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Thermal analysis of sodium azide and its mixtures

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Abstract

The reactions of sodium azide and its mixtures have been studied by the DTA–TG method. The reaction is very fast, and releases large amounts of gas and quantities of heat. With the addition of catalysis materials, the decomposition temperature will be reduced.

Keywords: Airbag; DTA–TG; Sodium azide

1. Introduction

Automotive airbag systems are well known to be a useful tool for reducing the overall risk of fatalities and injuries in car crashes. Sodium azide is now chiefly used as the base material for the gas-generating agents of airbag systems. Therefore, it is important to study the reaction characteristics of sodium azide and its mixtures. The behavior of the gas-generating agents have been reported [1–4], usually using burning methods to research the burning rate, pressure–time history and temperature–time history of the mixtures. Thermal analysis is very useful for researching reactive energy materials. Many thermal phenomena of pure single materials have been discussed in Refs. [5] and [6]. However, gas-generating mixtures have scarcely been examined by thermal analysis. Therefore, differential thermal analysis and thermogravimetry (DTA–TG) were used to examine the thermal behavior of sodium azide and sodium azide–oxidizer mixtures.

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2. Experimental

2.1. Materials and sample preparation

The materials used were: sodium azide (NaN_3) 98 wt% pure, powder; potassium perchlorate ($KClO_4$) 99 wt% pure, 67 μm; iron oxide (Fe_2O_3) 98.5 wt% pure, powder; silicon dioxide (SiO_2), acid anhydride, 67 μm. The sample mixtures containing sodium azide are shown in Table 1. The sodium azide–oxidizer powder compositions were mixed carefully by a wooden brush on a rubber plate.

2.2. Apparatus

The decomposition process of the sample was analyzed under atmospheric conditions with simultaneous differential thermal analysis and thermogravimetry (DTA–TG). These experiments were carried out at a heating rate of 20°C min^{-1}. The sample weight for each test was 10 mg.

3. Results and discussion

Fig. 1 shows the DTA curves of sodium azide and its mixtures. The curves 1, 2, 3, 4 correspond to samples 1, 2, 3, 4. We can obtain some thermal characteristics from the figure. There is no distinct crystal change or decomposition before 426°C in pure sodium azide. According to Ref. [5], $KClO_4$ thermal decomposition takes place at 300°C, releasing oxygen, which can react with sodium from sodium azide and generate sodium oxide, with the release of large quantities of heat.

$$KClO_4 \rightarrow KCl + 2O_2 + Q$$

$$2NaN_3 \rightarrow 2Na + 3N_2 - Q$$

$$4Na + O_2 \rightarrow 2Na_2O - Q$$

$$KClO_4 + 8NaN_3 \rightarrow KCl + 4Na_2O + 12N_2 - Q$$

These reactions are very fast. The phenomena can be seen in curves 2–4.

Table 1
Composition of the samples

No.	NaN_3 (wt%)	$KClO_4$ (wt%)	Fe_2O_3 (wt%)	SiO_2 (wt%)
1	100	0	0	0
2	65	35	0	0
3	65	35	3(add.)	0
4	65	35	3(add.)	15(add.)

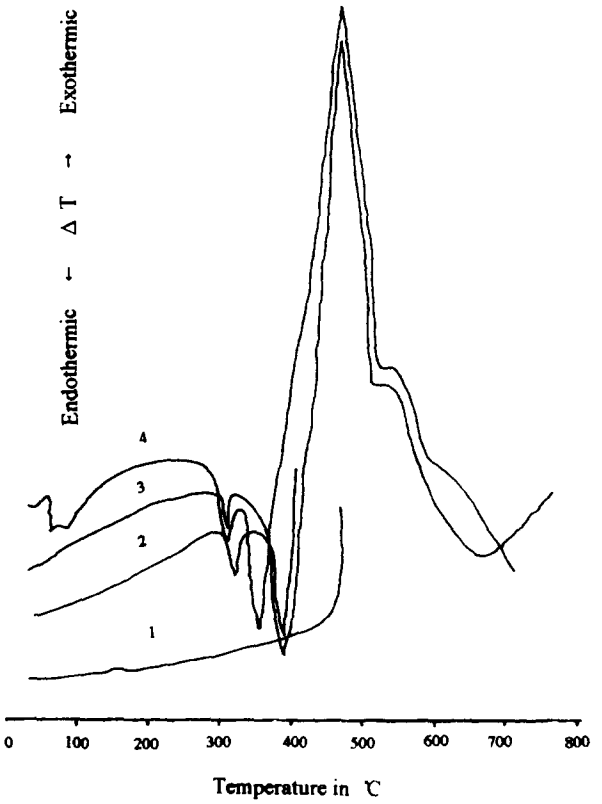

Fig. 1. DTA curves of sodium azide and its mixtures.

There are two endothermic peaks before 400°C. These are related to two steps in the decomposition of $KClO_4$ in these mixtures. From Fig. 1 we also know that the thermal decomposition temperature decreases with oxide addition. So Fe_2O_3 and SiO_2 can catalyze the $KClO_4$ decomposition. When heated to a temperature above 320°C, the NaN_3 in the mixtures begins to decompose, with relatively modest endothermic or exothermic effects, releasing nitrogen gas and sodium vapor. However, the sodium vapor immediately reacts with the oxygen gas from the $KClO_4$. These reactions release large quantities of heat, i.e., exothermicity. The DTA curves trend sharply upwards. The exothermic reaction reaches a maximum at about 450°C.

From Fig. 2 the TG curves, it can be seen that the mass decreases rapidly when the reaction takes place. In view of the weight loss, the reactions must be very fast, take place in the gas–solid phase, and produce large amounts of gas-phase products.

4. Conclusions

From the above we have obtained some thermal information for sodium azide and its mixtures. With the addition of oxide materials, the decomposition temperature is

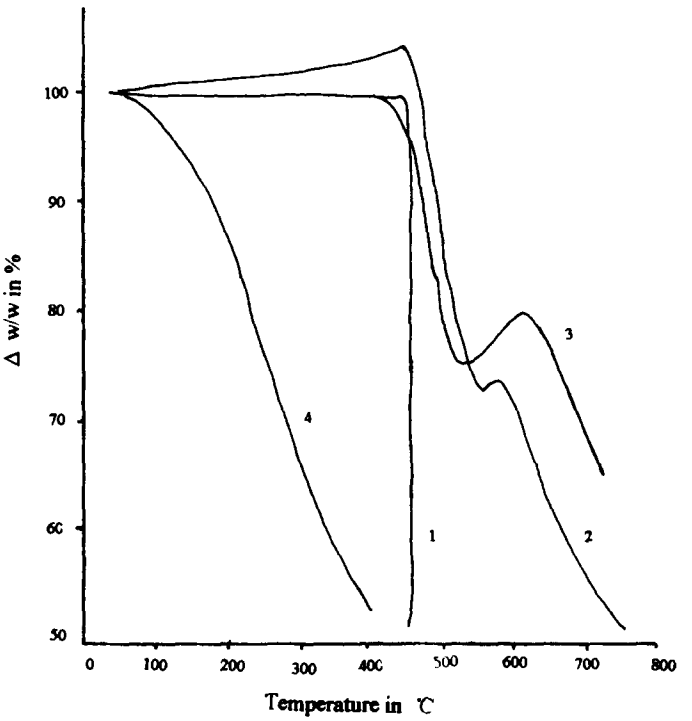

Fig. 2. TG curves of sodium azide and its mixtures.

reduced; the thermal reaction is very fast, takes place in the gas–solid phase, and produces large amounts of gas-phase products, releasing large quantities of heat.

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