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Life cycle assessment of alternative olefin production technologies using waste derived feedstock

Aim

This thesis aims at performing a full prospective life cycle assessment of novel waste-to-olefins technologies studied within LCT such as gasification and waste polyolefin pyrolysis with following steam cracking of obtained hydrocarbon mix and single – step catalytic upgrading of polyolefins.

Justification

Petrochemical industry in Europe (EU28 plus Norway and Switzerland) currently produces over 62 million tons of plastic packaging products, major fraction of which (~60%) is incinerated of landfilled at the end of it's life cycle. The emergence of circular economy opens market for novel recycling technologies designed to minimize carbon loss and ensure high quality of recycled material. Steam cracking of pyrolysis oils is expected to become a major pathway for recycling. Moreover, novel options such as single – step catalytic upgrading of polyolefins to olefin rich gas should be considered and benchmarked in terms of sustainability and economic feasibility.

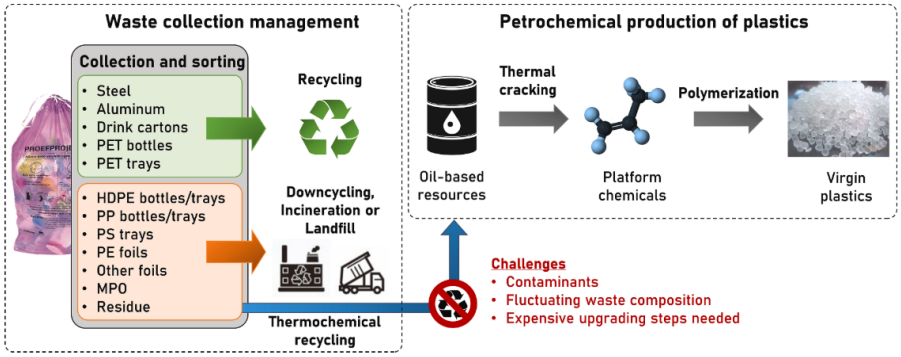

Figure 1. Schematic overview of current waste recycling options and potential of thermochemical recycling [1]

Five different options are being studied at LCT with a phosphorus-modified and steam-treated mesoporous HZSM-5 zeolite catalyst [2] as one of the most promising.

Program

- Literature survey on waste-to-olefin processes [3]
- Thorough simulation of considered process and validation against experimental data
- Prospective process design on cradle to gate basis (accounting for all processes needed to convert waste polyolefins into marketable basic chemicals)
- Heat integration and Pinch analysis
- Performing life cycle assessment according to ISO 14040 series of standards [4]

References

[1] M. Kusenberg *et al.*, "Opportunities and challenges for the application of post-consumer plastic waste pyrolysis oils as steam cracker feedstocks: To decontaminate or not to decontaminate?,"

Met opmaak: Engels (Verenigde Staten)

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Waste Manag., vol. 138, pp. 83–115, Feb. 2022, doi: 10.1016/J.WASMAN.2021.11.009.

[2] A. Eschenbacher *et al.*, "Highly selective, single-step conversion of mixed polyolefins to valuable base chemicals using phosphorus-modified and steam-treated mesoporous HZSM-5 zeolite with minimal carbon footprint," *Energy Environ. Sci.*, 2021.

[3] J. P. Lange, "Managing Plastic Waste-Sorting, Recycling, Disposal, and Product Redesign," *ACS Sustain. Chem. Eng.*, vol. 9, no. 47, pp. 15722–15738, 2021, doi: 10.1021/acssuschemeng.1c05013.

[4] ISO, "14040: Environmental management–life cycle assessment—Principles and framework," *Int. Organ. Stand.*, 2006.