting the process in the future.

Difficult to separate

Glucose and xylose are sugars that are used to make many everyday products such as medicine and clothes. When straw is processed these sugars can be obtained, however the challenge is that glucose and xylose have very similar chemical structures and are therefore notoriously difficult to separate. A PhD project by Sofie Thage Morthensen from the Centre for Bioprocess Engineering (BioEng) could change this.

She will develop a process based on the use of membranes and enzymes in order to separate the sugar molecules in bio-refineries.

“Membranes are super selective materials and have the potential to separate sugar molecules at a higher throughput and at milder process conditions compared to other separation processes,” says Sofie Thage Morthensen.

The performance of the membranes can be even further enhanced with the use of enzymes as biocatalysts to modify the process stream. In scientific terms, the concept of integrating conversion and purification is known as ‘reactive membrane separation’. However, there is yet another challenge to this: Enzymes are expensive.

“Designing processes that enable reusability and high biocatalytic productivity is a prerequisite for cost-effective enzyme use in biorefineries,” says the PhD student.

An EliteForsk-worthy idea

The idea has earned Sofie Thage Morthensen a travel grant from EliteForsk and she believes that travelling has given her some important experiences in working with membranes.

“When I received the travel grant, my first priority was to go to a university where I could learn something completely new within my field. In BioEng I have only worked with commercial membranes, but at KU Leuven in Belgium I had the opportunity to synthesize my own membranes and do some more advanced characterization of them”, says the EliteForsk grant winner.

Theory, however, is one thing. Practical application is another. Testing the reactive membrane separation on straw is the next phase of the project—and expectations are high.

“Taking into account that most of the cost of any biorefinery process corresponds to the separation steps, membrane technology by itself has a lot to say in the development of future green processes with a more feasible exploitation of biomass. But if membrane separation is integrated with enzyme technology, the viability and simplicity of the processes can be boosted to an even higher level,” says her supervisor Manuel Pinelo who has been researching the use of membranes for biomass conversion for around eight years at DTU Chemical Engineering.

MICRO-FLUIDICS INSIDE



A nutty professor welcomes the audience in three cartoons that were produced this year to share the otherwise complex science of the two EU projects BIOINTENSE and EUROMBR.

Watch the animated movies at:
www.worldofmicrofluidics.com

► Facts

BIOINTENSE is a single-stage knowledge-based bio economy (KBBE) collaborative project which started in August 2012. In collaboration with the EUROMBR project (European network for innovative MicroBioReactor application in bioprocess development) three cartoons were produced by Golderner Westen in order to disseminate the two projects to a wide audience.

The objectives of BIOINTENSE were to increase biocatalyst productivity and process intensity and thereby make way for more economically feasible processes by integration and intensification and also a shortening of the development times by developing optimized tools and protocols that can be widely applicable in industry. Furthermore, fundamental understanding on the interactions between reaction, biocatalyst and process characteristics achieved to minimize the uncertainties with respect to the cost of future biocatalytic processes. BIOINTENSE also increased understanding about the factors contributing to the total cost and environmental impact.

BIOINTENSE was EC-funded through the 7th Framework Cooperation Programme. The consortium was led by Professor John M. Woodley and manager of the project was Associate Professor Ulrich Krühne, both from the CAPEC-PROCESS research centre.

- EUROMBR is a Marie Curie initial training network (ITN). The main objective of the EUROMBR project is to deliver a trans-European network of industrially oriented specialists fully trained in the development and application of microbioreactor (MBR) technology to support the progress of innovative bio-based manufacturing processes. This project is coordinated by Ulrich Krühne and managed by Nicky Ehrlich.

Some things are highly important, but also highly complicated. Using micro technology, the 'Mastering integration and intensification of bioprocesses' project—also known as BIOINTENSE—has yielded new, greener, and more efficient methods for future chemical production. The complex science of this project has furthermore been made available through a series of animated films that invite everyone with an interest in this promising technology into the 'World of Microfluidics'.

Welcome to the World of Microfluidics

Food, pharma, and materials for everyday products are, more often than not, the result of several chemical processes. As such, the chemical industry is on a constant search to improve these processes to ensure that they stay competitive, remain economically attractive all the while keeping a low impact on the environment.

Traditionally, chemical processes are run on large equipment and can as a result be expensive and even harmful due to considerable waste production or use of toxic substances. One solution to avoid using such processes could be to apply enzymatic bioprocesses. In enzymatic bioprocesses enzymes from nature are used as catalysts and could in this way potentially be more productive under mild reaction conditions and yielding less waste. According to Associate Professor Ulrich Krühne from the CAPEC-PROCESS research centre, it is these bioprocess methods that need to be rethought.

“It’s nearly impossible to reduce waste production without finding a way to distinguish the good enzymes from the bad. Here microfluidics can help us,” says the Associate Professor who is also the project manager of the BIOINTENSE project which was concluded this year. He continues;

“New enzymes must be designed and tested. This is the core of our project. We used a technology which first emerged in the 80’s called microfluidics. The technology enables us to control and test very small volumes of liquid and determine very precisely what works well and what does not. In this way, we can get quicker results and the small scale means we can do multiple tests at the time, making the process much more efficient”.

Multiple results in short time

Just like technology of microfluidics, the BIOINTENSE project has brought many results in very short period of time. New methods to increase biocatalyst productivity and process intensity through the development and application of novel microfluidic and modelling tools have been discovered. Furthermore, other points of progress include development of new microfluidic products, 24 mass fabrication compatible micro-reactors for further commercial application, standardization of device formats, making the systems applicable with standard laboratory equipment, new enzyme products and much more.

Animating the public

There is another important side to the BIOINTENSE project. The project aimed at communicating outside of academic circles. This was done by creating the

‘World of Microfluidics’ animation films; short explanatory cartoons that have received much recognition at several science film festivals around the world. At the Shortfest International in Malta they were awarded Best Animation Cartoon 2016. At the Annual Multimedia Award they won silver for Web/TV-Animation for Bleech, and most recently they won an award at the European Science TV and New Media Festival in Lisbon. According to Ulrich Krühne, there are three main motivations for promoting the project in this way:

“We are technical nerds here. We work in an environment where people understand our scientific lingo but of course most people are not used to this language. So communicating the project to non-technical spheres can help us with three things: Reaching young people who we will one day need to be interested in carrying on the research; making the public aware that we need to think about new and more sustainable ways to produce; and of course living up to our grant givers’ demand for communicating complex, but important science,” says Ulrich Krühne.



Head of PILOT PLANT, Lars Kiørboe, next to a vessel connected to the CIP (Cleaning In Place) facility where students can visually experience how the plant and the process behave in real life.

Photo: Thorkild Christensen.

▶ Main activities of the PILOT PLANT–Centre for Experimental Process and Equipment Design:

Research and teaching focused on experimental work with large-scale equipment and processes. These activities are conducted with a strong focus on industrial practice. As a result the main activities include unit operations, reaction engineering, process control, process and plant design, instrumentation, automation, and industrial measuring technology, scale-up and scale-down as well as batch versus continuous processes. New focus areas are fermentation mainly from a process point of view and particle technology.

▶ Current projects

The project portfolio of the PILOT PLANT research centre currently includes, for instance, microbial conversion of slaughterhouse waste, syngas fermentation, and downstream processing of the liquids products, ammonia enhanced biogas production, along with fermentation experiments for the new bio-tech cluster BIOPRO and research on flowability of bulk solids and coating of particles.

▶ Technical competences:

- Designing and building large-scale plants (engineering, construction)
- Unit operations (theory and practice)
- Industrial chemical processes (designing the entire process)
- Operational experience, solving practical process problems
- Project management
- Plant safety
- GMP (Good Manufacturing Practice)
- Wide industry contact

At DTU Chemical Engineering we have many years of experience teaching Good Manufacturing Practice or 'GMP' to students. This year, we added a continuing education course to our programme portfolio. The new GMP course has been adapted to companies in the pharma and food industry and combines theoretical aspects with practical experience using our pilot plant equipment.

Good Manufacturing Practice —in practice

In a corner of the large pilot plant of DTU Chemical Engineering, a student is scratching his head, looking at a mobile washing station connected to a model process plant made of transparent plastic which ensures that everything going on inside is visible. A moment ago his supervisor, Lars Kiørboe, Head of the centre PILOT PLANT, pointed to a large stain of mustard stuck in one of the valves.

“Pretend you’re standing in the big production hall of a pharmaceutical manufacturing factory. You have discovered that the CIP facility has not been able to clean the process plant entirely and every delayed second before the next batch of medicine can be produced count—what do you do?” the experienced teacher asks.

Practical GMP

Creating a realistic scenario tops the agenda in the Good Manufacturing Practice (GMP) courses which the centre offers to undergraduates and now also to small, medium, and large companies in Denmark. In addition to the large body of theory that goes hand in hand with the GMP world, these courses are

especially focused on practical learning aspects.

According to Lars Kiørboe, the GMP philosophy states that you cannot base the product quality on chemical analysis of the finished drug alone—GMP activities have to completely permeate the entire production process. So GMP is very comprehensive.

“If your company is producing medicine, you cannot allow even the smallest mistake. Therefore, GMP is implemented into all steps of production from the raw material, to the design of the equipment and building, to the manufacturing processes, the education of employees further on to storage and transport of the finished products and the documentation. With our courses we want to ensure a workforce that can solve the practical challenges of GMP in the medical, food and biotech industry” says Lars Kiørboe.

The GMP courses cover general quality standards, hygienic design, cleaning technology, documentation practice in combination with work in the pilot plant and visit to industrial sites. Since GMP is so important to large Danish companies

various aspects are also applied in other courses at the department. This includes the experimental courses in chemical unit operations where the students can work with the CIP unit and include CIP cleaning in the operation of, for instance, ultrafiltration and evaporation technologies. So the students are given a much more realistic study with experiences they can use directly in their future engineer jobs.

Companies can test their cleaning methods

Although there are standards prescribing the best design of production equipment, the equipment will often vary from company to company and many construction details may be considered. In the pilot plant it is possible for companies to come and use our facilities for testing and developing equipment and processes, where easy changing of design and process parameters can go hand in hand with modelling and test of various raw materials. In this way, the companies can get a better understanding of the challenges they may meet and how to better solve them in the future.



Associate Professor Philip Fosbøl is pouring a sample of oil. The oil used for experiments within the SmartWater project was retrieved from two types of sedimentary rocks, chalk and greensand, which occur in the Danish part of the North Sea.

Photo: Thorkild Christensen

- ▶ Water flooding is a standard method used by oil companies all over the world in order to extract extra oil from mature fields. The 'SmartWater' project aimed to improve the theoretical understanding of the detailed mechanisms involved in water flooding and it has suggested possible ways to improve recovery rates in the Danish part of the North Sea.
- ▶ Industrial partners are Maersk Oil and DONG Energy. Funding is provided by the industry partners, by the Danish EUDP programme under the Danish Energy Agency and by the Danish research councils.
- ▶ The SmartWater project was inspired by findings in the Middle East which suggested that by modifying salinity and

What if we could get more oil from the same reservoirs? The research centre AT CERE has taken up the challenge. The SmartWater project, which was concluded this year, is an attempt to extract more oil from the available reservoirs in the Danish part of the North Sea. The methodology they have developed goes against one of the most widely held understandings in the chemistry of oil recovery.

Small revolution may have great consequences for oil recovery

This year, the SmartWater project came to an end. Since its birth in 2011, researchers have worked hard to make oil extraction more efficient. As Philip Loldrup Fosbøl, Associate Professor at AT CERÉ, explains, even a small improvement could mean a big difference:

“An oil reservoir basically consists of a big rock where the oil is embedded. Only about 30% of this oil is extracted with current conventional methods. If we could recover just 1% more oil out of the reservoirs, it would actually provide billions of DKK for the Danish State. SmartWater has been all about finding a way of doing this.”

Yet, oil recovery is by no means a simple discipline according to the Associate Professor.

“An oil reservoir is not a big ‘pool’ of oil somewhere under the sea floor, like many people intuitively think. It’s embedded in small holes and rooms in chalk like the kind you may remember from school. In the laboratory we use the exact same chalk combined with state-of-the-art technology to recreate the conditions

under which oil is extracted—all of which happens under enormous pressure. This has enabled us to find out more about the effectiveness of oil extraction without having to actually go underwater and underground”.

A small revolution in oil recovery

And the prospects are looking good. The project has challenged one of the basic understandings of how to best utilize the SmartWater concept. As Philip Loldrup Fosbøl says:

“I like to think that, in the course of the project, we have revolutionized the way we think about SmartWater technology. When injecting Smartwater into the oil reservoir, small particles are formed as it mixes with the other fluids in the reservoir. Until now, scientists have believed this to be a problem, which it still is if there is too much of it and it clogs the reservoir, of course. But, what our research has also shown is that the particles are actually part of the solution: The oil ‘sticks’ to the particles and carry it to the production site. This way, we can get even more oil out,” says the Associate Professor who has been researching oil recovery at AT

CERÉ for years, and believes we are now closer than ever to achieving the desired increase in oil production.

Industry is catching on

The project has not been confined to DTU Chemical Engineering alone. DTU Civil Engineering has coordinated the project which was funded by Maersk Oil, Dong Energy and EUDP. According to Associate Professor at AT CERÉ, Kaj Thomsen who has been a main actor in the project, the collaboration has been of great importance and is expected to have influence on oil production in Denmark and beyond.

The new methods for oil extraction that are presented as a result of the SmartWater project have not yet been applied on a larger, industrial scale. However, this may be about to change:

“We have a lot of ideas from the project and the industry is very interested in them—this has a lot of potential. As it looks now, one of the funders of the project will most likely try to apply the methods in the future,” says Associate Professor, Kaj Thomsen.



Assistant Professor Jakob Munkholt next to a new piece of equipment which enables catalytic processes to be studied at a wide range of temperatures and pressures.

Photo: Thorkild Christensen

► Catalysis research in the CHEC research centre

The research within catalysis in CHEC focuses mainly on providing solutions to energy and environmentally related challenges, but also covers parts of green chemistry. The objectives of the research are:

To synthesize new catalytic materials

To characterize the materials using spectroscopic methods and other techniques, and by theoretical means—such as density functional theory calculations—to understand and predict the properties of the materials

To test the activity and selectivity of the materials in relevant reactions and under industrially relevant conditions, and derive kinetic models including models describing diffusion limitations applicable for real reactor design

To investigate and minimize deactivation of the catalysts under relevant conditions; To model catalytic reactors and thereby obtain an improved understanding of the interplay between the process and the catalyst

The VILLUM Center for the Science of Sustainable Fuels and Chemicals is a constellation headed by Technical University of Denmark (DTU) and with the participation of Stanford University, University of Copenhagen (KU), and the University of Southern Denmark (SDU). It is an anniversary grant on account of the 75 year of the VKR group and is the biggest grant from VILLUM FONDEN to a scientific project.

'Low-temperature processes for CO₂ reduction to fuels and chemical building blocks' is a project in the centre which aims to find catalysts that will work at low pressure and temperature in distributed units compatible with solar hydrogen production.

It is a very promising, but so far not entirely cost-effective process to convert CO₂ into useful fuels and chemicals. Developing a cost-effective process will require the right catalyst and reaction. At the CHEC research centre, researchers are developing new and more effective catalysts.

CO₂ should be a sustainable business

Our planet is in need of alternative energy sources to replace fossil fuels. However, we are still far from being independent of oil, coal, and natural gases, the use of which every year leads to tons of CO₂ being emitted into the Earth's atmosphere. But what if you could use this otherwise harmful greenhouse gas for storing green energy or producing useful chemicals for everyday products? Around the world, researchers are racing to find an effective and affordable way to achieve exactly this. And, according to Anker Degn Jensen, Professor at DTU Chemical Engineering, CO₂ could very well become an important resource in the future.

“Almost all fuels and chemicals contain carbon which today is obtained from fossil fuels. However, CO₂ is also a possible source of carbon. So, when we no longer wish to use or do not have any more fossil fuels, the ability to effectively convert CO₂ into chemicals could prove to hold great potential in the long run. And in the meantime, large point sources – such as power plants and cement factories – are attractive sources of CO₂,” says the professor and catalysis expert.

Methods to convert CO₂ into, for instance, ethanol – one of the promising alternatives to fossil fuels – already exist. However, there is a significant bump on the road: The process remains too

ineffective and the yield of ethanol too low in the end. Therefore, Professor Anker Degn Jensen together with his colleague from the CHEC research centre, Assistant Professor Jakob Munkholt, are working with colleagues from DTU and Stanford University to find a solution that is both environmentally and economically attractive. Their research project is called ‘Thermally driven processes for CO₂ reduction to fuels and chemical building blocks’. The aim of the project is to develop a catalyst which can convert CO₂ into ethanol at a low pressure and temperature. Conversion of CO₂ traditionally requires a great amount of energy. However, if it can be done at lower pressures and temperatures, it will be feasible to use, for instance, solar or wind power for the process. The ethanol can, as such, become a way to store the electricity produced from these sustainable energy sources.

Too much is wasted

Ethanol can be produced by a reaction between CO₂ and hydrogen using a catalyst. However, the challenge with this process is that the currently best catalysts used for this reaction cannot prevent that a significant part of the CO₂ ends up as unwanted light hydrocarbons, particularly methane. Furthermore, too much of the hydrogen is wasted as it is converted into water.

“The waste of hydrogen is problematic, as there are significant costs associated with producing hydrogen and that means we are still relatively far from having anything of commercial interest. That’s why we are trying to develop new catalysts with the ability to effectively convert CO₂ into ethanol as well as other valuable alcohols to replace fossil fuels,” says Assistant Professor Jakob Munkholt Christensen.

Difficult, but with great potential

Although converting CO₂ is a challenging process, the team of researchers are optimistic about finding the right materials with the right abilities to make effective catalysts.

“Rhodium-based catalysts have shown great potential, but are expensive. We will research how and why it functions so well and with this knowledge we hope to imitate the properties to make a cheaper synthetic catalyst,” says Jakob Munkholt Christensen.

The project is part of the new V-Sustain research centre at DTU focusing on sustainable chemicals and fuels. The work was kicked off in the summer of 2016 and will continue for the next eight years with four new PhD students expected to be hired at DTU Chemical Engineering.



Here are the people behind the new KT Consortium. So far the consortium counts ten PhD students, a postdoc, a research assistant, a secretary along with associated faculty members—and not least—17 member companies from all over the world.

Photo: Thorkild Christensen

► Facts about the KT Consortium

The consortium was established in 1997 by Professors Rafiqul Gani and Sten Bay Jørgensen under the name CAPEC consortium.

Currently, the KT Consortium offers:

Computational tools

Property estimation methods, mathematical models, numerical solvers, process simulators, process-product synthesis/design toolbox, process control toolbox, and many more.

Technology

Methodologies for process-product synthesis, design, analysis and control/operation, simulation strategies, solvent selection/design, pollution prevention, sustainable process-product alternatives and many more.

Application

Industrial case studies, tutorial case studies, technology transfer studies, and consulting.

The former CAPEC consortium has been reorganized into a united cross-departmental consortium called KT Consortium. Masterminds behind the consortium are Head of Department Professor Kim Dam-Johansen and Professor Rafiqul Gani who with this strategic move will strive to take the department's collaboration with industry partners to the next level—a networking platform in full scale.

New cross-departmental consortium opens up for collaboration

KT Consortium is an industry-academia collaboration that offers networking opportunities, state-of-the-art methods, and tools to its members in the chemical, petrochemical, pharmaceutical, agrochemical, food and biochemical industries.

“KT is short for KemiTeknik, the Danish version of our name,” Kim Dam-Johansen explained at the opening of the very first KT Consortium Annual Meeting at DTU on 28 October 2016.

The consortium will continue to develop generic methods and tools using computer aided systems approach to solve and analyse problems related to product-process modelling, simulation, synthesis, design, analysis, control, and operation in collaboration with the member companies. Yet, these services are going to be broadened in the future according to Kim Dam-Johansen.

“The name is new, so are the future perspectives. Although the consortium originally was established in 1997, this is not a case of old wine in a new bottle,” says Kim Dam Johansen about the recent developments.

“In the future, research from all our six research centres will be included and more industrial partners from both small, medium and large enterprises from all over the world will be invited to join. My hope is that this broader mix of knowledge and experience will strengthen our ability to deliver directly applicable research that solve the future challenges of our global society,” he explains.

Going far for innovation

Present at the KT Consortium Annual Meeting was Graduate Programme Lead, Manufacturing at GlaxoSmith-Kline, Dr Conchita Jimenez-Gonzalez. Coming all the way from the US, there must be some good reasons to join the annual meetings according to Dr Jimenez-Gonzalez, who has been a frequent visitor since 2003 when Glaxo-SmithKline became a member.

“Always before I come here, I do a good amount of research and I always find good things on the agenda,” says Dr Jimenez-Gonzalez and continues, *“I like that I get updated on developments in the research arena. I like the opportunity to be in some projects. And now that I’m leading the graduate programme in my company, I’ve brought six of my UK grad-*

uates to this meeting. I’m really interested in hopefully providing them with a view of the world of research besides what we do at the company, because I do believe that the more people are exposed to different research, the better their work is and the more innovative their thoughts become”.

As Programme Lead, Conchita Jimenez-Gonzalez believes a good chemical engineer is a problem solving professional that is really good at thinking in networks, because nothing happens in isolation.

“It might be that there is a tool that we can’t use right away in the company, but it might spark another idea of something else that we can use. That’s always, I think, how innovation works, it’s not just somebody sitting alone in a room. It’s the cross-pollination of ideas,” says Conchita Jimenez-Gonzalez.

Open for new members

The KT Consortium is open for new company members. Read about the new consortium, services and how to apply for membership on the website www.kt.dtu.dk/research/kt-consortium.





EDUCATION

Polymers and particles

Synthesis of polymers (flask) and surface modification of particles (small vials) can be used to control agglomeration of particles (petri dish).

Photo: Thorkild Christensen

Programmes at DTU Chemical and Biochemical Engineering

The department participates in two 3½-year Bachelor of Engineering (BEng) programmes, one in Chemical and Biochemical Engineering and one in Chemical Engineering & International Business, a three-year Bachelor of Science (BSc) programme in Chemistry and Technology, three two-year Master of Science (MSc) programmes

in Applied Chemistry, Chemical and Biochemical Engineering, which includes an Honours programme, and Petroleum Engineering, and finally a Sino-Danish Master of Science programme in Chemical and Biochemical Engineering.

Our students work both theoretically and experimentally with the core disci-

plines in chemical engineering such as unit operations, transport phenomena, reaction engineering, mathematical modelling, and thermodynamics. They are taught by faculty specializing in these areas with applications in energy conversion, enzyme technology and biotechnology, polymers, computer modelling, process and product design.

COURSES 1 SEPTEMBER 2015 – 31 AUGUST 2016

PHD COURSES

| | |
|-------|---|
| 28901 | Advanced Computer Aided Modelling |
| 28902 | Process & Tools Integration |
| 28904 | Soft Matter Physics |
| 28905 | Advanced Topics in Process Systems Engineering |
| 28908 | Rheology of complex fluids |
| 28909 | Thermodynamics Models, Fundamentals and Computational Aspects |
| 28917 | Statistical Thermodynamics for Chemical Engineering |
| 28923 | Uncertainty and Sensitivity Analysis of Numerical Models |
| 28924 | Process Engineering Laboratory |
| 28927 | Advanced Topics in Process Technology |
| 28928 | Electrolyte Solution Thermodynamics |
| 28930 | Advances in Chemical and Biochemical Engineering |
| 28931 | Biorefinery and Sustainability |

SINO-DANISH CENTER (SDC) COURSES

| | |
|-------|--------------------------------------|
| 88700 | Industrial Reaction Engineering |
| 88701 | Transport Processes |
| 88703 | Laboratory Experiments |
| 88704 | Progress in Research |
| 88705 | Process Design—Principles & Methods |
| 88707 | Energy and Sustainability |
| 88708 | Green Chemical Engineering |
| 88711 | Industrial BioReaction Engineering |
| 88713 | SDC Green Challenge |
| 88714 | SDC Summer School in Unit Operations |
| 88715 | Biorefinery |

COURSES

MSC, BSC, AND BENG COURSES

Below, course numbers and names are shown for 2016, with the number of students attending shown in brackets. Courses for Bachelor of Engineering are marked with a (B). The other courses are Bachelor of Science courses, Master of Science courses or common courses.

SPRING SEMESTER

| | |
|-------|--|
| 28012 | Chemical and Biochemical Process Engineering (55) (B) |
| 28016 | Mathematical models for chemical and biochemical systems (72) (B) |
| 28017 | Chemical and Biochemical Process Engineering (21) (B) |
| 28020 | Introduction to Chemical and Biochemical Engineering (63) |
| 28022 | Unit Operations of Chemical Engineering and Biotechnology (87) (B) |
| 28025 | Bio Process Technology (83) |
| 28121 | Chemical Unit Operations Laboratory (10) |
| 28122 | Chemical Unit Operations Laboratory—3 weeks Summer University Laboratory (7) |
| 28124 | Summer course in chemical process and plant design (14) |
| 28157 | Process Design (40) (B) |
| 28160 | Mathematical models for chemical systems (45) |
| 28212 | Polymer Chemistry (15) |
| 28214 | Polymer Synthesis and Characterization (7) |
| 28221 | Chemical Engineering Thermodynamics (31) |
| 28231 | Laboratory in Chemical and Biochemical Engineering (18) |
| 28322 | Chemical Engineering Thermodynamics (61) (B) |
| 28342 | Chemical Reaction Engineering (53) (B) |
| 28344 | Biotechnology and process design (64) (B) |
| 28345 | Chemical Reaction Engineering (34) |
| 28350 | Process Design: Principles and Methods (47) |
| 28352 | Chemical Process Control (40) (B) |
| 28361 | Chemical Engineering Model Analysis (20) |
| 28415 | Oil and Gas Production (45) |
| 28423 | Phase Equilibria for Separation Processes (20) |
| 28434 | Membrane Technology (40) |
| 28443 | Industrial Reaction Engineering (33) |
| 28451 | Optimizing Plantwide Control (17) |
| 28811 | Polymers in Processes and Products (5) |
| 28850 | Quality by Design (QbD): Integration of product and process development (64) |
| 28855 | Good Manufacturing Practice (60) |
| 28864 | Introduction to Matlab Programming (26) |
| 28871 | Production of Biofuels (15) |
| 28885 | Technology and Economy of Oil and Gas Production (49) (B) |

Courses offered together with other departments:

| | |
|-------|---|
| 26317 | Instrumental Chemical Analysis (33) |
| 27944 | Biotechnology and process design (11) (B) |
| 41683 | Materials Science (70) (B) |

FALL SEMESTER

| | |
|--------|--|
| 228001 | Introduction to Chemistry and Chemical Engineering (67) |
| 28012 | Chemical and Biochemical Process Engineering (72) (B) |
| 28016 | Mathematical models for chemical and biochemical systems (89) (B) |
| 28022 | Unit Operations of Chemical Engineering and Biotechnology (86) (B) |
| 28121 | Chemical Unit Operations Laboratory (18) |
| 28125 | Chemical Unit Operations Laboratory (24) |
| 28140 | Introduction to Chemical Reaction Engineering (39) |
| 28150 | Introduction to Process Control (66) |
| 28157 | Process and product design (37) (B) |
| 28213 | Polymer Technology (55) |
| 28233 | Recovery and Purification of Biological Products (55) |
| 28242 | Chemical Kinetics and Catalysis (51) |
| 28244 | Combustion and High Temperature Process (55) |
| 28246 | Applied Enzyme Technology and Kinetics (55) |
| 28247 | Advanced Enzyme Technology (15) |
| 28310 | Chemical and Biochemical Product Design (51) |
| 28315 | Colloid and Surface Chemistry (63) |
| 28316 | Laboratory Course in Colloid and Surface Chemistry (19) |
| 28322 | Chemical Engineering Thermodynamics (78) (B) |
| 28342 | Chemical Reaction Engineering (34) (B) |
| 28352 | Chemical Process Control (32) (B) |
| 28361 | Chemical Engineering Model Analysis (56) |
| 28420 | Separation Processes (39) |
| 28515 | Enhanced Oil Recovery (42) |
| 28530 | Transport Processes (60) |
| 28831 | Computational fluid dynamics in chemical engineering (23) |
| 28845 | Chemical Reaction Engineering Laboratory (22) |
| 28852 | Risk Assessment in Chemical Industry (26) |
| 28864 | Introduction to Matlab Programming (31) |
| 28870 | Energy and Sustainability (127) |
| 28872 | Biorefinery (49) |

Courses offered together with other departments:

| | |
|-------|--|
| 23522 | Rheology of food and biological materials (10) |
| 26010 | Introductory Project in Chemistry (49) |
| 27004 | Health, Diseases and Technology (68) |
| 27944 | Biotechnology and process design (30) (B) |
| 41683 | Materials Science (35) (B) |

BACHELOR OF ENGINEERING DEGREES

15 students finished their research projects for the BEng degree. The project titles and names of the students are listed below:

| | |
|-------------------------------------|---|
| Agertoft, Frederik Cornali | Technical and economical evaluation of using a radial flow methanol converter as part of the reactor capacity in a methanol synthesis loop |
| Ali, Nabila Nasrudin Abdulqadir | Yield of Insulin aspart in purification |
| Alwan, Zaman Mothana | Removal of selenium from waste water |
| Al-Asfar, Ali Omar | Investigation of a rotational pumping element |
| Appelt, Julius Lai & Struve, Rasmus | Investigation of the properties of ceria-zirconia mixed oxide catalysts for systems removing particulates and NOx from diesel vehicle exhaust |
| Azizi, Haroon-Ur-Rashid | Cyclic separation |
| Cakir, Meral | Re-installation of utility-plant: Liquid waste handling and water circulation line |
| Carlsen, Niels Frahm Vilhelmsen | Technoeconomic analysis of a glycerol processing plant with forward osmosis for water recirculation |
| Jepsen, Ulf | Simulation of absorption heat pump for flue gas condensation |
| Kurlink, Kristian Wismann | Effect of adhesives on noise damping |
| Laczek, Kim | Processes for the separation of rare earth elements from ores |
| Larsen, Gudrun F. Gudmundsdottir | Modelling of carboxylic acid extraction from fermentation broth |
| Nærum, Nicolai Peter | Systematic synthesis of a methyl acetate production plant |
| Pallesen, Jeppe Væver | Stability measurement and equilibrium modelling of ozonated edible oils for medical treatments |

BACHELOR OF SCIENCE DEGREES

32 students finished their research programme for the BSc degree. The project titles and names of the students are listed below:

| | |
|------------------------------|---|
| Andersen, Bastian Borum | Model Development for Cyclic Distillation |
| Andersen, Jakob Afzali | Removal of particulates and NOx from automotive exhaust gas by combined diesel particulate filter and SCR |
| Andersen, Mads Gade | Dynamic Simulation Study of Falling Film Evaporation |
| Biel-Nielsen, Tessa Lund | Measurement and Modeling of Gas Diffusion in Coated Enzyme Particles |
| Bokhari, Syed Muhammad Qasim | Reaction Equilibria in Liquids |
| Boye, August | Mechanism for Fouling of Waste Heat Boiler Tubes in Regeneration of Spent Sulfuric Acid |
| Brogaard, Mads Schack | The Influence of the Operating Conditions and Influent Composition on the Reactor Performance in a Full-Scale μ Anaerobic |
| Bugge, Anders | Solvent Exchange in Continuous Processing |
| Fayyaz, Umar | Recycling of Phosphorus From Biomass Ashes |
| Freiesleben, Louise la Cour | Commissioning of Fluidized Bed Coating Equipment |
| Gong, Wentao | Modeling the Aqueous Acetic Acid-Sodium Acetate-Potassium Acetate System |
| Hambartsumyan, David Sargis | Screening of resins with improved binding capacity of Vancomycin under static and dynamic conditions |
| Hansen, Michael Kolling | Proactive Well Workover Maintenance Model |
| Jacobsen, Bjartur | Rate-Based Model for Enzyme Upgrading of Biogas |
| Jensen, Martin Pilgaard | Combustion Behavior of Bio Slurry Oils and Their Use in Boilers |
| Johansen, Mathias | Advanced Control Strategies for N2O Control From Wwtps |
| Jørgensen, Sigurd Bay | Studies of the Active Site and Reaction Mechanism for the Industrial Methanol Synthesis Catalyst |
| Kjeldbjerg, Camilla Maria | Heat Transfer in Dielectric Elastomers and its Influence on Dielectric Breakdown |
| Kreutzfeldt, Mads Grønald | Techno-Economic Study of Carbon Dioxide Capture and Conversion |
| Li, Jiangui | Measurement and Correlation of Kinetic Rate Constants in Enzymatic Promoted CO2 Removal Solvents |
| Lomholdt, Niels Frithjof | Pilot scale Development, Measurements and Modelling of Enzyme Catalysed CO2 Removal Processes |
| Nguyen, Thanh Thien | Synthesis and Quantification of Various New Poly(acrylate)/PDMS Interpenetrating Networks |
| Nielsen, Rasmus Fjordbak | Design of Cyclic Distillation Units |
| Olsen, Martin Due | Modeling of Phase Equilibria for Salt-Acetone-Water Mixtures |
| Pol, Isabel | Conversion of Lignosulfonate to Value-Added Chemicals |
| Rasmussen, Jess Bjørn | HCl Absorption by Raw Meal |
| Rehman, Mujeeb Ur | Recycling of Phosphorus From Biomass Ashes |
| Schmidt, Morten Saaby | Degradation of Keratin by Bacteria |
| Sieverts, Michael Gram | Methods of permeability measurements |
| Sode, Michael | Catalytic oxidation of methane |
| Tomás, Elena | Conversion of Lignosulfonate to Value-Added Chemicals |
| Zilstorff, Frederikke Byrial | Experimental Determination of the Solubility of Exotic Scales at High Pressures and High Temperatures |

MASTER OF SCIENCE DEGREES

67 students completed their research projects for the MSc degree. The project titles and names of the students are listed below:

| | |
|---------------------------------|---|
| Abdullahi, Abdirahman | Separation of trace components from aqueous solution |
| Aloupis, Georgios | Modelling of thermodynamics of hydrate inhibitor systems |
| Andersen, Christian | Preparation of bio-based polymers by enzymatic polymerization |
| Andreassen, David Richterhausen | Reduction of Metal Contaminants in Coal Tars |
| Assaf, Rima Adnan | Identification of antioxidants in polymers by HPLC |
| Baghooee, Hadise | Propagation of the liquid-liquid interface in a two-phase flow in a porous medium |
| Berendt, Kasper Leonhard | Enzyme immobilization on ceramic membranes |
| Bisgaard, Jonas | Development and use of sensor particles |
| Bonde, Christian Loft | Speciation of Chemistry in Biomass Ashes |
| Bloch, Cæcilie Sejr | Optimal catalyst composition for a propane dehydrogenation catalyst |
| Calvera, Cristina Plaza | Sustainable CO ₂ Capture and Conversion Process Design |
| Camacho Vergara, Edgar Luis | Modelling Gas Hydrates with Improved Langmuir Adsorption constants |

MASTER OF SCIENCE DEGREES

| | |
|---------------------------------------|---|
| Chatterjee, Rishika | Studies of the Interaction between Cu and ZnO in the Industrial type Methanol Catalyst |
| da Costa Martins, Duarte Miguel | Study of Vitamin Stability |
| Dias Freitas de Lima O. Marlene Alice | Development and use of sensor particles |
| Gadeberg, Matias Normann | Development of model predictive control for falling film evaporators |
| Garg, Nipun | Fines formation during CO ₂ low salinity WAG (CO ₂ LSWAG) EOR |
| Gonzalez Garcia, Marta | Solvent Based Separation of Azeotropic Mixtures |
| Gottschalck-Andersen, Jacob Rom | Modelling of drying and its effects on catalytic activity |
| Gupta, Shivangi | Long-term durability of silicone coatings for biofouling protection of ships |
| Hansen, Martin Møller | Upscaling of catalytic fixed bed reactors |
| Hao, Jiasheng | Experimental study of enhanced oil recovery by application of advanced chemicals |
| Højgaard, Lise Bomholt | Energy assessment of aspects related to conversion of seaweed into value-added products in Ghana |
| Israelsen, Kasper Christian | Development of a glucose oxidase method for mass transfer characterization in a bioreactor |
| Jhamb, Spardha Virendra | Development of a Model for Ultrafiltration Systems |
| Karlsen, Kristian Barreth | Seaweed fingerprinting and bioprocessing |
| Kepa, Katarzyna | Grafting on ionic monomers onto ePTFE for improvement of facial implants |
| Khusainov, Ilсур | Diffusion in Protective Organic Thermoset Coatings |
| Kikas, Erki | Simulation and Analysis of a Deodorization Process |
| Kurz, Dorothee Luise | Microbial diversity in a fast anaerobic biofilm digestion biogas system |
| Latipov, Rifnur | Characterization of PEO-based copolymers' behaviour and stability in fouling-release coatings |
| Leth-Espensen, Anna | Mathematical Modeling of Coffee Extraction in Packed Beds |
| Lodberg, Anders | Modeling and experiments for recycling of phosphorus |
| Lundquist, Casper Wolf | Improved dissolved oxygen control in fermentations with filamentous fungi |
| Lydom, Simon Ingvarth | Emissions from Cement Production |
| Lymperis, Konstantinos | Modeling H ₂ S and COS balances in underground natural gas storage facilities |
| Madsen, Line Riis | The effect of entrapped air on drying droplets in a spray dryer |
| Malek-Shah, Masoud Mohamed | Validation of a general acid-base equilibria model plug-in for bio-based processes |
| Marke, Henrik Sander | Modeling of a microfiltration recovery process |
| Marques Couto, Rita Margarida | Accessory enzymes for improved removal of carbohydrates from biorefinery lignin |
| Masik, Joosep | Modeling Oxygen Mass Transfer in a Static Mixer Section of a U-Loop Reactor |
| Meester, Michel | Influence of additives on soot formation in diffusion flames |
| Meyer, Kristian | Simulation tool development and control study of heat integrated distillation |
| Milla Diaz, Kevin Julio | Simulation of enzyme-based biogas upgrading |
| Mortensen, Søren | Further development of the electrolyte equation of state for electrolyte systems |
| Mosbech, Caroline | Genom-based enzyme discovery |
| Muse, Mohamud Abdi | Simulation of Heat pump for flue gas from wood chip combustion |
| Neerup, Randi | Kinetics of enzyme-enhanced CO ₂ capture |
| Nemming, Louise Kjer | Biogas production in fixed filter fixed film reactor systems |
| Nielsen, Mette Joan | Concentration of liquid from pre-treated sugar beets by using membrane technology |
| Nielsen, Nans Liv | Substrate selectivity of endo-beta 1,4-mannanases |
| Palazon, Lorena Bianco | Continuous production of solvent-based coatings |
| Paraskeva, Ioulietta | Solvent Swap Method for Separation Tasks |
| Pedersen, Patrick Nicklas | NO _x in RDF combustion |
| Pronk, Robin Christiaan | Experimental study of clay fines migration as a consequence of low-salinity water injection |
| Rajendram, Rajatheepan | Solubility modeling of active species |
| Rasmussen, Morten Lund | Thermal conversion of CH ₃ Cl |
| Rodriguez Pupo, Alejandro | Thermodynamic modeling of scale formation in brines from HP/HT reservoirs |
| Rosanas, Ana-Sofia Sanchez Arcilla | Superstructure based Optimization for Synthesis of Biofuels and Chemical Processing Routes |
| Sayed, Abdulllah Mohammad | Design and process for the removal of SO ₂ from diesel exhaust |
| Schmidt, Ricky Daniel | Polymeric materials for medical applications |
| Schouw, Mathias | Development of gasoline isomerization kinetics and study of carbon compounds deposited on the catalysts used in the upgrading of TIGAS gasoline |
| Seaby, Brian Graham | Value-added biochemical production from complex substrates |
| Sigurdardóttir, Sigyn Björk | A membrane bioreactor for high performance production of fluconic acid and lactic acid |
| Svith, Casper Stryhn | Single particle modeling of RDF combustion |
| Toderascu, Andreea Genoveva | Kinetics for gasification of biomass char |
| Torbensen, Kasper | Proactive well workover & maintenance model |

SDC MASTER DEGREES

14 students completed their research projects for the MSc degree/dual degree. The project titles and names of the students are listed below:

| | |
|-----------------|---|
| Cao, Xiaotong | The preparation and application of a multifunctional membrane based on polydopamine (PDA) coatings |
| Chen, Yuan | Co-production of activated carbon, bio-oil and combustible gases from pyrolysis of penicillin mycelial dreg |
| Feng, Kai | Stability of bioreactors responding to environmental disturbance associated with microbial diversity |
| Fu, Zhaolin | In-situ hydrodeoxygenation upgrading of bio-oil |
| Ge, Yuanzheng | System Evaluation of Power To Gas |
| Ni, Lingli | Synthesis of terephthalic acid from cellulose derivatives |
| Qi, Chunping | Recycle of TiO ₂ carrier from Waste SCR catalyst and property evaluation of fresh SCR catalyst made by this recycled carrier |
| Shan, Youna | Cellulose-based hybrid aerogels |
| Song, Yuanmei | Promotion of methane hydrate formation by adding other trace of gases |
| Tian, Tian | Validation study on the continuum modeling of dense granular flow |
| Wang, Xingxing | Synthesis of diphenyl carbonate from phenol and carbon dioxide catalyzed by multi-functionalized ionic liquid |
| Yao, Haoyu | Removal of nitrogen-containing compounds from fuel oil through reactive extraction |
| Zhang, Jingyuan | CFD simulation of an industrial MTO fluidized bed reactor |
| Zhang, Yaqin | Computational study of dissolution of lignin in ionic liquids |

THE FACULTY 2016

SCIENTIFIC



Jens Abildskov
Associate Professor



Jakob Munkholt
Christensen
Assistant Professor



Karsten H. Clement
Professor (Docent)



Kim Dam-Johansen
Professor,
Head of Dept.



Anders Egede Daugaard
Associate Professor



Philip Fosbøll
Associate Professor



Rafiqul Gani
Professor



Hariklia N. Gavala
Associate Professor



Krist V. B. Gernaey
Professor



Peter Glarborg
Professor



Ole Hassager
Professor



Jakob Kjøbsted Huusom
Associate Professor



Anker D. Jensen
Professor



Søren Kiil
Associate Professor



Georgios M.
Kontogeorgis
Professor



Ulrich Krühne
Associate Professor



Xiangdong Liang
Assistant Professor



Anne Meyer
Professor



Anna E. Lantz
Associate Professor



Manuel Pinelo
Associate Professor



Alexander A. Shapiro
Associate Professor



Gürkan Sin
Associate Professor



Ioannis V. Skiadas
Associate Professor



Anne Ladegaard Skov
Associate Professor



Nicolas Von Solms
Associate Professor



Peter Szabo
Associate Professor



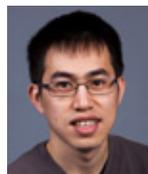
Kaj Thomsen
Associate Professor



Stig Wedel
Associate Professor



John Woodley
Professor



Hao Wu
Assistant Professor



Hanne Østergård
Research Specialist

ADMINISTRATIVE AND OPERATIVE



Gitte Brandt
Head of Secretariat



Ivan Hundebøl
Special Consultant,
PILOT PLANT



Lars Klørboe
Head of PILOT PLANT

EMERITUS



Søren Hvilsted
Professor
(Research manager)



Gunnar Jonsson
Associate Professor
Emeritus



Sten Bay Jørgensen
Professor Emeritus



Michael L. Michelsen
Professor Emeritus
(Docent)



John Villadsen
Professor Emeritus

KTSTUDENTS



Our student organization, KTStudents, represents all students in the courses at the department. Its goal is to improve the study environment for students through social and professional activities.

< From the top-left row: Joachim Thrane, Parth Joshi, Nail Tamaev from the left bottom row: Christian Schandel, Hugo Mobarec, Kristian Krum (missing from the photo: Andres Pelayo)
Photo by: Christian Carlsson

Company presentations

Companies within the chemical and biochemical areas are invited to present their daily work and challenges. The company presentations give the students a better understanding of their potential future jobs, an opportunity to network and thereby a way for the students to attain projects, internships, or student jobs.

Company visits

The students are given the opportunity to visit companies within the chemical

and biochemical fields. The tours around the production plants give the students insight into large-scale industry and the surrounding working environment.

Social events

Through social events, students get to socialize and network with other students. These activities especially strengthen the network between international and Danish students.

Liaison between the department and the students

In addition to providing knowledge about what a career in the chemical engineering industry entails, KTStudents also aims to help the academic development of chemical engineering students by acting as a liaison between the department and the students. We aim to expose students to research undertaken at DTU Chemical and Biochemical Engineering to generate awareness about the research centres and to facilitate a direction for BSc, MSc or PhD thesis topics.

GUESTS

VISITING PHD STUDENTS

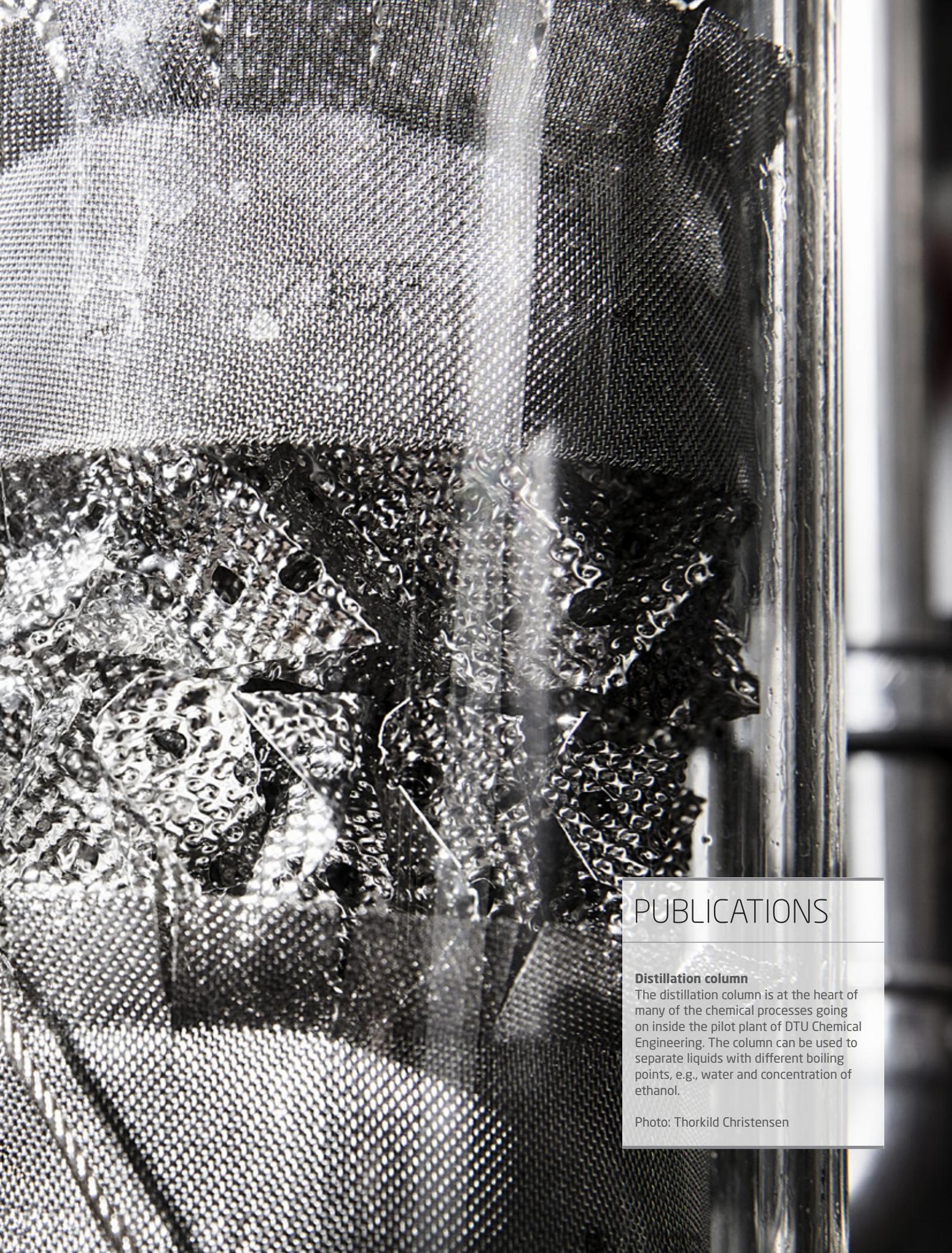
Yang Wang from North China Electric Power University, China
Miguel Àngel Vázquez Domínguez from Dept. de Ingeniería Química y Ambiental, Spain
He Liu from Chinese Academy of Sciences, China
Xiaolong Li from University of Petroleum, China
Isabel Maria Gonzalez Delgado from URJC, Spain
Seongwoong Bae from KAIST, South Korea
Shuai Yang from University of Chinese Academy of Sciences, China
Shiwen Sun from TU Graz, Austria
Maximilliam Kuhnhenh from TU, Darmstadt, Germany
Anna Panteli from Imperial College London, UK
Salvatore Constanzo from University of Kreta, Greece
Xianling Zheng from Institute of Bioenergy & bioprocess Technology, China
Shi Huang from Qingdao Institute of BioEnergy & Bioprocess Technology, China
Aurora Srishti from University Montpellier, France
Alessandro Rosengart from Politecnico de Milano, Italy
Boeun Kim from KAIST, South Korea
Dasom Lm from KAIST, South Korea
Klaus Pellicer Alborch from TU, Berlin, Germany
Matej Danko Slovak from University of Technology, Bratislava, Slovakia
Stefano Lillia from Politecnico de Milano, Italy

Teng Ma from Chinese Academy of Sciences, Beijing, China
Xinsheng Hu from China University of Mining & Technology, China
Huang Shi from QIBEBT, Chinese Academy of Science, China

OTHER VISITORS

Postdoc Xiaoguang Yang from Harbin Eng. University, China
Professor Luke E.K. Achenie from Virginia Tech., USA
Professor Victor M. Ugaz from Texas A&M University, USA
Professor Karim Muhammad Nazmul from Texas A&M University, USA
Professor John Kim from University of Alabama, USA
Professor Paul Marchall from University of North Texas, USA
Professor Bernhard Hauer from University of Stuttgart, Germany
Professor Heath Turner from University of Alabama, USA
Professor Michael A. Brook McMaster University, Canada
Professor Dimitrios Vlassopoulos from University of Crete, Greece
Professor Yujun Wang from Tsinghua University, China
Professor Zhimin Lu from South China University of Technology, China
Assistant Engineer Megane Richez from Polytech Grenoble, France
Engineer Julian Le from INSA Lyon, France
Senior researcher Dou Kejun from CNREC, China
Researcher Jisong Bai from Chongqing University of Science & Technology, China





PUBLICATIONS

Distillation column

The distillation column is at the heart of many of the chemical processes going on inside the pilot plant of DTU Chemical Engineering. The column can be used to separate liquids with different boiling points, e.g., water and concentration of ethanol.

Photo: Thorkild Christensen

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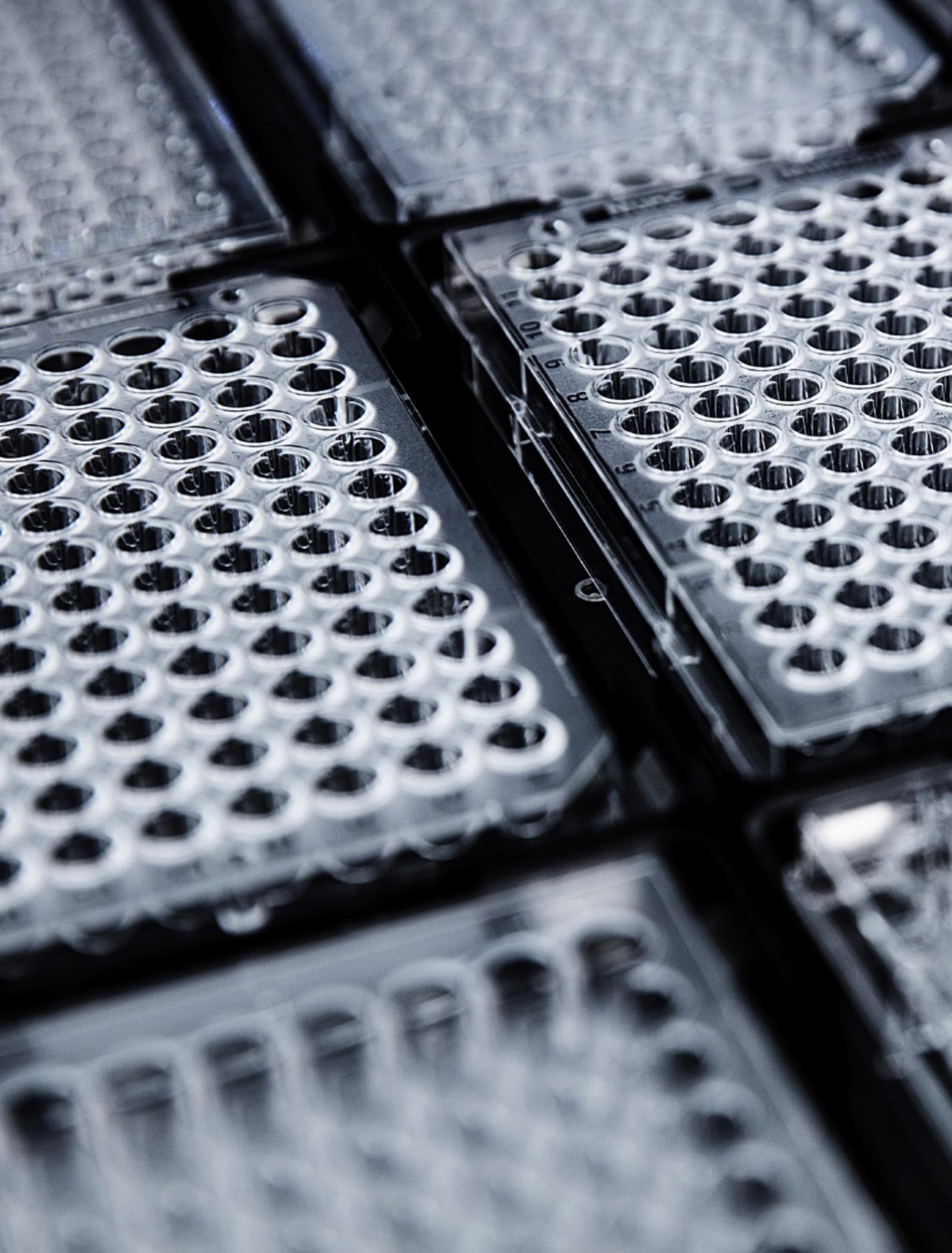
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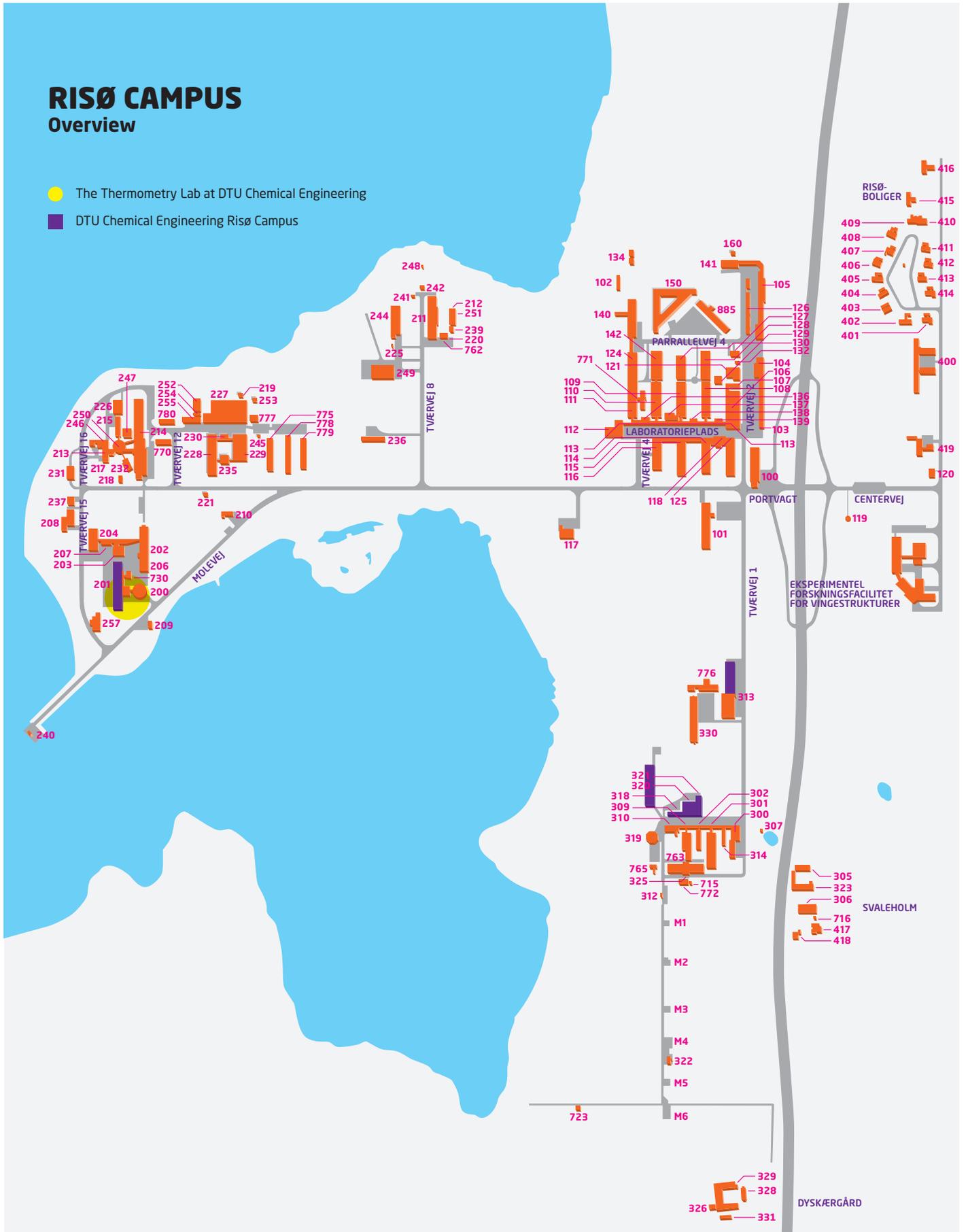
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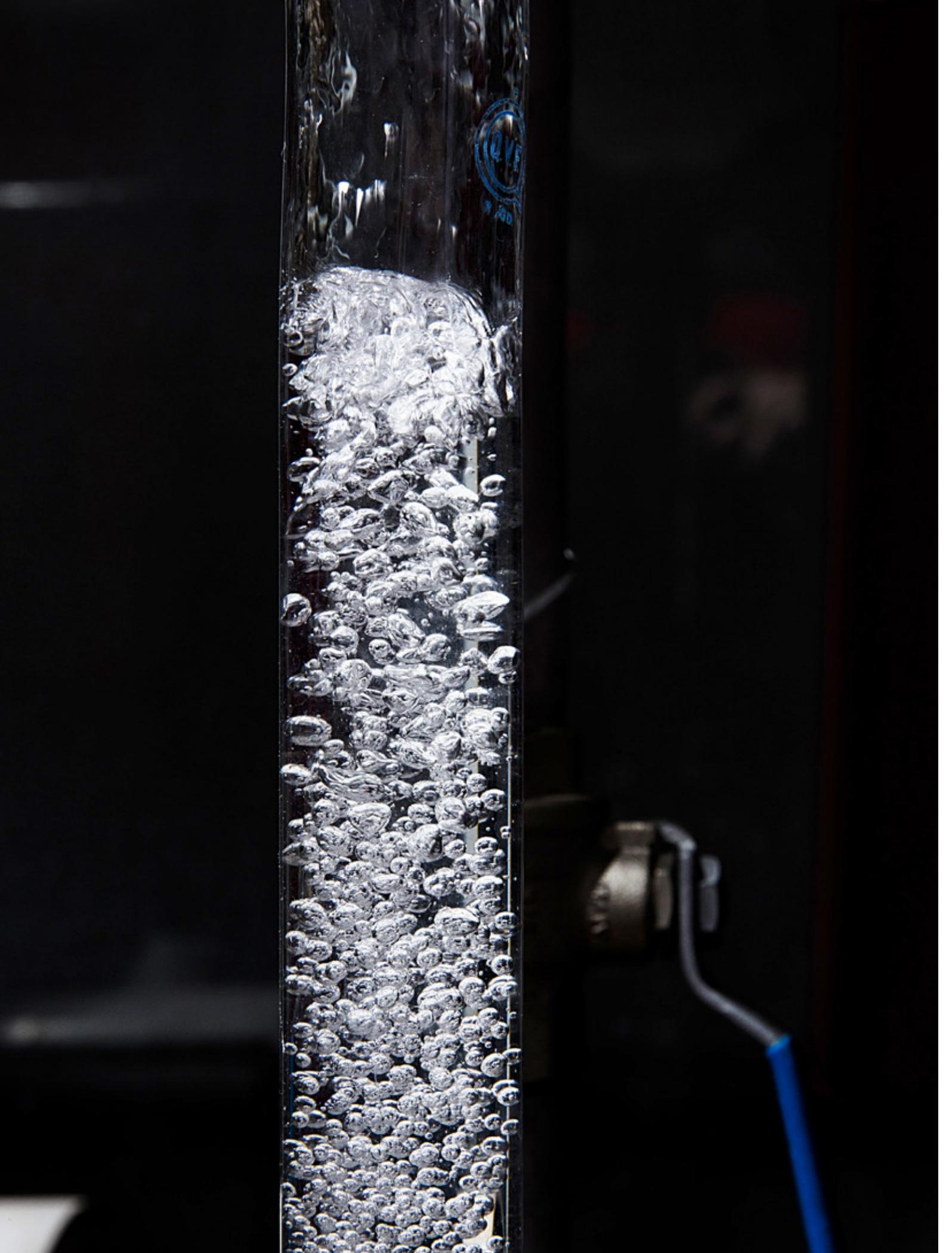


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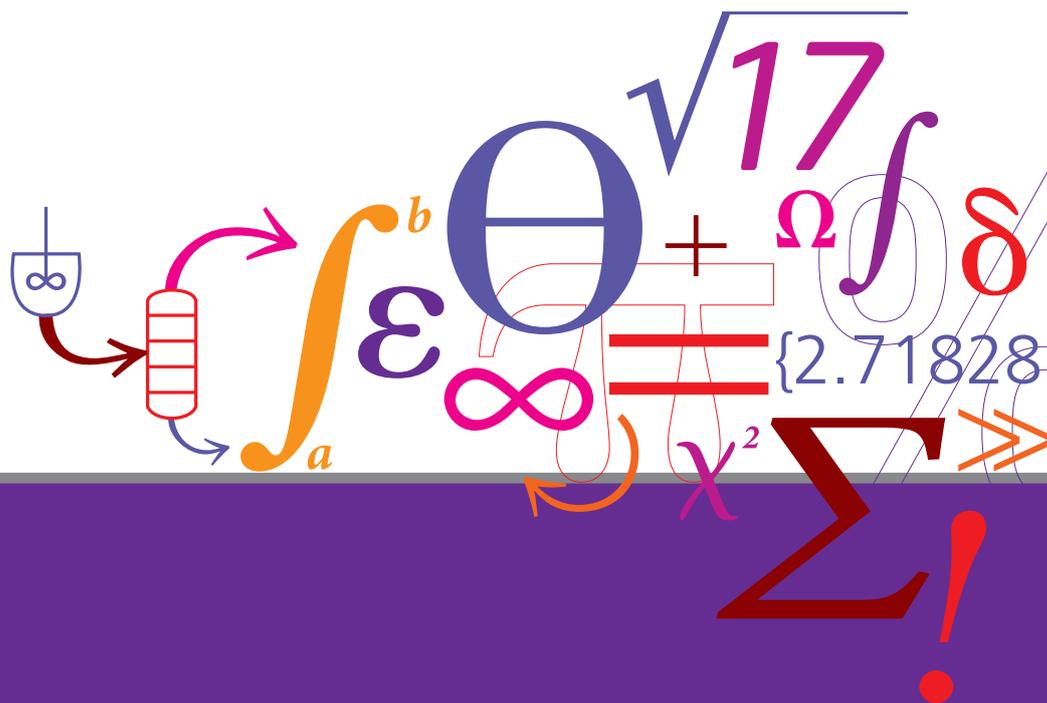
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