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# AMMONIUM NITRATE EXPLOSIVE COMPOSITION

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This invention relates to an improved ammonium nitrate explosive composition and more particularly concerns an ammoniacal ammonium nitrate explosive composition containing carbon as a sensitizer. It has been a desideratum in the explosives art to formulate and compound explosive compositions which may be handled and transported with relative safety yet reliably and effectively detonated. To fill this need various ammonium nitrate explosive compositions have been proposed but these have generally contained materials that are quite shock sensitive or the compositions have required boosters such as gelatin dynamite spaced throughout a large load to insure good provocation.

It is an object of the present invention to provide an ammonium nitrate explosive composition which may be safely handled and transported with little danger of shock initiation yet may be detonated effectively by a shaped charge using the Monroe jet principle.

It is another object of the invention to provide an ammonium nitrate explosive composition of moderate shock sensitivity which yet upon proper initiation produces a detonation of useful magnitude and force.

Another object of the invention is to provide an ammonium nitrate explosive composition in the form of a paste or slurry whereby a charge of the composition upon being loaded into a rigid or flexible container, or directly into a bore hole, contains a minimum of void spaces within the charge.

Another object of the invention is to provide an ammonium nitrate explosive composition containing a sensitizer which is not adversely affected by moisture during storage of the composition.

An additional object of the invention is to provide an ammonium nitrate explosive composition containing carbon as a sensitizer.

A still further object of the invention is to provide a low cost ammonium nitrate explosive composition which is adapted to be readily compounded near the point of use.

Other objects and advantages of the invention will become apparent to one skilled in the art upon becoming familiar with the following description and claims.

These and other objects are attained upon admixing ammonium nitrate, itself cap insensitive, with a carbon sensitizer and with an ammoniacal solution of ammonium nitrate in proportions hereinafter more fully described and further illustrated by examples of the invention. All proportions herein given in percent are to be understood as percent by weight unless otherwise indicated.

The composition of the invention may be compounded with fertilizer grade as well as explosive grade ammonium nitrate. While the explosive grade material tends to detonate with slightly greater force on an equal weight basis it is generally more economical to make up for this by using a slightly greater amount of fertilizer grade ammonium nitrate.

Fertilizer grade ammonium nitrate generally contains various additives or fine particulate coatings inhibiting caking and promoting free-flowing characteristics of the material. Ammonium nitrate as referred to herein is defined as ammonium nitrate containing up to 3 percent of various additives such as wax, diatomaceous earth and chalk, in addition to a moisture content ranging up to



about 1½ percent, either the granular or prilled form of the nitrate salt are satisfactory.

To avoid making cap sensitive mixtures the composition is best prepared from ammonium nitrate having particle sizes mainly in the range of 8 to 100 mesh, fines passing 100 to 200 mesh tending to increase the sensitivity of the mixture. An example of a satisfactory granular ammonium nitrate readily obtained commercially has the following sieve analysis:

*Table I*

| Number of sieve [1] passed | Number of sieve retained on | Percent retained |
|---|---|---|
| ------- | 12 | 0.3 |
| 12 | 20 | 34.4 |
| 20 | 30 | 16.4 |
| 30 | 40 | 13.4 |
| 40 | 60 | 14.4 |
| 60 | 80 | 8.4 |
| 80 | 100 | 1.9 |
| 100 | 200 | 6.4 |
| 200 | Pan | 4.4 |

[1] Sieves of the U.S. Sieve Series; U.S. Bureau of Standards.

An example of a satisfactory prilled ammonium nitrate which is commercially available has the following sieve analysis:

*Table II*

| Number of sieve passed | Number of sieve retained on | Percent retained |
|---|---|---|
| ------ | 6 | 0 |
| 6 | 10 | 56 |
| 10 | 12 | 24 |
| 12 | 14 | 9 |
| 14 | 20 | 9 |
| 20 | 35 | 2 |
| 35 | Pan | Tr. |

The above examples are not intended to limitative but indicative of the nature of commercially available ammonium nitrate.

Carbon in the form of finely ground coke, charcoal or coal as well as carbon black or lamp black is suitable for use in compounding the composition of the invention. Fine particulate carbon passing a 325 mesh sieve is to be preferred though carbon having particle sizes up to that retained on a 60 mesh sieve may be used if desired. Coarse particulate carbon tends to react slower during a detonation and is thus less efficiently use.

A suitable ammoniacal solution of ammonium nitrate is Diver's liquid which is a saturated or nearly saturated anhydrous solution of ammonium nitrate in liquid ammonia containing generally about 60 to 80 percent of ammonium nitrate. A similar ammoniacal solution of ammonium nitrate containing in addition up to 15 percent of water is referred to herein as an ammoniacal solution of ammonium nitrate. Such aqueous ammoniacal solutions are commercially available at lower cost and are easier to handle than the anhydrous Diver's liquid because of the reduced vapor pressure of the ammonia therein in the presence of water. As an example, a solution consisting of 60 percent of ammonium nitrate, 34 percent of liquid ammonia and 6 percent of water is commercially available.

The hereinabove described components of the explosive mixture of the invention may be combined in various proportions ranging from 6 to 95 percent of solid particulate ammonium nitrate, from 0.5 to 20 percent of finely divided carbon and from about 3 to 87 percent of an ammoniacal solution of ammonium nitrate con-

taining up to 30 percent of water and substantially saturated with respect to ammonium nitrate. It is to be understood that while compositions in this range, will, under room temperature conditions, contain both dissolved ammonium nitrate and solid phase particulate ammonium nitrate in the proportions described, the relative amount of ammonium nitrate in each phase is determined by the temperature and pressure of the mixture under equilibrium conditions. At higher temperatures under a constant pressure more solid particulate ammonium nitrate will be taken up by the solution and at lower temperatures a lesser amount. For this reason the invention has been defined above with respect to mixtures equilibrated at room temperature and under atmospheric pressure.

In another manner of defining the explosive composition of the invention, that is, in terms of the individual molecular or elemental species from which the composition may be prepared if desired, the proportions range from 60 to about 97 percent of ammonium nitrate total, from 0.5 to 20 percent of finely divided carbon, from 1 to 30 percent of ammonia and up to 3 percent of water.

Mixtures of the invention containing less than about 18 to 20 percent of liquid solution phase are generally in the form of a lumpy paste and are advantageously loaded into accessible bore holes or placed in suitable containers which may be charged into a bore hole as in mining or quarrying operations.

Mixtures of the invention containing more than about 20 percent of the liquid solution phase are to be preferred for pumping into a bore hole as a slurry and are especially advantageously used in loading an elongated horizontal or upwardly sloping bore hole.

If desired, the explosive composition of the invention may be thickened upon admixing therewith from about 0.12 to 5 percent, based on the weight of the liquid phase, of a thickening agent such as methyl cellulose or gum karaya. Other suitable thickening agents are carboxymethyl cellulose, kava-kava gum, guar gum, accroides gum, locust bean gum, gum tragacanth, balsam tolu natural, gum bezoin Sumatra, Irish moss, Iceland moss and Separan NP–10 (a high molecular weight polyacrylamide). The effects of various thickening agents on the viscosity respectively, of Diver's liquid and of an aqueous ammoniacal solution also known as Spensol D, a trademarked product, and containing 60 percent of ammonium nitrate, 34 percent of ammonia and 6 percent of water were determined and the results are listed in Table III.

*Table III*

| Thickener | Weight percent of thickener | Viscosity of ammoniacal solution after addition of thickener (cps.) | |
|---|---|---|---|
| | | Diver's liquid | Spensol D |
| None | | 1.5 | 7.5 |
| Carboxymethyl cellulose extra high | 5 | >100,000 | >100,000 |
| Guar gum | 5 | 41 | >100,000 |
| Kava kava gum | 5 | 5,100 | 450 |
| Accroides gum | 5 | | 120 |
| Locust bean gum | 1 | | 18 |
| Do | 5 | | >100,000 |
| Balsam tolu natural gum | 1 | | 20 |
| Irish moss | 5 | 121 | 60 |
| Iceland moss | 5 | | 42 |
| Separan NP 10 | 5 | | 140 |
| Methocel HG | 0.125 | | 10 |
| Do | .25 | | 19 |
| Do | .5 | | 77 |
| Do | 1 | 900 | 315 |
| Do | 5 | >100,000 | 95,000 |
| Karaya gum | 0.125 | | 18 |
| Do | .25 | | 28 |
| Do | .5 | | 142 |
| Do | 1 | | 395 |
| Do | 5 | 84,000 | 4,000 |

In preparing and detonating the composition of the invention the ingredients of the composition are mixed together in small quantities as by kneading in a plastic bag or in larger quantities as with a mechanical agitator or paddle mixer. A load or charge of the so prepared mixture is placed in the desired location, usually in the confinement of a bore hole. A shaped charge, such as a commercially available jet perforator containing a charge of RDX is armed with a suitable initiator such as a No. 8 blasting cap and placed next to the load. The shaped charge is oriented with respect to the explosive load so that the firing access is directed toward the load, preferably its mid-point. The electrical lead for the blasting cap is rigged to a time controlled firing mechanism or run to a remote control device and, if desired, a sand or gravel tamp is placed over the load and initiator. The load is then fired upon setting off the blasting cap and shaped charge.

To demonstrate the properties of the ammonium nitrate explosive mixture of the invention various embodiments of the invention were compared and tested. In each test a 10 pound quantity of explosive mixture was formulated of a particulated fertilizer grade of ammonium nitrate, finely divided carbon black and ammonia, or of a particulated fertilizer grade ammonium nitrate, finely divided carbon black and an aqueous ammoniacal solution of ammonium nitrate known as Spensol D in the proportions and amount shown hereinbelow in Table IV. The individual proportions were in each case mixed in a separate polyethylene plastic bag of sufficient size to readily hold the quantity prepared. The various components of the mixture were weighed into the bag, the bag closed and the contents mixed together by kneading the bag with the hands. The fertilizer grade of ammonium ntirate contained about 0.7 percent of wax, 1 percent of diatomaceous earth and 0.3 percent of chalk. The particle size of the ammonium nitrate was such that 94 percent by weight of the particles passed a 20 mesh sieve and 85 percent by weight were retained on a 100 mesh sieve. The carbon was in the form of carbon black.

The prepared mixtures were loaded into individual shallow bore holes drilled in clay soil and having a diameter of 4 inches and depth of about 4 feet. Successive bore holes were spaced about 20 feet apart. The loading of each hole was accomplished by first placing an initiator in the form of a shaped charge armed with a blasting cap in the bottom of the hole and running the lead wires from the blasting cap to a firing control switch. Each shaped charge used was positioned with the jet end or firing axis facing upwardly. The explosive mixtures, contained in the plastic bags in which they were mixed, were dumped into respective test holes, the bags in each case deforming over the initiator. Sand was used as a tamp, the hole being filled from the bag to ground level with sand. Detonation of the mixture was attempted by closing the firing switch thus setting off the initiator at the bottom of the hole. The magnitudes of the detonations obtained were determined by measuring the size of the crater produced. While the crater size alone is not indicative of the amount of earch formation that is broken up or loosened, it does give an indication of the work potential of the mixture detonated. The crater size herein reported shows how much material was thrown sufficiently so as not to fall back over the test hole. Test conditions and results are summarized in Table IV.

In order to compare the composition of the invention with conventional explosives varied amounts of 60 percent dynamite each with a No. 8 electric blasting cap therefore were placed in shallow test holes 4 feet deep, tamped with sand and detonated. 5 pounds of dynamite so loaded and detonated produced a crater 5 feet in diameter and 1.5 feet deep; 10 pounds of dynamite produced a crater 8 feet in diameter and 1 foot deep; while 25 pounds of dynamite produced a crater 11 feet in diameter and 5 feet deep.

In another test series additional embodiments of the invention were compounded. Each mixture was used to entirely fill a 3 inch x 12 inch steel pipe nipple which was capped on both ends and laid on the ground. The charge was initiated by a shaped charge containing 3.25 oz. of RDX which was positioned at one end of the nipple so as to fire longitudinally into the nipple. In one such test the steel pipe nipple was heated by electrical resistance heating elements and the contents of the nipple subjected to hydrolic pressure.

The compositions tested and the results obtained are summarized in Table V.

*Table IV*

| Test No. | Composition | | | | Gum Karaya [1] | Weight of load, lbs. | Initiator | | Crater dimensions, ft. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FGAN | C | $NH_3$ | S.D. | | | Blasting cap | Weight RDX in shaped charge, oz. | Diameter | Depth |
| 1 | 89 | 6 | 5 | | | 10 | 8 EBC | 1 | 8 | 2.5 |
| 2 | 94 | 1 | 5 | | | 10 | 8 EBC | 1 | 5 | .5 |
| 3 | 81 | 4 | | 15 | | 10 | 8 EBC | 1 | 6 | 2 |
| 4 | 94 | 1 | | 5 | | 10 | 8 EBC | 1 | 9 | 1 |
| 5 | 84 | 1 | | 15 | | 10 | 8 EBC | 1 | 9 | 1 |
| 6 | 78 | 2 | | 20 | | 10 | 8 EBC | 1 | 9 | 1 |
| 7 | 87 | 3 | | 10 | | 10 | 8 EBC | 1 | 9.5 | 1.5 |
| 8 | 80 | 15 | 5 | | | 10 | 8 EBC | 1 | 8 | 6 |
| 9 | 75 | 5 | 20 | | | 10 | 8 EBC | 1 | 6 | Heaved. |
| 10 | 85 | 13 | | 2 | ¼ | 10 | 8 EBC | 3.25 | 7 | 4 |
| 11 | 85 | 10 | | 5 | ¼ | 10 | 8 EBC | 3.25 | 7 | 4 |
| 12 | 90 | 8 | | 2 | ¼ | 10 | 8 EBC | 3.25 | 8 | 4.5 |
| 13 | 97 | 2 | | 1 | ¼ | 10 | 8 EBC | 3.25 | 8 | 4 |
| 14 | 80 | 10 | 10 | | ¼ | 10 | 8 EBC | 3.25 | 10 | 5 |
| 15 | 85 | 5 | 10 | | ¼ | 10 | 8 EBC | 3.25 | 12 | 6 |
| 16 | 93 | 4 | 3 | | ¼ | 10 | 8 EBC | 3.25 | 12 | 6 |
| 17 | 96 | 2 | 2 | | ¼ | 10 | 8 EBC | 3.25 | 12 | 6 |
| 18 | 84 | 3 | 13 | | ¼ | 10 | 8 EBC | 3.25 | 10 | 5 |
| 19 | 70 | 15 | 15 | | ¼ | 10 | 8 EBC | 3.25 | 8 | 6 |
| 20 | 73 | 20 | 7 | | ¼ | 10 | 8 EBC | 3.25 | 10 | 6 |

FGAN—fertilizer grade ammonium.
S.D.—Spensol D, a commercial aqueous ammoniacal solution of ammonium nitrate.
RDX—trimethylene trinitramine.
[1] Percent based on weight of liquid phase at room temperature.

*Table V*

| Test No. | Composition | | | | Weight of charge, lbs. | Applied temperature, °F. | Applied pressure, p.s.i. | Results of detonation |
|---|---|---|---|---|---|---|---|---|
| | FGAN | C | $NH_3$ | S.D. | | | | |
| 21 | 70 | 5 | 25 | | 2.3 | | | Pipe nipple partially destroyed. |
| 22 | 75 | 5 | 20 | | 3.25 | | | Pipe nipple destroyed. |
| 23 | 80 | 15 | 5 | | 2.2 | | | Do. |
| 24 | 75 | 12.5 | 12.5 | | 3.8 | | | Do. |
| 25 | 60 | 10 | 30 | | 4 | 235 | 2,000 | Pipe nipple burst. |
| 26 | 65 | 15 | | 20 | 4.5 | | | Pipe nipple partially destroyed. |

The results show that a composition of the invention containing from 60 to 80 percent of ammonium nitrate is effectively detonated by a shaped charge under the conditions of the test.

The compositions of the invention possess the advantage that they may be slurried in an additional amount of an ammoniacal solution of ammonium nitrate and pumped into a bore hole and there allowed to settle out to form a detonable composition.

What is claimed is:

1. An ammonium nitrate explosive composition consisting essentially of particulate ammonium nitrate in admixture with from 0.5 to 20 percent by weight of finely divided carbon and with an ammoniacal solution which is substantially saturated with respect to ammonium nitrate, said ammoniacal solution containing a proportion of ammonia equivalent to from 1 to 30 percent by weight of the total weight of the admixture, said ammoniacal solution further containing up to 30 percent by weight of water, but the said water not exceeding 3 percent of the total weight of the admixture, and said admixture containing a combined total in all phases of at least 60 percent by weight of ammonium nitrate.



2. The composition as in claim 1 containing from 1 to 6 percent of finely divided carbon.

3. An ammoniacal ammonium nitrate explosive composition consisting essentially of particulate ammonium nitrate in admixture with an ammoniacal solution substantially saturated with respect to ammonium nitrate and from 1 to 6 percent by weight of finely divided carbon, said ammoniacal solution containing up to 30 percent by weight of water based on the weight of the ammoniacal solution, the said water not exceeding 3 percent by weight of the total weight of the admixture, said ammoniacal solution having a proportion of ammonia equivalent to from about 5 to 15 percent by weight of the total weight of the admixture and said admixture containing a combined total in all phases of at least 80 percent by weight of ammonium nitrate.

4. The explosive composition as in claim 1 admixed with from 0.12 to 5 weight percent of gum karaya whereby the viscosity of the said ammoniacal solution is increased.

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