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Steam cracking distillates of plastics waste pyrolysis – effect of plastic type on product yields and coke formation

Aim

The aim of this master thesis is the assessment of the steam cracking yields and coke formation of (untreated) plastic waste pyrolysis oil distillates as a function of the blending ratio with fossil naphtha.

Justification

Thermochemical recycling of plastic 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. Major differences between plastic waste pyrolysis oils and conventional feedstocks are high olefin concentrations as well as contaminants which may lead to increased coke formation, fouling or corrosion.
However, due to the enormous scale of operation of industrial steam crackers which exceeds the availability of sorted plastic waste by far, a steam cracker will unlikely run on 100 % plastic waste feedstock but rather use blends with fossil feedstocks, thereby reducing the contaminant levels. In this study, distilled fractions of a contaminated pyrolysis oil from post-consumer mixed polyolefin (MPO) waste will be blended with fossil naphtha and subsequently steam cracked at the bench-scale steam cracking (BBSC) setup at LCT. Different mixing ratios will be tested with the aim to evaluate the impact of the olefin concentrations and contaminants on product yields and coke formation. Feedstocks will be thoroughly analyzed using comprehensive two-dimensional gas chromatography (GC × GC). Steam cracking effluent analysis will be performed using a combination of a so-called refinery gas analyzer (RGA) and on-line GC × GC. The experimental data will be complemented by simulations using COILSIM1D.
In this study systematic knowledge will be obtained on the effect of distilled but untreated plastic waste pyrolysis oils on steam cracking. This way, an ideal compromise between mixing ratio and negative effects from plastic waste pyrolysis oils in steam cracking will be identified.

Program

- Literature study:
  - Distillative upgrading of plastic waste pyrolysis oils.
  - Impact of olefinic compounds on coke formation and process fouling.
  - Pyrolysis kinetics of olefinic compounds in steam cracking.
- Steam cracking of a naphtha-range and a diesel-range fraction of MPO pyrolysis oil blended with naphtha.
  - Pure naphtha reference.
  - Varying mixing ratios.
- Analysis of the feedstocks using GC × GC-FID,-ToF-MS.
- On-line effluent analysis using GC × GC and coke formation assessment using an IR-meter.
- Steam cracking simulation using COILSIM1D.