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3,399,089

**GELATINIZED DINITROTOLUENE-
NITROSTARCH EXPLOSIVES**

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No Drawing. Continuation-in-part of application Ser. No. 567,396, July 25, 1966. This application June 29, 1967, Ser. No. 649,805

17 Claims. (Cl. 149—39)

ABSTRACT OF THE DISCLOSURE

A nitrostarch explosive sensitizer composition is provided comprising dinitrotoluene in gelatinized combination with nitrostarch as a supplemental sensitizer. This composition can be used as an explosive sensitizer in explosive formulations of various kinds. When formulated as an explosive, this composition also desirably contains an inorganic oxidizer salt and optional additional ingredients, such as fuels, stabilizers and other components conventional in explosive formulations.

This application is a continuation-in-part of application Ser. No. 567,396, filed July 25, 1966, now abandoned.

This invention relates to explosive compositions based on a gelatinized combination of nitrostarch and dinitrotoluene as explosive sensitizers, and more particularly, to explosive compositions comprising gelatinized nitrostarch-dinitrotoluene, and an inorganic oxidizer such as an inorganic nitrate.

Nitrostarch has been used as an explosive sensitizer for well over-fifty years, and usually compounded in explosive formulations with an inorganic nitrate such as ammonium nitrate or sodium nitrate. Nitrostarch has an oxygen deficiency and inorganic nitrates, such as sodium nitrate, a considerable oxygen excess, such that a mixture of nitrostarch and sodium nitrate permits complete combustion when detonated, without residual free oxygen. However, more than 55 parts of nitrostarch cannot be used efficiently in simple mixtures with sodium nitrate.

U.S. Patent No. 1,188,244, dated June 20, 1916, suggested that the explosive power of nitrostarch explosives could be enhanced if the nitrostarch were combined with trinitrotoluene and ammonium nitrate.

A further problem in the use of nitrostarch in explosive compositions is its insensitivity when wet. This problem is discussed in U.S. Patent No. 2,860,041, patented Nov. 11, 1958, which points out that explosives made with damp nitrostarch are so insensitive to detonation as to be unsuitable for use as blasting explosives. Also because of this problem, it is necessary to package nitrostarch explosives in a manner to protect them from moisture, so as to prevent desensitization of the explosive in storage. The use of damp nitrostarch is made possible in No. 2,860,041, by combining therewith a latent sensitizing agent which on standing absorbs the water from the originally damp nitrostarch, and thus sensitizes the explosive.

In accordance with the instant invention, a nitrostarch sensitizer composition is provided comprising dinitrotoluene in gelatinized combination with the nitrostarch as a supplemental sensitizer. This composition can be used as an explosive sensitizer in explosive formulations

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of various kinds. When formulated as an explosive this composition also desirably contains an inorganic oxidizer salt, such as an inorganic nitrate, and as optional additional ingredients, fuels, stabilizers and other components conventional in explosive formulations.

Dinitrotoluene in gelatinized combinations with nitrostarch provides explosive formulations of very desirable physical properties, having a consistency ranging from a plastic extrudable consistency to a solid hard material which can be pelleted, granulated or powdered, as may be convenient according to the intended use. In many respects, the compositions of the invention have the characteristic of a smokeless powder, but without the disadvantages of a nitrocellulose or nitroglycerine-based powder.

The relative proportion of dinitrotoluene lies within the range from about 5 to about 95%, and the proportion of nitrostarch within the range from about 95 to about 5%, based on the total explosive sensitizer. A composition containing upwards of 30% dinitrotoluene will be of soft, plastic consistency, which is readily extruded using a screw type or cylinder type extruder. Compositions in which the proportion of dinitrotoluene is less than 30% are solids, of increasing hardness as the proportion of nitrostarch is increased. The dinitrotoluene imparts a cohesiveness to the gelatinized mixture which makes it possible to formulate the compositions as pellets or granules which will retain their shape and are essentially non-friable.

The compositions of the invention are characterized by a high sensitivity and a high explosive power, such as are normally associated with nitrostarch.

The principal explosive sensitizer employed is the gelatinized nitrostarch-dinitrotoluene. Additional sensitizers can be used in addition to the gelatinized nitrostarch-dinitrotoluene, in an amount up to approximately 50% of the total explosive sensitizer. These include trinitrotoluene pentaerythritol tetranitrate, dipentaerythritol hexanitrate sorbitol hexanitrate, sucrose octanitrate, ethylene glycol dinitrate, diethylene glycol dinitrate, glycerol dinitrate, trimethylethane trinitrate, pentolite (an equal parts by weight mixture of pentaerythritol tetranitrate and trinitrotoluene), cyclonite (RDX, cyclotrimethylene trinitramine), composition B (a mixture of up to 60% RDX, up to 40% TNT, and 1 to 4% wax), cyclo-tol (composition B without the wax) and tetryl.

In formulating explosive compositions, these explosive sensitizers are preferably used with an inorganic oxidizer salt, to compensate for the oxygen deficiency of the organic nitrates. Preferably, the oxidizer employed is an inorganic nitrate. Ammonium nitrate, and nitrates of the alkali and alkaline earth metals, such as sodium nitrate, potassium nitrate, calcium nitrate, magnesium nitrate, strontium nitrate and barium nitrate, are exemplary inorganic nitrates. Ammonium nitrate and mixtures of ammonium nitrate and another nitrate are preferred. Excellent results are obtained with mixtures of ammonium nitrate and other inorganic nitrates, and such mixtures are frequently preferred over a single nitrate.

As the inorganic oxidizer there can also be used a chlorate or a perchlorate of an alkali or alkaline earth metal, such as sodium chlorate, potassium chlorate, barium chlorate, sodium perchlorate, potassium perchlorate, barium perchlorate, and calcium perchlorate. Mixtures of nitrates, chlorates and perchlorates, of nitrates and chlorates, or nitrates and perchlorates, and of chlorates and perchlorates, can be used.

When mixtures of ammonium oxidizer and the other oxidizer are used, the relative proportion of ammonium oxidizer is important for good explosive shock and power. The ammonium oxidizer is employed in a proportion within the range from about 50 to 95% by weight of the total oxidizer, and the other oxidizer or oxidizers in the proportion of from about 5 to about 50% of the total oxidizer. For optimum power, the proportions are from 80 to 90% ammonium oxidizer, and from 10 to 20% other oxidizer or oxidizers. The proportions of oxidizers selected within these ranges will depend upon the sensitivity and explosive effect desired, and these in turn are dependent upon the particular oxidizer used.

The inorganic oxidizer can be fine, coarse, or a blend of fine and coarse materials. Mill and prill inorganic oxidizers are quite satisfactory. For best results, the inorganic oxidizers should be fine-grained.

The relative proportions of oxidizer and explosive sensitizer will depend upon the sensitivity and explosive power desired, and these in turn are dependent upon the particular oxidizer and explosive sensitizer. For optimum effect, the oxidizer is used in an amount within the range from about 10 to 75% and the explosive sensitizer in an amount within the range from about 5 to about 40%, by weight of the explosive composition. From about 25 to about 30% explosive sensitizer and from about 50 to about 70% oxidizer give the best results.

In addition to these materials, the explosive compositions of the invention can include a fuel, which can be either a metal fuel or a carbonaceous fuel, in an amount of from about 0.5 to about 30%.

Satisfactory metal fuels include aluminum, which can be in the form of powder or flake, or in a very finely-divided form known as atomized aluminum, ferrosilicon and ferrophosphorus. The metal fuel will usually comprise from about 0.5 to about 15% of the composition.

A carbonaceous fuel can also be included, either as the only fuel or in combination with a metal fuel. Satisfactory carbonaceous fuels include powdered coal, petroleum oil, coke dust, charcoal, bagasse, dextrine starch, wood meal, wheat flour, bran, pecan meal, and similar nut shell meals. The carbonaceous fuel will usually be used in an amount within the range from 0.5 to 20%.

Mixtures of metal and carbonaceous fuels can also be used, if desired.

Stabilizers are normally employed in preparing the gelatinized combination of the nitrostarch and dinitrotoluene in an amount within the range from about 0.05 to about 10% of the composition. Examples of such stabilizers include zinc oxide, diphenylamine, dicyandiamide, carbazole, calcium carbonate, aluminum oxide and sodium carbonate. If desired, the stabilizer can be added after the gelatinized combination of nitrostarch and dinitrotoluene is formed, such as during the formation of a mixture of the gelatinized combination with other explosive ingredients.

For some purposes, the compositions of the invention can be formulated as slurries, using an inert liquid such as water or petroleum oil as the suspending liquid. The amount of liquid that is used is more than would be absorbed by the solid ingredients, and sufficient to produce a slurry. The slurry can have any desired consistency, from a tin, readily flowable material, to a viscous material of a semisolid consistency. As little as about 1% liquid in excess of that which is absorbed can suffice. Usually, not more than 30% liquid need be used.

In order to prevent large amounts of unabsorbed liquid from decreasing the consistency unduly, a liquid-soluble or liquid-dispersible thickener can be added to take up the liquid. The particular material employed will depend upon the liquid that is used, water-soluble or water-dispersible thickeners being used when water is the liquid, and oil-soluble or oil-dispersible thickeners being used when the oil is the liquid. Various gums, such as guar gum and cross-linked guar gum, can be used, as well as sodium

carboxymethylcellulose, methyl cellulose, psyllium seed mucilage, and pregelatinized starches, such as Hydroseal 3B, as well as silica aerogels, finely-divided silicas, inorganic gelling agents such as alumina, attapulgite, bentonite, and like materials.

The gelatinized explosive sensitizer is readily prepared by simple mixing of the nitrostarch and dinitrotoluene sensitizers. The dinitrotoluene, since it is a liquid, is usually absorbed or adsorbed by the nitrostarch. After the dinitrotoluene is incorporated with the nitrostarch particles, the remaining materials can be added. In most cases, the solid materials, including the gelatinized sensitizer mixture, inorganic nitrate, fuels and antacid, if any, would be mixed first, to form a homogeneous blend, and the liquid ingredients, if any, such as oil and water, would then be added, with stirring until a homogeneous mixture is formed.

These explosive compositions can be filled into explosive containers of any type, using conventional filling equipment suited to the particular consistency of the composition. A plastic composition is readily extruded into the containers. A powdered, granulated or pelleted formulation is conveniently added by conventional screw fillers.

The following examples, in the opinion of the inventor, represent the best embodiments of his invention.

Example 1

An explosive mixture of granular consistency was prepared, using dry nitrostarch, dinitrotoluene, flake aluminum, fine-grained ammonium nitrate, fine-grained sodium nitrate, and the additional ingredients noted in the table below. The dinitrotoluene, nitrostarch and diphenylamine stabilizer were mixed separately to form a gelatinized mixture of solid particles. The gelatinized particles of the dinitrotoluene and the nitrostarch were then mixed with particles of ammonium nitrate and sodium nitrate, and the remaining materials. The resulting composition was a simple mixture of the gelatinized particles of the dinitrotoluene and the nitrostarch, with the remaining materials. Inasmuch as the nitrostarch was in gelatinized combination with the dinitrotoluene, the nitrostarch could not coat any of the other materials, including the particles of ammonium nitrate and sodium nitrate.

The proportions of the final explosive composition were as follows—

Ingredient:	Percent
Nitrostarch	22.00
Dinitrotoluene	4.15
Grained ammonium nitrate	54.20
Grained sodium nitrate	14.80
Nut meal	2.00
Flake aluminum	2.50
Diphenylamine	0.05
Oil No. 5	0.30

This composition had a standard density of 1.195. It was a hard solid, and in granular form it was nondusting, and easily filled into cartridges eight inches long and 1¼ inches in diameter, made of kraft paper, to a density of 1.03. The cartridges were fired with a No. 1 test detonator, and gave a detonation rate greater than 3814 meters per second. The standard test for determining ballistic pendulum value gave a value of 11.2.

Example 2

A slurried explosive mixture was formulated as follows. The dinitrotoluene and dry nitrostarch were mixed separately to form a gelatinized mixture, in the form of hard particles which were then mixed with particles of ammonium nitrate and sodium nitrate, and diphenylamine. The mass was then mixed with water as the slurrying liquid. There were then added the flake aluminum, and guar gum, and a homogeneous mixture was prepared.

The proportions of the final explosive mixture were as follows—

Ingredient:	Percent
Nitrostarch -----	20.00
Dinitrotoluene -----	4.60
Ammonium nitrate -----	49.00
Sodium nitrate -----	10.75
Flake aluminum -----	2.00
Guar gum -----	0.60
Diphenylamine -----	0.10
Water -----	12.95
	100.00

The final slurry was a simple mixture of gelatinized particles of dinitrotoluene and nitrostarch and the remaining materials slurried in water. Inasmuch as the nitrostarch was in gelatinized combination with the dinitrotoluene, the nitrostarch could not coat any of the other materials, including the particles of ammonium nitrate and sodium nitrate.

The slurry had a density of 1.30, a sensitivity in 1½ inch x 12 inch steel pipe of No. 6 cap, and a rate of detonation in 1½ inch steel pipe of 4844 meters per second. Ballistic pendulum value was 10.6.

Examples 3 and 4

Three granular explosive mixtures were prepared, using varying proportions of nitrostarch and dinitrotoluene. The dinitrotoluene and nitrostarch were mixed separately to form a gelatinized mixture. The particles of Example 3 were soft and sticky. The particles of Example 4 were hard solids. The gelatinized mixture was thoroughly blended with mill ammonium nitrate, zinc oxide or dicyandiamide, flake aluminum, and nut meal.

The proportions of the final particulate solid explosive compositions were as follows:

Ingredient	Example No. (percent)	
	3	4
Nitrostarch-----	8.0	18.0
Dinitrotoluene-----	16.0	6.0
Ammonium nitrate-----	70.9	71.3
Flake aluminum-----	2.0	2.0
Nut meal-----	2.6	2.6
Zinc oxide-----	0.5	
Dicyandiamide-----		0.1

The resulting explosive formulations in Examples 3 and 4 were simple mixtures of the gelatinized particles of the dinitrotoluene and the nitrostarch, with the remaining materials. Inasmuch as the nitrostarch was in gelatinized combination with the dinitrotoluene the nitrostarch could not coat any of the other materials, including the ammonium nitrate. These formulations were granulated, and then filled, using a screw feeder, into cartridges 8 inches long and 1½ inches in diameter made of kraft paper, and the cartridges covered.

The standard tests for determining density, rate of detonation and sensitivity in a 1½ inch pipe were carried out:

Density-----	1.37-----	1.08-----
Rate of detonation-----	3,400 meters per sec- ond.	3,027 meters per sec- ond.
Sensitivity-----	5 g. PETN in 1½ inch pipe.	No. 2 cap.
Ballistic pendulum value.	12.5-----	12.1-----

Having regard to the foregoing disclosure, the following is claimed as the inventive and patentable embodiments thereof:

1. An explosive sensitizer composition consisting essentially of from about 5 to about 95% by weight of nitrostarch gelatinized by from 95 to 5% by weight of dinitrotoluene.

2. An explosive sensitizer composition in accordance with claim 1 including from about 0.05 to about 10% of a stabilizer.

3. An explosive composition consisting essentially of an inorganic oxidizer salt and an explosive sensitizer composition in accordance with claim 1.

4. An explosive composition in accordance with claim 3 in which the inorganic oxidizer salt is an inorganic nitrate.

5. An explosive composition in accordance with claim 4 in which the inorganic nitrate is ammonium nitrate.

6. An explosive composition in accordance with claim 4 in which the inorganic nitrate is a mixture of ammonium nitrate and an inorganic nitrate selected from the group consisting of alkali and alkaline earth metal nitrates.

7. An explosive composition in accordance with claim 3 including a fuel, selected from the group consisting of carbonaceous fuels and metallic fuels.

8. An explosive composition in accordance with claim 7 in which the fuel is a metal fuel.

9. An explosive composition in accordance with claim 8 in which the metal fuel is aluminum.

10. An explosive composition in accordance with claim 7 in which the fuel is a carbonaceous fuel.

11. An explosive composition in accordance with claim 3 including water in sufficient amount to form a suspension.

12. An explosive composition in accordance with claim 11 including in addition aluminum as a fuel.

13. An explosive composition consisting essentially of from about 10 to about 75% of an inorganic nitrate oxidizer salt, from about 5 to about 40% of a sensitizer consisting essentially of from 5 to 95% nitrostarch gelatinized by from 95 to 5% dinitrotoluene, and from about 0.5 to about 30% of a fuel, selected from the group consisting of carbonaceous fuels and metallic fuels.

14. An explosive composition in accordance with claim 13 in which the inorganic nitrate is ammonium nitrate.

15. An explosive composition in accordance with claim 13 in which the inorganic nitrate is a mixture of from about 50 to about 95% ammonium nitrate and from about 5 to about 50% of a nitrate selected from the group consisting of alkali metal and alkaline earth metal nitrates.

16. An explosive composition in accordance with claim 13 in which the fuel is a metal fuel.

17. An explosive composition in accordance with claim 13 in which the fuel is a carbonaceous fuel.

References Cited

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