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Thermogravimetric analysis of two Chinese used tires

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Abstract

Two Chinese used tire samples' components have been measured by using TGA technique. In general, a tire contains approximately 65% organic materials, 32% carbon black and less than 4% ash. The most commonly used tire rubbers, such as natural rubber (NR), styrene-butadiene rubber (SBR) and polybutadiene rubber (BR), were also investigated separately under the same conditions. NR is distinguished from BR or SBR in the tires' TG/DTG curves because that the NR in tires decompose mainly at lower temperature than SBR or BR. The similar TG/DTG patterns of SBR and BR result in a difficulty in identification of these two types of tire rubber.

Keywords: Used tires; Rubbers; TGA

1. Introduction

Increasing numbers of used tire is becoming an environmental and economic problem worldwide. Used tires can be used as a new source of hydrocarbons to increase energy and raw chemical material. To meet this need, used tires can be converted by pyrolysis into gas, oils and carbon black.

Tires contain vulcanized rubber in addition to the rubberized fabric with reinforcing textile cords, steel or fabric belts and steel-wire reinforcing beads. The most commonly used tire rubbers are natural rubber (NR), styrene-butadiene rubber (SBR) and polybutadiene rubber (BR) in China. To improve the tire properties and workability, the carbon black, mineral fillers, extender oil, plasticizers, sulfur, zinc oxide and other components are used in tire manufacture process. The yield and chemical composition of the pyrolysis products vary with the tire compositions that depend on the tire type, age and manufacturer [1–3].

Consequently, the increasing interest in tire pyrolysis requires an understanding of the tire proximate composition. Thermogravimetric analysis (TGA) is generally quicker and more reliable than other traditional methods, especially in the area of compositional analysis, such as in the measurement of coal proximate analysis.

This paper reports the composition analyses of two Chinese used tires using thermogravimetric analyzer. In addition, the most commonly used tire rubbers, natural rubber (polyisoprene, NR), styrene-butadiene rubber (SBR) and polybutadiene rubber (BR), were investigated. From the TG and DTG results, the rubber types in tires were determined.

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2. Experimental

Two Chinese used tires, A and B, were analyzed by a Setaram TGA92 in this study. Samples (10–20 mg) were placed in a silica crucible and heated in a thermobalance at rate of 10 K/min from ambient to 650°C with continuous N_2 flow (90 ml/min). When the sample mass became constant at about 500°C, oxygen as the auxiliary gas was then introduced to flow through the system up to the final temperature.

In order to determine the type of rubbers in a tire, the major rubber components in tires, such as natural rubber (NR), styrene-butadiene rubber (SBR) and polybutadiene rubber (BR), were also investigated under the same conditions.

3. Results and discussion

Fig. 1 illustrates a typical tire sample decomposition TG and DTG curves. It shows the four components of tire that correspond to its decomposition. Both tire A and B samples give similar TG and DTG curves.

At first, two weight loss parts in N_2 flow correspond to the decomposition of organic materials. It begins with the emission of volatile, and the next mass loss with DTG peak temperatures of T_1 and T_2 corresponds to the decomposition of rubbers including natural rubber and synthetic rubber (BR or SBR). After the tire sample achieved constant weight, oxygen was then introduced to react with the carbon black and led to the third weight loss part. Anything left may be ash that comprises mainly zinc oxide [4].

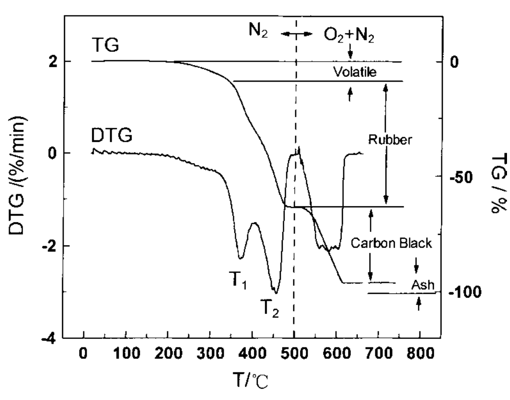

Fig. 1. Diagram illustrating the composition of the tire.

Table 1
Components of the tire samples using TGA

Sample	Volatile+ rubbers (%)	Carbon black (%)	Ash (%)
A	64.68	32.00	3.32
B	63.91	32.55	3.54

The TG experiments were carried out at least two times for each sample and the average results are listed in Table 1.

As mentioned before, the two distinct peaks of weight loss rate under N_2 atmosphere in Fig. 1 represent decomposition of rubbers which may be NR, BR or SBR. In order to identify the rubber types, the three rubbers commonly used in tire manufacture were also investigated. Fig. 2 shows the TG and DTG curves of the NR, SBR, BR and their mixtures (NR/SBR/BR and SBR/BR).

In general, the DTG peak temperature is considered to be the most important character in the temperature-programmed TG analysis. The characteristic temperatures of tires and rubbers are listed in Table 2.

NR is clearly identified from the other rubber samples in TG and DTG curves of Fig. 2. It has been also found that the characteristic temperature of NR, which decomposed mainly at lower temperature with a DTG peak at 385°C, is far from that of SBR and BR, Table 2. Although SBR or BR had a little weight loss around the NR decompose temperature, they decomposed mainly at relatively higher temperature. As a result, NR can be distinguished from SBR or BR and the weight loss peak at temperature T_1 is now considered to be decomposition of NR in the tire.

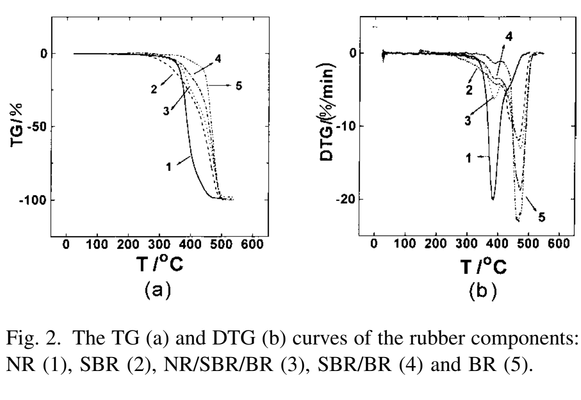

Fig. 2. The TG (a) and DTG (b) curves of the rubber components: NR (1), SBR (2), NR/SBR/BR (3), SBR/BR (4) and BR (5).

Table 2
The DTG peak temperatures (°C) for used-tire and rubber samples

Sample	A	B	NR	BR	SBR	BR/SBR	NR/SBR/BR
T_1	382.8	385.6	385.2	380.3	–	384.6	384.5
T_2	461.6	461.4	–	466.3	463.9	471.3	471.7

Although both BR and SBR decompose at higher temperature region, BR and SBR are different to a certain extent in the shape of TG and DTG curves. Fig. 2 shows decomposition of BR and SBR starts at 350°C and 200°C, respectively. The BR/SBR shows a tendency to two-stage decomposition, but the first decomposition is much less prominent. In fact, the TG and DTG curves of BR/SBR mixture do not show their characteristics. The NR/SBR/BR mixture decomposition is similar to the tire which has two distinct DTG peaks. It shows that the lower temperature peak is mainly due to NR decomposition and the higher temperature peak is to BR and SBR decomposition.

This would explain why the natural rubber (NR) and synthetic rubber (SBR and BR) in a tire can be identified and the type of synthetic rubber (SBR and BR) cannot be determined by using TG/DTG technique.

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References

[1] B. Benallal, H. Roy, H. Pakdel, S. Chabot, M.A. Poirier, Fuel 74 (1995) 1589.
[2] P.T. Williams, S. Besler, D.I. Taylor, Fuel 69 (1990) 1474.
[3] P.T. Williams, S. Besler, Fuel 74 (1959) 1277.
[4] S. Knappe, C. Urso, Thermochim. Acta 227 (1993) 35.