

JAARVERSLAG 2019



Advanced
Research Center
**Chemical Building
Blocks Consortium**



ARC CBBC researcher Rim van de Poll at the heterogeneous catalysis laboratory at the Eindhoven Hub.

JAARVERSLAG 2019



Table of contents

5	Foreword
6	ARC CBBC in a Nutshell
10	Highlights of 2019
12	Ambition and Mission
18	Three Hubs across the Netherlands
24	Scientific and Societal Output
34	Community Building and Education
44	Visibility and Collaboration
50	Organisation and Governance
58	Diversity and Scientific Integrity
60	ARC CBBC and Beyond

Foreword

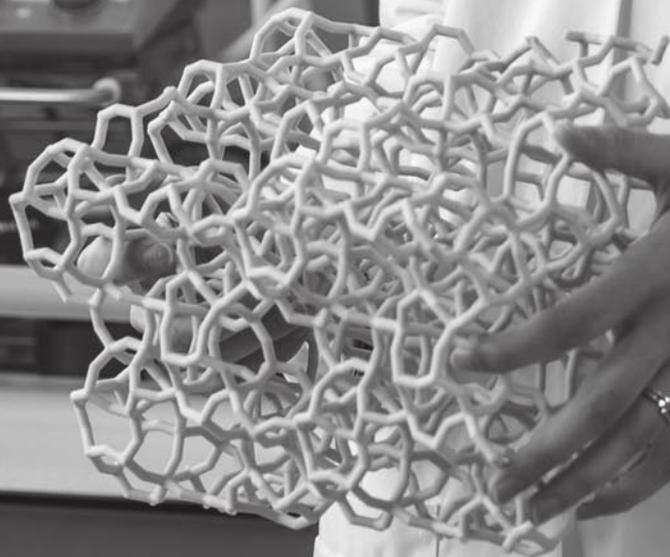
Many of us realize when talking with friends, family and colleagues that we have to minimize our impact on climate and make our daily living more sustainable. At the same time, there is a desire not to compromise on comfort in live and certainly not on safety and well-being. This can only done by using less fossil resources, such as crude oil, and instead using more renewable resources, including waste, biomass and CO₂ and using 'greener' alternatives to existing products. Although this ambition sounds at first sight simple, it is our obligation to indicate to the public that building a more sustainable and circular society requires large investments in science and technology. Indeed, this transition is only possible when we develop often completely new manufacturing routes for fuels, coatings, plastics, pharmaceuticals, and other daily goods, and ensure that alternative products are of similar (or even better) quality than traditional ones. Furthermore, scientific and technological breakthroughs require perseverance as the envisaged transition will take time and the involvement of many creative minds.

ARC CBBC, as a nationwide public-private initiative in the Netherlands, may be of help to generate some of the necessary breakthroughs. These discoveries can be disseminated in the form of publications and patents, as well as by directly transferring the knowledge to industry and society. As important are the education of a new generation of chemists, physicists, chemical engineers and materials scientists, skilled to work with these new technologies. This new generation of people will have a long-lasting impact on the Dutch science and technology infrastructure: Their new ideas and skills will create bottom-up sustainable solutions in academia and industry. I fully enjoy to see how our PhD students, postdoctoral fellows, and tenure-track assistant professors, fully engage and cooperate in our flagship programs on fundamentals of catalysis, coatings and small molecule activation. We are also well on our way to build unique research infrastructures, located at three hubs at the universities of Groningen, Eindhoven and Utrecht, to perform cutting-edge research. This excitement for new science and technology, fully endorsed by our executive, supervisory and scientific advisory boards, can be noted in this annual ARC CBBC report.

Bert Weckhuysen,
Scientific Director ARC CBBC

ARC CBBC in a Nutshell

Breakthrough research for a more sustainable world



To create a sustainable world, creative solutions with long-term impact are highly needed

- New solutions will need to be accepted by the general public, and we need to make sure these can be used in a safe and sustainable way.
- We have all set ourselves the target to succeed in the energy transition and in the transition to a circular economy.
- The technology that will enable the chemical industry to become fully sustainable is not available yet. Therefore, it is clear to industry and academia that real steps are now needed. Only with breakthrough innovation and technological advancement we can achieve our ambition of making industrial production sustainable.
- If this is done in the right way, this will lead to industrial leadership and growth. It is an enormous responsibility and we simply cannot wait for other countries.

We need to act now. Time is running.

This change asks for fundamental scientific research and new paradigms

- Chemistry is the starting point and the basis of many value chains. Developing new materials and transforming chemical production and processes will have a substantial impact globally.
- Fundamental science and strategic research is necessary to achieve success in the transitions. ARC CBBC can make a major contribution to this: for real change, it is necessary that academic and industrial research team up and work together to reconsider materials and production routes and reinvent the way that chemistry is applied on industrial scale.
- The Netherlands has a strong knowledge position in the field of chemistry with world-leading university groups and researchers. Also, it is home to R&D departments of globally active chemical industries. On top of that, the country is committed to be at the forefront of innovation and change. This is why ARC CBBC started off in such a small country.

We need to reinvent chemistry. To make the change.

Alternative materials and products, CO₂-neutral feedstock, eliminating waste, circulating and recycling products, designing and making the materials of the future.

Joining forces will be crucial to succeed

Enhancing the introduction of new materials, the role of CO₂-neutral feedstock, renewable feedstock and energy, eliminating waste, and circulating and recycling products will lower our CO₂-footprint, diminish the need for harmful raw materials and accelerate the necessary transition towards a more sustainable future.

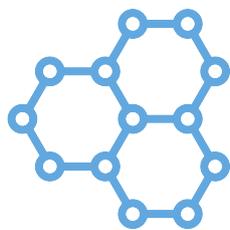
ARC CBBC

- has a unique public-private character with a long-term initial commitment of 10 years of its partners;
- brings together leading international chemical firms, research universities and high profile chemical researchers;
- has the power to make a real impact throughout the chemical industry's value chain with its innovation chain approach, from raw materials to building blocks and products;
- operates within a broad spectrum of the chemical sciences, sharing complementary expertise and a research infrastructure;
- can build on its partners and additional financial support of the Dutch Research Council (NWO), the Ministry of Economic Affairs and Climate Policy and Holland Chemistry;
- has an international Scientific Advisory Board which safeguards the innovativeness and scientific potential of its research programme;
- executes long-term research programmes which tackle the following challenges:
 - Advancing the use of sustainable products and materials;
 - Cutting down non-renewable energy consumption;
 - Substituting non-renewable feedstocks for sustainable alternatives;
 - Designing processes in a circular fashion to prevent feedstock waste, including CO₂.

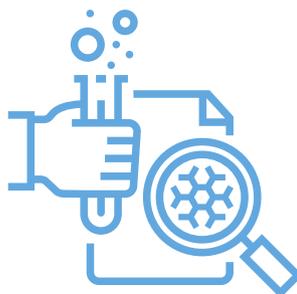
Imagine, if we could:

- **Compose a generation of high-performance paints and materials from bio-based building blocks and water.**
- **Design the functional materials of the future, which allow us to live our lives cleaner and in health by cleaning our air.**
- **Create sustainable electronic devices, for example a mobile phone without a carbon footprint.**
- **Drive and fly around using zero-emission fuels, ideally starting directly from e.g. CO₂.**

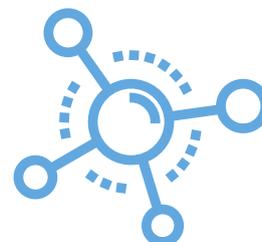
How does ARC CBBC organise this



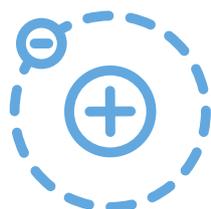
3 academic hubs at the universities of Utrecht, Groningen and Eindhoven with dedicated lab space, tenure-track assistant professors and technical staff



An extraordinarily talented group of 42 leading scientists affiliated with universities throughout the Netherlands



4 leading international industrial partners, AkzoNobel, BASF, Nouryon and Shell, with outstanding R&D activities and representing the majority of the chemical sector



19 one-on-one bilateral research projects in which the in-house R&D of the industrial partner works closely with a young researcher in academia



150 PhD and postdoc (PD) positions created to execute the joint research programme - 47 young researchers currently at work: 3 PD's and 44 PhD's; 20 female and 27 male



Three big flagship projects, in which multiple partners participate, on science for energy, functional materials and coatings.

ARC CBBC is unique. Its partners collaborate and want to put their joint research power into reinventing chemistry for a sustainable world.

Highlights of 2019

Building a leading platform for sustainable chemistry and with real impact

Ambition and New Focus

ARC CBBC is continuously sharpening its mission, vision and strategy to develop sustainable, circular chemistry technology to the benefit of the society, its members, and economy at large.

- The Supervisory Board (SB) advised to sharpen the focus and shared ambition of the consortium and to find a more coherent programme. It must lay the foundation for an impactful ARC CBBC and a strong public profile. The SB used an independent consultant, to explore the joint vision and mission of the partners for the consortium.
- The Executive Board (EB) concluded that they wish ARC CBBC to be known and recognized as the hotspot for *Circular Chemistry*, based on the principles of (1) renewable feedstock; (2) renewable energy and (3) circular process design. Emmo Meijer, chair of the Topsector Chemie, led a pressure cooker session within the EB in September 2019, in which the board defined its renewed role.
- It was decided to set up a fourth flagship with 16 PhD positions that builds on this new mission.
- The Scientific Advisory Board (SAB) held their annual meeting and provided independent advice on the formation of the research programmes, including the assessment of bilateral research project. They safeguard the quality and innovativeness of the running and newly planned research.
- At the initiative of the SB, the Communication Workgroup was established in 2019. This group, in which communication experts from all partners are involved, works on setting up and refining the communication strategy and creating a public profile of ARC CBBC.
- To play a leading role in providing the world with creative scientific solutions and technological advancement, collaboration and sharing complementary expertise is essential. Therefore, links were established with other initiatives, such as SUNERGY, which has substantial overlap in ambition with ARC CBBC.

Visibility & Collaboration

ARC CBBC strives to build pride, commitment and enthusiasm amongst its researchers, industry partners, universities and potential new partners. We want to stand out as a unique collaboration.

- February 13: ARC CBBC proudly opened its first own laboratory at the Utrecht University hub, a great step in building the consortium's unique research infrastructure.
- March 17 - 21: A delegation of the Dutch Topsector Chemistry, including ARC CBBC, visited China to foster cooperation and explore the topics 'coatings and functional materials' and 'chemical recycling of plastics'.
- April 16: the ARC CBBC community gathered for the second annual symposium, hosted by the Eindhoven University of Technology hub. More than hundred people including young researchers, members, board members, and support staff attended this symposium.
- August 24 - 27: Catalysis Connected, a post-conference of EuropaCat 2019, was organised by ARC CBBC together with VIRAN, DSC and MCEC, to advance the catalysis field and emphasise the importance of collaboration in the catalysis world.
- December 10 - 11: ARC CBBC organised a focus session during CHAINS which explored the potential of energy transfer from electricity and (sun)light via innovative catalytic reactions based on electrochemistry and electron plasmon resonances.

Community Updates

ARC CBBC builds a strong community of high-profile scientists and creates a dedicated research infrastructure to innovate and realise impact.

- Five new academic members joined in 2019: Peter Bolhuis, Erik Garnett, Kitty Nijmeijer, Evgeny Pidko and Monique van der Veen. These researchers bring in knowledge and experience in the fields of 1) the chemistry and physics of surface plasmon resonance phenomena 2) separation technology by membranes for controlling novel photo- and/or electrocatalytic reactions and (3) theoretical and computational chemistry.
- 19 new young scientific researcher positions (17 PhDs and two PDs) were filled in 2019. This brings the total amount of young academic researchers to 47.
- Three Tenure Track Assistant Professors were hired: Eline Hutter (Utrecht hub), Marta Costa Figueiredo and Nikolay Kosinov (both Eindhoven hub).
- The Utrecht hub currently has three fully equipped lab spaces with state-of-the-art equipment research equipment, such as a Grazing Incidence X-Ray Diffractometer (GI-XRD) and an advanced IR microscope combined with Atomic Force Microscopy (AFM).
- The Groningen Hub is building three expertise centres within two designated ARC CBBC synthesis labs: the Centre for Flow and Photochemistry, the Centre for Synthetic Electrochemistry and the Centre for Building Block Synthesis.
- The Eindhoven hub acquired new and unique instrumentation.

Scientific Excellence

ARC CBBC aims to perform research of the highest level, both in terms of excellence and impact.

- A total of 14 publications were published in peer reviewed journals, including publications in *Nature Communications*, *Nature Catalysis*, *ACS Catalysis*, *The Journal of the American Chemical Society* and *Science*.
- Two patent applications based on bilateral ARC CBBC projects were filed.
- Professor Ben Feringa received honorary doctorate degrees from the University of Santiago de Compostela and the University of Johannesburg.
- The National Academy of Sciences elected Ben Feringa as one of their new foreign associates.
- Professor Bert Weckhuysen awarded with the Karl Ziegler Guest Professorship.
- Professor Hans Kuipers was awarded with the Zhang Dayu Lectureship.
- Professor Jan van Hest and Professor became member of the Royal Dutch Academy of Sciences (KNAW).
- Professor Petra de Jongh became member of the Royal Holland Society of Sciences and Humanities (KHMW).
- Professor Marc Koper was awarded the 2019 Netherlands Catalysis and Chemistry Award.
- Professor Bert Meijer was awarded an Honorary Degree from the Freie Universität Berlin.
- Professor Detlef Lohse received the 2019 Max Planck Medal.
- Dr. Matteo Monai won the 2019 'Young Researcher of the Year' Eni award.

Community Building & Education

ARC CBBC develops complementary skills training for its PhDs and PDs, to help them develop professionally.

- The Talent Programme offered various trainings and workshops in 2019: Presentation, Infographic, Patents, and a tour of the research facility of Shell Technology Centre in Amsterdam.
- The PhD students and PDs of ARC CBBC initiated their own community: Young CBBC. Their mission is to inspire, inform and engage with each other.

Ambition and Mission

ARC CBBC is a Netherlands-based consortium with focus on creating breakthrough sustainability solutions in the areas of energy carriers, functional materials and coatings. In 2016, the partners committed to funding and building up a unique public-private partnership for at least ten years.



Collaboration

Through this consortium, leading multinational companies and Dutch universities have joined forces to fundamentally change the environmental footprint of products and production processes, by stepping up the circularity of our economy and creating a promising perspective of cleaner production, new functional materials and energy use.

The founding partners are Shell, AkzoNobel, BASF and Nouryon, and the Universities of Utrecht, Groningen and Eindhoven. The partners mutually recognised their strengths and complementary expertise which, together, will be powerful in addressing the complex challenges for the current industrial production processes of many goods and materials. The consortium is open, meaning that other partners can join upon investing. Additional financial support is received from the Dutch Research Council (NWO), the Ministry of Economic Affairs and Climate Policy (Ministerie van EZK) of the Netherlands and Holland Chemistry.

In order to create a more sustainable world, short-term restrictive measures are not likely to suffice, and, instead, creative solutions with real impact on the long-term energy and materials footprint are needed. Therefore, ARC CBBC has chosen a unique way of

working: the partners jointly decide on long-term programming and investments in research activities, infrastructure and human resources. The consortium strives for the highest possible quality and novelty of research, which is safeguarded by our independent international Scientific Advisory Board (SAB).

The consortium fosters links between leading academic researchers and industry. The resulting proprietary innovation programming comprises blue sky research, ranging from exploratory fundamental science to more demand-driven strategic research. Currently, there are already around 40 high-profile scientists in the Netherlands affiliated with ARC CBBC, which, together with industrial researchers, develop and foster new talent in the form of over 40 PhD students and postdoctoral researchers.

These are the workforce for research and development in the decades to come. In Utrecht and Groningen, ARC CBBC has already invested in new laboratories and created a dedicated research infrastructure.

ARC CBBC has proven a working model and with the continuous support of its partners it may become the leading platform for research on future chemistry within Europe.

Perspective for Impact

Impact

Feedstock use, material design and energy consumption are inherent to the working of the chemical sector. Given that the chemical industry supplies the base products in the form of fuels, solvents, polymers, and specialties widely and reforms these into products, the redesign of chemical

operations to make these processes and materials more sustainable will have a positive impact on the overall sustainability of many other industry sectors and general product use and consumption.

The Netherlands is home to world-class academic research groups in chemistry,

physics as well as chemical and materials engineering; world-renowned multinational chemical industries have research and development facilities here, and, on top of that, the country acts as industrial production site that supplies mainland Europe and overseas. The advantage of its relatively small size is that it forces companies and researchers to jointly choose focus, accelerate and specialise in order to be internationally competitive. The academia, industry and government are all willing to make real societal impact by offering the chemical sector the tools to become more sustainable. For the chemical sector, both the knowledge base and partners required to tackle crucial steps in the introduction of new materials, the climate transitions, energy transition, and transition to a circular

economy are present. With all basic requirements present, ARC CBBC aims to make a positive impact by providing the chemical sector with the knowledge, technology and tool network appropriate for the producing sector of the future. The consortium strives to enable partners of the consortium to have a head-start in a cleaner and more sustainable way of operating, thus allowing them to accelerate their adaptation to the new economy and, thereby, increase their competitiveness. At the moment, the urge to make the transition to new materials, a circular economy, the energy transition and implement real climate change mitigation measures are stronger than ever has been felt before. It is our ambition that new perspectives for the chemical industry will find its origin at ARC CBBC.

Ambitious Flagships address Societal Challenges

Joint research

The chemical sector is crucial to the industrial production of goods and materials that our society relies on. However, our society as a whole should take the initiative to change the current way of working regarding the depletion of natural resources and climate change. ARC CBBC brings together scientific excellence and leading chemical companies around their joint ambition of creating impact by new chemistry for a sustainable industry.

Transition to a circular economy

Current chemical production processes largely depend on the consumption of non-renewable feedstocks. The Netherlands has committed itself to preventing waste streams and making the transition to a circular economy with 100% circularity in the year 2050. For the chemical industry, this comes

down to redesigning feedstock choice and material streams, resulting in new-to-develop processes. The concept of circular chemistry aims to replace today's linear 'take-make-dispose' approach with circular processes. This will optimize resource efficiency across chemical value chains and enable a closed-loop, waste-free chemical industry. The chemical industry and its innovations can lead this transformation.

The flagship Small Molecule Activation contributes to the exploration of preventing feedstock waste towards a circular economy. Ultimately, we want to enable a transition from crude oil-based chemicals to a complete circular economy by using small molecules, such as CO₂, as feedstock. Also methane has tremendous potential as chemical feedstock as it is an abundant and

relatively cheap carbon source with a lower negative environmental footprint than other fossil resources, such as crude oil and coal. The flagship project will specifically explore the activation and chemistry of methane as a first and significant step in energy transition efforts, that later should comprise other small and stable molecules, notably CO₂ and N₂. In this flagship project, state of the art scientific expertise in the fields of heterogeneous catalysis, colloid chemistry, materials science and chemical reactor concepts are combined. The researchers of e.g. industrial participants BASF and Shell are involved and share the long-term ambitions and scientific interest. They have the industrial background to take up and bring further results from this flagship programme.

Climate change mitigation & energy transition

Currently, vast amounts of greenhouse gas emission, notably in the form of CO₂ are inherent to energy production and operations in the petrochemical, chemical and base metal sectors, such as the steel industry. All of these activities have significant presence in the Netherlands. Energy-intensive industrial operations at a few locations in the Netherlands are responsible for a vast share of the national energy consumption, and, for now, mostly run on non-renewable energy sources. At the same time, the Netherlands is committed to the energy transition, in which a significant part of the energy consumed has to be substituted by renewable energy, without concomitant carbon emissions or adverse effects on climate change.

The flagship Fundamentals of Catalysis explores novel chemical conversion pathways for the production of basic chemicals as well as fuel components.

Current and future energy and chemical industries will rely on a portfolio of highly active, selective and stable catalyst materials. Bimetallic catalysts are interesting because the presence of a second metal can add a wide range of additional functionalities to the catalytic surface, usually bringing about synergies in catalysis. Such synergies can lead to fundamentally different catalytic performance which by itself already may have value as it may lead to more product and less by-products. Such extraordinary performance also allows to partially replace expensive noble metals by base metals. In addition, the concept of bimetallic catalysis allows small amounts of expensive metal to be dispersed at atomic scale in a metallic environment, leading to a more efficient use of that metal. Also here, the involvement of industrial researchers from Nouryon, BASF and Shell are crucial to the success of this research line.

New functional materials

The synthesis and development of new functional materials is exciting, because materials end up everywhere in products and may add powerful functionality to final products. They are key to our future renewable energy, sustainable transportation, building materials and modern electronics. The synthesis and development of new functional materials will enable sustainable applications, preventing waste and avoidable energy consumption and substitution of scarce feedstocks.

The flagship Coatings & Functional Materials, Crosslinking in waterborne coatings with new building blocks illustrates how ARC CBBC explores the use of more sustainable alternatives instead of non-renewable feedstock and aims to improve the performance of sustainable solutions. To be

Research Programme to reinvent chemistry
Within ARC CBBC, science and industry together explore disruptive chemistry for new products, sustainable production processes based on renewable feedstock and renewable energy, without CO₂ emission and creating materials of the future.

ARC CBBC tackles these challenges in multilateral and bilateral programmes. Multilateral programmes involve two or more companies as well as two or more academic partners within the ARC CBBC community. They are typically of the size of 6-10 PhD students and initiated by the academic community in consultation with the ARC CBBC industries. Bilateral programmes are smaller and typically involve 1-2 PhD students. They are a cooperation between one ARC CBBC chemical company and one or more academic partners.

The multilateral programmes, which we call flagship projects, are truly multilateral and address challenges of joint interest of the academic and industrial communities. They are aimed at exploring platform technologies that will be sustainable by definition. In contrast, the bilateral programmes typically accommodate academic and industrial researchers to jointly explore how the new chemical technologies could be developed further before industrial uptake.

more specific, this flagship project explores routes towards novel sustainable binders for use in paints, inks and lacquers that can be obtained by chemical conversion of bio-based polymers such as carbohydrates including cellulose, humins and chitins. Furthermore, novel approaches for high quality coating film formation and novel chemistry for cross-linking of polymer coatings, both important to durable and functional coating products, will be explored. The drive towards sustainable and especially energy-efficient preparation of bio-based products over the next decades compels us, in the context of coatings, to consider readily available feedstocks that can be modified on large scale in a robust manner.

Knowledge on coatings is brought in by researchers from our industrial partners AkzoNobel, BASF, and Nouryon. It is expected that this flagship project will without doubt contribute to a more sustainable future through the development of water-based paints, inks, lacquers and similar coatings that can be produced on the basis of renewable bio-based building blocks. Another positive impact can be made through the design of new materials and techniques, focused on the needs for a modern, water-based paints. This will aid society through the enhanced performance of the final materials.

Three Hubs across the Netherlands

ARC CBBC is proud to be a national platform with its own, often unique research infrastructure consisting of three main 'hubs'. The three hubs are Utrecht University, University of Groningen and Eindhoven University of Technology, with satellite locations throughout the Netherlands.

The necessary infrastructure and human capital to support the research activities of the multidisciplinary ARC CBBC community consists of dedicated lab space, tenure-track assistant professors and technical staff. Each hub is at a different stage of building up its infrastructure and in attracting its scientific and technical staff.



- 1 Utrecht University
- 2 University of Groningen
- 3 Eindhoven University of Technology



Laboratory technician Hannie van Berlo from the Utrecht Hub handling heterogeneous catalyst materials under oxygen-free atmosphere.

Utrecht University Hub

The main focus of the Utrecht University hub is on heterogeneous catalysis. It is aimed to gain fundamental understanding of the relationship between catalyst composition and structure and its functionality. This is accomplished through a combination of advanced X-ray- and electron-based techniques as well as a wide variety of operando spectroscopy and microscopy techniques. These structure-performance relationship elucidations are complemented by various materials synthesis approaches, including those applied in colloid science. In line with this research focus, a Grazing Incidence X-Ray Diffractometer (GIXRD) was recently purchased and installed. This GIXRD instrument is used to study structural properties, such as crystallographic orientation and strain in thin-films and coatings. Furthermore, the Utrecht University hub has built

various set-ups to probe solid catalysts during reactions, using for example operando Raman spectroscopy, and detect reaction products under extreme reaction conditions such as acidic environments and high temperatures. In the near future, a Planar Laser-Induced Fluorescence (PLIF) set-up will be constructed to follow the gas composition just above a thin-layer of catalyst material so that reaction intermediates can be detected, giving new insights in reaction and deactivation mechanisms. The combination of these analytical methods will garner fundamental knowledge in the activation of small molecules, such as CO₂ and methane, and therefore complements the expertise areas of the other ARC CBBC hubs.

Lab and facilities

Since March 2018, Utrecht University harbours three fully equipped lab spaces with state-of-the-art equipment. Next to the aforementioned Grazing Incidence X-Ray Diffraction (GIXRD) instrument, an advanced infrared (IR) microscope combined with Atomic Force Microscopy (AFM), which can measure down to the nanoscale, has been installed. Both instruments are powerful characterisation tools to investigate with unprecedented detail solid materials, which are, for example, investigated in the Flagship Coatings. The 270 square meter space of the Utrecht hub furthermore contains several lab-rooms for catalyst synthesis, characterisation and testing. In 2019, a total number of 14 BSc and MSc students managed to finish their thesis work, showing that the next generation of researchers is already on board.



Ramon Oord, Hannie van Berlo-van den Broek and Eline Hutter, technical and scientific staff of the Utrecht University hub of ARC CBBC.

Staff and vacancies

In early 2018 two lab technicians, Ramon Oord and Hannie van Berlo-van den Broek started working for the ARC CBBC hub at Utrecht University. They started their activities to prepare and fully equip the new hub laboratories, financed by amongst other resources by the Large Equipment Fund (LEF) of ARC CBBC. On February 13 2019, the labs were officially opened. In 2019 they further equipped the three lab spaces with state-of-the-art equipment, which now includes a Grazing Incidence X-Ray Diffraction (XRD) instrument, an operando IR and Raman spectroscopy catalytic test setup for small molecule activation, a high pressure/high temperature operando multi-catalytic test setup (for CO₂ and methane conversion), an AFM-IR microscope and a nano-particle generator to produce very monodisperse nanoparticles in a short amount of time. As more ARC CBBC projects are starting, more home-made equipment is being designed, build and/or acquired. Next to this, Ramon Oord and Hannie van Berlo-van den Broek manage the labs. In addition,

Dr. Eline Hutter was appointed as Tenure Track Assistant professor at Utrecht University. She will use time-resolved spectroscopy techniques to study the relationship between opto-electronic properties of semiconductor materials and their activity and selectivity as photo-catalytic materials. There is one more tenure track assistant professor position available and the hub is recruiting for this position.

“I think it is more important than ever to unite people with different backgrounds and expertise to work together on solving the many global challenges related to energy.”

Eline Hutter, Tenure Track - Assistant professor at Utrecht University



The Linnaeusborg is currently renovated to create laboratories for the Groningen University Hub of ARC CBBC. Source: Ukrant.nl

University of Groningen Hub

The Groningen University hub is composed of three centres of excellence. First, the Centre for Flow and Photochemistry explores combined flow and photochemistry allowing small scale methodology, photoredox-catalyst design combined with upscaling research. Second, the Centre for Synthetic Electrochemistry explores electrification of chemical synthesis via direct electrochemical conversions or electrochemical (organo- and transition metal - redox). Third, the Centre for Building Block Synthesis explores the development of new cross coupling and polymerization methodology as a greener alternative for commonly employed industrial processes. All three centres will be implementing novel research lines, which are independent, but complementary to existing expertise strengths of ARC CBBC. The focus of the

research conducted within the Groningen University hub is on the activating building blocks from renewable resources by homogeneous catalysis and organic synthesis. The Groningen University hub aims to build a state-of-the-art core-facility with maximum flexibility regarding transformations and scale, based on novel sustainable flow, electrochemical, photochemical and photo-redox catalytic conversions.

Lab and facilities

Within the Groningen University Hub, an ARC CBBC lab is established at the 9th floor of the Linnaeusborg. Two synthesis labs will be realised to allow the foreseen expansion of the ARC CBBC team, including the hiring of two tenure-track assistant professors. The three above-mentioned expert centres will be located on the same

floor to fully benefit from its potential within the ARC CBBC community in Groningen. It is expected that these spaces are finished in September 2020.

Staff and vacancies

The three expert centres, together with two fully equipped synthetic laboratories will be made available to facilitate the to-be-hired Tenure Track Assistant Professors. Michael Hansen was appointed as lab technician from 1 November 2018 until 1 July 2019. As per July 1 2020, Dr. Nicole Imholz will start as lab technician for the Groningen hub of ARC CBBC. There are currently two vacancies for Tenure Track Assistant Professors: one in the field of electrochemical synthesis and catalysis and one in the field of functional molecular materials.



Magnetic Resonance Imaging (MRI) facility at the Eindhoven University of Technology Hub.

Eindhoven University of Technology Hub

The Eindhoven University of Technology hub focuses on three research directions. First of all, there are sustained activities on small molecule activation, thereby focusing on porous materials that are able to catalyse the conversion of single carbon-containing small molecules, such as methane and CO₂, into chemical building blocks. In particular, the development of synthesis techniques to prepare well-defined microporous single site catalysts, establishing structure-activity relationships using operando spectroscopy tools and the catalytic conversion mechanisms are studied. A second activity is focused on electrochemistry. Here, the direct use of the renewable electricity to enable chemical bond formation is studied. Electrochemical processes allow operation at mild temperatures, lower pressures and with less waste production than conventional

approaches. For all these reasons, electrochemistry and electrocatalysis are assuming a fundamental role in the development of more sustainable and environmentally friendly technologies. Of particular interest is how electrochemical reactions proceed at high current and elevated temperature needed in large-scale electrolyzing equipment. Investigating electrochemical reactions at industrial relevant condition is very challenging because it requires innovative and complex experimental setups (going beyond the typical lab-based three-electrode cells), well-established protocols, a strong effort in evaluating how these factors influence the efficiency of the electrochemical reactions and how they can contribute to meet industrial requirements. A third line of research focuses on multi-scale modelling of multiphase flows in chemical reactors of the future. Using

highly advanced computer simulations researchers develop accurate models for multiphase chemical reactors used in industry for the large-scale production of synthetic fuels, fertilizers, detergents, polymers and numerous other products. In addition, sophisticated non-invasive monitoring techniques, based on, for example, magnetic resonance imaging, are employed for the detailed validation of the computational models developed, thereby providing a combined theoretical-experimental approach in the field of chemical reaction engineering.

Lab and facilities

As of 2018, preparations were made for the extension of two lab facilities that enable advanced non-invasive characterisation and monitoring at different length scales relevant to the development of solid catalysts and



Marta Costa Figueiredo,
Nikolay Kosinov and
Brahim Mezari, all working in
the Eindhoven University of
Technology Hub of ARC CBBC.

multiphase catalytic reactors. With the combined experimental facilities, the detailed study of transport phenomena and the interplay with catalytic transformations can be performed. As such these investments connect very well with the key research elements addressed within the current and future flagships under the umbrella of Fundamentals of Catalysis and Small Molecule Activation. For gas phase flow imaging, the Magnetic Resonance Imaging (MRI) lab is extended. The lab houses a 7 Tesla MRI scanner capable of measuring both vertically and horizontally materials. The scanner is now fully operational enabling detailed flow and dispersion measurements in packed bed chemical reactors. The extension allows for unique imaging of flow and chemical species transport in gas-solid and gas-liquid-solid (trickle-flow) reactors. For catalytic characterisation, the capabilities of the solid-state Nuclear Magnetic Resonance (NMR) facilities will be extended with focus on the detailed characterisation of catalytic solids, including catalyst-reactant complexes and operando analysis. To make full use of the advanced probe head extensions, the current electronics of the NMR setup will be upgraded with the most powerful console available. The new and unique instrumentation will form an integral part of the advanced ARC CBBC hub's facilities.

Staff and vacancies

Two Tenure Track assistant professors started: Marta Costa Figueiredo has been appointed as assistant professor in electrochemistry. Her research is devoted to electrocatalysis and electro(catalytic)-synthesis of carbon dioxide and biomass. Nikolay Kosinov has been appointed as assistant professor in molecular heterogeneous catalysis. His research is aimed at the synthesis, advanced characterisation and applications of novel microporous catalytic materials for performing chemical reactions. In addition, two lab technicians, Larry de Graaf and Brahim Mezari have started working for the ARC CBBC hub at Eindhoven University of Technology.



Scientific and Societal Output

ARC CBBC aims to perform research of the highest level, both in terms of excellence and impact. Furthermore, it strongly believes in the importance of science communication and outreach activities to the general public and society.

The first research efforts within both one-on-one projects and consortium broad projects has not only led to important new findings, scientific publications and patent applications, but members and researchers of the consortium also contributed to many

events in the form of talks or poster presentations. Besides scientific results and contributions, members and researchers also reached out to a broader public, to inform and inspire others about their research.

Scientific Excellence

In what we report below we give a short overview of the scientific output for the ARC CBBC consortium.

Publications in peer reviewed journals	14
Number of oral presentations	16
Number of filed patents	2
Number of received awards	2
Number of organised conferences	3
Number of poster presentations	64

Summary of the 2019 scientific output of the ARC CBBC consortium.

A total of 14 publications were published in peer reviewed journals, including publications in *Nature Communications*, *Nature Catalysis*, *ACS Catalysis*, *The Journal of the American Chemical Society* and *Science*. Almost all publications are open access since our goal is to be fully compliant with the open access policy of NWO.

List of Scientific Publications

F. J. de Zwart, J. Bootsma, and B. de Bruin, 'Cross-linking polyethylene through carbenes,' *Science*, vol. 366, no. 6467, pp. 800–800, Nov. 2019, doi: 10.1126/science.aaz7612.

A. Bolshakov, R. van de Poll, T. van Bergen-Brenkman, S. C. C. Wiedemann, N. Kosinov, and E. J. M. Hensen, 'Hierarchically porous FER zeolite obtained via FAU transformation for fatty acid isomerization,' *Appl. Catal. B Environ.*, vol. 263, 118356, Apr. 2020, doi: 10.1016/j.apcatb.2019.118356.

A. Ryabchun, D. Yakovlev, A. Bobrovsky, and N. Katsonis, 'Dynamic Diffractive Patterns in Helix-Inverting Cholesteric Liquid Crystals,'

ACS Appl. Mater. Interfaces, vol. 11, no. 11, pp. 10895–10904, Mar. 2019, doi: 10.1021/acsami.8b22465.

A. Ryabchun and A. Bobrovsky, 'Photocontrollable Deformations of Polymer Particles in Elastic Matrix,' *Adv. Opt. Mater.*, vol. 7, no. 24, p. 1901486, Dec. 2019, doi: 10.1002/adom.201901486.

C. J. Bondue and M. T. M. Koper, 'A DEMS approach for the direct detection of CO formed during electro-chemical CO₂ reduction,' *J. Electroanal. Chem.*, 113842, Jan. 2020, doi: 10.1016/j.jelechem.2020.113842.

C. Vogt, M. Monai, G. J. Kramer, and B. M. Weckhuysen, 'The renaissance of the Sabatier reaction and its applications on Earth and in space,' *Nat. Catal.*, vol. 2, no. 3, pp. 188–197, Mar. 2019, doi: 10.1038/s41929-019-0244-4.

C. Vogt, M. Monai, E. B. Sterk, J. Palle, A. E. M. Melcherts, B. Zijlstra, E. Groeneveld, P. H. Berben, J. M. Boereboom, E. J. M. Hensen, F. Meirer, I. A. W. Filot, and B. M. Weckhuysen, 'Understanding carbon dioxide activation and carbon-carbon coupling over nickel,' *Nat. Commun.*, vol. 10, no. 1, 5330, Dec. 2019, doi: 10.1038/s41467-019-12858-3.

E. Blokker, C. G. T. Groen, J. M. van der Schuur, A. G. Talma, and F. M. Bickelhaupt, 'Hydride affinities of cationic main group element hydrides across the periodic table,' *Results Chem.*, vol. 1, p. 100007, Jan. 2019, doi: 10.1016/j.rechem.2019.100007.

C. Vogt, J. Kranenborg, M. Monai, and B. M. Weckhuysen, 'Structure Sensitivity in Steam and Dry Methane Reforming over Nickel: Activity and Carbon Formation,' *ACS Catal.*, vol. 10, no. 2, pp. 1428–1438, Jan. 2020, doi: 10.1021/acscatal.9b04193.

B. Venderbosch, J. P. H. Oudsen, L. A. Wolzak, D. J. Martin, T. J. Korstanje, and M. Tromp, 'Spectroscopic Investigation of the Activation of a Chromium-Pyrrolyl Ethene Trimerization Catalyst,' *ACS Catal.*, vol. 9, no. 2, pp. 1197–1210, Feb. 2019, doi: 10.1021/acscatal.8b03414.

C. Vogt, J. Wijten, C. L. Madeira, O. Kerkenaar, K. Xu, R. Holzinger, M. Monai, B. M. Weckhuysen, 'Alkali Promotion in the Formation of CH₄ from CO₂ and Renewably Produced H₂ over Supported Ni-based Catalysts,' *ChemCatChem*, vol. 12, Mar. 2020, doi: 10.1002/cctc.202000327.

C. S. Wondergem, J. J. G. Kromwijk, M. Slagter, W. L. Vrijburg, E. J. M. Hensen, M. Monai, C. Vogt, B. M. Weckhuysen, 'In Situ Shell-Isolated Nanoparticle-Enhanced Raman Spectroscopy of Nickel-Catalyzed Hydrogenation Reactions,' *ChemPhysChem*, vol. 21, no. 7, pp. 625–632, Apr. 2020, doi: 10.1002/cphc.201901162.

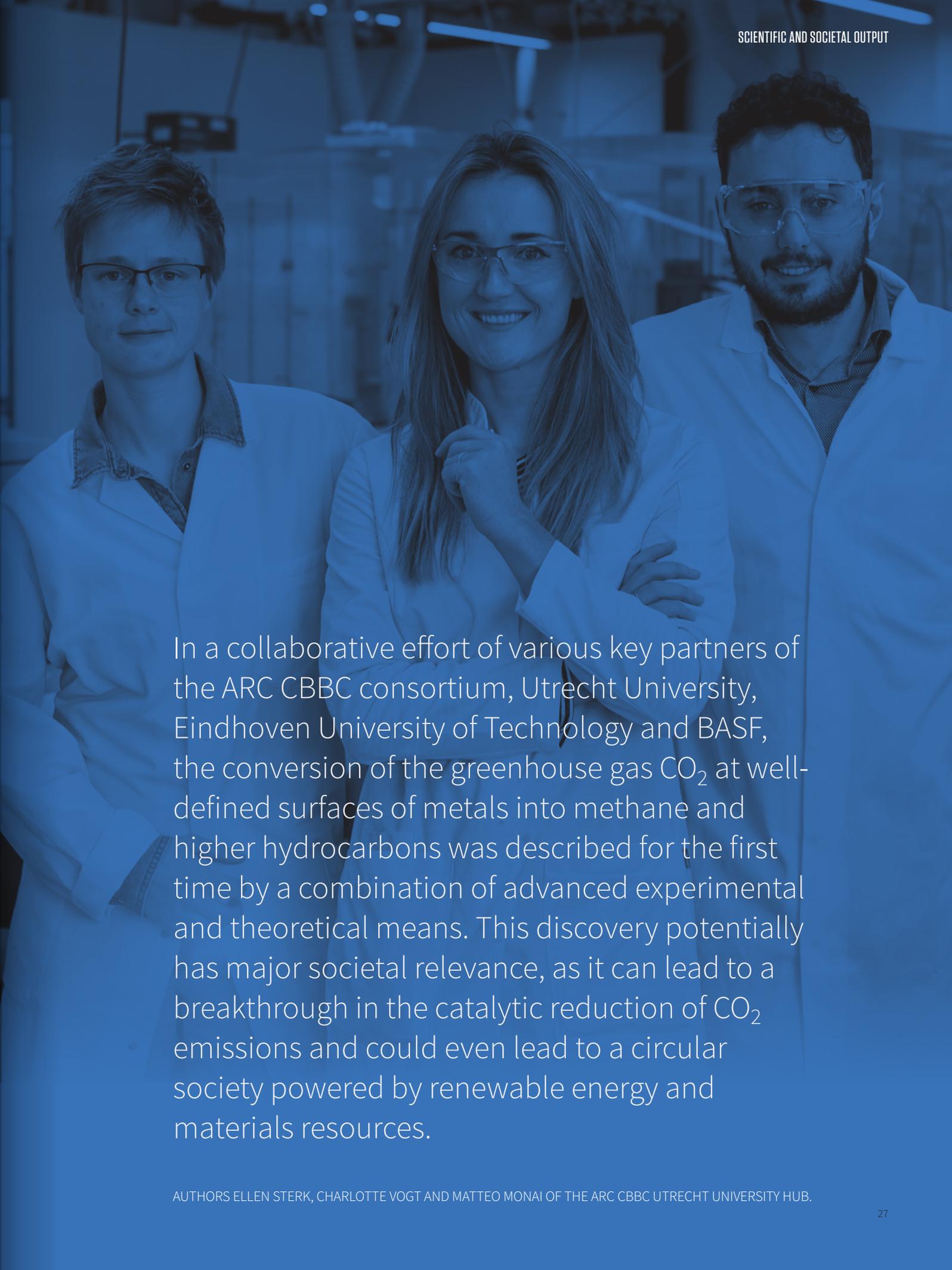
A. Goyal, G. Marcandalli, V. A. Mints, and M. T. M. Koper, 'Competition between CO₂ Reduction and Hydrogen Evolution on a Gold Electrode under Well-Defined Mass Transport Conditions,' *J. Am. Chem. Soc.*, vol. 142, no. 9, pp. 4154–4161, Mar. 2020, doi: 10.1021/jacs.9b10061.

K. M. van Vliet, N. S. van Leeuwen, A. M. Brouwer, and B. de Bruin, 'Visible-light-induced addition of carboxymethanide to styrene from monochloroacetic acid,' *Beilstein J. Org. Chem.*, vol. 16, pp. 398–408, Mar. 2020, doi: 10.3762/bjoc.16.38.

Patents

Two bilateral ARC CBBC projects have led to patent applications, based on the work of the University of Amsterdam and the University of Groningen.

Within the consortium, other patent applications are currently considered.

A photograph of three scientists in a laboratory setting, overlaid with a blue tint. On the left is a man with short hair and glasses, wearing a white lab coat over a denim shirt. In the center is a woman with long blonde hair and glasses, smiling, wearing a white lab coat. On the right is a man with a beard and safety glasses, wearing a white lab coat over a patterned shirt. The background shows laboratory equipment and shelves.

In a collaborative effort of various key partners of the ARC CBBC consortium, Utrecht University, Eindhoven University of Technology and BASF, the conversion of the greenhouse gas CO₂ at well-defined surfaces of metals into methane and higher hydrocarbons was described for the first time by a combination of advanced experimental and theoretical means. This discovery potentially has major societal relevance, as it can lead to a breakthrough in the catalytic reduction of CO₂ emissions and could even lead to a circular society powered by renewable energy and materials resources.

AUTHORS ELLEN STERK, CHARLOTTE VOGT AND MATTEO MONAI OF THE ARC CBBC UTRECHT UNIVERSITY HUB.



Professor Feringa receives the honorary doctorate at the University of Santiago de Compostela, Spain.

Right: with former collaborator Professor Diego Peña.



Matteo Monai, who worked as a postdoctoral researcher for ARC CBBC in a project with BASF, receives the 2019 Eni award from the Italian President, Sergio Mattarella at the Quirinal Palace in Rome.



Professor Bert Weckhuysen (right) receives the Karl Ziegler Guest Professorship from professor Tobias Ritter, Managing Director of the Max-Planck-Institut.



Professor Hans Kuipers receives the Zhang Dayu Lectureship from professor CAI Rui, the deputy director of Dalian Institute of Chemical Physics, on May 24 2019.

Scientific Awards and Recognitions

Professor Ben Feringa received an honorary doctorate degree from the University of Santiago de Compostela and the University of Johannesburg

On May 7 and 8 2019, professor Ben Feringa visited the University of Santiago de Compostela (USC, Spain). He has had a long-standing relation with USC since he was a visiting professor in 2001. During his visit in 2019, Ben Feringa received an honorary doctorate degree from the USC, met a group of high school students from Galicia and gave an invited talk for the general public.

Earlier on in April, professor Ben Feringa also received an Honoris Causa degree in recognition of his sterling international recognition in Chemistry by the University of Johannesburg (South Africa).

The National Academy of Sciences elected Ben Feringa as one of their new foreign associates

The National Academy of Sciences (NAS) announced the election of 100 new members and 25 foreign associates in recognition of their distinguished and continuing achievements in original research on April 30. Ben Feringa is one of the elected foreign associates, which is another recognition of his frontier research in chemistry. Professor Jean-Paul Sauvage, fellow Nobel Prize Winner in Chemistry, was also awarded this honour. NAS is a private, non-profit society of distinguished scholars. The NAS is charged with providing independent, objective advice to the nation on matters related to science and technology. Scientists are elected by their peers to membership of the NAS for outstanding contributions to research.

Professor Bert Weckhuysen was awarded with the Karl Ziegler Guest Professorship

Professor Bert Weckhuysen received the Karl Ziegler Guest Professorship from the Max-Planck-Institut für Kohlenforschung in Mülheim (Germany), the highest distinction of the institute. The Karl Ziegler Guest Professorship is awarded annually to a leading chemistry researcher. Bert Weckhuysen is particularly honoured for his outstanding achievements in the field of operando characterisation of solid catalysts. The Karl Ziegler Guest Professorship is named after chemist and Nobel Prize winner Karl Ziegler (1898-1973), who won the Nobel Prize for research on polymers in 1963, and was director of the Max-Planck Institute from 1943 to 1969.

Professor Hans Kuipers was awarded with the Zhang Dayu Lectureship

On May 24 2019, professor Hans Kuipers delivered the Zhang Dayu lecture at the Dalian Institute of Chemical Physics (DICP) in China. It was the first time a Dutch researcher was awarded this lectureship, which is the most prestigious prize of the DICP. The Zhang Dayu Lectureship honours outstanding scientists and scholars with high academic reputation. It was founded in 2006, in commemoration of Professor Dayu Zhang, the pioneer of the Chinese catalysis science and the founder of DICP. Hans Kuipers was also granted an honorary professorship of DICP.

Professor Jan van Hest and Professor Petra de Jongh became respectively member of the Royal Dutch Academy of Sciences and the Royal Holland Society of Sciences and Humanities

Jan van Hest, professor of Bio-organic Chemistry at Eindhoven University of Technology (TU/e), was elected as member of the Royal Dutch Academy of Sciences (KNAW) in 2019. The KNAW is an important advisory body to the government. It promotes the quality of scientific and scholarly work and strives to ensure that Dutch scholars and scientists make the best possible contribution to the cultural, social, and economic development of Dutch society. Petra de Jongh, professor Inorganic Nanomaterials at Utrecht University, has been appointed as member of the Royal Holland Society of Sciences and Humanities (KHMW). The KHMW acts as a meeting place for leading persons from within and outside academia. It also provides independent judgement in many fields, by serving in the review process for a number of prestigious awards and fellowships.

Professor Marc Koper was awarded the 2019 Netherlands Catalysis and Chemistry Award

During the 20th anniversary meeting of the Netherlands' Catalysis and Chemistry Conference (NCCC), Marc Koper received the 3rd Netherlands Catalysis and Chemistry Award (NCCA). The NCCA recognises and encourages significant achievements of individuals in fundamental and practice of catalysis. Mark Koper has made significant contributions in the area of theory of electrochemical transfer and electrocatalysis and is highly recognised within and outside the Netherlands.

Professor Bert Meijer was awarded an honorary degree from the Freie Universität Berlin

The quality of Bert Meijer's scientific work is awarded by the faculty of Biology, Chemistry and Medicine of the Freie Universität Berlin (FU Berlin). This award is the second honoris causa degree for Bert Meijer, who is highly recognised in the field of supramolecular chemistry and polymers. Meijer received his honorary degree during the International Symposium on Polyvalence in Chemistry and Biology on September 30 at the FU Berlin.

Professor Detlef Lohse received the 2019 Max Planck Medal

The highest international award for theoretical physics of the German Physical Society, the Max Planck Medal, was awarded to professor Detlef Lohse of the University of Twente. Former laureates were Albert Einstein, Niels Bohr and Erwin Schrödinger. Detlef Lohse contributed to solving the puzzle of sonoluminescence and developed a theory on heat transport in thermally-driven turbulence. The Max Planck Medal has been awarded since 1929, by the Deutsche Physikalische Gesellschaft.

Dr. Matteo Monai won the 2019 'Young Researcher of the Year' Eni award

Dr. Matteo Monai, who worked as ARC CBBC postdoctoral fellow at Utrecht University a project with BASF, won the prestigious young researcher of the year Eni award. Matteo Monai has worked on CO₂ valorisation and small molecule activation, using well-defined nanostructured materials and advanced spectroscopy techniques. The Eni awards were established in 2007 and have become internationally recognised over the years in the fields of energy and environmental research. This award is presented every year, to two researchers under the age of 30 who received a research doctorate from an Italian university.

Outreach Activities

ARC CBBC encourages its researchers to reach out and explain their scientific work to the general public. Below we provide a selection of outreach activity by ARC CBBC researchers in 2019.

Eye-openers

In a so-called 'Eye-opener', an initiative by the Royal Dutch Chemical Society (KNCV), a one-minute video supported by an animated background, researchers tell more about their research projects. Two Eye-openers or ARC CBBC researchers were made in 2019 and there are more to come in 2020.

Francesco Matterozzi from Utrecht University works, together with Shell, on electrochemical CO₂ conversion. In his Eye-opener he tells more about the role of the catalyst, the catalyst support and the electrolyte.

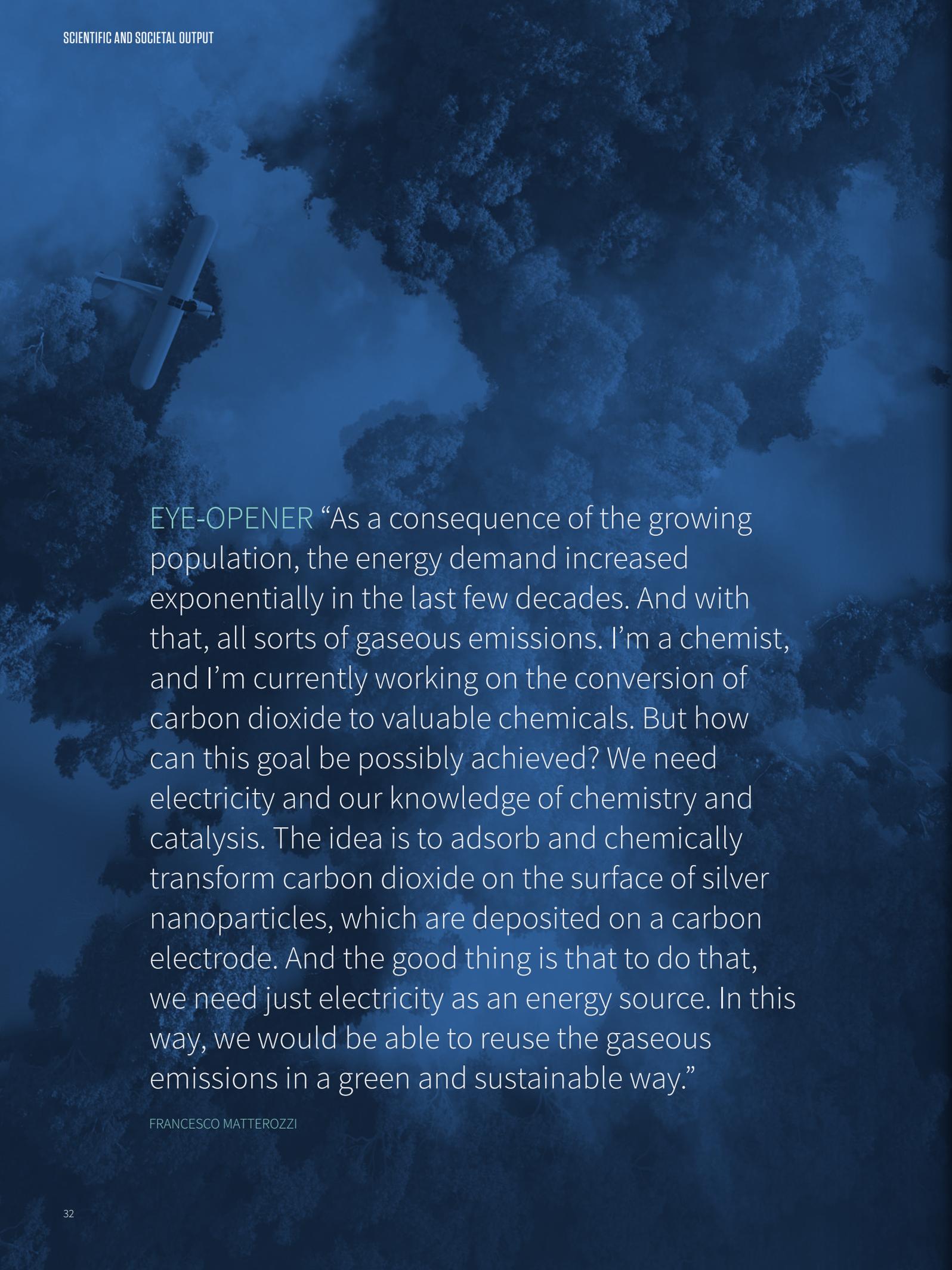
Lotte Metz from the University of Amsterdam works within the flagship Fundamentals of Catalysis on the synthesis of bimetallic particles via nanosphere complexes.



A still image from the Eye-opener of Francesco Matterozzi.



A still image from the Eye-opener of Lotte Metz.

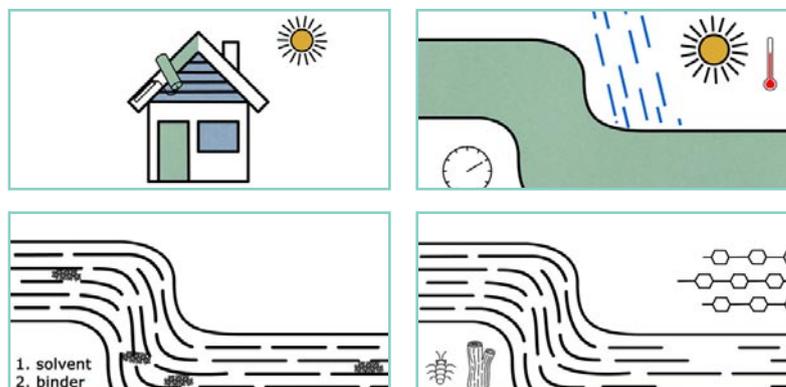
An aerial photograph of a dense forest, viewed from above. The trees are dark green and brown, creating a textured pattern. In the upper left quadrant, a small, white, single-engine airplane is flying over the forest, leaving a faint white trail behind it. The overall lighting is soft and natural, suggesting a clear day.

EYE-OPENER “As a consequence of the growing population, the energy demand increased exponentially in the last few decades. And with that, all sorts of gaseous emissions. I’m a chemist, and I’m currently working on the conversion of carbon dioxide to valuable chemicals. But how can this goal be possibly achieved? We need electricity and our knowledge of chemistry and catalysis. The idea is to adsorb and chemically transform carbon dioxide on the surface of silver nanoparticles, which are deposited on a carbon electrode. And the good thing is that to do that, we need just electricity as an energy source. In this way, we would be able to reuse the gaseous emissions in a green and sustainable way.”

FRANCESCO MATTEROZZI

Scientific Animations

Bruno van Wayenburg, scientific journalist and animator, prepared an animation movie based on the Flagship 'Coatings & Functional Materials'.



Four film stills of the animation video explaining the ARC CBBC Flagship 'Coatings & Functional Materials'.

Infographics

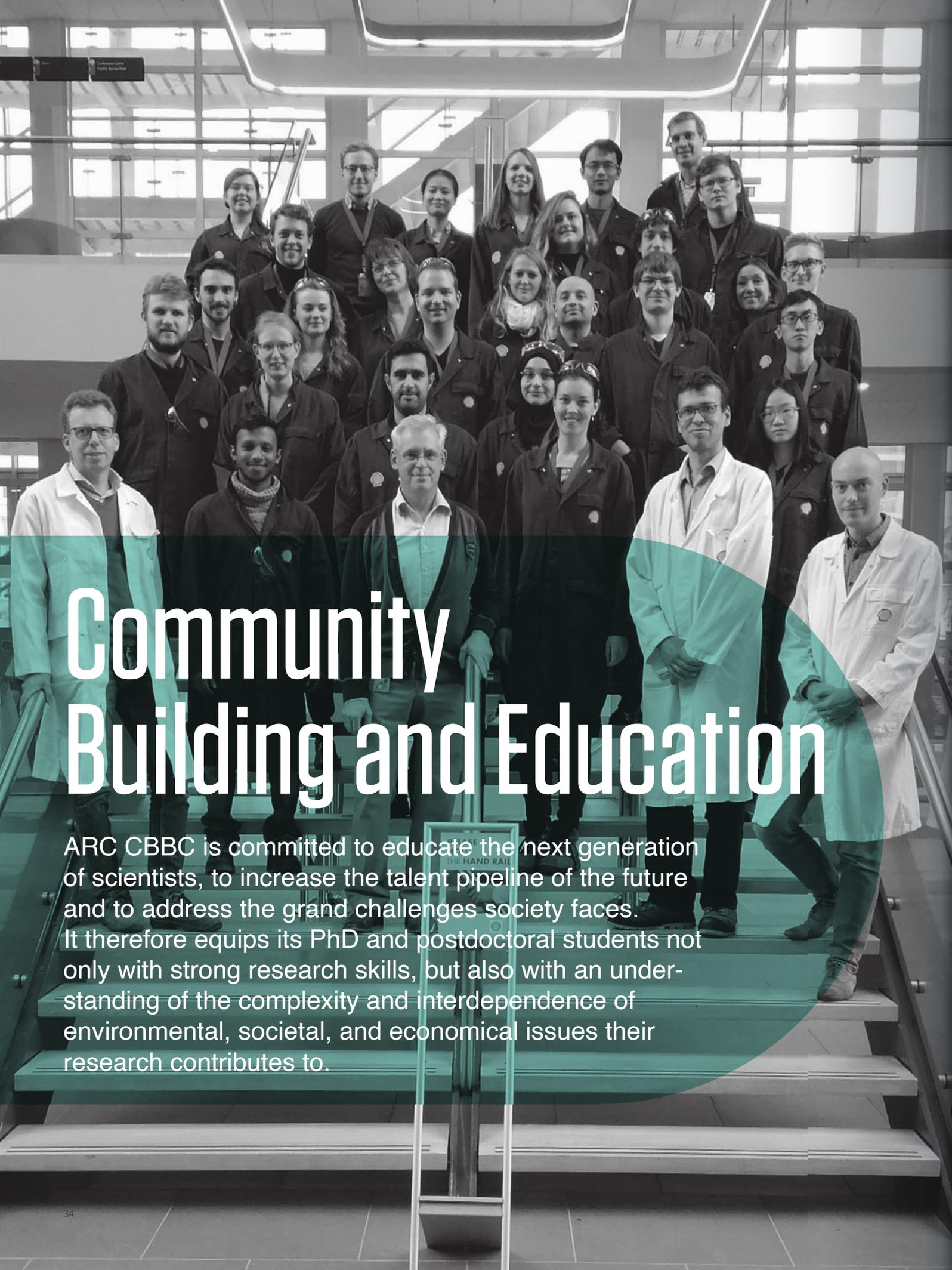
The Talent Programme of ARC CBBC organised a workshop on infographics.

Jiaying Li of the University of Twente aims to study water soluble polyelectrolytes that will be the binder polymer in such modern paints. Specifically, she tries if pH and salt control can be used to make high quality polymers films.

Sebastian Haben of Utrecht University studies methane dehydroaromatization that enables the selective transformation of methane into important platform chemicals, such as benzene and ethene. His research project has the aim to understand the current generation of catalysts and come up with solutions that will enable industry to use this catalytic process on a large scale.



Above: a sneak preview of the infographic of Jiaying Li. Under: a sneak preview of the infographic of Sebastian Haben.



Community Building and Education

ARC CBBC is committed to educate the next generation of scientists, to increase the talent pipeline of the future and to address the grand challenges society faces. It therefore equips its PhD and postdoctoral students not only with strong research skills, but also with an understanding of the complexity and interdependence of environmental, societal, and economical issues their research contributes to.

Education Committee and Talent Programme

The Education Committee is composed of members from the industry, academia and the ARC CBBC Office, representing the unique collaboration within the consortium:

Hans Kuipers (Chair),
Eindhoven University of Technology

Jitte Flapper, AkzoNobel

Mathieu Ahr, Nouryon

Peter Klusener, Shell

Hannah Thuijs, ARC CBBC

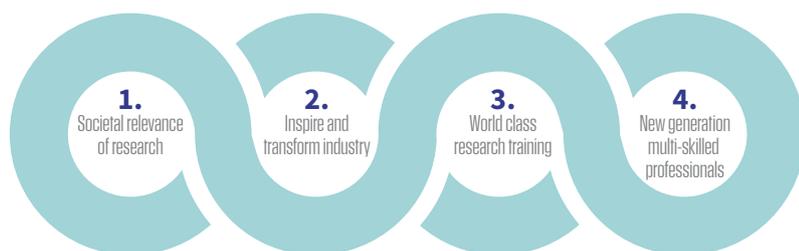
Maurice Mourad, ARC CBBC

The Education Committee is responsible for the implementation of parts of the Talent Programme to achieve the training goals and objectives of the consortium.

It organises (multidisciplinary) trainings and events in collaboration with external partners as well as with the industry and academia.

The Young CBBC community, which is composed of all young researchers, provide feedback and input to refine the Talent Programme. The Education Committee has the ambition to provide a varied programme, leading to well-trained scientists, deployable in the academic as well as in the industrial world. The Talent Programme is based on four pillars:

Pillars of the Talent Programme



Societal relevance of research demands the quest towards answering questions that society asks or solving the problems it faces. The Talent Programme helps ARC CBBC researchers to explore what the societal

impact of their research project is, keeping the main ambitions of the consortium in mind. The possible impact of ARC CBBC's research programme on society is a common thread through all of the activities initiated by the Education Committee. For example, in 2020 the researchers will be given a Debate Training and will hold a debate with the audience of the Annual Symposium in Groningen. One of the propositions which will be discussed, is the question whether all research at universities should aim to lead to sustainable solutions for society. Moreover, societal relevance in research performed within ARC CBBC will be demonstrated in the presentations given by a few of the PhD's. These presentations will show scientific highlights, but will also indicate the societal impact their research might have.

Although not officially initiated by the Education Committee, but organised by the consortium, are the multilateral project meetings. These meetings are held twice a year and are attended by all project members from academia and industry. They meet to discuss and share their research process and the challenges they face. The PhD's support each other by exchanging knowledge, sharing innovative ideas and offering collaboration or even facilities to lift the project as a whole to a higher level with.

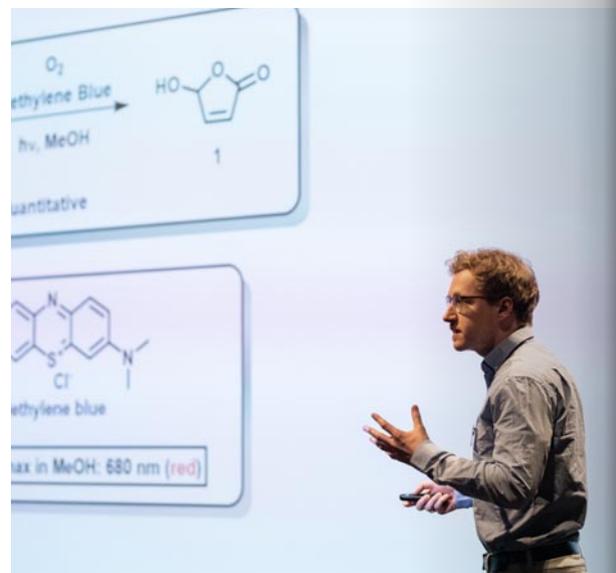
An integral part of the Training Programme is the industrial secondment, which is organised as one longer or multiple shorter visits to our industrial partners, depending on the needs of the research project. This internship enables the students to learn using new equipment, gain insight into industrial research approaches, culture and terminology and get familiar with the



Scientific poster session during the ARC CBBC annual symposium 2019.

Presentation trainings, put into practice in front of the Scientific Advisory Board of ARC CBBC, by George Hermens of the University of Groningen.

available expertise and infrastructure. Ultimately, these secondments help the students to put their fundamental knowledge into practice in the industrial world, contributing to a transformation of industry. The practical experience also opens potential career paths next to the academic world. For example, in October 2019 a group of researchers visited the premise of Shell Technology Centre in Amsterdam. They got to meet experts from industry in the chemical field and researchers from the Shell R&D department. The researchers learned more about the kind of research and development that is carried out in the industry level, how industries collaborate with academia to enhance technological application and what kind of job opportunities are available for young academic experts. A lab tour and a lecture on catalysis were included in the visit at Shell. A Patent Workshop was followed by the lab tour, given by an expert from Shell. This workshop informed the researchers about how technical inventions are legally being authorised. During this day, the researchers of ARC CBBC had the opportunity to be inspired by industrial experts, share their knowledge by giving poster



presentations and further build the community by getting to know each other during informal breaks. It was a first-class example of the variety the ARC CBBC programme offers. All PhD's and PD's from various universities had been invited and were given the chance to interact with industry and with each other.

Within ARC CBBC, PhDs and PDs profit from guidance and support from national and international high class researchers. Daily supervision is provided by the ARC CBBC members from various universities. The scientific excellence of each ARC CBBC research project is guaranteed by the supervision of the international Scientific Advisory Board. Working in a multi-disciplinary research programme asks for knowledge on more than just your own field of expertise. This enables young researchers to look beyond their own expertise to come to innovative ideas. To this end, the Education Committee has developed two community-wide obligatory activities: the ARC CBBC Summer School and the Annual Symposium, including an Education Day.

ARC CBBC Summer School

The ARC CBBC Summer School is planned to be a yearly event of which the first will be held in 2020. It will reflect the strong collaboration between the industrial partners and universities and will strongly focus on multidisciplinary training of the students. In the section 'PhD teaches PhD students', researchers will educate their fellow researchers about a topic in a different expertise field than their own. Industrial partners will give lectures focusing on practical experiences.

Annual Symposium

The Annual Symposium is held at the premises of one of the three ARC CBBC hubs. This one day event is accompanied by an Education Day. These yearly symposia are multidisciplinary and interactive events. Lectures are given by different stakeholders, members and PhD's. There is room for discussion and networking. In April 2019, the second Annual Symposium of ARC CBBC took place, where the community gathered for an inspiring programme. It was followed by an Education Day, on which the researchers developed their presentation skills. Three researchers gave an inspiring presentation to the Scientific Advisory Board.

The developed Talent Programme of ARC CBBC is strongly differentiating from regular PhD training programmes because of the strong collaboration with the industrial partners of the consortium. Students benefit from practical experience through internships and are supervised not only by academics but also by industrial supervisors. The input from industrial supervisors enables the students to also obtain knowledge in the applicability of their research. Being part of a high-quality community also means knowledge exchange

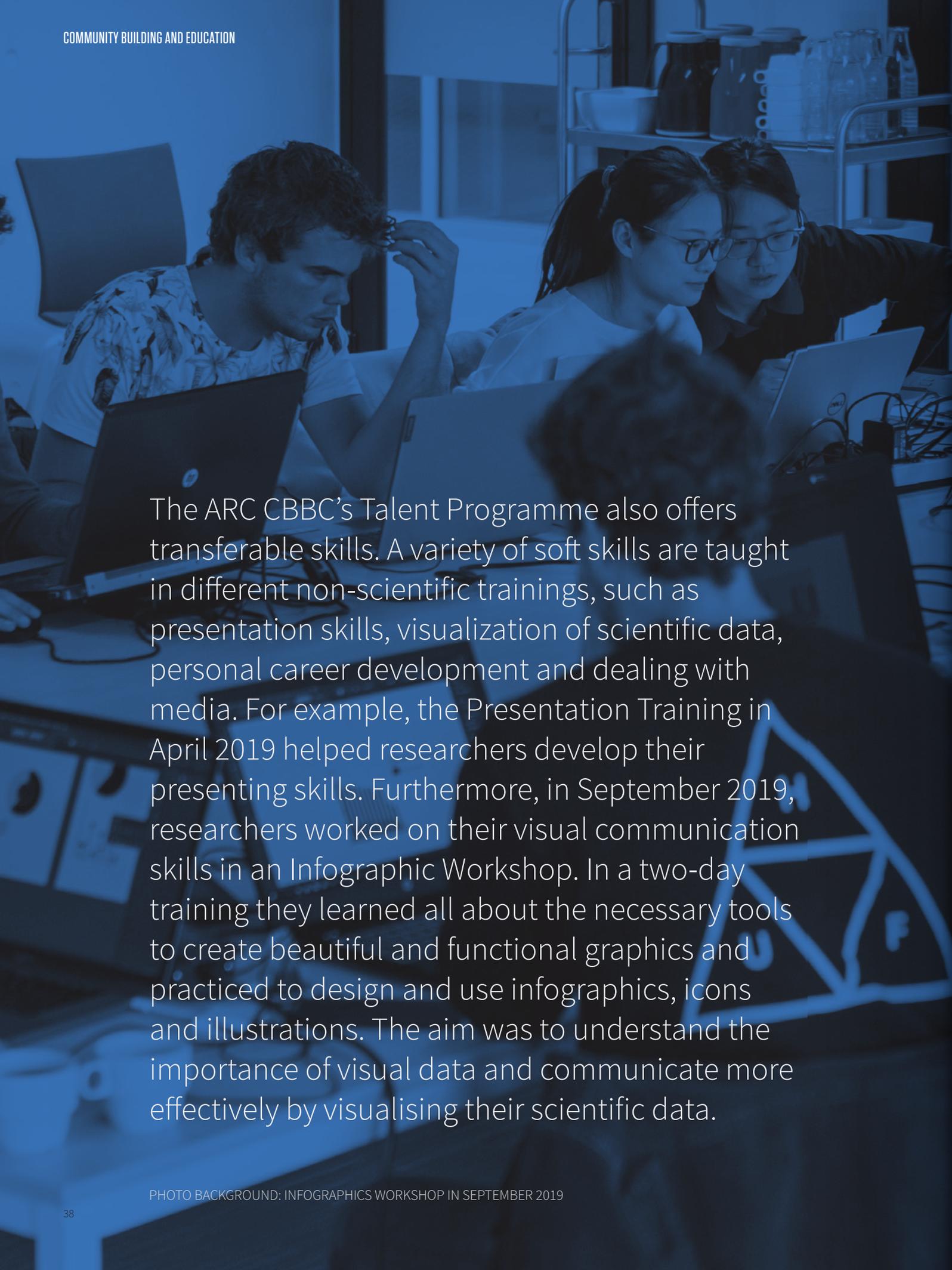
between the students from the various universities with which ARC CBBC collaborates. This exchange of expertise will build up a broad experience in working in interdisciplinary teams. Next to the intensive collaboration with industry and the broadening of interdisciplinary expertise, ARC CBBC emphasises the practical experience in transferable skill trainings. Knowledge gained in these trainings are constantly put into practice during presentations, events and meetings.

Educational Activities

All educational activities initiated and organised by the Education Committee and implemented in the Talent Programme for the years 2019 and 2020:

Presentation Training	04/2019
Annual Symposium	04/2019
Education Day (presentation)	04/2019
Catalysis Connected conference	08/2019
Infographic Workshop	09/2019
Patent Workshop	10/2019
Company visit Shell	10/2019
CHAINS conference	12/2019
Infographic Workshop	01/2020
Presentation Training	02/2020
Annual Symposium*	04/2020
Summer School*	08/2020
Company visit AkzoNobel*	08/2020
Debate Workshop*	09/2020
Annual Symposium*	09/2020
CHAINS conference	12/2020

* In relation to the COVID-19 crisis, these events have been postponed and will be held in another form than initially planned.

A blue-tinted photograph showing three people in a workshop or office environment. On the left, a man with curly hair is looking at a laptop. In the center, a woman with glasses is also looking at a laptop. On the right, another woman is leaning over, looking at a laptop. The background shows a metal cart with various items on it, including bottles and containers. The overall scene is focused on collaborative work and learning.

The ARC CBBC's Talent Programme also offers transferable skills. A variety of soft skills are taught in different non-scientific trainings, such as presentation skills, visualization of scientific data, personal career development and dealing with media. For example, the Presentation Training in April 2019 helped researchers develop their presenting skills. Furthermore, in September 2019, researchers worked on their visual communication skills in an Infographic Workshop. In a two-day training they learned all about the necessary tools to create beautiful and functional graphics and practiced to design and use infographics, icons and illustrations. The aim was to understand the importance of visual data and communicate more effectively by visualising their scientific data.

Young Researchers

Students located all over the Netherlands have joined the various research projects of ARC CBBC to contribute to its ambition, to fundamentally change the environmental footprint of products and production processes. ARC CBBC recognises the importance of building a diverse community. To make the great leaps in research that we aspire, promoting and embedding equality, diversity and inclusion is integral to achieving our mission. At this moment there are 47 PhD's and PD's from various backgrounds at work, 20 of them female and 27 male researchers. ARC CBBC aims to balance the diversity within the research community by adding more women to the PhD and PD community. The inspirational interaction between talented researchers from different backgrounds attract young talent from all over the country.

The PhD students and postdoctoral fellows of ARC CBBC are also united in their own community: Young CBBC. ARC CBBC encourages and facilitates its students to inspire, inform and engage each other. An online portal is being developed where students can ask each other questions, share information or advice, organise informal meetings and collaborate outside their field of expertise. The current board members of Young CBBC were involved in the development of the online portal. One example of how members of Young CBBC interact with each other outside the formal activities organised by ARC CBBC, is that of mini-symposia. The current board members of the Young CBBC initiated these gatherings with the aim to practice presentation skills with fellow researchers as an audience.

ARC CBBC believes that everyone has the right to be treated with dignity and respect and strives to create a culture that is inclusive and free of barriers. We recognise the benefit of creating an environment that nurtures talent and allows every individual the opportunity to flourish and reach their full potential. The ARC CBBC Office as well as the Education Committee have a very open attitude towards the whole community of young researchers in order to be aware and be noticed about not only training needs or other means of support, but also about issues related to scientific integrity and unwanted behaviour.

Young Researchers Currently Working for ARC CBBC

Currently, there are 47 research positions: 3 PD's and 44 PhD's. The following researchers will start their PhD work in 2012: Hugo den Besten, Kristiaan Helfferich and Vivek Sinha. Christoph Bondü and Matteo Monai have concluded their ARC CBBC research. They respectively worked on *Electrochemical CO₂ conversion: elucidating the role of catalyst, support and electrolyte* and *Unravelling structure sensitivity in CO₂ hydrogenation over nickel*. Finally, 16 PhD positions will be allocated to the new flagship programme, which is expected to start beginning 2021.

Young Researchers



AKANSHA GOYAL
Leiden University



ALEKSEI PEREVALOV
Eindhoven University
of Technology



ALEXANDER PARASTAYEV
Eindhoven University
of Technology



**ALEXANDER
RYABCHUN**
University of
Groningen



BAS VAN GORKOM
Eindhoven University
of Technology



BAS TERLINGEN
Utrecht University



BIANKA SIEREDZIŃSKA
University of
Groningen



CHRISTOPH BONDÜ
Leiden University



CHUNCHENG LIU
Delft University of
Technology



DAAN GROEFSEMA
Utrecht University



DAVID RIEDER
Eindhoven University
of Technology



ELLARD HOOIVELD
Wageningen
University & Research



EVA BLOKKER
VU Amsterdam



FELIX DE ZWART
University of
Amsterdam



FLORIAN ZAND
Utrecht University



**FRANCESCO
MATTAROZZI**
Utrecht University



GEORGE HERMENS
University of
Groningen



HAISSAM DERNAIKA
Utrecht University



HANNEKE SIEBE
University of
Groningen



HAO ZHANG
Eindhoven University
of Technology



**HARITH
GURUNARAYANAN**
Utrecht University



**HASNAA EL SAID
EL SAYED**
University of Twente



HUNG CHIEN LIN
University of
Groningen



JIANGTAO LU
Eindhoven University
of Technology



JIAYING LI
University of Twente



JOHAN BOOTSMA
University of
Amsterdam



KAIJIAN ZHU
University of Twente



KELLY BROUWER
Utrecht University



KORDULA SCHNABL
Utrecht University



LINDA EIJSINK
University of
Groningen



LOTTE METZ
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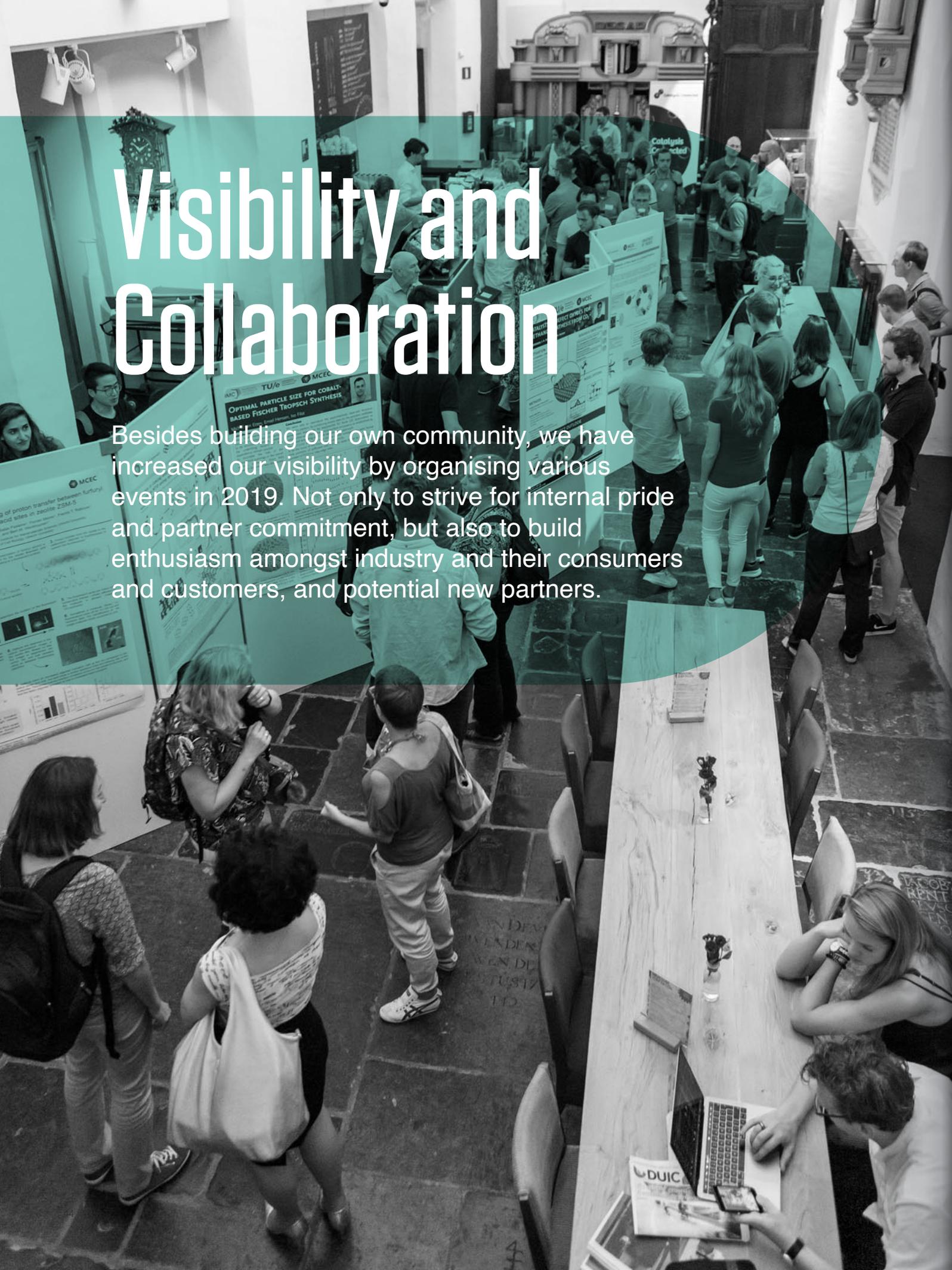
STERRE BAKKER
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Utrecht University



TIZIAN RAMSPOTH
University of
Groningen



Visibility and Collaboration

Besides building our own community, we have increased our visibility by organising various events in 2019. Not only to strive for internal pride and partner commitment, but also to build enthusiasm amongst industry and their consumers and customers, and potential new partners.

We have the high ambition to become a leading platform for sustainable chemistry that has substantial global impact.

Therefore, we have collaborated with or started different initiatives on a European and international level, to increase the strength and the value of the ARC CBBC as a knowledge institute.

ARC CBBC Events

In the past year, ARC CBBC has organised various events, all based on a clear aim and with the various stakeholders in mind. All events provide high quality scientific content, but are also opportunities for all partners of the consortium to interact with each other in a more informal way.

Opening lab Utrecht University Hub | 13 February 2019

ARC CBBC celebrated the official opening of its first own laboratories on February 13 2019, located in the Utrecht University hub. The festive opening ceremony was named 'Roadtrip to a Land of Sustainable Chemistry' and inspired by a journey through a varied

landscape. The opening act consisted of the filling of a glass version of the ARC CBBC logo with a blue liquid, which was jointly executed by Utrecht University's Rector Magnificus Henk Kummeling and the Dean of the Faculty of Science, Isabel Arends. Guests were taken on a journey past locations such as 'Nanoparticles River', 'Researchers' Hot Springs', 'Carbon Mountains' and the 'Coating Canyons'. Several young researchers affiliated to ARC CBBC presented their work to the guests. Finally, a wall poem written by Utrecht poet Ingmar Heytze for ARC CBBC was presented.

Annual Symposium Eindhoven | 16-17 April 2019

On Tuesday April 16th 2019, the second annual ARC CBBC symposium took place in Eindhoven. More than 110 of our Members, Scientific Advisory Board, young researchers, support staff and Supervisory Board attended presentations, took part in the panel discussion and shared insights on ARC CBBC's research topics. During lunch, 30 of our PhD students, postdocs and Master students presented a scientific poster. The following day, April 17th, was reserved

Opening act of the Utrecht hub laboratories on February 13 2019: (left) Professor Isabel Arends, Dean of the Faculty of Science of Utrecht University, (middle) Hannie van Berlo-van den Broek and (right) Professor Henk Kummeling, Rector Magnificus of Utrecht University.

Lecture during the Catalysis Connected workshop in Utrecht.





Scientific advisory board member Ib Chorkendorff (left) and new ARC CBBC members Monique van der Veen (middle) and Erik Garnett (right) lecturing at CHAINS 2019.

Opening act of the Utrecht hub laboratories on February 13 2019: (left) Professor Isabel Arends, Dean of the Faculty of Science of Utrecht University, (middle) Hanne van Berlo-van den Broek and (right) Professor Henk Kummeling, Rector Magnificus of Utrecht University.



for the first ARC CBBC Education Day. PhD candidates and postdocs followed training using a real interactive theatre class, aimed at improving their presentation skills.

Catalysis Connected | 24 – 27 August 2019

At the end of the summer of 2019, 'Catalysis Connected' was organised together with VIRAN (Industrial advisory board of the Netherlands Institute for Catalysis Research, NIOK), Dutch Catalysis Society (DSC) and the Netherlands Center for Multiscale Catalytic Energy Conversion (MCEC). 16 engaging lectures divided over four days were given with the aim to advance the catalysis field, show the potential of collaboration and prove the strength of Dutch catalysis. The focus of the conference was on three pillars: 'Connecting catalysis', 'Connecting spectroscopy' and 'Connecting chemical engineering and catalysis'. Lectures were given in the form of an interactive conference style allowing participants to actively be involved and discuss the topics.

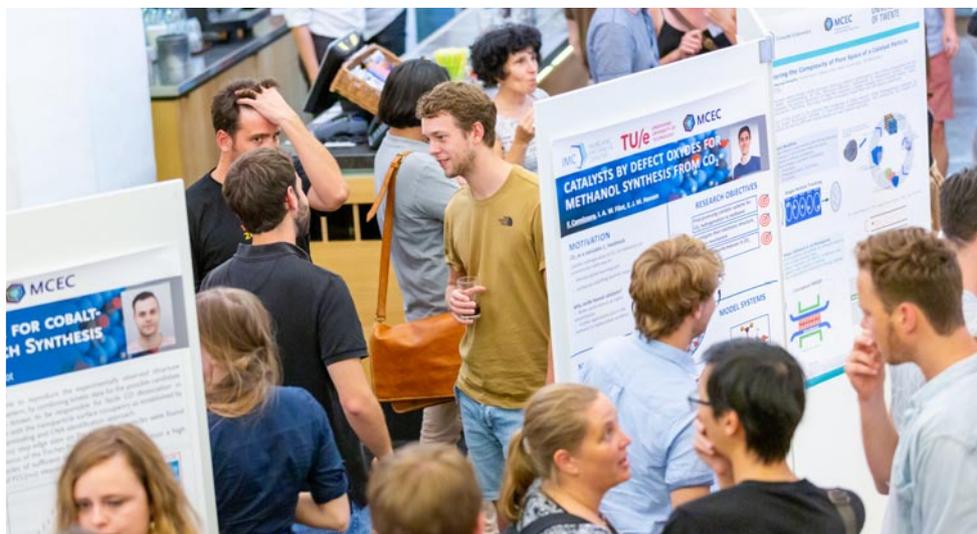
CHAINS | 10 December 2019

People from all chemical disciplines came together to inspire and inform each other during CHAINS 2019, the National Conference on Chemistry, held on December 10-11. ARC CBBC hosted one of the focus sessions, which explored the potential of energy transfer from electricity and (sun)light via innovative catalytic reactions based on electrochemistry and electron plasmon resonances. Ib Chorkendorff (Technical University of Denmark), Dr. Monique van der Veen (Delft University of Technology) and Dr. Erik Garnett (AMOLF), all members of ARC CBBC, each shared their insights on the subject. ARC CBBC was also represented in the body of two keynote speakers, both member of the ARC CBBC consortium: Professors Marjolein Dijkstra and Marc Koper. Dijkstra inspired her audience by explaining more about the inverse of soft materials, especially crystals, quasi crystals and liquid crystals. Koper presented new views of an old problem when it comes to electrochemistry of platinum.



ARC CBBC researchers Matteo Monai and Savannah Turner present during the lab tour at the Utrecht hub of ARC CBBC.

Scientific poster session during the Catalysis Connected workshop in Utrecht



Collaboration Opportunities

Effective interaction and exchange of information are very important for the success of ARC CBBC. Not only collaboration between partners, members and project groups are stimulated and facilitated, ARC CBBC also seeks collaboration with other initiatives active in similar research fields. This is done both at a national and international level. Collaboration not only increases the national and international visibility of the consortium and supports its positioning, it also complements the scope of

existing national and European partnerships. Ultimately, ARC CBBC wants to play a leading role in providing the world with creative scientific solutions and technological advancement that enables society to realise the energy transition and transition to a circular economy. Partnering and scaling-up can contribute to this. Several collaborative efforts or initiatives that started or took place in 2019, are highlighted below. These include activities in China and Europe.

Mission to China

In March 2019, ARC CBBC joined the Dutch trade mission to China, organised by Holland Chemistry, to explore potential cooperation options on the theme of circular chemistry. The aim of the visit was to connect to universities as well as to the Ministry of Science and Technology (MOST) in China. Both the Netherlands and China have a strong reputation in fundamental chemical science and innovation. Already now, there is

a significant number of PhD students with Chinese roots in the Netherlands. Therefore, it is expected that the two countries will mutually benefit through scientific cooperation.

ARC CBBC and its Chinese counterparts explored several possible overlapping research interests. In particular, the topics 'coatings and functional materials' and



Participants of the Dutch-Chinese chemistry scoping session organised by MOST during the Dutch trade mission to China, including delegates from ARC CBBC. Picture taken Beijing (China) on March 18 2019.

‘chemical recycling of plastics’ resonated among the participants. Coating chemistry is an existing key activity in the programme of ARC CBBC and its industrial partner, AkzoNobel, has research and development activities in China. ARC CBBC is also exploring the topic of chemical recycling of plastics, another route towards a more sustainable society. Since China is producing one fourth of all the plastics worldwide, this topic is also a priority for China. One of the outcomes of

this China mission was the signing of a Memorandum of Understanding (MoU) to cooperate with MOST. As a first topic, coatings research has been proposed and a first matchmaking session on this topic took place in Beijing. Currently, the modalities of this scientific cooperation between MOST and ARC CBBC are worked out. Later, other strategic research programmes may be added under the same MoU.

SUNERGY

ARC CBBC complements and has overlapping ambitions with other initiatives to lead the way to a climate-neutral EU by 2050 and achieve the European Green Deal objectives. One example is that of SUNERGY. SUNERGY unites and builds on two Coordination and Support Actions (CSA) funded under Horizon 2020: SUNRISE and ENERGY-X. Both ARC CBBC and SUNERGY have the ambition to make the transition from a linear to a circular economy by developing high-impact, cross-cutting technology, thereby contributing to a

fossil-independent world. SUNERGY focusses on the solution to use energy from renewable sources (i.e., sunlight and wind) and sufficiently abundant molecules (i.e., CO₂ and N₂). SUNERGY is currently working on community building at the European level and advocates for strong support and sufficient funding from the European Union. It is foreseen that substantial collaboration between the communities of SUNERGY and ARC CBBC will be build up and already at the start there is a strong overlap of both the

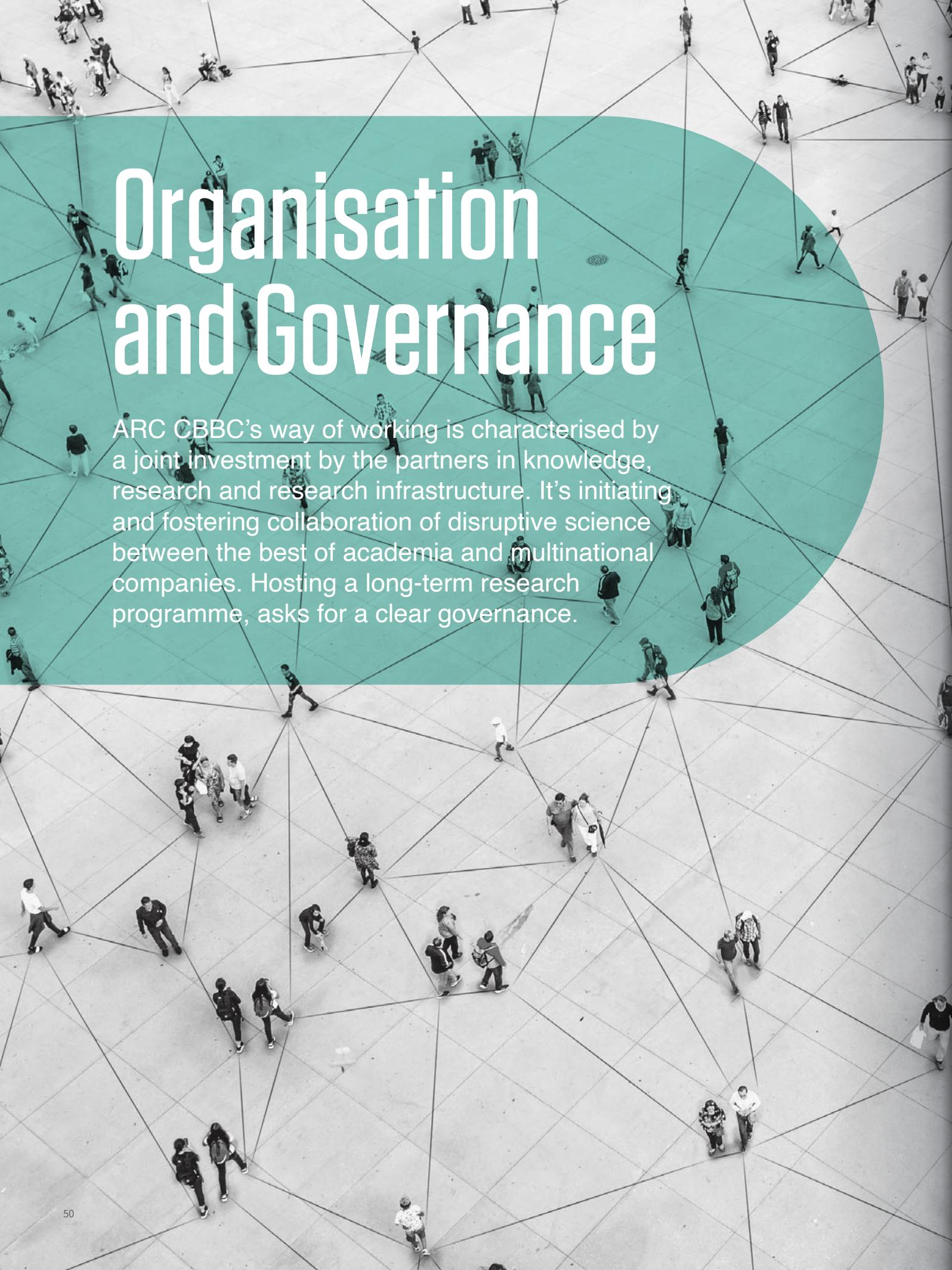


Audience during the ARC CBBC annual symposium at Eindhoven.

Professor Jens Norskov, Energy-X coordinator; the predecessor of SUNERGY, which is now coordinated by Utrecht University on behalf of a large consortium of academic institutions and companies across Europe.



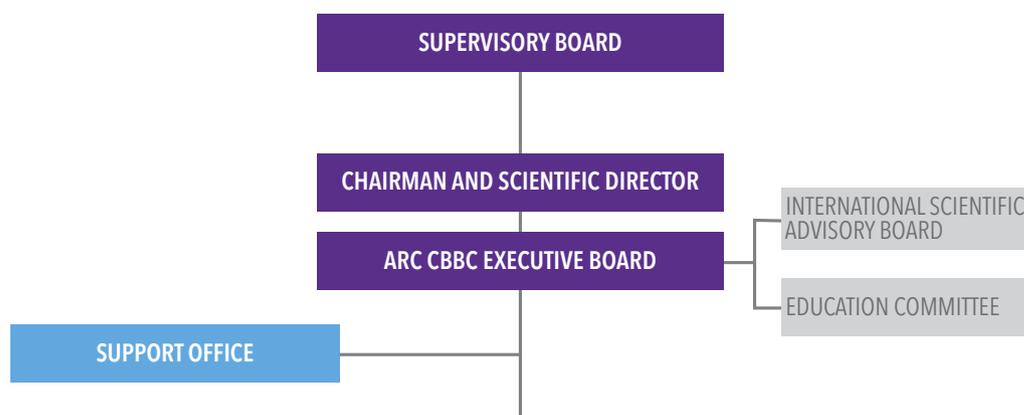
research topics and the community members. For example, several scientists involved with ARC CBBC have been initiators of SUNERGY (including Bert Weckhuysen, Ib Chorkendorff and Guy Marin) or participated in multiple activities of the two initial CSAs (e.g. representatives of Shell). The increased funding opportunities at the European level, especially in view of the Green Deal ambitions, due to SUNERGY's advocacy may be beneficial for ARC CBBC in the coming years.



Organisation and Governance

ARC CBBC's way of working is characterised by a joint investment by the partners in knowledge, research and research infrastructure. It's initiating and fostering collaboration of disruptive science between the best of academia and multinational companies. Hosting a long-term research programme, asks for a clear governance.

Tasks and Responsibilities



A visualization. ARC CBBC Organization Chart, including the role of the Supervisory Board, Executive Board and Scientific Advisory Board.

The overall responsibility for ARC CBBC lies with the Executive Board (EB). It is formed by the Programme Directors, representatives from the Full Private Partners and a scientific observer on behalf of NWO in a non-voting capacity. The EB meets six times a year and is responsible for the management of the research programmes. The Supervisory Board (SB) meets at least twice a year and decides on intended decisions regarding project allocations prepared by the EB, monitors programme progress, advises the EB concerning long-term strategy and safeguards the national character of the research centre. The Scientific Advisory Board (SAB) consists of international, independent experts from academia in the research fields of ARC CBBC. The SAB advises the EB on the nominations of new ARC CBBC members and on the overall quality of the research projects. The composition of the SAB is approved by NWO and its members will operate according to the latest version of the NWO Code of Conduct on Conflicts of Interest.

The Education Committee (EC) is chaired by one of the EB members and further consists of two academic and two industrial members. The EC coordinates the training programme and is amongst others responsible for organizing the annual Summer School and the internship programme.

The consortium is supported by the ARC CBBC Support Office, which is responsible for the coordination of all activities in the programme and its day-to-day management.

Quality Assessment by the Scientific Advisory Board

To guarantee high quality research, the Scientific Advisory Boards is responsible for quality assessment of the science and novelty:

- Project plans are independently evaluated on scientific quality and technical feasibility by (part of) the Scientific Advisory Board (SAB). The SAB provides the EB with advice on bilateral projects as well as on multilateral project proposals.
- Progress within all projects is monitored annually on the basis of progress reports. These are discussed in the Scientific Advisory Board and in (part of) the Executive Board. These confidential reports are provided to NWO and the TKI Chemistry.

Finance Control Commission ARC CBBC

The Finance Control Commission reviews the consortium financial administration and reporting and advises the EB. In 2019, the following commission was composed as follows: Michiel Veening (RUG), Michiel Timmer (TU/e) and André van Linden

(AkzoNobel). Michiel Veening is the chairman of the Commission and André van Linden is spokesman towards the EB. Thus far, the Finance Control Commission reviewed the consortium finances from the start up to the book year 2019.

Multilateral and Bilateral Programme Lines

ARC CBBC's aim is to provide knowledge and understanding that enables the private partners to make new and improved products, processes and services, focusing on fundamental research for breakthrough options and underpinning technologies. The research programme of ARC CBBC is composed of two main parts: the multilateral and bilateral programme. Central to our multilateral programme are our flagship projects. Within these projects, multidisciplinary researchers of several partners, both academic and industrial, form a research team that pioneers a research challenge. The aim is to carry out blue sky research, making use of the best academic researchers around as well as benefitting of the direct feedback from industry.

The bilateral programme contains projects that allow academic and industrial researchers to jointly explore a fundamental scientific subject related to the chemical technology with potential to be further developed in industry. Project members of bilateral projects consist of the private partner that initiated the project and the public partner(s) directly involved in carrying out the research project.

Boards, Members and Support Office

Executive Board (EB)



PROF. DR. IR. BERT WECKHUYSEN
Scientific Director,
Utrecht University



PROF. DR. BEN FERINGA
Chair,
University of Groningen



PROF. DR. IR. HANS KUIPERS
Eindhoven University
of Technology



IR. ANDRÉ VAN LINDEN
AkzoNobel



IR. ADRIE HUESMAN
Shell



DR. ROBERT TERÖRDE
BASF



DR. MATHIEU AHR
Nouryon

The Executive Board members are supported by the following knowledge experts:

Dr. Jitte Flapper (AkzoNobel)

Dr. Peter Berben (BASF)

Dr. ir. Sander van Bavel (Shell)

Drs. Mark Schmets (NWO)

The following members have left the Executive Board in 2019:

Dr. Marcel Schreuder Goedheijt (Nouryon), replaced by

Dr. Mathieu Ahr

The following members have joined the Executive Board in 2020:

Dr. ir. Frank Wubbolts (Shell)

Dr. Emma Winkels (Liaison NWO)

Supervisory Board (SB)



MR. MARJAN OUDEMAN
Chair



PROF. DR. ANTON PIJPERS
Utrecht University



PROF. DR. JASPER KNOESTER
University of Groningen



DR. DIRK SMIT
Shell



DRS. ROBERT-JAN SMITS
Eindhoven University
of Technology



DR. KLAUS HARTH
BASF



DR. KLAAS KRUIHOF
AkzoNobel



DR. MARCEL SCHREUDER GOEDHEIJT
Nouryon

The Supervisory Board members are supported by the following observers:
Prof. dr. Stan Gielen (Netherlands Organisation for Scientific Research, NWO)
Prof. dr. Emmo Meijer (Holland Chemistry)
Drs. Mark Schmets (NWO)
Drs. Michiel Sweers (Ministry of Economic Affairs and Climate Policy)

The following members left the Supervisory Board in 2019:
Ir. Jan Mengelers (Eindhoven University of Technology),
replaced by Drs. Robert-Jan Smits
Prof. dr. Magnus Nydén (Nouryon), replaced by
Dr. Marcel Schreuder Goedheijt
Dr. Peter Nieuwenhuizen (AkzoNobel)

Scientific Advisory Board (SAB)

Prof. dr. Matthias Beller , Chair (Leibniz-Institut für Katalyse, Germany)
Prof. dr. Markus Antonietti (Max-Planck Institute of Colloids and Interfaces, Germany)
Prof. dr. Ib Chorkendorff (Technical University of Denmark, Denmark)
Prof. dr. Christophe Copéret (ETH Zürich, Switzerland)
Prof. dr. Tanja Cuk (University of California at Berkeley, CA, USA)
Prof. dr. John Dennis (University of Cambridge, UK)
Prof. dr. Rodney O. Fox (Iowa State University, USA)
Prof. dr. ir. Bettina Frohnäpfel (Karlsruhe Institute of Technology, Germany)
Prof. dr. Matthew Gaunt (University of Cambridge, UK)
Prof. dr. Joseph Keddle (University of Surrey, UK)
Prof. dr. Martin Möller (Leibniz Institute for Interactive Materials, Germany)
Prof. dr. Ferdi Schüth (Max-Planck-Institut für Kohlenforschung, Germany)
Prof. dr. Timothy Swager (Massachusetts Institute of Technology, USA)
Prof. dr. ir. Guy Marin , Deputy Chair (Ghent University, Belgium)

The following members have joined the Scientific Advisory Board in 2020:

Prof. dr. Beatriz Roldan (Fritz Haber Institute of the Max Planck Society, Germany)
Prof. dr. Helma Wennemers (ETH Zürich, Switzerland)
Prof. dr. Unni Olsbye (University of Oslo, Norway)

Members

Prof. dr. ir. Adri Minnaard (Groningen University)
Prof. dr. Albert Schenning (Eindhoven University of Technology)
Prof. dr. Alfons van Blaaderen (Utrecht University)
Prof. dr. Bas de Bruin (University of Amsterdam)
Prof. dr. Ben Feringa (University of Groningen)
Prof. dr. Bert Meijer (Eindhoven University of Technology)
Prof. dr. ir. Bert Weckhuysen (Utrecht University)
Dr. Catarina de Carvalho Esteves (Eindhoven University of Technology)
Dr. Daniela Wilson (Radboud University Nijmegen)
Prof. dr. Detlef Lohse (University of Twente)
Prof. dr. ir. Emiel Hensen (Eindhoven University of Technology)
Prof. dr. Erik Garnett (University of Amsterdam)
Dr. Evgeny Pidko (Delft University of Technology)
Prof. dr. Floris Rutjes (Radboud University Nijmegen)
Prof. dr. Frank de Groot (Utrecht University)
Prof. dr. Freek Kapteijn (Delft University of Technology)
Prof. dr. Guido Mul (University of Twente)
Prof. dr. ir. Hans Kuipers (Eindhoven University of Technology)
Prof. dr. Hans de Vries (University of Groningen)
Prof. dr. ir. Jan van Hest (Eindhoven University of Technology)
Prof. dr. ir. Jasper van der Gucht (Wageningen University & Research)
Prof. dr. Joost Reek (University of Amsterdam)
Prof. dr. ir. Kitty Nijmeijer (Eindhoven University of Technology)
Prof. dr. ir. Krijn de Jong (Utrecht University)
Prof. dr. Marc Koper (Leiden University)
Prof. dr. Marjolein Dijkstra (Utrecht University)
Prof. dr. Matthias Bickelhaupt (Vrije Universiteit Amsterdam)
Prof. dr. Moniek Tromp (Groningen University)
Dr. Monique van der Veen (Delft University of Technology)
Prof. dr. Nathalie Katsonis (University of Twente)
Prof. dr. ir. Niels Deen (Eindhoven University of Technology)
Prof. dr. Peter Bolhuis (University of Amsterdam) (joined in 2019)
Prof. dr. Petra de Jongh (Utrecht University)
Prof. dr. Pieter Bruijninx (Utrecht University)
Prof. dr. ir. René Janssen (Eindhoven University of Technology)
Prof. dr. ir. J.R. Ruud van Ommen (Delft University of Technology)
Prof. dr. Sijbren Otto (Groningen University)
Prof. dr. Syuzanna Harutyunyan (Groningen University)
Prof. dr. ir. Thijs Vlugt (Delft University of Technology)
Prof. dr. Wesley Browne (Groningen University)
Dr. ir. W.M. Wiebe de Vos (University of Twente)
Dr. Wilson Smith (Delft University of Technology)

ARC CBBC welcomed the following five new members in 2019



PETER BOLHUIS

Full professor at the University of Amsterdam, head of Amsterdam Center for Multiscale Modeling (ACMM) and current director of the van 't Hoff Institute for Molecular Sciences (HIMS).



ERIK GARNETT

Obtained his PhD from the University of California Berkeley (US) in 2009, followed by a postdoctoral fellowship at Stanford University. He joined AMOLF to launch the Nanoscale Solar Cells group in 2012 and became Professor by special appointment at the University of Amsterdam in 2018.



KITTY NIJMEIJER

Full professor and head of the Membrane Materials and Processes group at Eindhoven University of Technology (TU/e). Her research expertise focuses on the fundamentals of membrane chemistry and morphology to control mass transport in macroscopic applications.



EVGENY PIDKO

Associate professor and head of the Inorganic Systems Engineering group at the Chemical Engineering Department of Delft University of Technology. He received his PhD from Eindhoven University of Technology in 2008, where in 2011-2017 he was an Assistant Professor of Catalysis for Sustainability.



MONIQUE VAN DER VEEN

Full professor at the University of Amsterdam, head of Amsterdam Center for Multiscale Modeling (ACMM) and current director of the van 't Hoff Institute for Molecular Sciences (HIMS).

All new members will contribute to the ARC CBBC as an inspiring platform to conduct truly fundamental, interdisciplinary research in collaboration with leading partners.

Public Partners

Utrecht University
 University of Groningen
 Eindhoven University of Technology
 NWO
 Holland Chemistry
 Ministry of Economic Affairs and Climate
 Policy
 Private Partners
 AkzoNobel
 BASF
 Nouryon
 Shell
 Associate Public Partners
 Delft University of Technology
 Leiden University
 Radboud University Nijmegen
 University of Amsterdam
 University of Twente
 Free University Amsterdam
 Wageningen University & Research

ARC CBBC Support Office

The ARC CBBC Support Office is hosted by the coordinating partner, Utrecht University. The composition of the Support Office in 2019 was as follows:

Maurice Mourad, Programme Coordinator
Anita ter Haar, Financial Controller
Hannah Thuijs, Community Manager (joined in 2019)
Anne-Lot de Heus, Communication Officer (joined in 2019)

The following team members left the ARC CBBC Support Office in 2019:

Marga Jansen (Secretary)
Tjitske Visscher (Communication Officer)

Diversity and Scientific Integrity

To solve the world's problems and tackle its challenges, we need to reflect on the world's diverse composition. Diversity breeds creativity and innovation and allows knowledge and discoveries to flourish.



Diversity at ARC CBBC covers every aspect from multidisciplinary to organisational partnerships, from research application areas to international collaborations, and is of equal importance across the range of people working with us, attending our events, reading our work, conducting our research and more.

Since the population of people working full-time in chemistry-oriented research institutes as well as enterprises in The Netherlands is (still) dominated by white heterosexual males with a Dutch nationality, we need to become more effective at drawing people from the widest possible pool, to ensure that proposed solutions reflect the needs and values of a progressive society. Therefore, special attention is given to increasing gender balance and diversity within the group of people working in ARC CBBC. This starts with raising awareness, for example in addressing the importance of diversity in job adds for new hires.

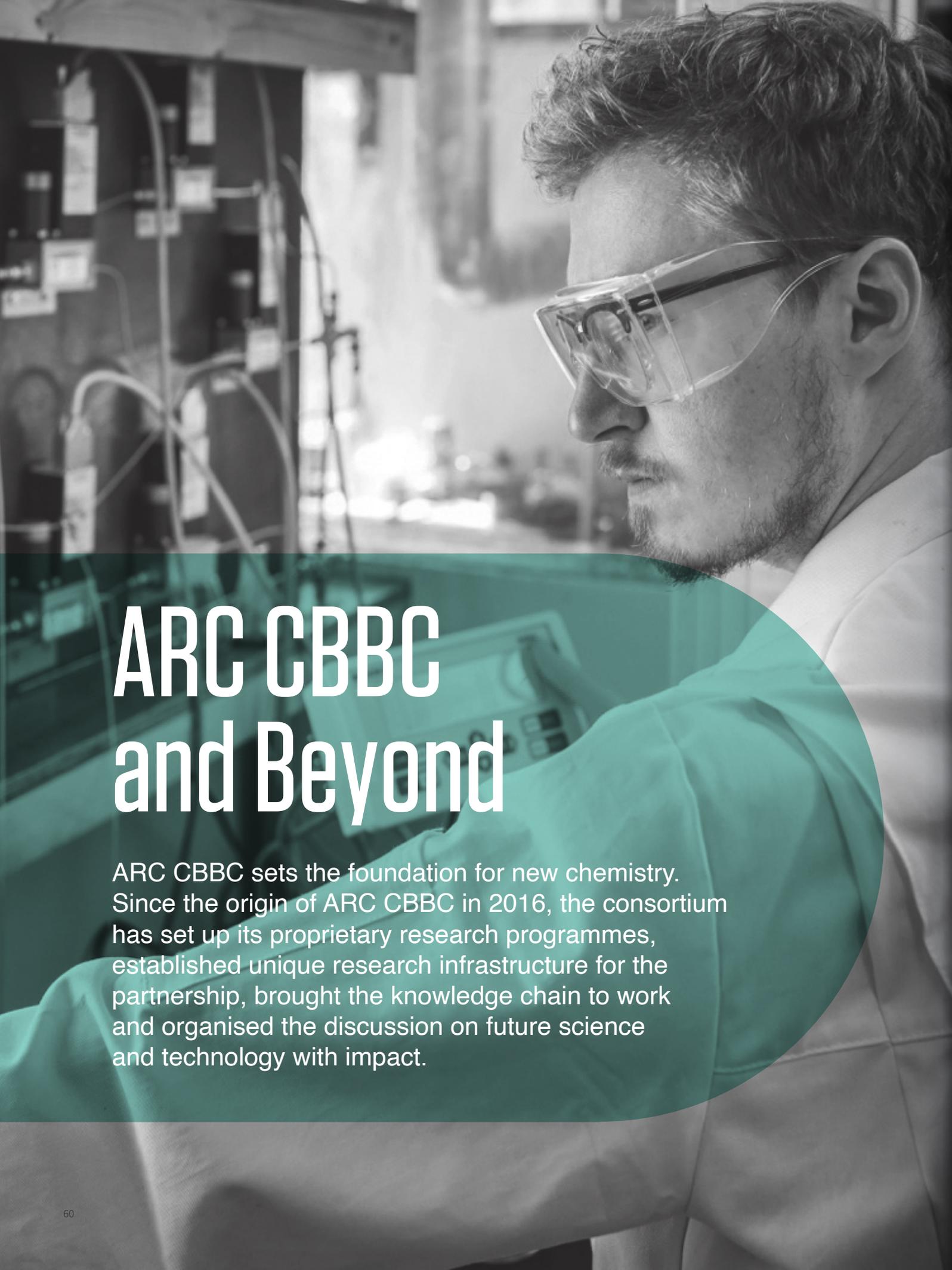
Actions

The partners of ARC CBBC emphasise in job advertisements for tenure track assistant professors and technicians that they are equal opportunity employers that value diversity within their organizations. Selection processes for job hiring within ARC CBBC may not discriminate on the basis of ethnicity, religion, national origin, gender, sexual orientation, age, marital status or disability status. The selection procedures followed are in line with the guidelines of the NVP Recruitment Code and the European Code of Conduct for recruitment of researchers from the European Commission.

Within ARC CBBC, young researchers are developing themselves during their PhD or first postdoctoral research appointments under the guidance of academic as well as industrial supervisors. Apart from the added value and inspiration that the additional viewpoint and guidance from an individual that works for an industrial company may have, this also puts additional responsibility with respect to scientific independency, integrity and openness. Therefore, it was decided that the education programme will explicitly focus on these aspects in order to create awareness as well as ethical consciousness on topics such as the (open access) publication, confidentiality and patenting of research output and the implications and impact that may result.

Scientific integrity is another essential basis of all research performed at ARC CBBC. The consortium works only with research institutions that have an active policy on scientific integrity. On the initiative of several organisations and institutions, a committee has drawn up a new Netherlands Code of Conduct for Research Integrity. The Code of Conduct has been adopted by all universities and applies as from 1 October 2018. The Code includes the five principles which form the basis of integrity in research: honesty, scrupulousness, transparency, independence and responsibility.

ARC CBBC will continue to give attention to diversity and scientific integrity in for example its recruitment policy, but also by incorporating both subjects in ARC CBBC's educational programme.



ARC CBBC and Beyond

ARC CBBC sets the foundation for new chemistry. Since the origin of ARC CBBC in 2016, the consortium has set up its proprietary research programmes, established unique research infrastructure for the partnership, brought the knowledge chain to work and organised the discussion on future science and technology with impact.

The plans for the coming years are ambitious. It is decided that the consortium wants to bring more coherence in new parts of the research programme, expanding the knowledge build-up in chosen focus areas strongly related to energy, circularity, and materials. Therefore, a flagship will be launched that will bring together as many as possible members around the central theme of new chemical conversions and functionalisation. Given the growing importance of climate change mitigation internationally, it is the ambition of ARC CBBC to become a real powerhouse and driving force of creative, inspirational and non-incremental innovative chemistry for our future.

ARC CBBC remains open to new (international) partners and keeps exploring new topics and opportunities, such as the National Investment Fund of the Netherlands and European funding. At the same time the consortium is preparing for some significant milestones: a self-evaluation and external evaluation will pave the path to the first lustrum, to be celebrated in 2021. That will also kick off the start of the second phase of the consortium.

The successful transformation of the chemical industry depends on collaborative efforts and the ARC CBBC is one of them that hosts the production and knowledge chains. Only together we can create the new future of chemistry. It is ARC CBBC's aim to make that we can come to realistic and effective solutions that will enable a significantly lower CO₂ footprint and acceleration of the circular economy within the chemical industry.

Transformation in industry is not a future event, but has started already.

Colophon

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