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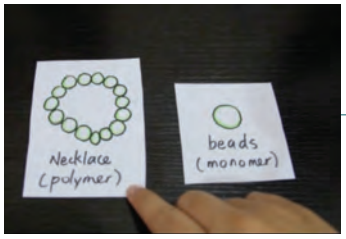
You're coming!



Past President's Column:
Looking Back on Six Years of Service as an Officer

Photo by Peter Cutts

by Mark Cesa

The Past President has an opportunity to write a column for *Chemistry International* near the end of his or her term, looking back on six years of service as an Officer of the Union and taking stock of the Union's accomplishments during that time. It is a particular pleasure for me to do this because all of our volunteers, leaders and staff have accomplished an outstanding number of important achievements that have strengthened and vitalized IUPAC in that time. I would like to take a look at what everyone has accomplished during the last six years—we have come a long way—and what lies ahead.

First, our new Strategic Plan has been a success in focusing the Union's activities and emphasizing core values of openness, transparency, inclusiveness, and multi-, inter-, and trans-disciplinarity in our projects and outreach activities. Our mission, as "the global organization that provides objective scientific expertise and develops the essential tools for the application and communication of chemical knowledge for the benefit of humankind and the world," has been taken to heart by our volunteers and is reflec ed in IUPAC's many new initiatives.

To fulfill our mission, we have fortified the Union's infrastructure. With our Executive Director, Dr. Lynn Soby, we have built a strong, high-functioning Secretariat with improved processes and responsiveness to our members' needs. We have benefi ed from improved accounting and financial management processes, hiring a full-time financial controller; established a successful partnership between our Finance Committee and an external financial advisor; we are well on the way to establishing a new National Subscription structure that will be fair to all our National Adhering Organizations; and Council has approved the proposal to establish an endowment fund; for all of which we owe thanks to the Secretariat, to our Treasurer, Colin Humphris, and to the Finance Committee, chaired by Prof. John Corish.

We are focusing on recruiting new members of IUPAC and providing excellent service to all our current members: NAO's, Associated Organizations, volunteers, affil tes, and fellows. Our new website is developing continuously and has been well received. The Membership Relations Committee has completed surveys of our member stakeholders that have helped create new value propositions that will clearly state why they should be members of IUPAC and participate in our success. The surveys reveal that there is strong interest in the Union's main purpose as the provider of "a common language for chemistry," and in contributing to the furtherance of the science. In São Paulo in July, Council has also approved increased benefits for Affil te Members and Company Associates, including enabling scientists who are IUPAC Affil tes or employed at CAs to have a greater stake in governance.

While IUPAC focuses on service to chemistry and its related sciences, nothing we do excites the general public as much as the discovery of new chemical elements. Six new elements have been added to the periodic table in the last six years, and with President Natalia Tarasova's leadership, IUPAC is now working to establish an International Year of the Periodic Table for 2019. The Evaluation Committee, due to the recommendation of Secretary General Richard Hartshorn, will be developing a process for periodic evaluation of each of the Divisions and Standing Committees toward their objectives. The new Interdivisional Committee on Green Chemistry for Sustainable Development, established in 2017, is the most recent example of IUPAC's focus on its mission to foster sustainable development, through collaborations with all the Divisions and Standing Committees.

The Committee on Publications and Cheminformatics Data Standards has strengthened *Chemistry International* and *Pure and Applied Chemistry.* With Scientific Editor Prof. Hugh Burrows, PAC's impact factor is rising, and CPCDS has worked effectively to maximize the benefits of working with our publishing partner, DeGruyter.

IUPAC has also strengthened its ties with external organizations with which IUPAC shares elements of its mission and goals. With the Organization for the Prohibition of Chemical Weapons (OPCW), IUPAC now has a Memorandum of Understanding that underpins its collaborative efforts. The Hague Ethical Guidelines, developed from principles outlined in an IUPAC project on guidelines for conduct of chemists; IUPAC has permanent observer status on the OPCW Advisory Board on Education and Outreach; and IUPAC helped to organize a productive workshop in July on innovative technologies for chemical security, papers from which will constitute a special topics issue of *Pure and Applied Chemistry* in 2018. With the International Council for Science (ICSU), IUPAC received a major award for funding of a three-year collaborative project on gender gap issues in science, and IUPAC leaders have provided advice to

ICSU and the International Social Sciences Council regarding their proposal to merge the two organizations. IUPAC's continuing encouragement of younger chemists' participation in the Union was cemented this year with the signing of a Memorandum of Understanding with the International Younger Chemists Network, and the awardees in 2017 of the IUPAC-Solvay Award were selected from one of the strongest sets of applications in many years. Solvay has generously offered to continue its financial support of the Award and has doubled the amount it will contribute for 2019 in recognition of the IUPAC Centenary.

All of these accomplishments—the work of our hundreds of volunteers on project task groups, Division Committees, Standing Committees, the Bureau, the Executive Committee and the officers, with the support of all our Members—have built a foundation for growth of the Union as it approaches its second century. We can be proud of how far IUPAC has come, and we can look forward to substantial growth in membership, influence and scientific contributions.

The past six years have been among the most productive, exciting, difficult, enjoyable, exhausting, and wonderful of my life. I am honored and grateful to be a part of a succession of past, current and future IUPAC Presidents that includes Leiv Sydnes, Bryan Henry, Jung-Il Jin, Nicole Moreau, Kazuyuki Tatsumi, Natalia Tarasova, Qi-Feng Zhou, and Christopher Brett; all of whom have advised and encouraged me and helped make IUPAC the vital organization that it is today. It has been a pleasure working with all of the members of the Bureau, Executive Committee, the Committee on Chemistry and Industry, where I started in IUPAC as a young observer, and all of the members of the Divisions and Standing Committees. It is impossible to overestimate how rewarding it is to be a part of a global enterprise in the service of science, and I hope that all of our volunteers will experience the broadening of perspective that comes from working with enthusiastic people from all over the world.

A special thanks to all of my IUPAC friends and colleagues. Thank goodness for volunteers!

Mark Cesa <mcesa@iupac.org> is past president of IUPAC since January 2016. Previously he served as president in 2014-2015, vice president in 2012-1013, and on the Committee on Chemistry and Industry as secretary (2000–2003), vice chair (2004– 2005), and chair (2006–2009). Cesa is a process chemistry consultant with INEOS Nitriles in Naperville, Illinois, USA.

PURE AND APPLIED CHEMISTRY

The Scientific Journal of IUPAC

Edited by Hugh D. Burrows, Ron D. Weir, Jürgen Stohner

Since 1960, the International Union of Pure and Applied Chemistry (IUPAC) has made available to chemists everywhere a large amount of important chemical information published in the journal *Pure and Applied Chemistry*.

Pure and Applied Chemistry is the official monthly Journal of IUPAC, with responsibility for publishing works arising from those international scientific events and projects that are sponsored and undertaken by the Union. The policy is to publish highly topical and credible works at the forefront of all aspects of pure and applied chemistry, and the attendant goal is to promote widespread acceptance of the Journal as an authoritative and indispensable holding in academic and institutional libraries.

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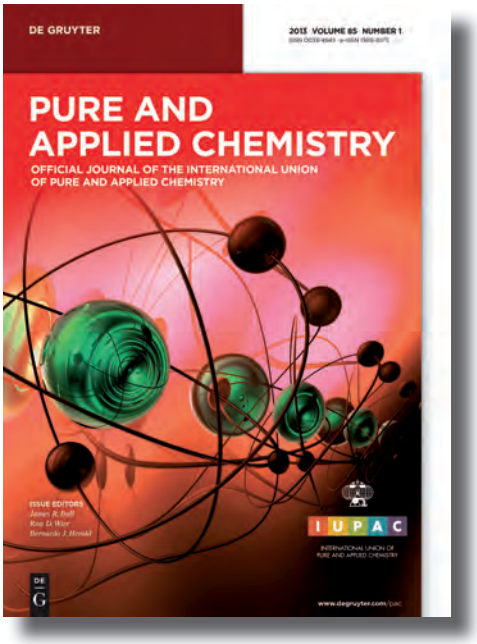

IUPAC Polymer Division at 50 Years

by Richard "Dick" Jones

For most of us, history is marked by significant anniversaries following from recognisable start or end dates: birthdays, wedding anniversaries, monarchical reigns, wars. So it is that this year we are celebrating the 50th anniversary of the formal inception of the Polymer Division under its former name as the IUPAC Macromolecular Division. However, the Division has a significant pre-history that essentially maps the development of polymer chemistry to a mature discipline in its own right. By the 1920s, through the efforts of individuals who recognized the need, a common language of communication was already in the offing. These people formed committees to consider the development of systematic nomenclature, terminology and definitions, symbols, and other matters of importance in polymer science. All of this work became the foundations on which IUPAC built its growing interest in macromolecules, of which I would know very little if it were not for the excellent *History of IUPAC 1919-1987* [1] and *History of IUPAC 1988-1999* [2] upon which I have been able to draw.

By the late 1940s, before IUPAC had established the divisional structures with which we are familiar today, there was already a Commission on Macromolecules (later Macromolecular Chemistry) within what was then the Physical Chemistry Section and a Division on Plastics and High Polymers in an Applied Chemistry Section. In 1952, IUPAC published its fir t paper in the area of macromolecular nomenclature under the aegis of the Sub-commission on Nomenclature of the Commission on Macromolecules, this being a subgroup of those concerned with nomenclature, terminology and symbols in inorganic, organic and physical chemistry. This paper, by such notables as J. J. Hermans, M. L. Huggins, O. Kratky, and H. F. Mark [3], was a landmark in that, for the fir t time, it systematized the naming of macromolecules and various symbols and terms commonly used in polymer science. It introduced the use of parentheses in source-based polymer names when the monomer from which the polymer is derived consists of more than one word, a practice that is now widely followed. It recommended an entirely new way of naming polymers based on their structure that included the suffi "amer", a recommendation that in contrast has been almost totally ignored. After ten years, the Sub-commission published its second report [4], which dealt with the rapidly developing field of stereoregular polymers consequent upon the synthetic procedures discovered by Ziegler and Natta, while

Driving ahead in the 21st century and lead by Jung-Il Jin, the Polymer Division met at the IUPAC General Assembly in Torino, Italy in 2007. Direct Past Division President at the time was Bob Stepto (3rd from the right).

a revision [5,6] of the definitions in the original report appeared in 1966. Meanwhile, the IUPAC International Symposia on Macromolecules had been conceived, the fir t taking place in 1957, and by 1966 there had been fi e: two in Prague and one each in Wiesbaden, Paris, and Tokyo-Kyoto. So, in view of the burgeoning industrial importance of polymers and the evidently increasing profile of IUPAC in polymer chemistry, the eminent Czech scientist famed for his development of poly(hydroxyethyl methacrylate) and the invention of the soft contact lens, Otto Wichterle, [7,8] a Bureau Member and Chair of the Commission on Macromolecules, was asked to coordinate IUPAC interests in macromolecular science. His report led to the creation of a new Macromolecular Division (Division IV) in 1967, the 50th anniversary of which we mark in the following pages.

At birth, the Macromolecular Division Committee consisted of eight Titular Members and fi e Associate Members under the presidency of Otto Wichterle, and for a few years its work continued to be in the organization of division meetings and international symposia, and otherwise that of the former Commission on Macromolecules and of the Plastics and High Polymers Section. It seems to have been an early determination of the founding fathers that these activities should develop without forming permanent commissions. The only one that was formed and approved in those early days was to deal solely with nomenclature issues: the Commission on Macromolecular Nomenclature (IV.1). All other work

Otto Wichterle [8]

was to be done by working groups, *ad hoc* committees and carefully selected experts.

By the mid-1970s, it was clear that this essentially unique organization of the Division's business was an impairment to progress and that the establishment of another commission to embrace the work of working parties would be a sensible development. In 1975, following agreement within Council, the Commission on Polymer Characterization and Properties (IV.2) came into being at the 28th IUPAC Conference, the last to be so-called as thereafter they have been termed General Assemblies.

During the 26th Conference in 1971, the Officers of Division IV had met with their opposite numbers in Division VI, the Applied Chemistry Division and, in particular, representatives of the Section on Organic Coatings (VI.6). The goal of the meeting was to negotiate the possible relocation of the Section to the Macromolecular Division, this being seen as a sensible requirement of a reorganization of Division VI. This was agreed to at the 27th Conference and the Section was duly incorporated as a Working Party on Supported Polymer Films within Commission IV.2.

At this point, perhaps a short digression can be permitted. The Macromolecular Division was noteworthy not only in its rejection of the word *Chemistry* from its name and its evident dislike of commission structures, at least in its early days, but also in the composition of the Division Committee. This was unusual, in that such committees did not have Associate Members. With a total of thirteen members, it was already one over the number that had been approved by the Executive Committee at inception. Undeterred, by the end of the 25th Conference the number of Division Committee members had already risen to 11 Titular Members, 7 Associate Members, and, as another departure from custom, 18 National Representatives. With the inclusion of representatives of other International Unions—those of Pure and Applied Physics and of Biophysics—the Division was becoming a law unto itself. All this to manage the affairs of one division and what would eventually be two commissions? It was little surprise that the Bureau required the Division to reduce its membership to just 10 by 1975, but even then nothing was done about the attendance of National Representatives at meetings.

In 1971, Otto Wichterle was succeeded as Division President by Henri Benoit (France) and thereafter at four-yearly intervals up to 2001 by such eminent scientists as Charles Overberger (USA), Viktor Kabanov (USSR), Clement Bamford (UK), Takeo Saegusa (Japan), Walter Heitz (FGR), James Economy (USA) and Robert Gilbert (Australia). Within this period, another

At right, The Polymer Division poses in Seoul, 1996. front row: Máximo Barón, Jung-Il Jin, James Economy (Division President), Jim Guillet, Robert (Bob) Gilbert.

Below, attendees at the Beijing 2002 Conference: back row: Werner Mormann, Alain Fradet, Ted Wilks, Jaroslav Kahovec, Jiři Vohlídal, Pavel Kratochvil, Dick Jones, Bob Stepto (Division President), Bill Work, Przemyslaw Kubisa, Jiasong He; front row: David Tabak, Jung-Il Jin, Kazuyuki Horie, , Michael Hess, Máximo Barón, Tatsuki Kitayama, Taihyun Chang

commission was established within the Division, that of Functional Polymers (IV.3), otherwise the direction and purpose was maintained without interruption.

In the 1980s, what had started out as intended annual International Symposia on Macromolecules switched to being biennial meetings which were renamed as World Polymer Congresses, the fir t being under the concise label MACRO 1998, a brand name which pertains to this day. (see more page 28) These are held in so-called off years, the years between General Assemblies. By the 1990s, the Congresses had assumed much of the complexity that surrounds bids for the Olympic Games. Invitations for National Adhering Organisations to host the events are issued some ten years in advance with contenders being expected to present their plans to a meeting of the Division Committee during a General Assembly and to elaborate on their development at subsequent meetings until a victor emerges, after which they must report progress year-on-year until the event takes place.

In 2002, following a lengthy consultation process, the details of which are too complex to enter into here, IUPAC underwent a significant reorganization of its structures and methods. As far as Division IV was concerned, the most significant changes were the abolition of commissions and their replacement with subcommittees dedicated to tasks within a specific area, and otherwise what was to follow from the establishment of a new Division of Chemical Nomenclature and Structural Representation (Division VIII). It seemed that, at a stroke, all of the Commission IV.1 work would transfer to the new division. As a rationalization this was illogical, as all the background knowledge and expertise that was idiosyncratic to polymers resided within the membership of Division IV. Fortunately, it was soon evident that the new division had no more enthusiasm for acquiring polymer-related expertise that would not sit comfortably within its fields of study than Division IV had for relinquishing it. Accordingly, Commission IV.1 morphed into a Subcommittee on Macromolecular Terminology and the two Division Presidents agreed that, whilst overall responsibility for macromolecular nomenclature must reside in Division VIII, its development would be delegated to the new subcommittee. This is an arrangement that has worked very well and for which we owe debts of gratitude to the then President, Robert Stepto, and his opposite number in Division VIII, Alan McNaught, for satisfactorily resolving what would otherwise have been an almost intractable problem.

The valuable work of Division IV has thus been maintained into the 21st Century under the leadership of Presidents Robert Stepto (UK), Jung-Il Jin (South Korea)—who left the Division when he was elected IUPAC President, Christopher Ober (USA), Michael Buback (Germany), and now Gregory Russell (New Zealand). A review of the Division's mission statement recognised that macromolecules as individual molecular entities comprise materials called polymers. Both of these are our concern, which has led to the renaming of the Division as the Polymer Division. A similar rationale has been applied to the names of the divisional subcommittees of which there are now four: Polymer Terminology, Polymer Education, Modelling of Polymerization Kinetics and Processes, and Structure and Properties of Commercial Polymers.

Amongst the ensuing articles are contributions that describe conference activities and the evolution and inner workings of selected subcommittees and which identify some of the dedicated people who 'keep and have kept the show on the road' to the present day.

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Richard G. Jones, Emeritus Professor of Polymer Science at the University of Kent, Canterbury, UK was the chair of the Polymer Division's Subcommittee on Polymer Terminology from 2005-13. Having joined the Division in 1997, he has served variously as a TM, AM and latterly has just retired as the UK NR of the Division. He has also served on Division VIII and as a member of ICTNS, and over the years has seen numerous projects through to publication in *Pure and Applied Chemistry* either as Task Group Chair or Member.

Polymer Chemistry: Current Status and Perspective

by Krzysztof Matyjaszewski

The last decades witnessed significant progress in the synthesis of macromolecules with precisely controlled architectures.

These polymers have been prepared by various chain-growth reactions predominantly using either vinyl or cyclic monomers [1]. Generally, well-defined polymers are prepared by reversible deactivation polymerization (RDP) with the concurrent growth of all polymer chains (fast initiation) and greatly diminished contribution of chain breaking reactions (transfer and termination). In this manner, low dispersity polymers, approaching Poisson distribution ($Đ = \overline{M}_w / \overline{M}_n \sim 1 + 1/\overline{X}_n$) are prepared. Originally, living polymerizations were developed for anionic polymerization of non-polar vinyl monomers such as dienes and styrene and required very stringent conditions, namely complete exclusion of moisture and air [2]. Nevertheless, such systems, from laboratory curiosity, were successfully transferred to industry, generating over $1 billion in revenue for Kraton, and even more for other companies.

Living polymerizations were subsequently expanded to ionic ring-opening polymerization, coordination polymerization of both olefins and cycloolefins (ROMP), and eventually to radical polymerization (reversible deactivation radical polymerization, RDRP). Classical living polymerization requires that all growing polymer chain ends are mediated by control agents that can be relatively expensive; *e.g.* metallocenes, post-metallocenes or stable free radicals. Recently, however, various catalysts that can be used at parts per million level have been developed for use in the presence of less expensive reagents, such as alkyl halides in atom transfer radical polymerization (ATRP), sulfur containing chain transfer agents in reversible addition-fragmentation (RAFT) polymerization, and alkylzinc or alkylaluminum compounds in degenerative transfer shufflin catalyst systems in olefin polymerization [3]. This approach has significan - ly reduced the cost of commercial synthesis of various block copolymers. The further reduction of the cost and development of more environmentally friendly conditions in these processes remains a challenge.

RDP permits precise control of the primary structure of polymer chains. These chains consist of carbon-carbon backbones formed in polymerization of vinyl monomers. In ring-opening polymerization, one can incorporate various heteroatoms to the backbone. It is also possible to copolymerize vinyl and cyclic comonomers facilitating their subsequent degradation. Currently, each particular polymerization method may have its own "preferred" monomers; coordination

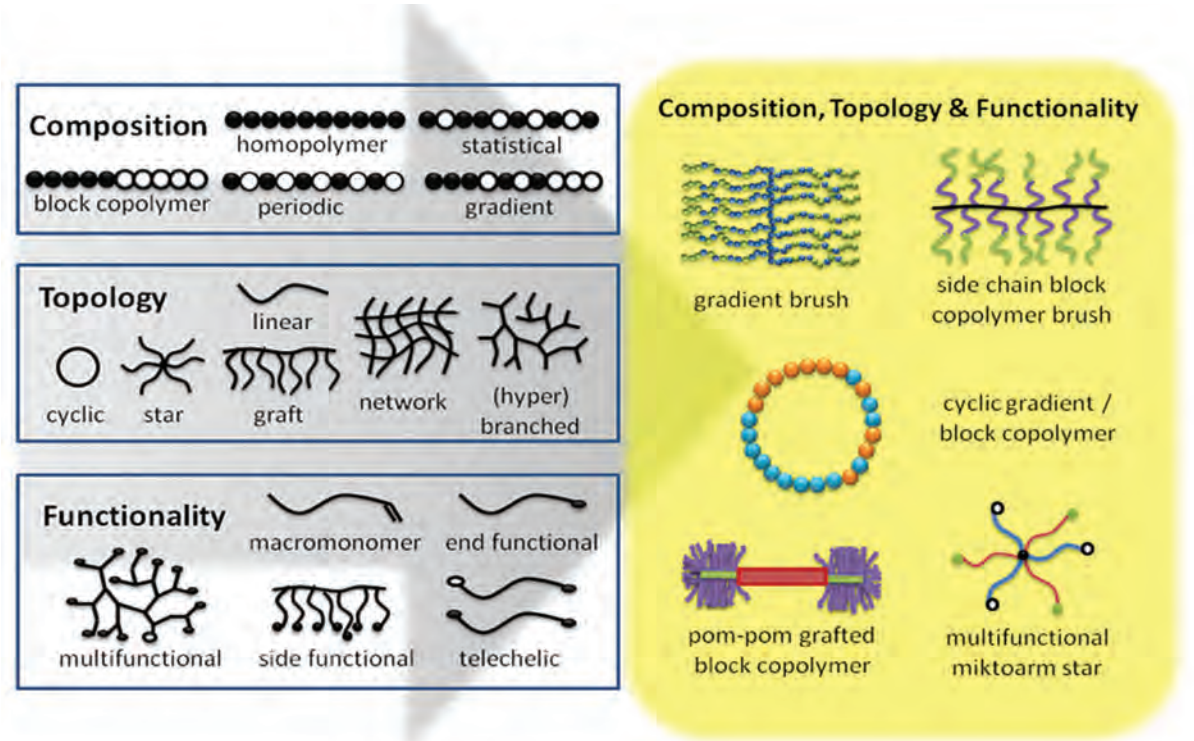

Fig. 1. Individual and combined basic elements of macromolecular architecture [4].

polymerization is used for ethylene and olefins, isobutylene for cationic polymerization and polar vinyl monomers for radical polymerization. However, there has been progress in using polar comonomers in coordination polymerization or olefins in radical polymerization. It is also important to extend the range of monomers from those that are "petroleum-based" to those from renewable resources thereby facilitating better control of polymer degradation and recycling. Nevertheless, the efficien copolymerization of "incompatible" monomers is still challenging.

Several elements of macromolecular architecture can be controlled in RDP. They include chain topology, chain composition, chain functionality, chain stereostructure and chain uniformity. They can be also combined as illustrated in Fig. 1 (reproduced from [4]). These elements are based on chains with covalent bonds connecting monomeric units. In addition, dynamic non-covalent bonds can also form macromolecular chains with properties strongly affected by the dynamics of chain interactions (dynamers, vitrimers and many self-healing materials) [5-7]. Eventually polymer chains can be assembled to secondary or even higher order structures through various weak supramolecular interactions in bulk or in solution as in polymerization-induced self-assembly (PISA) [8].

Chain topology elements span from linear chains to cycles and various branching features. They can include long or short chain branching, loose or dense branching, or even hyperbranched systems and dendrimers. Branches can be distributed with a tunable density along the chain, typically in graft copolymers, or very densely as in bottlebrush copolymers. Branches can be limited to one focal point as in star polymers which can be formed by an arm-fir t or core-fir t approach. They can also be distributed in bulk material, forming networks of different uniformity, mesh size and composition. The type and degree of branching can tremendously affect mechanical or rheological properties of resulting polymers. For example, bottlebrush copolymers can form photonic materials with periods of hundreds of nanometres. Bottlebrush copolymers can become supersoft and superelastic with moduli lower than those of hydrogels. In contrast to hydrogels, which become hard after water evaporation, bottlebrushes can never dry out since their backbones are diluted by their short, unentangled side chains rather than by water [9,10]. By varying graft density, length of side chains, and crosslinking density, it is now possible to prepare elastomeric materials with thermomechanical properties mimicking various biological tissues. It remains a challenge to design branching degree, uniformity, or location and correlate these elements with macroscopic properties and then precisely carry out synthesis of such materials.

Kris Matyjaszewski (right) with Michael Buback (IUPAC Polymer Division President 2012-15) at the banquet of MACRO 2014

Another important parameter is chain composition. Block copolymers and segmented copolymers revolutionized polymer science 60 years ago and have been the subject of very intense research both in academia and industry. In the chains of block copolymers, there are abrupt changes in composition on passing from one to another segment. This results in phase separation and formation of various nanostructured morphologies. Until recently, only diblock and triblock copolymers have been studied. In the latter case over 30 different morphologies were identified, greatly expanding upon the classical spherical, cylindrical, gyroidal and lamellar structures observed for binary systems. Recent progress in ATRP and RAFT has permitted synthesis of segmented copolymers with 20 or more blocks. The question remains: "what morphologies can they adopt?" Another important objective is to design and prepare gradient copolymers with a smooth change of composition along the

polymer chains. Such copolymers may have gradient with a linear, V-like, hyperbolic, exponential, or tapered shape. It is also possible to use gradient control not only in a binary system but also ternary, etc. systems. Recently, there is a strong interest in controlling sequence in polymer chains, decreasing dimensions from long to short segments and to individual monomeric units. This approach has been expanded from classical periodic sequence such as $(AB)_n$ for alternating copolymers, to $(ABC)_n$, $(ABCD)_n$ and eventually to a programmed sequence that can be recorded and written back or even erased [11]. Such sequence control is inspired by biological systems, such as nucleic acids or proteins and is indispensable for passing from primary to secondary and eventually to the tertiary structures. It is not only a challenge to make materials with a particular sequence, including multiblock copolymers and gradient copolymers but also to predict how these copolymers will assemble to secondary and higher order structures and what kind of properties they will have.

Functional groups can be placed in various parts of macromolecules. They can be located with a pre-determined density along the polymer backbones, at the extreme position of chains, including chain ends in telechelics, chain centers, ends of arms in stars and bottlebrushes or in the cores of stars, or chain ends for hyperbranched or dendritic molecules. These groups should carry specific functions that can be used for further reactions, crosslinking or attachments of other moieties whether they be biomolecules, drugs, optoelectronic materials or other species. The site-specific functionalities can be of a singular type or based on several different functionalities. Some functional systems can form self-catalyzed structures that can provide additional control and even facilitate regeneration of formed products by concurrent or consecutive covalent and non-covalent polymerizations [12]. One challenge is to incorporate moieties in a specific position within macromolecules with reactive orthogonal functionalities for further reactions and synergistic effects.

Control of stereostructure is now essentially limited to coordination polymerization of vinyl and cyclic monomers, though some limited control can be achieved in anionic systems. Specially designed catalysts can provide excellent and programmable stereocontrol for polypropylene and other polyolefins, and can be even extended to the synthesis of stereoblock copolymers. Such control for cationic and radical polymerizations is very difficult to achieve, though there has been some success through complexation with lanthanide cations in the polymerization of acrylamides, leading at fir t to stereoblock, and then stereo-gradient copolymers by a radical mechanism. Extending and improving such a control in radical polymerization to (meth)acrylates, acrylonitrile or styrenes is a challenge.

RDPs can provide polymers with very low dispersity. However, there is a growing interest in synthesis of polymers with higher dispersities and even those with intentionally programmed distributions. This can be accomplished by various exchange reactions including depropagation, transesterific tion or transacetalization reactions. However, a designed slow exchange reaction between active and dormant species that is slower than propagation, which can be accomplished by using a very low concentration of Cu catalysts in ATRP or using less efficien RAFT reagents (dithiocarbamate for methacrylates), has also proved to be effective. Another possible method of controlling molecular weight distribution is by slow feeding the initiators, or a continuous addition of terminating agents. Programmed feeding (constant rate, linear or nonlinear addition rate) can also be used to change the skew and asymmetry of distributions [13]. Block copolymers with broader distributions may have lower order-disorder transition temperature, form larger domains, generate new bicontinuous morphologies, and even exhibit photonic properties. Thus, controlled and predesigned heterogeneity, including molecular weight distribution, tacticity, composition (gradients), and shape (branching) can lead to new classes of materials with novel properties [14]. On the other hand, synthesis of block copolymers with short, precisely controlled segments may provide efficien phase separation at the scale below 5 nm, an important feature for ever-diminishing dimensions in microelectronics. It is a challenge to harness these parameters and prepare advanced materials with tunable processing windows, broader glass transition, higher critical micellar concentrations, and precisely controlled low molecular weight block copolymers with new morphological features.

Most RDPs are carried out under homogeneous conditions. However, some new opportunities arise from polymerization in confined spaces. For examples, in a tiny microemulsion droplet (10 nm), essentially only one very large macromolecule can grow by radical means and cannot terminate with another one, as they are separated by phase boundaries. This can lead to fast terminationless radical polymerization or dendrimer-like structures (*cf. infra*). Even more interesting opportunities arise from polymerization in small

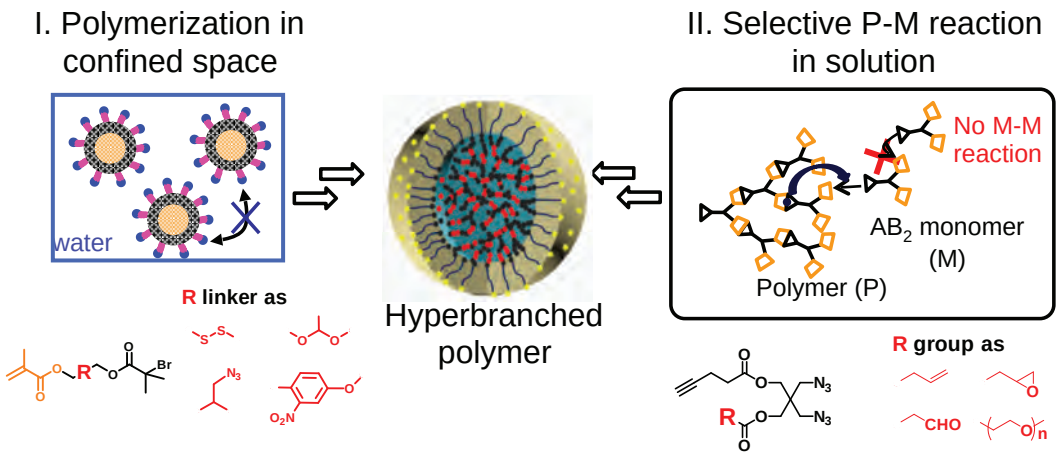

Fig 2. Two approaches to highly branched uniform polymers.

inclusion complexes: metal oxide frameworks (MOFs), zeolites or in the very small pores of mesoporous silica where tacticity control can be enhanced. Alternatively, templated polymerization can provide control of chain length, stereostructure and sequence. Cost-effective re-use of such confined/templated systems in preparing large quantities of materials in confined space remains a challenge.

Figure 2 illustrates two approaches to highly uniform hyperbranched polymers from AB_2 monomers or inimers (*i.e.* monomers and initiators combined within one molecule) prepared in dispersed media. Polymerized inimers can reach high degrees of branching (DB ~ 0.5) but are typically characterized by low molar mass and very broad molecular weight distributions that arise from a unique combination of a chain-growth and a step-growth mechanism. However, confinement of inimers into a discrete nanospace, (typically microemulsion micelles), permits complete inimer conversion while preventing inter-micellar reaction [15]. Thus, at the end of polymerization, each micelle contains only one hyperbranched polymer with the molecular weight directly determined by the micelle dimensions. The synthesized hyperbranched polymers were further used as multifunctional macroinitiators for a subsequent polymerization of a second monomer to produce core-shell structured hyperbranched polymers in one pot. An alternative approach to similar materials, but in solution, employs AB_2 monomers with 1 alkyne and 2 azide moieties in a highly efficient Cu-catalyzed azide-alkyne cycloaddition (CuAAC) [16]. Due to complexation between the Cu catalyst and the triazole product, all added Cu^{I} catalysts are quickly bound to the formed functional groups and confined in the polytriazole polymers at low conversion and the free Cu catalysts in the solution are depleted. Thereafter, monomer-monomer reaction in solution (step-growth) becomes suppressed and all monomers have to diffuse to the proximity of the polytriazoles units, where they interact with the Cu catalysts and react with the locally abundant azido groups on polymer molecules (chain-growth). In this manner, hyperbranched polymers with very high DB ~ 1.0, predetermined molecular weight, and low dispersity ($\overline{M}_w/\overline{M}_n$ < 1.05) are formed in a one-pot reaction within hours.

RDPs are typically carried out under constant temperature or pressure. However, it is advantageous to use several external triggers to control polymerization rates and loci. Such temporal and spatial control can be accomplished using light, electrical current, mechanical force, or chemistry *(e.g.* pH variation) [17]. Generally, development of more selective, more efficient, and less expensive, recyclable polymerization catalysts is very important. These can be metal free and responsive to external stimuli leading to new classes of smart or intelligent materials which can respond to light, pH, solvent or gas vapor, mechanical forces and can change shape, exhibit shape memory, self-heal, repair, and perhaps even self-replicate. The challenge is how to use them together and provide dual control, start and stop polymerization at will, and perhaps switch from one to another mechanism of polymerization, expanding the range of accessible elements of polymer architectures.

New RDPs, especially proceeding by radical mechanisms, have opened avenues to prepare hybrid materials. They include organic/inorganic hybrids based on grafting from nanoparticles, nanotubes and flat surfaces but also bioconjugates formed by the covalent linking of natural products (proteins, nucleic acids, carbohydrates) with synthetic polymers. Covalent grafting

of polymers from inorganic surfaces provides access to very densely grafted brushes that affect many properties, including enhanced lubrication, antifouling, or antimicrobial properties [18]. Nanoparticles, nanorods or nanotubes with densely grafted polymers do not aggregate and disperse very well in either solvents or polymer matrices. Proteins with grafted polymer chains can circulate for a longer time in the human body, can survive at low pH, can be dispersed in organic solvents, and be used as catalysts at higher temperatures or as therapeutics [19,20]. Nucleic acids combined with polymers can self-assemble and pass efficientl through cell membranes and can form various polyplexes. They can be loaded with dyes forming very bright fluo escent probes which can target specific cells after linking with antibodies or aptamers. It is interesting to extend such bioconjugation to larger objects such as living cells or tissue. Designing the most efficien materials and carrying out their precise synthesis is a challenge.

All these areas can be significantly aided by computational methods at ab initio level for better understanding mechanisms [21] and catalyst design, at mesoscopic and macroscopic level through various reaction kinetic and materials properties simulations. This can guide polymer chemists to develop comprehensive structure-reactivity and structure-properties relationships and to prepare a range of polymeric materials with new superior properties.

This short article attempted to illustrate the complexities of modern and post-modern polymerization chemistry. As these new processes take hold and new polymeric materials evolve, IUPAC must continue its historic purpose in the development of nomenclature and terminology, appropriate to these methods and materials and transcending the confines of the subject and national boundaries.

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PolDiv101: A Brief Guide to the Polymer Division

by Christopher M. Fellows, Christine K. Luscombe and Gregory T. Russell

When all is said and done, the IUPAC Polymer Division is a group of people. So here we all are, well, a good number of us anyway.

This photo above was taken at our most recent get-together, which was at the just completed IUPAC General Assembly and World Chemistry Congress in São Paulo [1]. We have a grand meeting like this precisely once per year. In odd years (*i.e.,* 2017, 2015, ...) the meeting is at the GA/WCC of that year. In so-called off years, which are actually even years (*i.e.,* 2016, 2014, ...), the meeting is at the World Polymer Congress (a.k.a. MACRO conference) of that year. Most people pay most of their own way to attend these meetings. That's what camaraderie and noble endeavor can inspire. Truly we do this for love, not money.

Each meeting spans six days. Two of these are devoted to the overarching Polymer Division, the other four to the deep cogitations of the Subcommittee on Polymer Terminology. Other Subcommittees and groupings meet furtively as time allows. Everyone leaves with a deep conviction that IUPAC has an important place in the world of polymers.

The overall goal of the Polymer Division is to promote the science and technology of macromolecules and polymers (yes, there is a difference! [2]) at the international level by facilitating international scientific exchanges, by cooperating with international organizations for activities such as education and conferences, and by defining terminology and standards related to macromolecules and polymers. Mostly this is achieved via projects that are run by Task Groups, and mostly these are set up within the four Subcommittees of the Division:

Subcommittee on Polymer Terminology (SPT): Currently headed by Roger Hiorns, SPT develops terminological rules and definitions related to polymers, while also working with Division VIII (Chemical Nomenclature and Structure Representation Division) to provide recommendations on polymer nomenclature. It is a highly active group.

Subcommittee on Modeling of Polymerization Kinetics and Processes: This Subcommittee aspires to promote the science and technology of macromolecules and polymers by organizing studies that aim to create uniform standards related to polymerization kinetics. While many individual research groups around the world have reported kinetic parameters related to polymerizations, these parameters frequently differ from group to group because of different assumptions that have been made in the mechanistic models used. The members of this subcommittee are rectifying this situation through international collaboration.

Subcommittee on Polymer Education: The goal of SPEd is to provide support towards recurrent educational activities for students in underdeveloped countries. With this in mind, one of the major activities of this Subcommittee has been to maintain a polymer education website in the name of IUPAC [3]. This website has become so popular that when one searches for "What is a polymer?" in Google, it appears as the top suggestion. Additionally, the Subcommittee has organized education sessions at MACRO World Polymer Congresses so that speakers can share best practices in polymer education from their respective countries.

Subcommittee on Structure and Properties of Commercial Polymers: Begun in 1963, this

Subcommittee is dedicated towards obtaining and reporting accurate information about commercial polymers. It consists of a large and financially self-supporting membership from both academia and industry. It has produced nearly one hundred refereed scientific publications, and it continues to roll them out at a rate of two per year, a remarkable record of sustained achievement in the name of IUPAC.

Different to others, the Polymer Division puts all its eggs in the one basket when it comes to conferences: every two years we preside over a MACRO World Polymer Congress. Recent venues have been Istanbul (2016), Chiang Mai (2014), Blacksburg VA (2012), Glasgow (2010), Taipei (2008), Rio de Janeiro (2006) and Paris (2004). In the future, we look forward to Cairns (2018), Jeju Island (2020), and Winnipeg (2022). The love is spread around!

Additionally, the Polymer Division grants IUPAC endorsement to approximately ten conferences per year, which is about one third of the IUPAC total.

The Polymer Division is privileged to offer four prestigious prizes on a biennial basis, all conferred at MACRO World Polymer Congresses. There is the DSM Materials Award for innovative research in materials sciences, the *Polymer International*-IUPAC Award for creativity in applied polymer science or polymer technology, and the Hanwha Total-IUPAC Award for the most promising young polymer scientist from any country. We are sincerely grateful to these three organizations for their generous patronage. Most recently we have instituted the Bob Stepto Plenary Lecture Award in memory of our late and much admired ex-President [4].

Mosques, minarets and the current Officers of the Polymer Division: Michael Walter (left; Division Secretary), Greg Russell (3rd; Division President) and Christine Luscombe (4th; Division Vice-President) link arms in the fashion of a macromolecule. Second to the left is Natalie Stingelin (Titular Member).

As we look towards the next 50 years for the Polymer Division, the Subcommittees are focusing on efforts that will allow us to disseminate information more easily, so that we can increase our international impact and global reach. One such example is the Wikipedia project, in which task group members from SPT are working with Wikipedia to update polymer-related entries with IUPAC recommended definitions [5]. Another example is the Multilingual Project, in which basic polymer science terms are being translated into languages including Spanish, Japanese, Chinese and Russian in order to ensure that uniform standards exist in non-English languages as well. Finally, SPT has been preparing Brief Guides. These are shorter, pamphlet-like documents that are intended for a more general audience, thus achieving wider dissemination of IUPAC gospel. "A brief guide to polymer nomenclature" has already been published [6] and has gained traction amongst a number of publishers. Currently there are several other brief guides in preparation: to polymer terminology, to polymerization, and to polymer semiconductors. Their launchings will be trumpeted by the Division's nascent Twitter page!

In these and other ways we hope that our large, vibrant Division of IUPAC will remain large, vibrant and relevant.

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A Personal View of the Life and Times of the Subcommittee on Polymer Terminology

by Roger C. Hiorns

You're coming!

Dick said over the phone. The crimson heat of the office in mid-summer wasn't helping me to take the call seriously.

I'm not sure about this. Errm. I've got a lot on. You know—papers to write, a couple of new students coming in. I'm not sure where I'd find the mon y.

The call had been going on for fi e minutes already and I was starting to get desperate for excuses.

Look don't worry about the money—we can find something o get you there—it's not a lot, but it should pay for your travel and the hotel. Not fi e-star, probably not even two-star, something near the station...

Dick was quite clear about this.

Well that's very generous, you know, but, err, I've, I've got a holiday coming up.

I thought that would work. No one can refuse someone else a holiday.

"No Rog. Look, you'll enjoy it. I really think you'll enjoy it. Just make sure you can come."

I'm thinking he didn't hear me say holiday.

No, I really don't think I can.

Two weeks later, I walked into a stark metal and glass meeting room in Torino. The year was 2007. Anyone who has ever been to a meeting of the Subcommittee on Polymer Terminology, SPT to its friends, doesn't forget the fir t time. I certainly haven't. I arrived late, having only just managed to get a ticket on the train and, by adept use of internet booking, a hotel somewhere "local-ish" to the meeting venue and away from the station. Of this I was quite proud. However, as it turned out, the hotel wasn't quite as close to the meeting. As late had turned into later, I squeezed in at the end of the table and was astonished to find myself next to Dr. Graeme Moad, one of the discoverers of RAFT, a man whom I later found to have a wonderful sense of humour, but at that moment was making room so that I could settle in and look around at the forty or so people crammed into what looked like a greenhouse stuffed with square, modern furniture. As my hearing tuned in like an old radio, the succession of phrases, thrown like spears across the room, started to become comprehensible. I listened in awe as conversations about changing polymer education in some country or other, working with Africa, organising a conference in *Tierra del Fuego* (more of which later), were followed by deliberations on how such and such a polymerization might best be defined for the benefit of the whole world. As it all turned about in my head, it felt as if I had by some strange accident gained a place at a meeting of Greek Gods as they oversaw, measured, and planned future events and the fates of nations and individuals in the world below.

Given my naivety, everything was, of course, mixed up. Over the few days that I was there, in that room, with new found friends—they welcomed me at coffee, and later on a tour and at an end-of-meeting dinner—I was treated as an equal but still had little idea of what they were saying and how all of the meetings had panned out. Professor Bob Stepto, the former Division President, architect of the modern Polymer Division, and destined to become known to me as the person who, amongst other achievements, had adapted the term *dispersity* to polymers, took time to welcome me with biscuits while handing out coffee. All the while, he nodded and smiled gently at the conversations around him and listened seriously to any suggestions, even from a complete ignoramus like me. Professor Michael Hess, the Division Secretary with an Asterix-like glint in the eyes, said, "Yes, all these great people—they always make you feel welcome. I know how you feel! Isn't it great!" while Professor Dick Jones (disclosure: Dick had been my PhD supervisor so I'm a little biased), then the Chair of the Subcommittee, directed the meetings with aplomb. "OK, you initiate that..." 'that' meaning a new conference in Prague. "That's decided then," was a declaration that the new term *dispersity* was to replace *polydispersity index* for millions in industry, research, and education worldwide. But it was all still very vague. What I didn't realise was that I had attended three meetings compressed into one, and in one very small room. One meeting was of the whole Polymer Division, overseeing its roles, finan es, and activities and receiving reports from above and below.

Some, though not all, of the SPT members and observers in São Paulo, Brazil, 2017. From left to right: Paul Topham (UK), Karl-Heinz Hellwich (Germany), Michael Walter (USA), Tamaki Nakano (Japan), Ray Boucher (UK), Claudio dos Santos (Brazil), Michel Vert (France), Jiasong He (China), Volker Abetz (Germany), Olga Philippova (Russia), Patrick Theato (Germany), Graeme Moad (Australia), Jiri Vohlídal (Czech Republic), Mario Malinconico (Italy), Guido Raos (Italy), Adriana Sturcova (Czech Republic), Jan Merna (Czech Republic), Melissa Chin Han Chan (Malaysia), Marloes Peeters (Netherlands), Werner Mormann (Germany), Greg Russell (New Zealand), Jiazhong Chen (USA), and Roger Hiorns (France).

Another concerned the then embryonic Subcommittee on Polymer Education, which was planning to develop projects and web-based materials for worldwide use. The final meeting was that of the SPT, within which, I had—perhaps recklessly—opened my mouth.

Notwithstanding the Division's 50 years, the Subcommittee has itself a long and particular history which I should summarize here, the full story being told elsewhere [1]. What is now called SPT has changed its name, position and responsibilities within IUPAC over the 50 years since the birth of the Polymer Division. Originally it was called the IUPAC Commission on Macromolecular Nomenclature. It was this body that really set the language and standards of polymer terminology and nomenclature for our time, and though in the early days the distinction was not explicitly drawn, produced a series of papers that laid the ground for the key publications in each area, *Definitions of Basic Terms in Polymer Science* [2,3], and *Nomenclature of Regular Single-Strand Organic Polymers* [4]. The latter was the prime publication on structure-based nomenclature dealing with the naming of organic polymers whose unique repeating structures can be written within the framework of ordinary chemical principles. Starting in the 1970s, this work continued through to the 1990s and beyond, always with a group of high level scientists drawn from many different countries. More diverse subjects such as stereochemistry [5], inorganic polymers [6], and source-based nomenclature for copolymers [7] were also being addressed.

Polymer science more generally, and not just polymer chemistry, became the focus of later terminology papers such as those dealing with dilute solutions [8], and crystalline polymers [9] and their classific tion [10]. An early compilation of these documents resulted in the publication of the fir t edition of the so-called Purple Book, or Compendium of Macromolecular Nomenclature, in 1991 [11]. The '90s saw an extension to new areas such as the nomenclature of double-strand polymers and of irregular single-strand polymers, and the terminology of liquid crystal polymers and of non-ultimate mechanical properties [12], amongst others.

With the restructuring of IUPAC in 2001, in the course of which the Division of Chemical Nomenclature and Structure Representation (Division VIII) was

created along with the shift from commission-based to project-based work, the Commission changed its name to that of the present-day subcommittee, and the distinction between terminology and nomenclature was thereby at long last explicitly acknowledged. The terminological work continued unabated with publications on functional polymers, polymer composites, sol-gels, and ionic polymers. However, nomenclature work did not end, as by mutual agreement Division VIII was happy to delegate the development of polymer nomenclature to SPT while not relinquishing overall responsibility.

The 2nd Edition of the Purple Book appeared in 2008, and in it one can find many of SPT's key publications [13]. The last decade or so has seen a continued expansion of terminological work towards inter-science areas, those where polymers find application in electronics (resist materials and semiconducting polymers), biology (polylactides) and computing (modelling and simulation of polymers). In the nomenclature arena, the more commonly used source-based nomenclature has for the fir t time been elaborated in its totality [14]. Structure-based nomenclature is now being developed for star polymers under the excellent leadership of Jiazhong Chen, from Dupont, one of our valued members from within industry [15] and, importantly, given the different possible names for any one polymer, the publication of recommendations of preferred names is imminent [16].

[A]s soon as I'd spoken, Dick said, "Go away and develop a project." He knew that if the idea was a bad one, the membership would turn it into a good one or shoot it down in flames.

The problem for many scientists and students of accessing and assimilating all this work in order to use it correctly has been attacked on various fronts. The Purple Book was made available online as a pdf file in 2014 [17], while numerous efforts to make terminology and nomenclature more available have been made through work with Wikipedia [18], and on an active online multilingual translation facility for the *Glossary of Basic Terms in Polymer Science* [19]. The point at which I fir t opened my mouth in SPT, without giving it any great thought, was to launch the idea of preparing *A Brief Guide to Polymer Nomenclature*—a Polymer Division analogue of the Physical Chemistry Division's Green 2-page leaflet *A Concise Summary of Quantities, Units and Symbols in Physical Chemistry* published in 2009—the intention being to offer a ready understanding and easy access to all our definiti e nomenclature publications. To me, it shows the strength of SPT that, as soon as I'd spoken, Dick said, "Go away and develop a project." He knew that if the idea was a bad one, the membership would turn it into a good one or shoot it down in flames. In fact, the team rallied around what seemed at fir t sight to be a daft idea, *i.e.,* to compress all of IUPAC's polymer nomenclature into two pages to make it more accessible; they then turned it into something tangible. A true team-effort ensued, resulting in a student-friendly reference document that is now also used by most polymer journals and societies around the world [20].

All the above describes how SPT has evolved and what it produces, but why does it do it and how does it do it? Furthermore, how have events and personalities shaped the work in SPT?

IUPAC publications are used world-wide by governmental and non-governmental bodies (the EEC, UNESCO, *etc.*), legal entities (litigation courts, solicitors and patent offices), publishers (such as ACS, Elsevier, RSC, Springer, Wiley, *etc.*), universities and schools for their research and teaching, and Wikipedia and other websites adopt our definitions. Why though? I think that this question is best answered by a quote from the Director of Patents for a large, multi-national company: "In the drafting, prosecution and litigation of chemistry patents we are grateful if we can rely on exact nomenclature and definitions as provided by IUPAC, as this helps us to define the claimed scope of protection more precisely. In patent law, clear and concise claims are also an important requirement for a patent to be valid. So, your work is much appreciated." While this statement validates the work done within SPT, it also shows that the crafting of definitions for terminology and of rules for nomenclature can have a very real economic impact. The work of SPT and of IUPAC more widely helps companies maintain their scientific programs. For scientists at the bench, we help ensure that concepts, and chemicals and other materials are clearly defined and specified. Similarly, in the publishing industry, our work saves editors time and money by ensuring that expressions and names used by authors identify specific parameters and materials that do not require deciphering or transcription. Additionally, our defin tions help ensure that searches lead to relevant publications. In education, the usage is even simpler to understand. We provide clear, simple definitions for what can sometimes be quite complex concepts. Teachers

and students know that these have been carefully examined by working groups of world leading experts in the relevant fields. What they might not know is that the definitions can go through twenty or more iterations and be subject to scrutiny over a period of several years in intense meetings and ping-pong like electronic exchanges before being presented for public review and final approval for publication by the higher committees in IUPAC. What is also rarely known is that all IUPAC recommendations are made freely available and can be reproduced in any form whatsoever as long as they are done so in whole and with citation, which is fine as they are often short. So much for the why, now for the how.

SPT is only one of four subcommittees in the Polymer Division, and while not being the largest, it is the greatest user of funds. The reason is that for its work to be completed assuredly, it requires regular face-to-face meetings of its members so that the meanings and implications of each definition and rule are not open to misinterpretation. Recently, as electronic communication improves, from time to time some members engage with each other using Skype or meetings by video link. However, experience has shown that a maximum of two video connections are possible for any meeting. Every year without fail SPT meets for four days. These meetings are quite often in exotic locations from around the world, preferably near a beach but always near a bar. Following the changes of 2001, it was decided that project funds were to be used to ensure Division members—in particular SPT members—get help with travel and accommodation at the annual meeting venues. When distributed, this does not result in a great deal of money and it certainly doesn't cover all costs; it reflects the dedication of our volunteers that they are prepared to find the balance from other sources and sometimes from their own pockets.

Val Metanomski

Itaru Mita

Bob Stepto

Once assembled at our annual meetings, a recent innovation has been to have a lecture on a topic of relevance, and then to get any administrative business out of the way before spending an hour planning the coming week of project meetings. The Subcommittee currently has about 18 projects, each with a team of between 4 and 10 people chosen from both inside and outside of SPT. Weighed against the constraints of available time and the ability of members to move between rooms simultaneously like Schrödinger's cat, each is allocated an hour or two for discussion time. Once the timetable is set, members begin work, discussing terms and defining rules for nomenclature. This might sound dry, but dealing with issues of chemistry, for which full understanding of the underlying principles is required in order to develop definitions that can be understood by all, the frankest of discussions develop amongst friends and colleagues. There is respect for all views expressed and a team spirit guides all work towards clarity and consensus. This is surely one of the highest callings in science: that of an international team of volunteers working to the limit of its abilities. Inevitably there are some heated arguments but these are to be weighed against farcical exchanges when laughter reigns. However, when all is said and done, everyone comes together around the work in hand.

The years since SPT came into being have been witness to the sad demise of some of those who were in at the beginning: Val Metanomski from the Chemical Abstracts Service, whose scholarly contributions spanned the years between the publications of the 1st and 2nd editions of the Purple Book. Itaru Mita from Japan, who served for even longer, brought his gentle manner, patience and clear understanding of how IUPAC documents are best presented for the benefit of the non-English-speaking world. Our former Division President, Bob Stepto steered us to safe waters following the 2001 reorganization. Others from that era no longer travel to our meetings but still contribute to our progress and keep us safely aware of all that has gone before, in particular Pavel Kratochvil of the Czech Republic and Aubrey Jenkins (UK), both chairs of the former Commission on Macromolecular Nomenclature. The same years have also seen the recruitment of many excellent new members: Karl-Heinz Hellwich from Germany, who is presently the President of Division VIII and a mine of knowledge concerning nomenclature; Michel Vert from France, who has led SPT in addressing issues concerning biological polymers; and

Werner Mormann, also from Germany, who has been a leader in the field of polymer education as well as contributing to terminology and nomenclature.

In 2017, the Subcommittee continues to pursue traditional projects, typically *Definitions of Terms Pertaining to Polymers in the Solid state: Molecular Arrangement from the Nano- to the Micrometer Scale*, and a *Guide and (Brief Guide) to Polymer Semiconductors,* respectively under the leaderships of Natalie Stingelin and Michael Walter. These are just two of a number of younger members who have joined SPT recently, and the 'Brief Guide' that will be an integral, though self-standing, part of the latter project is indicative of a shift towards the preparation of shorter documents directed towards achieving far wider dissemination of our recommendations. *A Brief Guide to Polymer Terminology*, a sequel to the fir t of these concise documents, the *Brief Guide to Polymer Nomenclature* (*vide supra*), is in preparation.

A particular key to our success is the very strong camaraderie within SPT. A couple of years ago in South Korea, we had a delightful lecture from Professor Werner Mormann on the occasion of his retirement from the Subcommittee. He told about how he would fill his time in future, of his family activities and on how he had enjoyed being a member of SPT. It seems, however, that he couldn't keep away, for we were particularly pleased to see him return to join us in Brazil in 2017! We hope that other 'retired' members, such as Dick Jones, will follow his example at the next General Assembly planned for Paris in 2019 and be able to return.

Recent years have also seen tumultuous events, the most notable being when MACRO 2016 and our annual division and SPT meetings were held in Istanbul. (see page 33) The timing was such that we fl w straight into the attempted Turkish *coup d'état*. I remember many things from that time: the warm spirited strength and open friendliness of Professor Yusuf Yagci and his team who looked after us so well; all of the SPT members and observers, alongside others from the Division, participating and making their very best and courageous contributions to ensure that all SPT meetings were so productive; and the tours and the wonderful late night meals and bars that were such good fun. Everyone, including new members and young observers, wanted to make sure that the right thing was done. I particularly remember the camaraderie and support of friends and colleagues from all around the world who were much more worried about us than we were for ourselves. This strong bond that exists between all members of SPT now also helps to warmly welcome our new members and observers.

It's easy to see that part of SPT's ethos is to ensure that after hard days spent debating there are good evenings to be enjoyed. Here we are very much indebted to the efforts of the Subcommittee Secretary, presently Dr. Paul Topham, a friend and colleague of remarkable efficie y. With the help of local members, he has organised meeting rooms and tours which this year included a visit to the tallest building in São Paulo to drink champagne, in addition to taking concise minutes and keeping the Chair in timely order. Indeed, the annual Thursday afternoon tour is always an important social event of SPT members' week abroad. When I was the Secretary a few years ago, I organised one in Puerto Rico at which our bus driver was replaced at the last minute by someone called John. John, as it turned out, had been retired for longer than he had worked. This is no great problem for many, but for John, as driver and tour guide rolled into one, it presented a challenge. As he animatedly explained that Obama was President, and how such and such a building was a hotel, he rattled us through San Juan to the Bacardi rum centre. Once there, we were relieved to find that a one-drink ticket was seemingly recyclable, and that the barman was happy to take us on for any cocktail we could imagine. On our return to the city in the full heat of the day, we were too joyful to care whether or not John could unstick the bus from a corner wall that he'd wrapped it around, and as the traffi in the centre of San Juan stopped moving and police motorbikes swooped in, we abandoned him to his fate and headed to the nearest bar.

Early on I mentioned *Tierra del Fuego.* This was written whimsically in the hope that poetic licence will be allowed in *Chemistry International,* but given that it is an IUPAC publication, even the slightest flight of fancy, not even for a story hook, can be allowed. In all truth, finding new venues for our meetings is becoming increasingly difficult, so this year Chris Fellows proposed that we consider holding MACRO-2028 at the very tip of South America, in *Tierra del Fuego.* In later conversations with Professor Carlos Graeff of São Paulo State University, it became apparent that this idea is not quite as crazy as it seems, and even though the average temperature in July is only 4 ˚C, there are some towns which might be able to cater for 1500 people. While Argentina is not currently affil ted to IUPAC, Chile is, so it would have to be held on its side of the border. Sadly, there wasn't enough time at this year's meeting for Chris to do a test run before presenting the idea to the Polymer Division, but I hope that maybe there would be support for a conference in February when temperatures have been known to soar to 9˚C!

All of this is an entirely personal snapshot of SPT past and present. There are many people that I haven't been able to mention for reasons of space, but all our members play important and often complementary roles in developing recommendations that are acceptable world-wide in a peaceful atmosphere of fun and goodwill, thereby clearing the road for the communication of science. I'd like to take this opportunity to thank all members for the wonderful job that they do; it's an amazing team of which I'm proud to be part.

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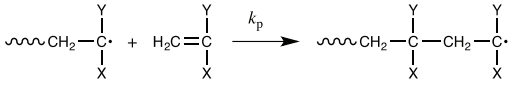
Modeling of Polymerization Kinetics and Processes—from Voting to Toting

by Gregory T. Russell

The reaction at the heart of radical polymerization is:



Termed propagation, it now occurs to the tune of a stupendous 100 million tons per annum. It is therefore no surprise that right from the moment the mechanism of radical polymerization was fir t elucidated, which was in the late 1930s, there has been strong interest in determining propagation rate coefficients k_p. After 50 years of mortal toil, the state of play in this regard was captured by Fig. 1, which presents bulk polymerization values of k_p for methyl methacrylate (Y = CH_3, X = CO–O–CH_3) from the 1989 edition of the Polymer Handbook [1], a compendium of polymer-related data.

For what is such a fundamental and important rate coefficient Fig. 1 paints a deplorable picture: there is near order-of-magnitude uncertainty in k_p! An obvious question is whether there is something recalcitrant about the monomer methyl methacrylate, from which Perspex is made. The answer is that it has been referred to as the fruit fly of radical polymerization kinetics, for it is the most studied monomer in this regard. Therefore, one may wonder whether the problem of measuring k_p was ever taken seriously. The answer is that many upstanding groups had addressed it, and at least three Nobel Prize winners—Paul Flory, Ronald G.W. Norrish and Pierre-Gilles de Gennes—had dipped their toes into the turbulent waters of radical polymerization kinetics, so Figure 1 does not reflect that lightweights were at work!

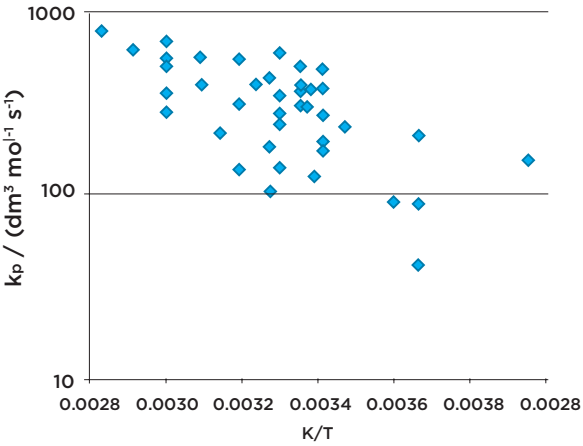


Fig. 1. Arrhenius plot of measured propagation rate coefficients, k_p, for bulk polymerization of methyl methacrylate, as of the late 1980s [1].

Of course, it is obvious from Figure 1 that there must be a fundamental problem, and in fact in the late 1970s an IUPAC Working Party under the leadership of Dr. Geoff Eastmond of the University of Liverpool was formed to investigate this [2]. Painstakingly, it was shown that the problem is not one of irreproducibility of raw data, for when laboratories in different parts of the world were given the task of determining the same raw data (*e.g.* monomer densities, for use in dilatometric studies), the results were far too close to explain the scatter. Thus, by the time the Eastmond Working Party wound up in 1987, there seemed to be cause for despair. And yet, just under a decade later, another IUPAC Working Party published Figure 2, a highly precise set of benchmark k_p values for methyl methacrylate [3], in which not one of the 1989 points remains. What had brought about this remarkable transformation?

With the benefit of hindsight, one may now discern that radical polymerization's equivalent of the 1927 Solvay Conference [4] took place in May 1987, namely the (1st) International Symposium on "Free Radical Polymerization: Kinetics and Mechanisms," held at the stunning Santa Margherita Ligure on the Italian Riviera. Pleasingly, IUPAC was right behind this conference.

The fir t significant event of 1987 conference was that Professor Bob Gilbert of the University of Sydney called a meeting of his newly minted IUPAC Working Party on "Modeling of Polymerization Kinetics and Processes", the successor to Geoff Eastmond's. A man of scientific gravitas, great charisma and irresistible drive, Bob was exactly the right person to be handed this chalice at this time. In view of the situation depicted in Figure 1, he would irreverently refer to the *Polymer Handbook* as "the book of random numbers." This was not intended as an offence, but merely to convey that the state of play was thoroughly inadequate. Indeed, Bob reports a Damascene moment at the 1987 meeting when it was proposed to decide the correct value of k_p for styrene through a vote: he knew things had to change—rate coefficient are determined by accurate measurement, not by plebiscite!

As fate would have it, the desired change was immediately facilitated by the reporting at the 1987 conference of a new method for measuring k_p, namely the "pulsed-laser polymerization – size exclusion

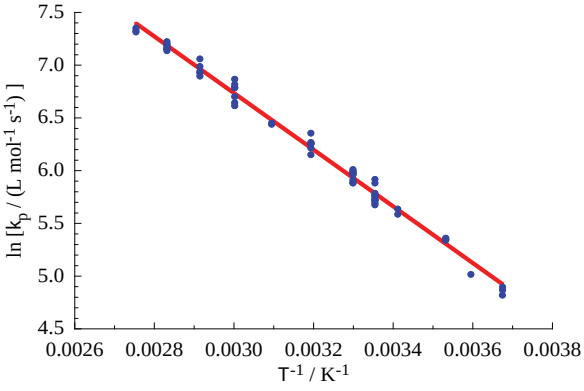


Fig. 2. IUPAC's replacement of Fig. 1: critically evaluated values of methyl methacrylate k_p, as determined by the IUPAC-recommended technique of PLP SEC [3].

chromatography" (PLP SEC) method of Professor Oskar Friedrich Olaj and colleagues at Wien Universität [5]. The cartoon of Fig. 3 depicts how this method works.

Imagine a population of creatures is born at t = 0. This is the result of the laser pulse in the left-hand box of Figure 3. Then imagine that these creatures grow at a constant but unknown rate, which it is desired to determine. This is what is happening in the second box of Fig. 3. At a known time later, action is taken to stop the growth of the creatures, while at the same time some new creatures are generated. This is the effect of the laser pulse in the third box of Figure 3, hence the "PLP" part of the experiment. The dead creatures are then taken away and their size measured—this is the "SEC" part of the experiment. Thus, one obtains the size grown in a known duration of time. The rate of growth—equivalent to k_p in radical polymerization—is thus trivially obtained. That is the beauty of the PLP SEC method.

How devoid of assumptions the PLP SEC method should be evident. A third thing that started to become crystal clear at the 1987 conference was that a phenomenon known as chain-length-dependent termination acts in such a way as to make termination rate coefficients k_t, sensitive even to the most seemingly minor variations in conditions. Given that constancy of k_t had hitherto been assumed in determining k_p values, the origin of the scatter in Figure 1 becomes clear, and the fundamental problem referred to above is revealed. The PLP SEC method was revolutionary in that it liberated k_p determinations from this yolk, for it involves no assumptions about k_t values.

This is the fertile ground that has given rise to nearly three decades of hugely successful endeavor by the Working Party (now Subcommittee) on "Modeling of Polymerization Kinetics and Processes." Of course, nothing is ever as simple as it sounds, and there is more to it than just toting the k_p values. Initially the Working Party focused on establishing "consistency criteria" to indicate if a PLP SEC experiment was generating reliable k_p values [7]. Later on, the Subcommittee played a key role in unraveling issues that beset the polymerization of acrylates (Y = H, X = CO–O–R), in which a reaction known in the vernacular as backbiting— more

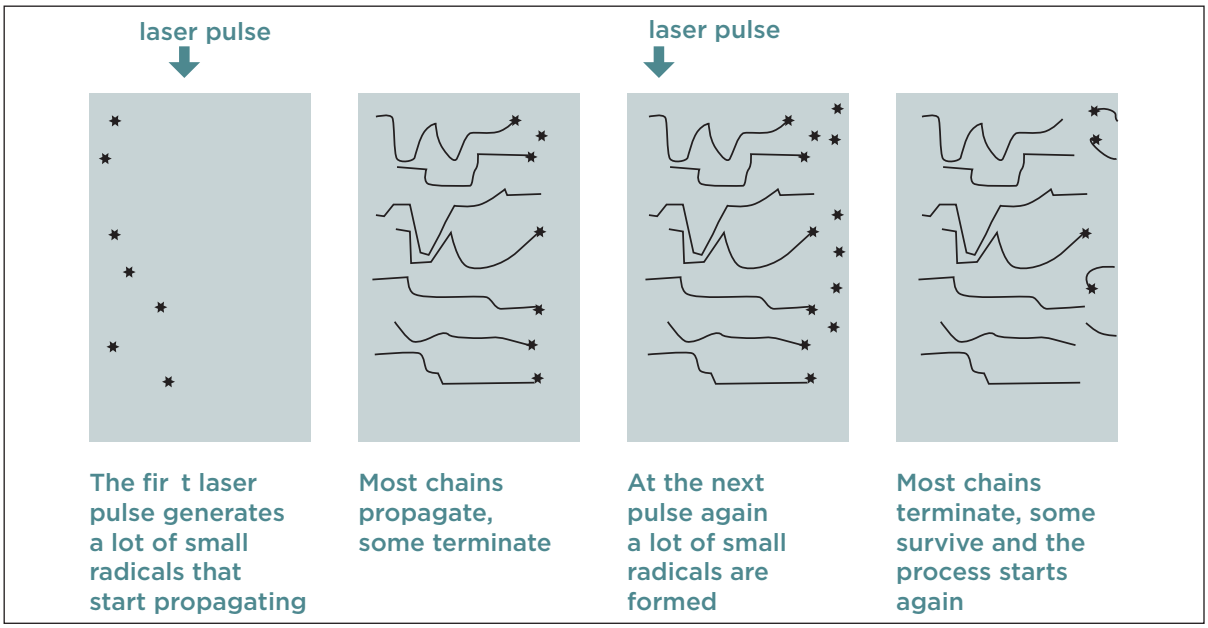


Fig. 3. Schematic representation of a PLP experiment for determination of k_p (reproduced from [6]).

formally, intramolecular chain transfer to polymer—acts to interrupt chain growth, thus compromising the simple correlation between polymer size and pulse time [8], as described above. There have been other complicating scientific issues—cottage industries always mushroom around a big, successful venture—but these have been the main ones.

Not to be underestimated is the power of IUPAC to bring people together to work in harmony. It is easy to say that anyone could have collated data to produce Figure 2. But the IUPAC imprimatur imparts Figure 2 with an authority and objectivity it would lack if any individual had produced it. This is because behind Figure 2 stands group agreement that every datum within has credibility. Essential to this process has been leadership. As already mentioned, initially this was provided by Bob Gilbert, a larger-than-life figu e who immediately grasped the transformative potency of PLP SEC when coupled with the IUPAC brand. Bob acted as a beacon to bring disparate workers into the IUPAC fold, and he brought his scientific acumen to bear on the "critical evaluation" and publication processes. Equally, he made sure there were capable leaders to follow: in turn, Michael Buback (Universität Göttingen), myself (though I say it myself), and now Robin Hutchinson (Queen's University) have led the Subcommittee—see Fig. 4.

The extent and impact of the Subcommittee's oeuvre may be gleaned from Table 1. First of all, this table shows the steady, accumulative nature of the work that has taken place—IUPAC has to wait until a critical mass of individual work has occurred before it can step in and decree a benchmark data set. Secondly it shows the variety of monomers that have been investigated by now—most (but not all) major classes of vinyl monomers are represented. But what really stands out is the impact of the work, emphasizing its value to the scientific community and the consensus it has generated. It may well be that no IUPAC scientific paper has ever been cited as heavily as the fir t paper of Table 1 [7].

There are several important things that Table 1 does not convey. One is the volume of data in each publication. For example, the most recent paper, that on vinyl acetate, contains 178 individual k_p measurements from 6 different laboratories [9]. These are serious numbers. Secondly, behind every line of Table 1 is a plot like that of Fig. 2, together with Arrhenius parameters and their uncertainties. Thirdly, these publications are more than just compilations of accurate numbers. What they have progressively revealed is that there are clear patterns in these data, something unimaginable from the 'pin-the-tail-on-the-donkey' nature of Fig. 1. Specifically, it has emerged that within a monomer family,

Fig. 4. Three Men in a Boat—(l. to r.) Greg Russell, Michael Buback and Robin Hutchinson contemplating rate coefficients under the high-temperature conditions of the Bosphorus in mid-summer (August 2013).

the activation energy, E_a, for propagation is constant whereas the pre-exponential factor increases with the size of the pendant group. Transition-state theory can explain this, while quantum chemistry can explain how E_a varies from family to family. These are tremendously useful scientific advances. Fourthly, radical polymerization has a chain-reaction mechanism, which means that its overall rate of reaction is a function of several elementary rate coefficients With the problem of k_p well and truly nailed, it has been possible to shift focus to some of these other rate coefficients most notably—but not restricted to—that for termination. The key here is that once k_p is accurately known, generally k_t may also be accurately determined. This has led to well-cited IUPAC outputs, with more in the pipeline. Mention should also be made of an important IUPAC paper on the mechanism of RAFT polymerization [10]. The point here is that while k_p has been the cornerstone of the Kinetics Subcommittee's work, other plants have been watered and have bloomed—my apologies, I cannot resist mixing good metaphors when the opportunity presents.

I should like to end with a thought-provoking observation. The annual budget of the IUPAC Polymer

Monomer(s)	Journal	Year	Citations
1. Styrene	*Macromol. Chem. Phys.*	1995	584
2. Methyl methacrylate	*Macromol. Chem. Phys.*	1997	455
3. *n*-Alkyl methacrylates	*Macromol. Chem. Phys.*	2000	201
4. Functional methacrylates	*Macromol. Chem. Phys.*	2003	84
5. *n*-Butyl acrylate	*Macromol. Chem. Phys.*	2004	256
6. Methacrylic acid	*Pure Appl. Chem.*	2007	52
7. Methyl acrylate	*Polym. Chem.*	2014	37
8. Vinyl acetate	*Macromol. Chem. Phys.*	2017	1

Table 1. Publications by the IUPAC Subcommittee on Modeling of Polymerization Kinetics and Processes on "Critically evaluated propagation rate coefficients in radical polymerization." Citation numbers are from Web of Science on 17 June 2017.

Division is USD 25k. Over the period of existence of the Subcommittee on Modeling of Polymerization Kinetics and Mechanisms, this translates into US$ 750k of funding. But the Subcommittee is only one of four in the Division. So, Table 1 has cost under US$ 200k to produce. Think now of 100 million tons of (commercial) product per annum, and the importance to this of the information in the publications of Table 1. The only possible conclusion is that this table is a billion dollar return on the cost of just 1 or 2 PhD students. And to think that people question whether IUPAC returns anything of value from its meager national subscriptions!

Lastly, I would like to thank all members of the IUPAC Subcommittee on Modeling of Polymerization Kinetics and Mechanisms who have given freely of their time to make this cooperative a success. You can read more about us on iupac.org/body/428 [11].

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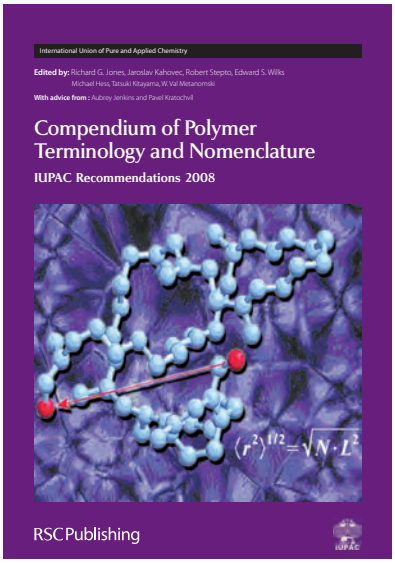
IUPAC in Polymer Education

by Christopher Fellows and Patrick Theato

For as long as the Polymer Division of IUPAC has existed, it has put a high priority on education. In 1996, it first supported a dedicated educational project in the form of the UNESCO/IUPAC Postgraduate Course in Polymer Science, which continues to be organised annually by the Institute of Macromolecular Science in the Czech Republic and supported by the Polymer Division. In 2005, the Division IV Subcommittee on Polymer Education (SPEd) was established "to bring existing educational activities under one roof, to emphasise the importance of polymer education as well as the dedication of the IUPAC Polymer Division to this important field" [1]. Since then, educational projects have been the focus of this subcommittee. It has provided a forum for exchange of practice in polymer education worldwide, supported workshops in polymer science for undergraduates and postgraduate students on most continents, developed its own educational resources for free distribution to the world, and provided a website linking to other groups active in polymer education and other education resources.



The "Purple Book" [2]

What do chemists need to know about polymers? What do people in general need to know about polymers? These are questions that do not really have a good answer. The answer will depend on the chemist, or the person, their individual situation and what goal they are trying to accomplish at a given time.

A secondary school student will require different information than an employee of a company wanting to source a product for a food processing application, who will in turn require different information from a government officia investigating an incident caused by materials failure or a biomedical researcher seeking an appropriate substrate for a therapeutic biomolecule. Within chemistry, there is no consensus on what content is essential for a chemist to know — this is frequently driven by which industries are important locally and which research specialties have historically been important. Polymers are often one of the fir t topics to be omitted from a chemistry program, sitting as they do on the margins of physics and engineering, relatively far from the core topics of chemistry.

So, leaving behind the difficult question of what people ought to know about polymers, we will move on to an easier one: assuming someone wants to know *something* about polymers: **Which source should they refer to when they need to know about polymers?** The correct answer to this question is almost always: "IUPAC's Compendium of Polymer Terminology and Nomenclature" [2] (*i.e.*, the 'Purple Book'). This compendium of definitions has been subjected to many iterations of exhaustive discussion and contains the definiti e, internationally agreed-upon explanations of the many terms that lurk in wait to confuse newcomers to polymer science. Now available with a purple title page and free to the world on the internet, it is as far as possible comprehensive, accurate, and usable. While it might not answer all of your questions, the Purple Book will almost certainly give a solid start to your quest for polymer knowledge and provide you with the correct search terms to help you find the answer to the question you really want to answer, whatever it may be. The next question that should be asked is: **In practice, what source does someone typically refer to when they need to know about polymers?**

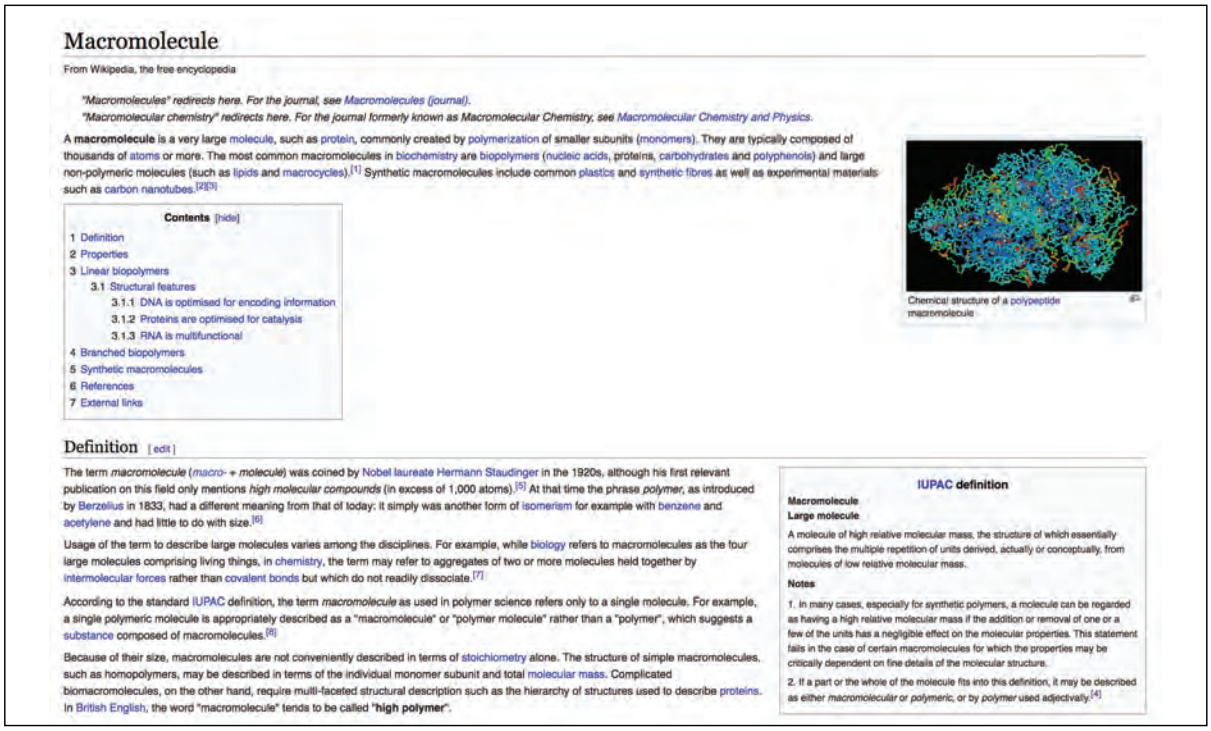
While around the world there are many sources of information of differing degrees of accessibility and quality, the answer to this question is, more and more, "Wikipedia." There is nothing wrong with this, because Wikipedia is a fantastic place to begin your search for information on just about anything. In recognition of the shift in the behaviour of learners worldwide, who seek help fir t from a few pervasive online resources, SPEd has, over the past several years, sought out every opportunity to incorporate Purple Book definitions into polymer-related Wikipedia articles. There is no point in providing beautifully curated up-to-date and accurate information in a place where no one will read it, so SPEd has sought to go where the learners are. This is not a project where IUPAC editors ride roughshod over other Wikipedia editors — an unhappy possibility that is impossible at any rate — but one that ideally results in a negotiated outcome, where the IUPAC definitions are clearly branded and prominently displayed as

inalterable nuggets within the Wikipedia entry, while the open philosophy of Wikipedia continues to prevail elsewhere. An example of how this works in practice is shown below for 'macromolecule'. (It should be noted that to date this is only implemented in this manner in the English Wikipedia. In other languages, which are independently handled, it has not yet been possible to negotiate this implementation.)

In order to go where the learners are, it is also becoming more and more important to move beyond the traditional strongholds of chemistry and polymer chemistry in North America, Western Europe, and Northeast Asia. An ever-increasing fraction of the world's chemists and the world's polymer industry is located in developing nations, as advances in knowledge and its application have lifted billions out of poverty. Linking polymer science and education closely to the needs of local industry is critical to spanning the 'middle income gap', in which nations escape absolute poverty but fail to achieve developed status [3]. As synthetic polymers have become a more important part of material culture around the world, it has also become a priority that they be part of a typical student's primary and secondary education:

> *"During the last 30 years the world's materials around us have changed … to new materials … Emphasis is on polymers, advanced materials for the electronic and medical industries and novel ceramics, amongst others. Yet, a school leaver often doesn't know … what a plastic bag is and how to recycle it. There is an urgent need to address the improved teaching of materials (and polymer) science, especially in Africa. We are of the opinion that new courses could do much to improve science teaching in Africa and make the matric student much more conscious of materials around him/her."* [4]

Fortunately, the omnipresence of the internet and mobile devices to access it means that it has never been easier to reach out to learners worldwide, at all levels. A core belief of SPEd is that educational materials should be freely available for all users anywhere in the world, not quarantined behind university firewalls for the exclusive use of fee-paying students. The website of the SPEd, https://iupac.org/polymer-edu/, provides links to the polymer education resources developed under the auspices of the IUPAC Polymer Division. For example, 'A Brief Guide to Polymer Nomenclature' [5] carefully picks enough detail out of the Purple Book to answer most everyday questions about naming polymers. The educational materials developed for the postgraduate courses held around the world under SPEd auspices — whether in Prague, Stellenbosch, or Kathmandu — are also available online. There is still much work to be



Macromolecule

From Wikipedia, the free encyclopedia

"Macromolecules" redirects here. For the journal, see Macromolecules (journal).
"Macromolecular chemistry" redirects here. For the journal formerly known as Macromolecular Chemistry, see Macromolecular Chemistry and Physics.

A **macromolecule** is a very large molecule, such as protein, commonly created by polymerization of smaller subunits (monomers). They are typically composed of thousands of atoms or more. The most common macromolecules in biochemistry are biopolymers (nucleic acids, proteins, carbohydrates and polyphenols) and large non-polymeric molecules (such as lipids and macrocycles).[1] Synthetic macromolecules include common plastics and synthetic fibres as well as experimental materials such as carbon nanotubes.[2][3]

Chemical structure of a polypeptide macromolecule

Contents [hide]

1 Definition
2 Properties
3 Linear biopolymers
3.1 Structural features
3.1.1 DNA is optimised for encoding information
3.1.2 Proteins are optimised for catalysis
3.1.3 RNA is multifunctional
4 Branched biopolymers
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Definition [edit]

The term *macromolecule* (*macro-* + *molecule*) was coined by Nobel laureate Hermann Staudinger in the 1920s, although his first relevant publication on this field only mentions *high molecular compounds* (in excess of 1,000 atoms).[5] At that time the phrase *polymer*, as introduced by Berzelius in 1833, had a different meaning from that of today: it simply was another form of isomerism for example with benzene and acetylene and had little to do with size.[6]

Usage of the term to describe large molecules varies among the disciplines. For example, while biology refers to macromolecules as the four large molecules comprising living things, in chemistry, the term may refer to aggregates of two or more molecules held together by intermolecular forces rather than covalent bonds but which do not readily dissociate.[7]

According to the standard IUPAC definition, the term *macromolecule* as used in polymer science refers only to a single molecule. For example, a single polymeric molecule is appropriately described as a "macromolecule" or "polymer molecule" rather than a "polymer", which suggests a substance composed of macromolecules.[8]

Because of their size, macromolecules are not conveniently described in terms of stoichiometry alone. The structure of simple macromolecules, such as homopolymers, may be described in terms of the individual monomer subunit and total molecular mass. Complicated biomacromolecules, on the other hand, require multi-faceted structural description such as the hierarchy of structures used to describe proteins. In British English, the word "macromolecule" tends to be called **"high polymer"**.

IUPAC definition

Macromolecule
Large molecule

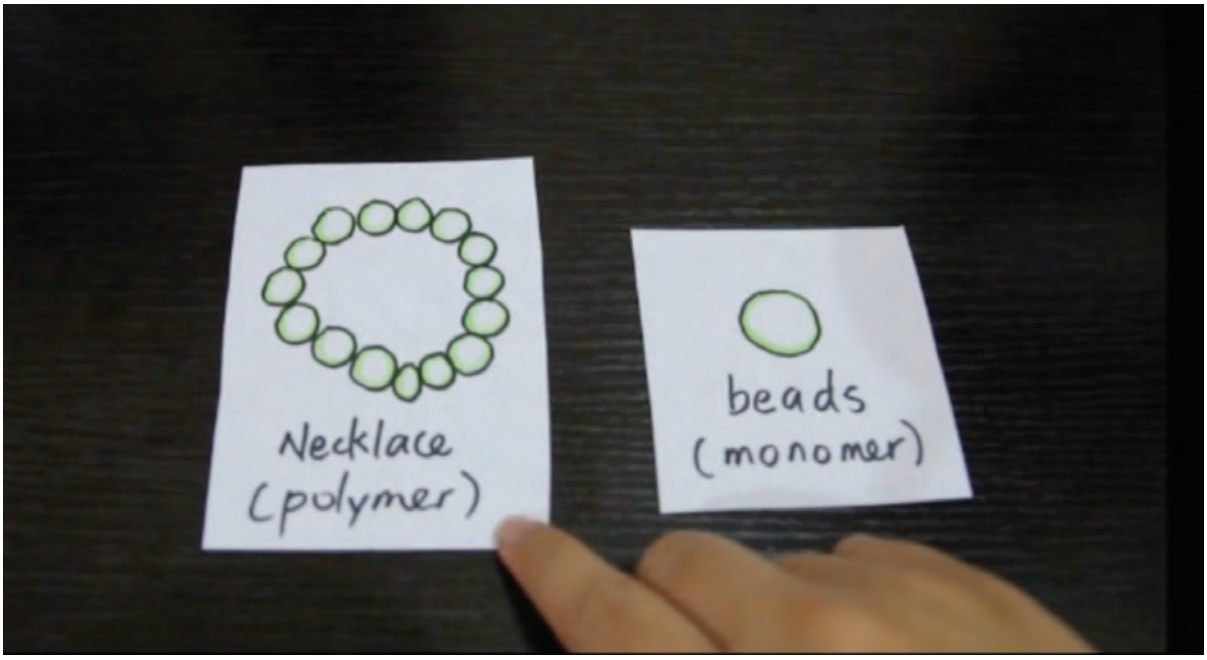
A molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass.

Notes

1. In many cases, especially for synthetic polymers, a molecule can be regarded as having a high relative molecular mass if the addition or removal of one or a few of the units has a negligible effect on the molecular properties. This statement fails in the case of certain macromolecules for which the properties may be critically dependent on fine details of the molecular structure.

2. If a part or the whole of the molecule fits into this definition, it may be described as either *macromolecular* or *polymeric*, or by *polymer* used adjectivally.[4]

Wikipedia Screenshot, https://en.wikipedia.org/wiki/Macromolecule, accessed 15 September 2017



A screenshot from Yvonne Choo's prize-winning 2011 IYC 'A World Without Polymers' video [6]

done to raise awareness of IUPAC's polymer education resources and improve their usability, but it has never been easier to access information. The number one current priority of the SPEd is making existing IUPAC educational resources available on this website.

Since most SPEd members are drawn from academia and spend a great deal of their time teaching at the tertiary level, it has primarily engaged in educational activities at that level, with relatively few projects to engage secondary school students and the general public. These are areas where we can and should do more in the future. One event where SPEd did engage with the general public was held at the time of the International Year of Chemistry (2011), when SPEd ran a video essay contest entitled 'A World Without Polymers'. In this project, young people were asked to imagine the impractical possibility of life in a world with only low molar mass compounds: many of these videos can be found in the great sea of information which is the internet, and a number, including the winning entry by Malaysian final year secondary student Yvonne Choo, can be found on the SPEd website [6].

It should not be assumed that only SPEd is involved in polymer education within IUPAC. Most members of the IUPAC Polymer Division are active educators, while polymer-related educational projects are also carried out under the banner of the IUPAC Committee on Chemical Education. Those activities that form part of formal projects within SPEd are very much the tip of the iceberg in terms of IUPAC's involvement in polymer education.

At the Macro 2014 meeting in Chiang Mai, Thailand, SPEd organised a session on activities in polymer education worldwide, which has been captured for posterity in a special issue of *Macromolecular Symposia* (doi.org/10.1002/masy.v355.1). At this symposium, SPEd considered a wide range of questions in education, from broad fundamental principles to the details of how learning about polymers takes place at specific events. For example, it considered appropriate development of resources and curriculum in secondary school education [7] and the effectiveness both of short postgraduate courses in polymer science and of even shorter tutorial events held in conjunction with conferences [8, 9].

The chair of the IUPAC Subcommittee on Polymer Terminology, Dr. Roger Hiorns, spoke at the Macro 2014 meeting on the uptake of resources such as the 'Brief Guide to Polymer Nomenclature', which has been linked to by a large number of organisations involved in both formal and informal secondary and tertiary education. Dr. Hiorns also spoke on the development of new polymer-related laboratory activities that can be carried out with household items for secondary school students and stressed the importance of the fundamental work of IUPAC for education in general:

"Misunderstanding between different communities creates more work and hinders

science and education! Rigorous, worldwide definitions facilitate understanding, communication, scientific endeavour, and education." [10]

The SPEd session at Macro 2014 also considered common pitfalls in tertiary polymer education of particular relevance to developing countries. Frequently, there is an emphasis on the relation between synthesis and structure, while the all-important links between structure and macroscopic properties which are critical for the application of polymers are neglected. The habit of thinking in 'disconnected mental boxes' must be broken down so that students can better integrate what they learn in separate chemistry, physics, and engineering units to obtain a useful mental model they can apply when they are faced with challenges involving polymers in the workforce [3].

Reviews of the state of tertiary polymer education at the time in a number of countries — Zimbabwe, Vietnam, Thailand, Tanzania, South Africa, Nigeria, New Zealand, Malaysia, Korea, Japan, Germany, China, Brazil, Australia — were also presented at Macro 2014 [11-20]. These reports together give a valuable benchmark for assessing global trends. It will be important to revisit these same countries in another decade or so to assess where polymer education is moving. Significantl , similar challenges and opportunities exist all over the world: polymer education is on the fringe of most secondary and tertiary degree programs and lack of general knowledge of polymers is widespread among decision makers and the public at large, while at the same time polymer education is fundamental to the operation of industries of enormous scale and importance.

In summary, IUPAC can play a significant role in polymer education worldwide and has many members who are passionately committed to this goal. Within IUPAC, these efforts are localised most strongly in SPEd, which strives to be the central source of information for polymer education resources. Yet, as a project run solely by the voluntary work of polymer scientists worldwide, progress is never as rapid as we would like, and SPEd welcomes support from anyone who is interested in contributing to our work. Please feel free to drop in on our next full face-to-face meeting at Macro 2018 in Cairns, Australia!

Acknowledgements

The kind advice of Prof. Werner Mormann in the preparation of this article is gratefully acknowledged.

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IUPAC Polymer Conferences

by Michael Hess

It is now almost 100 years since Staudinger's pioneering work that can be taken as the start of polymer science [1]. However, it took more than another 10 years until the concept of macromolecules began slowly to be accepted by the scientific community, and the Nobel Prize was not awarded to Staudinger until 1953. The first IUPAC publication about nomenclature of macromolecules [2] was published by the Sub-Commission on Nomenclature of the IUPAC Commission on Macromolecules (Chair H. F. Mark) in 1952. The Macromolecular Division, the 50th birthday of which we celebrate this year, was founded in 1967. Within this IUPAC Division IV there was also founded a Commission on Macromolecular Nomenclature in 1968 with Kurt Loening as its Chair. However, the division goal always was clearly defined by the principles upon which to this day the Union is founded:

- We serve humankind by advancing chemistry worldwide.
- We view scientific excellence and objectivity as the cornerstone of all our work.
- We value collaboration and communication among all our stakeholders.
- We strive for diversity and inclusiveness in all forms.
- We respect each other and the Union.
- We uphold the highest standards of transparent, responsible and ethical behaviour.

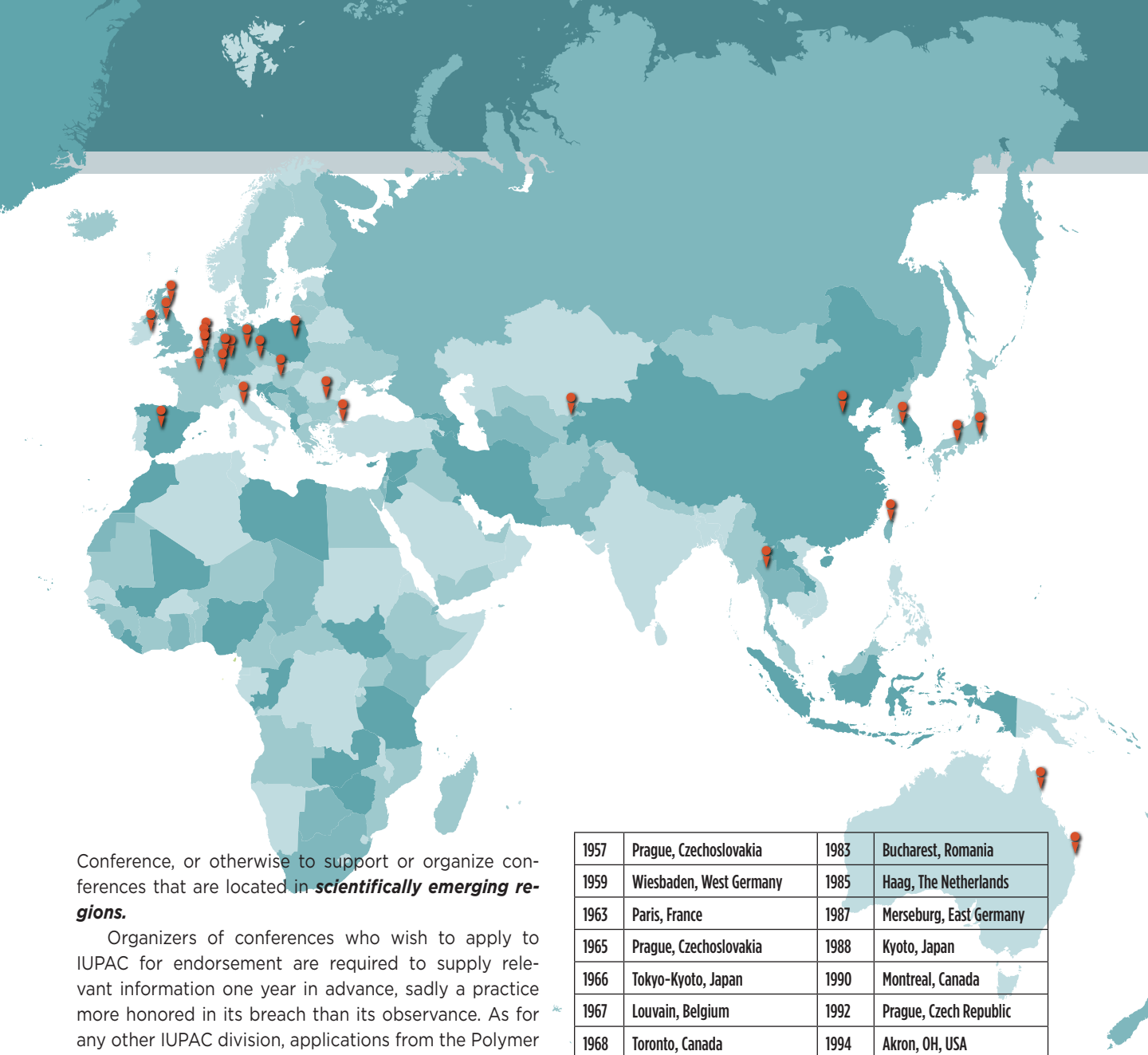
Building upon these principles, the Division's aims are:

- To facilitate international scientific exchange
- To cooperate with other international organizations
- To promote macromolecular and polymer science and technology at the international level, including education, conferences and the assessment of societal impact
- To define terminology and standards in macromolecular and polymer science and technology.

The means by which the Division achieves these aims include:

- Developing position papers on issues of importance to the international community
- Organizing studies of polymer-related industrial technologies to define critical issues
- Promoting scientific and technological education and exchange of ideas
- **Actively sponsoring international conferences**
- Providing financial support for approved projects in terminology, in polymer, molecular and process characterization, in special topics and in education.

It is the fourth of this last set of bullet points that is the focus of this article. As the only worldwide organization representing polymer science and technology, not just polymer chemistry, the Division's engagement in organizing conferences is second to none. It endorses and, where it is appropriate to do so, it funds conferences of relevance to the future development and application of polymers for the benefit of the world community. It distributes knowledge about polymers, in particular to students from economically disadvantaged countries, through educational projects, tutorials and courses that it sponsors [3]. The IUPAC endorsement (misleadingly called 'sponsorship' in the past) is first and foremost a quality label, as direct financial support is only granted in two special cases: for conferences on ***New Directions in Chemistry*** for Divisions or Standing Committees that wish to support or organize a symposium or workshop on the *"frontiers of science"* within the framework of a



Conference, or otherwise to support or organize conferences that are located in ***scientifically emerging regions.***

Organizers of conferences who wish to apply to IUPAC for endorsement are required to supply relevant information one year in advance, sadly a practice more honored in its breach than its observance. As for any other IUPAC division, applications from the Polymer Division are coordinated and endorsed by the Division President thus involving the organizer in discussions of the conference program and objectives, and the identification of the proposed lecturers with the Division during preparation of the application, and, of course, there are prerequisites: (1) the conference has to be located in a country represented within IUPAC by a National Adhering Organization, and (2) in general, IUPAC endorsed conferences should be international in the sense that they are intended to attract participants from anywhere in the world. Conferences that are mainly regional in nature may, however, be eligible for endorsement if it would help attract a more international audience.

In Division IV, our conferences are not just occasions where scientific results are presented, they are scientific meeting places with vivid face-to-face discussions. They include social events that keep the community together,

1957	Prague, Czechoslovakia	1983	Bucharest, Romania
1959	Wiesbaden, West Germany	1985	Haag, The Netherlands
1963	Paris, France	1987	Merseburg, East Germany
1965	Prague, Czechoslovakia	1988	Kyoto, Japan
1966	Tokyo-Kyoto, Japan	1990	Montreal, Canada
1967	Louvain, Belgium	1992	Prague, Czech Republic
1968	Toronto, Canada	1994	Akron, OH, USA
1969	Budapest, Hungary	1996	Seoul, Korea
1970	Leiden, The Netherlands	1998*	Gold Coast, Australia
1971	Boston, USA	2000*	Warsaw, Poland
1972	Helsinki, Finland	2002*	Beijing, China
1973	Aberdeen, UK	2004*	Paris, France
1974	Madrid, Spain	2006*	Rio de Janeiro, Brazil
1977	Dublin, Ireland	2008*	Taipei, Taiwan
1978	Tashkent, USSR	2010*	Glasgow, UK
1979	Mainz, West Germany	2012*	Blacksburg, VA, USA
1980	Florence, Italy	2014*	Chiang Mai, Thailand
1981	Strasbourg, France	2016*	Istanbul, Turkey
1982	Amherst, MA, USA	2018*	Cairns, Australia

*Table 1: International Symposia on Macromolecules and World Polymer Congresses**

sometimes developing a family-like atmosphere within which students can establish international contacts; where groups with common interests can be identified with a view to collaboration and future exchanges; where young scientists can find post-doctoral positions or make contact with industry. Everyone presents their results in front of an international audience and get to meet distinguished scientists, even Nobel laureates—a rare opportunity. Our major conferences, the well-known IUPAC World Polymer Congress—MACRO (see below) and the POLYCHAR (POLYCHAR stands for Polymer Characterization) World Forum on Advanced Materials, grant particular awards for students or young scientists to attend. This is commonly coordinated through National Adhering Organizations, some of which supplement the funding available for this purpose. Usually, there is an IUPAC Poster Prize for Young Scientists at all our endorsed conferences. Presently, the routinely-endorsed Division IV conferences are:

- International Symposium on Ionic Polymerization
- International Symposium on Macromolecular-Metal Complexes (MMC)
- International Conference on Polymer Characterization (POLYCHAR)
- International Conference on Polymers and Organic Chemistry
- UNESCO School & IUPAC Conference on Macromolecules (South Africa)
- Novel Materials and their Synthesis (NMS) (China)
- IUPAC World Polymer Congress (International Symposium on Macromolecules-MACRO)

Young scientists, as indicated above, were sponsored by IUPAC in such a way that some from underprivileged countries were able to attend courses, for example the Short Course on Polymer Characterization held in combination with POLYCHAR, by now the institutionalized and traditionally prestigious Postgraduate Course of the Macromolecular Institute in Prague, Czech Republic and, more recently, the tutorial on the occasion of MACRO 46 in Istanbul, Turkey, 2016. As well as receiving travel and subsistence expenses, the young scientists' fees were also waived.

The IUPAC World Polymer Congresses (MACRO) held in even years are the flagship events of the Polymer Division, hosting about 1000 or more participants. Whatever notice the polymer community takes of the Division and its activities, this is the polymer conference that every country wishes to host and at which every polymer scientist makes an effort to be present. Under the banner of the IUPAC International Symposium on Macromolecules and aiming to be an annual conference, the fir t 'MACRO' was held in 1957 in Prague in the Czech Republic. In 1988, it became a biennial event. The various venues are shown in Table 1 and mapped on pages 28-29; the next in the series being due to be held in Cairns, Australia in 2018.

On the occasion of MACRO Paris 2004, the Polymer Division awarded the fir t of the prestigious Samsung-IUPAC Young Scientist Award (since 2014 renamed Hanwha-Total IUPAC Young Scientist Award) for "the most promising young polymer scientists from any country under the age of 40." Since 2008, two other prizes, the Polymer International Award "for creativity in applied polymer science or polymer technology for a scientist

Above, Division President, Greg Russell, opens MACRO-2016 in Istanbul. At right, Past-president Michael Buback presents the inaugural Robert Stepto Memorial Lecture.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
No. of conferences	11	10	10	11	9	9	7	11	8	13	8
No. of volumes of *Macromol. Symp.**	8	9	4	4	6	4	3	3	6	3	4
No. of pages in *Macromol Symp.*	1743	2903	1648	1170	1821	1233	459	566	1580	390	426

Table 2: **Fully peer reviewed manuscripts of the conferences are published in* Macromol. Symp., *while a few selected manuscripts may be published in* Pure Appl. Chem.

under the age of 40," and the DSM Performance Materials Award (that in 2014 was re-named the DSM Materials Science Award) "bestowed in recognition of outstanding scientific work of an established scientist who has significantly contributed to the advancement of the materials science field " have also been awarded at MACRO conferences. In addition, in 2016 one of the plenary lectures was named "Robert Stepto Memorial Lecture" with the intention that it should be so called in perpetuity as a mark of the enormous contribution to the Division from its former president, Bob Stepto.

There have been two important IUPAC Strategic Conferences on the Mission and Challenges of Polymer Science and Technology held in Kyoto, Japan in 2002, and in New York in 2005.

The full extent of Division IV's involvement in conference organization, however, is best illustrated by the following list of our IUPAC endorsements covering three years of events from 2010 to 2012:

2010

- 18th International Conference on Polymer Characterization; World Forum on Advanced Materials, Siegen, Germany, April 2010
- 74th Prague Meeting on Macromolecules. Contemporary Ways to Tailor-Made Polymers, Modern Methods of Polymer Synthesis, Prague, Czech Republic, July 2010
- 8th International Conference on Polymer-Solvent Complexes and Intercalates Prof. Jean-Michel Guenet, Université de Strasbourg, Strasbourg, France, July 2010
- 43rd International Symposium on Macromolecules—IUPAC World Polymer Congress (Macro 2010), Glasgow, UK, July 2010
- MAM-10, 5th International Symposium on Macro-and Supramolecular Architectures and Materials: New Science and Technologies for the Improvement of Human Living Standards, Montego Bay, Jamaica, August 2010
- 4th International Conference on Polymer Behaviour, Łodz, Poland, September 2010
- 6th Symposium on Novel Materials and their Synthesis, Wuhan, China, October 2010
- 8th Hellenic Society Symposium on Polymer Science and Technology, Hersonissos, Greece, October 2010

2011

- 32nd Australian Polymer Symposium, Coffs Harbour, Australia, February 2011
- 19th International Conference on Polymer Characterization: World Forum on Advanced Materials, Katmandu, Nepal, March 2011
- International Symposium on Materials Education, Pune, India, March 2011
- 11th UNESCO/IUPAC Workshop and Conference on Functional Polymeric Materials and Composites, Stellenbosch, South Africa, April 2011
- 2nd Federation of Asian Polymer Societies Congress, Beijing, China, May 2011
- 11th Conference on Frontiers of Polymers and Advanced Materials, Pretoria, South Africa, May 2011
- 7th International Symposium on Molecular Mobility and Order in Polymer Systems, Saint Petersburg, Russia, June 2011
- European Polymer Congress, Granada, Spain, June 2011

Geographical distributions of endorsed conferences; see text for full listings of year 2010 to 2012.

- 75th Prague Meeting on Macromolecules: Conducting Polymers, Prague, Czech Republic, June 2011
- International Symposium on Ionic Polymerization, Akron, USA, July 2011
- 14th International Symposium on Macromolecular Complexes, Helsinki, Suomi, August 2011
- 9th International Conference on Advanced Polymers via Macromolecular Engineering, Cappadocia, Turkey, September 2011
- 7th International Symposium on Novel Materials and their Synthesis, Shanghai, China, October 2011

2012

- 14th International IUPAC Conference on Polymers and Organic Chemistry, Doha, Qatar, January 2012
- 20th International Conference on Polymer Characterization - World Forum on Advanced Materials, Dubrovnik, Croatia, March 2012
- Kathmandu Symposium on Advanced Materials, Kathmandu, Nepal, May 2012
- 44th International Symposium on Macromolecules—IUPAC World Polymer Congress , Blacksburg, Virginia, USA, June 2012
- 76th Prague Meeting on Macromolecules: Polymers in Medicine, Prague, Czech Republic, July 2012
- 9th International Conference on Polymer-Solvent Complexes and Intercalates (PolySolvat 9), Kiev, Ukraine, September 2012
- 4th Federation of Asian Polymer Societies – International Polymer Congress, Kuala Lumpur, Malaysia, October 2012
- 8th International Conference on Novel Materials and their Synthesis, Xian, China , October 2012

Although they do not embrace the same periods, Table 2 on page 31 representing the written output from our endorsed conferences and the ensuing selected statistics of geographical locations depicted in a series of pie charts gives an even fuller picture of the extent of the underlying effort in this area of the divisional activities.

Conclusion

Besides the publication of IUPAC documents such as "technical reports" or "recommendations" in terminology and nomenclature, endorsement, acknowledgement as a high-standard event, and sponsorship of selected high-quality conferences and tutorials, is a way to shine light on the important contribution of the work of the IUPAC Polymer Division during the now 50 years of its existence. Many of these meetings—in particular the MACRO World Polymer Congress—have become known as standard meetings, as a "must" for polymer scientists. Some of the conferences have initiated prestigious awards, such as the DSM-Award (MACRO) or the Paul J. Flory Research Prize (POLYCHAR), awards honoring the work of distinguished, well-established scientists and, in particular, distinguished awards designated for students and young scientists. These activities of the IUPAC Polymer Division help to spread the results of research and technology within the polymer community and thereby make it popular through strongly visible events—MACRO usually counts more than one thousand participants. In addition, such activities also support students and young scientists by providing platforms from which to present their work in public, including lively face-to-face discussions, the opportunity to meet other scientists, and to be awarded for outstanding work; all of which are helpful for their career.

Acknowledgements

The author expresses his thanks to Aubrey Jenkins and Pavel Kratochvil for providing important information about the early days of Division IV and its predecessor.

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MACRO 2016, Istanbul: An IUPAC Morality Tale

by Gregory T. Russell

My favorite statistic concerning risk is that one 60-year-old out of a million will die every twenty minutes [1]. If I am not mistaken, this equates to 26 300 deaths per million per annum—just from living.

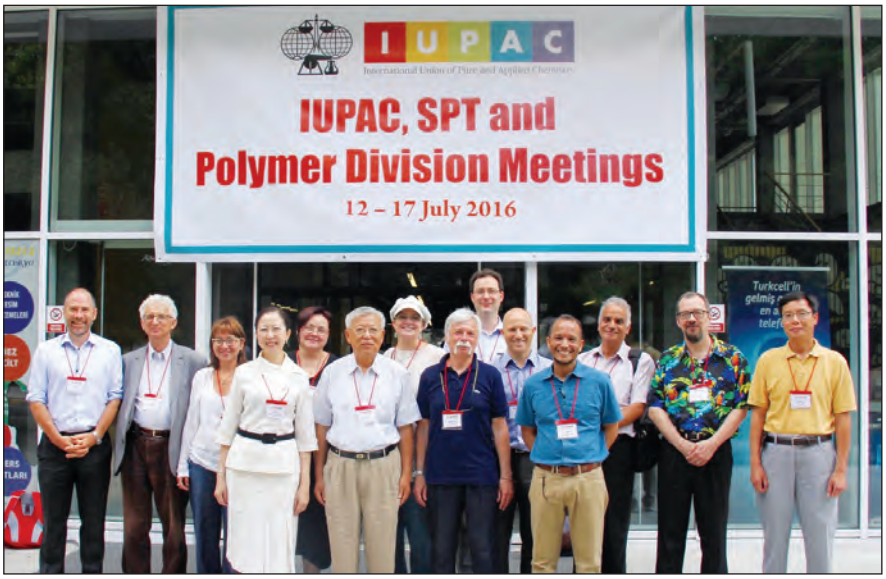
Which brings me to the photograph below. I would like to offer some reflections inspired by it. It shows a group of people meeting on the campus of Istanbul Technical University. The group is the Subcommittee on Polymer Terminology, most of whom stayed on for an IUPAC Polymer Division meeting a few days later. We were all there because in the following week—to be precise, 17-21 July 2016—the 46th World Polymer Congress (WPC) was to take place in Istanbul. Also known as MACRO meetings, WPCs are biennial and are the flagship events of the IUPAC Polymer Division, one might say the Olympic Games of polymer chemistry.

The record attendance at a WPC is 2400 in Paris in 2004. When Istanbul was awarded the 2016 WPC, it was expected that this record would be challenged, such are the attractions, location, and affordability of this great city. In the end the attendance was 470, close to an order of magnitude below expectation. Furthermore, over half of these people were from the host country. What happened? It certainly was not down to the conference chair, Yusuf Yagci, who has charisma to burn, is an extremely well-known, and well-credentialed polymer chemist; he worked indefatigably to make the conference succeed. Nor was it down to the conference organizing company, for Cem Tunçel and his Brosgroup showed themselves to be extremely competent at their job. What happened was that terrorism and political intrigue intervened.

Starting in January 2016, there were several bombings in Istanbul, two of which were terrorist attacks [2,3] designed to scare the western world, and one of which was an attack on Turkish police motivated by the Kurdish situation [4]. In total 17 foreigners were killed in these attacks [2,3]. Undeniably this is appalling. Nevertheless, 11.27 million people visited Istanbul in 2014, and this was projected to rise to 12.56 in 2015 [5]. So even in a really bad period, the level of risk from terrorist bombings in Istanbul is approximately 1.5 deaths per million per annum.

Yet with every 2016 attack, emails to Yusuf and me would flood in. Americans showed no awareness that the numbers in Istanbul paled beside 30 000 gun-related deaths per year in the USA. This is approximately 100 deaths per million per annum. Just from being in the USA. People from everywhere showed no knowledge that even the very safest countries in the world—Sweden and Switzerland, of course—have 30 deaths per million people per annum on their roads [6]. In the USA, this number is 106, much the same as the risk from guns. In Turkey it is 89, which equates to 1320 road deaths per annum for Istanbul's population. In other words, the roads in Istanbul are a far greater risk than the terrorists.

One of my favorite emails was from a person saying that terrorists would surely target the World Polymer Congress, as such an attack would make a huge statement on the world stage. This made me wonder whether Lionel Messi and FC Barcelona had been signed up as delegates without me knowing. Another person



12 July 2016 in Istanbul: (l to r) Roger Hiorns (France), Stan Slomkowski (Poland), Paola Carbone (UK), Melissa Chan (Malaysia), Olga Philippova (Russia), Jiasong He (China), Natalie Stingelin (UK), Michael Hess (Germany), Patrick Theato (Germany), Paul Topham (UK), Cláudio dos Santos (Brazil), Ram Adhikari (Nepal), Chris Fellows (Australia) and Jiazhong Chen (USA) gather in the name of IUPAC.

wrote that as the father of two young children, it was not conscionable for him to go. I wondered whether I should show this email to my own young children. Most people wrote of the need to stand up to terrorism, even as they excused themselves from attending. As if all this was not enough, the Atatürk Airport attack occurred on 28 June 2016, under three weeks before the start of MACRO 2016, killing 45 people; interestingly, not a single one of the dead was from a western country [7]. Finally, a coup d'état attempt took place on 15 July 2016 [8], just two days before the start of the WPC. Comprehensively reported in the world media, these two banner events provided an excuse for anyone to stay away. But were they fatal to the conference? Truth be known, it was already in mortal trouble before the airport bombing, with registrations at only about 670. The damage had largely been done by the relatively inconsequential events; the grand happenings were just the icing on the cake.

In view of all of this, it was a miracle that the conference took place at all. That it did is because of IUPAC, which was already meeting before the coup attempt, as evidenced by the photo above. We advised on the morning after the coup that the WPC should proceed, because to cancel at the last minute would not change the financial situation and would punish those who had made every effort against the odds. Also, it would make a positive statement.

So the WPC and the remaining IUPAC meetings went ahead, and they were as successful as they could have been under the circumstances. There was no sense of danger, which is not a surprise given that we had dined through the coup attempt on a beautiful Istanbul evening, we could see a traffi jam on a bridge below us, and we experienced this traffi on our bus trip home—it was cars being held up by soldiers—but we were oblivious to its cause. When we got back to our hotels and we learned of the coup attempt, we watched CNN. If a jet fl w overhead, we listened as reporters declared that bombs were being dropped, which was a blatant lie. I now have a keener understanding of sensationalism and what the media does to gain traction.

What is the point of this tale? I think it is as follows. I am a human being, and am prey to human forces. One of the reasons I am a scientist is so that I can hold the darker of these forces in check. I want to understand risk, so that I can use it to inform my actions. I want to be able to distinguish between hysteria and reality. I want to see my place in the world and I don't want to overrate my importance. I want to contribute to a cause that genuinely promotes the betterment of mankind, and I want to stand up to forces that seek to undermine this good. Unexpectedly, the World Polymer Congress and IUPAC Polymer Division meetings of mid-July 2016 presented my IUPAC colleagues and myself with an opportunity to test ourselves in these regards. Pleasingly, by and large we stood firm. We even smiled for the photo. It was easy, because it's what we felt. I cannot conceive of a better advertisement for the IUPAC spirit, which is alive and flourishing in the Polymer Division, 50 years after its founding.

July 2016 also marked the centenary of the Battle of the Somme. 18 000 members of the New Zealand Division were involved in it. More than one in nine were killed, and one in three were injured [9]. That rather puts it all in perspective.

Acknowledgements

I dedicate this article to the many Polymer Division troops who fronted up in Istanbul. In particular I pay tribute to Yusuf Yagci, who could not have worked harder to achieve success for MACRO 2016 and IUPAC in the face of insurmountable odds.

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Greg Russell is at the University of Canterbury, New Zealand. He is the current President of the IUPAC Polymer Division. He missed his daughter's 12th birthday while he was in Istanbul in July 2016. She understood.

IUPAC Celebrates 100th Anniversary in 2019

IUPAC, the globally-recognized authority on chemical nomenclature and terminology, will celebrate its 100th anniversary on 28 July 2019. The anniversary theme is *A Common Language for Chemistry*, and while the celebration will recognize the successes of IUPAC's first one hundred years, its purpose is not to solely dwell upon the past. It will also look what this international community of chemists, working closely together, can contribute in meeting the world's needs, now and in the future, through chemical research.

"For almost a century IUPAC's mission has been to provide objective scientific expertise for the resolution of critical global issues that involve every aspect of chemistry, all of which have had societal impact," said IUPAC President, Natalia Tarasova. "In 2019, we will pause to celebrate our successes and give serious deliberation as to how IUPAC can best continue in the years ahead to serve as an advocate for the free exchange of scientific information for the benefit of humankind worldwide. While this celebration is just one moment in time, we hope that it will have a lasting impact through events that will advocate the value and importance of science literacy to students worldwide, inspire younger generations of men and women to become the innovative chemists of the 21st century and beyond, and have a positive influen e on the public's perception of science in general and chemistry in particular."

Preparations for the celebration have been initiated by the Centenary Planning Committee under the leadership of Professor Mary Garson and Dr. Laura McConnell. Professor Garson noted that "while the Committee has taken the lead in initiating special events, we strongly encourage IUPAC's National and Associate National Adhering Organizations, Associated Organizations, Company Associates, Affil tes, and friends – indeed, the worldwide chemistry community, to participate in this celebration, by becoming involved in events currently in development or by creating their own."

Garson also noted that the celebration will start in early 2018 with the monthly release of a series of stories highlighting the essential IUPAC tools and activities that were developed during the past century and continue to be used by scientists today. Other special events in development include a worldwide online competition for young students centered on the Periodic Table and IUPAC; a global breakfast for women chemists and students who will be "gathered together" in early 2019 via Skype, teleconference, and social media to celebrate the anniversary; a visualization of IUPAC's history and its major contributions; and a summer, inspired by the IUPAC Centenary, for young graduate and post-graduate students from all over the world—in particular from Africa—with a focus on teaching Green Chemistry and its role in sustainable development. The anniversary will also be highlighted during the 47th World Chemistry Congress scheduled to take place 7-12 July 2019 at the Palais des congrès in Paris, France.

For more information on the IUPAC Centenary and the 47th World Chemistry Congress see: www.iupac.org/iupac100 and www.iupac2019.org. For information on how you or your organization can become involved in a particular event, develop your own, or take advantage of sponsorship opportunities that will be announced shortly, contact the IUPAC Secretariat and be sure to visit the IUPAC web site in the coming months for updates.

E-mail iupac100@iupac.org for more information.
Join the conversation on social media using the hashtag #IUPAC100

The Periodic Table at the University of Murcia

The Periodic Table is the most representative icon of chemistry, because it contains all the chemical elements currently known, which constitute the true bricks of the universe. In 1869 the Russian chemist Dimitri Mendeleyev published his first periodic table, placing in order the 63 elements known at the time. On 28 November 2016 IUPAC announced the official names and the symbols of four elements, defining the current Periodic Table with 118 elements.

All the matter that surrounds us consists of the atoms contained in the Periodic Table, and their combinations. These combinations are the molecules that, which as a result of the enormous variety of chemical

transformations, have made possible, among other things, life on this planet.

From its origin, chemistry as a science has been the engine that has allowed humanity to advance, contributing to the continuous improvement to quality of life and life expectancy. The negative perception that society has towards chemistry is fully unjustified. One must remember that at the beginning of the Twentieth Century, the world population was 1.2 billion people and had a life expectancy of approximately 40 years, while today an estimated population of more than 7.4 billion inhabitants have a life expectancy higher than 80 years old in developed countries. Chemistry has provided pharmaceutical drugs to cure diseases, safer and more nutritious foods, clean drinking water, fertilizers and insecticides to improve agricultural productions, fuels, hygiene and beauty products, and many other things. Our quality of life depends entirely and positively on chemistry, and chemistry is called to continue to play a leading role towards solving the great challenges of humanity by providing appropriate solutions based on sustainability criteria in the near future.

In 1940, when the regional economy of Murcia was based almost exclusively on an archaic primary sector of small family farms, Prof. José Loustau y Gómez de la Membrillera, the fir t dean of the Faculty of Sciences, consolidated the implantation of the Degree in Chemistry at the University of Murcia. The school thus became a unique scientific studies program at the university level in the south-east of Spain. This helped the birth and consolidation of many agro-food industries, in particular canning industries, (devoted to the processing the excellent fruit and vegetables *e.g.* Hero, Crown Food, *etc.),* of the Region of Murcia. The Faculty of Chemistry provided the necessary knowledge and expertise. In the same way, in the 1960s, REPSOL implemented its fir t oil refinery in Cartagena (Mu cia) where the graduates in chemistry of the University of Murcia were incorporated. This refinery has continuously grown to become the fir t Spanish refiner , and one of the most important at the European level. It also consolidated an important chemical sector in its surroundings (*e.g.* SABIC), where companies now employ hundreds of graduates.

Since 1940, the Faculty of Chemistry at the University of Murcia has graduated more than 4000 students in all fields of chemistry, chemical engineering, physics, and biochemistry, as well as 500 Ph.Ds. In our classrooms and laboratories, we have trained the excellent professionals who lead or have lead the staff of a large number of industries in our region. These include all sectors, such as food, energy, cosmetics, chemical-pharmaceutical, and more. All these factors contributed to the Government of the Region of

Murcia awarding the Gold Medal of the Region of Murcia to the Faculty of Chemistry at the University of Murcia in 2015. This award, which is the highest distinction of the region, coincided with the 75th anniversary of the fir t graduation of chemists, as a "recognition of the social and economic importance of its training and its role as a reference in the formation of human and scientific capital of the region, as well as for its scientific productivity and contribution to the increase of excellence research at the University of Murcia", as stated in Decree 77/2015, BORM on 15 May 2015. It was the fir t time that the Government recognized and awarded a university centre. Without any doubt, the chemistry and chemical developments in the Murcian industries have decisively contributed to the economic development and the standard of living of Murcia.

In this context, and promoted by the Faculty, this year a consortium of twelve of the most important companies from Murcia, (including AMC Juices Ltd, Tecnological Centre of Marble, Crown Food Spain Ltd S.A., Grupo Fuertes Ltd., Hero Spain Ltd.; Estrella de Levante Ltd; Hidrogea Ltd.; Linasa Ltd., J.J. Albarracin Ltd., Marín Giménez Ltd, REPSOL Ltd. and TAHE Cosmetic Ltd.), also wanted to pay tribute to the Faculty of Chemistry for the important role played in the development of the industrial sector of Murcia. The construction of the giant periodic table has been the aim, made possible by the particular design of the building of the Faculty of Chemistry where the façade is formed by glass windows and walls arranged in bevel. Eduardo Batan, architect of the University of Murcia, provided the technical feasibility. Each of the 118 chemical elements is included on a coloured metal panel (0.75 x 0.75 m), and represented by its symbol, atomic number, and atomic mass. These panels are screwed onto screens located directly on the facade of the Faculty. The surface of this giant periodic table is approximately 150 m^2, likely the largest permanent Periodic Table in the world. This large size allows all the elements to be seen when walking around the perimeter of the University of Murcia campus or even from the tramway.

The artistic ensemble will be finali ed with a 50-seat grandstand. Every year, the Faculty meets students from many high-schools as prospective students in the chemistry program. Usually, we prepare a complete journey for the young students, including a tour of the Faculty, a simple experiment conducted in the lab, and now a seminar about the periodic table using this grandstand as an open-air classroom for their "fir t lesson" at the university.

The periodic table built on the facade of the Faculty of Chemistry at the University of Murcia converges past and future, work and perseverance, training and economic development, science and beauty. This facade is a new icon for chemistry and the city of Murcia, and we encourage all chemists to visit Murcia.

In the Faculty of Chemistry at the University of Murcia, we are extremely proud of the work we have done in these 77 years, and sincerely grateful to the Region of Murcia and its industries for this recognition, which supports us for the important pages of the future that we must write together.

Written and shared by Prof. Pedro Lozano, e-mail: plozanor@um.es, Dean of the Faculty of Chemistry of the University of Murcia. www.um.es/web/quimica/

IUPAC Standards Online

IUPAC and its publishing partner, De Gruyter, are pleased to announce that subscribers to *Pure and Applied Chemistry* (PAC) can purchase the IUPAC Standards Online database at a special discount of 70 % off the list price. This offer is guaranteed until 31 December 2017.

This database is the only digital compilation of IUPAC's internationally-binding standards and recommendations for chemistry and related disciplines. Extracted from the print edition of *PAC*, these standards and recommendations are used worldwide by scientists in industry and academia, patent lawyers, and others who need access to authoritative information on chemical nomenclature, symbols, terminology, and similar scientific onventions.

Why subscribe to the database when you already have a subscription to *PAC*?

Because rather than searching for hours through *PAC* archives, you can use the database to retrieve the specific information you need quickly and easily in a matter of minutes. Updated annually, the database provides granular access to content, while a variety of search options, sorting criteria, and refi ing fil ers streamline the search and retrieval process. New features for 2017 include an interactive Periodic Table that lets you go directly to the entry of each element, and fact sheets on specific compounds. The database now also uses InChI codes and InChI keys, making it even easier to find specific substances.

To sign-up for a no obligation 30-day free trial, visit De Gruyter website at: www.degruyter.com/dg/page/1455/test-the-database or www.iupac.org/iupac-standards-online/.

2018 IUPAC-Solvay International Award for Young Chemists

The 2018 IUPAC-SOLVAY International Award for Young Chemists is intended to encourage outstanding young research scientists at the beginning of their careers. The awards are given for the most outstanding Ph.D. theses in the general area of the chemical sciences, as described in a 1000-word essay. The award is generously sponsored by Solvay.

IUPAC will award up to fi e prizes in 2018. Each prize will consist of USD 1000 cash and travel expenses to the 2019 IUPAC Congress in Paris (July 2019; see www.iupac2019.org). In keeping with IUPAC's status as a global organization, efforts will be made to assure fair geographic distribution of prizes.

The awards will be presented at the 2019 IUPAC Congress. Each awardee will be invited to present a poster on his/her research and to participate in a plenary award session, and is expected to submit a review article for possible publication in *Pure and Applied Chemistry*.

Entrants must have received the Ph.D. (or equivalent) degree, or completed all Ph.D. requirements including successful defense of the doctoral thesis, during calendar year 2017 in any of the countries that are members or associate members of IUPAC. Entrants need not be citizens or residents of one of these countries at the time the application is submitted.

The research described in the entrant's thesis must be in the field of the chemical sciences, defined as "chemistry and those disciplines and technologies that make significant use of chemistry." Complete applications must be received at the IUPAC Secretariat by **1 February 2018.**

See IUPAC.org for more details and access to submission form.

Thieme–IUPAC Prize 2018—Call for Nominations

Thieme Chemistry, IUPAC, and the Editors of SYNTHESIS, SYNLETT, SYNFACTS, and Science of Synthesis announce the Thieme–IUPAC Prize for 2018.

This award is presented every two years on the occasion of the IUPAC International Conference on Organic Synthesis (ICOS). In 2018, ICOS will be in Florence, Italy, 16-21 September.

The prize is awarded to a scientist who must be under 40 years of age as of 1 January of the year in which the prize is awarded. The candidate's research must have had a major impact in synthetic organic chemistry. The prize will be awarded on the basis of scientific merit for independent research dealing with synthesis in the broadest context of organic chemistry, including organometallic chemistry, medicinal and biological chemistry, designed molecules, and materials. The deadline for nominations is **9 December 2017.** Nomination materials should be submitted by e-mail to marcus.white@thieme.de.

For more details see www.thieme.de.

2018 IUPAC-Richter Prize—Call for Nominations

IUPAC and Gedeon Richter, Plc. are pleased to announce the 2018 IUPAC-Richter Prize in Medicinal Chemistry. The prize was established in 2006 by a generous gift from the Chemical Works of Gedeon Richter, Plc. (Budapest, Hungary) to acknowledge the key role that medicinal chemistry plays toward improving human health. The prize—USD 10 000—is to be awarded to an internationally recognized scientist, preferably a medicinal chemist, whose activities or published accounts have made an outstanding contribution to the practice of medicinal chemistry or to an outstanding example of new drug discovery.

Previous IUPAC-Richter Prizes were awarded to Malcolm F.G. Stevens in 2006, Jan Heeres in 2008, Arun K. Ghosh in 2010, Stephen Hanessian in 2012, Helmut Buschmann in 2014, and Michael J Sofia in 2 16.

The 2018 IUPAC-Richter Prize will be presented during the 36th National Medicinal Chemistry Symposium (29 April—2 May 2018) on Medicinal Chemistry in Nashville, Tennessee (USA), where the recipient will also give a plenary lecture on the subject of his/her research.

Applicants should be received by nomination only, with just one person needing to serve in that capacity, although a total of fi e individuals should be listed as referees overall.

See IUPAC.org for more details and access to submission form. Nomination materials should be submitted by **15 December 2017.** For further information please contact Professor Janos Fischer, Chair of the IUPAC Subcommittee on Drug Discovery and Drug Development, j.fischer@rich er.hu.

2018 IUPAC International Award for Advances in Harmonized Approaches to Crop Protection Chemistry—Call for Nominations

The IUPAC International Award for Advances in Harmonized Approaches to Crop Protection Chemistry recognizes individuals in government, intergovernmental organizations, industry, and academia who have exercised personal leadership for outstanding contributions to international harmonization for the regulation of crop protection chemistry.

The award is administered by the IUPAC Advisory Committee on Crop Protection Chemistry, and is presented on a biennial basis during even-numbered years in conjunction with an IUPAC-endorsed conference or special symposium. Awardees receive an honorarium plus travel and per diem reimbursement to attend the award presentation ceremony. Corporate sponsorship for the award has been arranged with Dow AgroSciences.

Nominations for the 2018 award are due **1 December 2017**, and should be emailed to Dr. John Unsworth at unsworjo@aol.com.

Nominations must consist of: A nomination letter including a description (200-1000 words) of the reasons why the nominee should receive this award, stressing the individual's major accomplishments toward international harmonization for the regulation of crop protection chemistry; A curriculum vitae of the candidate that includes places and names of employment, professional affil tions, committee and working group assignments, and listing of relevant regulatory guidance documents, reports, and/or publications; and one or more letters of support.

Polymer International–IUPAC Award—2018 Call for Nominations

The Executive Editorial Board of *Polymer International* and the IUPAC Polymer Division are pleased to announce the 6th award for creativity in applied polymer science or polymer technology. This award celebrates the achievements of young researchers in the polymer community.

The award will be presented at IUPAC World Polymer Congress – MACRO 2018, 1-5 July 2018 in Cairns, Australia. The winner will be awarded USD 5000 plus travel and hotel accommodation expenses to attend MACRO 2018, where they will present an award lecture. The winner will be selected by the Scientific Committee, representing *Polymer International* and the IUPAC Polymer Division.

Nominees must be under age 40 on 31 December 2017, and must be available to present an award lecture at MACRO 2018.

For more details, including requirements, see http://news.wiley.com/R8248. Please send your nominations by email to *Polymer International*: polyint@wiley.com before 30 October 2017.

2018 ChemRAWN VII Prize for Green Chemistry—Call for Nominations

IUPAC is seeking nominations for the 2018 CHEMRAWN VII Prize for Green Chemistry. The CHEMRAWN VII Prize was first announced in August 2008 and since, has been awarded every two years at the IUPAC International Conference on Green Chemistry. The Prize of USD 5000 is granted to a young investigator (less than 45 years of age) from an emerging region who is actively contributing to research in Green Chemistry. The Prize has been awarded to Noureddine Yassaa (Algeria) in 2010, Rashimi Sanghi (India) in 2012, Vania G. Zuin (Brazil) in 2014, and Ali Maleki (Iran) in 2016.

Nominations for the 2018 Prize must be submitted by **31 March 2018**. Each nomination should include a CV and two letters of support, plus a brief summary of accomplishments illustrating the contributions of the applicant to research in Green Chemistry. Examples of research topics that are covered by the prize include:

- Atmospheric Chemistry
- Use of Alternative Feedstocks
- Use of Innocuous Reagents
- Employing Natural Processes
- Use of Alternative Solvents
- Design of Safer Chemicals
- Developing Alternative Reaction Conditions
- Minimizing Energy Consumption

The Award will be presented at the 8th IUPAC International Conference on Green Chemistry, 9-14 September 2018, Bangkok, Thailand, where the winner will be asked to give a lecture.

See IUPAC.org for more details.

Actions Taken at IUPAC Council and Bureau, São Paulo, Brazil 2017

The IUPAC Council met in São Paulo, Brazil 12-13 July, and the Bureau met on 11-14 July 2017. The following actions were taken:

1. Election of the Officers

On 1 January 2018, Qi-Feng Zhou (China), Vice President and President-Elect of IUPAC, will become President. Natalia Tarasova (Russia), current President, will become Past President and remain an officer and a member of the Bureau for a period of two years. Meanwhile, Marc Cesa (USA), current Past President, will retire. Secretary General Richard Hartshorn (New Zealand) and Treasurer Colin Humphris (UK) were both elected by the Council in August 2015 for a four-year term and will continue their service for two more years.

Vice President and President Elect

The candidates for Vice President were Professor Christopher M.A. Brett (Portugal) and Professor Javier García Martinez (Spain). Christopher M.A. Brett was elected.

2. Election of Members of the Bureau

The following were elected to the Bureau:

- Russell J. Boyd (Canada) (2014-2017); *reappoint*
- Javier García-Martínez (Spain)
- Mary Garson (Australia)
- Christopher K. Ober (USA) (2014-2017); *reappoint*
- Ken Sakai (Japan)

The following are Members whose terms continue to the end of 2019:

- Mei-Hung Chiu (China/Taipei)
- Hemda Garelick (UK)
- Ehud Keinan (Israel)
- Kew-Ho Lee (Korea)
- Pietro Tundo (Italy)

3. The Bureau elected the following members to the Executive Committee:

- Mei-Hung Chiu (China/Taipei); continue
- Javier García-Martínez (Spain)
- Christopher K. Ober (USA)

4. The appointments of the Division Officers were approved. See below for details.

5. Council authorized the IUPAC Executive Committee to review documents on the proposed ICSU-ISSC merger and to vote accordingly on the merger at the 2017 ICSU General Assembly.

6. Council approved the Czech Chemical Society as successor to the Czech Committee for Chemistry as National Adhering Organization.

7. Council formally adopted the Recommendations approved by the Interdivisional Committee on Terminology, Nomenclature and Symbols (ICTNS) and published in *Pure and Applied Chemistry* from August 2015 through June 2017.

The appointments of the Division Officers

Division I – Physical and Biophysical Chemistry
President: Ron Weir (Canada)
Vice President: Timothy Wallington (USA)
Secretary: Attila Csaszar (Hungary)

Division II – Inorganic Chemistry
DP: Lars R. Ohrström (Sweden)
DVP: Javier García-Martínez (Spain)
DS: Markku Leskelä* (Finland)

Division III – Organic and Biomolecular Chemistry
DP: Francesco Nicotra (Italy)
DVP: Nikolay Nifantiev (Russia)
DS: Amelia Rauter* (Portugal)

Division IV – Polymer
DP: Gregory Russell* (New Zealand)
DVP: Christine Luscombe* (USA)
DS: Michael Walter* (USA)

Division V – Analytical Chemistry
DP: Zoltan Mester (Canada)
DVP: Erico Flores (Brazil)
DS: Takae Takeuchi (Japan)

Division VI – Chemistry and the Environment
DP: Rai Kookana (Australia)
DVP: Hemda Garelick (UK)
DS: Roberto Terzano (Italy)

Division VII – Chemistry and Human Health
DP: Rita Cornelis (Belgium)
DVP: Helle Johannessen (Denmark)
DS: Valdimir Gubala (UK)

Division VIII – Chemical Nomenclature and Structure Representation
DP: Alan Hutton (South Africa)
DS: Risto Laitinen* (Finland)

*officer continuing his/her service

Professor Adriano Andricopulo, chair of the IUPAC2017 Congress with IUPAC Executive Director Lynn Soby in the Gloden Hall.

8. Council ratified the decision of Bureau for the names and symbols of the four new elements, Z = 113, Z = 115, Z = 117, and Z = 118.

9. Council voted for the site and dates of the 48th World Chemistry Congress and 51st General Assembly-2021. Montréal, Canada received the majority votes and will host the 51st General Assembly and 48th World Chemistry Congress, 13-20 August 2021.

10. Council voted for the site and dates of 49th World Chemistry Congress and 52nd General Assembly-2023. The Hague, Netherlands received the majority votes will host the 49th World Chemistry Congress and 52nd General Assembly, 20-25 August 2023.

11. Council approved the appointment of Batchelor, Tillery and Roberts, LLP, of Raleigh, North Carolina USA as IUPAC Auditors for 2017 and 2018, and Council approved the process for a change of auditors for fi - cal year 2019 onwards.

12. Council approved the proposal for the reassessment of the Company Associates program.

13. Council approved the proposal for the revision of subscriptions and benefits of the Affil te Members Program.

14. Council approved the proposed budget for 2018-2019 and approved the proposal to proceed with the creation of the endowment fund.

15. Council supported the continuation of National Subscription task force to verify all data and to recommend a new approach by July 2018 for implementation for 2019 onwards superseding those agreed in the agreed in the 2019 Budget.

16. Council approved the proposal to invoice using USD in the future.

17. Council approved designation of the International Younger Chemists Network as an Associated Organization of the Union.

18. Council approved the proposed Terms of Reference for the Evaluation Committee.

19. Council ratified the Executive Committee's decision to establish the Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD) and approved the proposed Terms of Reference of the Committee.

20. Council approved the proposed changes and additions to the Statutes and Bylaws.

21. Council reauthorized the Commission on Physicochemical Symbols, Terminology and Units (I.1), the Commission on Isotopic Abundances and Atomic Weights (II.1), and the IUBMB- IUPAC Joint Commission on Biochemical Nomenclature (JCBN).

22. Council approved English as the one language in which the officia records of the meeting of the Council, Bureau and Executive Committee shall be kept and published for the period of 2018-2021.

IYCN and IUPAC Work Together

IYCN, the International Younger Chemists Network is now an Associated Organization of the Union. The relationship is more than a formality and both organizations are committed to partner together; while IYCN seeks to growas a global network helping to advance the voice and concerns of younger chemists worldwide, IUPAC wishes to facilitate the participation of younger chemists in IUPAC through the active integration of IYCN members into IUPAC activities. This includes programs such as conferences, committee activities, divisions, and projects.

At the General Assembly in São Paulo, IYCN and IUPAC signed a Memorandum of Understanding (MoU), which outlines the following commitments:

IUPAC commits to:

1. Accept IYCN as an Associated Organization (AO) of IUPAC.
2. Waive Associated Organization (AO) fees for IYCN for five years.
3. Cooperate and coordinate with IYCN to promote IYCN-sponsored programming and activities at the World Chemistry Congress and other relevant conferences.
4. Provide limited administrative support via the Secretariat, (i.e. receiving funds on behalf of IYCN and reimburse costs from those funds).
5. Cooperate with IYCN to support growth of their organization and to improve outreach to younger chemists.
6. Provide consultation, mentorship, and advice on governance, membership, and organizational issues to facilitate a successful launch for IYCN.
7. Develop new programs to more rapidly and seamlessly integrate younger chemists into IUPAC activities.

IYCN commits to:

8. Participate in IUPAC as an AO.
9. Provide the IUPAC Secretariat with a current contact list for the IYCN Executive Board.
10. Develop IYCN programming in cooperation with IUPAC for the IUPAC World Chemistry Congresses.
11. Promote participation in IUPAC activities, conferences, and projects with IYCN members, including, but not limited to: IUPAC World Chemistry Congress, IUPAC General Assembly, and World Chemistry Leadership Meeting.
12. Cooperate with IUPAC on improving programs for younger chemists (such as the Young Observer program).
13. Coordinate development of new IUPAC projects; encourage IYCN members to join the IUPAC Affiliate Membership Program, especially if they are from a country that is not an IUPAC member.
14. Serve as a voice for younger chemists within IUPAC.
15. Openly communicate and work with IUPAC to provide support to young chemists and develop a fully represented international network without discrimination.

This MoU is ultimately designed to benefit younger chemists worldwide through provision of increased resources and opportunities for professional development, networking, and open access to scientific information. It is designed to benefit IUPAC through the involvement of IYCN scientists in IUPAC activities and events.

The MoU was signed by Ilya Vorotyntsev, elected IYCN chair, and Natalia Tarasova, IUPAC President.

http://iycnglobal.wixsite.com/iycniycn

Top: Ilya Vorotyntsev, elected IYCN chair, and Natalia Tarasova, IUPAC President, at the signing of the MoU during the IUPAC General Assembly in São Paulo, in July 2017.

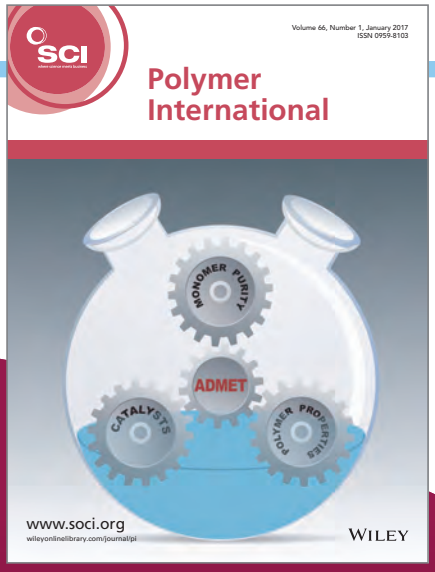
At right: Participants at the IYCN meeting during the 2017 IUPAC General Assembly

6th Polymer International–IUPAC Award for Creativity in Applied Polymer Science or Polymer Technology

Call for Nominations

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

Recognize the achievements of your colleagues by nominating them for this award. Your nominee could win $5,000!



The award will be presented at IUPAC World Polymer Congress – MACRO 2018, 1st July to 5th July 2018 in Cairns, Australia. The winner will be awarded $5,000 plus travel and hotel accommodation expenses to attend MACRO 2018, where he/she will present an award lecture. The winner will be selected by the Scientific Committee, representing Polymer International and the IUPAC Polymer Division.

Join our previous PI-IUPAC Award Winners:

2008: Zhenan Bao
2010: Molly Stevens
2012: Ali Khademhosseini
2014: William Dichtel
2016: Richard Hoogenboom

Nominees must be under age 40 on 31st December 2017, and must be available to present an award lecture at MACRO 2018.

For further details please go to: **wileyonlinelibrary.com/journal/pi** and click on 'PI-IUPAC Award'

Please include a current resumé for the nominee including the following information in your nomination:

- Your name and address
- Full name and date of birth of nominee
- Business address of nominee
- Nominee's academic background and education
- Nominee's employment history (position, organization, duties, dates)
- Nominee's publications, patents, unpublished reports, papers presented at meetings
- Nominee's honors and awards
- Scientific achievements for which the candidate is nominated for this award

*Self nominations will not be accepted

Please send your nominations by email to Polymer International: **polyint@wiley.com before 30th October 2017**.

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Boron Chemistry (IMEBORON XVI)

by Michael A. Beckett

The 16th International meeting on Boron chemistry (IMEBORON XVI), was held over the period 9-13 July 2017 on the beautiful campus of The Chinese University of Hong Kong (CUHK), Sha Tin, Hong Kong. This is close to the vibrant and cosmopolitan waterfront area and Hong Kong island. Previous meetings of this triennial conference have been held in various countries around the world, but this is the fir t time it has visited China. Topics addressed at IMEBORON XVI included organic and bioorganic boron chemistry, inorganic and cluster boron chemistry, boron in medicine, and materials. There were 222 registered participants who came from 19 different countries; the continents of Europe, North America, Asia and Australia were represented. The programme included 5 plenary lectures, 22 keynote lectures, 39 invited lectures, 51 contributed lectures and 61 poster presentations.

The conference started with a warm welcoming reception Sunday evening. The well-attended opening ceremony on Monday morning contained short presentations by the Dean of Science (Prof. H. N.-C. Wong, CUHK), the IUPAC Representative (Prof. M.A. Beckett) and the Conference Chair (Prof. Z. Xie). This was followed by the fir t plenary lecture by Prof J. Michl who spoke on "Highly halogenated icosahedral CB11 carborane anions and radicals." Keynote, invited and contributed lectures were then run in parallel sessions, and a special parallel BNCT session on the Monday afternoon was dedicated to the memory of Dr Y. Mishima. There was plenty of time allocated in the program for poster viewing and discussions on Monday evening. Further plenary lectures were delivered on the Tuesday morning (Prof. H. Braunschweig—Turning boron chemistry on its head: the unusual coordination chemistry of boron in low oxidation states, and Prof I. Manners—Catalytic, metal-mediated, and metal free routes to molecules and materials based on boron and other p-block elements) and Wednesday morning (Prof F. Teixidor—Boron clusters, not just one chemistry but also one opportunity) and the scientific part of the conference was concluded on Thursday lunchtime with the final plenary lecture by Prof. S. Wang who delivered a lecture on "Controlling molecular transformations of organoboron compounds." The plenary, keynote and invited lectures will be published in a special volume of *Pure and Applied Chemistry* in due course.

The social programme included the conference dinner which was an excellent Banquet held at ClubOne in Science Park on Wednesday evening and concluded after the final closing remarks. Guests were offered the options of a "City tour" or a "Culture and Heritage Tour" of Hong Kong island on the Thursday afternoon.

The conference concluded by closing remarks from the Conference Chair Prof Z. Xie and poster prize presentations. The poster prizes sponsored by *Dalton Transactions and Organometallics*, were presented to the six winners: Ruofei Cheng (Shanghai Institute of Organic Chemistry), Anangsha De (Indian Institute of Technology, Madras), Delong Han (University of Rostock), Hsiu-Chen Tsai (National Taiwan University), Florian Rauch (Julius-Maximilians-Universität Würzburg), and Junwei Wang (Beijing Institute of Technology) by Associate Editor of *Dalton Transactions*

Prof. G.-X. Jin and Associate Editor of *Organometallics* Prof. F. Gabbai.

The Local Organizing Committee, chaired by Prof. Z. Xie, was thanked and congratulated at the end of the conference on the wonderful job of producing a varied programme, comprising all aspects of boron chemistry and for a thoughtful social programme.

The next conference in this series will be held in Rennes, France, in early July 2020 with Prof. J.F. Halet and Prof G. Alcaraz (Nationale Supérieure de Chimie de Rennes, Université de Rennes) as Honorary Co-Chairs.

Ecological Risk Assessment

by John B. Unsworth and Elizabeth Carazo

As part of the ongoing IUPAC project "A Global Framework for Implementing Consistent Ecological Risk Assessment for Pesticides for Sustainable Agriculture" (project 2016-025-1-600) a sixth Workshop was held in San José, Costa Rica on 13-14 May 2017, in conjunction with the 6th Latin American Pesticide Residue Workshop. Previous Ecological Risk Assessment Workshops were held in Beijing, China; Bogota, Colombia; Santiago, Chile; Nairobi, Kenya; and New Delhi, India. Pesticides are a necessary tool in increasing global food production in order to feed the growing population, however, with their use comes the need to ensure that their ecological impact is kept to a minimum. Many countries include an ecological risk assessment in their registration requirements but as risk assessment is an evolving science it is important, particularly in scientifically emerging regions, that the best practices are understood and implemented properly. The current interest in ecological risk assessment is witnessed by the several different countries where Workshops have been held. As for previous Workshops the aim was, therefore, to present the current thinking on ecological risk assessment and to underline the pros and cons of various approaches. Presentations were made by 9 lecturers coming from industry, academia and government which covered:

- Principles of good regulation and regulatory risk assessment
- Protection goals and their implementation
- Principles of ecotoxicity testing and international test requirements
- Exposure assessments
- Risk characterization and uncertainties in risk estimation
- Risk perception, communication, and management
- Implementation and enforcement of risk mitigation measures
- Principles for developing regional exposure scenarios and integration of local conditions in risk assessment

At the end of the Workshop, a practical session allowed the participants to use for themselves a model entitled Tier 1 Tools for Ecological and Drinking Water Risk Assessment of Pesticides developed by CropLife International, the trade association for pesticide manufacturers. Simultaneous translation was provided by the University of Costa Rica and the Organizing Committee of the LAPRW 2017. The presentations were well-received by the 40 participants coming from 13 different countries: Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Ecuador, Germany, Mexico, Peru, Switzerland, and the United States. After each presentation and during breaks in the programme, participants were able to discuss all aspects of ecological

Professor Solomon from Canada giving the presentation on "Ecological Test Requirements"

risk assessment, including good modelling practices, scenario development, and local requirements. In addition, they were able to network with the experts present, and each participant received copies of the presentations. As with the previous workshops, the participants agreed that much useful information was given which enabled them to understand better the complexities of ecological risk assessment. Thanks are due to IUPAC, ACS-AGRO and CropLife International for supporting the Workshop.

For further information contact Task Group Chair J.B. Unsworth, <unsworjo@aol.com. > www.iupac.org/project/2016-025-1-600

IUPAC 2017 - World Chemistry Congress and IUPAC General Assembly

by Bipul Behari Saha

The 46th World Chemistry Congress (IUPAC 2017) was held in São Paulo, Brazil, 9-14 July 2017. The 49th General Assembly was also held in the same venue on 7-13 July. The program was organized by the Brazilian Chemical Society. More than 3500 delegates from 66 countries attended the Congress, the theme of which was "Sustainability & Diversity through Chemistry."

The joint opening ceremony of General Assembly and Congress was held in the Golden Hall on 9 July. The opening address was delivered by Prof. Adriano Andricopulo of Brazilian Chemical Society. It was followed by a musical program directed by Prof. Ramos, and then Prof. Aldo J. G. Zarbin declared the opening of IUPAC 2017. The IUPAC President's address was delivered by Prof. Natalia Tarasova. The 2016 and 2017 IUPAC–Solvay International Awards for Young Chemists were presented by Prof. Richard Hartshorn, Secretary General of IUPAC, and Prof. Natalia Tarasova. It was followed by the presentation of the "Distinguished Women Awards" by Dr. Carolyn Ribes and Prof. Angela Wilson.

Congress Scientific Programme

The World Congress had an excellent scientific programme, with symposia covering 12 major areas:

- Analytical and Food Chemistry
- Chemistry Education

Golden Hall or Multiverse?

Everyone who attended the Congress had something to say about their experience in attending or presenting a lecture in the Golden Hall. The Golden Hall is a multipurpose arena that was set with a central circular stage that can accommodate up to 8 speakers simultaneously while the surrounding audiences are not delineated in space and can fl w around simply by tuning in a specific audio channel on their individual headset. Raychelle Burks, a Young Observer from USA, tweeted about it several times and referred to it as the "multiverse"!

CI asked Angela Wilson to share her experience:

Angela Wilson: I found the presentation opportunity in the Golden Room to be empowering and convenient, while also being quite unusual. I moderated a panel in the room, and then had my talk in another technical section right after that. It was very simple to move from one to another in the same room.

An aspect that was empowering was the large audience. The opening ceremony was exciting in that venue, having an audience surrounding nearly all sides of the stage.

The room was also interesting in terms of the technical presentations. I enjoy challenges and competitions, so not knowing exactly who was listening to you, nor who may turn their channel to listen to your presentation from the nearby sections, was interesting and invigorating. I viewed this as an opportunity to show others who might not necessarily go to my talk about my work. In fact, there were a number of people who were in the sections next to where I was presenting talk to me about my work afterwards. These individuals were not theoretical/computational chemists, and they thanked me for introducing them to some areas of theoretical/computational chemistry—they said that some of my slides caught their attention, so they had switched channels to listen to my presentation.

What was somewhat off-putting, however, was that even with the headset on, I could hear the other speakers talking. Hearing my own voice through the headset during my talk was also a bit odd. So, it took a great deal more focus than in a typical room to give a talk and answer questions without getting distracted. As the talks did not start and end at the same time, when there was applause, the speakers at the sections near to that part of the room needed to

- Chemistry for Industry Innovation
- Chemical Synthesis
- Energy, Water and Environmental Sciences
- Analytical Chemistry and Environment
- Green Chemistry and Biotechnology
- Inorganic and Structural Chemistry
- Macromolecules and Materials
- Medicinal Chemistry and Chemical Biology
- Nanoscience and Technology
- Natural Products and Biodiversity

The programme featured keynote and invited lectures, oral presentations, and posters in each area.

Plenary lectures included three Nobel Laureates: Prof. Robert Huber, Prof. Ada E. Yonath, and Sir J. Fraser Stoddart. Six further plenary lectures were delivered by Prof. Katharina Landfester (Max Planck Institute for Polymer Research, Munich), Prof. Clare Grey (University of Cambridge, UK), Prof. Mei-Hung Chiu (National Taiwan Normal University, Taiwan), Prof. David MacMillan (Princeton University, USA), Prof. Frances Separovic (University of Melbourne, Australia), and Sir Tom Blundell (University of Cambridge, UK). In addition, there were over 36 keynote and invited Lectures and a large number of oral and poster presentations. Selected papers from the 46th World Congress will be published in an issue of *Pure and Applied Chemistry*, with Professors Adriano Andricopulo and Pedro Camargo as guest editors.

Several Special Symposia were also held during the Congress:

- **"Research Data, Big Data and Chemistry"**, organized by David Martinsen and Leah McEwen. In this symposium, importance of "Big Data" in chemistry was discussed in detail. The July 2017 issue of *Chemistry International* set the stage for the symposium and selected papers will be featured in *Pure and Applied Chemistry*.
- **"Women in Chemistry"**, organized by Carolyn Ribes and Vanderlan da S. Bolzani. In this program, winners of "Women Chemists Awards" shared their experiences with generations of chemists.
- **"Environmental Chemistry"**, a series of three symposia coordinated by the Chemistry and the Environment Division of IUPAC:
  - "E –waste – an emerging global environmental challenge"

pause— otherwise, it was difficult to hear the speakers.

From the perspective of an audience member, I enjoyed being able to see slides from three different presenters at one time. It was nice to be able to catch some slides from other fields, and have the opportunity to switch to what other nearby speakers were discussing. This provided me with a unique opportunity to catch my "usual" talks, while also having the opportunity to hear talks that I would not normally attend due to time conflicts.

I must admit, however, that the experience also felt surreal at times, with so many conversations on so many different technical "languages" all going on at one time (and, depending upon where you were seated, you could hear more than one topic!)—Defini ely a very different feeling!

Angela K. Wilson, wilson@chemistry.msu.edu, is John A. Hannah Distinguished Professor at the Department of Chemistry of Michigan State University. In IUPAC, she is President of the Physical and Biophysical Chemistry Division. At the Congress, she had an invited lecture entitled "Quantum Chemistry Strategies for Transition Metals and Beyond" and on the same afternoon was the moderator of a panel featuring Women in Chemistry.

The Golden Hall during parallel sessions; center stage is the Women in Chemistry panel, with three panelists seated and standing is the moderator, and on the far right stage is Angela Wilson during her invited lecture.

- "Fate of Pesticides in Latin American Environments"
- "Global Environmental Challenges of Nanomaterials"

- **"Young Researchers in Chemistry"**, a symposium organized by a group of talented young chemists representing IYCN

IUPAC General Assembly

The IUPAC General Assembly (GA) is the occasion for meetings of the statutory bodies of the Union, specifically of the Council, Bureau, Division Committees, and Standing Committees and was in São Paulo attended by about 300 members and national delegates. The Council is the primary IUPAC governing body to which the Bureau, Executive Committee, Standing Committees, Divisions, Commissions, and all other IUPAC bodies are responsible. Council is composed of delegations from the National Adhering Organizations (NAO) and each NAO appoints its delegates for every Council meeting. Regular meetings of the Council take place every two years as part of a General Assembly.

Council delegates (about 160 in attendance from 47 NAOs) moved smoothly through the numerous agenda items under the orderly guidance of Secretary General Richard Hartshorn and President Natalia Tarasova.

The Council elected members of the Bureau, as well as Prof. Chris Brett (Portugal) as the next Vice President. The Council also voted for the venue of the following sites for future Congresses: in 2021, the 48th World Chemistry Congress and 51st General Assembly will be held in Montréal, Canada, 13-20 August; in 2023, the 49th World Chemistry Congress and 52nd General Assembly will go to The Hague, Netherlands, 20-25 August.

The full text of the Council Agenda is accessible online at https://iupac.org/2017-iupac-general-assembly/ and the list of actions taken by the Council is reported p. 40.

During the General Assembly, all the Divisions and Standing Committees met and reviewed ongoing projects and discussed other matter pertaining to their section. Each presented at Council and written reports are available in the Council Agenda Book.

The 2017 Distinguished Women in Chemistry recognized in São Paulo (L to R): Vanderlan Bolzani (Women in Chemistry Special Symposium coordinator), Ingrid Montes, Misako Aida, Veronika Meyer, Yvonne Mascarenhas, Angela Wilson (Symposium co-chair), Zafra Lerman, Frances Separovic, Carolyn Ribes (Symposium co-chair), Concepcion Gimeno, Thisbe Lindhorst, Lifeng Chi, and on the far right, IUPAC President Natalia Tarasova. The gentleman in the back row is IUPAC Secretary General Richard Hartshorn. For background information about these awards, see iupac.org/iupac-2017-distinguished-women

World Chemistry Leadership Meeting (WCLM)

In the WCLM forum, members of the National Adhering Organizations (NAO) have an opportunity to come together and discuss emerging issues. This year, the theme of WCLM was "IUPAC's role in developing interdisciplinary/collaborative work in the chemistry community and beyond". The programming, led by Hemda Garelick and Chris Ober, was supported by the active participation of many IUPAC members, including Jan Apotheker, Valdimir Gubala and Pietro Tundo.

This year again, the WCLM activities were designed to engage with the Young Observers. In addition, the International Younger Chemists Network (IYCN) was also involved in bringing younger energy to many activities in IUPAC. The WCLM team will report separately.

IUPAC Centenary

In July 1919, chemists from France, Italy, Belgium, UK and USA met in Paris and founded IUPAC. There are plans to celebrate IUPAC centenary in 2019 and with this in mind, IUPAC100 Management Committee has been formed with Mary Garson and Laura McConnell as co-chairs. A number of events are being planned which includes periodic table competition, Green Chemistry Summer School, proposals from young chemists, IUPAC100 World Chemistry Leadership Meetings etc. The 2019 anniversary represents an opportunity to celebrate the role and contributions of chemistry within society, today and into the future, and is not solely a celebration of the IUPAC birthday. National events to celebrate IUPAC100 are encouraged. (see more p.35)

Closing Ceremony

After one week of hectic activities, IUPAC 46th World Chemistry Congress and 49th General Assembly came to an end on 14 July. It was a grand success due to hard work by the Brazilian Chemical Society and IUPAC Secretariat.

At the closing ceremony, Professor Nicole Moreau, former IUPAC President, invited the audience to gather in Paris for IUPAC 2019 and on the occasion of IUPAC Centenary.

Dr Bipul Behari Saha, <drbsaha@rediffmail.com> is an Indian delegate, member of the IUPAC Committee on Chemistry and Industry (COCI). He is Director of R&D at L R Research Laboratories, Nagarjuna Ageichem Limited, Hyderabad, India.

View the Photo Gallery at iupac2017.org

Up for Discussion

A forum for members and member organizations to share ideas and concerns.
Send your comments by e-mail to <edit.ci@iupac.org>.

From Young Observers to Young Actors: A Message to IUPAC from a few Young Observers

For many years, IUPAC has opened its doors to the younger chemists as observers to its activities, welcoming them in the midst of their General Assemblies. This is a unique opportunity for younger chemists to acquaint themselves with the work of the Divisions and Committees at an early stage and with limited commitment. In an article published in 2002, the *Young Observers* (YOs) program was characterized as "a way to seek innovative scientists" and "bring new expertise to IUPAC" [1]. Since 2013, the *World Chemistry Leadership Meeting* (WCLM) has invited all young observers to its symposium. In 2017, with a clever combination of "speed-networking" round tables, brainstorming and projects-crafting during the symposium, there is strong hope that a significant proportion of young observers will return as IUPAC active members during future meetings in Paris (2019) and Montréal (2021).

We were all very interested in participating in these activities, useful to newcomers, and we would like to thank IUPAC2017 organizing team as well as the symposia conveners for the excellent program that was put together to the mutual benefit of IUPAC members and younger chemists.

This being said, almost all division members we met expressed their concern about our generation not being involved enough with the Union. We often heard

that there should be many more Young Observers: a challenging goal, not only because of limited funding from national societies and sponsors but also by lack of interest amongst early-stage career chemists who, busy in establishing themselves as independent and successful scientists, do not see their involvement with IUPAC as a way to achieve their objectives.

In addition to activities that already involve YOs, wouldn't there be a more operative way to engage and empower the youth? To reverse the trend and make IUPAC more attractive and open to our generation, we propose a recast of the role of the Youth in IUPAC, more in line with current trends and the efforts of similar organizations.

The Young Observers attending IUPAC General Assemblies are in fact selected for their productivity, creativity, skills, and potential. They are already contributing to solve some of the greatest challenges of our time: climate change, resources scarcity, and energetic transition. On top of the scientific questions raised by these challenges (*e.g.* sustainable development, green chemistry, renewable energy resources, and all technologies dealing with safety and healthcare), our generation will also—sooner rather than later—have to address the political and humanist ones: insuring that shared knowledge is not turned into weapons, and that politicians receive appropriate advice in society-defining decisions. In other words, fight the "fake news." In the long haul, collaboration of IUPAC with organizations such as the Organization for the Prohibition of Chemical Weapons (OPCW) seems especially relevant, and it will require the involvement of the younger generations [2,3]. Today, IUPAC leadership plays a critical role in these matters, but it should strengthen its endeavor to prepare its succession.

Undoubtedly, every newcomer has a lot to learn about IUPAC machinery. The same applies for members freshly elected in Divisions and Committees, yet they are not asked to observe but to get immediately involved in the activities of their groups. We minimize our ability to attract the best and bright young chemists to IUPAC if we keep treating them as observers. All the attendees to the General Assembly are active early career professionals, and some of them, under 45 (current age limit for YO), are already prolific and accomplished scientists, who should be treated as peers rather than mere observers.

We thus propose that the passive connotation of an "Observer" should be replaced by a more engaging one, not just in the naming. We believe that there simply is no time to lose in tackling our main global problems, especially since we are ready to contribute. Today, we propose to set together well-defined goals, such as

By 2018, a web presence for Younger Chemists within IUPAC is established via both website and social media.

By 2019, each division and committee has elected a member that will work with the YOs and *International Younger Chemists Network* as a liaison to both mentor but also hear new ideas from the younger chemists.

By 2021 each division has one member under the age of 45.

We write this letter in a spirit of dialog and cooperation to build a stronger and more inclusive organization, not only as Young Observers, but also as peers willing to work together to create a better world through Chemistry. To that regard, we believe that the recent creation of the *International Younger Chemists Network* (IYCN) [4], here in São Paulo, is highly encouraging. We call on IUPAC to associate its young members to the centenary celebration (IUPAC100), not only as observers, but as participants and as co-leaders to some of the relevant events and symposia, such as WCLM.

São Paulo, 14 July 2017.

Disclaimer: The opinions expressed in this letter are these of the individuals who signed it. In no quality does this letter express officia positions of their affil tions.

Sophie Carenco (Paris, France – Researcher at *CNRS*), Laurean Ilies (Tokyo, Japan – Associate Professor at the *University of Tokyo*), Leonardo Scarabelli (Pavia, Italy – Post-doctoral fellow at the *University of California, Los Angeles*), Dean Tantillo (Davis California, USA – Professor at the *University of California, Davis*). Signatories were Young Observers at the 49th General Assembly of IUPAC in São Paulo, Brazil.

References

1. E. P. Przybylowicz, *Chem.Int*, **24**(1):7-9 (2002)
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3. https://iupac.org/iupac-opcw-take-partnership-new-level/
4. C. E. Dunne and F. Gomollón-Bel, *Chem. Int.*, **39**(2):4-6 (2017)

Mark Your Calendar

Upcoming IUPAC-endorsed events
See also www.iupac.org/events for links to specific event websites

2017 (after October 1)

2-5 October 2017 • Green Chemistry • Moscow, Russian Federation
7th IUPAC International Conference on Green Chemistry
Prof. Natalia P. Tarasova, Conference Chair, D. Mendeleev University of Chemical Technology, Moscow. Dr. Anna S. Makarova, Chair of Local Organizing Committee, E-mail: annmakarova@mail.ru; http://greeniupac2017.muctr.ru

2-6 October 2017 - Waste Management - Cagliari, Italy
16th International Waste Management and Landfill Symposium
Scientific Secretariat: Roberto RAGA, University of Padova (IT), E-mail: roberto.raga@unipd.it ; Adelia PRESUTTI, General Manager EUROWASTE Srl, E-mail: info@eurowaste.it www.sardiniasymposium.it

8-11 October 2017 • Chemistry Education • Sétif, Algeria
ACRICE 2017, 3rd African Conference on Research in Chemistry Education
Prof Djafer Benachour, Department of Process Engineering, Ferhat Abbas University SETIF 1, Sétif 19 000, Alegria; E-mail: bendjafer@univ-setif.dz; www.univ-setif.dz/OCS/FT/ACRICE

9-13 October 2017 • Advanced Materials • Kuala Lumpur, Malaysia
25th Annual World Forum on Advanced Materials (POLYCHAR 25)
Ong Eng Long, Organizing Chair, E-mail: ongelong@gmail.com; ikmhq@ikm.org.my. 25th POLYCHAR 2017 Secretariat, Institut Kimia Malaysia, secretariat@25polychar.org.my, www.25polychar.org.my

11-13 October 2017 • Smart Materials • Jeju Island, Korea
IUPAC-FAPS 2017 Polymer Congress on Smart Materials for Emerging Technology
Jungahn Kim, Chair of the Organizing Committee, Department of Chemistry, Kyung Hee University, Seoul, Korea, E-mail: jakim05@khu.ac.kr; www.faps2017.org

2-4 November 2017 - Impact of Pesticides - Bengaluru, India
International Conference on Potential Impact of Pesticides on Environment and Human Health
Conference Convener: Associate Professor Sreenivasa Rao Amaraneni, Dept. of Chemistry, School of Engineering, Dayananda Sagar University, Bengaluru-560068, India; E-mail: sramaraneni-chem@dsu.edu.in http://www.dsu.edu.in/index.php/international-conference-on-icpipehh-2017-by-chemistry-department-DSU-SOE

5-9 November 2017 • HPLC 2017 • Jeju Island, Korea
46th International Symposium on High Performance Liquid Phase Separations and Related Techniques
HPLC 2017 Secretariat contact: Haengdo Lee, Department of Chemistry, Seoul National University, Seoul 151-747, Korea, E-mail: hplc2017@gmail.com; www.hplc2017-jeju.org

2018

21-23 February 2018 • Chemistry Conference for Young Scientists • Blankenberge, Belgium
Chemistry Conference for Young Scientists (ChemCYS 2018)
Koninklijke Vlaamse Chemische Vereniging vzw; E-mail: support@chemcys.be; www.chemcys.be

10-12 May 2018 - Kinetics in the Real World - Hannover, Germany
117th General Assembly of the Bunsen Society for Physical Chemistry 2018
Prof. Dr. Jens-Uwe Grabow, Gottfried Wilhelm Leibniz Universität Hannover, Callinstrasse 3A, D-30167 Hannover, E-mail: jens-uwe.grabow@pci.uni-hannover.de, www.bunsentagung.de

3-7 June 2018 • Polymers and Organic Chemistry • Montpellier, France
Polymers and Organic Chemistry 2018 (POC 2018)
Dr Ghislain David (Chair), Institute Charles Gerhardt, School of Chemistry of Montpellier, 8 rue de l'Ecole Normale, F-34296 Montpellier Cedex 5, France, E-mail: ghislain.david@enscm.fr http://poc2018.enscm.fr

4-7 June 2018 • Isotopes and Isotopically Labelled Compound • Prague, Czech Republic
13th International Symposium on the Synthesis and Applications of Isotopes and Isotopically Labelled Compounds
Prof. Tomáš Elbert (Chair of the Local Organising Committee), E-mail: elbert@uochb.cas.cz
www.iis-prague2018.cz

25-27 June 2018 - Global Challenges in Neglected Tropical Diseases - San Juan, Puerto Rico
Dr. Néstor M. Carballeira, Department of Chemistry, University of Puerto Rico, PO Box 23346, San Juan, PR 00931-3346; E-mail: nestor.carballeira1@upr.edu

1-5 July 2018 • MACRO2018 • Cairns, Australia
World Polymer Congress
Prof. Sébastien Perrier and Prof. Martina Stenzel (conference co-chairs); Conference Coordinator: Taylor Mills, Leishman Associates, E-mail: taylor@leishman-associates.com.au; www.macro18.org

2-6 July 2018 - High Temperature Materials -Ekaterinburg, Russian Federation
XVI International IUPAC Conference on High Temperature Materials Chemistry (HTMC-XVI)
Dr. Andrey S. Bykov, Institute of. Metallurgy, UB Rus. Acad. Sci, 101 Amundsena Str., Ekaterinburg 620016, Russia; E-mail: a.s.bykov54@mail.ru; http://htmc16.ru

8-13 July 2018 – Photochemistry • Dublin, Ireland
27th IUPAC International Symposium on Photochemistry
Dr. Miguel A. Garcia-Garibay (Conference co-chair), Los Angeles, E-mail: mgg@chem.ucla.edu, and Dr. Susan Quinn, University College Dublin, Ireland, E-mail: susan.quinn@ucd.ie http://photoiupac2018.com

10-14 July 2018 • Chemistry Education • Sydney, Australia
International Conference on Chemistry Education (ICCE) 2018
Chair of the Program Committee: Prof Siegbert Schmid, University of Sydney, School of Chemistry, Siegbert. schmid@sydney.edu.au http://www.icce2018.org

15-20 July 2018 - Solubility Phenomena - Tours, France
The 18th International Symposium on Solubility Phenomena and Related Equilibrium Processes (ISSP)
Chair of Local Organizing Committee: Dr. J. Jacquemin, Université F. Rabelais, Tours, France;
E-mail: jj@univ-tours.fr SECRETARY ISSP18, E-mail: secretary@issp18.org; http://issp18.org

30 July – 4 August 2018 - Coordination Chemistry - Sendai, Miyagi, Japan
The 43rd International Conference on Coordination Chemistry (ICCC 2018)
Prof. Ken Sakai, Chair of the Program Committee, E-mail: ksakai@chem.kyushu-univ.jp
Yoshiko Ishibashi, Conference Manager, Department of Chemistry, Kyushu University, Motooka 744, Nishi-ku, Fukuoka 819-0395, Japan; Email : secretariat@iccc2018.jp, http://www.iccc2018.jp

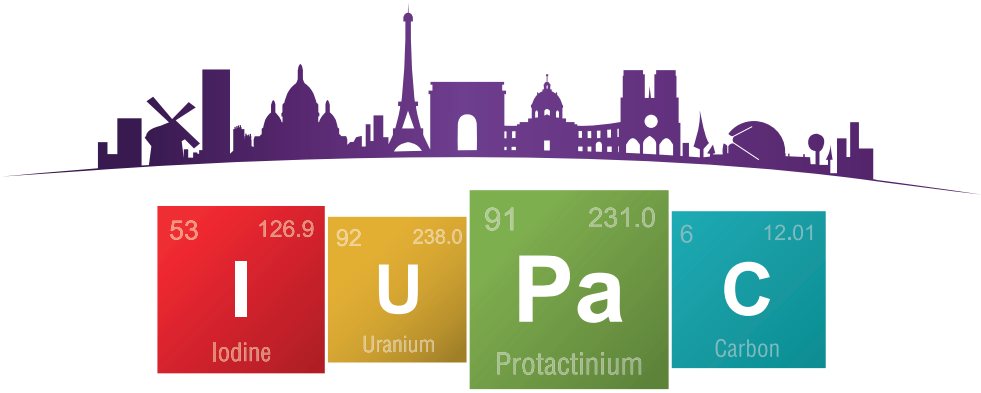
16-21 September 2018 • Organic Synthesis • Florence, Italy
22nd International Conference on Organic Synthesis (22-ICOS)
Professor Alberto Brandi (Conference Chair) and Professor Maurizio Taddei (Vice-Chair), E-mail: secretariat@22-icos-flo ence.it; www.22-icos-flo ence.it

2019

19-24 May 2019 - Crop Protection - Ghent, Belgium
14th IUPAC International Congress of Crop Protection Chemistry
Prof. ir. Pieter Spanoghe; E-mail: Pieter.Spanoghe@UGent.be, Onderzoeksgroep Fytofarmacie/Crop Protection Chemistry, Campus Coupure, 9000 Ghent, Belgium; https://www.iupac2019.be

5-12 July 2019 – IUPAC Congress/General Assembly – Paris, France
contact@iupac2019.org; http://www.iupac2019.org

21-26 July 2019 - Novel Aromatic Compounds - Sapporo, Japan
The 18th international Symposium on Novel Aromatic Compounds (ISNA-18)
Prof. Dr. Shigehiro Yamaguchi, Chair of Program Committee,
E-mail: yamaguchi.shigehiro@b.mbox.nagoya-u.ac.jp; http://www.isna18.org

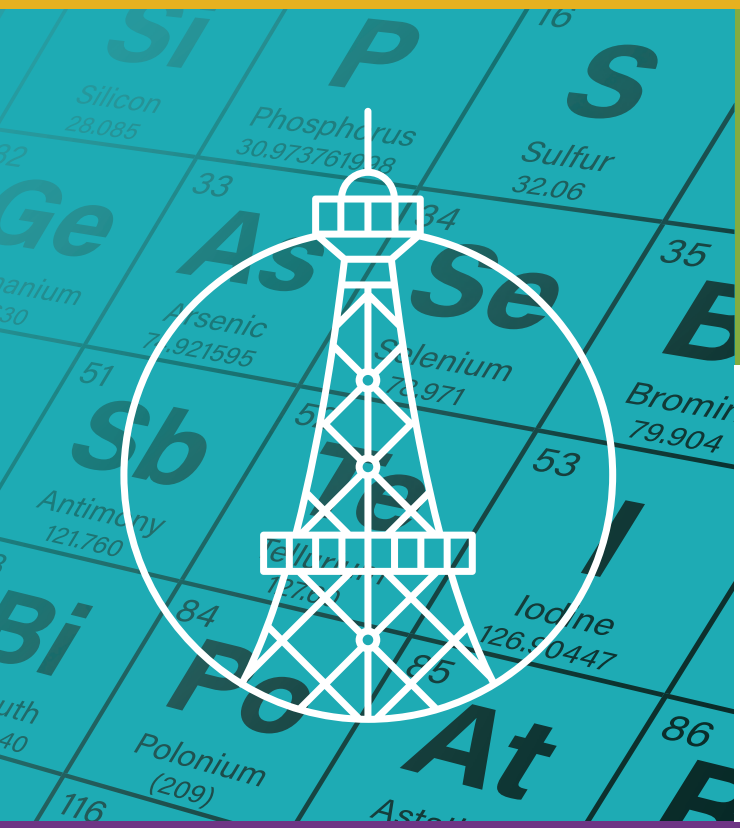


PARIS, FRANCE

50th General Assembly & 47th IUPAC World Chemistry Congress

« Frontiers in Chemistry: Let's create our Future! 100 years with IUPAC »

JULY 5-12 2019



IUPAC will celebrate its Centenary holding its General Assembly and World Congress in Paris, France, along with dedicated sessions and events.

IUPAC

IUPAC CENTENARY CELEBRATION

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Stamps International

Polymers Everyday and Everywhere

I recently looked back at all the notes I've written for Chemistry International during the past decade or so, and polymer chemistry seems to be a recurrent theme, with a range of topics that underscores the multifarious applications of polymeric materials, both natural and synthetic. For example, the common polypropylene stacking chair, created in 1962 by Robin Day, one of the most influential furniture designers of the 20th century, was featured on a British stamp used to illustrate a Stamps International article published in 2011.

The rising popularity of plastics in the 1960s, referred to in a scene played by Dustin Hoffman in the movie *The Graduate,* released four years after the 1963 Nobel Prize in Chemistry was awarded to Karl Ziegler and Giulio Natta "for their discoveries in the field of the chemistry and technology of high polymers", was described in a note that appeared in 2013.

And the pioneering work on hydrogels by Otto Wichterle, an ingenious Czech organic chemist usually credited with the invention of soft contact lenses, was outlined in another note a couple of years ago. In 1967, incidentally, Wichterle was the founder and first president of IUPAC's Macromolecular Division, which became the Polymer Division ("Division IV") in 2004. Now that the Polymer Division is celebrating its 50th anniversary, it is worth remembering that polymers are today truly ubiquitous materials and almost 300 million tonnes of plastics are produced in the world each year, more than half of which are based on polypropylene and various types of polyethylene.

More sophisticated polymers, such as those used in plastic banknotes and drug delivery systems, are becoming increasingly important, and only time will tell what fascinating applications arise from the new materials being developed these days.

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