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Upgrading of plastic waste pyrolysis oils towards suitable steam cracker feedstocks: technology assessment and experimental investigation

Aim

The aim of this master thesis is the comprehensive assessment of upgrading techniques for plastic waste pyrolysis oils towards suitable feedstocks for industrial-scale steam crackers including in-depth experimental investigation of selected techniques.

Justification

Thermochemical recycling of plastic packaging waste to base chemicals via pyrolysis followed by a minimal amount of upgrading and steam cracking is expected to be the dominant chemical recycling technology in the coming decade. However, there are substantial safety and operational risks when using plastic waste pyrolysis oils instead of conventional fossil-based feedstocks. Plastic waste pyrolysis oils typically do not comply with industrial feedstock specifications due to high amounts of olefins and contaminants. Consequently, thorough upgrading is needed before pyrolysis oils can (partly) replace fossil-based feedstocks such as fossil naphtha. In this endeavor it is very important that techniques are found that reliably remove contaminants while at the same time are feasible from an economic standpoint to enable competition with fossil-based feedstocks. Potential techniques are distillation, hydrotreatment, filtration and adsorption.
In this thesis project, an extensive literature study will be performed on potential decontamination techniques, industrial applications and integrated solutions to gain a comprehensive understanding of all upgrading solutions. Based on this knowledge, a set of continuous steam cracking experiments will be performed at the bench-scale steam cracking (BBSC) setup at LCT using an untreated distilled pyrolysis oil, a filtered oil and a hydrotreated oil. Steam cracking effluent analysis will be performed using a combination of a so-called refinery gas analyzer (RGA) and on-line comprehensive two-dimensional gas chromatography (GC × GC). Combined with a coke-formation assessment using infrared analysis, a detailed overview of the performance of the respective feedstocks will be gained and hence a conclusive assessment of the performance of the respective upgrading techniques can be made. This way, an important knowledge gap will be closed and thermochemical recycling of plastic waste will be pushed one step closer to industrial application.

Program

- Literature study:
  - Steam cracking of plastic waste pyrolysis oil
  - Decontamination techniques for pyrolysis oils
- Detailed analysis of treated and untreated pyrolysis oils using a wide set of analytical techniques
- Steam cracking of pyrolysis oils (untreated vs. upgraded)
  - Studying the effect on the product yields
  - Coke formation assessment