EuCheMS
European Chemical Sciences

Integrating CO_2 in the value Chain – The role of chemistry

European Economic and Social Committee, Brussels, Belgium

3 March 2015, 10h - 12h

Carbon management is an essential component of future sustainable developments. Carbon dioxide is available as “waste” in huge amounts from various industrial sources. Tapping on this potential feedstock allows harvesting renewable energy into the chemical value chain. Possible applications include fuels, basic chemicals, polymers, and even fine chemicals and pharmaceuticals.

Sustainable chemistry focuses on the development of environmentally benign chemical reactions and products. It helps enhancing more efficient chemical processes, technologies and product designs that conserve resources, generate less waste and hazardous emissions, and deliver a sustainable, cleaner and healthier environment. In this context, carbon management is one of the key challenges that European chemistry is addressing, by contributing to research, academic work, and industrial application.

The workshop will bring together European policy-makers, the chemical sector, the academic world, and civil society, with the aim of raising awareness on the scientific challenges that chemistry faces in order to be able to capitalize on the economical and ecological opportunities of harvesting renewable energy into the chemical value chain. **By highlighting successful examples and best practices, the workshop will present concrete perspectives for carbon management as an essential component of sustainable development.**

The key speakers:

Prof. Walter Leitner and **Prof. Jurgen Klankermayer** (CVs attached) received the European Sustainable chemistry Award in 2014.

Prof. Leitner and Prof. Klankermayer from the Institute of Technical and Macromolecular Chemistry at the RWTH Aachen University, who are being recognised for their important contribution to the field of catalytic transformation of carbon dioxide.

The European Sustainable Chemistry Award (ESCA)– a EuCheMS initiative

In 2010, the European Association for Chemical and Molecular Sciences (EuCheMS) has launched the European Sustainable Chemistry Award (ESCA). This has been encouraged by the European Environment Agency (EEA) and supported by the European Platform for Sustainable Chemistry (SusChem) and the European Chemical Industry Association (CEFIC).

Rationale

The European Sustainable Chemistry Award is designed to:

- recognise individuals or small research groups which make an outstanding contribution to sustainable development by applying green and sustainable chemistry;

- promote innovation in chemistry and chemicals that will deliver clear improvements in the sustainable production and use of chemicals and chemical products;

- demonstrate that chemistry and chemicals can play a central role in delivering society's needs, while minimizing and solving environmental problems.

Successful national green and sustainable chemistry award schemes have been in place for some years in several European countries and outside Europe and a recent study by the Economist Intelligence Unit points to the value of awards as demand side solutions as a key element in pushing the EU further up the global innovation rankings. The European Sustainable Chemistry Award is intended to be a prestigious scheme which will raise the profile of sustainable chemistry and be a spur to innovation and competitiveness.

Scientific focus

The Award covers innovations in the following scientific areas:

- the use of alternative synthetic pathways, that increase resource efficiency and selectivity e.g. with the help of catalysis or natural processes;

- the use of alternative feedstocks which are safer and/or renewable e.g. based on biomass;

- the use of alternative reactor design and reaction conditions, such as use of solvents which deliver health and environmental benefits, or increased yield and reduced waste and emissions;

- the design and use of chemicals and chemical products that are, for example, less environmentally harmful than current alternatives, or inherently safer with regard to hazardous concerns.

Professor Emeritus David Cole-Hamilton, EuCheMS President (CV attached)

This workshop will discuss most recent research developments in this area and it continues what started to be debated in 2013 (see attached report).

Nineta Hrastelj Majcen, PhD
EuCheMS General Secretary
February 2015

Curriculum Vitae Prof. Dr. Walter Leitner

Affiliation:

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Personal Data:

Born on February 1, 1963, in Pfarrkirchen, Germany

Married with Andrea Leitner (nee Schön), 2 children, Eva-Maria (born 1993) and Johannes (born 1995)

Education and Professional Experience:

10/1982-12/1987	Studying Chemistry at the University of Regensburg (Dipl.-Chem. Univ.)
12/1987 - 12/1989	PhD (Dr. rer. nat.) with Prof. H. Brunner, Institute for Inorganic Chemistry at the University of Regensburg (*Thesis*: Enantioselective Catalytic Transferhydrogenation using Formates)
01/1990 - 12/1990	Postdoctoral Studies at the Dyson Perrins Laboratory for Organic Chemistry, University of Oxford, UK, with Prof. J. M. Brown
01/1991 - 08/1992	Liebig Fellow of the Fonds der Chemischen Industrie at the Institute for Inorganic Chemistry at the University of Regensburg
08/1992 - 05/1995	Research associate at the Max-Planck-Working Group „CO_2-Chemistry“ (Director: Prof. E. Dinjus) at the Friedrich-Schiller-University Jena.
05/1995	Habilitation (Dr. rer. nat. habil.) in Inorganic Chemistry and appointment as Privatdozent (lecturer) at the Friedrich-Schiller-University Jena (*Thesis*: Catalytic Hydrogenation of Carbon Dioxide to Formic Acid)
06/1995 - 01/1998	Group leader at the Department of “Organic Synthesis” (Director: Prof. M. T. Reetz) at the Max-Planck-Institut für Kohlenforschung, Mülheim/Ruhr.
01/1998 – 02/2002	Head of the Technical Laboratories at the Max-Planck-Institute for Coal Research, Mülheim/Ruhr
04/2000 - 02/2002	Acting Chair of “Technical Chemistry and Petrochemistry” at RWTH Aachen
since 02/2002	Chair of Technical Chemistry and Petrochemistry (Successor to. Prof. W. Keim) at the Institut für Technische and Makromolekulare Chemie at RWTH Aachen
since 12/2002	External Scientific Member of the Max-Planck-Institut für Kohlenforschung, Mülheim/Ruhr

Research Interests

Green Chemistry through sustainable catalytic processes

Mechanisms and structure/activity-relationships in organometallic catalysis

New chemical transformations and new raw materials for energy carriers and chemical products

Supercritical fluids and other advanced fluids as benign reaction media for catalysis

Multiphase catalysis and catalyst immobilization for continuous-flow molecular catalysis

Publications

More than 220 contributions to peer-reviewed international journals and edited monographs

Co-Editor of the books *Chemical Synthesis Using Supercritical Fluids* (Wiley/VCH 1999, *Multiphase Homogeneous Catalysis* (Wiley/VCH 2005), and *Handbook of Green Chemistry, Vol. 4: Supercritical Solvents* (Wiley/VCH 2010**)**.

Over 25 patents and patent applications in the field of catalytic chemical synthesis and/or the application of supercritical fluids

More than 100 invited lectures at international conferences and research institutions

Professional Activities

Member of the Strategy Council of RWTH Aachen University (since 2009)

Scientific Director of CAT, the joint Catalytic Center of RWTH Aachen, Bayer Material Science and Bayer Technology Services (since 2007)

Member of the Scientific Management Board of the Cluster of Excellence “Tailor-Made Fuels form Biomass” at RWTH Aachen (since 2007)

Co-Chairman of the DFG Graduiertenkolleg “Biocatalysis in Non-Conventional Reaction Media (BioNoCo)” at RWTH Aachen (since 2005)

Scientific Editor of the RSC journal “Green Chemistry” (since 2004; IF 2011: 6.85)

Member of the International Advisory Board of “Advanced Synthesis and Catalysis” (since 2005)

Member of the Board of DECHEMA (from 2011)

Chairman of the Catalysis Section of DECHEMA (2006-2008)

Chairman of the German Catalysis Society GeCatS (since 2011)

Member of the Board of the Petrochemical Division of DGMK (2005 - 2011)

Member of the Board of the Section “Sustainable Chemistry” of GDCh (since 2006)

Fellowships, Scientific Recognition, and Awards

1982-1987	Hundhammer-Stipendium of the Government of Bavaria
1987-1989	Promotions-Stipendium of the Government of Bavaria
1990	Studienabschluss-Stipendium of the Fonds der Chemischen Industrie (FCI)
1990	Award for Best PhD Thesis in Sciences of Energieversorgung Ostbayern AG
1990	Postdoctoral Fellowship of the Stiftung Volkswagenwerk
1991-1992	Liebig-Fellowship of the Fonds der Chemischen Industrie (FCI)
1997	Gerhard-Hess-Award of the Deutsche Forschungsgemeinschaft (DFG)
1997	Angewandte-Chemie-Award for best lecture at the Chemiedozententagung
1998	Bennigsen-Foerder-Preis of Nordrhein-Westfalen
1998	Carl-Zerbe-Award of the Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle (DMGK)
01/1999	Visiting Scientist at the National Institute for Chemicals and Materials Research in Tsukuba, Japan
11/1999	Nozaki Lecture, Univ. Osaka, Japan
2000	2nd International Messer Innovation-Award
2001	Otto-Roelen-Medal of DECHEMA
2003	Griess Lectureship of the Royal Society of Chemistry
2005	Guest Professorship at the Universitè de Bourgogne, Dijon, France
2008	CATSA Eminent Visitor Award of the South African Catalysis Society
2009	Wöhler Award of the Gesellschaft Deutscher Chemiker
2010	Fellow of the Royal Society of Chemistry (FRSC)
2011	Honorary Member of the Ethiopian Chemical Society
2013	Visiting Lecturer for the Promotion of Chemistry, National Science Council Taiwan

CURRICULUM VITAE

PROF. DR. JÜRGEN KLANKERMAYER
(PROFESSOR AS JUNIOR-PROFESSOR)

Institut für Technische und Makromolekulare Chemie
Junior-Professur „Mechanismen in der Katalyse“
RWTH Aachen
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Education and Professional Experience

1993 - 1999	Chemistry Studies, University of Regensburg, Germany
1998 - 1999	Diploma Thesis, *Prof. Dr. Henri Brunner* (University of Regensburg) "*Chiral 1-Phospha[1]ferrocenophanes and 1,12-Diphospha [1.1]ferrocene-phanes - Synthesis, Characterization and Ring-Opening Polymerization*"
1999 - 2002	PhD Thesis, *Prof. Dr. Henri Brunner* (University of Regensburg) "*Synthesis and comparative stereochemical studies of chiral-at-metal cycloheptatrienyl-molybdenum and cyclopentadienyl-ruthenium complexes*"
2002 - 2003	Post-Doc with *Prof. Dr. François Mathey*, École Polytechnique, Paris, France *“Synthesis of planar chiral phosphametallocenes and their application in asymmetric catalysis”*
2003 - 2004	Post-Doc with *Dr. John M. Brown*, Dyson Perrins Laboratory und Chemistry Research Laboratory, University of Oxford, UK *“NMR and computational studies on the mechanism of Soai’s asymmetric autocatalytic reaction”*
2005 - 2009	Scientific Assistant with *Prof. Dr. Walter Leitner*, Institut für Technische und Makromolekulare Chemie (ITMC), RWTH Aachen University Head of NMR-Department Head of GC/HPLC/MS-Department
since 10/2009	Professor as Junior-Professor „Mechanisms in Catalysis“ Institut für Technische und Makromolekulare Chemie (ITMC), RWTH Aachen University
11/2012	Positive Evaluation of Junior-Professorship „Mechanisms in Catalysis“

Five selected publications:

1. F. M. A. Geilen, Barthel Engendahl, A. Harwardt, W. Marquardt, J. Klankermayer, W. Leitner, Selective and flexible transformation of biomass-derived platform chemicals by a multifunctional catalytic system, *Angew. Chem. Int. Ed.* **2010**, *50*, 5510.
2. D. Chen, Y. Wang, J. Klankermayer, Enantioselective Hydrogenation with Chiral Frustrated Lewis Pairs, *Angew. Chem. Int. Ed.* **2010**, *49*, 9475.
3. F. M. A. Geilen, T. vom Stein, B. Engendahl, S. Winterle, M. Liauw, J. Klankermayer, W. Leitner, Highly Selective Decarbonylation of 5-(Hydroxymethyl)furfural in the Presence of Compressed Carbon Dioxide, *Angew. Chem. Int. Ed.* **2011**, *50*, 6831.
4. S. Wesselbaum, T. vom Stein, J. Klankermayer, W. Leitner, Hydrogenation of Carbon Dioxide to Methanol using a Homogeneous Ruthenium-Phosphine Catalyst, *Angew. Chem. Int. Ed.* **2012**, *51*, 7499.
5. K. Beydoun, T. vom Stein, J. Klankermayer, W. Leitner, Ruthenium-Catalyzed Direct Methylation of Primary and Secondary Aromatic Amines Using Carbon Dioxide and Molecular Hydrogen, *Angew. Chem. Int. Ed.* **2013**, *52*, 9554.

Synergistic Activities:

- Member of the core group of the “Center for Molecular Transformations“ (since 2010)
- Member of GeCATS (since 2010)
- Member of the group for sustainable chemistry of the GDCh (since 2010)
- Development of the lecture series “Sustainable industrial Catalysis” at RWTH Aachen University

David Cole-Hamilton (Professor Emeritus) has served the scientific community as President of the Chemistry Section of the British Association for the Advancement of Science, Chair of the Royal Society of Edinburgh Chemistry Committee and as member of several Committees of the Royal Society of Chemistry. Moreover, he has served 4 years on the Council of the Royal Society of Chemistry and he has been the UK representative on the EuCheMS Division for Organometallic Chemistry since 2005. He has recently been elected to serve as President of the Dalton Division of the Royal Society of Chemistry.
David Cole Hamilton is Professor Emeritus of Chemistry at the University of St. Andrews, Scotland. His main research interests are on applications of organometallic compounds to solving problems in material chemistry and homogenous catalysis. He also had excursions into diverse fields as electron transfer across membranes, developing a new process for the conservation of wooden archaeological artefacts using supercritical drying and extensive studies of reaction mechanisms in solutions and in the gas phase.
David Cole-Hamilton defines himself as a committed European and a committed chemist, who truly believes that chemistry holds the keys to the future prosperity and quality of life for all.

David J. Cole-Hamilton, Irvine Professor of Chemistry, University of St. Andrews, Scotland, U. K.

Research

I have spent all my working life in Academic positions; the last 28 year as Professor of Chemistry in St. Andrews. My main research interests are on applications of Organometallic compounds to solving problems in materials Chemistry and homogeneous catalysis, although I have had excursions into such diverse fields as electron transfer across membranes, developing a new process for the conservation of wooden archaeological artefacts using supercritical drying and extensive studies of reaction mechanisms in solution and in the gas phase. I have published 367 papers, patents and book chapters with an h factor of 40. I have given 180 Conference presentations and 170 seminars at Universities and in Industry. In addition to training 66 PhD students and 47 Postdoctoral Fellows, I have received over £10 M in grant income from UK Research Councils, UK and Overseas Industry, UK Government sources and the EU .

Teaching

I am devoted to teaching, having taught lecture and laboratory courses in transition metal and main group Chemistry at all levels and have won four prizes for teaching based on student opinion.

National Adminstration

I have been President of the Chemistry Section of the British Association for the Advancement of Science, Chair of the Royal Society if Edinburgh Chemistry Committee and served on very many Committees of the Royal Society of Chemistry. Most recently, I have served 4 years on the Council of the Royal Society of Chemistry, its main governing body and on the Audit Committee, being its Chair for the last two years. I have recently been elected to serve as President of the Dalton Division of the Royal Society of Chemistry from July 2013 for 3 years.

This Committee work has given me tremendous insight into the workings of a large Chemical Society, which would help me to become familiar with the workings of EuCheMS very quickly. I have excellent working relationships with the President, Professor Lesley Yellowlees, the President-elect, Professor Dominic Tildeseley and the Chief Executive Officer, Dr. Robert Parker.

The European Dimension

I have been the UK representative on the EuCheMS Divison for Organometallic Chemistry since 2005. and am currently Chair of the Organising Committee for the 20th EuCheMS Conference on Organometallic Chemistry (www.eucomcxx.com), which will be held in St. Andrews 30th June - 4th July, 2013 and has attracted some 480 delegates.

I have been involved in the EU Network of Excellence, IDECAT as a Workpackage Leader and member of the Governing Board. I currently serve on the Executive Committee and am both a Work package Leader and Case Study Coordinator for the Large EU Collaborative project, SYNFLOW I have participated in three Initial Training Networks (or equivalent) most recently as Deputy Coordinator and Chair of the Training Committee for Nanohost.

Industry

Much of my work has an applied bent and substantial amounts of my research funding have come from Industry. A process for the synthesis of trimethylgallium developed in my group was commercialised through Epichem (now SAFC), with the product being used in the manufacture of gallium arsenide for solar cells. It has earned >£1M per year for the last 20 years. My work in catalysis was instrumental in attracting Sasol, the international Fuels and Chemicals Company to site their *European Research Laboratory* in St. Andrews (2002) in laboratories adjacent to my own. Sasol now employ 25 people in St. Andrews and have just signed a second 10 year lease on the premises. They have contributed >£20 M to the UK economy through this laboratory over the last 11 years.

SUMMARY REPORT

On the 13th of November, the chair of the "Water" Working Group of the European Parliament Intergroup on "Climate Change, Biodiversity and Sustainable Development" **MEP Cristina Gutiérrez Cortines** hosted a workshop on the subject of "Sustainable Chemistry: Supporting Research, Innovation and Competitiveness in Europe" which was organized in cooperation with the European Association of Molecular and Chemical Sciences (EuCheMS). The meeting brought together policymakers from the European Commission, experts from chemical associations and the academic world, representatives from the NGO community and the industry, to discuss the role of sustainable chemistry and its ability in responding effectively to society's challenges and global changes.

MEP Cristina Gutiérrez Cortines

MEP Gutiérrez Cortines stated that chemistry is a key sector in environmental policy yet it is a sector that is too often misunderstood. Politicians, media and citizens do not dig deep enough to understand what lies behind chemistry issues. However, green chemistry is the future: it will help changing old industrial models and the industry has a key role to play in this process.

In the area of raw materials for instance, it is important to find alternatives to the current economy that is based on fossils and non-renewable primary raw materials and to work on the lowering of resource consumption.

The second pillar, green production, is also too often overlooked. A lot of research is being carried throughout the world to look for new models but this is often too technical and not sufficiently popular in the political arena and the public is often not aware of it.

The European Commission is currently working on developing a model of public-private partnership (PPP) with industry. *"It is important to understand that all the achievements that are needed cannot be done solely under public administration, but the industry has to work hand in hand with researchers, the Commission and the Member States. Countries need to change old practices of putting all responsibilities in the hands of the administration. Solutions will only be found through partnerships: PPPs should be a top priority for the future."* It will be, in this light, also essential to give property rights to SMEs and more visibility to the researchers and technicians working for big industries.

Greater public and administrative awareness is needed; old administrative settings are not prepared to work under PPPs and with SMEs. This will be a key issue for the future, especially under Horizon 2020. The same goes for new regulations under structural funds and how industry will work with regions.

Prof. Ulrich Schubert, EuCheMS President, Vienna University of Technology

Prof. Schubert explained that EuCheMS is the umbrella organisation of chemical societies in Europe. It benefits from a huge pool of expertise covering scientific, technological and industrial aspects of chemistry and neighbouring areas.

Chemistry represents a key economic factor in Europe. Knowledge and innovation created by chemical science and the chemical industry has contributed to create the present standards of living in Europe, which contribute to improve prosperity and health.

Chemists also have to take into account ecological footprint and lifecycle perspectives. Thus growth as such has no perspectives: what we need is sustainable growth, as clearly addressed in Horizon 2020 programme.

Chemistry as a science and a branch of industry is prepared to tackle current challenges. This requires major investments from industry and from society in general. There are other issues, however, which are not scientific, technical or monetary in nature. It is, for instance, not always easy to find substitutes for some critical materials that are essential to maintain our standards of living. Our society needs to take a decision on how to compromise. Furthermore, chemistry has to be perceived as a problem-solving discipline and a key innovation factor, and not as a threat.
Knowledge-oriented science is a fundamental element in the innovation chain. To this end, science education needs to be intensified in schools and the curricula in universities need to be reviewed. We need highly educated and trained people with a broad background to deal with these key issues of sustainability. Among others, "we must stop the trend towards hyper-specialisation at the universities."
Prof. Schubert raised awareness on one of EuCheMS' flagship initiatives, which is the ***European Sustainable Chemistry Award*** (more info).

Presentations

Renzo Tomellini, Head of Unit "Materials" in DG Research and Innovation, European Commission
Mr. Tomellini recalled that Europe has a glorious past in the area of chemistry. Chemistry is everywhere and in everything but there has been a lack of communication on it. The question is how to pass this fact into a political language?
In the current FP7, more than 600 million Euros are available under running projects on topics linked to chemistry, and this figure is now being increased.
Chemistry must be seen as addressing societal challenges and as a provider of solutions on questions of ageing population, energy, transport, water purification, pharmaceuticals, and so on. Research made under FP7 is in products, processes and organisation, both upstream and downstream, and is following an integrated approach (circular economy). All the actors in the value chain of knowledge creation and exploitation are encompassing to achieve consensual innovation.
Horizon 2020 aims at helping further the transformation and modernisation of the chemical industry towards the goals of competitiveness and sustainability.
Is REACH the only of regulating chemistry and industrial production? Certainly not: the solutions to current challenges will be found increasingly more in new ideas and new technological approaches. *"We cannot continue to do things in the same manner as we have been doing up until now. We need to use intelligence in what we do and change our approach towards more sustainability without losing sight of our industry's competitiveness."*
It would be very difficult to think of Europe without chemistry: chemistry is likely to be one of the big stakeholder sectors in horizon 2020 and in European industrial production and economy.

Bjorn Hansen, Head of Unit "Chemicals", DG Environment, European Commission
Mr. Hansen held that sustainable chemistry in the long run is essential. *"Looking at the 7th Environmental Action Programme (EAP), it is obvious in its vision of where we want to be as a society in 2050 that sustainable chemistry is one essential element of how to get there and to reach a number of other objectives, such as non-toxic environment and resource-efficiency."*
There aren't many things that are either not made of chemicals or at some point in their production phase that were not in contact with chemicals. Furthermore, in terms of economic factor, the annual turnover of chemicals in the world is 230 billion Euros worth of chemicals manufactured. It is the chemistry that effectively defines the limitations of how long a wing in a windmill can be and hence

it is chemistry that defines how much of wind power and therefore alternative energy we can get out of one windmill.

Chemistry is central in our economy, in a number of our policies, and is a limiting factor in many of our technological developments; hence support for this area is essential.

Chemical legislation can play a role in this by supporting the development of green chemicals. For instance, putting legislative demands on chemicals that deserve a future and on chemicals that deserve to be rethought, which makes it easier to use better chemicals and implicitly more difficult to use less good chemicals. This sets a clear direction as to which types of chemicals do we want in our society in 20 years. Under REACH for instance, the safety concerns and safety elements are incorporated in the chemical product. Prior to REACH, chemicals were sold because of their performance; now, chemicals compete not only on their performance but also based on a combination of performance and safety. Practically speaking, if we have two chemicals that have similar performances, if one is safer compared to another then REACH will promote the product that is easier to handle safely compared to the other across the board. Another example of how legislation can contribute towards green chemistry is REACH authorisation system, which has the objective of phasing out all substances of very high concern for which there are no economically and technologically feasible alternatives available. If there is an alternative, the hazardous substance should then be substituted.

Ultimately, if we are to achieve sustainability and develop green chemistry, we will also need to look at waste streams as chemical streams. Chemicals have to be seen as resources in these streams: we have to find ways to recover the chemicals and to design chemicals in such ways to ease their recovery. We can only get there if we get knowledge on chemicals and this is an area in which DG Environment and DG Enterprise work a lot together.

In conclusion, development needs innovation and innovation needs regulatory predictability. But innovation also needs knowledge and information that can be used and made available to enable better design of chemicals.

Prof. Marc Taillefer, research team leader at the Institut Charles Gerhardt (ICG), Montpellier, France and Winner of the European Sustainable Chemistry Award (ESCA II)

Prof. Taillefer affirmed that chemistry has an important role to play for sustainable development, namely in the sectors of transport, sea, energy, health, and so forth. Chemistry helps to create new materials to lighten vehicles and increase their resistance, discover new fuels from plants, or improve the efficiency of batteries for electric vehicles. Chemists can understand the sea, its chemical reactions and exchange, use its resources for drugs and energy production, and also help the sea in cases of oil spills for example with oil dispersants. Chemistry can also develop and enhance future-oriented energy technology such as storage, photovoltaic cells, energy transport, and so forth. Chemistry plays a key role for health: it allows the development of new chemical tools, allows understanding chemical reactions, and helps to treat humans and animals by discovering chemical molecules and imagine new technical treatment tools. Thanks to chemistry, we can understand, reproduce and create new molecules inspired by nature. In addition, nowadays, chemistry enables to create and produce new drugs in sustainable conditions. Marc Taillefer illustrated this point by describing a new green synthetic route to a drug that is the most administered drug to fight breast cancer nowadays.

For those reasons that are part of our everyday lives and the development of our societies and populations, research and innovation has to be fundamentally supported. Chemistry is at a crossroad of several sciences (medicine, aeronautics, physics, electronics, geology, biology, computing, oceanography, etc): it represents a key discipline with a direct impact on daily lives and the development of our industries in the sectors of transport, sea, energy, health, food, housing, sports, art, etc.

Katalin Barta, Assistant Professor of Green Chemistry and Catalysis, Stratingh Institute for Chemistry, Groningen, The Netherlands

Ms. Barta started her presentation by showing the Danube and expressing her hope that something will be done urgently to prevent persistent organic pollutants, halogenated chemicals, heavy metals and non-biodegradable waste such as plastic bottled from polluting it. She illustrated this reality by saying that for every minute she has been speaking 3 tonnes of toxic chemicals have been release directly to air and water.

One major concern with sustainable chemistry is whether scientists understand the toxicity of materials they use and that citizens get daily contact with.

Another question we should be asking ourselves is how long our resources will last. For example, rhodium metal is used in the production of many chemical products we are in daily touch with (for example in the synthesis of menthol used in chewing gums). It is an optimistic guess to say that in 50 years there will be no rhodium left. The question thus is: how will we produce these chemicals that we need in our lives?

96% of the chemicals we produce come from non-renewable petroleum; we produce 10 billion tonnes of fossil fuels per year. In 50 years, there will be massive changes regarding this situation.

Can we continue down this path, she asked. “We are on an unsustainable trajectory. Chemists have the power to innovate and have the responsibility to change this situation.”

P.T. Anastas from the University of Yale laid down 12 principles of sustainable chemistry. In simplistic terms, green chemistry provides chemists guidelines for design at the molecular level. For example, develop new chemical reactions that do not create waste, do not use harmful solvents, that starting materials end up in the products, and have low toxicity. It means a new way of thinking about chemistry and chemicals in general. However, in practice to design a chemical reaction that is entirely in agreement with these principles is a highly challenging task. More basic research is needed to find these sustainable chemical processes. 150 years ago chemists did not take into account sustainability questions: thus, new knowledge has to be created and research goals have to be redefined.

“We need to change our mindsets.” All actors in society, academia, industry and politics, have to work together in a symbiotic manner to make a change and relevant impact. The industry has to understand that green methodologies are also economically more sustainable. Furthermore, government subsidies can help the industry to bridge the ‘innovation to production gap’. On the side of research, more funding is needed, that is more transparent, accessible and simple to get.

Vito Buonsante, Lawyer, Health and Environment, ClientEarth

Mr. Buonsante stated that the European chemicals industry accounted for 30% of global sales of chemicals in 2003 and for 21% in 2012 as China became the biggest player; yet, the EU chemicals industry remains the world’s largest exporter and its turnover has increased in absolute terms. Current EU laws and regulations push for the design of safe chemicals and seek to discourage the development and use of hazardous ones. Recently the EU has banned the use of 3 recognised hazardous pesticides, and hazardous chemicals will increasingly be under scrutiny. The key concepts that are now pushed for are substitution when possible with a less hazardous chemical and the use of the precautionary principle.

Yet, hazardous chemicals represent a clear business risk as it renders difficult to plan in the long term due to regulatory uncertainty. Furthermore, the reputation of users and suppliers can be undermined by growing public knowledge on their potential liability for failing to prove safe use of substances or product containing them. Indeed, hazardous chemicals use may increase the costs of compliance for businesses.

On the other hand, there are clear benefits in legislating on the use of chemicals and in banning the use of hazardous chemicals. For instance: the incidence of diseases caused by chemicals is lowered; fewer chemicals persist in water, soil and air; it contributes to safer food; it boosts the circular economy and contributes to waste reduction and decreasing related-costs; and it ultimately allows higher competitiveness on non-EU markets.

As means of recommendation, Mr. Buonsante called for the improvement of the polluter pays principle for manufacturers and users of hazardous chemicals. Another useful action would be to increase citizens' knowledge about hazardous chemicals in products. For instance, chemicals should be identified on the basis of their hazardous properties such as whether they contain endocrine disruptors. Finally, promotion of research in sustainable innovation should be increased and strengthened.

Fabrice Stassin, Manager EU Government Affairs, UMICORE

Dr. Stassin explained that Umicore is a global materials technology company that transforms metals into materials for specific high-tech applications. Umicore follows a 'closing the loop' business model, which consists of using chemistry, material science and metallurgy to turn metals into material solutions. Umicore is also the largest precious metals' recycler in the world, turning material back into metal.

Umicore's development fits with sustainability-driven trends, as the company is a leading producer of key materials for rechargeable batteries for laptops, mobile phones and electric vehicles. The company is also very active in recycling (driven by resource-scarcity) with the ability to recycle over 20 different metals from different feed-ins. More stringent emission controls is the driver behind Umicore developing catalysts that are used throughout the world for cars, trucks and non-road vehicles.

Umicore is a leader in renewable energy applications, such as energy storage using batteries, fuel cells, concentrated photovoltaics (CPV). Europe is facing major challenges from an energy point of view, driven by competitiveness, as the cost of energy in Europe is much higher than in other parts of the world, because of lack of security of supply, as Europe spends enormous amounts of money to import energy from non-EU countries, and for sustainability reasons, such as the fight against climate change and its consequences. These are the 20-20-20 targets that are driving the agenda today.

In a business as usual scenario, the power sector is responsible for about 30% of greenhouse gas emissions. Something has to be done about that in a world where services in products offered to a growing population are on the increase. One solution would be to reduce CO_2 emissions by increasing efficiency and reducing the carbon intensity of energy, and making sure that energy produced has a low carbon component. In order to do that, advanced materials discovered through innovation facilitate the deployment of sustainable energy technologies (energy harvesting, storage, distribution and efficiency).

The development of new technologies is contributing to the creation of value chains in Europe that are non-existent today, which offers a way to increase competitiveness and create jobs in Europe.

Advanced materials help develop technologies that are sustainable (pushing energy density and reducing metal costs) and use sustainable energy sources.
However, sustainable technologies require metals that are sometimes very critical for Europe and located in non-EU countries. Therefore, science and technology has to adapt to this situation: scientists need to consider the availability (price and access) of needed elements for innovative materials, whether the critical materials can be recycled at their end-of-life (recovering constituents of the material and bringing it back to the flow sheets), how to design a product in a way that the critical components remain accessible for separation and recycling, and the impact that substitution of critical materials has on the recyclability of the product or component.
In conclusion, the EU is facing global competition from countries like US, China, Japan, etc. that are moving fast in this area. Thus, the EU needs to reinforce and develop its assets to compete and to reconcile the disconnect that exists between R&D and innovation. These have to be increasingly linked to develop the innovation value chain. It is therefore important to ensure that the industry is stimulated in order to be very active in an efficient & effective Horizon 2020.
In the field of Advanced Materials for low-carbon energy technologies, Umicore decided to team up with 50+ other organizations (whether industrial players or research & technology organizations / university research labs) to found the European industry-driven grouping called EMIRI (Energy Materials Industrial Research Initiative – www.emiri.eu). The goal of EMIRI is to establish Industrial Leadership in EU in advanced materials for competitive low carbon energy in line with the
SET Plan goals and its materials roadmap, through involvement of all stakeholders for strategic RESEARCH & INNOVATION programmes (use more effectively resources available at EU scale). EMIRI is therefore the organisation to propose a cross-cutting focus to develop advanced materials for low carbon energy, be based on SET Plan Materials Roadmap, and span the entire innovation value chain to achieve commercially successful development of advanced materials for energy applications in Europe.

Questions and debate:

Representative of San Antonio
The need for sustainable chemicals is undeniable, particularly looking at the area of renewable energy. The 3% of energy produced worldwide come from renewable sources but consumes 20% of available rare metals. It takes a simple calculation to see that if we are going to a 50% target of renewable energy, we have completely run out of the materials that are necessary to produce renewable energy sources.
Q: What kind of incentives exist within Horizon 2020 to drive technology and innovation towards research that would help either reduce significantly the amount of these rare earth metals in renewable energy or find substitutes for these materials to ensure a sustainable production of renewable energy?

Low Carbon facts Initiative:
Most people understand the importance of the industry in our lives and economy. Chemistry has played a key role for making renewable energy possible form solar panels for instance. However, none of the speakers has touched the subject of energy intensity of the chemical industry as a whole. It is one of the energy-intensive sectors and it represents one of the vocal constituencies in Business Europe, which is definitively trying to lower the GHG emission cuts ambitions and the climate ambitions within Europe. Furthermore, in the 12 principles of green chemistry, not one

relates to the energy intensity of chemistry. Other sectors that are highly energy-intensive such as the paper industry have taken serious measures to reduce their carbon footprint.
Q: Are the intentions of the chemical industry to participate in the GHG emissions cuts? The emissions report that was recently released shows that if we continue with the current trends it would mean the end of civilization before the end of the century.

Bayer:
Most are in support of green chemistry although there might be different understandings about what it is and how to materialise it.
Q: How does green chemistry relate to REACH? Does DG ENV propose the view that REACH is a tool to ensure safety of performance and thus becomes the criteria to be optimised – the principle 'safer than safe'?
Bayer's view on REACH is that safe products are on the market and selection can occur based on performance. The consequence of DG ENV's vision would be that marketing arguments would be generated to denigrate possibly safe or not so safe chemicals that would then reinforce the perception of the public and consumers that unsafe products are on the market. This would only further contribute to existing 'chemophobia'.

Bjorn Hansen
The market prior to REACH was one where most substances had insufficient data to ensure their safety. It was difficult for a downstream user to choose which chemical is appropriate for his use, also in an innovation setting, because he was faced with many uncertainties, which is bad for his business and forced to focus simply on functionality because of lack of information.
REACH therefore brings all chemicals up to par in terms of information and availability to enable that choice by the downstream user. Through its mechanisms of risk management REACH also sends the message that the product available for use has less hazards or is easier to ensure safety, which will then be much more attractive than a substance that has higher risks and is more complicated to control. It is effectively moving safety into the market space and forcing the downstream user to consider the costs of ensuring safety, which will automatically favour a safer chemical. REACH is about getting ell the information available to enable the downstream user to choose a substance where safety is a component. Europe needs to move towards a chemicals' innovative society by moving away from a society where companies compete based on information that they hold on chemicals to a society where companies compete based on the knowledge of applying information on chemicals. The way to do that is to ensure that information is available to everybody.

Prof. Schubert
The question of energy intensity is an intrinsic issue to all the points that have been discussed although it was not explicitly mentioned. Green chemistry comprises use of less energy to produce certain chemicals. For example, a very high proportion of the energy consumed by the chemical industry is not so much for the chemical reactions themselves but for separation processes. Thus, if chemical reactions are designed, for example by using new catalysts, which not only lower the reaction temperatures but also render the processes more product-efficient, then the intensity of energy used is implicitly reduced.
It is important to stress the fact that all the elements of green and sustainable chemistry that were discussed in this meeting are intrinsically interconnected.

Renzo Tomellini
On the issue of incentives to find substitutes for critical materials, this will certainly be addressed under Horizon 2020. The Commission would not say that there will be incentives but rather that there will be funding available for research on this issue, although at this stage it cannot comment on the exact numbers.

Conclusions

Prof. Schubert
"Nothing in life is without risk, so we have to tolerate a certain level of risk and to reach a balance between risk and innovation. We need to reach consensus on how much risk we want to tolerate in a certain area while maintaining or improving our standard of living." For example, gasoline is dangerous and ecologically critical but society has developed means to deal with that. While chemists are clearly committed to sustainability and resource efficiency, it is not always possible to find solutions for the global challenges and to foster innovation while at the same avoiding any critical substances. Our society has to reconcile these issues.

MEP Cristina Gutiérrez Cortines
Legislation is a process, the application of REACH is a process and research is a process. We need to continue working together to find the best solutions.
Policy-makers are faced with moral and ethical problems all the time and need to find the best solutions possible. Politicians need to be careful with the principle of substitution and the hidden interests that sometimes lie behind it.

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