The Effect of Sample Containers on the Ignition Temperature of Sulfur/Chlorate Mixtures

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ABSTRACT

In this communication we report the lowered thermal stability of sulfur/chlorate mixtures in contact with glass surfaces. Ignition temperatures as low as 100 °C were found in glass test tubes and are about 15 °C less than for the same mixture in a cardboard fireworks tube.

Keywords: chlorate, sulfur, thermal stability, ignition temperature, glass

Introduction

In our study[1] of the thermal stability of sulfur/chlorate mixtures under a number of different conditions we used cardboard fireworks tubes to hold the test samples. Ignition temperatures in the region of 115–120 °C were commonly found, and the variation in the results was attributed to, particle size distribution in the samples.[2] Tanner[3] has previously reported ignitions at 82–91 °C when sulfur/chlorate mixtures, in cardboard, were heated by a lamp. Storey[4] observed low ignition temperatures at about 100 °C and non-ignition exotherms as low as 75 °C for sulfur/chlorate mixtures in unspecified vessels.

In an attempt to investigate the effect of container material on the ignition temperature of sulfur/chlorate mixtures, we have examined glass and stainless steel tubes. In this short paper we report the effect of these tubes on the thermal stability of 2 g sulfur/chlorate mixtures (sulfur 30%) and compare the results with those obtained in cardboard fireworks tubes.

Table 1. The Effect of Container Material on the Ignition Temperature of Loose Sulfur/Chlorate Mixtures (30% Sulfur, 70% Potassium Chlorate).

Containment	Notes	Ignition Temp (°C)	
		Tube 1	Tube 2
Open Pyrex glass tube ‡		110	110
Sealed Pyrex glass tube ‡	Rubber bung in top of tube	107	108
Open steel tube		121	—
Open cardboard tube	Composition contained 30% powdered glass (from a Pyrex test tube)	125	129
Open cardboard tube	control samples	120	121

‡ Glass test tubes taken from "laboratory stock" (i.e., clean, previously used and not pre-treated).

Results and Discussion

The first series of tests (Table 1) indicated that the use of glass test tubes produced lower ignition temperatures than any other container. It is likely that some previous work on sulfur/chlorate could have been carried out in glass vessels and we believe that this may have contributed to the low non-ignition exotherms and ignition temperatures.[4] Interestingly, the addition of powered Pyrex glass (not sieved to give a specific fraction) to the composition in the cardboard tube did not result in the reduction in ignition temperature observed when the basic composition was placed in glass tubes.

A second series of tests was carried out using a fresh batch of potassium chlorate (Table 2). The control samples (cardboard tubes) had a lower ignition temperature, which we attribute to a change in the particle size distribution of the potassium chlorate.[2] In this second series, glass tubes of different histories and types were investigated. In all cases the contact between the glass and the sulfur/chlorate mixture produced a reduction in the ignition temperature. This effect was more pronounced with "new" test tubes and appeared to reduce with freshly washed glass.

Currently we have not found a suitable explanation for the observed effect of glass on the reactivity of sulfur/chlorate mixtures. However, this note has been produced to warn pyrotechnicians of the heightened risk when this mixture is placed in glass containers.

Tanner[3] heated sulfur/chlorate mixtures using a lamp with the material contained in cardboard salvaged from books of matches. It is likely that the temperature measured in the bulk of the sample (82–91 °C) was lower than that at the surface. Storey[4] reported exotherms as low as 75 °C for mixtures of sulfur and chlorate. Re-examination of the thermal traces suggests that these were non-ignition exotherms since the subsequent exotherms at about 100 ºC or higher were more energetic and therefore more likely to have been ignitions.

Contact with a glass surface is not the sole explanation for low temperature reactions of sulfur/chlorate mixtures. Other contributing factors could include source, acidity and history of the sulfur sample, particle size distribution, heating rate and relative humidity.

References

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Materials", *Journal of Pyrotechnics*, Issue 11 (2000) pp 16–24.

3) H. G. Tanner, "Instability of Sulfur–Potassium Chlorate Mixture", *Journal of Chemical Education*, Vol. 36 (1959) p 58.

4) P. D. Storey, "Identification and Assessment of Hazardous Mixtures in Pyrotechnics", *13th International Pyrotechnics Seminar*, Grand Junction, CO, USA (1988) p 765.

Table 2. The Effect of Pre-Treatment of Glass on Sulfur/Chlorate Ignition Temperature (30% Sulfur).

Tube type	Pre-treatment	Ignition Temp. (°C)	
		Tube 1	Tube 2
Pyrex	None, "new tubes"	101	100
Pyrex	None, "previously used"	110	108
Soda Glass	None, "new tubes"	100	101
Pyrex	New, washed with distilled water	104	104
Soda Glass	New, washed with distilled water	101	102
Pyrex	New, washed DECON 90, rinsed distilled water	111	111
Soda Glass	New, washed DECON 90, rinsed distilled water	113	112
Control samples in cardboard fireworks tubes ignited at 115 °C			