

# CORNING

Advanced-Flow™ Reactors



## AFR-related Publications

Issued: June 2020

### AFR performance\*

- A. Roibu, C. R. Horn, T. van Gerven, S. Kuhn  
Photon Transport and Hydrodynamics in Gas-Liquid Flows  
Part 2: Characterization of Bubbly Flow in an Advanced-Flow Reactor  
WILEY-VCH Verlag GmbH & Co <https://doi.org/10.1002/cptc.202000066> (2020)  
*Topic: Photochemistry*
- O. Lobet, A. Vizza  
SiC Advanced-Flow Reactors for Highly Corrosive Media  
Specialty Chemical Magazine, 36(08), 32-35 (2016)  
*Topic: Silicon carbide description and characterization*
- M.J. Nieves-Remacha, K.F. Jensen  
Mass transfer characteristics of ozonolysis in microreactors and Advanced-Flow reactors  
Journal of Flow Chemistry, 5 (3), pp. 160-165 (2015)  
*Topic: Low Flow and G1 fluidic modules, gas/liquid mass transfer*
- M.J. Nieves-Remacha, A.A. Kulkarni, K.F. Jensen  
OpenFOAM Computational Fluid Dynamic Simulations of Single-Phase Flows in an Advanced-Flow Reactor  
Industrial and Engineering Chemistry Research, 54 (30), pp. 7543-7553 (2015)  
*Topic: G1 fluidic module, liquid flow, pressure drop, residence time distribution*
- M.J. Nieves-Remacha, L. Yang, K.F. Jensen  
OpenFOAM Computational Fluid Dynamic Simulations of Two-Phase Flow and Mass Transfer in an Advanced-Flow Reactor  
Industrial and Engineering Chemistry Research, 54 (26), pp. 6649-6659 (2015)  
*Topic: G1 fluidic module, liquid/liquid flow and mass transfer*
- K.J. Wu, V. Nappo, S. Kuhn  
Hydrodynamic Study of Single- and Two-Phase Flow in an Advanced-Flow Reactor  
Industrial and Engineering Chemistry Research, 54 (30), pp. 7554-7564 (2015)  
*Topic: G1 fluidic module, PIV (particle image velocimetry), liquid and gas/liquid flow*
- M. Moreau, N. Di Miceli Raimondi, N. Le Sauze, M. Cabassud, C. Gourdon  
Pressure drop and axial dispersion in industrial millistructured heat exchange reactors  
Chemical Engineering and Processing, 95, pp. 54–62 (2015)  
*Topic: G1 fluidic modules, pressure drop and residence time distribution*

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- A. Woitalka, S. Kuhn, K.F. Jensen  
Scalability of mass transfer in liquid–liquid flow  
Chemical Engineering Science 116, 1-8 (2014)  
*Topic: G1 and Low Flow fluidic modules, Liquid/Liquid flow and mass transfer*
- M.J. Nieves-Remacha, A.A. Kulkarni, K.F. Jensen  
Gas-liquid flow and mass transfer in an Advanced-Flow reactor  
Industrial and Engineering Chemistry Research, 52 (26), pp. 8996-9010 (2013)  
*Topic: G1 fluidic module, Gas/Liquid flow and mass transfer*
- E.D. Lavric, C. Cerato-Noyerie  
Mass transfer in gas-liquid flow in Corning® Advanced-Flow™ reactors  
Chemical Engineering Transactions, 29, pp. 979-984 (2012)  
*Topic: G1 fluidic module, gas/Liquid flow and mass transfer*
- M.J. Nieves-Remacha, A.A. Kulkarni, K.F. Jensen  
Hydrodynamics of liquid-liquid dispersion in an advanced-flow reactor  
Industrial and Engineering Chemistry Research, 51 (50), pp. 16251-16262 (2012)  
*Topic: G1 fluidic module, liquid/liquid flow and mass transfer*
- J. Jorda, A. Vizza  
From laboratory to production: A seamless scale-up  
Speciality Chemicals Magazine, Nov., pp. 19-21, (2012)  
*Topic: scale-up*
- M.S. Chivilikhin, L.L. Kuandykov, C. Cerato-Noyerie, P. Woehl, E.D. Lavric  
Residence Time Distribution in Corning AFR. Experiment and modeling  
Chemical Engineering Transactions, 25, pp. 791-796 (2011)  
*Topic: G1 and Low Flow fluidic modules, residence time distribution*
- F. Zhang, C. Cerato-Noyerie, P. Woehl, E.D. Lavric  
Intensified liquid/liquid mass transfer in Corning® Advanced-Flow™ Reactors  
Chemical Engineering Transactions, 24, pp. 1369-1374 (2011)  
*Topic: Low Flow fluidic module, liquid/liquid mass transfer*
- M.S. Chivilikhin, V. Soboleva, L. Kuandykov, P. Woehl, E.D. Lavric  
CFD analysis of hydrodynamic and thermal behaviour of Advanced-Flow™ reactors  
Chemical Engineering Transactions, 21, pp. 1099-1104 (2010)  
*Topic: G1 fluidic module, velocity field, pressure drop and heat transfer*
- E.D. Lavric, P. Woehl  
Advanced-Flow™ glass reactors for seamless scale-up  
Chemistry Today, 27 (3), pp. 45-48 (2009)  
*Topic: G1 and G2 fluidic modules, mixing, pressure drop, residence time distribution, heat transfer coefficient*
- E.D. Lavric  
Thermal performance of Corning glass microstructures, Heat Transfer and Fluidic Flow in Microscale III 2008

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## Photochemistry applications\*

- P. Bianchi, G. Petit, J. C. Monbaliu  
Scalable and robust photochemical flow process towards small spherical gold nanoparticles  
Reaction Chemistry Engineering, Accepted Manuscript, <https://doi.org/10.1039/D0RE00092B> (2020)
- C. R. Horn, S. Gremetz  
A method to determine the correct photocatalyst concentration for photooxidation reactions conducted in continuous flow reactors  
Beilstein Journal of Organic Chemistry, 16, 871-879 (2020)
- N. Emmanuel, P. Bianchi, J. Legros, J. M. Monbaliu  
A safe and compact flow platform for the neutralization of a mustard gas simulant with air and light  
Green Chemistry, DOI: 10.1039/D0GC01142H (2020)
- A. Steiner, J.D. Williams, O. de Frutos, J.A. Rincón, C. Mateos, C.O. Kappe  
Continuous photochemical benzylic bromination using in situ generated Br<sub>2</sub>: process intensification towards optimal PMI and throughput  
Green Chemistry, 22, pp. 448-454, (2020)
- A. Steiner, J.D. Williams, J. A Rincón, O. de Frutos, C. Mateos, C. O. Kappe  
Implementing Hydrogen Atom Transfer (HAT) Catalysis for Rapid and Selective Reductive Photoredox Transformations in Continuous Flow  
European Journal of Organic Chemistry, 25, 5807-5811. DOI: 10.1002/ejoc.201900952 (2019)
- R. Lebl, D. Cantillo, C.O. Kappe  
Continuous generation, in-line quantification and utilization of nitrosyl chloride in photonitrosation reactions  
Reaction Chemistry & Engineering, 4 (4), pp. 738-746 (2019)
- J.D. Williams, M. Nakano, R. Gérardy, J.A. Rincón, Ó. de Frutos, C. Mateos, J.C.M. Monbaliu  
C.O. Kappe  
Finding the Perfect Match: A Combined Computational and Experimental Study toward Efficient and Scalable Photosensitized [2 + 2] Cycloadditions in Flow  
Organic Process Research & Development, 23 (1), pp. 78-87 (2019)
- X.-F. Tang, J.-N. Zhao, Y.-F. Wu, Z.-H. Zheng, S.-H. Feng, Z.-Y. Yu, G.-Z. Liu, Q.-W. Meng  
Enantioselective photooxygenation of  $\beta$ -dicarbonyl compounds in batch and flow photomicroreactors  
Organic & Biomolecular Chemistry, 17, 7938-7942, (2019)
- Cristian Rosso, Jason D. Williams, Giacomo Filippini, Maurizio Prato, C. Oliver Kappe  
Visible-Light-Mediated Iodoperfluoroalkylation of Alkenes in Flow and Its Application to the Synthesis of a Key Fulvestrant Intermediate  
Organic Letters, 21 (13), 5341-5345, (2019)
- Anhua Hu, Yilin Chen, Jing-Jing Guo, Na Yu, Qing An, Zhiwei Zuo  
Cerium-catalyzed Formal Cycloaddition of Cycloalkanols with Alkenes through Dual Photoexcitation  
J. Am. Chem. Soc., 140, 42, pp 13580-13585, (2018)

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- Y. Chen, O. de Frutos, C. Mateos, J.A. Rincon, D. Cantillo, C.O. Kappe  
Continuous Flow Photochemical Benzylic Bromination of a Key Intermediate in the Synthesis of a 2-Oxazolidinone  
ChemPhotoChem 2 (2018)
- G. Gauron, J. Ao, S. Gremetz, C.R. Horn  
Powerful scalable photochemistry: The efficient use of light  
Chemistry Today, 36 (4), pp. 12-15 (2018)
- Anhua Hu\*, Jing-Jing Guo\*, Hui Pan, Zhiwei Zuo  
Selective functionalization of methane, ethane, and higher alkanes by cerium photocatalysis  
Science, Vol. 361, Issue 6403, pp. 668-672 (2018)
- R. Gérardy, M. Winter, C.R. Horn, A. Vizza, K. Van Hecke, J-C.M. Monbaliu  
Continuous-flow preparation of  $\gamma$ -butyrolactone scaffolds from renewable fumaric and itaconic acids under photosensitized conditions  
Organic Process Research and Development 21 (12), pp. 2012-2017 (2017)
- N. Emmanuel, C. Mendoza, M. Winter, C.R. Horn, A. Vizza, L. Dreesen, B. Heinrichs, J-C.M. Monbaliu  
Scalable Photocatalytic Oxidation of Methionine under Continuous-Flow Conditions  
Organic Process Research and Development 21 (9), pp 1435–1438 (2017)
- S. Elgue, T. Aillet, K. Loubiere, A. Conté, O. Dechy-Cabaret, L. Prat, C.R. Horn, O. Lobet, S. Vallon  
Flow photochemistry: A meso-scale reactor for industrial applications  
Chemistry Today, 33 (5), pp. 58-61 (2015)

#### Other applications\*

- D.M. Le, Bougrine A.J., O. Duclos, V. Pasquet, H. Delalu  
A new strategy for the synthesis of monomethylhydrazine using the Raschig process. 2: Continuous synthesis of stoichiometric monochloramine using the microreactor technology  
Reaction Kinetics, Mechanisms and Catalysis (2020)
- V.H Kassin, T. Toupy, G. Petit, P. Bianchi, E. Salvadeo, J-C M. Monbaliu  
Metal-free hydroxylation of tertiary ketones under intensified and scalable continuous flow conditions  
Journal of Flow Chemistry 10, 167–179 (2020)
- R. Gérardy, J. Estager, P. Luis, D. P. Debecker, J-C. M. Monbaliu  
Versatile and scalable synthesis of cyclic organic carbonates under organocatalytic continuous flow conditions  
Catalysis Science & Technology, 9, pp. 6841-6851, (2019)
- R. Morodo, R. Gérardy, G. Petit, J-C. M. Monbaliu  
Continuous flow upgrading of glycerol toward oxiranes and active pharmaceutical ingredients thereof  
Green Chemistry, 21, pp. 4422-4433, (2019)

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- V.-E. Kassin, R. Gérardy, T. Toupy, D. Collin, E. Salvadeo, F. Toussaint, K. Van Hecke, J-C. M. Monbaliu  
Expedient Preparation of Active Pharmaceutical Ingredient Ketamine under Sustainable Continuous Flow Conditions  
Green Chemistry, 21, pp. 2952-2966, (2019)
- Z. Wang, R. Gérardy, G. Gauron, C. Damblon, J-C.M. Monbaliu  
Solvent-free organocatalytic preparation of cyclic organic carbonates under scalable continuous flow conditions  
Reaction Chemistry & Engineering, 4 (1), pp. 17–26 (2019)
- S.C. Born, C.E.R. Edwards, B. Martin, K.F. Jensen  
Continuous, on-demand generation and separation of diphenylphosphoryl azide  
Tetrahedron 74 (25), pp. 3137-3142 (2018)
- S. Suranani, Y. Maralla, S.M. Gaikwad, S.H. Sonawane  
Process intensification using Corning® Advanced-Flow™ reactor for continuous flow synthesis of biodiesel from fresh oil and used cooking oil  
Chemical Engineering & Processing: Process Intensification, 126, pp. 62–73 (2018)
- P.L. Suryawanshi, S.H. Sonawane, B.A. Bhanvase, M. Ashokkumar, M.S. Pimplapure, P.R. Gogate  
Synthesis of iron oxide nanoparticles in a continuous flow spiral microreactor and Corning® Advanced-Flow™ reactor  
Green Processing and Synthesis, 7 (1), pp. 1-11 (2018)
- C. Penverne, B. Hazard, C. Rolando, M. Penhoat  
Scale-up Study of Benzoic Acid Alkylation in Flow: From Microflow Capillary Reactor to a Milliflow Reactor  
Organic Process Research and Development 21 (11), pp. 1864-1868 (2017)
- R. Gerardy, M. Winter, A. Vizza, J-C.M. Monbaliu  
Assessing inter- and intramolecular continuous flow strategies towards methylphenidate (Ritalin) hydrochloride  
Reaction Chemistry & Engineering 2, 149-158 (2017)
- K. Lee, H. Lin, K.F. Jensen  
Ozonolysis of quinoline and quinoline derivatives in a Corning low flow reactor  
Reaction Chemistry & Engineering, 2(5), 696-702 (2017)
- S.M. Gaikwad, P.D. Jolhe, B.A. Bhanvase, (...), S.H. Sonawane, S.S. Sonawane  
Process intensification for continuous synthesis of performic acid using Corning Advanced-Flow reactors  
Green Processing and Synthesis, 6 (2), pp. 189-196 (2017)
- Y. Maralla, S. Sonawane, D. Kashinath, M. Pimplapure, B. Paplal  
Process Intensification of Tetrazole reaction through tritylation of 5-[4'-(Methyl) Biphenyl-2-YI] using microreactors,  
Chemical Engineering & Processing: Process Intensification, 112, pp. 9-17 (2017)

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- U. Novak, D. Lavric, P. Žnidaršič-Plazl  
Continuous lipase B-catalyzed isoamyl acetate synthesis in a two-liquid phase system using Corning® AFR™ module coupled with a membrane separator enabling biocatalyst recycle  
Journal of Flow Chemistry, 6 (1), pp. 33-38 (2016)
- M. Peer, N. Weeranoppanant, A. Adamo, Y. Zhang, K.F. Jensen  
Biphasic Catalytic Hydrogen Peroxide Oxidation of Alcohols in Flow: Scale-up and Extraction  
Organic Process Research & Development, 20 (9), pp. 1677-1685 (2016)
- Y. Zhang, S.C. Born, K.F. Jensen  
Scale-up investigation of the continuous phase-transfer-catalyzed hypochlorite oxidation of alcohols and aldehydes  
Organic Process Research and Development, 18 (11), pp. 1476-1481 (2014)
- C. Horn, C. Cerato-Noyerie  
A PdCl<sub>2</sub>-based hydrogenation catalyst for glass microreactors  
Journal of Flow Chemistry, 4 (3), pp. 110-112 (2014)
- E. Rossi, P. Woehl, M. Maggini  
Scalable in Situ Diazomethane Generation in Continuous-Flow Reactors  
Organic Process Research & Development 16, pp. 1146-1149 (2012)
- J.C.M. Monbaliu, M. Winter, B. Chevalier, F. Schmidt, Y. Jiang, R. Hoogendoorn, M.A. Kousemaker, C.V. Stevens  
Effective production of the biodiesel additive STBE by a continuous flow process  
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- J.C.M. Monbaliu, J. Jorda, B. Chevalier, C.V. Stevens, B. Morvan  
Continuous-flow production of alkyl nitrites  
Chemistry Today 29 (3), pp. 50-52 (2011)
- G.S. Calabrese, S. Pissavini  
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- J.C.M. Monbaliu, M. Winter, B. Chevalier, F. Schmidt, Y.I. Jiang, R. Hoogendoorn, M. Kousemaker, C.V. Stevens  
Feasibility study for industrial production of fuel additives from glycerol  
Chemistry Today 28 (4), pp. 8-11 (2010)
- S. Braune, P. Pöchlauer, R. Reintjens, S. Steinhöfer, M. Winter, O. Lobet, R. Guidat, P. Woehl, C. Guermeur  
Selective nitration in a microreactor for pharmaceutical production under cGMP conditions  
Chemistry Today 27, pp. 26-29 (2009)
- B. Buisson, S. Donegan, D. Wray, A. Parracho, J. Gamble, P. Caze, J. Jorda, C. Guermeur  
Slurry hydrogenation in a continuous flow reactor for pharmaceutical application  
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## Miscellaneous\*

- A. Moniri, H. Wang, X. (Eric) Wu  
Application of corrosion-resistant Corning advanced-flow reactors for multiphase Bunsen reaction  
Part one: Investigation on SO<sub>2</sub> absorption  
International Journal of Petrochemical Science & Engineering 4(4), 122-136, (2019)
- A. Moniri, H. Wang, X. (Eric) Wu  
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- R. Gérardy, N. Emmanuel, T. Toupy, V. Kassin, N. Ntumba Tshibalonza, M. Schmitz, J.-C. M. Monbaliu  
Continuous Flow Organic Chemistry: Successes and Pitfalls at the Interface with Current Societal Challenges  
European Journal of Organic Chemistry, pp. 2301-2351, (2018)
- D. Lavric, O. Lobet, R. Guidat, A. Vizza, Y. Jiang  
Corning® Advanced-Flow™ Reactors: Innovation Drives Continuous Flow Manufacturing of Chemicals  
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- H.G. Jolliffe, D.I. Gerogiorgis  
Plantwide design and economic evaluation of two Continuous Pharmaceutical Manufacturing (CPM) cases:  
Ibuprofen and artemisinin  
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- R. Guidat, A. Vizza, Y. Jiang  
Advanced-Flow Reactor Technologies Makes Continuous-Flow Industrial Production Real  
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- O. Bleie, M.F. Roberto, T. I. Dearing, Ch.W. Branham, O.M. Kvalheim, B.J. Marquardt  
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Integration of Continuous Flow Reactors and Online Raman Spectroscopy for Process Optimization  
J Pharm Innov 7, pp. 69–75 (2012)
- G.A. Marus  
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- F. Schmidt, B.Chevalier  
The future flows through Corning® Advanced-Flow™ glass reactors. Engineered to move you to market  
faster and more efficiently  
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- D. Roberge, M. Gottsponer, M. Eyholzer, N. Kockmann  
Industrial design, scale-up and use of microreactors  
Chemistry Today. Vol 27 n4 / July-August (2009)

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- P. Barthe, C. Guermeur, O. Lobet, M. Moreno, P. Woehl, D.M. Roberge, N. Bieler, B. Zimmermann, Continuous multi-injection reactor for multipurpose production - Part I  
Chemical Engineering and Technology 31, pp. 1146-1154 (2008)
- D.M. Roberge, N. Bieler, M. Mathier, M. Eyholzer, B. Zimmermann, P. Barthe, C. Guermeur, O. Lobet, M. Moreno, P. Woehl  
Development of an industrial multi-injection microreactor for fast and exothermic reactions - Part II  
Chemical Engineering and Technology 31, pp. 1155-1161 (2008)
- B. Chevalier  
Corning microreaction technology, a process intensification solution designed for industrial production  
Chemistry Today 26 (5), pp. 6-7 (2008)
- B. Chevalier, E.D. Lavric, C. Cerato-Noyerie, C.R. Horn, P. Woehl  
Microreactors for industrial multi-phase applications. Test reactions to develop innovative glass microstructure designs  
Chemistry Today, 26 (2), pp. 38-42 (2008)

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