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AMMONIUM NITRATE-FUEL OIL EXPLOSIVE CONTAINING ANTI-STATIC INGREDIENT

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This invention relates to explosive compositions comprising ammonium nitrate and a fuel or sensitizer and which are resistant to the development of charges of static electricity.

Explosives composed of ammonium nitrate and oleaginous fuel of the fuel oil type are commonly known in the trade as "ammonium nitrate-fuel oil explosives," or simply as "AN/FO explosives." Those of the AN/FO explosives which contain as an additional fuel or sensitizer particulate aluminum or magnesium or alloy thereof are generally referred to as "AN/FO/metal explosives." These explosives are at present widely used in both the construction and mining industries.

Originally employed in surface blasting operations such as in quarrying, open pit mining and the like, these types of explosives have now been introduced into underground mining operations, which application has required new methods of loading the explosives into boreholes. Whereas in surface blasting operations, the boreholes are normally wide diameter vertical holes into which the explosives can be introduced by gravity methods, the boreholes used in underground mining operations may be horizontal or may be driven into the roof of the working area. Because of the granular and free-flowing consistency of AN/FO and AN/FO/metal explosives, it has been necessary to develop means of forcibly injecting the explosives into the boreholes.

An apparatus now commonly employed for this purpose is a pneumatically operated eductor which discharges the AN/FO or AN/FO/metal mixtures into the boreholes through a tube or hose. However, when the explosive mixtures pass through the eductor and hose, large charges of static electricity are developed. These electrical charges have been measured and in laboratory-simulated borehole loading conditions, charges over 20,000 volts have been recorded. This static electricity causes discomfort to persons operating the eductor loading apparatus and constitutes a continuing hazard in an area where explosives are present. Such charges are capable of detonating electric blasting caps prematurely. Furthermore, they have been shown to be conductible along a length of ordinary safety fuse and are of sufficient intensity to detonate an ordinary blasting cap attached thereto.

The use or presence of electric blasting caps in areas where AN/FO or AN/FO/metal explosives are in use has been strongly discouraged and has, in fact, in many jurisdictions, been prohibited.

It is an object of the present invention to provide a sensitized ammonium nitrate explosive composition which is resistant to the development of charges of static electricity. Another object of the invention is to provide a sensitized ammonium nitrate explosive composition which, when employed in a pneumatic borehole loading machine, will not develop hazardous charges of static electricity. Additional object of the invention will appear hereinafter.

The static-resistant explosive of this invention com-

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prises ammonium nitrate, an oleaginous fuel and, optionally, a particulate light metal, and at least one additive selected from the group consisting of the products resulting from the reaction of a mixture of secondary and tertiary aliphatic amines with a mixture of high molecular weight fatty acids, the additive being responsible for the static resistance of the explosive. In addition, the explosive compositions may advantageously contain acid acceptors, for example, calcium carbonate, sodium carbonate, ammonium carbonate, triethylamine or piperidine as a means of absorbing any free nitric acid which may be present in the ammonium nitrate ingredient and which may oxidize and destroy the static-proofing ingredient.

The ammonium nitrate ingredient is usually in the form of prills but other physical forms capable of retaining the oleaginous fuel are suitable. It may be modified by small amounts of materials which impart anti-setting or water-proofing properties. Examples of such materials are kieselguhr, kaolinite, the sodium salt of a mixture of methyl and dimethyl naphthalene, sulphonic acids and calcium stearate. The ammonium nitrate is suitably present in a concentration ranging from 60 to 98% by weight of the composition. It is, in some cases, advantageous to replace some, suitably up to 35% of the ammonium nitrate by sodium nitrate.

The oleaginous fuel ingredient of the explosive composition is preferably diesel oil or fuel oil but other suitable fuels may be used such as lubricating oils, vegetable oils, low melting petroleum greases and waxes and partially nitrated derivatives of benzene, toluene, xylene and naphthalene. Suitable amounts of these fuels lie in the range of from 2% to 20% by weight of the composition. For petroleum hydrocarbons, the preferred amount of fuel is between 4% to 8% by weight of the composition.

The optional particulate light metal ingredient is preferably aluminum or an alloy of aluminum, but magnesium, alloys of magnesium, silicon, ferrosilicon and boron may be used although the latter may prove to be more expensive, less effective or more difficult to employ from a production and safety viewpoint than aluminum or aluminum alloys. The particulate metals, when used, may suitably range in particle size from a fine dust to a form not coarser than that which will pass through a size 10 Tyler mesh screen. The aluminum or aluminum alloy is suitably present in a concentration ranging from 1 to 25% by weight of the composition.

As previously mentioned, the static-proofing ingredient of the composition may be any one or a combination of the products resulting from the reaction of a mixture of secondary and tertiary aliphatic amines with a mixture of high molecular weight fatty acids, which amines and acids have the chemical formulae:



in the case of the amines, where R is an aliphatic hydrocarbon group having 1 to 5 carbon atoms, and X is hydrogen or R; and R'COOH in the case of the fatty acids which are well known materials wherein R' is an aliphatic hydrocarbon group normally containing between 12 and 20 carbon atoms. Thus the reaction products used as the static-proofing ingredients of the compositions of this invention are complex mixtures of secondary amides and amine salts. They are available as items of commerce hitherto used only as adhesion improvers in industrial asphalt products.

The static-proofing ingredient is preferably used in a concentration of from 0.05% to 1.0% by weight of the composition.

The acid acceptor ingredient is preferably used in a concentration of from 0.05 to 0.5% by weight of the composition.

The discovery that the static-proofing ingredient of the composition provides the high degree of static generation resistance required in a pneumatically loaded explosive composition is most surprising since, as stated above, the ingredient is normally employed as an adhesion improver in industrial asphalt products.

It has also been surprisingly found that many so-called anti-static agents commonly employed in the textile, plastics and other industries to reduce static accumulation are not effective static-proofing ingredients in AN/FO and AN/FO/metal explosives. Many of these well known anti-static agents produce little or no change in the static-generating tendency of AN/FO and AN/FO/metal mixtures while others have been found to increase the quantity of static electrical build-up in pneumatically loaded explosives. Particularly, it has been found also that the use of some well known anti-static agents in these explosives contribute significantly to the setting-up or caking of the explosives under conditions of normal storage, thus making the explosives unsuitable for use.

The explosive composition of this invention is conveniently and simply prepared by dispersing the static-proofing agent in the oleaginous fuel and adding the dispersion to the ammonium nitrate, which may be coated with an anti-setting and/or moisture proofing agent.

Where it is desired to employ a particulate light metal as a sensitizer in addition to the oleaginous fuel, the ammonium nitrate and metal may first be blended together, the oleaginous fuel being then added after dispersion in the static-proofing agent.

The static-resistant explosive composition of this invention may be prepared in any suitable type of mixing equipment which is adequately grounded to earth. Preferably, the mixer should have no rapidly moving parts and have a tumbling action combined with a lifting of the material from the bottom of the mixer to the top to ensure intimate blending. The conventional ribbon type, zig-zag or rotating plough type mixers are suitable for this purpose.

As previously mentioned, these compositions have potential uses in blasting operations where the explosive is forced into the borehole through a tube or hose, thus introducing the hazard of building up electrical charges on the hose and the explosive. They are likely to be most useful in underground blasting operations although they will be useful also in surface blasting as electrical charges may be produced through the tumbling action of the composition in gravity loading of vertical boreholes.

The invention is further illustrated but not limited by the following examples in which parts and percentages are by weight unless otherwise stated.

EXAMPLE 1

An ammonium nitrate-fuel oil blasting composition was prepared by mixing 94 parts of ammonium nitrate prills and 6 parts of diesel oil. A series of mixtures were made up from this composition by adding definite percentages of the materials shown in Table I and 100 grams of each mixture were then placed in a polythene lined wood drum. The drum was set rotating at 33 $\frac{1}{3}$ r.p.m., the explosive composition tumbling over the polythene lining. Electrical charges generated were picked up by means of a metallic probe in contact with the tumbling explosive composition and lead to a voltmeter the full range of which was 20 volts. The results are given in Table I where the electrical charge generated is expressed in terms of the voltage recorded after 10 minutes of tumbling in the drum. Alternatively, where the full 20

volt scale reading was reached before 10 minutes of tumbling, the time required to generate 20 volts is shown.

Table I

	Explosive Composition	Age of Composition (days)	Charge Generated (secs.)
1	94% ammonium nitrate..... 6% diesel oil.....	1 16 91	1.5 1.1 1.8
2	94% ammonium nitrate..... 5.75% diesel oil..... 0.25% antistatic agent*.....	14 84 279	18.7 11.7 3.9
3	94% ammonium nitrate..... 5.65% diesel oil..... 0.25% antistatic agent*.....	1 257	16.2 17.4
4	0.10% CaCO ₃ 94% ammonium nitrate..... 5.9% diesel oil..... 0.1% CaCO ₃	3 98 355	2.1 1.2 1.7

¹ Volts.

*A reaction product of a mixture of secondary and tertiary aliphatic amines with a mixture of high molecular weight fatty acids which amines and acids have the chemical formulae previously defined.

As can be seen from the results shown in Table I, ammonium nitrate/fuel oil explosives composition containing the anti-static additive of this invention show a substantial improvement in static generating properties over ammonium nitrate/fuel oil compositions devoid of the anti-static additive. Similarly, where an acid acceptor is added (Composition 3), the antistatic agent containing composition retains its antistatic properties over long periods of time. Composition 4, wherein only the acid acceptor is added to an AN/FO composition, is included to demonstrate that the acid acceptor by itself plays no part in reducing the static generating properties of the mixture.

EXAMPLE 2

An ammonium nitrate-fuel oil blasting composition was prepared by the method described in Example 1 and three mixtures were prepared, each containing 0.1% of a well known anti-static agent. The mixtures were then tumbled in a polythene lined wood drum as in Example 1 and the static electricity measured. In Table II the results are expressed on the basis of 100% for the ammonium nitrate-fuel oil mixture without additive.

Table II

Additive:	Percent static Electricity
(1) None	100
(2) 0.1% isopropylamide of dodecyl benzene sulphonic acid	421
(3) 0.1% sorbitan monopalmitate	204
(4) 0.1% polyoxyethylene (3.5) tridecyl alcohol	135

What we claim is:

1. An explosive composition resistant to the development of charges of static electricity comprising ammonium nitrate, an oleaginous fuel and at least one additive selected from the group consisting of the reaction products of a mixture of secondary and tertiary aliphatic amines with a mixture of high molecular weight fatty acids.

2. An explosive composition as claimed in claim 1 wherein sodium nitrate is substituted for part of the ammonium nitrate.

3. An explosive composition as claimed in claim 1 wherein a member selected from the group consisting of finely divided aluminum and alloys thereof is substituted for part of the ammonium nitrate.

4. An explosive composition as claimed in claim 1 containing an acid acceptor selected from the group consisting of calcium carbonate, sodium carbonate, ammonium carbonate, triethylamine and piperidine.

5. An explosive composition resistant to the develop-

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ment of charges of static electricity comprising from 60% to 90% by weight of ammonium nitrate, from 2% to 20% by weight of an oleaginous fuel and from 0.05% to 1.0% by weight of at least one additive selected from the group consisting of the reaction products of a mixture of secondary and tertiary aliphatic amines with a mixture of high molecular weight fatty acids.

6. An explosive composition resistant to the development of charges of static electricity comprising from 30% to 96% by weight of ammonium nitrate, from 1% to 25% by weight of a member selected from the group consisting of finely divided aluminum and alloys thereof, from 2% to 15% by weight of an oleaginous fuel from 0% to 35% by weight of sodium nitrate, and from 0.05% to 1.0% by weight of at least one additive selected from the group consisting of the reaction products of a mixture of secondary and tertiary aliphatic amines with a mixture of high molecular weight fatty acids.

7. An explosive composition as claimed in claim 1, wherein the secondary aliphatic amines have the formula:



wherein R is an aliphatic hydrocarbon group having from 1 to 5 carbon atoms.

8. An explosive composition as claimed in claim 1, wherein the tertiary aliphatic amines have the formula:



wherein R is an aliphatic hydrocarbon group having from 1 to 5 carbon atoms.

9. An explosive composition as claimed in claim 1, wherein the high molecular weight fatty acids have the formula:



wherein R' is an aliphatic hydrocarbon group having from 12 to 20 carbon atoms.

10. An explosive composition as claimed in claim 5 wherein the secondary aliphatic amines have the formula:



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wherein R is an aliphatic hydrocarbon group having from 1 to 5 carbon atoms.

11. An explosive composition as claimed in claim 5 wherein the tertiary aliphatic amines have the formula:



wherein R is an aliphatic hydrocarbon group having from 1 to 5 carbon atoms.

12. An explosive composition as claimed in claim 5 wherein the high molecular weight fatty acids have the formula:



wherein R' is an aliphatic hydrocarbon group having from 12 to 20 carbon atoms.

13. An explosive composition as claimed in claim 1, wherein the oleaginous fuel is a member selected from the group consisting of liquid petroleum hydrocarbons, low melting petroleum greases and waxes and partially nitrated derivatives of benzene, toluene, xylene, and naphthalene.

14. An explosive composition as claimed in claim 1, wherein the ammonium nitrate is pre-treated with a member selected from the group consisting of anti-setting and waterproofing agents.

15. An explosive composition as claimed in claim 3 wherein the aluminum ingredient has a particle size not greater than 10 standard Tyler mesh size.

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