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Chemical recycling of mixed plastic waste: a combined experimental and modelling study

Aim

The aim of this thesis is to develop a detailed understanding of the pyrolysis of complex mixed plastic waste streams, with a focus on the impact of contaminants, using a combination of experimental and modelling work. Figure 1 summarizes the underlying philosophy.

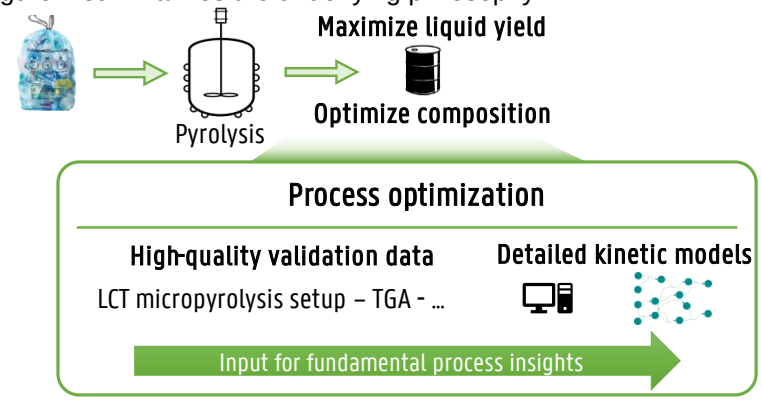

Figure 1: Graphical illustration of the working approach that will be followed during this thesis.

Justification

Alternative chemical recycling processes are needed to solve the global plastic waste crisis, with pyrolysis being the most promising one. Pyrolysis breaks plastics down into lighter products: char, light gases, and a pyrolysis oil. The latter product is a high-potential, renewable feedstock for the chemical industry, drawing significant industrial attention from companies like DOW, Borealis, TotalEnergies, Shell, and Neste.

Given the inhomogeneity of the SPW, especially the presence of heteroatom-containing polymers (PET, PVC, PA…), pyrolysis processes can only be optimized if the underlying kinetics, reaction mechanism, and product spectrum are thoroughly studied and understood. This understanding can only be obtained by constructing detailed kinetic models, validated using high-quality experimental data (as illustrated in Figure 1).

Therefore, this thesis will combine both an experimental and modelling effort. First, detailed experimental data will be gathered from thermogravimetric measurements, (time-resolved) experiments on LCT's unique experimental infrastructure, including the micropyrolysis and RQChem pilot setups. This data will facilitate an accurate identification and quantification of all pyrolysis products. These data will lay an ideal foundation for the construction of detailed single-event microkinetic models, which will describe the full complexity of the pyrolysis process.

Program

The envisioned program of the thesis contains the topics listed below. The exact focus of the work is to be discussed between the coach and the student.

- Detailed literature study on pyrolysis of solid plastic waste (SPW) as well as pure and mixed polymer feedstocks such as PE, PS, PET, biomass, PA, PU, and PP.
- Apply and extend the currently available in-house kinetic models to accurately simulate the experimental data.

- Experimental study of the pyrolysis of several plastic waste and model compounds, using the LCT's dedicated experimental infrastructure (GC x GC, micropyrolyzer, pilot-scale pyrolysis setup). These data will be bundled with the developed kinetic models.