Acknowledgments

The FCEP was made possible by the financial support of Green Chemistry LLC and the National University of Mongolia, as well as ICGCSD and CCE from IUPAC. During the week we had work lunches and dinners with several representatives from companies and institutions in Ulang Bataar, like the New Mongol Institute of Technology, The German Mongolian Institute for Resources and Technology, Synaps and Green Chemistry LLC. The last two are both companies trading in laboratory glassware and chemicals.

As a delegation we were fortunate to be able to meet Ghengis Kahn.

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Innovative Chemistry for Environmental Enhancement

by Diane Purchase, Wenlin Chen, Hemda Garelick, Nadia G. Kandile, Rai Kookana, Bradley Miller, and Roberto Terzano

The IUPAC 47th World Chemistry Congress (Paris, 5-12 July 2019) celebrated the 100 years of IUPAC and the 150th anniversary of the Periodic Table of Chemical Elements. The congress showcased how chemistry addresses today's most challenging issues relevant to human well-being and sustainable development. The Chemistry and the Environment Division of IUPAC (Division VI) has sponsored and organized a symposium highlighting the role of innovative chemistry in: a) end-of-pipe solutions for industrial processes; b) technologies for pollution and wastes reduction and control; and c) approaches to tackle global environmental challenges. Additional financial support was provided by IUPAC under the 'New Directions in Chemistry' initiative.

Increasing global economic competitiveness, social inequalities and the dimension of environmental problems have raised awareness of the need to change the technological paradigm and challenge the technological status quo. Environmental innovations are essential in reducing environmental impacts and resolving the environment vs. economy dilemma, and chemistry has a significant role underpinning these innovations. Environmental innovations can be achieved via a combination of inputs, such as raw materials, energy and labour. These innovations may be specifically developed to mitigate a specific environmental adverse effect, for instance, in response to regulations; or their benefit is the result of the environmental components of other types of innovations.

The symposia took place over two days (10-11 July), during which a number of high-profile international speakers presented on three special sessions:

- Innovative chemistry in industrial solutions
- Advanced techniques for pollution and waste reduction
- Novel approaches to tackle global environmental challenges

All three sessions were well-attended and well-received, raising awareness of the important topics associated with the work and expertise of Division VI membership. They also provided the opportunity to address specific regional problems and expand current, mainly EU and US based networks.

Innovative chemistry in industrial solutions

This session celebrated the key role of chemistry in providing innovative solutions to a number of industrial processes to overcome pre-existing challenges, including regulation compliance, carbon footprint reduction, waste and energy consumption minimisation, performance enhancement and sustainability attainment. Life Cycle Analysis (LCA) has already been applied to support different decision-making procedures in product lifecycle management, such as eco-design, process optimizations, supply-chain management, and marketing or strategic decisions.

Our keynote speaker, Anne Gaffney, is the Chief Science Officer and Distinguished Fellow at Idaho National Laboratory, USA. She has worked in industry inventing and commercializing new technologies for major chemical manufacturing companies including Koch Industries, Lummus Technology, Dow, Dupont and ARCO Chemical Company. Gaffney provided a valuable insight into the commercialization of technologies that can transform carbon waste streams into products at a reasonable cost and a net lifecycle reduction of greenhouse gas emissions to the atmosphere. Carbon utilization is based on the notion that waste carbon

Some of the speakers and organisers at the "Innovative Chemistry for Environmental Enhancement" Symposium (From left to right: Prof Petr Pedotov, Prof Hemda Garelick, Prof Willie Peijnenburg, Prof Sabu Thomas, Prof Diane Purchase, Dr Angela Serpe, Dr Roberto Terzano)

need not be a waste product to be sequestered, but instead as a resource to be capitalized upon by turning it to feedstock for products that have market value, such as fuels, building materials, plastics or other useful solids, chemicals or animal feed. Gaffney identified the carbon utilization technologies could play a critical role in dealing with global carbon emissions.

Our first invited speaker, Simone Ligi, CEO of Graphene-XT, Italy, has developed an interesting and innovative solution to the industrial processes to produce graphene that reduces carbon footprint, minimises waste and energy consumption, and enhances performance. Ligi provided a case study on using graphene to replace aluminium in electronic packaging to transform a waste material to fully recyclable polymer. The life cycle assessment (LCA) analysis on graphene bags technology, compared to the benchmark, shows a potential reduction of 54-99% of the CO_2 equivalent emission.

Willie Peijnenburg of Leiden University, The Netherlands, the second invited speaker, presented a case study of nanowire-based solar cells to challenge the common-held view of "green and clean." Using LCA and risk assessment to analyse emerging technologies in the energy sector, specifically the solar sector, only a limited number of technologies was found to support the claim. This is mainly due to the characteristic high cradle-to-gate energy demands that result in high carbon emissions.

Five other oral presentations offered different innovative chemical solutions, including new crosslinking processes for self-healing coatings and phenolic materials, using palladium nanoparticles for C-C coupling, and using artificial flavo-enzymes as environmental friendly catalysts to perform the Baeyer-Villiger reaction in good yield with high turnover numbers.

Advanced techniques for pollution and waste reduction

This session focused on the contributions of chemistry in advanced treatment of pollution and the alternative solutions to minimise the release of pollutants into the environment. The development of circular economy was identified as particularly important to overcome the challenges related to our finite resource and increasing trend of waste production.

A keynote presentation was delivered by Sabu Thomas, Vice-chancellor and founder director of the International and inter-university Centre for Nanoscience and Nanotechnology of Mahatma Gandhi University, India. Thomas presented a strategy to modify carbohydrate polymeric materials to the nano-scale or modify them with other nano-materials for an eco-friendly and low cost solution for water purification. By enhancing the specific surface area, nano-cellulose, nano-chitin and graphene oxides could be prepared from different biomass sources. Different functional groups could also be introduced to these nano-biopolymers to improve their removal efficacy and reusability.

Angela Serpe of University of Cagliari, Italy, was our first invited speaker. She introduced an innovative sustainable method to recover rare earth elements

from electronic and electrical wastes (WEEE), with the aim of developing the green vision from the molecular scale to the industrial scale process, implementing circular economy models. The process is based on the use of powerful non-acid leaching agents combining complexing/oxidizing properties in the same molecule working in mild conditions. As a past winner of the Best Italian Inventor and the European recognition awards from ITWIIN and EUWIIN organizations for innovative patents and entrepreneurship, Serpe also shared her own experience on a recent crowdfunded project.

Petr Fedotov of the Russian Academy of Science, the Russian Federation, gave our second invited presentation on the application of dynamic fractionation in a rotating coiled column to the exposure assessment of metals in hazardous wastes that had been buried under tailing dumps for seventy years. The mobility, availability, and vertical transport of metals under his study were shown to be very different in the different strata. The technique enabled studies of soils containing an important pool of available/bioaccessible metals that could further pose potential risk of contaminating the environment such as ground water. The data obtained are of particular importance for environmental management including pollution reduction.

We also heard a number of very interesting oral presentations from chemists around the world, presenting different novel and advanced solutions to tackle pollution in the environment. For example: tailored nanomaterials to catalyse the remediation of toxic environmental pollutants such as organohalides, organophosphorus pesticides and carbon dioxide; using non-covalent halogen bonding (XB) for a strong binding enhancement towards halide anions upon self-assembled monolayer oxidation with a limit of detection around $6x10^{-6}$ M to provide a powerful selective tool for the development of chemo-sensors targeting environmental pollutants; a novel thin-film composite membrane for new forward osmosis with interlayer decorated by UiO-66 particles between the thin polyamide (PA) layer and the thick porous support layer for an economic way to remove arsenic in polluted water; and an electrocoagulation method to treat wastewater from wool washing.

Novel approaches to tackle global environmental challenges

This section highlighted how novel chemical approaches helped to meet some of the UN Sustainable Development Goals *e.g.* providing clean water and sanitation and affordable and clean energy.

Melanie Kah was the keynote of this session. Kah obtained an MSc in Agronomy and Soil Sciences from the University of Nancy (ENSAIA, France) and completed her PhD at the University of York (UK). She worked at the UK Food and Environmental Research Agency (FERA) before joining the University of Vienna (Austria) in 2009. She was a Distinguished Visiting Scientist at the CSIRO (Australia) in 2018, and joined the University of Auckland (New Zealand) in 2019. Dr Kah discussed how nanotechnology could reduce some significant inefficiencies in current agricultural practices and its potential applications and benefits are likely to be enormous. In 2019 nanopesticides have been identified by IUPAC as one of the top emerging technologies in Chemistry with potential to make our planet more sustainable. As agroecosystems and the associated landscapes are incredibly diverse and complex, designing viable products for precision application in the field is challenging, she argued that the successful development and evaluation of nano-enabled strategies requires the establishment of intersectorial partnerships including scientists in academia and industry as well as regulatory bodies together with end users (including farmers and the public). Disciplinary convergence is also essential to develop viable and sustainable nano-enabled solutions in agriculture, by combining expertise from pure and applied chemistry (*e.g.* polymer, formulation) together with that of agronomy, plant physiology, soil science and (eco)toxicology, among others.

Volker Abetz of Helmholtz-Zentrum Geesthacht, Germany, delivered our first invited presentation on the development of isoporous integral-asymmetric membranes from block copolymers and the parameters influencing the structure formation. He presented an example of flat sheet membranes and the influence of additives on the structure, and also hollow fiber membranes with the isoporous layer outside or inside, showing the potential of these copolymers block to be used to form different shaped membranes.

Maria Valnice Boldrin Zanoni of UNESP, Brazil, gave an energetic invited lecture on her research on photoelectrocatalysis as an alternative to generate high-energy content fuel and also to remove harmful compounds in wastewater. She presented the development of photoelectrocatalytic reactors with the applications of TiO_2 and the modification of its surface at nanoscale architectures. This innovative technology was highly versatile, it can promote the degradation of organic pollutants, reduction of inorganic contaminants, microorganism inactivation, and CO_2 conversion

to biofuel in different experimental settings. The method is based on economic semiconductors materials used as photocatalysts, coupled with external bias potential and generation of e^-/H^+ charges on the electrode surface. She also discussed the efficiency of nanostructured TiO_2 and/or WO_3 modified by co-catalyst (metal nanoparticles and metal complexes, MO, etc.) to degrade micropollutants and water disinfection by generation of hydroxyl radicals under a photoelectrocatalytic processes activated by artificial and solar irradiation.

Other innovative solutions to tackle global environment challenges were presented in the session. One oral presentation examined the ways to minimise e-waste oil by a chemistry-based hydrometallurgy process using in-house waste H_2SO_4 and HNO_3 mixture for rapid dissolution, sonication-assisted chelation as well as a novel solid phase purification process to turn detoxified oils into high-value carbon quantum dots (CQDs) as "green gold." A new process to produce supplementary cementitious materials (SCMs) that can replace and reduce the CO_2 footprint of ordinary Portland cement (OPC) was presented. The use of SCMs such as blast-furnace slag (BFS), a byproduct of pig iron production, has been proven to be a viable solution to partially substitute OPC. The use of such byproducts, where no additional clinkering process is involved, leads to a significant reduction in CO_2 emissions per ton of cementitious materials, is a good technical solution to recycle byproducts of industrial manufacturing processes. The utilization of humic substance in a novel nature-like nanotechnology products was presented. The presentation gave examples of those syntheses for producing slow-release iron nanofertilizers, which demonstrates the potential for a technology to field applications.

Chemistry and the Environment Division Award

We were pleased to present the Chemistry and the Environment Division Award to three excellent posters at the conference. The winners were chosen from over 180 entries to the *Chemistry for the Environment* theme, based on the overall aesthetics, scientific merit and country of origin.

1st place—S. Canchari Chacon, G. Picasso Escobar, C. Santolalla, and R. Sun Kuo on "Preparation of catalysts based on supported and unsupported mixed oxides of Ni-Ga for application in the oxidative dehydrogenation of ethane"

2nd place—P.A. Diaw, M. Mbaye, N. Oturan, M.D. Gaye-Seye, A. Coly, T. Tine, J.J. Aaron, and M. OPturan on "Advanced electro-fenton process for removal of monolinuron in aqueous medium"

3rd place—S.D.S. Carvalho and N.M.F. Carvalho on "Synthesis and characterisation of iron (III) complexes as catalysts for the degradation of methyl orange and methylene blue dyes"

Many congratulations to the winners!

We like to say a big 'thank you' to Syngenta for sponsoring this Division VI Award.

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Caribbean Celebrations

CAS celebrated 30 years with its 21st General Meeting and Conference

by Robert J Lancashire, Foreign Secretary of CAS

In November 2018, the Caribbean Academy of Sciences, Jamaica (CASJ: the NAO for IUPAC in Jamaica since 2005) hosted the 21st Conference and Biennial General Meeting of the Caribbean Academy of Sciences (CAS) in conjunction with The University of the West Indies, Mona Campus, Jamaica. 2018 corresponded to the 30th anniversary of CAS and the 70th anniversary of The UWI. The theme of the conference was: **"Science, Technology and Innovation—Vehicles for a Knowledge based Economy."**

Further information on the Conference is available at the CAS website (http://www.caswi.org).

Over 130 contributions (including plenary and invited presentations) were submitted to the Conference;