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[54] **UREA STABILIZED GELLED SLURRY EXPLOSIVE**


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[52] **U.S. Cl.** .....**149/21**, 149/38, 149/39, 149/41, 149/43, 149/44

[51] **Int. Cl.** .....**C06b 1/04**

[58] **Field of Search**.....149/21, 40, 38, 41, 43, 39, 149/44



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[57] **ABSTRACT**

A highly stable cap sensitive explosive gel comprising ammonium nitrate, metallic fuel sensitizer, gelling agent, inorganic polyvalent metal salt cross-linking agent, phosphate buffer, water and urea in an amount of 0.3–0.7 weight percent. When urea is added in the same amounts to a composition including the above ingredients and NaCl, which NaCl is incorporated for the purpose of non-incendivity, a highly stable non-incendive explosive gel is formed.


**10 Claims, No Drawings**

# UREA STABILIZED GELLED SLURRY EXPLOSIVE

It has been recognized that although aqueous slurry-type explosive compositions comprising ammonium nitrate and a sensitizer are highly useful, upon storage they tend to separate into layers which makes them not only difficult to handle but adversely affects their explosive characteristics and consequently their reliability. These disadvantages have been overcome to some degree by the incorporation of gelling agents and cross-linking agents in the compositions. However, even cross-linked gelled slurries are unstable to the degree that they will usually adversely degrade within 30 days. Substantial swelling of the gel is visible evidence of such degradation. Alternatively, water may separate out (syneresis) from the gel, which water contains inorganic salts in solution. In either case, the composition eventually is no longer cap sensitive, and often loses its basic explosive properties.

We have now developed a stable cap sensitive explosive gel. In arriving at our invention, it was observed that gel stability is directly related to the evolution of gas (usually hydrogen or ammonia) from the composition. In prior art gel explosives, gas evolution begins almost immediately, and shortly thereafter swelling is evident or a separate aqueous phase is visible. Pursuant to this problem, we have discovered that, in the presence of an inorganic polyvalent metal salt cross-linking agent, the addition of about 0.3–0.7 weight percent urea to the gel constituents, unexpectedly retards such gas evolution, and thereby results in a highly stable explosive gel. The invention is particularly effective with regard to non-incendive gelled slurry explosives.

It is therefore an object of the present invention to provide stable gelled slurry explosives which retain cap sensitivity.

Another object is to provide such explosives in which, during storage, gas evolution is minimized and wherein swelling or water separation are effectively retarded.

A further object is to provide such explosives which are non-incendive.

Other objects and advantages will be obvious from the more detailed description of the invention as follows.

In the practice of the present invention the urea is mixed with other components in the prior art manner. Various mixing procedures have heretofore been employed in the gelled explosive art, and the present invention does not reside in, nor is it limited in any way by the manufacturing procedures used to prepare the compositions. However, as has been disclosed in the prior art, the particular mixing technique (e.g., the mixing temperatures or the sequence in which constituents are combined) does have significant effects upon product density or cap sensitivity. Accordingly, the optimum mixing technique is best determined experimentally for each particular batch of ingredients.

Generally, the constituents of the explosive gel are:

a. ammonium nitrate either alone or in combination with an alkali metal nitrate such as sodium nitrate;
b. water;
c. a gelling agent;
d. an inorganic polyvalent metal salt cross-linking agent;
e. a metallic fuel sensitizer;
f. a phosphate buffer; and
g. urea.



Such gelling agents include guar gum, cellulose derivatives, gum arabic, starches, dextrin, gelatin, etc. Guar gum and methyl cellulose are particularly effective in the composition.

With regard to polyvalent metal salt cross-linking agents, these include salts (e.g., sulfates, nitrates, chlorides) of chromium, iron, aluminum, tin and the like. Potassium dichromate is particularly effective.

Metallic fuel sensitizers include particulate aluminum, magnesium, iron or alloys thereof, or ferrosilicon or ferrophosphorus. A particularly effective sensitizer is flake aluminum or flake aluminum in combination with atomized aluminum in which the flake aluminum is at least 3 weight percent of the gel composition. Use of metallic fuels as sensitizers is important in order to attain adequate cap sensitivity after relatively long term storage of the gel.

Phosphate buffering agents include alkali metal hydrogen phosphate solutions alone or in combination with alkali metal hydroxides in various ratios (e.g., $KH_2PO_4$L NaOH, 29:1 mol ratio). Such a buffering agent is important to the composition of the present invention in that, in the absence thereof, the long term stabilizing effects of the urea appear to be substantially nullified.

Additional fuels can be incorporated in the explosive composition besides the metallic fuels. These include such substances as sugar, starch, hydrocarbonaceous (hydrocarbon compound-containing) materials such as gilsonite, and carbonaceous (i.e., free caron-containing) materials such as graphite. So-called self-explosive type fuels can also be incorporated such as 1, 3, 5-trinitro- 1, 3, 5-triazacyclohexane (RDX), trinitrotoluene (TNT), dinitrotoluene (DNT), 1, 3, 5, 7-tetranitro- 1, 3, 5, 7-tetrazacyclooctane (HMX), dinitrobenzene (DNB), and smokeless powder.

Incendive compositions of the present invention have about the following ranges of components:

| Component | Weight percent Preferred range | General range |
|---|---|---|
| Ammonium nitrate | 45–55 | 20–80 |
| Alkali metal nitrate | 5–20 | 0.25 |
| Sensitizer | 5–15 | 2–40 |
| Gelling agent | 1.5–2.5 | 1.0–3.0 |
| Cross-linking agent | 0.75–1.0 | 0.5–1.0 |
| Water | 15–30 | 5–40 |
| Urea | 0.3–.5 | 0.3–.7 |
| Additional fuel | 0.05–1.0 | 0–3.5 |
| Buffer | 0.3 | 0.2–.5 |

As indicated above, the present invention is also applicable to non-incendive gel explosives. Such explosives are disclosed in U.S. Bureau of Mines Report of Investigations No. 7195. Generally, these compositions include NaCl in addition to the ingredients previously set forth. NaCl, in combination with the water content of the gel, renders the explosive relatively non-incendive.

Except for the addition of NaCl, the individual ingredients of the non-incendive explosives of the present invention are the same as those in the incendive gels, and the composition ranges are about as follows:

| Component | Weight percent Preferred range | General range |
|---|---|---|
| Ammonium nitrate | 40–50 | 30–65 |

| | | |
|---|---|---|
| Alkali metal nitrate | 3.5–5.0 | 0–70 |
| Sensitizer | 4–8 | 3–12 |
| Gelling agent | 1.5–2.5 | 1.0–3.0 |
| Cross-linking agent | 0.75–1.0 | 0.5–1.0 |
| Water | 15–30 | 5–40 |
| Urea | 0.3–.5 | 0.3–,7 |
| Additional fuel | 0.5–1.0 | .7 3.5 |
| Buffer | 0.3 | 0.2–.5 |
| NaCl | 7–15 | 5–40 |

These non-incendive compositions are especially suitable for use in underground mines with potentially flammable atmospheres.

The following examples illustrate the present invention:

## EXAMPLES

The following ingredients were blended together to form an non-incendive explosive gel:

| | Weight percent | | | |
|---|---|---|---|---|
| | gel 01 | Gel 02 | Gel 03 | Gel 04 |
| $NH_4NO_3$ | 43.7 | 44.4 | 50.0 | 42.7 |
| $NaNO_3$ | 3.5 | 3.5 | 4.1 | 3.5 |
| $H_20$ | 30.0 | 30.0 | 20.0 | 20.0 |
| NaCl | 10.0 | 10.0 | 10.0 | 20.0 |
| Flake A1 | 8.0 | 8.0 | 9.3 | 8.0 |
| $K_2Cr_2O_7$ | 1.0 | 1.0 | 1.0 | 1.0 |
| Urea | 0.3 | 0.3 | 1.0 | 1.0 |
| Guar | 2.5 | 2.5 | 1.5 | 1.5 |
| Sugar | 0.7 | - | 2.75 | 2.0 |
| Buffer | 0.3 | 0.3 | 0.35 | 0.3 |

*(1:29 ratio of $NaOH:KH_2PO_4$)

After 120 days of storage, all these gels exhibited suitable detonation characteristics including cap sensitivity. The following results specifically show the results for gel 01 (the other gels exhibited similar results).

| | |
|---|---|
| Density (gm/cc) | 1.00 |
| Detonation velocity (meters/sec) | 3500 |
| Ballistic mortar (% TNT) | 77.0 |
| Air gap (inches) | 3.5 |
| Incendivity ($W_{50}$ grams) | > 906 |
| Cap sensitivity (06 electric blasting cap) | yes |

As can be seen from these examples the compositions were still cap sensitive and strong after relatively long storage. Other tests, conducted after 1½ years of storage, have shown that the gels of the present invention still retain cap sensitivity with no gas evolution and swelling, and minimal syneresis. The specific combination of urea and cross-linking agent in the explosive gels of the present invention gives rise to unexpected synergistic effects resulting in unusual stability.

What is claimed is:

1. In an explosive gel having the following composition on a weight basis:

a. about 20–30 percent ammonium nitrate;

b. about 0–25 percent alkali metal nitrate;



c. about 2–40 percent metallic fuel sensitizer;

d. about 1.0–3.0 percent gelling agent;

e. about 0.5–1.0 percent inorganic polyvalent metal salt cross-linking agent;

f. about 5–40 percent water;

g. about 0–3.5 percent additional fuel; and

h. about 0.2–0.5 percent phosphate buffer; the improvement comprising a stabilizer consisting of about 0.3–0.7 percent urea.

2. The composition of claim wherein said ammonium nitrate content is about 45–55 percent; said alkali metal nitrate content is about 5–20 percent; said sensitizer is about 5–15 percent; said gelling agent is about 1.5–2.5 percent; said cross-linking agent is about 0.75–1.0 percent; said water is about 15–30 percent; said urea is about 0.3–0.5 percent; said additional fuel is about 0.5–1.0 percent; and said buffer is about 0.3 percent.

3. The composition of claim 1 wherein about 5–40 percent NaCl is also present; wherein said ammonium nitrate content is about 30–65 percent; said alkali metal nitrate is about 0–7.0 percent; and said sensitizer is about 3–12 percent.

4. The composition of claim 2 wherein about 7–15 percent NaCl is also present; wherein said ammonia nitrate content is about 40–50 percent; said alkali metal nitrate is about 3.5–5.0 percent; and said sensitizer is about 4–8 percent.

5. The composition of claim 3 wherein said sensitizer is flake aluminum or a mixture of flake aluminum and atomized aluminum in which mixture flake aluminum is present in at least 3 percent by weight of the explosive composition.

6. The composition of claim 4 wherein said sensitizer is flake aluminum or a mixture of flake aluminum and atomized aluminum in which mixture flake aluminum is present in at least 3 percent by weight of the explosive composition.

7. The composition of claim 5 wherein said cross-linking agent is potassium dichromate.

8. The composition of claim 6 wherein said cross-linking agent is potassium dichromate.

9. The composition of claim 7 wherein said additional fuel is selected from the group consisting of sugar, starch, hydrocarbonaceous materials, carbonaceous materials, 1, 3, 5-trinitro- 1, 3, 5-triazacyclohexane, trinitrotoluene, dinitrotoluene, 1, 3, 5, 7-tetranitro- 1, 3, 5, 7-tetrazacyclooctane, dinitrobenzene and smokeless powder.

10. The composition of claim 9 wherein said gelling agent is selected from the group consisting of guar gum, cellulose derivatives, gum arabic, starches, dextrin, and gelatin.

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