Characterization of volatile fire effluent from thermoplastic polyurethane under variable oxygen concentration using TG-FTIR

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Introduction

Thermoplastic polyurethane (TPU) is a versatile engineering thermoplastic with excellent abrasion resistance, chemical stability, and mechanical performance. However, it has a high combustible potential due to its high calorific value, leading to the production of toxic gases such as CO, HCN, and NOx during combustion. Previous studies have mainly focused on the decomposition of cellulose and biomass and studied the effects of reduced oxygen concentrations on combustion. This work aims to study the combustion characteristics of TPU under variable oxygen concentrations.

Experimental Work

The TPU sample used in this study was obtained from Dongguan Xinsu yuan plastic technology Co., Ltd. The weight of each sample was approximately 10.0 mg, with a density of 1.17 g/cm3 and a softening temperature of 73℃. The TPU samples were analyzed using thermogravimetric Fourier transform infrared (TG-FTIR) analysis under variable oxygen concentrations ranging from 0% to 70% at a heating rate of 20℃/min. The volatile fire effluents (HCN and CO) from the TPU were analyzed.

Findings

The TG-FTIR analysis showed that TPU decomposed in three stages under all oxygen concentrations. The weight loss increased with increasing oxygen concentration up to 21%, and then decreased with further increases in oxygen concentration. The release of HCN and CO increased with increasing oxygen concentration, indicating that the oxygen concentration affects the fire effluent of TPU.

The maximum release of HCN and CO occurred at 21% oxygen concentration, which is the ambient oxygen concentration. The increase in HCN and CO emissions with increasing oxygen concentration suggests that the combustion of TPU is incomplete, even at high oxygen concentrations.

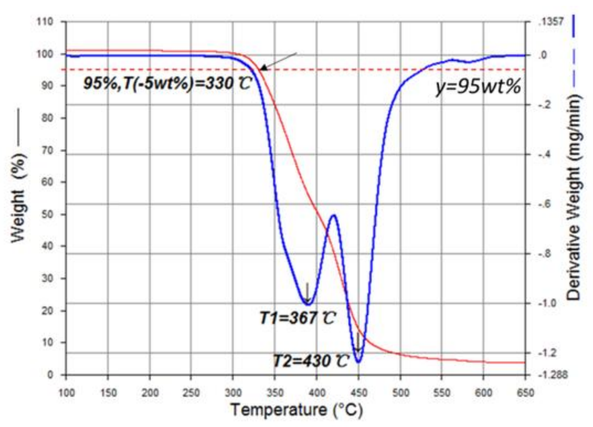

Fig. 1. Temperature profiles of TPU under nitrogen atmosphere.

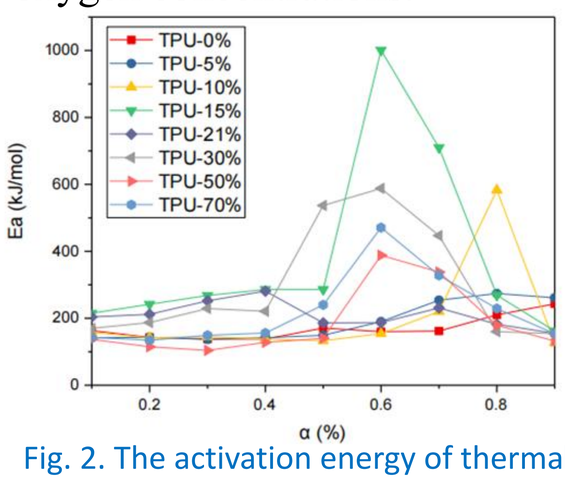

Fig. 2. The activation energy of thermal decomposition in different weight loss rate of TPU at different heating rates.

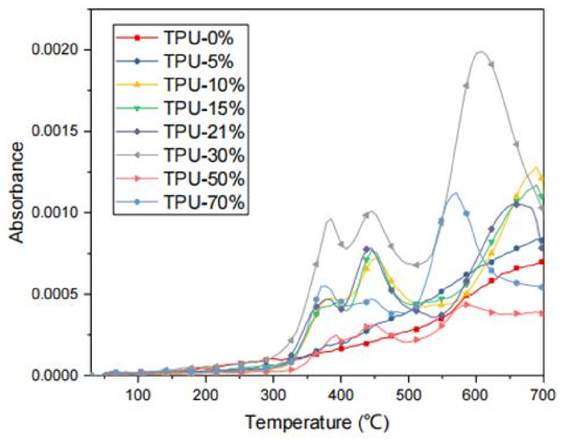

Fig. 3. Intensity of total decomposition products for TPU versus temperature.

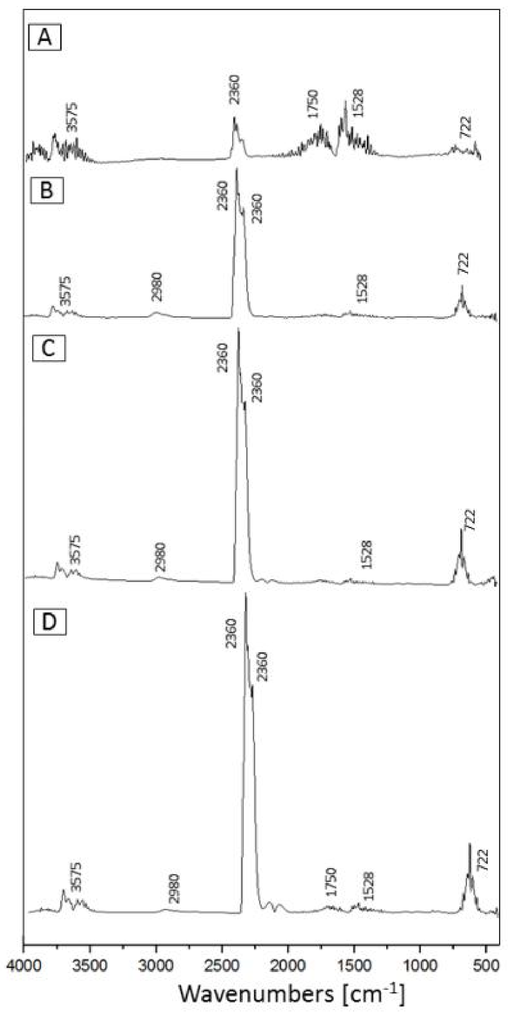

Fig. 4. TG-IR spectra of the decomposition products from the TPU at T1. (a) TPU-0%, (b) TPU-10%, (c) TPU-30%, (d) TPU-70%.

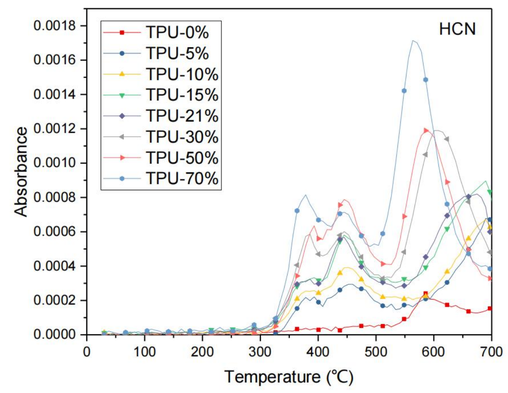

Fig. 5. Intensity of HCN for TPU versus temperature.

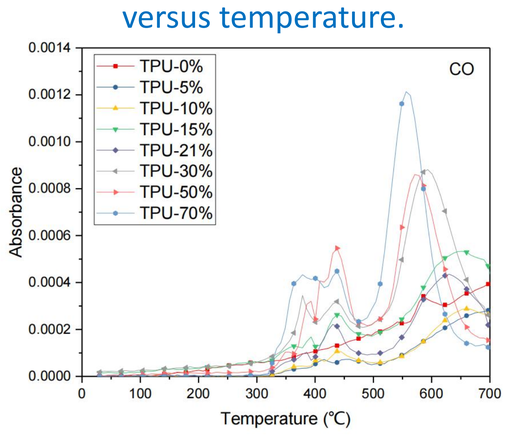

Fig. 6. Intensity of CO for TPU versus temperature.

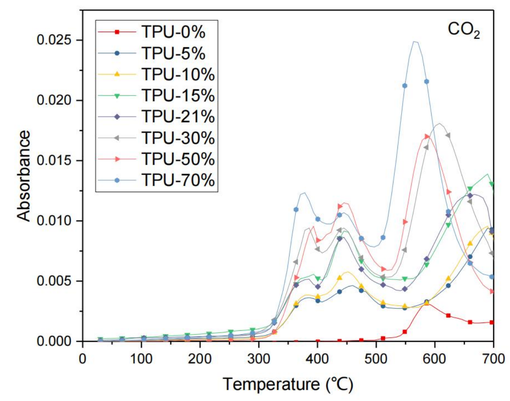

Fig. 7. Intensity of CO2 for TPU versus temperature.

Conclusions

The results suggest that oxygen concentration affects the combustion behavior and fire effluent of TPU. The TG-FTIR analysis shows that the combustion of TPU is incomplete, even at high oxygen concentrations, resulting in the production of toxic gases. The study emphasizes the importance of considering the variable oxygen concentration in assessing the fire safety of polymer materials. Future work will focus on studying the effect of oxygen concentration on the char formation and heat release of TPU to further understand its combustion behavior.

Reference

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