Chemical and Biochemical Engineering

**Motivation and Background**

Lead acid batteries (LAB) are efficient, safe and low-cost. Their market was valued at 37.5 billion $ in Europe alone in 2020. The main application in the automotive sector is starting, lighting and ignition (75%). Polymeric materials account for 22-30% of the whole end-of-life battery and hold great value. The research interest in plastic waste pyrolysis has more than doubled in the last three years. The main focus is virgin plastics treatment at the laboratory scale.

For this reason, our research focuses on real industrial plastic waste. To identify the impacts of contamination on yields and product composition. Moreover, process and plant scale-up are carried out to achieve industrial implementation of plastic waste pyrolysis.

**Methodology**

- Lead acid battery-derived plastics were provided by Rovereta s.r.l.
- Single-stage pyrolysis in a mechanically fluidized bed reactor (MFR), feeding rate of 0.90 kg h⁻¹, temperature 550-650°C, nitrogen flow 1 L min⁻¹.
- Techno-economic analysis development method
- Plant scale-up to treat 3,000 tons per year of LAB plastic.
- Top-down analysis to define the minimum plant size required for the process to be industrially realized.
- The scale-up scenarios consider the economic parameters as in the base scenario and the influence of different energy sources (electricity, natural gas, methane recycle).

**Results**

- **Yields**
  - Solid: 21% 44% 45%
  - Liquid: 11% 21%
  - Gas: 24% 34%
  - 550°C 650°C

- **Gas Composition**
  - 550°C 650°C
  - Gas: H₂O, CO₂, CO
  - Hydrogen: 72.95% 65.20%
  - Methane: 1.16% 2.89%

- **Char Composition**
  - Lab plastic pyrolysis char
  - Whole battery pyrolysis char

- **Liquid Composition**
  - OIL Cond. 1 53.68 ± 3.11 5.88 ± 2.06 2.47 ± 1.30 0 ± 0
  - OIL Cond. 2 69.40 ± 2.12 5.72 ± 0.25 2.39 ± 0.21 0 ± 0

- **Techno-economic assessment**
  - NPV at 20 years [M]
  - ±10, ±20, ±30
  - Payback period of 4 years and an internal rate of return of 30% is achieved.

**Conclusions**

- At 550°C the liquid production is maximized.
- At 650°C the gas production is maximized and 39% of the feedstock is converted into hydrogen.
- A plant capacity of 3000 tons per year is not economically sustainable in any case.
- The best scenario is given by a plant size of 10500 tons per year and methane recycling.

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