United States Patent Office 3,083,127
Patented Mar. 26, 1963

3,083,127

AQUEOUS NITROSTARCH EXPLOSIVE SLURRIES

George L. Griffith, Coopersburg, and Franklin B. Wells, Emaus, Pa., assignors to Trojan Powder Company, a corporation of New York

No Drawing. Filed June 17, 1960, Ser. No. 36,710
19 Claims. (Cl. 149—59)

This invention relates to aqueous explosive slurries, and more particularly to explosive slurries based on an inorganic nitrate and sensitized with nitrostarch.

Explosive mixtures containing relatively large amounts of water have recently become of considerable interest in the explosive art. They have greater versatility than dry mixtures, because they can be used under conditions where water cannot be excluded, and the flowable slurries also may be brought more easily to certain types of sites such as bore holes and rock crevices. The water content is more than that which is absorbed by the components of the mixture, and is sufficient to act as a suspending agent for the mixture. Such a water content in most cases ranges from about 10% to more than 30%, depending upon the materials present in the mixture and upon the consistency desired.

A slurry having a reasonably stiff consistency containing as little as 10% water may be preferred for use in bulk in wet bore holes, where the composition may be diluted with water already present. Thickening or gelatinizing agents are employed when thick slurries are required containing high proportions of water. A slurry which can be poured may be desired for use in bulk in dry bore holes, and such a slurry is easily obtained by using a rather large proportion of water, for example, 20–40%, without a thickening or gelatinizing agent.

Slurries of this type are described in U.S. Patent No. 2,930,685 to Cook and Farnam, patented March 29, 1960. These compositions are based upon ammonium nitrate and sensitized with TNT, and may contain powdered aluminum. The patentees emphasize a statement made previously by one of them, Melvin A. Cook, in his text The Science of High Explosives, pages 316 to 321, that in such slurries fine grained TNT cannot be used, and that the TNT particles must be coarser than 30 mesh, standard Tyler mesh size.

This is a great disadvantage, since the normal form of TNT is the fine grained form, so that these slurries require a special material. Furthermore, as the patentees themselves point out at column 3, lines 70 to 74, the fine grain particles have a greater sensitivity when dry, and can be detonated in diameters as low as ¼ inch with ordinary blasting caps. They also are more easily kept in suspension in the slurry, because they are smaller, whereas Cook et al. with their larger particles encounter a settling problem which results in the formation of two layers at water contents beyond 18%, with an ammonium nitrate solution on top. However, it is quite clear that in the case of TNT slurries, the curve of sensitivity plotted against mesh size moves abruptly towards increased sensitivity at about 30 mesh. These findings for TNT slurries definitely suggest that powdered explosives cannot be used in aqueous slurry form. This of course conforms to the general understanding of the art that water desensitizes powdered explosive mixtures, and Cook et al. indeed point out that the art has always taken extensive precautions both in formulating and in storing explosives to exclude moisture.

In accordance with the instant invention, aqueous explosive slurries are provided based on an inorganic nitrate and sensitized with nitrostarch as the principal explosive ingredients. These slurries unexpectedly are superior in nearly all respects to similar slurries made with coarse-grained TNT, despite the fact that nitrostarch is a fine-grained powder. The explosive slurries of the invention have higher rates of dentonation, and greater power. They are impact resistant, and yet far more sensitive to detonating agents than are the coarse-grained TNT-sensitized slurries. Also, they freeze more slowly, and when frozen are not as difficult to work. These improvements are in large measure due to the fine-grained condition of the nitrostarch, and are obtained with slurries of approximately the same consistency as the corresponding coarse-grained TNT-sensitized slurries, when the nitrostarch is present in proportions not exceeding approximately 25%. Larger amounts of nitrostarch may require more water than those containing coarse-grained TNT for a similar consistency, again probably due to the smaller particle size of the nitrostarch.

The explosive slurries of the invention contain enough water to act as a suspending medium for the solid ingredients. Some explosives and sensitizers are capable of absorbing surprisingly large amounts of water. The water added in the slurries of the invention is always enough more than this amount to suspend the mixture. Usually, 7% water is enough to barely slurry the mixture, but more may be required to make the slurry flowable. The practical upper limit is set by excessive dilution and dissipation of the explosive power, taking into account any loss of water by volatilization and absorption into the ground. In most cases, the preferred range of water content will be from about 10% to 40%, although in some cases as much as 50% might be used.

The relative proportions of inorganic nitrate and nitrostarch will depend upon the sensitivity and explosive effect desired, and are not critical. These in turn are dependent upon the particular nitrate or nitrates used. For optimum effect, the inorganic nitrate is used in an amount within the range from about 50 to about 75%, and the nitrostarch in an amount within the range from about 15 to about 25%. The preferred ratios of nitrate: nitrostarch are from 5:1 to 2:1.

However, from about 35 to about 75% inorganic nitrate and from about 10 to about 30% nitrostarch give quite satisfactory results in the slurried explosive mixtures of the invention.

Any inorganic nitrate can be employed as the oxidizer in the slurried mixtures of the invention. Ammonium nitrate is the nitrate normally used. However, any inorganic nitrate can be employed in admixture with or in place of ammonium nitrate. Nitrates of the alkali and alkaline earth metals such as sodium nitrate, potassium nitrate, calcium nitrate, strontium nitrate and barium nitrate are exemplary additional inorganic nitrates. Mixtures of ammonium nitrate with alkali and/or alkaline earth metal nitrates in proportions within the range from 25 to 75% of ammonium nitrate and from 75 to 25% of the other nitrate are preferred in many instances because of their high power as shown by crater values, which values give a true picture of the power from the standpoint of the practical application, contrary to the suggestion of low power from the results of the ballistic pendulum tests. Compositions based on ammonium nitrate as the sole inorganic nitrate are also preferred because of their high power, as evidenced by the crater values.

The inorganic nitrate may be fine, coarse, or a blend of fine and coarse material. Mill and prill inorganic nitrates are quite satisfactory.

In addition to these materials, which are the essential ingredients, the explosive slurries may include one or more fuels. Illustrative are particulate metals, for example, aluminum powder, flake aluminum, and ferrosilicon. A metal fuel when present will usually comprise about 10 to about 25% of the mixture. Also useful are carbonaceous materials such as powdered coal, coal dust, charcoal, bagasse, dextrin, starch, wood meal, flour, bran,

pecan meal or similar nut shell meals, and paraffin oil. The carbonaceous fuel when present will usually comprise from 5 to about 10% of the mixture. Mixtures of such fuels can also be used, in amounts from about 5 to about 25%.

An antacid, such as zinc oxide, may be added if desired.

The consistency of the composition for any given amount of water can be increased as desired by incorporating a thickening or gelatinizing agent. In this way it is possible to prepare a thick slurry containing a large proportion of water for use in bulk in dry bore holes. The thickening agent is water-soluble or water-dispersible, and inert to the other ingredients present. These are well known materials, and any of those known to the art can be used, such as carboxymethyl cellulose, methyl cellulose, guar gum, psyllium seed mucilage, and pregelatinized starches such as Hydroseal 3B. The amount of thickening agent will depend on the consistency desired, and will be within the range from 0 up to about 5%.

The mixture is readily prepared by simple mixing of the ingredients. The solid materials, including the nitrostarch and inorganic nitrate, and fuel, and antacid, if any, would usually be mixed first to form a homogeneous blend, and then sufficient water and thickener or gelatinizing agent, if required, would be added to bring the mixture to the desired consistency, which can range from a thick, barely pourable mixture to a quick flowing liquid.

The following examples in the opinion of the inventors represent the best embodiments of their invention.

Example 1

A slurry was prepared using dry mill nitrostarch, mill ammonium nitrate, flake aluminum, and water. The three solid materials were mixed thoroughly, and then the water was added. The proportions were as follows:

	Parts by weight
Dry mill nitrostarch	30
Mill ammonium nitrate	50
Flake aluminum	30
Water	31
	141

The density, ballistic pendulum value, sensitivity in 2 inch pipe, and rate of detonation in 2 inch pipe were determined for this slurry. In the sensitivity tests, when the scope of the standard caps had been passed there were used progressively as more powerful initiators 3 g. PETN [1] boosters, and then 5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200, and 250 g. and then ½ pound, 1 pound, and 2 pound cast pentolite boosters. The following data was taken:

[1] Pentaerythritol tetranitrate.

Density	1.24.
Ballistic pendulum value	12.5.
Sensitivity in 2 inch pipe	3 g.[1] PETN.
Rate of detonation in 2 inch pipe	5010 m./sec.

[1] Pentaerythritol tetranitrate.

The above data show that the ballistic pendulum value was good. This slurry is extremely sensitive, and has an excellent rate of detonation.

A cratering test was carried out as follows. The slurry was loaded into a polyethylene-lined cartridge 4½ inches in diameter and 15 inches long. This cartridge was placed upright in a hole in the ground 30 inches deep, and was tamped firmly in place with loose dirt until the level of tamping reached that of the surrounding ground. A 1 pound cast pentolite (mixture of equal parts pentaerythritol tetranitrate and trinitrotoluene) booster at the top of the cartridge was used for initiation. When correction was made for the booster, 9.6 cubic feet of earth was found to have been moved per pound of explosive. This clearly shows the power of this explosive slurry.

This test data is to be contrasted with that obtained for a slurry having the same composition as the above, but containing 30 parts of 14 mesh TNT in place of the dry mill nitrostarch. This composition had a density of 1.32, a ballistic pendulum value of 12.8, a sensitivity in 2 inch pipe of a 250 gram pentolite booster or of a 250 gram composition B booster, and a rate of detonation in 2 inch pipe of 4360 m./sec. The superiority of the nitrostarch slurry in sensitivity and detonation rate is evident in this data. In the cratering test, the TNT slurry moved 7.9 cubic feet of earth per pound of explosive, much inferior to the nitrostarch slurry.

Example 2

A slurry was prepared by the same method as in Example 1, based upon a mixture of mill ammonium nitrate and mill sodium nitrate, and having the following composition:

	Parts by weight
Dry mill nitrostarch	20.0
Mill ammonium nitrate	56.5
Mill sodium nitrate	5.0
Zinc oxide	0.3
Bagasse	1.0
Cornstarch	3.2
Hydroseal 3B	2.0
Water	16.0
	104.0

The comparative tests of Example 1 gave the following results on this slurry:

Density	1.405.
Ballistic pendulum value	9.8.
Sensitivity in 2 inch pipe	3 g.[1] PETN.

[1] Pentaerythritol tetranitrate.

Rates of detonation were run in various sizes of pipe. The rates in m./sec. in the different pipes were as follows.

Pipe diameter:	M./sec.
¾ inch	5216
1¼ inch	5364
2 inch	5427

These results are to be contrasted with the results for a composition identical in every respect but containing 20 parts of 14 mesh TNT in place of the nitrostarch. This composition had a density of 1.410, a ballistic pendulum value of 9.5, and a sensitivity in a 2 inch pipe of a 1 pound pentolite booster. Rates of detonation run in the various sizes of pipe for the nitrostarch slurry showed that the TNT slurry failed in pipes less than 2 inches in diameter. The rate of detonation in a 2 inch pipe was 4465 m./sec. and in a 3 inch pipe 4644 m./sec. In the cratering test described in Example 1, the nitrostarch slurry moved 8.4 cubic feet of earth per pound of explosive, whereas the TNT slurry moved only 7.2 cubic feet of earth per pound. The superiority of the nitrostarch slurry is evident from this data.

Freezing tests were carried out upon both the nitrostarch and TNT slurries. The nitrostarch slurry solidified much more slowly than the TNT mixture, and after freezing, it was not as hard but could still be worked. For example, 1 inch x 8 inch cylinders of the two slurries were suspended in a freezing bath at −20° C. The TNT slurry set to a very hard rod in less than one hour, whereas the nitrostarch slurry had not solidified after seven hours. Overnight the nitrostarch slurry set, but the rod so formed could be crumbled by the fingers alone and worked into different forms, whereas the TNT slurry rod was brittle enough so that it could be snapped by hand and could not be crumbled or otherwise worked by the fingers. At −70° C. the TNT slurry set completely in five minutes. Thus, nitrostarch slurries are considerably better in resistance to cold.

In all cases, the frozen slurry softened and liquefied at −11° C.

Example 3

A slurry was prepared by the same method as in Example 1 based upon a mixture of mill ammonium nitrate and mill sodium nitrate and having the following composition:

	Parts by weight
Dry nitrostarch	20.0
Mill ammonium nitrate	46.5
Mill sodium nitrate	15.0
Zinc oxide	0.3
Bagasse	1.0
Cornstarch	2.2
Hydroseal 3B	2.0
Oil No. 5	1.0
Water	16.0
	104.0

The comparative tests of Example 1 gave the following results on this slurry:

Density	1.420.
Ballistic pendulum value	9.4.
Sensitivity in 2 inch pipe	3 grams of PETN.

Rates of detonation were run in 2 inch pipe at densities of from 1.4 to 1.5. The average rate of detonation was 5439 m./sec. In the cratering test described in Example 1, this slurry moved 9.6 cubic feet of earth per pound of explosive.

Example 4

A slurry was prepared by the same method as in Example 1 based upon a mixture of mill ammonium nitrate and mill sodium nitrate and having the following composition:

	Parts by weight
Dry nitrostarch	20.0
Mill ammonium nitrate	37.0
Mill sodium nitrate	24.2
Zinc oxide	0.3
Bagasse	1.0
Hydroseal 3B	3.0
Oil No. 5	1.0
Sea coal	1.5
Water	16.0
	104.0

The comparative tests of Example 1 gave the following results on this slurry:

Density	1.44.
Ballistic pendulum value	8.8.
Sensitivity in 2 inch pipe	3 grams PETN.

Rates of detonation were run in 2 inch pipe at densities of from 1.4 to 1.5. The average rate of detonation was 5545 m./sec. In the cratering test described in Example 1, this slurry moved 10.4 cubic feet of earth per pound of explosive.

Example 5

A slurry was prepared by the same method as in Example 1 based upon a mixture of mill ammonium nitrate and mill sodium nitrate and having the following composition:

	Parts by weight
Dry nitrostarch	20.0
Mill ammonium nitrate	22.0
Mill sodium nitrate	37.7
Zinc oxide	0.3
Bagasse	1.0
Hydroseal 3B	3.0
Oil No. 5	1.0
Sea coal	3.0
Water	20.0
	108.0

The comparative tests of Example 1 gave the following results on this slurry:

Density	1.50.
Ballistic pendulum value	6.9.
Sensitivity in 2 inch pipe	5 grams pentolite.

Rates of detonation were run in 2 inch pipe at densities of from 1.4 to 1.5. The average rate of detonation was 5303 m./sec. In the cratering test described in Example 1, this slurry moved 9.5 cubic feet of earth per pound of explosive.

Example 6

A slurry was prepared by the same method as in Example 1 based upon a mixture of mill ammonium nitrate and mill sodium nitrate and having the following composition:

	Parts by weight
Dry nitrostarch	20.0
Mill ammonium nitrate	6.0
Mill sodium nitrate	52.5
Zinc oxide	0.3
Bagasse	1.0
Hydroseal 3B	3.0
Oil No. 5	1.5
Sea coal	3.7
Water	22.0
	110.0

The comparative tests of Example 1 gave the following results on this slurry:

Density	1.56.
Ballistic pendulum value	5.7.
Sensitivity in 2 inch pipe	10 grams pentolite.

Rates of detonation were run in 2 inch pipe at densities of from 1.4 to 1.5. The average rate of detonation was 5043 m./sec. In the cratering test described in Example 1, this slurry moved 6.0 cubic feet of earth per pound of explosive.

All proportions in the specifications and claims are by weight of the entire explosive slurry.

What is claimed is:

1. An aqueous explosive slurry consisting essentially of from about 35 to about 75% by weight of an inorganic nitrate oxidizer, from about 10 to about 30% by weight of nitrostarch, and an amount of water within the range of about 7 to about 50% by weight of the composition sufficient to act as a suspending medium for the solid ingredients.

2. An aqueous explosive slurry in accordance with claim 1, in which the inorganic nitrate oxidizer is ammonium nitrate.

3. An aqueous explosive slurry in accordance with claim 1, in which the inorganic nitrate oxidizer is an inorganic nitrate selected from the group consisting of alkali and alkaline earth metal nitrates.

4. An aqueous explosive slurry in accordance with claim 1 including from about 5 to about 25% of a fuel.

5. An aqueous explosive slurry in accordance with claim 4 in which the fuel is particulate aluminum.

6. An aqueous explosive slurry in accordance with claim 4 in which the fuel is a carbonaceous material.

7. An aqueous explosive slurry in accordance with claim 4 in which the fuel is a mixture of particulate aluminum and a carbonaceous material.

8. An aqueous explosive slurry in accordance with claim 1 including a thickening agent in an amount to appreciably increase the viscosity of the slurry.

9. An aqueous explosive slurry in accordance with claim 8 in which the amount of the thickening agent is up to about 5%.

10. A blasting agent comprising an aqueous explosive slurry in accordance with claim 1 in combination with a booster charge.

11. A blasting agent in accordance with claim 10 in which the booster is pentaerythritol tetranitrate.

12. A blasting agent in accordance with claim 10 in which the booster is pentolite.

13. An aqueous explosive slurry consisting essentially of from about 50 to about 75% ammonium nitrate, from about 15 to about 25% nitrostarch, from about 5 to about 25% of a fuel, and an amount of water within the range of about 7 to about 50% by weight of the composition sufficient to act as a suspending medium for the solid ingredients, and from 0 to about 5% of a thickening agent, if required, to increase the consistency of the slurry.

14. An aqueous explosive slurry in accordance with claim 13 in which the fuel is a carbonaceous material.

15. An aqueous explosive slurry in accordance with claim 13 in which the fuel is particulate aluminum.

16. An aqueous explosive slurry consisting essentially of from about 50 to about 75% of an inorganic nitrate, from about 15 to about 25% nitrostarch, from about 5 to about 25% of a fuel, and an amount of water within the range of about 7 to about 50% by weight of the composition sufficient to act as a suspending medium for the solid ingredients, and from 0 to about 5% of a thickening agent, if required, to increase the consistency of the slurry.

17. An aqueous explosive slurry consisting essentially of from about 50 to about 75% of an inorganic nitrate selected from the group consisting of alkali and alkaline earth metal nitrates, from about 15 to about 25% nitrostarch, from about 5 to about 25% of a fuel, and an amount of water within the range of about 7 to about 50% by weight of the composition sufficient to act as a suspending medium for the solid ingredients, and from 0 to about 5% of a thickening agent, if required, to increase the consistency of the slurry.

18. An aqueous explosive slurry consisting essentially of from about 35 to about 75% by weight of a mixture of ammonium nitrate and an inorganic nitrate selected from the group consisting of the alkali and alkaline earth metal nitrates, in the proportion of from about 25 to about 75% ammonium nitrate and from about 75 to about 25% alkali or alkaline earth metal nitrate, from about 10 to about 30% by weight of nitrostarch, and an amount of water within the range of about 7 to about 50% by weight of the composition sufficient to act as a suspending medium for the solid ingredients.

19. An aqueous explosive slurry consisting essentially of from about 50 to about 75% of a mixture of ammonium nitrate and an inorganic nitrate selected from the group consisting of alkali and alkaline earth meta' nitrates, in the proportions of about 25 to about 75% ammonium nitrate and from about 75 to about 25% by weight of alkali or alkaline earth metal nitrate, from about 15 to about 25% nitrostarch, from about 5 to about 25% of fuel, and an amount of water within the range of about 7 to about 50% by weight of the composition sufficient to act as a suspending medium for the solid ingredients, and from 0 to about 5% of a thickening agent, if required to increase the thickness of the slurry.

References Cited in the file of this patent

UNITED STATES PATENTS

1,386,478	Waller	Aug. 2, 1921
2,860,041	Griffith et al.	Nov. 11, 1958
2,867,172	Hradel	Jan. 6, 1959