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EXPLOSIVE

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This invention relates to a detonating explosive in granular form, and more particularly to a high density explosive of high ammonium nitrate content capable of effective use in the presence of water.

Free flowing explosives offer a number of advantages in use, particularly with respect to loading, since they can be poured into the borehole and made to fill it completely without the necessity of cartridging or tamping. Black powder and various explosives containing high ammonium nitrate contents are examples of free flowing explosives of the prior art. Such compositions have been satisfactory from the viewpoint of loading properties under dry conditions, but have been out of the question when the boreholes contained, or were filled with, water. Because of the high content of water-soluble salts in such explosives, largely sodium or ammonium nitrate, or both, such compositions not only lose much of their soluble content by leaching but cease to be capable of functioning as explosives under wet conditions.

The object of the present invention is a high explosive of free-flowing nature, capable of functioning effectively after immersion in water. A further object is an ammonium nitrate explosive in granular form which is compatible with water. A still further object is a high density explosive of the foregoing type, possessing high strength. Additional advantages will be disclosed as the invention is described more fully hereinafter.

We have found that the foregoing advantages are accomplished and the disadvantages of the prior art overcome when we prepare pressed aggregates or grains preferably of flowable size comprising an inorganic oxidizing agent, a solid explosive nitrate of an aliphatic polysaccharide, and desirably a vegetable product capable of forming a cohesive paste with unheated water. The individual grains should have a density greater than 1.0, or, in other words, should be sufficiently heavy that they will sink in water.

While we preferably employ ammonium nitrate as the inorganic oxidizing agent because of the additional explosive strength imparted by its use, this salt may be replaced completely or in part by other oxygen-supplying salts, such as sodium nitrate, potassium nitrate, various inorganic perchlorates, and the like.

The presence of a certain amount of a solid explosive nitrate of an aliphatic polysaccharide is necessary in the compressed aggregates according to our invention in order to impart the desired degree of sensitiveness to propagation, so that the explosive when once initiated will function effectively. Various such explosive nitrates are applicable advantageously, for example nitrostarch, nitrocellulose, ground smokeless powder, which consists mainly of nitrocellulose, pentaerythritol tetranitrate, nitromannite, and the like.

In addition to the foregoing ingredients, it is desirable that a binding agent be present, comprising a plant product capable of forming a cohesive paste on contact with unheated water. The presence of this ingredient prevents disintegration of the explosive grains during passage through water. Various materials of this type may be used, for example a pregelatinized cereal product such as a flaked corn product in finely divided condition, where the cereal product has been preheated to an elevated temperature or otherwise treated so that it is capable of forming a cohesive paste with cold water. Other suitable paste-forming vegetable products are rye flour, barley flour, oat flour, spelt meal, linseed meal, and the like. Preferably we employ linseed meal or barley flour, since these tend to cause a constrictive effect on contact with water and formation of the cohesive protective paste. This in turn tends to give an increased density. The formation of the paste at the initial penetration of water into the explosive tends to bind together the materials and to prevent loss of the sensitizing agent from the explosive grain. Pulverulent explosives containing such ingredients are claimed in the patent to Winning, United States Patent No. 2,231,043. We find it desirable to use the paste-forming material in an amount between 2.5 and 10% of the entire composition.

Examples are given in the following of methods for carrying out our invention and for obtaining the desired free-flowing, water-compatible explosives.

Example I

The following ingredients were weighed in the proportions designated and were introduced into a figure-8 gelatin dynamite mixing bowl:

	Per cent
Nitrostarch	22.0
Ammonium nitrate	58.0
Linseed meal	4.5
Barley flour	4.5
Sodium nitrate	10.0
Aluminum powder	0.5
Chalk	0.5
	100.0

Five parts of water was added also, based on the weight of the total dry ingredients. Actually, the water was added with the nitrostarch as nitrostarch of 22.7% water content. After mixture, the above composition formed a stiff gel. The material was removed from the mixer, pressed into flat layers about 1" thick, and then dried until firm, though not to absolute removal of water. The material was granulated through a 4-mesh screen on a suitable granulator and dried completely to hard grains.

The following velocities of detonation were obtained when tin tubes were filled with water and the explosive poured in until it reached the top of the tube:

Diameter of can	Per cent water present	Velocity-meters/sec.
Inches		
1½	0	2,460
1½	5	2,460
1½	10	2,260
2	0	2,550
2	20	5,100

From the foregoing results it is seen that the explosive is not only compatible with water and capable of detonation after immersion, but that greatly increased velocity resulted in the case of the immersed powder when this was in a 2-inch diameter column. A half-stick of 40% straight dynamite was used as primer in all cases.

Example II

A mixing of the following composition was made in the same type of apparatus as used for Example I, and by the same procedure:

	Per cent
Nitrocotton	20.0
Ammonium nitrate	59.6
Sodium nitrate	8.0
Sulfur	1.6
Wood pulp	4.8
Paste-forming starch product	5.6
Chalk	0.4
	100.0

In this case, five parts of water was added with the nitrocotton, based on the total weight of the mixing.

The granulated material was again poured into tin tubes filled with water, as in Example I, the water amounting to 33⅓% of the total weight of the material in the can. Detonation was obtained.

Example III

A 7000 gram mixture was made of the following ingredients in a figure-8 mixing bowl:

	Per cent
Nitrostarch	30.0
Ammonium nitrate	56.5
Flaked corn product	4.5
Linseed meal	4.5
Wood pulp	4.0
Chalk	0.5
	100.0

The above ingredients were first mixed dry for 5 minutes, then 400 grams of water was added. The mixing was continued for 5 minutes, at which time the composition had become a stiff gel. The material was removed from the bowl, spread on trays, pressed gently and dried partly at 130° F. It was then granulated through a 6-mesh screen, and dried completely. The material that passed through a 16-mesh screen was removed. The grains were poured into 2" tin tubes. When initiated with a #6 cap, a velocity of detonation of 2200 meters per second was obtained. The powder, when in 3" cans containing 33⅓% water, gave a complete detonation with a 40% straight dynamite primer.

The foregoing examples illustrate specific embodiments of the explosive according to our invention. It will be seen that the invention permits the preparation of a free-flowing explosive that is capable of initiation and propagation of the detonation after immersion in water. In its ability to give satisfactory blasting execution after immersion in water for several hours, our explosive is equaled only by the gelatin dynamites or ammonium nitrate explosives completely enclosed in metal or other water-proof containers. No other free-flowing explosive can approach it in this respect. Preferably we employ compositions containing more than 50% ammonium nitrate. Lower strength explosives are obtained when the above salt is replaced partly or entirely by sodium nitrate, the contents of solid organic nitrate being equal. In copending case, Serial No. 376,842, filed January 31, 1941, a granular explosive is disclosed compatible with water, which utilizes grains into which not less than 15% of nitroglycerin or other liquid explosive nitric ester has been absorbed sufficiently to leave the grain dry and free-flowing. The explosive according to the present invention, containing no liquid explosive ingredient, has the advantage that the absorptiveness of the grain need not be considered; hence there is no limit to the density of the grain that can be used, and for use in water we would prefer a grain of the highest attainable density.

It will be understood that the exact solid nitric ester used will control composition to a certain extent. Preferably we use nitrostarch as such solid nitric ester, as this allows the preparation of a high density explosive without the necessity of a great amount of compression but merely granulation. This sensitizing ingredient preferably should be present in an amount not less than 15%. The presence of the paste-forming material, and its behavior on contact with water, not only aids in binding the materials of the grain together, but will in many cases tend to increase the density. High density, of course, means a greater bulk strength for the explosive, which is an important consideration. It has been stated that the individual grains should be sufficiently dense to sink when poured into water. When using nitrostarch as sensitizer, we desirably employ grains having a density greater than 1.25, and advantageously above 1.4.

Various methods may be used for manufacturing the foregoing explosive. We may, for example, employ methods common to black powder manufacture and incorporate the blend under heavy revolving wheels, subsequently granulating the wheelcake. A second method would consist in blending the ingredients in an ordinary dynamite mixing apparatus, preferably of the type used in the manufacture of gelatinous dynamites, after which the caked material could be put through a conventional granular. In both of the foregoing methods, the ingredients would be mixed in the presence of water. A third procedure would be to mix the blended materials in

substantially dry condition, containing for example less than 1% of water, and then to feed the blend through a tablet or pill machine. If a free-flowing powder is desired, it will be desirable to screen out the fine particles. Preferably we use finished grains of a degree of fineness such that substantially the greater part will pass a 3-mesh and be held on a 16-mesh screen.

A granular explosive of the type described herein will ordinarily be insensitive to the action of a blasting cap when free from fine dust, but will detonate when initiated with a suitable booster, especially under water. The explosive, therefore, can be packed in bags and handled in accordance with this degree of insensitiveness. In other words, the explosive of our invention would possess a high order of safety in handling.

It has been stated in the foregoing that desirably a binding agent is present comprising a plant product capable of forming a cohesive paste on contact with unheated water. While such an ingredient aids in binding the grains together and is highly preferable, its presence is not essential. Sufficient carbonaceous combustible material must be present, however, in addition to the organic sensitizer, to react with at least a portion of the oxygen available from the ammonium nitrate or other inorganic oxidizing agent.

When the explosive of our invention is poured into water, the grains quickly become wet and sink rapidly to the bottom. While the soluble portion of the grains is dissolved and passes into the surrounding water, the grains retain their structure and appearance and no solid aliphatic nitrate is lost or segregated. The dissolved ingredients appear to take part in the explosive chemical reactions during detonation and contribute to the energy of the explosion.

While our invention has been described with considerable thoroughness in the foregoing, it will be understood that many departures may be made from the details of operations and the compositions cited without deviation from the scope of the invention. We intend, therefore, to be limited only by the following claims.

We claim:

1. A free-flowing detonable explosive in granular form free from liquid explosive ingredients comprising compressed blended aggregates of an inorganic oxidizing agent, at least 15% of a solid explosive nitrate of an aliphatic polysaccharide, and a plant product capable of forming a cohesive paste with unheated water, the individual grains of said explosive having a density greater than 1.0.

2. A free-flowing detonable explosive in granular form free from liquid explosive ingredients comprising blended aggregates of ammonium nitrate, at least 15% of a solid explosive nitrate of an aliphatic polysaccharide, and a vegetable product capable of forming a cohesive paste with unheated water, the individual grains of said explosive being compressed to a density sufficient to cause them to sink in water.

3. The explosive of claim 2, in which the solid aliphatic nitrate of an aliphatic polysaccharide is nitrostarch.

4. The explosive of claim 2, in which the solid aliphatic nitrate of an aliphatic polysaccharide is nitrocellulose.

5. The explosive of claim 2, in which the solid aliphatic nitrate of an aliphatic polysaccharide is ground smokeless powder.

6. A free-flowing detonating explosive in granular form free from liquid explosive ingredients and capable of functioning effectively after immersion in water, said explosive comprising compressed blended aggregates of ammonium nitrate, at least 15% of a solid explosive nitrate of an aliphatic polysaccharide and a plant product capable of forming a cohesive paste with unheated water, the individual blended aggregates of said explosive having a density greater than 1.0.

7. A free-flowing, granular detonating explosive capable of functioning effectively after immersion in water, said explosive being free from liquid explosive ingredients and comprising compressed blended aggregates of not less than 15% nitrostarch, between 40 and 75% ammonium nitrate, and not less than 4% of a plant product capable of forming a cohesive paste with unheated water, the individual grains of said explosive having a density greater than 1.25.

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