

[54] **PYROTECHNIC COMPOSITION WITH
COMBINED BINDER-COOLANT**

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[56] **References Cited**

UNITED STATES PATENTS

- 3,532,359 10/1970 Teague et al. 250/150 AB
3,647,393 3/1972 Leising et al. 102/39 X

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[57]

ABSTRACT

This pyrotechnic composition is adapted, upon combustion, for generating a low-flame temperature, non-toxic gas for inflating a vehicle safety bag. The composition comprises: a fuel, such as a carbonaceous material, aluminum or magnesium; an inorganic oxidizer, such as a metal chlorate, a metal perchlorate, a metal nitrate, ammonium chlorate, ammonium perchlorate or ammonium nitrate; and a combined binder and coolant, such as magnesium hydroxide or a mixture of magnesium hydroxide and magnesium carbonate. A typical example of this composition comprises: carbon as the fuel; potassium chlorate as the oxidizer; and a mixture of magnesium hydroxide and magnesium carbonate as the binder-coolant. One may use as much of this binder-coolant as is necessary to obtain the desired binding properties in the composition, without raising the flame temperature of the gas to an unacceptable level.

9 Claims, No Drawings

PYROTECHNIC COMPOSITION WITH COMBINED BINDER-COOLANT

BACKGROUND OF THE INVENTION

This invention relates to a pyrotechnic composition adapted, upon combustion, for generating a gas. In particular, this invention relates to a pyrotechnic composition which, upon combustion, generates a low-flame temperature, non-toxic gas. Among the uses for such a gas is to inflate a safety bag in a vehicle to restrain movement of an occupant in the vehicle in the event of collision.

It is necessary that such a pyrotechnic composition be able to meet certain criteria in order to be adapted for use with a vehicle safety bag. The pyrotechnic composition must be able to withstand storage in an environment from approximately -40°F . to approximately $+220^{\circ}\text{F}$. It is also necessary that the composition be capable of being ignited rapidly, for example, within a matter of milliseconds, and that it be capable of being totally ignited to produce gas. It is necessary that the gas produced have only a negligible amount of toxic gases, such as nitrogen oxides or carbon monoxide, at relatively low temperatures, such as less than 2000°F . when burned at pressures of from 100 to 20,000 lbs./sq.in.

Previously used pyrotechnic compositions normally include the use of an organic binder. The organic binder also acts as a fuel and tends to raise the flame temperature of the gas to an unacceptable level. As a result, the temperature of the outer surface of the vehicle safety bag, using such prior art compositions, would be so high that it might burn the occupant of the vehicle or at least result in discomfort to the occupant. In order to keep the flame temperature of the gas as low as possible, one had to limit the amount of the organic binder-fuel used in such prior art compositions. As a result, there was a problem in not having enough binder for the composition.

This is understandable because the compositions using such binders were intended for applications, such as high-energy propellants for rockets, where low-flame temperature was not an objective. See: U.S. Pat. Nos. 2,929,697 to Perry and 2,994,598 to Dickey. In addition, many of the compositions disclosed in the prior art produce a toxic gas, such as some of the compositions in U.S. Pat. Nos. 3,020,180 to Morello and 3,047,524 to Bowman.

SUMMARY OF THE INVENTION

The pyrotechnic composition of this invention is adapted, upon combustion, for generating a low-flame temperature, non-toxic gas. This gas is useful for inflating various devices, such as a safety bag in a vehicle. A safety bag is inflated to restrain the movement of an occupant of the vehicle in the event of collision. In general, the pyrotechnic composition comprises a fuel; an inorganic oxidizer; and a combined binder and coolant, which is selected from the group consisting of; magnesium hydroxide, and a mixture of magnesium hydroxide and magnesium carbonate. It has been found that one may use as much of this binder-coolant as is necessary in the pyrotechnic composition to obtain the desired binder properties for the composition without raising the flame temperature of the gas, generated upon combustion, to an unacceptable level. The fuel may be se-

lected from the group consisting of: a carbonaceous material, aluminum and magnesium. The inorganic oxidizer may be selected from the group consisting of: a metal chlorate, a metal perchlorate, a metal nitrate, ammonium chlorate, ammonium perchlorate and ammonium nitrate.

DETAILED DESCRIPTION

This pyrotechnic composition is adapted for generating a low-flame temperature, non-toxic gas upon combustion for inflating a vehicle safety bag. In general, the composition comprises: a fuel selected from the group consisting of a carbonaceous material (such as carbon, carbon black or lamp black), aluminum and magnesium; an inorganic oxidizer selected from the group consisting of an alkali metal chlorate, such as potassium chlorate or sodium chlorate, an alkali metal perchlorate, such as potassium perchlorate or sodium perchlorate, an alkali metal nitrate, such as potassium nitrate or sodium nitrate, ammonium chlorate, ammonium perchlorate, and ammonium nitrate; and a combined binder and coolant selected from the group consisting of: magnesium hydroxide and a mixture of magnesium hydroxide and magnesium carbonate.

A typical formulation of this pyrotechnic composition comprises: carbon which acts as a fuel; potassium chlorate (KClO_3) or potassium perchlorate (KClO_4) which acts as an oxidizer; and magnesium hydroxide $\text{Mg}(\text{OH})_2$ which acts as a coolant and a binder.

The pyrotechnic composition of this invention comprises by weight: from less than 1 to about 10% of one of the foregoing fuels, such as carbon; from about 30 to about 70% of one of the foregoing inorganic oxidizers, such as potassium chlorate; and from about 10 to about 60% of one of the foregoing combined binders and coolants, such as a mixture of magnesium hydroxide and magnesium carbonate. Preferably, the pyrotechnic composition comprises by weight: about 3 to about 7% of one of the foregoing fuels, such as carbon; about 40 to about 60% of one of the foregoing inorganic oxidizers, such as potassium chlorate; and about 35 to about 55% of one of the foregoing combined binders and coolants, such as a mixture of magnesium hydroxide and magnesium carbonate.

When such compositions are burned in the presence of air, the magnesium hydroxide reacts with carbon dioxide (CO_2) in the air to form magnesium carbonate (MgCO_3). Magnesium carbonate is a highly oxygenated, cement-like material and, by itself, provides no binding properties. The conversion of magnesium hydroxide to magnesium carbonate provides the binding effect. Neither the magnesium hydroxide nor the magnesium carbonate acts as a fuel. Since magnesium hydroxide and magnesium carbonate are both coolants, not fuels, one can use as much as necessary. As a result, one has enough binder for the composition without raising the flame temperature of the gas to unacceptable levels. The free oxygen formed from the inorganic oxidizer, such as potassium perchlorate, is consumed by the fuel, such as carbon, forming carbon dioxide and evolving heat which is cooled by the magnesium hydroxide.

It is preferable, in most instances, to start with a mixture of magnesium hydroxide and magnesium carbonate, rather than magnesium hydroxide without magnesium carbonate. One should use enough magnesium hydroxide in the mixture to obtain the desired binding ef-

fect caused by the carbonation of the magnesium hydroxide. But, one should use only enough magnesium hydroxide to obtain the necessary physical properties as a binder because in compositions using a mixture of magnesium hydroxide and magnesium carbonate, it has been found that the higher the proportion of magnesium hydroxide to magnesium carbonate that is used in the composition, the longer the reaction time will take.

More specifically, the magnesium hydroxide in the pyrotechnic composition should comprise by weight not less than about 10% of the entire composition and preferably from about 10 to about 30% of the entire composition. In instances where a mixture of magnesium hydroxide and magnesium carbonate is used as the combined binder and coolant, the composition may comprise: from about 10 to about 30% magnesium hydroxide as compared to the entire composition and from about 20 to about 40% magnesium carbonate as compared to the entire composition. In many compositions it has been found advantageous for the mixture of magnesium hydroxide and magnesium carbonate to comprise about one-half magnesium hydroxide and about one-half magnesium carbonate.

The following examples, in which percent is by weight, are provided for purposes of illustration:

EXAMPLE 1

The composition used comprised: 5% carbon as the fuel, 50% potassium chlorate as the inorganic oxidizer, and 45% of a mixture of magnesium hydroxide and magnesium carbonate as the binder-coolant. The proportion of this mixture was approximately one-half magnesium hydroxide and one-half magnesium carbonate so that the magnesium hydroxide and the magnesium carbonate each formed 22½% of the total composition.

EXAMPLE 2

The composition comprised: 5% carbon; 50% potassium chlorate; and 45% magnesium hydroxide.

EXAMPLE 3

The composition comprised: 5% carbon; 51% potassium chlorate; and 44% magnesium hydroxide.

EXAMPLE 4

The composition comprised: 6% carbon; 50% potassium chlorate; and 44% magnesium hydroxide.

EXAMPLE 5

The composition comprised: 5% carbon; 50% potassium chlorate; and 45% magnesium hydroxide.

The compositions in the foregoing examples each produce a gas having a flame temperature from about 1500°F. to less than 2000°F.

The pyrotechnic compositions of this invention achieve flexibility in reference to the amount of binder which may be used, consistent with the object of producing a gas having a low-flame temperature and a negligible amount of toxic gases, such as nitrogen oxides or carbon monoxide.

It has been found useful to pelletize the pyrotechnic composition of this invention in order to achieve a predictable combustion performance of the composition, rather than to use the composition in powder form. Pelletizing can be achieved by severely mixing the powdered ingredients and then using a pill press to produce

pellets, or by granulating the powdered mixture, extruding it through a screen and forming noodles. Pelletizing has been found advantageous because of the following undesirable characteristics of a mixed powder.

The powder tends to separate, with the oxidizer at the bottom and the fuel at the top. When the powder burns, it burns with different characteristics depending upon the degree to which the powder mixture is homogeneous. In addition, the powder may be loosely packed or it may become tightly packed which also affects its burning or combustion characteristics. The result is that inconsistent results are sometimes obtained when using the composition in powder form. When using the composition in pellet form, more consistent results are generally produced. Optionally, an organic lubricant, such as stearic acid or Carbowax (a trade name of Union Carbide Corporation for polyethylene glycols), may be added for pelletizing.

I claim:

1. A pyrotechnic composition adapted, upon combustion, for generating a low-flame temperature, non-toxic gas, said composition comprising:

a fuel selected from the group consisting of a carbonaceous material, aluminum and magnesium;

an inorganic oxidizer selected from the group consisting of a metal chlorate, a metal perchlorate, a metal nitrate, ammonium nitrate, ammonium chlorate, and ammonium perchlorate; and

a combined binder and coolant selected from the group consisting of magnesium hydroxide and a mixture of magnesium hydroxide and magnesium carbonate.

2. The pyrotechnic composition according to claim 1 comprising by weight: less than 1 to about 10% of said fuel; about 30 to about 70% of said inorganic oxidizer; and about 10 to about 60% of said combined binder and coolant.

3. The pyrotechnic composition according to claim 1 comprising by weight: about 3 to about 7% of said fuel; about 40 to about 60% of said inorganic oxidizer; and about 35 to about 55% of said combined binder and coolant.

4. The pyrotechnic composition according to claim 1 wherein said magnesium hydroxide comprises by weight about 10 to about 30% of the entire composition.

5. The pyrotechnic composition according to claim 1 wherein said combined binder and coolant consists of a mixture of magnesium hydroxide and magnesium carbonate.

6. The pyrotechnic composition according to claim 5 wherein said combined binder and coolant comprises about 10 to about 30% magnesium hydroxide as compared to the entire composition and about 20 to about 40% magnesium carbonate as compared to the entire composition.

7. The pyrotechnic composition according to claim 6 wherein said mixture of magnesium hydroxide and magnesium carbonate comprises about equal amounts of magnesium hydroxide and magnesium carbonate.

8. The composition according to claim 1 comprising by weight: about 5% carbon; about 50% potassium chlorate; and about 45% of a mixture of about equal amounts of magnesium hydroxide and magnesium carbonate.

9. The pyrotechnic composition according to claim 1 in the form of pellets.

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