Driving Change towards **Sustainable Chemistry**

International Sustainable Chemistry Collaborative Centre (ISC_3)
Annual Report May 2019 – May 2020

Sustainable Chemistry *is a holistic, value chain-oriented approach that we can pursue. For a long time, chemistry tended to play a very passive role. This is now starting to change. Chemists, researchers, students and practitioners are now beginning to take on a new vital role in tackling environmental challenges. Sustainable chemistry can develop solutions, for example, benign materials with which we can meet challenges we are facing. So, as a consequence, it's all hands on deck. Chemists play a vital and pivotal role in research, design and implementation.* *Dr Jaisheila Rajput, CEO, TOMA-Now, South Africa*

About ISC_3

The mission of the International Sustainable Chemistry Collaborative Centre (ISC_3) is to promote and develop sustainable chemistry solutions worldwide. It engages with civil society, the public sector and the private sector to contribute to international chemicals policies and build up a global network for sustainable chemistry. The ISC_3 is run by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. GIZ's partners in this project are the German Society for Chemical Engineering and Biotechnology (DECHEMA), where the Innovation Hub is located, and Leuphana University Lüneburg (Germany), which hosts the Research and Education Hub. The centre was founded in 2017 on the initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the German Environment Agency (UBA).

ISC_3 engages in international policy dialogue processes to promote the concept of sustainable chemistry and sound management of chemicals and waste, especially in the Strategic Approach to International Chemicals Management (SAICM) beyond 2020 process. As a multistakeholder platform, the ISC_3 serves as an interface between the public and the private sector. By connecting different stakeholders, the centre supports transformative collaboration in the field of chemicals management, the United Nations Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development.

Acting as an innovation promoter and start-up supporter, the ISC_3 scouts for innovation to discover new sustainable chemical solutions and business ideas, especially in developing countries. Through its Global Start-up Service, delivered by the Innovation Hub at DECHEMA, the centre offers start-ups, entrepreneurs and innovators in the field of sustainable chemistry mentoring, training and other supporting services to bring innovative products and services to market.

As part of its educational activities implemented through the Research & Education Hub at Leuphana University Lüneburg, the ISC_3 recently launched the first Master's Degree in Sustainable Chemistry and runs an annual Summer School on Sustainable Chemistry. At its research unit, ISC_3 explores emerging concepts and current research topics relating to green and sustainable chemistry and collects and evaluates examples of green and sustainable chemistry. Working towards a new mindset in the chemicals sector, the centre engages in the international scientific dialogue on sustainable chemistry.

As a knowledge hub and dialogue forum for sustainable chemistry, the ISC_3 organises events, conferences, workshops and exhibitions to engage with stakeholders, gather and exchange knowledge, raise awareness and disseminate information.

Contents

Opportunities for **Sustainable Chemistry** in challenging times

Two main topics dominated the reporting period from May 2019 to April 2020: first, a growing awareness of environmental problems, accompanied by an increasing number of protest movements, such as Fridays for Future, and initiatives calling for more sustainability and climate protection at all levels of politics and the economy; and second, the outbreak of the COVID-19 pandemic which, as in the rest of the world, led to programme changes at ISC_3.

In the first instance, the pandemic pushed environmental and climate problems into the background. However, the crisis was also seen as a chance to rethink human lifestyles, to bring about necessary changes and to invest in sustainable future technologies to rebuild the economy. In particular, the flexibility with which governments and companies were able to react to the pandemic gives reason to hope that similarly far-reaching measures could be taken to pursue sustainability. While the fight against the pandemic remained the highest priority, a discussion was triggered about forging a new economic model, one that is more resilient, more protective, more sovereign and more inclusive. It was also realised that the transition to a climate-neutral economy and the protection of biodiversity have the potential to rapidly deliver jobs, stimulate growth, contribute to the SDGs and build more resilient societies. In mid-April 2020, the European Green Recovery Alliance was founded by 180 chief executive officers (CEOs), politicians, trade unions, non-governmental organisations (NGOs) and think tanks.

At the international level, the Strategic Approach to International Chemicals Management (SAICM) beyond 2020 process aims to set up a framework for the sound management of chemicals and waste. The ongoing negotiations provide a window of opportunity not only to strengthen international cooperation on chemicals management but also to integrate the new concept of Sustainable Chemistry into the future framework on the sound management of chemicals and waste. With the fifth session of the International Conference on Chemicals Management (ICCM5) the ISC_3 is engaged in fostering and informing dialogues on sustainable chemistry at the interface for policy, thus supporting the process for the development of an ambitious framework beyond 2020.

Despite the challenging times, there are silver linings in all sectors: Companies in all industries and sectors are increasingly aware of the SDGs and are taking steps to mainstream sustainability measures in their products and supply chains although measuring net progress towards sustainable development remains challenging. The United Nations study 'The decade to deliver: A call to business action, The United Nations Global Compact – Accenture Strategy CEO Study on Sustainability 2019' confirms that sustainable development continues to move higher on the agenda of international companies, with growing commitment, belief and action from CEOs. Sustainable development and the redesigning of products have proven to be a driver of innovation, and companies with a strong sustainability strategy are more successful at attracting and retaining talent and young professionals. Research and development in the academic sector and in the development departments of companies is providing more and more solutions for sustainable production and disposal. Innovations are gradually being successfully implemented in production processes by start-ups and other companies. Within its fields of activities, the ISC_3 is committed to ensuring that these positive developments continue to gain momentum.

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Implementation of the first ISC$_3$ workstream

In 2019, the ISC$_3$ carried out its first workstream. The topic of the 2019/20 workstream was "Plastics in Sustainable Building and Living". Experts from all over the world and from different disciplines contributed their knowledge to a total of four workshops held in the context of international conferences (AchemAsia in Shanghai, Nairobi Innovation Week, Sustainable Built Environment in Graz and Greenbuild 2019 in Atlanta). The result report summarises knowledge and recommendations for decision-makers.

First ISC$_3$ Stakeholder Forum

For ISC$_3$, as a multistakeholder organisation, engagement and a cross-sectoral dialogue with all stakeholders is an essential element of strategic development. The Stakeholder Forum, held in **June 2019** in Königswinter, close to Bonn in Germany, provided an open platform to bring together representatives from policy-making bodies, industry, academia and civil society. The participants discussed how sustainable chemistry could contribute to achieving the SDGs and become a solution provider for a circular, climate-resilient society. More than 110 experts from Africa, Asia, Europe, and North and South America joined the new dialogue event and helped to shape the ISC$_3$ work programme.

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The first ISC$_3$ Innovation Challenge in Sustainable Building and Living, in line with the workstream topic, led to 47 applications with many top-notch ideas from 6 continents and over 15 countries. The jury selected eight finalists, who received training and ongoing customised support from ISC$_3$ and the Think Beyond™ Innovation Accelerator. The winner was announced at the Investor Forum, which was postponed due to the COVID-19 pandemic and held in **October 2020** as a virtual event.

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First Master's Degree in Sustainable Chemistry starts at Leuphana University

In cooperation with ISC_3, Leuphana University Lüneburg established the world's first Master's Degree (MSc) in Sustainable Chemistry. The programme is designed for international professionals in the chemical sector and started in **March 2020** as an e-learning course. The four-semester syllabus offers comprehensive interdisciplinary training in sustainable chemistry – from the molecular level to global material flows.

Summer School 2019: The myths of renewables

The fifth Summer School on Sustainable Chemistry for Sustainable Development, jointly organised by ISC_3 and Leuphana University Lüneburg, provided participants with an understanding of the latest developments in concepts relating to sustainable chemistry and chemicals management. During the training event, which ran from **16 to 20 September 2019**, students and professionals from all parts of the world got together and took a closer look at renewables.

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ISC_3 workshop at the Industrial Green Chemistry World (IGCW) Convention

In **October 2019**, in cooperation with the Green ChemisTree Foundation, ISC_3 organised the Workshop on Green and Sustainable Chemistry-based Entrepreneurship at IGCW. Some 40 students and other stakeholders from the Indian Institute of Technology (IIT) Bombay joined the workshop which featured showcase presentations by local entrepreneurs developing sustainable chemistry solutions and a panel discussion on the question 'How can we build a more supportive innovation ecosystem for green and sustainable chemistry in India?'

Approaching Sustainable Chemistry from different angles: Our five fields of activity

Collaboration

ISC_3 connects stakeholders from all sectors and facilitates a transparent and collaborative discussion and promotion of Sustainable Chemistry. As a platform for dialogue, the ISC_3 brings together experts from industry, academia, politics, government agencies and civil society to share ideas, voice expectations and raise concerns about the emerging concept of sustainable chemistry.

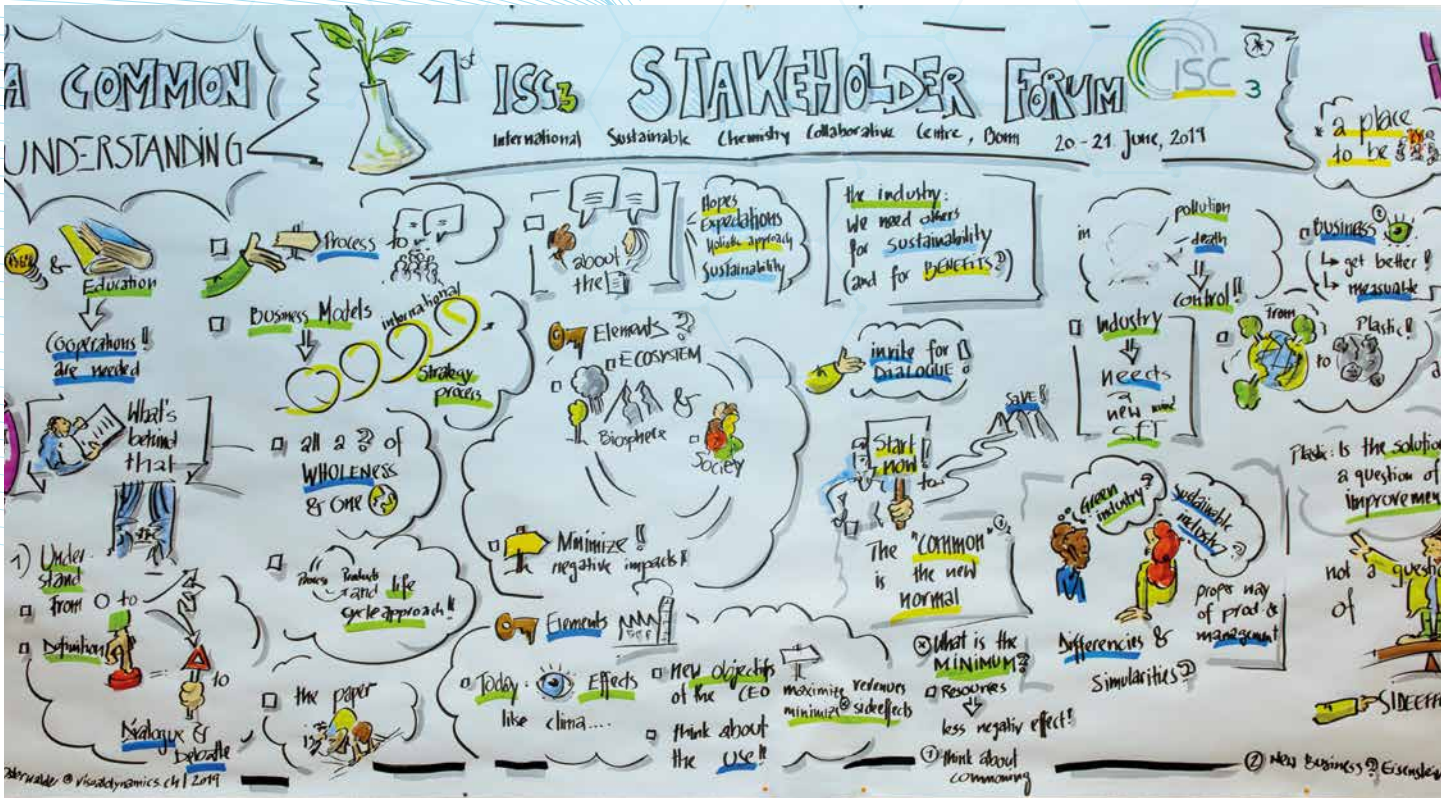
The collaborative work of the ISC_3 in 2019 and 2020 was focused on three areas: an international and conceptual dialogue on sustainable chemistry with contributions to the United Nations Environment Programme (UNEP) and the SAICM beyond 2020 process, technical and expert collaboration within the first ISC_3 foresight workstream and the preparation of flagship projects to showcase sustainable chemistry.

Discussing the concept of Sustainable Chemistry with our international partners

As a globally operating institution and think tank, ISC_3 is committed to the transformation of chemistry towards sustainability in cooperation with all relevant stakeholders. Key elements of ISC_3 stakeholder engagement are the Advisory Board and the Scientific Board as well as the ISC_3 Stakeholder Forum. These three complementary forums allow the ISC_3 to discuss its work programme and provide experts and activists with an opportunity to share ideas and activities, thus building up an 'international sustainable chemistry community'. Members and participants of all three forums met in Königswinter (near Bonn), Germany, in June 2019.

*For me, **Sustainable Chemistry** means a precautionary principle, a concept that encompasses different tools, such as green chemistry and sustainable development. Coming from a developing country, I consider sustainable chemistry to be especially important because we have weak institutions. With sustainable chemistry, we can do things differently and better.* *Edu Inam (PhD), Department of Chemistry, University of Uyo, Nigeria*

The meeting of the Advisory Board on the sidelines of the ISC_3 Stakeholder Forum gave new impetus to the ISC_3 work programme and contributed to the further development of the concept of Sustainable Chemistry. The Scientific Board provided advice on the research activities and the education programme, specifically preparations for the new Master's Degree in Sustainable Chemistry.



As a dialogue event, the Stakeholder Forum involves the ISC$_3$ stakeholders in its work programme and engages them in a cross-sectoral dialogue on the emerging concept of Sustainable Chemistry. The first ISC$_3$ Stakeholder Forum provided an open platform to bring together representatives from politics, industry, academia and civil society to discuss how sustainable chemistry could contribute to achieving the SDGs and become a solution provider for a circular, climate-resilient society. More than 110 experts from Africa, Asia, Europe, and North and South America participated in the new dialogue event. During the two-day conference, participants engaged in an intense interactive programme. All the documentation relating to the Stakeholder Forum 2019 can be found in our report, which is available online and on request.

Promoting Sustainable Chemistry in the international community within the SAICM process

In the lead-up to the third meeting of the Intersessional Process in Bangkok, the ISC$_3$ hosted a workshop to discuss the key elements of the first draft for a 'Common Understanding of Sustainable Chemistry' and the potential contributions of the emerging concept to the SDGs. Experts from 17 countries exchanged views on the ISC$_3$ thought-starter 'Reaping the full potential of sustainable chemistry for SAICM, the Sound Management of Chemicals and Waste beyond 2020 and the 2030 Agenda' and on the ongoing dialogue and current expectations surrounding the emerging concept of sustainable chemistry.

The first ISC$_3$ workstream: Plastics in Sustainable Building and Living

In its workstream process, ISC$_3$ focuses each year on an essential SDG-oriented branch topic. The workstream involves international experts from various fields and hosts a series of dialogues. With the results of these dialogues, experts prepare a final report which contains recommendations for experts and decision-makers. The first workstream 2019/2020 covered the specialist topic of Plastics in Sustainable Building and Living. The ISC$_3$ gathered experts for a total of four workshops, which took place within the context of international specialist events and conferences – AchemAsia in Shanghai, Nairobi Innovation Week, the Sustainable Built Environment Conference in Graz and Greenbuild 2019 in Atlanta. The workstream was further presented and discussed at the Healthy Buildings Conference in London, the Sustainable Built Environment Con-

ference 2019 in Scilla and the Regulatory Summit in Brussels. In addition to the workshops, several online surveys were designed and distributed to stakeholders. The workshops addressed the following topics: urbanisation and resilience, demography and affordable housing, health and environmental protection, and energy demand in the building life cycle. They were attended by 58 local and international experts from various sectors, including the chemical industry, engineering, construction recycling and waste management, and representatives from ministries and agencies (construction and environment), the financial sector, NGOs and large international organisations. More than 100 respondents from all continents took part in the online surveys. The contributions of the experts, together with the documented stakeholder discussions and the online surveys, were compiled to produce a final report under the direction of ISC_3. The report discusses possible solutions to improve the sustainability of the construction sector and examines sustainable construction chemicals. It also identifies relevant fields of innovation based on the work of exemplary start-ups.

Sustainable building and living: The ISC_3 workstream addresses current topical issues and provides recommendations for decision-makers

Expert workshop on Digital Transformation and Artificial Intelligence

Like all industries, the chemical industry is undergoing a 'digital transformation' in which more and more digital technologies are triggering a profound change in processes and business models. Blockchain, Big Data, Artificial Intelligence (AI) and Quantum Computing are the current drivers of the transformation of industry and the economy. ISC_3 brought experts from academia, NGOs and industry together with entrepreneurs to discuss opportunities and challenges arising from the combination of sustainable chemistry and digitalisation. During the workshop held on 25 and 26 February 2020 in Frankfurt, all the participants agreed that digital processes are optimisers in the industry that can be used to adjust production parameters and increase safety and efficiency. They also help to reduce waste and emissions and to source raw materials with greater precision. One example is blockchain technology which is already used for tracing conflict minerals and nanomaterials.

The potential of sustainable chemistry is further enhanced when AI and huge computing power are put to use as a tool for chemical research and development. This starts with benign-by-design approaches and estimating chemical exposure and related toxicity effects for humans and ecosystems. The automatic assembly of data for life cycle inventories, for example, can significantly simplify access to sustainability assessment, impact characterisation and sustainable development. The workshop participants concluded that supercomputing and AI open up new horizons of knowledge and opportunities for action. Digital technologies could contribute to exploring – and overcoming – the critical limits of technology.

Plastic Waste Management in Lagos, Nigeria

In Lagos, plastic waste clogs rivers and lakes, pollutes the ocean and is incinerated in the open air. This poses health and hygiene risks, endangers life on land and in the sea and increases greenhouse gases. To develop and implement solutions to this problem, BASF initiated the Plastic Waste lighthouse project at the beginning of 2019 and invited ISC_3 to participate. The project aims to develop sustainable and circular solutions to the plastic waste problem in Lagos.

In addition, the project aims to create jobs in the region and to improve not only the ecological situation but also social living conditions, and the solutions developed should be transferable to other geographical areas. In May 2019, BASF and ISC_3 decided on the strategic and technological direction of the project. The concept envisages various activities, such as the establishment of a waste to chemicals (W2C) system (pyrolysis), the development of waste management systems and capacity building. According to the agreed activity plan, ISC_3 in Lagos carried out comprehensive stakeholder mapping and held an expert workshop with participants from Nigeria in June 2019 as a side event at the ISC_3 Stakeholder Forum. BASF started planning

a pilot-scale pyrolysis plant in Lagos. A memorandum of understanding is to be signed between the partners to regulate cooperation on the project.

Climate Protection Programme for the chemical industry in developing and emerging countries as part of the International Climate Initiative (IKI)

The chemical and petrochemical industry accounts for around 10% of the world's final energy demand and 7% of global greenhouse gas emissions. However, the impact of the chemical industry sector on climate change, the environment and health goes far beyond energy- and material-intensive production processes. More than 90% of all industrial production processes use products from the chemical industry. The design and life cycle of chemical products therefore play an important part in greenhouse gas generation. Although the chemical sector in the European Union has continued to grow at market growth rates, a significant 61% reduction in CO_2 emissions has been achieved since 1990. Given the challenges, a sector-specific climate protection programme for the chemical industry in developing and emerging countries is urgently needed to enable them to achieve their Nationally Determined Contributions.

To address these challenges, the ISC_3 has initiated a process to raise funds within the framework of the International Climate Initiative (IKI). The project proposal is to transfer know-how from Europe to developing and transition countries through a dedicated training programme for capacity building, with the main focus on climate mitigation and chemicals management for the chemical industry. This will be the basis for a later in-depth implementation and upscaling of the project.

Better access to infrastructure for sustainable (chemistry) innovation in Brazil and South Africa (Airbnb4Labs)

The pilot project idea is to promote the sharing of lab space, equipment and services in a way that resembles the Airbnb business idea. The aim is to democratise access to labs step by step and increase collaboration between scientific, research and industry institutions. The project was initiated by ISC_3 and is now being advanced as a public-private partnership with Merck KGaA as the main private partner and with the support of the London-based start-up Clustermarket. Given its potential as a lighthouse project and contributor to SDG 9 – Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation – the German Federal Ministry for Economic Cooperation and Development (BMZ) granted ISC_3 approximately EUR 50,000 to support preparatory activities in pilot countries. With this funding, local ecosystems in Brazil and South Africa were mapped, and the team gained the support of around 15 public institutions that would like to use the project to share labs, equipment and services.

***Sustainable Chemistry** covers the entire process from cradle to cradle. It starts with the production process, with the procurement of raw materials, production, transport and marketing. And ideally, once the materials have been processed, the process starts all over again. This entire value chain must become sustainable. People around the world have begun to realise that our consumption habits are not sustainable, and nature is making this very clear to us right now. Sustainable chemistry provides us with the tools to tackle these problems.* Nitesh Mehta, Director, Green ChemisTree Foundation, India

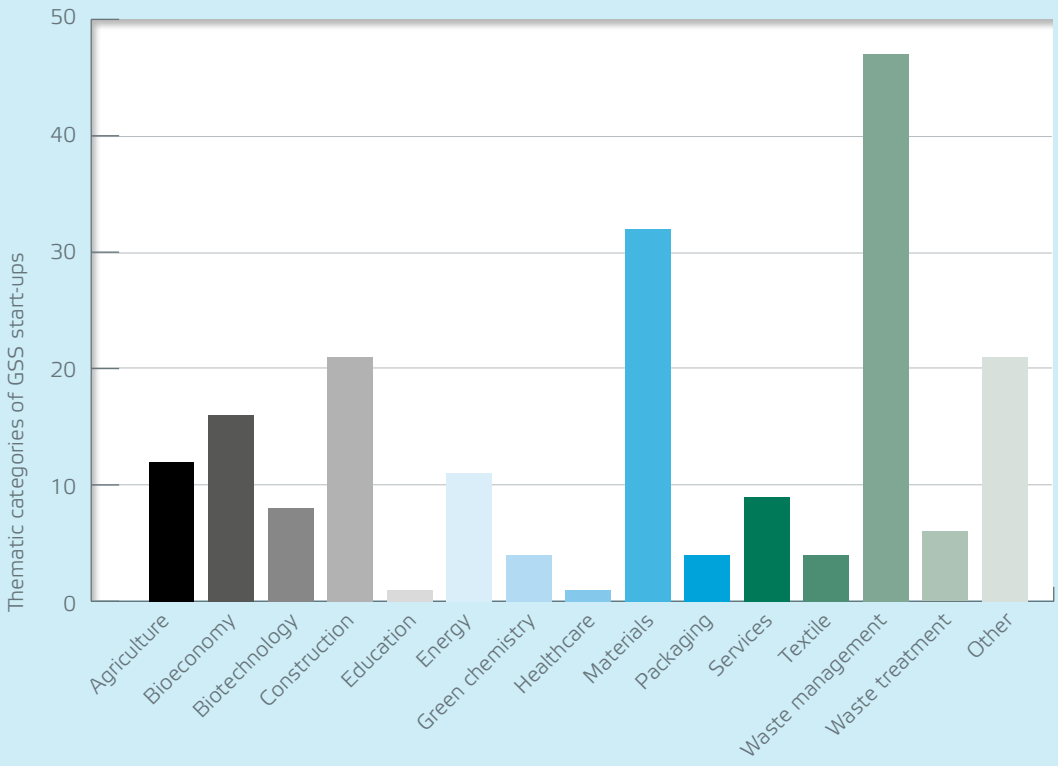
Innovation

Innovative and sustainable solutions in the chemical sector can combat and prevent pollution in the areas of mobility, energy, urbanisation and agriculture. The mission of the ISC_3 Innovation Hub is to initiate and support sustainable innovation and entrepreneurship in the chemical and chemical-related industries. The main outputs of the Global Start-up Service have been the first ISC_3 Innovation Challenge and the development and implementation of a growing portfolio of services and events.

Global Start-up Service

A key activity of the ISC_3 Innovation Hub is the delivery of the ISC_3 Global Start-up Service, the world's first programme supporting entrepreneurs in sustainable chemistry-related fields and providing holistic support to sustainable chemistry innovators globally. The service targets entrepreneurs along the entire innovation chain: ideators, early-stage innovators and advanced entrepreneurs who have the potential to solve urgent challenges to sustainable and inclusive development. It is delivered using the Stage-Gate approach, meaning that start-ups can benefit from three different levels of support: General Support, General Support Plus and Customised Support, depending on how far they are on their journey to becoming sustainable chemistry changemakers.

Sectors in which the 82 start-ups of Global Start-up Services are active (as of April 2020)



During the past year, the ISC₃ Innovation Hub has continued to recruit promising innovators. In April 2020, 82 entrepreneurs from around the world were on-boarded, 23 from Africa, 11 from Asia, 28 from Europe, 12 from Latin America and 8 from North America. To enter the Global Start-up Service, entrepreneurs fill in the on-boarding questionnaire available on the ISC₃ website, which is then evaluated by the ISC₃ Innovation Hub team. The innovations developed by the entrepreneurs span a wide range of categories, including agriculture, bioeconomy, new materials, waste management and construction.

The ISC₃ team and its partner, Think Beyond™ Innovation Accelerator, have set up a curated set of information to support innovators and entrepreneurs exploring opportunities in the sustainable chemistry space. The toolbox is structured according to the stages 'Discover, Create and Expand' and is continuously updated with the most relevant and useful tools and resources to help start-ups on their journey towards market success.

Further, the ISC₃ Innovation Hub has launched a series of customised services, provided mostly on request, such as advice on the feasibility of business ideas, suggestions for improvements and potential partners. The team also provided start-ups with support to identify possible partners, advice on how to find the right site, figures (e.g. on market opportunities) to support decision-making processes, and information on the best trade fairs and events for marketing products.

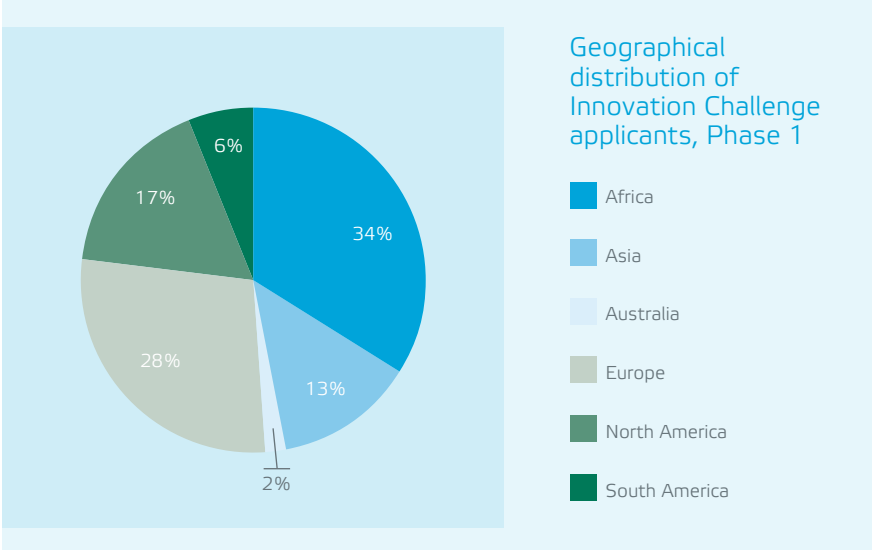
Peer-to-peer networking LinkedIn group

ISC₃ has set up a LinkedIn group for on-boarded start-ups and uses this channel to post topical news, articles, investment opportunities, competition announcements, etc., keeping the community continuously informed about current events and topics relevant to sustainable chemistry. Within the ISC₃ Global Start-up Service Changemaker Group, it also encourages members to team up, engage in discussions and share interesting information. As of April 2020, ISC₃ has 44 start-ups in this group and is continuously adding newly on-boarded members.

ISC₃ Innovation Challenge in Sustainable Building and Living

The first edition of the article Innovation Challenge was launched in May 2019 at the AchemAsia international exhibition and conference in Shanghai, China. The Challenge invited ideators and more advanced entrepreneurs to submit solutions for sustainable building and living. The first application phase resulted in 47 proposals from 26 countries. Based on a pre-screening by the ISC₃ team, 30 selected applicants were asked to submit extended application forms, which were then reviewed by a panel of 16 international judges from different partner organisations, including members of the ISC₃ Advisory Board and external experts brought in by ISC₃.

From the large number of top-notch ideas, eight finalists from three continents and six different countries were selected. Their innovative solutions span a broad range of topics, including the design of construction materials that facilitate recycling, low-cost solutions for affordable housing, and sustainable performance materials and technologies. All eight finalists are receiving ongoing customised support within the Global Start-up Service and will participate in the expert workshops and the Investor Forum 2020. In preparation for the Forum, the finalists are taking part in an online start-up training course provided by Think Beyond™ Innovation Accelerator. On the basis of these training sessions, which include a final rehearsal pitch, five finalists were shortlisted and given the chance to pitch their idea during the online Investor Forum in October 2020, competing to win EUR 25,000.



Research

Research is carried out by the ISC_3 Research and Education Hub (R&EH), which screens new emerging academic research ideas, materials and processes and analyses their potential and pitfalls. Currently, four main research streams are being pursued.

Electrochemical synthesis of chemicals

The synthesis of chemicals based on renewable electricity is a new trend in academic research that is increasingly being discussed in the industry. However, there are many sectors, such as digitalisation, electromobility and communications, that compete for renewable electricity. It is therefore crucial to understand whether there will be bottlenecks in the future in the availability of renewable power on the one hand and the materials required (e.g. metals, see below) on the other. The limitations, pitfalls and neglected problems have been identified and understood. The results, open questions and possible solutions will be discussed in scientific publications. Based on the work done, two publications are currently under development, the results of which will be presented at scientific conferences.

Metals as critical non-renewable resources

As metals are critical for low-carbon technologies, including electrochemical synthesis of chemicals,the findings on this topic will be included in the publications mentioned above. Metal recycling and dissipation can also be used as an example of the entropy change-based sustainability assessment approach. The Research and Education Hub co-organised two very successful workshops to discuss metal-related problems. Both workshops brought together diverse stakeholder groups, including academia, industry, NGOs and government, among others. The multidisciplinary exchange was of great benefit to all the participants and resulted in several further cooperation efforts among actors from different fields and environments.

Entropy change as a measure of chemical sustainability

The first ideas developed by the R&EH on the applicability of entropy change as a measure of sustainability were discussed, and guest experts shared their thoughts on the subject at the workshop 'Entropy change – a suitable measure for (chemical) sustainability?' held in Vienna in June 2019. The workshop resulted in several partnerships and research groups being established. It was concluded that entropy change is a promising measure of sustainability. In this context, entropy change can complement existing approaches by addressing thermodynamic aspects beyond energy, including product complexity, the dissipation of resources and the limits of recycling, among others, that are neglected in commonly applied approaches such as life cycle assessment and material flow accounting. Participants identified numerous possible fields of application and case studies, including plastics and recycling, the steel industry and downcycling, copper and renewable energy, the utilisation of batteries, and microplastics and nanoplastics in water treatment. It was also agreed that addressing such aspects as quality and function assessment, toxicity and climate change using entropy change-based approaches would be challenging and needs to be further investigated.

***Sustainable Chemistry** will address three problems we are facing: resource depletion, pollution and, of course, people's aspirations to live better and better. There are two possible solutions to these problems: the improvement of existing infrastructure and processes and the invention of new chemical processes and products in order to use resources more efficiently and, ideally, without producing harmful substances. I think sustainable chemistry is a fundamental concept, and the ISC_3 is doing something essential in driving these developments forward.* Prof. Changwei Hu, Sichuan University, China*

*Green and **Sustainable Chemistry** is a way to tackle the SDGs and some of the biggest challenges we're facing today. For the Elsevier Foundation, it's a way to spur more science supporting the SDGs as well as research from developing countries and targeted localised solutions. For Elsevier, the scientific publisher and information analytics company, it's very much about fostering a new research area. In all of this, ISC_3 is essential because it brings in a real cross section of stakeholders beyond academia and raises awareness around the critical need for **Green** and **Sustainable Chemistry**.* *Ylann Schemm, Director, Elsevier Foundation, Netherlands*

Chemo-informatics as a versatile tool in Green and Sustainable Chemistry – Study on the biotic and abiotic degradation of ionic liquids as an example

Based on the substance class of ionic liquids, this research looks at the potential and limitations of chemoinformatic tools, with a focus on quantitative structure–activity relationship (QSAR) models and their contribution to the implementation of sustainable chemistry. Ionic liquids are seen as promising solvents in green chemistry (e.g. extraction of cellulose), because of their low vapour pressure, and are called green solvents. They offer many tunable properties and can be easily synthesised. However, other applications that are under discussion will release ionic liquids into the environment, for example, active pharmaceutical ingredients, herbicidal ionic liquids or electrolytes in solar cells and batteries. These are examples where chemicals cannot be circulated in a circular economy. Since ionic liquids are often persistent in the environment, such chemicals and products have to be designed from scratch so that they can be completely mineralised. Under the benign-by-design approach, QSAR models help decide which chemical structures would be a promising candidate for further experimental testing. Currently, QSAR models available for biodegradability need more and better data on ionic liquids to generate reliable predictions for benign design. Last year, ISC_3 reviewed the data available on the biodegradability of ionic li quids in order to better understand the potential role of chemoinformatics in such a context. The results of an extensive literature study are currently being compiled to produce a scientific article.

Rethinking chemistry for a circular economy – Article published in the renowned journal Science

In January 2020, Prof. Klaus Kümmerer, Director of the ISC_3 Research and Innovation Hub and Professor of Sustainable Chemistry and Material Resources at Leuphana University Lüneburg, and ISC_3 Scientific Board members Prof. John Clark from the University of York and Prof. Vânia Zuin from the University of São Carlos published the article 'Rethinking chemistry for a circular economy' in the renowned journal Science. In their article, the authors put forward 15 rules on how chemistry can be integrated into a circular economy and suggest that scientists decipher chemicals at the atomic and molecular level and decode how their design can fit into the concept of a circular economy. This involves simplifying the molecular complexity of products so that they are as simple as possible in their composition and contain fewer additives and avoiding toxic components and those that are difficult to separate during the recycling process.

Education

The activities of the Research and Education Hub (R&EH) in the field of Education include the development of international study programmes for sustainable chemistry in cooperation with Leuphana University Lüneburg to gradually include this subject in higher education. Its activities also include planning and holding the annual Summer School on Sustainable Chemistry for Sustainable Development at the university.

In cooperation with the Leuphana University, the ISC_3 has developed two Master programmes: a Master of Sustainable Chemistry and a Master of Business WAdministration (MBA) in Sustainable Chemistry

Start of the professional Master's Degree (MSc) in Sustainable Chemistry

ISC_3 and Leuphana University Lüneburg have jointly designed the world's first professional Master's Degree in Sustainable Chemistry, which started on 16 March 2020. ISC_3 and the university jointly developed the syllabus for the degree, which is hosted by the Leuphana Professional School. By educating scientists in sustainable chemistry, the Master's Degree aims to leverage the potential of chemistry. The course is taught by internal and external international teaching staff with a background in science, industry and public administration.

It was possible to start the degree in March despite the corona crisis since the course content is mainly taught via e-learning. The programme was launched successfully with very positive feedback all round from the participants at the end of the first classroom session. Ten participants from different regions and with varying chemistry-related backgrounds and professional experience have enrolled for the new study programme. During the four-semester degree course, there are three attendance blocks with lectures, seminars and practical laboratory courses in Lüneburg. The programme has already been awarded the label of the German Accreditation Council (Akkreditierungsrat) and the European Euromaster label by the European Chemistry Thematic Network (ECTN).

Development of an online-based professional Master of Business Administration (MBA) Degree in Sustainable Chemistry

ISC_3 and Leuphana University Lüneburg are planning to launch a professional MBA Degree in Sustainable Chemistry in the summer semester of 2022. Important steps were taken to develop the programme, such as submitting a draft syllabus to the decision-making body (Ministry for Science and Culture of Lower Saxony) and setting up a collaboration initiative for streamlining and sharing educational content with a related degree at Leuphana Professional School. Once the draft syllabus has been approved by the Ministry, the development of the programme will proceed in line with that of the Master's Degree in Sustainable Chemistry.

Fifth Summer School on Sustainable Chemistry for Sustainable Development in Lüneburg, Germany

Another milestone in the work at the R&EH is the holding of the Summer School on Sustainable Chemistry for Sustainable Development. Since 2017, the Summer School has been a well-established yearly event jointly organised by the R&EH and Leuphana University Lüneburg and held on the university campus. The fifth Summer School took place from 16 to 20 September 2019 on the theme 'Sustainable chemistry and the myths of renewables'. It provided participants with an understanding of the latest developments in concepts relating to sustainable chemistry and chemicals management. The team of trainers consisted of scientists and practitioners in different fields of sustainable chemistry and international cooperation. The 50 participants, representing 25 nationalities, were selected from almost 80 applicants. The international participants accounted for 70% of the total.

Information

The exchange of knowledge and the dissemination of information on sustainable chemistry in the fields of innovation, policy, research and education are essential cross-cutting tasks carried out by ISC_3. The centre aims to promote a better understanding of sustainable chemistry and to stimulate an in-depth discussion on the benefits of the emerging concept. With an up-to-date website (▸ www.isc3.org), news tools, social media channels (Twitter, LinkedIn, Facebook and YouTube), events, videos and conferences, ISC_3 seeks to inform stakeholders and invite them to join forces and co-operate with each other for the further development of sustainable chemistry.

In February 2019, ISC_3 released a public relations video highlighting three start-ups and the contributions of the Global Start-up Service to driving innovation and transformation towards sustainability and a circular economy.

The ISC_3 thought-starter 'Reaping the full potential of sustainable chemistry' – first presented at the SAICM (Sound Management of Chemicals and Waste beyond 2020) Open-ended Working Group which met in Montevideo from 2 to 4 April 2019 – has been published on the website and stakeholders invited to contribute their comments. This thought-starter was also discussed during the ISC_3 Stakeholder Forum which was held on 21 and 22 June 2019 in Bonn and attended by 110 participants from Africa, Asia, Europe and North and South America who joined the dialogue on green and sustainable chemistry and its role in achieving the 2030 Agenda.

In September 2019, ISC_3 launched the article series Start-up of the Month. It presents outstanding start-ups from our Global Start-up Service pool on the ISC_3 website and social media channels. The start-ups presented were chosen for their outstanding innovation and sustainability efforts and their potential to promote regional economies and gender equality. The articles are based on the ISC_3 on-board questionnaire and interviews with the founders describing their motivation and the history of their start-up.

So, for me – and not specifically for me because I represent my country and also Africa and developing countries in general – talking about sustainable chemistry means going beyond normal chemistry, beyond the classical world of chemistry, which is all about atoms, molecules, transformation and then producing products. This is where ***Sustainable Chemistry*** *comes in, offering benefits in economic, social and environmental terms. The whole of society must benefit from the sources, materials and products that chemistry provides.* *Sam Adu-Kumi, Director, Chemicals Control and Management Centre, Environmental Protection Agency (EPA), Ghana*

Welcoming new partners: **Together for Sustainable Chemistry**

On the road to sustainable chemistry, the ISC_3 has started to develop a wide network of partner organisations and multipliers worldwide. In the reporting period, ISC_3 welcomed five new members to the ISC_3 Spiderweb Network. It connects organisations with a shared vision of sustainable chemistry as an important contribution to the 2030 Agenda for Sustainable Development. Its members foster support for innovators in their regions, mobilise resources and knowledge towards sustainable chemistry solutions and empower other players, in particular start-ups, to join the community.

The five new partners welcomed by ISC_3

National Agency for Research and Innovation, Uruguay (ANII)

ANII executes the country's strategic research and innovation policy guidelines in Uruguay. It promotes, coordinates and strengthens the capabilities of the National Innovation System to achieve sustainable, productive and social development. Thanks to a sound legal framework and an effective information technology infrastructure, the National Innovation System has the potential to become a role model for the Southern Cone. The ANII currently holds the presidency of the newly formed Latin American Network of Innovation Agencies, known as RELAI.

Brightlands Chemelot Campus, Netherlands

At Brightlands Chemelot Campus in Sittard-Geleen (Netherlands), entrepreneurs, scientists and students work together in the fields of performance materials, process technology and biomedical solutions. This helps build bridges between research and innovations in companies. The campus and the adjacent Chemelot industrial park together form one giant laboratory, where the brightest, highly qualified experts from universities and the business community work together.Brightlands Chemelot Campus is part of Brightlands, an open innovation community made up of four campuses that are working on major challenges in the fields of materials, circular chemistry, health, agri-food, data science and smart digital services.

Green ChemisTree Foundation/India

The Green ChemisTree Foundation – India is a registered not-for-profit organisation founded with the vision of advancing technical know-how on green chemistry and engineering applications among the chemical community, including industry, academia, research institutes, government bodies and students. The foundation's focus has been mainly on the process industry, covering sectors such as pharmaceuticals, dyes and pigments, agrochemicals and speciality fine chemicals. Green ChemisTree Foundation collaborates with various local and international experts and agencies to create diverse initiatives aimed at accelerating the implementation of green chemistry and engineering to achieve environmental sustainability. IGCW is the Green ChemisTree Foundation's flagship convention, a platform that brings all the stakeholders of the Indian chemical industry together to deliberate on innovative solutions, best practices and tools in the field of green and sustainable chemistry.

Start-Up Chile

Start-Up Chile is a public start-up accelerator created by the Chilean Government to help high-potential entrepreneurs bootstrap their start-ups and use Chile as their base. Today, Start-Up Chile is the leading accelerator in Latin America, among the top ten globally and one of the biggest and most diverse start-up communities in the world. It has been a global game-changer. After it was created, 50 countries followed suit and created similar programmes.

youthinkgreen/Egypt

youthinkgreen Egypt is a social enterprise engaged in educating and empowering youth to apply sustainable ecological solutions to global challenges and problems by designing world-class, hands-on empowerment programmes for young people. The organisation runs a Sustainability and Entrepreneurship Youth Programme in Egypt each year, aiming to provide training to young emerging environmental entrepreneurs and enable them to create innovative solutions to Egypt's most pressing sustainability challenges and develop start-up models for such solutions.

ISC_3 Events and Activities

Fourth Green and Sustainable Chemistry Conference, Dresden, Germany, 5 to 8 May 2019

The annual high-level conference discussed and put forward green and sustainable chemistry issues in a unique interdisciplinary manner. The conference was chaired by Prof. Klaus Kümmerer, Director of the ISC_3 Research & Education Hub and organised by Elsevier in cooperation with Leuphana University Lüneburg and the ISC_3.

ISC_3 Fact-Finding Mission to India, 1 to 10 May 2019

Based on ecosystem mapping for India, the ISC_3 Innovation Hub conducted a fact-finding mission to India to expand the network of partners supporting start-ups. The mission was focused on the Mumbai, Pune, Hyderabad and Delhi areas, where meetings with thirteen incubators, four aggregators, two corporates, one industry organisation and one service provider were conducted.

Innovators Roundtable of the Green Chemistry and Commerce Council (GC3), Cincinnati, United States, 7 to 9 May 2019

The ISC_3 Innovation Hub organised the participation of delegations from three South American institutions – the Technological Laboratory of Uruguay (LATU), the Uruguayan Agency for Research and Innovation (ANII) and the Peruvian environmental NGO Grupo GEA – in the GC3 Innovators Roundtable in Cincinnati.

Workshop 'Entropy change – a suitable measure for (chemical) sustainability?', Vienna, Austria, 25 to 26 June 2019

The workshop explored the applicability of entropy change as a measure of sustainability. It was organised by the ISC_3 Research and Education Hub, the Austrian Federal Ministry for Sustainability and Tourism and the Institute of Sustainable and Environmental Chemistry at Leuphana University Lüneburg.

Workshop 'Metall des Jahres' (Metal of the Year), Goslar, Germany, 4 to 5 July 2019

The R&EH contributed to the Metal of the Year Workshop which addressed the increasing demand for metals and the consequences of this trend. It was jointly or-

ganised by Die Transformateure – Akteure der Großen Transformation, the German Federal Environmental Foundation, the Mines of Rammelsberg World Heritage Site Museum and Visitor Mine, Clausthal University of Technology, the Institute of Materials Resource Management of Augsburg University, Leuphana University Lüneburg and ISC₃.

Fact-Finding Missions to Chile and Uruguay, July 2019

The purpose of the fact-finding missions was to expand the network of partners supporting the Global Start-up Service. The missions were combined with meetings with existing partners to advance joint work and initiate new collaborative activities. In total, 25 institutions were visited for kick-off conversations or to further expand existing cooperation.

Fifth Summer School on Sustainable Chemistry for Sustainable Development in Lüneburg, Germany, 6 to 20 September 2019

The ISC₃ Summer School 2019 addressed the myths of renewables. It was jointly organised by the ISC₃ R&EH and Leuphana University Lüneburg and provided participants with an understanding of the latest developments in concepts relating to sustainable chemistry and chemicals management.

ISC₃ workshop 'Striving towards a common understanding of sustainable chemistry' Bangkok, Thailand, 29 September 2019

In the lead-up to the third meeting of the Intersessional Process considering the Strategic Approach and sound management of chemicals and waste beyond 2020, ISC₃ prepared a workshop to introduce and discuss the concept of sustainable chemistry with all interested parties.

ISC₃ Workshop on Green and Sustainable Chemistry-based Entrepreneurship at IGCW, Mumbai, India, 18 October 2019

The Workshop on Green and Sustainable Chemistry-based Entrepreneurship was aimed at young Indian chemistry and chemical engineering students interested in exploring entrepreneurship. It was organised together with the Green ChemisTree Foundation at the Industrial Green Chemistry World 2019 (IGCW) in Mumbai.

Workshop 'Metals – a prerequisite for digital transformation', Tutzing, Germany, 8 to 10 November, 2019

The three-day workshop was organised by the Evangelische Akademie Tutzing in cooperation with the ISC₃ R&EH, Leuphana University Lüneburg, the German Federal Environmental Foundation, Entwicklungsfonds Seltene Metalle (ESM Foundation), the Institute of Materials Resource Management of Augsburg University and Die Transformateure – Akteure der Großen Transformation. Participants discussed how to address the increasing demand for metals needed for digital transformation and sought solutions for their use in a wise and sustainable manner.

ISC₃ workshop 'Visions for Sustainable Chemistry – How can digitalisation contribute?', Frankfurt, Germany, 25 to 26 February 2020

The workshop identified trends, methods and tools and looked at how digitalisation can contribute to sustainable chemistry. ISC₃ organised the event in collaboration with the University of Cambridge, the Technical University of Denmark, UNEP and Forum Start-up Chemie at DECHEMA.

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We were kindly provided with the portrait photos from the quoters.

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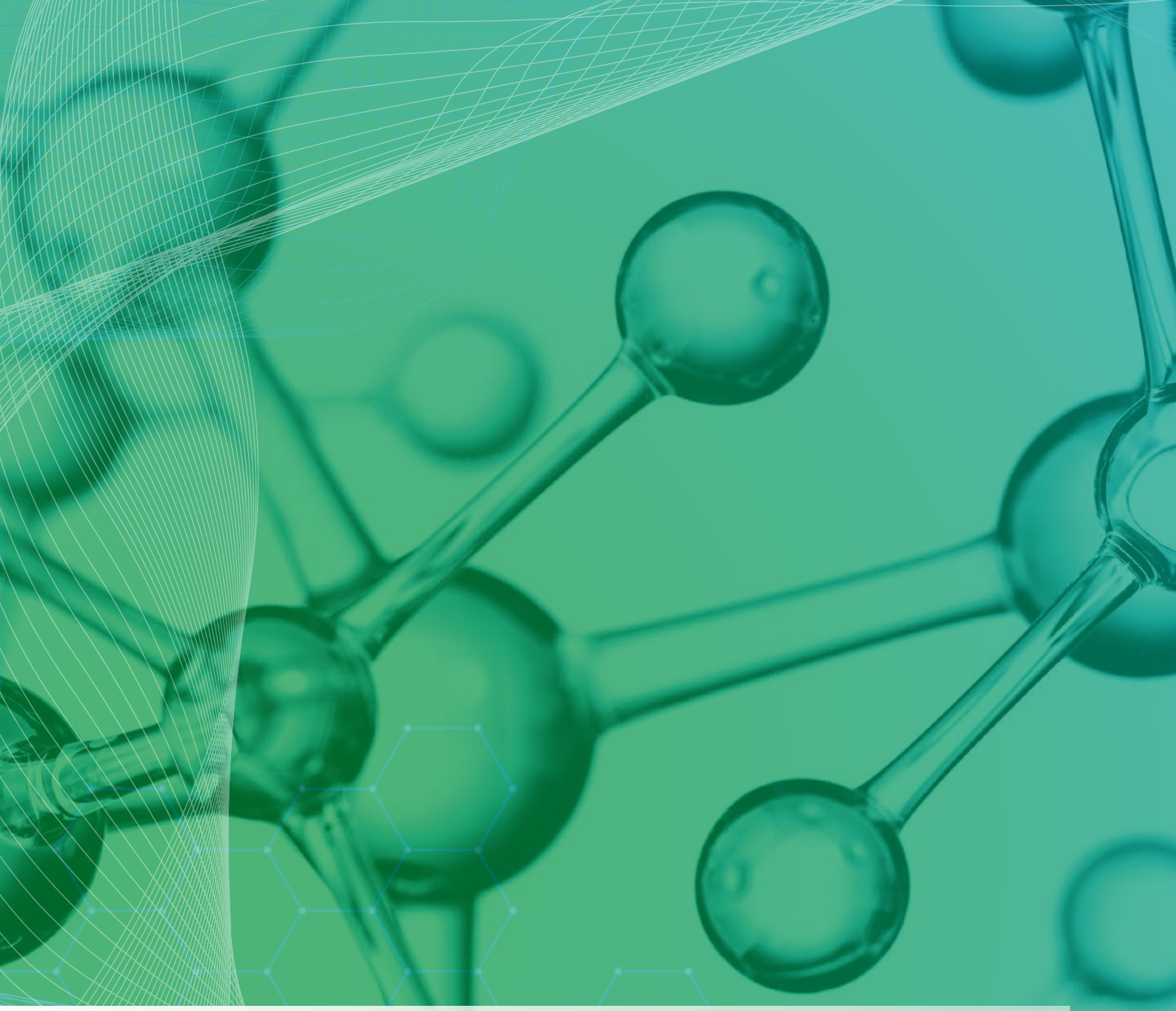
#ISC

To drive sustainability, we have to look after our entire economy, and chemistry plays a significant role in this; it reaches into every aspect of our lives. We need to take care of the impact we have environmentally and socially all over the world. When we talk about sustainable chemistry, speed is the key. To accelerate innovation processes, we need to foster start-ups; they are light and agile companies that move really fast.

Sebastian Diaz, former CEO at Start-Up Chile



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