

Part 1. Highlights and/or Executive Summary (one-page ~500 words):

Polymer division IUPAC is a family of close to 100 volunteers, bringing to IUPAC a unique expertise in polymer science and in scientific (multidisciplinary) fields, in which the polymer science plays central role.

The strength of our division is:

- in interest to dedicated work on activities being in line with the IUPAC priorities
- diversity in expertise in polymer science, involving chemical synthesis, analytical chemistry, physical chemistry, biomaterials, and others, spanning to multidisciplinary fields and global challenges such as health, sustainability, energy, digitalization etc., also with strong emphasis on education
- open, informal, and frequent communication of the division committee with subcommittees, and within the subcommittees (virtually and in-person)

These activities are carried out within 4 subcommittees: (i) Polymer terminology, (ii) Polymer education, (iii) Structure and properties of commercial polymers, and (iv) Kinetics and processes of polymerization.

The work of subcommittees is formally organized around the projects. Currently, we have almost 30 active projects, with 10 projects initiated since 2022. There are ideas for new projects (some are already formulated in the form of proposals), of which outcomes (recommendations, technical reports, standards, etc., see [Polymer Division Google Scholar](#) page) are needed by the international polymer community.

Highlights:

- Successful flagship congress of our division IUPAC MACRO 2024, The 50th World Polymer Congress, July 1 – 4 2024, Warwick, UK. This congress is organized biannually, being a festival of polymer science that was undeniably the case of this congress in Warwick.
- The 2-days hybrid meeting preceding IUPAC MACRO 2024, with approximately 40 participants in-person, addressing a number of issues related to the division and its impact on the world polymer science.
- The in-person and virtual meetings of subcommittees summarizing achievements and setting the future directions.
- Educational Workshop in Polymer Sciences 2024 on “Characterization” during the IUPAC MACRO 2024.
- Training course on Wikipedia and Wikidata for application of IUPAC terms across Wikipedia during the PhD School of the Politecnico di Milano, July 8 - 12 2024.
- An International Exercise-Based Syllabus to create a resource for teachers and students in less developed countries to support an undergraduate course of study in polymer chemistry.
- Polymer video competition.
- Development of an online database of benchmarked propagation rate constants for radical polymerizations, with tools for ongoing maintenance and future data expansions.

- Development of robust methods for determining radical copolymerization reactivity ratios, supported by open-access software and highly cited publications.
- Recommendations for structure-based nomenclature that uniquely identifies polymers and copolymers, which contain a multiple number of constitutional repeating units in complex linear, star, comb and brush-based structures.
- Terminology related to simulations and modeling of polymers.
- A brief guide on basic polymer terminology with hyperlinks to relevant primary IUPAC documents.
- Interdivisional activities (to highlight: CPCDS, CCE, PC, EC, CEDEI).

Part 2. Plans and priorities for the remainder of 2024-2025 biennium, and beyond (one-page ~500 words)

The ongoing Polymer Division IUPAC activities are within the current IUPAC scientific and strategic priorities, with measurable outcomes in nomenclature, terminology, data standards and management, constants, best practices, external outreach, and education.

These activities are closely aligned with Strategic Priorities and Outcomes 2030, identified recently by the Science board IUPAC. In 2025, it is our plan to analyze, which further actions should be taken in regard to these priorities. Importantly, we will identify the steps on how to focus our activities towards the digital IUPAC.

At the subcommittee level, plans include (selected):

- preparation of open-access IUPAC-validated resources (slide decks/presentation slides) for teaching an introductory course in (undergraduate) polymer science.
- preparation of educational workshops in polymer science 2026+.
- critical evaluation of initiation and termination kinetics.
- standardization of size exclusion chromatography methodologies (round-robin studies).
- advancements in understanding depolymerization kinetics.
- expansion into other polymerization processes than radical polymerization: benchmark kinetic parameters for catalysts used in polyethylene polymerization and ring opening polymerizations
- data standardization.
- completion of activities concerning (i) the terms for mechanisms of polymer growth: the “step-growth” and “chain-growth” dilemma, and (ii) the graphical representations of polymers.

Regarding chemistry and sustainability, Prof. A. Ryan from Sheffield University (AM) proposed the areas of potential future activities of IUPAC and Polymer Division. This information has been forwarded to M. Garson and F. Kerton (the chair of CHEMRAWN) in order to shape future ideas and the IUPAC outcomes in this area.

Part 3. Overall report of activities and achievements of Division/Committee since the last report to Council and organized according to the priorities

- (a) *Global scientific cooperation and collaboration that creates a common language of chemistry, including data or technical standards, nomenclature, terminology, and symbols;*

THE SUBCOMMITTEE ON KINETICS AND PROCESSES OF POLYMERIZATION

held an in person meeting at Macro2024 (July 3rd, 2024), and a virtual meeting on December 10, 2024, with 16 members present and several members providing apologies. The meeting reviewed past activities, ongoing projects, and discussed potential new initiatives.

Closed Projects. Two projects were closed in 2024.

Project 2019-045-1-400. Development of a Machine-Accessible Kinetic Databank for Radical Polymerizations (T. Junkers)

The project was closed on June 28, 2024. The database of benchmarked propagation rate constants is online at <http://sql.polymatter.net/>.

Two publications resulted from this project:

- A machine-readable online database for rate coefficients in radical polymerization
J. Van Herck, S. Harrisson, R. A. Hutchinson, G. T. Russell, T. Junkers, *Polym. Chem.* **2021**, *12*, 3688-3692
- Update and critical reanalysis of IUPAC benchmark propagation rate coefficient data
S. Beuermann, S. Harrisson, R. A. Hutchinson, T. Junkers, G. T. Russell, *Polym. Chem.* **2022**, *13*, 1891-

Project 2019-023-1-400. Experimental methods and data evaluation procedures for the determination of radical copolymerization reactivity ratios (A. M. van Herk)

The project was closed on April 1, 2024

A robust method has been established to obtain reactivity ratios, including measurement procedures and data processing. The methodology has been captured in free software packages, including Python code, an Excel workbook, and Contour software. Links to the software can be found at the IUPAC Polymer Division Github: <https://github.com/IUPAC-Polymer-Division/>

Two publications resulted from this project:

- The contributions of Prof. Kenneth F. O'Driscoll to radical copolymerization kinetics, R. A. Hutchinson, B. Klumperman, G. T Russell, A. M. Van Herk, *Can. J. Chem. Eng.* **2022**, *100*, 680-688
- IUPAC Recommended Experimental Methods and Data Evaluation Procedures for the Determination of Radical Copolymerization Reactivity Ratios from Composition Data. A. A. A. Autzen, S. Beuermann, M. Drache, C. M. Fellows, S. Harrisson, A. M. van Herk*, R. A. Hutchinson, A. Kajiwara, D. J. Keddie, B. Klumperman, G. T. Russell *Polym. Chem.*, **2024**, *15*, 1851–1861

A manuscript on the determination of radical copolymerization reactivity ratios has been submitted to Pure and Applied Chemistry.

Ongoing Projects. The Subcommittee currently participates in 7 ongoing projects, including 1 interdivisional project (Project 2018-009-2-500), and 2 projects which were approved since 2023.

Project 2013-051-1-400. Critically evaluated rate coefficients associated with initiation of radical polymerization (G. Moad)

This project aims to provide benchmark data for rates of initiation in radical polymerization. A critical review on azo initiation was published in *Prog. Polym. Sci.* in 2019. A paper in *Pure Appl. Chem.* is currently under revision.

Project 2013-051-1-400. Critically Evaluated Rate Parameters for Chain-Length-Dependent Termination Kinetics in Radical Polymerization of Styrene and Methyl Methacrylate (G. T. Russell)

This project aims to provide benchmark data for rate parameters for termination kinetics. A review article was published in 2023, which will be followed by a paper on benchmark values for chain-length dependent termination in radical polymerization (data have been obtained for 7 methacrylates).

Project 2018-009-2-500. Guidance for the Compilation, Critical Evaluation and Dissemination of Chemical Data (D. Shaw – Interdivisional project)

This project, run by the Analytical Chemistry Division (Division V) aims to develop IUPAC guidance for the production and use of high-visibility evaluated data. G. T. Russell, T. Junkers and S. Harrisson participate in the working group. A manuscript on critical evaluation of data is in the final stages of preparation, led by Brynn Hibbert (GTR, SH contribution to statistical treatment of PLP data).

Project 2017-028-1-400. Critically evaluated rate coefficients for backbiting in acrylate radical polymerization. (R. A. Hutchinson, D. D'hooge)

This project aims to provide critically evaluated rate coefficients for backbiting reactions in acrylate radical polymerization. A simulation study was published by the Hutchinson group in 2021. Dagmar D'Hooge has taken over co-leadership of the project from Tanja Junkers.

Project 2022-030-2-400. Accuracy of size exclusion chromatography in relation to polymer synthesis and polymerization modelling (T. Junkers, S. Harrisson)

This project aims to develop best practices and recommendations for size exclusion chromatography measurements, carry out a round robin study on SEC measurement, establish benchmark values for Mark-Houwink coefficients and dn/dc , and investigate alternatives to SEC (e.g. DOSY)

Recent activities have focused on the round robin study: the Anastasaki group has prepared ~10 samples of varying size, dispersity for distribution to interested laboratories. Identification of participating labs will begin shortly.

Recently approved projects:

Project 2023-021-2-400. Catalyst activity determination (J. Merna)

This project aims to identify sources of variation in catalyst activity results in homogeneous coordination polymerization. The participants will develop an agreed-on best practice protocol and provide a benchmark value for a homogeneous metallocene catalyst in polyethylene polymerization.

Seven laboratories with similar equipment will participate in study : task group members include George Britovsek, Geoffrey W. Coates, Robin Hutchinson, Tomáš Jakubec, Giuseppe Leone, Brian K. Long and Jean Raynaud. Preliminary benchmark tests are in progress at UCT Prague. After validation, these will be performed in Lyon at larger scale before distributing the benchmark catalyst to all labs.

Project 2023-035-1-400. Critical Evaluation of Depolymerization Kinetics for Chemical Recycling of Polymers (T. Junkers)

This project aims to evaluate methods for the determination of depolymerization kinetic coefficients and critically evaluate the current literature data. An initial task group meeting was held during the Macro2024 conference. The first step is to write a paper describing issues in depolymerization kinetics, based on literature data.

THE SUBCOMMITTEE ON POLYMER TERMINOLOGY

met at the annual meeting, which took place on June 25-28, 2024 at Birmingham. More than 20 members joined in person with about 9 members participating online. Several projects have been wrapped up and submitted or are under review for publication: 2014-014-1-400 (MODSIM), 2019-036-1-800 (STARS2), 2012-048-3-400 (B-TERMS).

Project 2019-036-1-800 (STARS2) is a follow-up to 2013-031-3-800 Chen (STAR), The earlier STAR project focused on structure-based nomenclature for regular linear, star, comb and brush polymers and was published in 2021. The recently completed STARS2 project focused on irregular linear, star, comb, and brush polymers, extending the concepts from the earlier project. Ultimately, the project delivers recommendations for structure-based nomenclature that uniquely identify polymers and copolymers which contain a multiple number of constitutional repeating units in complex linear, star, comb and brush-based structures.

Project 2014-014-1-400 (MODSIM) is a large and intricate project focusing on terminology related to simulations and modeling of polymers. The task group worked diligently over several years to define XX terms in a document that has essentially no precedent. The project is currently undergoing revisions after review.

Project 2012-048-3-400 (B-TERMS) provides a new 2-page brief guide covering polymer terminology. Currently at the proofs stage, it will act as a basic guide to IUPAC terminology for authors publishing in polymer and related science journals. The document is more than just a summary of all terms; instead, it puts the most commonly used terms into context in plain English in a manner that is widely comprehensible, including those with little prior knowledge of polymers. The guidelines include the important basic terms used in polymer science, careful distinctions of terms that are often misused, and hyperlinks to the relevant primary IUPAC documents.

SPT nominated four new members: Laure Kayser (USA), Herdeline (Digs) Ardoña (USA), Eleftheria Roumeli (USA), and Roxanne Kieltyka (the Netherlands).

- (b) *Interaction with chemistry organisations, professional societies, industry and other relevant bodies to facilitate best practice in chemistry and chemistry education, or which support educational initiatives in data standards and management*

THE SUBCOMMITTEE FOR POLYMER EDUCATION works towards these goals:

2021-021-1-400 (WORKSHOP) Educational Workshop in Polymer Sciences 2024. A total of five educational workshops in Polymer Sciences have been organized between 2016 and 2022: the themes were synthesis (2016) (#2015-057-1-400), characterization (2017) (#2015-057-1-400), processing (2018) (#2017-029-2-400) and applications (2020+) (#2019-022-1-400), polymerization induced self-assembly (2022). The 2024 topic was “characterization” and took place in Warwick on July 3 with >30 participants. SPEd committee voted on the modification of the lecture series to: “*Melissa Chin-Han Educational Workshop series*”. The three lectures presented were:

- a) Advanced field-flow fractionation for supramolecular and complex polymers (A. Lederer)
- b) Characterisation of wave-dependent photochemistry (C. Barner-Kowollik)
- c) NMR as a quantitative method (M. Gaborieau)

Future topics are: Processing (2026), Applications (2028), synthesis (2030).

2018-038-1-400 (WIKI2) Hands-on training on Wikipedia and Wikidata for application of IUPAC terms across Wikipedia. A new (in person) edition of the course took place at the PhD School of the Politecnico di Milano, on 8-12 July 2024. Online participation was also enabled and open to SPEd members. Update on status of (ongoing) project 2015-032-2-400 (WIKI) Synchronizing Wikipedia: Polymer Definitions and Terminology concerned the deletion of image boxes, which will be reverted to textboxes.

2017-019-2-400 (SYLLABUS) An International Exercise-Based Syllabus in Polymer Chemistry. Intended to create a resource for teachers and students in less developed countries, providing the ‘skeleton’ of a textbook with enough exercises to support an undergraduate course of study in polymer chemistry. An article was published in PAC on June 2024 to promote the project ([link](#)). Revision of text is ongoing with the inclusion of a chapter on sustainability and additional exercises.

2022-003-2-400 (VIDEO) Polymer video competition. The deadline for video submissions was 31st March 2024. A total of 55 videos were submitted, with most coming from the Asian continent. The evaluation process has not yet taken place.

THE SUBCOMMITTEE ON STRUCTURE AND PROPERTIES OF COMMERCIAL POLYMERS

successfully run two in person meetings in year 2024. One for the East Asian (EA) chapter on October 11 and 12, 2024 in Gyeongju, Korea and another for the West Europe (WE) chapter on September 30, October 1 and 2 in Oftringen, Switzerland. The one for the WE meeting was the first in-person one after a long break due to pandemic.

For the 2024 EA meeting, we had 24 participants from 3 countries (China 10, Korea 8 + 2 observers, Japan 4). Among the 10 Chinese participants, 5 were from research centers of leading chemical companies based in China such as SINPEC, BASF, Covestro, SABIC). Several new ideas of feasibility studies have been discussed during the meeting. For the 2024 WE meeting, it was the first in-person meeting since 2019. There were 12 participants including 4 from Asia. It was a hybrid meeting with some European colleagues participating online. Several interesting topics and future projects were discussed. Samples for the thermoplastic starch have been distributed during the meeting.

Prof. Jiasong He published an article in Chemistry International, an IUPAC journal, reporting on the activities of our IUPAC EA Research Meeting. (Jiasong He, Chemistry International, October-December 2024, 26-31.)

Part 4. Tabular material (list of publications since 2023. It might also include a list or summary of conferences and symposia organized by the Division or its component bodies. It should include a list of all current Division projects)

Publications

1. R. A. Hutchinson, B. Klumperman, G. T Russell, A. M. Van Herk, *Can. J. Chem. Eng.* **2022**, *100*, 680-688 (The contributions of Prof. Kenneth F. O'Driscoll to radical copolymerization kinetics,)
2. IUPAC Recommended Experimental Methods and Data Evaluation Procedures for the Determination of Radical Copolymerization Reactivity Ratios from Composition Data. A. A. A. Autzen, S. Beuermann, M. Drache, C. M. Fellows, S. Harrison, A. M. van Herk*, R. A. Hutchinson, A. Kajiwara, D. J. Keddie, B. Klumperman, G. T. Russell *Polym. Chem.*, **2024**, *15*, 1851–1861
3. Buback, M., Russell, G. T. Detailed analysis of termination kinetics in radical polymerization. *Polym. Int.* **2023**, *72*, 869-880
4. J. He. Subcommittee on Structure and Properties of Commercial Polymers – East Asia Research Meeting, Chemistry International, October-December 2024, 26-31

List of ongoing projects

1. 2024-013-2-400 - Polymer Slide Decks
2. 2024-001-2-400 - Knowledge exchange for multi-material additive manufacturing
3. 2023-035-1-400 - Critical Evaluation of Depolymerization Kinetics for Chemical Recycling of Polymers
4. 2023-021-2-400 - Catalyst Activity Determination
5. 2023-032-1-400 - Brief Guide to Polymer Characterization: Behavior and Performance
6. 2023-015-2-400 - Thermoplastic starch-based materials: properties and characterization
7. 2023-007-1-400 - Clarification of Definitions for Polymer Molar Mass Averages
8. 2022-030-2-400 - Accuracy of size exclusion chromatography in relation to polymer synthesis and polymerization modelling
9. 2022-003-2-400 - Polymer video competition
10. 2022-006-2-400 - Revision of the Brief Guide to Polymer Nomenclature
11. 2020-024-3-400 - Nomenclature and terminology for supramolecular polymers
12. 2021-012-2-400 - Personal Protective Equipment Disposal for the Future
13. 2019-043-2-400 - Gold Book Update for Polymers
14. 2019-041-3-400 - Nomenclature of Sequence-Controlled Polymers
15. 2019-027-1-400 - Basic Classification and Definitions of Polymerization Reactions
16. 2019-014-2-400 - Terminology of Polymer Aggregates
17. 2018-033-1-400 - Additives intended to promote the degradation of polyolefin-based thermoplastic materials: terminology and testing (ADDIPLAST)
18. 2018-038-1-400 - Hands-on training on Wikipedia and Wikidata for application of IUPAC terms across Wikipedia
19. 2017-028-1-400 - Critically evaluated rate coefficients for backbiting in acrylate radical polymerization
20. 2017-019-2-400 - An International Exercise-Based Syllabus in Polymer Chemistry

21. 2016-018-1-400 - Definition of Terms Pertaining to Polymers in the Solid State: Molecular Arrangement from the Nano- to the Micrometer Scale
22. 2015-050-3-400 - Definition of Terms Relating to the Ultimate Mechanical Properties of Polymers
23. 2015-014-1-400 - Guide (and Brief Guide) to Polymer Semiconductors
24. 2014-014-1-400 - Terminology for modeling and simulation of polymers
25. 2013-049-1-400 - Terminology for Separation of Macromolecules
26. 2013-051-1-400 - Critically evaluated rate parameters for chain-length-dependent termination in radical polymerization of styrene and n-alkyl methacrylates
27. 2012-048-3-400 - A Brief Guide to Polymer Terminology
28. 2009-050-1-400 - Critically evaluated rate coefficients associated with initiation of radical polymerization

Interdivisional Project

1. **Project 2018-009-2-500.** Guidance for the Compilation, Critical Evaluation and Dissemination of Chemical Data (D. Shaw – Interdivisional project)

List of conferences endorsed by the division

1. IUPAC MACRO 2024, The 50th World Polymer Congress, Warwick University, United Kingdom, July 1 – 2 2024, chair: Dave Haddleton (Warwick University), Paul Topham (Aston University)
2. 8th International Soft Matter Conference (ISMC2024), supported by IUPAP Working Group 15 on Soft Matter, Raleigh, North Carolina, July 30 – August 2 2024, chair: Michael Rubinstein, Duke University
3. POLY-CHAR Madrid 2024, Madrid, Spain, May 27 - 31 2024, chair: Araceli Flores, Institute of Polymer Science and Technology
4. 85th Prague Meeting on Macromolecules, Prague, Czech Republic, June 24 – 28 2024, chairs: Hynek Beneš, Zdeněk Starý