LABORATORY FOR CHEMICAL TECHNOLOGY
Technologiepark 125, 9052 Gent, Belgium

Postdoctoral Researcher: Catalytic Chemical Recycling of Plastic Waste using a Vortex Reactor

Aim

Advance the development of the vortex reactor as a platform for catalytic chemical recycling of mixed plastic waste, focusing on understanding the interplay between reactor hydrodynamics, catalytic activity, and product selectivity in fast pyrolysis conditions.

Justification

Plastics are indispensable materials but represent a major challenge at end-of-life, particularly for mixed and contaminated waste streams that cannot be efficiently treated by mechanical recycling. Chemical recycling, and specifically pyrolysis, provides a pathway to convert these materials into monomers and valuable hydrocarbons. However, conventional reactor technologies such as fluidized beds or stirred tanks often suffer from poor heat transfer and long residence times, leading to unwanted secondary reactions and byproduct formation.

The vortex reactor, recently demonstrated at the Laboratory for Chemical Technology (LCT) at Ghent University, enables fast heating, short residence times (milliseconds), and enhanced mass and heat transfer. This design minimizes secondary reactions and maximizes monomer yields, such as styrene from polystyrene pyrolysis, achieving recoveries above 85 wt%.

Building on this foundation, the next step is to integrate catalytic functionality into the vortex reactor to selectively upgrade plastic-derived intermediates and tackle mixed plastic waste. Catalysts—acidic, metal-based, or bifunctional—can promote dechlorination, aromatization, or selective cracking, while the vortex regime ensures excellent contact between the hot gas and reactive surface.

Program

The postdoctoral researcher will:

- Characterize representative mixed plastic waste streams (polyolefins, polystyrene, PVC-containing fractions) and quantify the impact of impurities and additives on catalytic and non-catalytic pyrolysis behavior.
- Design and conduct experiments in the pilot-scale vortex reactor under both thermal and catalytic conditions, testing various catalyst formulations (e.g., zeolites, aluminosilicates, metal oxides, bifunctional materials).
- Develop catalyst integration strategies, including in situ or ex situ configurations, supported catalyst coatings, or co-feeding of particulate catalysts.
- Use advanced online analytics (GC×GC-FID, RGA, MS) to quantify products and intermediates, enabling mechanistic insight into catalytic pathways and secondary reactions.
- Establish kinetic and reactor models linking operating parameters, catalyst characteristics, and hydrodynamics to product selectivity and reactor performance.
- Assess scalability and process intensification potential, identifying optimal catalytic conditions that balance selectivity, stability, and energy efficiency.

Expected Outcomes

- Mechanistic understanding of catalytic versus non-catalytic pyrolysis under vortex flow conditions.
- Identification of catalyst–reactor synergies that enable selective monomer recovery and impurity mitigation.
- Quantitative models to guide scaling and design of catalytic vortex reactors for industrial advanced recycling.
- Contribution to the development of sustainable, circular routes for mixed plastic waste valorization.

Supervisor(s): Prof. Kevin M. Van Geem and Prof. Yi Ouyang, Laboratory for Chemical Technology (LCT), Department of Materials, Textiles and Chemical Engineering, Ghent University.

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