

- [54] **EXPLOSIVE COMPOSITION**  
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- [56] **References Cited**  
**UNITED STATES PATENTS**  
2,867,647 1/1959 Gow et al. .... 149/11  
**FOREIGN PATENTS OR APPLICATIONS**  
574,271 12/1945 United Kingdom..... 149/11

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**EXEMPLARY CLAIM**

1. An explosive composition consisting of pellets of a crystalline high-explosive compound selected from the group consisting of pentaerythritol tetranitrate, cyclotrimethylenetrinitramine, cyclotetramethylenetetranitramine, tetranitromethylaniline, and trinitrotoluene, said explosive compound being coated with an epoxy hydroxy polyether nonreactive with the high-explosive compound and which is at least partially cured by means of a curing agent nonreactive with the high-explosive compound, said epoxy hydroxy polyether being present in the amount of 3–15 percent by weight of the mixture of high-explosive compound and epoxy hydroxy polyether.

**5 Claims, No Drawings**

## EXPLOSIVE COMPOSITION

The present invention relates to a novel explosive composition. More particularly, the present invention relates to a novel explosive composition comprising a crystalline high-explosive compound and an epoxy hydroxy polyether.

Many crystalline high-explosive compounds, such as for example PETN (pentaerythritol tetranitrate) and RDX (cyclotrimethylenetrinitramine), are obtained in the form of dusty powders, which are difficult to handle, especially in the automatic loading machines now in widespread use in explosives manufacture, because they do not flow freely but tend to clog up in various parts of the loading machines. In addition, these compounds in the pure state, in many cases, are too sensitive to shock to be loaded and pressed safely.

Moreover, the use of these crystalline high-explosive compounds in the form of more easily handled pellets or other rigid, cohesive, contoured shapes rather than as crystals or granules is becoming more and more prevalent in the explosives art. For example, rigid, cohesive, molded sleeves of explosives are used in the method of joining metallic elements described in U.S. Pat. No. 2,367,206 issued Jan. 16, 1945.

Furthermore, although many of the crystalline high-explosive compounds are nonhygroscopic and water-insoluble, these compounds become insensitive to initiation when in contact with water.

Heretofore, various materials have been mixed with crystalline high-explosive compounds in efforts to impart various desired characteristics to the resultant compositions. For example, in efforts to make PETN and RDX free-flowing, materials such as wax, fatty acid salts, e.g., calcium stearate, and graphite have been mixed with these compounds. This method has been unsatisfactory in many cases, because when a sufficient quantity of these materials has been added to render the powder adequately free-flowing, the resulting powder is too insensitive to initiation to be useful.

In efforts to desensitize RDX to shock, the RDX has been treated with various desensitizing agents such as wax and vaseline. However, the nature of these agents is such that, in many cases, the particles of explosive compound are not completely coated, and, therefore, after treatment with these agents, sensitive particles remain. These agents are heat sensitive, and thus failures of the wax- or vaseline-coated RDX to detonate are often encountered in high-temperature applications in which the temperature exceeds the melting point of the desensitizing agent. Furthermore, the addition of wax to RDX lowers the flammability temperature of the resultant powder and thereby increases manufacturing hazards.

Nitrocellulose has been used as a binding agent in the pelleting and the pressing or molding of high-explosive compounds into rigid contoured shapes such as the sleeves of explosive discussed previously. However, not only is nitrocellulose as extremely hazardous material, but also the use of the nitrocellulose as a binding agent requires the use of a solvent, which must be removed from the resulting mixture by evaporation. In some applications, for instance in the making of large pellets or sleeves of explosive, the thickness of the pellet or sleeve prevents complete evaporation of the solvent. Moreover, the use of nitrocellulose sometimes results in the formation of contoured shapes lacking the required rigidity and cohesiveness.

Certain materials such as oil, wax, and vaseline have been mixed with crystalline high-explosive compounds to prevent the contact of water with the explosive compound. In many instances, however, the nature of these materials is such that a discontinuous coating is deposited on the particles of explosive, which coating permits the contact of water with the explosive and the subsequent desensitization of the explosive to initiation.

Accordingly, an object of the present invention is the provision of a free-flowing explosive composition of desired initiation-sensitiveness. Another object of the present invention is the provision of an explosive composition in which the high-explosive component is desensitized to shock and which also is suitable for use in high-temperature applications. A further object of the present invention is the provision of an explosive composition which easily and efficiently is pelleted or molded into rigid, cohesive, contoured shapes. A still further object of the present invention is the provision of an explosive composition in which the particles of high-explosive compound are protected from contact with water by the presence of a uniform, continuous coating.

I have found that the foregoing objects may be achieved when I provide an explosive composition consisting of a crystalline high-explosive compound coated with an epoxy hydroxy polyether which is at least partially cured.

In accordance with the present invention, the crystalline high-explosive compound is mixed with a nonreactive epoxy hydroxy polyether and a curing agent for said polyether which is nonreactive with the high-explosive compound, and the mixture is subjected to heat treatment to cure at least partially the epoxy hydroxy polyether.

The following examples serve to illustrate specific embodiments of the method of preparing the explosive composition of the present invention. However, they will be understood to be illustrative only and not to limit the invention in any manner. The epoxy hydroxy polyether used in the examples is "Araldite" 6020, and the curing agent is phthalic anhydride; of course, as is evident, other polyethers and curing agents can be substituted for these. "Araldite" 6020 is one of the well-known "Araldite" line of epoxy resins commercially available from the Ciba Company Inc. It is formed by the condensation of epichlorohydrin with 4,4'-isopropylidenediphenol. This resin is an amber-colored liquid epoxy resin having a specific gravity (23°C./23°C.) of 1.16-1.18, a viscosity at 23°C. of 20,000-40,000 cps., and an epoxy value (eq./100 gms.) of 0.440-0.480. The parts in the examples are parts by weight unless otherwise specified.

### EXAMPLE I

One part of the epoxy hydroxy polyether was melted, and 0.3 part of the curing agent was added to the molten polyether. The temperature of the mixture was brought to 100°C., and then boiling water was added to the mixture. Ten parts of RDX was added to the mixture, and the resultant thick slurry was agitated to obtain a good incorporation of the components. The slurry was held at 100°C. and agitated for about 3 hours. At the end of this period, the polyether was in a pre-cured state, and the coated RDX was dried. The dried, coated RDX was in the form of free-flowing granules which would not pass through a 30-mesh

screen. In the standard impact or drop test on the coated RDX in which a 5-kg. weight was used, the point of 50 percent detonations was 52 inches.

Pellets of the explosive composition were prepared by lightly pressing the powder into a cylinder, 0.2 inch in diameter and 0.75 inch in length, which was placed upright in a 220°F. oven for 20 hours. During the heat treatment, the curing of the polyether was completed. The cylinder was removed from the oven and cooled. The pellet of explosive thus prepared retained its shape and was of a cement-like hardness.

#### EXAMPLE 2

Three formulations of RDX and the epoxy hydroxy polyether were prepared by dissolving the polyether and 30 percent (by weight based upon the weight of the polyether) of the curing agent in acetone, adding the RDX with stirring to form a thick slurry, and allowing the mass to air-dry slightly. The formulations prepared had the following compositions:

| Formulation | RDX (%) | Polyether (%) |
|-------------|---------|---------------|
| A           | 86.5    | 13.5          |
| B           | 93      | 7             |
| C           | 97      | 3             |

Each formulation was treated in three ways: (1) a part was spread out to air-dry and then was grained through a 20-mesh screen, (2) a part was dried in a 220°F. oven for 1-4 hours and then grained, and (3) a part was added to boiling water maintained at 100°C. for 2-4 hours. The powders treated by Methods 2 and 3 were free-flowing, whereas those treated by Method 1 were tacky and less free-flowing. All the treated powders could be initiated by a blasting cap having a 1.5-grain PETN base load. The density of the treated powders and the results of impact tests (5-kg. weight) made on the powders are summarized in the following table:

| Formulation | Treatment              | Point of 50% Detonations in Impact Test (inches) | Density (g./cc.) |
|-------------|------------------------|--------------------------------------------------|------------------|
| A           | 1                      | 46+                                              | 1.46             |
| A           | 2 (4 hrs. in oven)     | 41                                               | 1.40             |
| B           | 1                      | 35                                               | 1.40             |
| B           | 2 (1 1/4 hrs. in oven) | 43+                                              | 1.47             |
| B           | 3 (2 hrs. of boiling)  | 36                                               | 1.42             |
| C           | 1                      | 37                                               | —                |
| C           | 2 (4 hrs. in oven)     | 31                                               | 1.48             |
| C           | 3 (4 hrs. of boiling)  | 41                                               | 1.52             |

Pellets which were prepared from the treated powders were immersed in water for a 3- and a 7-day period. After both periods of immersion, the pellets could be initiated by a No. 6 blasting cap.

#### EXAMPLE 3

A formulation consisting of 90 percent PETN and 10 percent of the epoxy hydroxy polyether was prepared according to the method described in Example 1 with the exception that the pre-curing or boiling time was 2 hours. In the standard impact or drop test (5-kg.

weight) on the free-flowing coated powder, the point of 50 percent detonations was 23 inches.

The explosive compositions of the present invention are obtained in the form of hard, free-flowing granules of the desired sensitiveness which can be pressed to form extremely hard pellets or molded into rigid, cohesive, contoured shapes. The epoxy hydroxy polyether acts as a binding agent which facilitates the formation of extremely hard pellets and rigid, cohesive, contoured bodies and is simpler to use than the conventionally used nitrocellulose because the necessity for a solvent, which is difficult to remove from the mixture, is obviated. Furthermore, the polyether provides a uniform, continuous coating on the particles. This continuous coating prevents the contact of any water with the particles and thus prevents desensitization to initiation of the high-explosive compound when used in applications in which the explosive composition comes in contact with water.

The desired sensitiveness can be imparted to the explosive composition of the present invention simply by regulating the amount of the epoxy hydroxy polyether in the mixture. For example, if a desensitized composition is desired, larger amounts of the polyether are used, whereas if a denser, more sensitive composition is desired, smaller amounts of the polyether are used. Proper selection of the amount of the polyether incorporated in the mixture will provide a free-flowing moisture-resistant composition of sensitiveness equivalent to that of the pure high-explosive compound.

In addition, the use in high-temperature applications of the explosive composition of the present invention containing the highly heat-resistant or -stable polyether eliminates the problem of failure of the explosive composition to detonate and the subsequent complications which are encountered when explosive compositions containing the conventional desensitizing agents or binding agents are used in said applications.

As mentioned previously, the selection of the amount of epoxy hydroxy polyether incorporated into the explosive composition is governed by the properties required of the explosive composition. In general, 3-15 percent by weight of the polyether, based upon the weight of the polyether-explosive compound mixture, has been found to provide the most satisfactory results and, therefore, is the preferred amount. Less than 3 percent of the polyether may be used, but, in some cases, the resulting explosive composition may contain uncoated particles and, thus, may be more liable to desensitization by water. However, in some applications, water is not encountered, and, thus, the explosive composition containing less than 3 percent of the polyether may be useful in said applications. More than 15 percent by weight of the polyether may be used, but, in some cases, the free-flowing characteristics and sensitiveness of the resulting explosive composition will be lessened. However, such a composition would be suitable for use in some applications for which a very sensitive and free-flowing powder is not required.

The method of preparing the explosive composition of the present invention is not critical, the only requirement being that a uniform admixture of the high-explosive compound and the epoxy hydroxy polyether be obtained. In general, the curing agent is mixed with the polyether, a diluent is added to the mixture, the high-explosive compound then is added, the resultant thick slurry being well agitated, and the mixture is heat

treated to cure at least partially the polyether. The diluent is added to the mixture merely to facilitate agitation of the slurry, and if a solvent such as acetone is used to assist in the mixing of the curing agent and the polyether, the addition of a diluent is unnecessary, the presence of the solvent facilitating the agitation of the slurry. The mixture can be heat-treated in various ways. The mixture can be dried in an oven or can be added to boiling water maintained at the boiling point for a specified period of time. The use of the boiling water method is preferred because thereby the agglomeration of the particles which necessitates a subsequent grain-ing procedure is prevented. As may be seen by reference to Example 2, the mixture must be partially cured in some way to effect some binding of the powders in order to obtain the desired free-flowing granules. In pelleting the free-flowing granules, completion of the curing by heat treatment or other means is especially effective. Moreover, after forming contoured bodies of explosive, completion of the cure is preferred because of the increased rigidity and cohesiveness thereby obtained.

The selection of the epoxy hydroxy polyether used in the preparation of the explosive composition of the present invention is not critical. The only requirements in this selection are that the polyether is one that can be cured at a temperature within the thermal stability range of the high-explosive compound and/or below the melting point of the high-explosive compound and is one that is nonreactive with the high-explosive compound. The choice of curing agent depends upon the specific polyether used, the only requirement being that the curing agent be nonreactive with the high-explosive compound. Of course, the polyether-curing agent system chosen must be such that the reaction between the two components is not exothermic to the extent that too rapid cure is effected, which cure would hamper thorough incorporation of the high-explosive compound and the polyether. The amount of curing agent used depends upon the amount of polyether used, sufficient curing agent being used to bring about efficient curing of the polyether.

By "crystalline high-explosive compound" as used herein is meant solid detonating compounds, for example, nitramines, nitro compounds, organic nitrates, and mixtures of these compounds. Such compounds include PETN (pentaerythritol tetranitrate), RDX (cyclotrimethylenetrinitramine), HMX (cyclotetramethylenetetranitramine), tetryl (tetranitromethylaniline), and TNT (trinitrotoluene).

The invention has been described in detail in the foregoing. It will be apparent to those skilled in the art

that many variations are possible without departure from the scope of the invention. I intend, therefore, to be limited only by the following claims.

I claim:

1. An explosive composition consisting of pellets of a crystalline high-explosive compound selected from the group consisting of pentaerythritol tetranitrate, cyclotrimethylenetrinitramine, cyclotetramethylenetetranitramine, tetranitromethylaniline, and trinitrotoluene, said explosive compound being coated with an epoxy hydroxy polyether nonreactive with the high-explosive compound and which is at least partially cured by means of a curing agent nonreactive with the high-explosive compound, said epoxy hydroxy polyether being present in the amount of 3-15 percent by weight of the mixture of high-explosive compound and epoxy hydroxy polyether.
2. An explosive composition consisting of a crystalline high-explosive compound selected from the group consisting of pentaerythritol tetranitrate, cyclotrimethylenetrinitramine, cyclotetramethylenetetranitramine, tetranitromethylaniline, and trinitrotoluene, said explosive compound being coated with an epoxy hydroxy polyether nonreactive with the high-explosive compound and which is at least partially cured by means of a curing agent nonreactive with the high-explosive compound, said epoxy hydroxy polyether being present in the amount of 3-15 percent by weight of the mixture of high-explosive compound and epoxy hydroxy polyether.
3. An explosive composition according to claim 2, wherein the crystalline high-explosive compound is RDX.
4. An explosive composition according to claim 2, wherein the crystalline high-explosive compound is pentaerythritol tetranitrate.
5. An explosive composition consisting of free-flowing granules of a crystalline high-explosive compound selected from the group consisting of pentaerythritol tetranitrate, cyclotrimethylenetrinitramine, cyclotetramethylenetetranitramine, tetranitromethylaniline, and trinitrotoluene, said explosive compound being coated with an epoxy hydroxy polyether nonreactive with the high-explosive compound and which is at least partially cured by means of a curing agent nonreactive with the high-explosive compound, said epoxy hydroxy polyether being present in the amount of 3-15 percent by weight of the mixture of high-explosive compound and epoxy hydroxy polyether.

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