Scientific expertise and research achievements

Patrice Perreault obtained his PhD with honors in 2016 in Chemical Engineering from Polytechnique Montreal, then joined the Laboratory for Chemical Technology as a postdoctoral researcher. He then spent 2 years in Mexico as a professor at the UADY. In 2019, he joined the University of Antwerp in the DuEL research group, leading research on hydrogen storage. Since 2023, he created the Laboratory for the Electrification of Chemical Processes and Hydrogen (ElectrifHy) at UAntwerp, dedicated to revolutionizing how energy is harnessed and utilized in the chemical sector. At ElectrifHy, jointly with UGent's LCT, he develops new solutions and offer engineering expertise to ensure the smooth deployment of urgently needed energy-efficient power-to-heat technologies. By electrically supplying the heat required for chemical conversion, we are pioneering new methods to optimize energy usage, reduce carbon emissions, and enhance the overall sustainability of industrial processes.

ElectrifHy is located in UAntwerp's brand new innovation hub Blue App, is dedicated to chemical reactor design (CFD and engineering models), prototyping and experimental characterization of heat & mass transfer of electrified processes (ohmic and induction heating, and the use of electrical field to enhance chemical conversion). Through collaboration with industry partners and leveraging state-of-the-art facilities, we provide guidelines for the cost-effective scaling-up of electrical chemical processes. We strive to improve their energy efficiencies, to elaborate temperature control strategies and to integrate a modular approach to deal with the fluctuating nature of renewable electricity.

The applications studied range from hydrogen-related processes (e.g., ammonia cracking, SMR, dehydrogenation of LOHC) to any chemical processes where heat is replaced by electricity (e.g., non-oxidative coupling of methane in an electrothermal fluidized bed). In addition, Prof Perreault specializes in fluidization (various conventional 2-3 phases and swirling fluidized bed prototypes, including fluidization at extreme conditions – up to 60 bars). ElectrifHy has extensive infrastructure related to process intensification (centrifugal devices, electrification of chemical processes via induction and resistive heating), in addition to in-line gas analysis techniques (QMS, TCD, RGA GC) necessary to follow the performance of chemical reactors, as well as to diagnose their proper operation with non-instrusive tools (pressure fluctuation, PIV, DIA).

Principle scientific staff

As a recently appointed professor**, Prof. Patrice Perreault** supervises 8 ongoing PhDs (5 at UA, 3 at UGent), and 1 postdoctoral fellow. He is author of 32 articles (h-index 16) and holder of 1 international patent (a second one in the PCT phase). He was appointed as the Blue App (University of Antwerp preincubator) Technology developer. His research focuses on reactor development and scale-up for heterogeneous catalytic and non-catalytic applications in intensified chemical reactors, by combining simulations (CFD and engineering models), multi-parameter, shape optimization of turbulent reacting flows, and experimental prototyping. In terms of applications, Prof Perreault develops and characterize innovative electrified (joule and inductively-heated) reactors for ammonia cracking, non-oxidative coupling of methane for hydrogen and olefins production (Cameleon project), release of H_2 from LOHC and hydrogen storage in solids (Arclath project), as well as hydrogen purification using adsorption (HyPact project) and membranes (Cameleon project). Relevant for this project, Patrice Perreault designed various packed and electrified and intensified fluidized bed reactors for operation at extreme conditions (high pressure & low/high temperature).

5 most important publications with scientific relevance for the project

1. P. Perreault, C.R. Boruntea, H. Dhawan Yadav, I. Portela Soliño, N.B. Kummamuru, *Combined Methane Pyrolysis and Solid Carbon Gasification for Electrified CO_2-Free Hydrogen and Syngas Production*. Energies, **2023**, 16 (21), 7316.

2. G. Jiménez, A. Verdeza, A.J. Orozco-Jimenez, A. Bula, P. Perreault, A. Gonzalez-Quiroga, *Swirling fluidized bed hydrodynamics: Experimental and angular momentum-based assessment*. Chem. Eng. J., **2025**, 505, 158867.
3. A.J. Orozco-Jimenez, D.A. Pinilla-Fernandez, V. Pugliese, A. Bula, P. Perreault, A. Gonzalez-Quiroga, *Angular momentum Based-Analysis of Gas-Solid fluidized beds in vortex chambers*. Chem. Eng. J., **2023,** 407, 141222.
4. L. Van Hoecke, N.B. Kummamuru, H. Pourfallah, S. Verbruggen, P. Perreault, *Intensified swirling reactor for the dehydrogenation of LOHC*. Int. J. Hydrogen Energy, **2024**, 51, 611-623.
5. A. Gonzalez-Quiroga, P.A. Reyniers, S.R. Kulkarni, M.M. Torregrosa, P. Perreault, G.J. Heynderickx, K.M. Van Geem, G.B. Marin, *Design and cold flow testing of a Gas-Solid Vortex Reactor demonstration unit for biomass fast pyrolysis*. Chem. Eng. J., **2017**, 329, 198-210.

Previous, current and planned research activities and projects related to the electrification of chemical processes

CAMELEON (Moonshot ESI, 2024-2028): A new energy efficiency paradigm via the formation of olephins and by-product hydrogen by the non-oxidative coupling of methane in an electrothermal fluidized bed.

ATLANTIS (Moonshot ESI, 2025-2029): Coupling of the Oxidative Coupling of Methane (OCM), a highly exothermic process, with steam cracking, a highly endothermic process. This allows the production of olefins without the need for expensive renewable electricity or the combustion of fuel gas or natural gas. Furthermore, the ATLANTIS project aims to couple the OCM effluent to a hydroformylation (HF) reactor to exploit typical OCM compositions and obtain C3 molecules, such as propanol, derived from methane.

HyPact & HyPact 2 (FOD-economie, 2022-2029): Cracking of green ammonia to hydrogen using innovative catalyst and adsorbent assisted plasma technology. Our WP is concerned with the purification and recovery of ammonia from the cracked gas using an electrified TSA.

ARCLATH-2 (Moonshot ESI, 2019-2023): How energy, in the form of molecular hydrogen, can be stored and transported in a crystal structure, so-called clathrates. As part of the Arclath 2 sprint cSBO continuation project, we are scaling up the technology in a 50 g fluidized bed at -15 °C and 60 bar. Non-intrusive reactor diagnosis tools are also investigated (pressure fluctuation analysis).

ARCLATH (Moonshot sprint cSBO, 2017-2019): How energy, in the form of molecular hydrogen, can be stored and transported in a crystal structure, so-called clathrates. This way, a new storage and transportation system is available so renewable energy can be used where and when it is needed.

IOF SBO Research Grant: "Electrified chemical reactor for fast release of hydrogen (H2) from liquid organic hydrogen carriers (LOHCs) for generator set (genset). H_2 genset testing on a ship (Port of Future)"

BOF DOCPRO4 PhD Fellowship: "CFD-Assisted Design of an Innovative Multiphase Chemical Reactor for Hydrogen Release"