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AQUEOUS EXPLOSIVE COMPRISING HIGHER AMINE, GELLING AGENT AND INORGANIC OXIDIZER SALT

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ABSTRACT OF THE DISCLOSURE

An explosive composition containing a surfactant, a gelling agent, an aqueous medium, and an oxidizer. The surfactant promotes the rapid gelation of the gelling agent so that the gelling process is complete before the components of the composition have segregated.

This invention relates to an explosive composition which rapidly gels.

PRIOR ART

Slurry explosives generally contain a gelling agent such as guar gum to prevent the insoluble components of the explosive from segregating, leaving the explosive insensitive. These explosives are generally not pourable because they are too gelled; as such they are difficult to handle and do not fill all the voids in a borehole which results in an inefficient explosive.

Since most gelling agents require time to gel, the commercial practice is to use excess gelling agent so that the gelation is complete enough at the end of the mixing stage to prevent segregation of the components. However, in addition to producing gels which are not pourable, this practice can also produce gels which are so "tight" that the water is squeezed out leaving the explosive insensitive.

On the other hand, if less gelling agent is used, segregation may result, especially when the explosive is stored shortly after being manufactured at low temperatures which inhibit the gelling process. An explosive containing small amounts of gelling agent can sometimes be heated during the mixing stage in an attempt to ensure completion of the gelling process prior to storage. Normally, heat alone will not complete all of the crosslinking available from the conventional gelling agents present in the formulation. Thus, additional cross-linking takes place during storage with the possibility of ingredient separation due to the incomplete initial gelation.

ADVANTAGES OF THE INVENTION

I have discovered explosive compositions which gel rapidly and more completely during mixing and which can be made pourable. A more complete gelation during mixing permits the use of less gelling agent and helps prevent the formation of tight gels on storage, although sufficient gelling agent is used to prevent segregation on storage. In addition, these compositions generally have much better bag release than prior art compositions (bag release is the facility and completeness with which the explosive can be removed from a plastic bag), and the preferred compositions of this invention can be made pourable.

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COMPOSITIONS

The compositions of this invention contain a particular type of surfactant in addition to a gelling agent, an aqueous medium, and an oxidizer. A composition of this invention may be made from about 0.0025 to 0.1 p.b.w. (parts by weight) of the surfactant, about 0.0025 to 0.1 p.b.w. of a gelling agent, about 0.06 to 1.5 p.b.w. of an aqueous medium, and 1 p.b.w. of an oxidizer. Preferably, the compositions comprise about 0.0025 to 0.05 p.b.w. of the surfactant, about 0.005 to 0.05 p.b.w. of a gelling agent, about 0.125 to 1 p.b.w. of an aqueous medium, and 1 p.b.w. of an oxidizer. About 0.0001 to 0.05 p.b.w. of a gel promoter such as boric acid, borax, chromates, metal salts, etc., is preferably included to help promote gelation. In addition, the compositions preferably contain up to about 1.25 p.b.w. of a sensitizer and up to about 1.25 p.b.w. of a fuel in addition to other substances commonly used in explosives.

SURFACTANTS

The surfactants of this invention are long-chain (i.e. at least about 8 carbon atoms) amines, preferably tertiary amines, which are soluble in a 50% ammonium nitrate solution. Examples of suitable surfactants include polyoxyethylene and polyoxypropylene alkyl amines, N-soya N-ethyl morpholinium ethosulphate, octyl dimethyl amine, decyl dimethyl amine, and octadecyl amine. The preferred surfactants are polyoxyethylene alkyl amines and N-soya N-ethyl morpholinium ethosulfate.

GELLING AGENT

The gelling agent is a compound which cross-links to gel the explosive composition. Suitable gelling agents include polysaccharides, such as galactomannans, and polyacrylamides; guar gum is preferred.

AQUEOUS MEDIUM

The aqueous medium is preferably water, but up to about 50% of the water may be substituted for with organic liquids such as ethylene glycol, formamide, glycerine, etc.

OXIDIZER

The oxidizer is a compound which is a source of oxygen during the explosion and is preferably an inorganic oxidizer salt, preferably ammonium nitrate. Other suitable oxidizers include sodium nitrate, calcium nitrate, magnesium nitrate, potassium nitrate, lithium nitrate, ammonium chlorate, potassium chlorate, sodium chlorate, ammonium perchlorate, potassium perchlorate, and sodium perchlorate.

SENSITIZER

The sensitizer increases the detonability of the explosive. Suitable sensitizers include air bubbles and air-trapping materials such as glass, urea-formaldehyde and phenol-formaldehyde resin spheres, bagasse, perlite, etc., explosive compounds such as TNT, DNT, tetryl, PETN, nitrostarch, smokeless powder, and alkyl amine nitrates such as methyl amine nitrate and ethylene diamine dini-

trate, nitroparaffins such as nitromethane and nitropropane, and finely-divided metals such as aluminum and its alloys and magnesium and its alloys.

FUEL

The fuel consumes oxygen during the explosion; examples of suitable fuels include fuel oil, mineral oil, paraffin oil, bagasse, vegetable compounds, sulfur, coal, etc.; sulfur is preferred.

EXAMPLES

The following examples illustrate this invention, and compare compositions within the scope of the invention with other compositions. The compositions listed in Column A of Table I below were formed by mixing together 200 gms. of a 60% ammonium nitrate solution and 2.8 gms. of a gelling agent. A second group of compositions were prepared in an identical manner except that 2 gms. of a surfactant was also added. Table I below gives the viscosity (cps.) at room temperature using a Brookfield Viscometer and gives the pH of the compositions in Column A when fresh.

TABLE I

Gelling agent	A, viscosity (cps.)			B, viscosity (cps.)		
	Fresh	1 day	pH	Fresh	1 day	pH
Polysaccharide sold by Stein-Hall Co. under the trademark "705D-A"-----	9,440	10,080	15.1	9,560	10,320	6.5
Polysaccharide sold by Stein-Hall Co. under the trademark "D-163"-----	19,280	21,040	15.1	19,840	21,520	6.5
Polysaccharide sold by Stein-Hall Co. under the trademark "1212A"-----	9,280	10,840	15.1	9,680	12,640	6.5
Nonionic guar gum provided by Stein-Hall Co. under the trademark "Jaguar DE-1"-----	22,560	24,960	15.1	23,120	25,520	6.5
Modified guar gum provided by Stein-Hall Co. under the trademark "Jaguar EX-JB"-----	4,080	5,520	15.1	4,560	5,920	6.5
Nonionic guar gum sold by Stein-Hall Co. under the trademark "Jaguar 100"-----	18,320	20,160	15.1	23,360	25,440	6.5
Modified guar gum sold by General Mills under the trademark "Gendriv 570"-----	1,240	8,360	15.0	1,480	12,760	6.2

¹ Polyoxyethylene octadecyl amine having an average of about 20 ethoxy groups per molecule sold by Atlas Chemical Industries, Inc., hereinafter referred to as polyoxyethylene (20) octadecyl amine.
² Sodium lauryl sulfate sold by E. I. du Pont de Nemours and Company under the trademark "Duponol C".

Table I shows that a surfactant of this invention, polyoxyethylene(20)octadecyl amine, significantly increased the viscosity of compositions using various gelling agents, while a surfactant not included within the scope of this invention, sodium lauryl sulfate, did not have a comparable effect on viscosity.

In another set of experiments, 200 gms. of a 60% ammonium nitrate solution and 2.8 gms. of a nonionic guar gum (Jaguar DE-1) were mixed together to form control compositions. A second group of compositions were prepared in an identical manner except that 2 gms. of various surfactants were also mixed in. Table II below shows the increase in viscosity (cps.) at room temperature, using a Brookfield Viscometer, which resulted when various surfactants of this invention were used. Since pH has an effect on viscosity, the first group of compositions and corresponding control were prepared at a pH of 6.45 to 6.5 and another composition and control were prepared at a pH of 6.15 to 6.2.

TABLE II

Surfactant	Viscosity (cps.)		pH fresh
	Fresh	1 day	
5 Octyl dimethyl amine sold by Baird Chemical Industries under the trademark "Barlene 8S"-----	38,840	50,000	6.5
Decyl dimethyl amine sold by Baird Chemical Industries under the trademark "Barlene 10S"-----	28,480	70,000	6.45
Octadecyl amine sold by Armour Industrial Chemical Industries under the trademark "Armeen 18"-----	32,000	49,520	6.45
Control-----	28,840	46,720	6.5
10 35% solution of N-soya N-ethyl morpholinium ethosulphate sold by Atlas Chemical Industries, Inc., under the trademark "G-271"-----	21,680	24,160	6.2
Control-----	20,880	23,840	6.15

In still another experiment, 150 gms. of 60% ammonium nitrate solution, 40 gms. of 50% ethylene diamine dinitrate solution, and 2.8 gms. of a polysaccharide (705D-A) were mixed together. Another composition was prepared in the same manner except that 2.0 gms. of polyoxyethylene(20)octadecyl amine was included. Table III below gives the viscosity (in cps.) at room temperature using a Brookfield Viscometer and shows the increase in viscosity which resulted when the surfactant was used.

TABLE III

	pH	Control	With surfactant
30 Fresh-----	5.2	8,200	9,200
1 day-----		9,600	11,000

In Table IV, compositions A to K were prepared by mixing the water, surfactant, and the nitrates and dinitrate at 140 to 150° F. The pH was adjusted to 2 to 3 and the nitrostarch and TNT were added where used; after stirring the aluminum was added (composition G). A pre-mix containing the resin spheres, sulfur, and the gelling mixture was prepared and added with stirring. When the compositions began to thicken, the pH was adjusted with acetic acid to 3.5 to 4.5, and the ethylene glycol and nitromethane were added and stirred in for one minute where used. The pH was then adjusted with ammonium hydroxide to the final pH which instantly resulted in the formation of the gel. Whole ammonium nitrate prills were then stirred in, 15% (this percentage is included in the figure given in Table IV for ammonium nitrate) in cases B and C; 10% in case E; and 5% in cases H, J, and K.

Composition L was prepared by mixing the nitrates, dinitrate, and the water, heating to 160° F., and adjusting the pH to 4.0 with acetic acid. The air-entrapping spheres, sulfur, gelling mixture, and boric acid were blended and the heated nitrate solution was added incrementally while the temperature was maintained at 145° F. The surfactant was added and the pH adjusted to 4.5 to 5.0 with sodium hydroxide solution. The nitromethane and ethylene glycol were mixed in and the pH was adjusted to the final pH with sodium hydroxide.

Composition M was prepared by mixing the sodium and ammonium nitrates and water at 150° F. The pH was adjusted to 3 to 4 with acetic acid and the "Jaguar 100" and boric acid were mixed in until thick. The air-entrapping spheres, sulfur, and ethylene diamine dinitrate were mixed in and the pH adjusted to 4 with sodium hydroxide. The ethylene glycol and nitromethane were added and the final pH adjustment was made with sodium hydroxide.

All of the compositions of Table IV were pourable, and most of the compositions (H, I, and K, for example) are pourable at low temperatures (20 to 30° F.); all the compositions had an oxygen balance between +10 and -30. The compositions were placed in 3" diameter plastic cartridges and were detonated with a 3" x 6" 75% gelatin dynamite.

TABLE IV

	Composition (percent) of—												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Ammonium nitrate.....	41.5	36.2	31.2	40.7	39.2	34.2	32.3	52.9	35.8	39.2	47.05	43.3	42.9
Sodium nitrate.....	18.0	11.0	11.0	16.0	11.0	11.0	18.0	-----	11.0	11.0	-----	10.0	10.0
Calcium nitrate.....	-----	5.0	5.0	-----	5.0	5.0	-----	-----	-----	5.0	-----	-----	-----
Gelling mixture ¹	1.1	0.9	0.9	0.9	0.9	0.9	1.3	1.0	0.75	0.9	0.85	0.6	1.1
Boric acid.....	-----	-----	-----	-----	-----	-----	-----	0.5	1.0	-----	0.5	0.8	-----
Water.....	14.0	20.0	20.0	18.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Ethylene glycol.....	-----	7.5	7.5	-----	7.5	7.5	-----	10.0	10.0	7.5	10.0	5.0	5.0
Surfactant ²	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.45	0.4	0.6	0.5	1.0
Sulfur.....	-----	3.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0
Aluminum.....	-----	-----	-----	-----	-----	-----	3.0	-----	-----	-----	-----	-----	-----
Air-entrapping spheres ³	-----	-----	-----	2.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	2.0	2.0
Ethylene-diamine dinitrate.....	-----	-----	5.0	-----	10.0	15.0	20.0	5.0	5.0	-----	-----	5.0	5.0
Nitromethane.....	-----	-----	-----	-----	-----	-----	-----	5.0	10.0	10.0	15.0	10.0	10.0
Nitrostarch.....	-----	16.0	16.0	20.0	-----	-----	-----	-----	-----	-----	-----	-----	-----
T.N.T.....	25.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Final pH.....	nt	5.55	5.8	5.0	5.95	5.75	nt	5.55	5.7	6.1	5.75	5.85	-----
Density, grams/cc.....	1.47	1.46	1.44	1.40	1.26	1.28	nt	1.16	1.22	1.25	1.20	1.29	-----
Velocity, f.p.s.....	16,200	12,195	11,900	17,090	16,340	16,025	17,045	14,285	17,095	17,360	17,360	17,010	16,670

¹ 41.7% boric acid, 49.2% guar gum, 9.2% polyacrylamide in A to K; 50-50 mixture of "Jaguar 100" and "Jaguar DE," non-ionic guar gums sold by Stein, Hall & Co., Inc. in L; 50% boric acid and 50% "Jaguar 100" in M.

² Polyoxyethylene(20)octadecyl amine sold by Atlas Chemical Industries, Inc.

³ Phenol formaldehyde in D, E, F, G, I, and J; glass in H, K, L, and M.

NOTE.—nt=Not tested.

I claim:

1. An explosive composition comprising a surfactant selected from the group consisting of polyoxyethylene and polyoxypropylene alkyl amines, N-soya N-ethyl morpholinium ethosulfate, octyl dimethyl amine, decyl dimethyl amine and octadecyl amine, a gelling agent, a sensitizer, an aqueous medium, and an inorganic oxidizer salt.

2. A composition of claim 1 containing a fuel.

3. A composition of claim 2 wherein the gelling agent is guar gum.

4. A composition of claim 3 wherein the sensitizer is nitromethane.

5. A composition of claim 4 containing an air-entrapping material.

6. An explosive composition comprising about 0.0025 to about 0.1 p.b.w. of a surfactant selected from the group consisting of polyoxyethylene and polyoxypropylene alkyl amines, N-soya N-ethyl morpholinium ethosulfate, octyl dimethyl amine, decyl dimethyl amine and octadecyl amine, about 0.0025 to about 0.1 p.b.w. of a gelling agent, about 0.06 to about 1.5 p.b.w. of an aqueous medium, up to about 1.25 p.b.w. of a fuel, up to about 1.25 p.b.w. of a sensitizer, and 1 p.b.w. of an inorganic oxidizer salt.

7. An explosive composition comprising about 0.0025 to about 0.1 p.b.w. of a surfactant selected from the group consisting of polyoxyethylene and polyoxypropylene alkyl

amines, N-soya N-ethyl morpholinium ethosulfate, octyl dimethyl amine, decyl dimethyl amine and octadecyl amine, about 0.005 to 0.05 p.b.w. of a gelling agent, about 0.125 to 1 p.b.w. of an aqueous medium, 0.0001 to about 0.05 p.b.w. of a gel promoter, 1 p.b.w. of an inorganic oxidizer salt, up to about 1.25 p.b.w. of a sensitizer, and up to about 1.25 p.b.w. of a fuel.

8. A composition of claim 7 wherein the sensitizer is nitromethane.

9. The composition of claim 7 wherein said oxidizer is ammonium nitrate.

10. The composition of claim 9 wherein said gelling agent is guar gum.

11. The composition of claim 10 wherein said aqueous medium comprises water.

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