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(54) Explosive compositions.

(57) An explosive composition which is in an at least semi-fluid form, such as an emulsion or a gel, and which includes a polymerizable fuel component which, on polymerization, serves to increase the viscosity of the composition and to improve its stability in so far as the retention of any gas bubbles which are present in it as sensitising agent is concerned.

The polymerization is carried out in such a manner that at least a skin of polymeric material is formed around the product which obviates the need for any further packing of the product prior to its commercial use.

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EXPLOSIVE COMPOSITIONS

This invention relates to explosive compositions in the fluid or semi-fluid form, i.e. compositions such as emulsions, gels, and the like, and their method of preparation.

Explosive compositions of the aforesaid kind (which will be referred to as such in the rest of this specification) usually comprises a suitable aqueous solution of an oxidiser salt (usually ammonium nitrate or mixtures thereof) and a suitable fuel (usually a hydrocarbon oil), together with one or more compounds such as dispersing and/or emulsifying agents, thickeners, and sensitising agents. The latter can, for example, entail gas bubbles which can be introduced into the composition either chemically, mechanically, or through the addition of a gas entrainment agent such as microballoons, for example.

One of the problems encountered with explosive compositions of the aforesaid kind relates to the accurate control of the viscosity and/or density of the final product. Thus, for example, in the case of the viscosity of such compositions, it is usually advantageous for the handling of the composition in the blasting hole to have a product which has a relatively high viscosity, and which will be able to retain its physical form in the blasting hole in spite of any tamping, etc. which may be affected in such hole during of after the loading of the explosives charge. In the case of the density of such compositions, it can, for example, be advantageous to the blasting power of the final composition if the product has a relatively high density. However, because the sensitivity of the explosive compositions decreases with increased density, such increase often requires rectification through the employment of more of the sensitising agent. There are several disadvantages attached to the latter requirement, one of which relates to the relatively high costs of such agents.

Another problem encountered with explosive compositions of the aforesaid kind relates to the way in which they are packed for commercial use. Usually such packing comprises the provision of an envelope of wax coated paper or the like, or of a suitable synthetic resinous material, into which the composition is located in the fluid or semi-fluid form. Apart from the fact that this may comprise a cumbersome and expensive procedure, the envelope is also subject to breakage, especially during the loading of the explosive charge into the blasting hole, which of course, often leads to the explosive charge being damaged, and its blasting power possibly also deminished.

It is accordingly an object of this invention to provide an explosive composition of the aforesaid kind, and a method and apparatus for its manufacture, with which the applicant believes the aforesaid problems may be overcome or at least minimised.

According to the invention a method of manufacturing an explosive composition which is in an at least semi-fluid form includes the step of employing a polymerizable compound in the composition, and causing it to polymerize.

Applicant has found that through such polymerization the viscosity of the composition can be controlled in a manner which has less disadvantages than those experienced with the known arrangements.

The invention accordingly also includes within its scope a method of controlling the viscosity of an explosive composition which is in an at least semi-fluid form by employing a polymerizable compound as one of the constituents of the composition, and causing the compound to polymerize to a predetermined degree.

It will be appreciated that the higher the degree of polymerization, the higher the viscosity of the resulting product.

Applicant has furthermore found that where a sensitising agent such as gas bubbles or the like is employed in the composition, the prolonged trapping of such bubbles, and hence the stability of the composition, can be enhanced through such polymerization of the composition.

The invention accordingly also includes within its scope a method of controlling the stability of an explosive composition of the aforesaid kind which contains a sensitizing agent in the form of gas bubbles or the like by employing a polymerizable compound as one of the constituents of the composition and causing it to polymerize.

It will be appreciated that the polymerization can be effected in any suitable manner, and that the composition may include any other suitable constituents which may be required for enhancing and/or controlling such polymerization.

Thus, for example, the polymerization may be effected by means of chemical reaction, heat and/or any suitable form of irradiation such as light (ultraviolet or infarred); electron beam, X-ray, gamma ray, etc. The composition may, of course, also include one or more suitable initiators, accelerators, cross linking agents, catalysts, etc.

Further according to the invention the polymerizable compound constitutes at least part of the fuel

component of the explosive composition.

The polymerizable compound may constitute any suitable one, and may, for example, constitute at least one of the compounds from the group including organic polymers, or prepolymers and resins, particularly alkyd resins and the like.

Preferably the polymerizable compound comprises a suitable alkyd polymer.

Further according to the invention the method includes the step of performing the polymerization in such a manner that the final product is at least enveloped in a skin of polymerized material.

Applicant has found that the provision of such a polymer skin around the composition can obviate or at least minimise the need for having to provide an additional arrangement for the packing of the final composition.

Such a skin can furthermore be made strong enough to ensure that the final product will be able to withstand the normal handling thereof without breakage.

Still further according to the invention the method includes the step of providing the explosive composition in the final form in which it will be made available for commercial use before allowing it to polymerize.

Thus, for example, in one form of the invention the unpolymerized explosive composition may be provided in the form of an elongated cylinder or the like, and the polymerization so performed that the polymerized composition is of substantially the same configuration.

In a presently preferred form of the invention the explosive composition includes a polymerizable carbon containing fuel compound, and the polymerization is effected by subjecting the composition to a suitable form of irradiation, such as ultra violet irradiation, for example.

With such an arrangement the polymerization of the composition accordingly starts to take place over the entire periphery of the compound so that at least the whole of the outside of the composition becomes covered with a polymer skin.

Applicant has found that where ultra violet irradiation is employed, it can be applied at an intensity of from 80 to 500 watts per cm^2, and an exposure time of from 0.5 to 500 seconds.

If required, such polymerization can be stopped when a skin of predetermined thickness has been formed, or alternatively, it can be allowed to continue until the whole of the composition has been polymerized.

In a presently preferred form of the invention the unpolymerized product is extruded in cylindrical form from a suitable mixing apparatus, whereafter the irradiation can be effected to the extruded product.

Alternatively, the unpolymerized product can be located in a tube of a suitable material such as quartz, for example, and the irradiation of the product effected through the wall of the tube.

It will be appreciated that where the product is initially only partly polymerized, the polymerization of the rest of the composition can be allowed to take place at any later stage of the operation.

It will further be appreciated that the invention also includes within its scope an explosive composition of the aforesaid kind which includes a polymerized fuel compound, as well as apparatus as herein described for making such a composition.

The invention will now be described further by way of example with reference to the enclosed drawing, which is a diagrammatic perspective view of apparatus employed in the manufacturing of an explosive composition according to the invention.

In these examples of the invention, the properties of two explosives compositions (hereinafter respectively referred to as compounds A and B) which were made according to the method of the invention, were compared to those of a similar composition (hereinafter referred to as compound C) made in conventional manner.

The conventionally known composition C constituted a water-in-oil emulsion comprising, on a mass to mass basis, 84.3% of an oxidiser salt such as ammonium nitrate or mixtures thereof, dissolved in an amount of water which constituted 10.2% (m/m) of the final product; 4.8% of a fuel such as a suitable hydrocarbon oil together with a suitable emulsifier; and 0.7% of a suitable sensitiser.

Composition A differed in constitution from composition C in that its fuel component comprised 2.8% fuel and emulsifier, and 2% of a suitable alkyd polymer.

In the case of composition B its constituents differed from those of compound C in that all of its fuel component comprised the aforesaid alkyd polymer, which accordingly constituted 4.8% of the final product on a mass per mass basis.

Referring now to the apparatus shown in the drawing, each of the prior made water-in-oil emulsion compositions A, B and C was in turn extruded from a mixer 1 in the form of an elongated cylinder 2 onto conveyers 3, where they were cut into predetermined lengths by means of a cutting device 4, and from which they were allowed to roll down an inclined chute 5 onto a pair of tapered rollers 6, which rotate in the

same direction relative to each other, and which accordingly serve to make cylinder 2 retain its cylindrical shape.

In the case of compositions A and B, there were subjected to ultraviolet radiation from a source 7 while they were retained on rollers 6. The radiation was effected at an intensity of 50-80 watts/cm^2, and an exposure time of 15 seconds.

The final compounds A and B differed physically from compounds C in that they were enveloped in a polymeric skin which was of such thickness and strength that no subsequent packaging thereof was required in order to render them suitable for ordinary commercial use as explosive compositions.

In the case of compound C, the final product was packed in conventional manner in an envelope of a wax-coated paper or polymeric material in order to render it suitable for ordinary commercial use as an explosive composition.

After compositions A, B and C were removed from rollers 6, some of their physical and blasting properties were determined, and some of these were reflected in the following table:

COMPOUNDS	PENETRATION (mm)	DENSITY (g/cm^3)	VISCOSITY (BROOKFIELD) (CENTPOISE x 10^3)	VELOCITY OF DETONATION (m/s)	CRITICAL DIAMETER (mm)
A	1.5	1.1-1.3	>120(plastic behaviour)	4000-5000	15
B	1.0	1.1-1.3	>120(plastic behaviour)	4000-5000	15
C	2.6	1.1-1.3	90-120	4000-5000	18

In temperature shock tests which were carried out on the final compositions, it was found in the case of compositions A and B that they could still successfully be detonated at ambient temperature after their temperatures had been lowered to -40 $^\circ$ C, while composition C completely failed to detonate under such conditions.

In stability tests done after an exposure of the compounds to the atmophsere over a period of two weeks during which the average temperature was 23 $^\circ$ C and the relative humidity 50%, it was found that compositions A and B could still be detonated sucessfully, while compound C completely failed to detonate.

It will accordingly be appreciated that the invention provides a novel explosion composition, and a method for its preparation, with which the problems sated in the preamble of this specification as being encountered with the conventional type of explosive composition, can be overcome or at least minimised.

It will still further be appreciated that there are no doubt many variations in detail possible with a method, product, and apparatus according to the invention without departing from the spirit and/or scope of the appended claims.

Claims

1. A method of manufacturing an explosive composition which is in an at least semi-fluid form, including the steps of employing a polymerizable compound in the composition, and causing it to polymerize.

2. A method of controlling the viscosity of an explosive composition which is in an at least semi-fluid form by employing a polymerizable compound as one of the constituents of the composition, and causing it to polymerize to a predetermined degree.

3. A method of controlling the stability of an explosive composition of the aforesaid kind which contains a sensitising agent in the form of gas bubbles or the like, by employing a polymerizable compound as one of the constituents of the composition, and causing it to polymerize.

4. The method of any one of the preceding claims wherein the polymerizable compound constitutes at least part of the fuel component of the explosive composition.

5. The method of any one of the preceding claims wherein the polymerizable compound constitutes at least one of the compounds from the group including organic polymers, or prepolymers; and resins, particularly alkyd resins and the like.

6. The method of any one of claims 1 to 4 wherein the polymerizable compound comprises a suitable alkyd polymer.

7. The method of any one of the preceding claims wherein the polymerization is effected in such a manner that the final product is at least enveloped in a skin of polymerized material.

8. The method of any one of the preceding claims including the step of providing the explosive composition in the final form in which it will be made available for commercial use before allowing it polymerize.

9. The method of any one of the preceding claims wherein the explosive composition includes a polymerizable carbon containing fuel compound, and the polymerization is effected by subjecting the composition to a suitable form of irradiation, such as ultra violet irradiation, for example.

10. The method of any one of the preceding claims wherein the polymerization is effected with ultra violet irradiation which is applied at an intensity of from 80 to 500 watts/cm^2, and an exposure time of from 0,5 to 500 seconds.

11. A method of manufacturing an explosive composition substantially as herein described with reference to the examples and the drawing.

12. Apparatus for carrying out the method of any one of the previous claims, substantially as herein described, and as shown in the drawing.

13. An explosive component which is in an at least semi-fluid form, and which includes a polymerized fuel component.