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Unraveling the Role of Additives in Thermal Pyrolysis of Polyolefins: An Analytical Perspective

Keywords: Pyrolysis, polyolefins, additives, antioxidants, comprehensive two-dimensional GC

Aim

To investigate the influence of the Irganox 1010 on the product distribution of polyolefin pyrolysis.

Justification

In 2024, Belgium produced 1.7 million tonnes of plastic waste, making it one of the top countries for per capita plastic waste generation at 147.7 kg per person per year. Despite this, only 6% of this waste remains unrecycled, positioning Belgium among the countries with the highest plastic recycling rates [1]. Plastic waste comprises a wide range of materials, including polyethylene terephthalate (PET), polyvinyl chloride (PVC), nylon, polyamide, polyurethane, and polyolefins such as high-density polyethylene (HDPE), low-density polyethylene (LDPE), and polypropylene (PP). Among these, polyolefins represent the largest proportion of plastic waste generated from packaging. Furthermore, plastic waste often contains organic and inorganic contaminants, antioxidants, and other additives. Conventional disposal methods, including landfilling and incineration, pose significant environmental challenges. Mechanical recycling leads to downcycling, yielding materials of lower quality, especially from polyolefin waste. In contrast, thermochemical recycling methods, such as pyrolysis, have garnered significant attention due to their potential to convert plastic waste into pyrolysis oil. This oil can subsequently be processed into valuable platform chemicals, including C_2–C_4 olefins. Pyrolysis involves a series of thermochemical reactions conducted at moderate to high temperatures (400 °C–600 °C) under an inert, oxygen-free atmosphere. The thermal decomposition of plastics with pyrolysis produces three main product groups: pyrolysis oil, non-condensable gases, and solid residues (char). The hydrocarbons generated within the gasoline-diesel range are promising alternatives to conventional fossil derived feedstock, while the naphtha fraction can be valorized in steam crackers. Key pyrolysis parameters, including temperature, the residence time of pyrolysis vapors within the reactor, and the feedstock composition strongly influence the distribution of these products. This research aims to explore the impact of Irganox 1010 antioxidant on the thermal pyrolysis of various polyolefins and their mixtures with different compositional profiles. The analysis of pyrolysis products will be conducted using comprehensive two-dimensional gas chromatography coupled with a flame ionization detector and a time-of-flight mass spectrometer (GC×GC-FID/TOF MS). This state-of-the-art analytical method enables qualitative and quantitative online characterization of pyrolysis products, providing critical insights into the decomposition mechanisms and their relationships with different polymer types.

Program

1. Literature review on the thermal pyrolysis of contaminated polyolefins.
2. Performing feedstock characterization techniques to determine thermal (TGA/DTG, DSC) and physicochemical (proximate and ultimate analysis, ICP-OES) properties.
3. Investigate the effects of Irganox 1010 on pyrolysis products at various temperatures.
4. The on-line analysis of the pyrolysis products by using GC x GC-FID/TOF MS unit.

[1] Plastic Overshoot Day 2024 report. EA – Environmental Action, Lausanne, Switzerland. www.plasticovershoot.earth.