Editorial

Milad Abolhasani¹ · Jean-Christophe M. Monbaliu²

Published online: 19 February 2020
© Akadémiai Kiadó 2020

Journal of Flow Chemistry was established in 2010 with the goal of showcasing the recent research efforts of the emerging field of flow chemistry. After a decade of groundbreaking progress, we believe the field of flow chemistry and its widespread applications across multiple disciplines have reached a level of maturity that can be readily adopted by traditional organic/inorganic chemists to significantly improve the way chemical reactions are being conducted. In celebrating a decade of success stories of *going with the flow*, the editorial team of the Journal of Flow Chemistry has decided to start a new annual series of Emerging Investigators.

Welcome to the inaugural Emerging Investigators issue of the Journal of Flow Chemistry! Starting this year, with the help of the editorial team, we invite a group of early career researchers from academia and industry to contribute their state-of-the-art research efforts in the field of flow chemistry to the journal. This special issue showcases the pioneering work of some of the emerging flow chemists from a diverse background including, organic/inorganic chemistry, mechanical/chemical engineering, and materials science.

✉ Milad Abolhasani
abolhasani@ncsu.edu

Jean-Christophe M. Monbaliu
jc.monbaliu@uliege.be

¹ Department of Chemical and Biomolecular Engineering, North Carolina State University, 911 Partners Way, Raleigh, NC 27695, USA

² Center for Integrated Technology and Organic Synthesis, MolSys Research Unit, University of Liège, Quartier Agora Allée du six Aout 13, B-4000 Liège, Sart Tilman, Belgium

Heidrun Gruber-Woelfler (Associate Professor, Graz University of Technology, Austria) is a chemical engineer working in the areas of heterogeneous (bio)catalysis, continuous syntheses and crystallization, reactor design including additive manufacturing and inline characterization. Her publication represents the successful development of a con-

tinuous approach for the synthesis of a late-stage sacubitril precursor in multiple steps. Furthermore, it highlights the applicability and benefits of continuous flow chemistry for the synthesis of advanced chemical intermediates, which has become a hot topic concerning the improvement of production processes in pharmaceutical industry.

Jun Yue (Associate Professor, University of Groningen, Netherlands) is a chemist working on the development of novel reactor concepts and their applications for sustainable chemical conversion. In his review article, the recent progress on the utilization of continuous flow microreactors for carrying out efficient chemical

processes in gas-liquid-liquid systems is reviewed, with a focus on the application examples including triphasic reactions, reaction-extraction coupling, inert gas assisted liquid-liquid reactions and particle synthesis under three-phase flow.

Hui-Dong Zheng (Professor, Fuzhou University, China) is a chemical engineer working on the development of advanced synthesis methods of fine chemicals and the process intensification of traditional industrial process. His contribution discloses an intensified organocatalyzed styrene epoxidation achieved under continuous flow conditions that combined experimental and theoretical approaches.

tions that combined experimental and theoretical approaches.

Fig. 1 Scale up droplet production reported by Kai Wang

Yuanhai Su (Associate Professor, Shanghai Jiao Tong University, China) is a chemical engineer working in the areas of process intensification, microreactor technology, polymerization engineering, flow chemistry, photochemistry, and functional materials synthesis. In his publication, he developed a continuous-flow synthesis

strategy which would be beneficial for the commercial manufacturing of fine chemicals and pharmaceutical intermediates with the involvement of nitration.

Simon Kuhn (Associate Professor, KU Leuven, Belgium) is a chemical engineer working in the areas of characterization of transport processes in complex flows using experiments and simulations, scaling-up microreaction systems, and design of novel flow reactors incorporating alternative activation modes (light, ultrasound, electro-

chemistry). His publication discusses the fundamentals of laminar flow electrochemical reactors, enabling rational mapping of typically encountered operating regimes (Fig. 2). His work demonstrates that ultrasound assisted mixing is enabling self-supported synthesis at elevated flow rates and throughput.

Kai Wang (Associate Professor, Tsinghua University, China) is a chemical engineer working in the areas of microflow chemical synthesis, multiphase microfluidics, and microreaction engineering. His publication reports a novel scale-up method for their previously developed capillary embedded stepwise microchannel. Uniform tinny droplets were

successfully generated in a 20-capillary embedded device with generation frequency up to 80 kHz (Fig. 1).

Fig. 2 Fundamentals of laminar flow electrochemical reactors reported by Simon Kuhn

Nopphon Weeranoppanant (Assistant Professor, Burapha University, Thailand) is a chemical engineer working in the areas of flow chemistry, multiphase systems and integration of chemical and biochemical processes. His publication presents a continuous flow chemistry strategy for synthesis and purification of silver nanoparticles using a

membrane-based liquid-liquid phase separator module (Fig. 3).

Fig. 3 Continuous flow synthesis and purification of silver nanoparticles reported by Nopphon Weeranoppanant

Jisong Zhang (Assistant Professor, State Key Laboratory of Chemical Engineering, Tsinghua University, China) is a chemical engineer with research interests focused on micro-reaction technology, gas-liquid-solid reactions (hydrogenation and oxidation reactions) in micropacked bed reactors, continuous production

of pharmaceuticals and online analysis with micro-equipment. His publication discusses the integration of infrared thermography in a microsystem for measuring the kinetics of fast exothermic reactions (Fig. 4).

Fig. 4 Infrared thermography in a microsystem for measuring the kinetics of fast exothermic reaction reported by Jisong Zhang

Richard Bourne (Associate Professor, University of Leeds, UK) is a chemist working on rapid process development and continuous flow chemistry. Richard is a Senior Research Fellow of the Royal Academy of Engineering. He works at the Institute of Process Research and Development (IPRD) at Leeds. His research group is particularly focused on rapid optimization using automated systems integrating control, inline analysis and optimization methods. His publication deals with the self-optimization of reactive extractions.

research group is particularly focused on rapid optimization using automated systems integrating control, inline analysis and optimization methods. His publication deals with the self-optimization of reactive extractions.

Rene M. Koenigs (Junior Professor, RWTH Aachen University, Germany) is an organic chemist. His research interests are focused on the discovery of new reaction pathways using metalcatalyzed and photochemical carbene transfer reactions, continuous-flow chemistry and fluorine chemistry. His publication describes a facile and easily scalable approach to conduct photochemical carbene transfer reaction of aryl diazoacetates under flow conditions (Fig. 5).

able approach to conduct photochemical carbene transfer reaction of aryl diazoacetates under flow conditions (Fig. 5).

photochemical carbene transfer reactions in continuous flow

Fig. 5 Facile and easily scalable approach to conduct photochemical carbene transfer reaction of aryldiazoacetates under flow conditions reported by Rene M. Koenigs

- short reaction time
- easy reaction setup in flow
- metal-free synthesis
- large scale

Fig. 6 Organocatalytic approach to the synthesis of 2,2-dimethylchromans using tropylium tetrafluoroborate as a Lewis acid catalyst for metal-free prenylation reactions of phenols under flow conditions reported by Vinh Nguyen

Julien Legros (CNRS Research Director, University of Rouen, France) is an organic chemist. His research is oriented toward the use of non-conventional media in organic chemistry (flow microreactors, hyperbaric conditions, fluorinated solvents). His work details a study on the unique generation and reactivity of vinyl

carbenoids under flash microfluidic conditions.

Gabriela Oksdath-Mansilla (Assistant Professor, Universidad Nacional de Córdoba Argentina) is an organic chemist. Her research interest revolves around the development of greener, scalable and innovative approaches for the preparation of value-added organosulfur and organoselenium compounds. In her review, she

gives an overview on the contribution of flow chemistry for the development of new oxidative methods within the context of organosulfur chemistry (Fig. 7).

Vinh Nguyen (Senior Lecturer, University of New South Wales, Sydney, Australia) is an organic chemist involved in organocatalysis, aromatic cation activation, synthesis of naturally occurring and bioactive compounds as well as flow and photo-mediated chemistry. In this issue, he reports a new organocatalytic approach to

the synthesis of 2,2-dimethylchromans where tropylium tetrafluoroborate is used as a Lewis acid catalyst for metal-free prenylation reactions of phenols under flow conditions (Fig. 6).

Fig. 7 An overview on the contribution of flow chemistry for the development of new oxidative methods within the context of organosulfur chemistry reported by Gabriela Oksdath-Mansilla

Maël Penhoat (Assistant Professor, University of Lille, France) is an organic chemist. Since 2010, he is responsible for the “Flow Chemistry” team of Miniaturization for Synthesis, Analysis and Proteomics CNRS USR 3290 unit. His research activities deal with the development of new activation methods in flow reactors (photochemistry, electrochemistry, catalysis) for applications in organic chemistry and nanomaterial synthesis. In his contribution, he reports a simple continuous flow process for the aerobic oxidation of benzylic organotrifluoroborate salts by photoredox catalysis under UV irradiation (Fig. 8).

try, electrochemistry, catalysis) for applications in organic chemistry and nanomaterial synthesis. In his contribution, he reports a simple continuous flow process for the aerobic oxidation of benzylic organotrifluoroborate salts by photoredox catalysis under UV irradiation (Fig. 8).

Fig. 8 A simple continuous flow process for the aerobic oxidation of benzylic organotrifluoroborate salts by photoredox catalysis under UV irradiation reported by Maël Penhoat

Francesca Paradisi (Professor, University of Bern, Switzerland) is an organic chemist specialized in biocatalysis. Her research interests are focused on flow biocatalysis for the preparation of high value-added compounds with several highly successful examples of increasing complexity. Her publication discloses a highly

sustainable strategy for the preparation of natural flavor esters, using exclusively reagents found in nature and relying on immobilized *M. smegmatis* (Fig. 9).

Fig. 9 Highly sustainable strategy for the preparation of natural flavor esters relying on immobilized *M. smegmatis* reported by Francesca Paradisi

Filipe Vilela (Associate Professor, Heriot-Watt University, Edinburgh, UK) is an organic chemist. Filipe has made continuous flow chemistry an integral part of his research to greatly enhance the photocatalytic efficiency of novel polymeric materials. In this contribution, he discusses the development of a metal-free synthesis of polymer-

supported BODIPY photosensitizers in continuous flow, as well as their utilization for singlet oxygen oxidations (Fig. 10).

Fig. 10 Continuous flow singlet oxygen photo oxidations relying on a polymer-supported BODIPY featuring an in-line ^1H -NMR reported by Filipe Vilela

Dirk Ziegenbalg (Professor, Ulm University, Germany) is a chemical engineer. His research focuses on photochemical reaction engineering. His manuscript illustrates, comments and explains various possible pitfalls of chemical actinometry. He insists on the fundamental importance of the incident photon flux to determine the efficiency of photochemical reactor setups and on the challenges of actinometry in flow (Fig. 11).

(Fig. 11).

Fig. 11 Continuous flow actinometry by Dirk Ziegenbalg

Bart Rimez (Senior Researcher, Université libre de Bruxelles, Belgium and co-founder of Secoya Technologies SRL) obtained his PhD at the faculty of Engineering of the Vrije Universiteit Brussels specializing in flame retardant materials for coating applications. His work discusses the impact of flow restrictions on the nucleation behavior, with potentially groundbreaking applications for continuous flow crystallizations (Fig. 12).

the nucleation behavior, with potentially groundbreaking applications for continuous flow crystallizations (Fig. 12).

Fig. 12 The impact of flow restrictions inside the flow path on the nucleation behavior reported by Bart Rimez

Elena Salvadeo (Lead Research Engineer, Alysophil France, Strasbourg, France) is an organist chemist. She devoted her PhD thesis on the design of bioinspired catalysts for oxidation reactions. Since November 2018, she works as Lead Research Engineer in flow chemistry at Alysophil France. Her work details the optimization of a sustainable

continuous flow procedure toward allantoin, a commodity molecule in the cosmetic industry (Fig. 13).

Fig. 13 Sustainable continuous flow synthesis of allantoin, a commodity molecule in the cosmetic industry reported by Elena Salvadeo

David Snead (Director of Research, Medicines for All Institute, Virginia Commonwealth University, Richmond, VA, USA) is an organic chemist. He was introduced to continuous flow as a postdoc at MIT working on the Pharmacy on Demand project and further refined those skills while at Merck in the process chemistry

group. David joined the Medicines for All Institute in 2018 where he is now Director of Research. His research interests encompass synthetic organic chemistry, organometallic catalysis and flow chemistry. His review discusses solutions to typical problems encountered in plug flow reactors (PFR) related to heat transfer, mixing, handling biphasic reactions, and photochemistry at kilogram level syntheses of active pharmaceutical ingredients.

Timothy Noël (Associate Professor, Eindhoven University of Technology, The Netherlands) is an organic chemist. He chairs the Micro Flow Chemistry & Synthetic Methodology group at Eindhoven University of Technology and is the Editor in Chief of the Journal of Flow Chemistry. His research interests are flow chemistry, ho-

mogeneous catalysis and organic synthesis. He contributed an original manuscript on the development of an electrochemical flow protocol on the synthesis of sulfonyl fluorides and a review on the use of flow for C–H activation chemistry.

Jean-Christophe M. Monbaliu (Associate Professor, University of Liège, Belgium) is an organic chemist. He serves as Associate Editor for the Journal of Flow Chemistry. His research interests revolve around synthetic organic chemistry, flow chemistry and computational chemistry. His lab is mostly active in the areas of (a) active pharma-

ceutical manufacturing and (b) upgrading of biobased platform chemicals toward value-added compounds. His manuscript discloses an intensified and scalable continuous flow process for the hydroxylation of enolizable tertiary ketones.

Milad Abolhasani (Assistant Professor, North Carolina State University, USA) is a mechanical/chemical engineer working at the interface of microreaction engineering, flow chemistry, and colloidal nanoscience. His research interests include smart manufacturing of nanomaterials, microscale process intensification, and

continuous manufacturing of fine chemicals. His publication reviews the latest advancements of the flow chemistry platforms utilizing membrane-based flow reactors for fundamental and applied studies of high-pressure gas-liquid reactions involving carbon monoxide and hydrogen.

David Cantillo obtained his PhD from the University of Extremadura, Spain in 2011. His PhD focused on the experimental and theoretical study of 1,3-dipolar cycloadditions of mesoionic compounds. In 2011 he joined the Kappe Group at the University of Graz as a post-doctoral associate. Since this time his research interests and

experience involve computational chemistry, photoredox catalysis and multistep API synthesis. David Cantillo is an Area Leader at the Research Center Pharmaceutical Engineering GmbH (RCPE) and in 2018 joined the faculty of University of Graz as Assistant Professor. His current research focuses on flow electrochemistry.

We hope you enjoy reading this exciting issue, demonstrating the great potential of the emerging scholars in the field of flow chemistry. It was a great pleasure to highlight some of the most innovative flow chemistry solutions to challenging chemistry problems! The future of flow chemistry is bright.

Milad and Jean-Christophe
January 2020

Meet The Flow Chemist – Prof. Milad Abolhasani

- 1) *When did you start with flow chemistry? Describe the first paper or the first experiments.*

I was introduced to the field of flow chemistry during the first year of my Ph.D. studies at the University of Toronto (2010). I was tasked to develop a time- and material-efficient fluidic strategy for fast and accurate screening of new chemical absorbents designed for energy-efficient CO₂ capture and recovery. That's when I learned how to design, fabricate, and assemble microreactors for conducting chemical reactions in small scales. I was (and still am) fascinated by the potential of flow chemistry in rapidly conducting and efficiently screening challenging single/multi-phase chemical reactions. During the remaining 3 years of my graduate studies at the University of Toronto, I developed and utilized a variety of flow chemistry platforms utilizing silicon- and glass-based microreactors for in situ thermodynamic studies of fast gas-liquid reactions enabled by an image-based reaction monitoring strategy.

- 2) *What are the main benefits of flow that convinced you to use and implement this technology in your research?*

Accelerating the pace of research and discovery of new chemicals/materials through enhancing the heat and mass transfer rates, expanding the accessible reaction parameter space, and precise process control of chemical reactions while minimizing the reagent consumption and waste generation are the main reasons that we use flow chemistry in our research group. In addition, the overall process intensification and reduced process footprint for manufacturing of organic/inorganic materials achieved by *going with the flow* combined with the suitability of fluidic reactors with the *smart* manufacturing concept make flow synthesis the main thrust in our research laboratory.

Name	Milad Abolhasani
Date of Birth	03/21/1987
Position	Assistant Professor Department of Chemical and Biomolecular Engineering North Carolina State University Raleigh, NC, USA
E-mail	abolhasani@ncsu.edu
Homepage	www.abolhasanilab.com
Education	2014–2016 Postdoc, Chemical Engineering, Massachusetts Institute of Technology (USA) <i>Advisor: Prof. Klavs F. Jensen</i> 2010–2014 Ph.D., Mechanical & Industrial Engineering, University of Toronto (Canada) <i>Advisors: Prof. Eugenia Kumacheva and Prof. Axel Guenther</i> 2008–2010 M.A.Sc., Mechanical Engineering, University of British Columbia (Canada) 2004–2008 B.Sc., Mechanical Engineering, Sharif University of Technology (Iran)
Awards	2019 National Science Foundation (NSF) CAREER Award 2018 American Chemical Society Petroleum Research Fund (ACS PRF), Doctoral New Investigator Award 2018 Selected as the Editor's Choice of the inaugural Futures issue of the AIChE Journal 2018 Reaction Chemistry & Engineering Emerging Investigator 2017 Lab on a Chip Emerging Investigator 2015 Natural Sciences and Engineering Research Council of Canada (NSERC) Postdoctoral Fellowship

- 3) *What do you think the future holds for flow chemistry?*

Flow chemistry holds a great potential to revolutionize the way we have traditionally been conducting chemical reactions (i.e., cooking) for more than 2000 years. With the increased awareness of specialty and fine chemical industries about the benefits of flow chemistry and modular manufacturing in both R&D and scale-up production, I expect a major paradigm shift in the educational and research training of chemists/chemical engineers over the next decade. The future of flow chemistry is glowing!

- 4) *Do you have any relevant tips for newcomers in the field?*

The most important advice I can give to the newcomers in the field of flow chemistry is to try to understand the process of transferring a batch chemistry to flow in detail. Understanding the differences in heat and mass transport rates between batch and flow reactors will help you avoid getting frustrated when your reaction behaves differently in flow. Do not use a randomly designed microreactor to run your relatively complex multistep organic/inorganic synthesis in flow! Before *going with the flow*, choose (or design) the microreactor that meets all the requirements of

your specific chemical reaction (e.g., chemical compatibility, pressure and temperature rating, throughput, and mixing timescale).

Prof. Abolhasani's three most relevant papers related to flow chemistry:

- 1) K. Abdel-Latif, R. W. Epps, C. B. Kerr, C. papa, F. M. Castellano, and M. Abolhasani, "Facile Room Temperature Anion Exchange Reactions of Inorganic Perovskite Quantum Dots Enabled by a Modular Microfluidic Platform", *Adv. Funct. Mater.* **2019**, 29, 1,900,712.

This paper presents the unique advantages of modular flow reactors for accelerating the synthesis, screening, and optimization of colloidal nanomaterials).

- 2) C. Zhu, K. Raghuvanshi, C. W. Coley, D. Mason, J. Rodgers, M. Janka, and M. Abolhasani, "Flow Chemistry-Enabled Studies of Rhodium-Catalyzed

Hydroformylation Reactions", *Chem. Commun.* **2018**, 54, 8567–8570.

This paper presents a time- and material-efficient microscale flow chemistry strategy utilizing a single-droplet microreactor for rapid fundamental and applied studies of homogenous catalytic reactions.

- 3) J. Bennett, A. Kristof, V. Vasudevan, J. Genzer, J. Srogl, and M. Abolhasani, "Microfluidic Synthesis of Elastomeric Microparticles: A Case Study in Catalysis of Palladium-Mediated Cross-Coupling", *AIChE J.* **2018**, 64, 3188–3197.

This paper presents continuous flow synthesis and utilization of gel-supported catalytic microparticles using silicone elastomers as the catalyst support and palladium as the transition metal catalyst. The in-flow synthesized catalytic microparticles were then utilized in a micro packed-bed reactor to efficiently conduct Suzuki-Miyaura cross-coupling reactions under mild process conditions with minimum catalyst leaching.

Meet The Flow Chemist – Prof. Dr. Jean-Christophe M. Monbaliu

Name	Jean-Christophe M. Monbaliu
Date of Birth	September 23, 1982
Position	Associate Professor (University of Liège, Belgium)
E-mail	jc.monbaliu@uliege.be
Homepage	www.citos.uliege.be
Education	PhD (Organic Chemistry), 2008, Université catholique de Louvain, Belgium Postdoctoral Associate, 2008–2010, Ghent University, Belgium Postdoctoral Researcher, 2010–2013, FWO-Vlaanderen, Belgium Postdoctoral Fellow, 2010–2012, University of Florida, USA Postdoctoral Fellow, 2012–2013, Massachusetts Institute of Technology, USA
Awards	Belgian nominee for the EuChemS Young Investigator Award, 2017

- 1) *When did you start with flow chemistry? Describe the first paper or the first experiments.*

My first experience with flow chemistry dates back to my first postdoc in 2009. I had just defended my PhD in synthetic organic chemistry and had no clues on alternative process technologies – I came de facto with a batch mindset that is inherent to a conventional background in synthetic organic chemistry. I was therefore a bit intimidated at first. Flow chemistry was still in its infancy at the time, and education or resources were still scarce. I was in charge of a research program dedicated to the upgrading of biobased glycerol toward a fuel additive (solketal *tert*-butyl ether, STBE) at the Ghent University. The process involved isobutene among other chemicals. I soon realized that the efficiency, the safety and the potential scalability of the batch process were major hurdles to the successful development of such ambitious industrial project (the project originally aimed at 12,000 tons/year of fuel additive). Flow chemistry was first considered as plan B, but rapidly appeared to be the only viable option. This research program was a major turn in my scientific career and my first encounter with Corning's Advanced Flow Reactors. Since then, I have further strengthened my scientific relationship with Corning and my lab became in 2017 the first European Corning Qualified Laboratory.

- 2) *What are the main benefits of flow that convinced you to use and implement this technology in your research?*

In my early research years, I often used to get very frustrated with the feeling of not being able to unleash my full creativity as a chemist. My acquaintance with flow chemistry drastically changed my perspectives and expanded the horizon of what was achievable on a daily basis. The research developed in my group (www.citos.uliege.be)

combines innovative chemical strategies with flow process technologies. We exploit all the inherent assets of flow chemistry for (a) enabling more efficient routes for essential active pharmaceutical ingredients (APIs), (b) sustaining the transition toward biobased alternatives, (c) accelerating the transition toward safer/more efficient processes and (d) strategies with a lower environmental impact. Intensified process conditions, integration of multistep processes (reaction concatenation/telescoping) for the design of low footprint production strategies and/or safe generation of transient or hazardous chemical species are representative assets of flow chemistry that we exploit on a daily basis. Besides, the fast transition from lab to production scale with flow also concerns a significant part of my work since most of our research programs aim at scalable conditions. The group is partly operated as a technology platform that offers service to Industry for the development of pilot scale processes and for the preparation “à la carte” of value-added chemicals.

- 3) *What do you think the future holds for flow chemistry?*

Besides the obvious developing areas for flow chemistry (flow photochemistry, flow electrochemistry, personalized medication, chemistry in space, high energy materials) and its promising combination with AI and advanced automation, the fact that flow chemistry has the power to unleash the creativity of organic chemists is most certainly the main driving force for its future. Flow chemistry helps scientists to design completely unprecedented chemical strategies and is therefore vector of a profound revolution of the organic chemistry mindset, either for R&D and production purposes. As many of my

flow chemist fellows and mentors have already pointed out, education in flow chemistry in the early chemistry curricula is key to support this revolution. The lack of education is often presented as the main obstacle to a generalized adoption of flow by the synthetic organic chemistry community. Most of the new generations of chemists still enter their professional careers de facto with a batch mindset. Being involved myself in education, I am committed to demystify the core concepts of flow chemistry from the first years of the chemistry curriculum. The Corning Qualified Lab hosted in the group is a great platform for the students to get acquainted with new process technologies and acquire a mindset in phase with the challenges of the twenty-first century.

4) *Do you have any relevant tips for newcomers in the field?*

I strongly believe that every chemist should consider flow chemistry as a part of his/her mandatory background. Newcomers should not be intimidated neither by starting costs or the apparent complexity of flow chemistry; affordable solutions do exist to practice lab scale flow chemistry with fairly large groups of students or researchers. While being at the interface of chemical engineering and chemistry, flow chemistry does require some background in engineering, yet the concepts are rather accessible and should not be considered as a limiting factor for the adoption of flow as a daily tool for research in academic and industrial labs. One of the missions of the Corning Qualified Lab in my group is to promote training and education, even for chemistry professionals. Trained chemists typically become skilled flow chemists after a few weeks of practice. Some newcomers believe that flow chemistry is a universal solution for all process issues; it is not, and some might be very disappointed with the first trials. With practice however, it will open so many new windows and bring up so many different opportunities that flow chemistry drastically changes your perception of what is achievable in chemistry.

Prof. Monbaliu's three most relevant papers related to flow chemistry:

- 1) “Continuous flow upgrading of glycerol toward oxiranes and active pharmaceutical ingredients thereof” R. Morodo, R. Gérardy, G. Petit and J.-C. M. Monbaliu^{*}, *Green Chem.*, **2019**, 21, 4422–4433.

This article illustrates our efforts for the upgrading of biobased chemical platforms toward high valued-added chemicals (here pharmaceuticals). The assets of flow chemistry are exploited to convert biobased glycerol toward glycidol and epichlorohydrin using a unique organocatalyst.

- 2) “Expedient preparation of active pharmaceutical ingredient ketamine under sustainable continuous flow conditions” V.-E. Kassin, R. Gérardy, T. Toupay, D. Collin, E. Salvadeo, F. Toussaint, K. Van Hecke and J.-C. M. Monbaliu^{*}, *Green Chem.* **2019**, 21, 2952–2966.

Ketamine was one of the most intense research programs carried out in my group. We revisited the gold standard route toward active pharmaceutical ingredient ketamine and disclosed here a more sustainable and efficient strategy than any other batch precedents.

- 3) “On-demand continuous flow production of pharmaceuticals in a compact, reconfigurable system”, A. Adamo, R. L. Beingessner, M. Behnam, J. Chen, T. F. Jamison, K. F. Jensen, J.-C. M. Monbaliu, A. S. Myerson, E. Revalor, D. R. Snead, T. Stelzer, N. Weeranoppanant, S. Y. Wong, P. Zhang, *Science* **2016**, 352, 61–67.

This paper comes from my last postdoc at MIT with K. F. Jensen; it discloses the development of a fully integrated and automated production unit that relies on flow chemistry for the production of 4 active pharmaceutical ingredients (pharmacy on demand) with a minimal footprint. It rapidly became a landmark article for the flow chemistry community.