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Thermogravimetric Analysis of Arson Evidence

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Abstract

Combustion residue is one of the main research subjects in arson evidence identification. In this paper, the common evidence of arson were tested and analyzed by thermogravimetric analysis. The combustion residue of the mixture of combustion agent and the carrier was selected as the research object, in order to research the thermal properties of the residue under different conditions. The results show that characteristic temperature of each sample is mainly affected by the types of carrier, and the characteristic temperature of the same carrier is similar. Combustion of PE and PET is not sufficient, and the corresponding residue has a significant weight loss in the text. In the process of combustion, wood and cotton cloth is burning completely, and the corresponding residue is not obvious in heat loss. The pyrolysis temperature of the combustion residue is higher than 400°C, and it will be not deteriorate before 400°C.

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Keywords: combustion residue, thermogravimetric analysis, arson, physical evidence identification.

1. Preface

Arson with its bad nature of the crime is extremely harmful to social public safety and people's security. Arson investigation is complicated that the scene of the burning traces and fire environment is different from general fires'.

Fire investigators often need to utilize the laboratory identification conclusions to detect arson cases. At present, identification department extracts the combustion residue within the characteristics of components by some pre-treatment methods to achieve the purpose of identification. But it is not common that identification department analyze solid combustion residue directly. Thermogravimetric analysis is an important measure of judicial identification [1-2], and a complete analysis procedures has been developed. Thermogravimetric analysis was used in this study, and two common combustion agents (gasoline and diesel) was selected. The most common carrier of the fire with combustion agents was the polymer, and we have selected thermoplastic polymers (PE, PET) and natural fiber polymers (wood and cotton cloth) as experimental materials. Then, simulated fire conditions, the study prepared a fire burning scene of the common combustion residue.

Then, the prepared combustion residue was subjected to thermogravimetric analysis. By selecting the characteristic temperature of the combustion residue and finding the heat weight loss of each heating stage, the study analyzed the connection between thermal characteristics and the types of sample [3-4]. By summarizing the law, we hope to offer some assistance and inspiration for the identification of such fire and provide basic data for further in-depth analysis.

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2. Experiments

2.1. Equipment

NETZSCH STA449F3

2.2. Conditions

According to the property of this experimental sample, Al_2O_3 crucible is selected as test container. There was making a baseline with Al_2O_3 to eliminate the impact. In order to observe the thermal stability of the samples, nitrogen is selected as the purge gas and the shielding gas at a rate of 30 mL/min in the thermal analysis experiment

Under nitrogen atmosphere conditions, TGA measurement is heating from 30°C to 1000°C at 20°C/min. 4mg was selected as opportune sample volume to analyze. In this analysis, taking into account the high thermal parameters of some composite carrier parameters, choose the range of temperature from 30°C ~ 1000°C [5].

2.3. Preparation of samples

Firstly, cut the four kinds of carriers (PE, PET, wood and cotton cloth) into 8cm × 8cm size, weighing about 5g. Then, the carriers were put it in the tin foil box and poured on the 10mL gasoline or diesel. Next, lit the sample, observe the phenomenon until the natural extinguished. Last, place the solid combustion residue into the sealed plastic box to be measured

2.4. Macroscopic characteristics of samples

(1) Combustion residue of PE

In the process of combustion, PE carrier occurred flowing combustion. After combustion, there was producing a layer of film-like residue at the bottom of the container, which surface was glossy. There was no carbonized layer on the residue's surface. The combustion residue of original sample was black and opaque. Transparency of gasoline combustion residue was not high, and the color is grey. Diesel combustion residue was brown and has a certain degree of transparency.

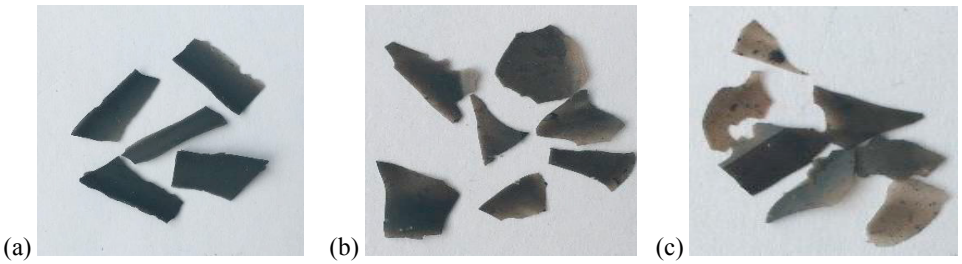

Fig. 1. Illustration of PE combustion residue for (a) Combustion of Original sample and (b) Combustion with gasoline and (c) Combustion with diesel.

(2) Combustion residue of PET

In the process of combustion, PET carrier melted firstly when exposed to heat, and then it curled inwardly. After combustion, a hard lump was formed. The surface was glossy and there was no carbonization layer. The combustion residue of original sample appeared black and followed a certain degree of transparency. Gasoline combustion residue appeared the lowest transparency and the color is irregular. Diesel combustion residue appeared the highest transparency and reddish brown.