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Plastics waste to light olefins – an experimental and optimization study

Aim

The aim of this master thesis is the assessment of optimal steam cracking conditions for plastic waste derived feedstocks via advanced experimentation and simulation.

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. 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 endeavor it is still largely unknown if the steam cracking conditions typically used for fossil feedstocks are extracting the full potential out of these synthetic feedstocks. In this study, steam cracking experiments at the bench-scale steam cracking (BBSC) setup at LCT will be performed in order to assess the optimal steam cracking conditions and mixing ratios with fossil naphtha in terms of product yields and coke formation. 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. The aim of this optimization study is to identify the optimal temperature profiles and residence times to maximize ethylene yields while at the same time keeping formation of heavy products and coke formation to a minimum.
In this study systematic knowledge will be obtained to optimize the steam cracking of pyrolysis oils from plastic waste. 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 olefin rich feedstocks
  - Pyrolysis kinetics of olefins, naphthenes and aromatics in steam cracking
  - Process optimization
  - Process simulation.
- Steam cracking of naphtha-range and diesel-range pyrolysis oils
  - Varying conditions
  - Varying mixing ratios.
- On-line effluent analysis using GC × GC and coke formation assessment.
- Steam cracking simulation using COILSIM1D.