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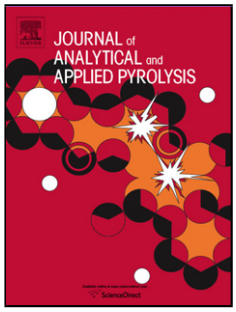

Title: Thermal conversion of polyolefins/polystyrene ternary mixtures: kinetics and pyrolysis on a laboratory and commercial scales

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Thermal conversion of polyolefins/polystyrene ternary mixtures: kinetics and pyrolysis on a laboratory and commercial scales

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Highlights

- The thermal treatment of three-component mixtures of PE, PP and PS was investigated.
- Thermal reactions were described and the kinetics of thermal decomposition evaluated.
- The obtained results showed that PS radicals promote the decomposition of polyolefins.
- Pyrolysis products were identified by TG-FTIR, TG-MS and GC-MS methods.
- Laboratory- and commercial-scale pyrolyses proved that the oils obtained can be further used.

ABSTRACT

The thermal treatment of the three-component mixtures of polyethylene, polypropylene and polystyrene has been investigated. Thermal reactions have been described and the kinetics of thermal decomposition using the Friedman´s differential isoconversional method have been evaluated; slow pyrolysis on a laboratory scale and the pyrolysis of a contaminated waste mixture on a commercial scale have been carried out. The obtained results show that polystyrene radicals promote the decomposition of polyolefins, as a result of which the thermal decomposition of polyethylene and polypropylene proceeds faster and the yields of the gas and oil obtained during pyrolysis are quite high: 4–6 wt.% of gas and 88–90 wt.% of oil in the case of laboratory-scale pyrolysis and 15 wt.% of gas and losses and 80 wt.% of oil in the case of commercial-scale pyrolysis. TG-FTIR and TG-MS analyses have proved that the composition of volatile pyrolysis products varies. In the case of the ternary mixture with prevailing polyethylene (and polypropylene and polystyrene being in minority), the volatiles contained mainly aliphatic hydrocarbons and substituted benzenes; in the case of the ternary mixture with prevailing polypropylene, a significantly higher amount of substituted alicyclic compounds was found. This was confirmed by the GC-MS analysis of the oils obtained. Considering the quite high HHV and LHV of oils (46–48 MJ/kg and 43–45 MJ/kg, resp., in the case of laboratory-scale pyrolysis and 43 and 41 MJ/kg, resp., in the case of commercial-scale pyrolysis) as well as the very low content of sulfur and nitrogen, the oils can be used as a clean liquid fuel; because of their composition, they can also serve as a source of chemicals and solvents.

Keywords: three-component mixtures; kinetics of pyrolysis; oil; GC-MS; TG-FTIR; TG-MS.

1. Introduction

Waste plastics disposal is still a serious environmental and technological problem. A promising solution is pyrolysis, which makes it possible to convert waste plastics into utilizable fuels and thus save valuable oil resources and protect the environment by processing bulky, non-biodegradable waste. Pyrolysis quickly converts plastics into oil, which may serve both as fuel and as feedstock for refineries. Another product is energetic gas. Recycling through pyrolysis has great potential for the processing of various types of plastic waste, because its separation is not economical. Since the main advantage of pyrolysis is its high flexibility with respect to the character of the raw material treated, it may be applied to mixtures of plastics containing contaminants.