United States Patent Office 3,723,204 Patented Mar. 27, 1973

3,723,204

FLEXIBLE HIGH-VELOCITY EXPLOSIVE

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No Drawing. Filed Oct. 1, 1969, Ser. No. 862,922
Int. Cl. C06b 3/00, 15/02; C06c 1/00
U.S. Cl. 149—19 8 Claims

ABSTRACT OF THE DISCLOSURE

Tough, flexible, high-velocity explosive composition comprising an intimate uniform mixture of a cap-sensitive particulate high explosive, a polyethylacrylate rubber, and optionally a plasticizer.

BACKGROUND OF THE INVENTION

This invention relates to a flexible, high-velocity explosive composition.

In recent years, flexible explosive compositions have found wide application in the explosives art, e.g., for detonating cord, sheet explosives, primers, and shaped charges. Typical detonation velocities of the known compositions have been on the order of about from 3,000 to 7,500 meters per second. While these detonation velocities are adequate for most uses, higher velocities are desirable in some instances, e.g., in primers for detonating the more insensitive blasting agents and when small-size primers or detonating cords are needed which have high initiation capabilities. Thus, there is needed a flexible explosive composition suitable for use in detonating cords, primers, etc., which has a high detonation velocity, e.g., on the order of from about 7,700 to 8,200 meters per second.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a tough, flexible, high-velocity explosive composition which can be molded, extruded, cast, rolled, pressed, or stamped from sheets into special shapes, which is especially useful in detonating cords, sheets, primers, and shaped charges, and which has a detonation velocity on the order of about from 7,700 to 8,200 meters per second.

More specifically, this invention provides an explosive composition which comprises an intimate uniform mixture of about from 60 to 85 percent by weight of cap-sensitive particulate high explosive, about from 10 to 40 percent by weight polyethylacrylate rubber having a Shore A Durometer hardness of about from 20 to 70, and from 0 to about 20 percent by weight plasticizer.

DESCRIPTION OF PREFERRED EMBODIMENTS

Any particulate cap-sensitive high explosive which is stable under the processing conditions, and which is compatible with other ingredients is suitable for use in this invention. As used in this invention, cap-sensitive high explosive is meant to include a single cap-sensitive high explosive, a mixture of one or more cap-sensitive high explosives, and mixtures of one or more cap-sensitive high explosives with one or more other high explosives, e.g., trinitrotoluene or ammonium nitrate, the mixture being cap-sensitive, i.e., sensitive to initiation by a No. 8 blasting cap.

Especially suitable for use in this invention are cap-sensitive high explosive organic nitrates, nitramines, and aromatic nitro compounds.

Examples of specific cap-sensitive high explosive compounds that can be used in this invention include pentaerythritol tetranitrate (PETN), trinitrophenylmethylnitramine (tetryl), potassium dinitroacetonitrile, cyclotrimethylenetrinitramine (RDX), cyclotramethylenetetranitramine (HMX), tetranitrodibenzo-1,3a,6a-tetraazapentalene (including all its isomers based on the various positions of the nitro groups), lead azide, mannitol hexanitrate, diazodinitrophenol, hexamethylenetriperoxydiamine, picrylsulfone, and mixtures thereof. RDX and PETN have optimum properties for use in this invention and are accordingly preferred.

The cap-sensitive high explosive constitutes about from 60 to 85 percent of the final composition. If substantially greater amounts of the explosive component are utilized, the final compositions lack the desired degree of cohesiveness, whereas the use of substantially lesser amounts of the high explosive results in products which have unreliable detonation characteristics. An optimum balance of explosive characteristics any physical properties has been found to be present in the final explosive compositions when the high explosive component is about from 70 to 80 percent of the total weight. Accordingly, this latter concentration range is preferred in the instant explosive compositions.

The particle size of the high explosive is not critical, although particles which pass a No. 80 U.S. Standard sieve are preferred, and especially preferred are particles whose average major dimension does not exceed 100 microns. The latter are described as superfine explosives. In addition, the explosive compositions are more sensitive to initiation if the high explosive particles are prepared by the process of mixing a solution of the explosive with a non-solvent, which is miscible with the solvent, in a jet-impingment mixer, such as thep rocess disclosed in Canadian Pat. 533,487.

The polyethylacrylate rubbers useful in this invention have a hardness on the Shore A Durometer hardness scale of about from 20 to 70. As is familiar to those skilled in the art, the Shore method of measuring hardness consists of measuring the penetration of a truncated conical indentor under the force of a spring. The scale is arbitrary, from 0 (infinitely soft) to 100 (bone hard). The polyethylacrylate rubber constitutes by weight about from 10 to 40, and preferably about from 11 to 35, percent of the final explosive composition.

The polyethylacrylate rubbers used can comprise, for example, polyethylacrylate or copolymers or terpolymers of ethyl acrylate with other substituted olefins which are compatible with the high explosive used and which yield copolymers or terpolymers having the requisite Shore hardness. Such substituted olefins include, for example, styrene, acrylic nitriles, e.g., acrylonitrile, methacrylonitrile, ethacrylonitrile, alpha-butylacrylonitrile, alpha-phenylacrylonitrile, alpha-chloroacrylonitrile and alpha-methoxymethylacrylonitrile, and acrylic acids, e.g., acrylic acid, methacrylic acid, ethacrylic acid and alpha-chloroacrylic acid.

Preferred for use in this invention are polyethylacrylate (Shore hardness about 25), copolymers of 95 to 97 percent by weight ethylacrylate and 3 to 5 percent by weight acrylonitrile (Shore hardness about 30), terpolymers of 68 to 72 percent by weight ethyl acrylate, 24 to 27 percent by weight styrene, and 2 to 5 perecnt by weight acrylonitrile (Shore hardness about 65), and mixtures thereof.

Although the polyethylacrylate rubbers may be incorporated into the explosive composition by first dispersing them in volatile organic solvents such as aliphatic hydrocarbons, halogenated aliphatic hydrocarbons, toluene, or methyl ethyl ketone, the preferred form of the rubbers is a latex containing from about 35 to 60% of solids dispersed in an aqueous medium. Such latices present several advantages since latices are the form in which the rubbers are made and, therefore, represent the lowest cost form of the rubbers; no costly and hazardous organic solvents are required to fabricate the articles of this invention; and finally the presence of water in the latex greatly inicreases the safety of mixing operations wherein a cap-sensitive particulate high explosive is incorporated with the rubber and the optional plasticizer. During mixing the reaction mixture may be heated to slowly remove the water or solvent. Such latices are commercially available as,

for example, "Hycar" 2600 x 84 (terpolymer of, by weight, 68 to 72 percent ethylacrylate, 24 to 27 percent styrene, and 2 to 5 percent acrylonitrile), 2601 (polyethylacrylate), and 2671 (copolymer of, by weight, 95 to 97 percent ethyl acrylate and 3 to 5 percent acrylonitrile), of which "Hycar" 2601 is especially preferred. Such latices can be used alone or in combination.

Any plastticizer for the polyethylacrylate rubber of the explosive composition can be used. Incorporating up to about 20 percent, preferably 10 percent or less, plasticizer by weight assists in maintaining desirable properties over a wide range of environmental conditions, e.g., providing low temperature flexibility for the explosive composition. Plasticizers which are particularly suitable for use either alone or in combination in the compositions are esters and polyethers and include, for example, triethyl citrate, tributyl citrate, acetyltriethyl citrate, acetyltributyl citrate, triethyleneglycol di-2-ethylhexoate, dibutyl phthalate, diisodecyl adipate, diisooctyl adiptate, di-2-ethylhexyl adipate, dioctyl adipate, butyl epoxy stearate, and di(butoxyethoxyethyl) formal. Preferred plasticizers, either alone or in combination, are acetyltributyl citrate, triethyleneglycol isodecyl adipate, diisooctyl adipate, di-2-ethylhexyl adipate, butylepoxy stearate and di(butoxyethoxyethyl)formal, with dibutyl phthalate, di-2-ethylhexyl adipate, and triethyleneglycol di - 2 - ethylhexoate being especially preferred.

The explosive compositions of this invention can be prepared by uniformly blending the components and fashioning the resulting rubbery mass into desired shapes. More specifically, the explosive compositions can be prepared by charging the ingredients into a mixer and, while circulating water through a jacket, preferably at about from 150–180° F., mixing under reduced pressure until a homogeneous rubbery mass is formed and substantially all water is removed. Although reduced pressure is not a limiting factor, reduced pressure tends to reduce the entrapment of air bubbles in the composition, thereby making it tougher, and also speeds up the processing. The rubbery mass is removed from the mixer and is then molded, extruded, cast, rolled, pressed, stamped, or otherwise fashioned into desired shapes.

The product is flexible, tough, and solvent resistant. It is detonated by conventional blasting caps, typical detonation velocities being on the order of about from 7700 to 8200 meters per second. Finally, it has good thermal stability at temperatures up to about 250° F.

It will be understood that small amounts of other ingredients if desired, may be incorporated in the explosive compositions of this invention; for example, stabilizers, pigments, and coloring agents can be used for identification or for increasing visibility, odorants can be used to create a pleasant aroma or to overcome an objectionable odor of the cured elastomeric binder matrix, and antioxidants and retardants can be used.

Useful shaped articles may be formed from the explosive compositions of this invention as hereinbefore described, without incorporating reinforcing means, and the scope of the invention should be understood to include such articles. For example, the explosive compositions may be shaped into blocks, slabs, tubes, sheets, cords, strips, trains, and other forms. Such explosive articles find many uses in the explosive field, but their utility is greatly increased by including in the article a reinforcing means bound to the explosive composition in such manner as to provide an article having great flexibility, even at subzero temperatures, little extensibility, and much greater tensile strength than in the absence of such reinforcing means.

The compositions and articles of the present invention, whether they include a reinforcing means or not, are particularly effective and have a high order of utility in the explosives industry because the explosive compositions and articles made therefrom are surprisingly insensitive to impact and mechanical abuse, they remain completely effective after long exposure to water, they require no supplementary protective covering for handling, they are nontoxic to users, and in comparison with other explosive compositions used in the industry they have enhanced initiating or priming power because of the high concentration of explosive at the initiation point and the freedom from inert layers of protective covering between initiator and receptor bodies. Finally, they have high detonation velocities of about from 7700 to 8200 meters per second.

The following examples are intended to provide further specific illustrations of this invention, but not to limit it in any way. In the examples, parts and percentages are by weight, unless otherwise specified.

EXAMPLE 1

Into a jacketed, kneading-type mixer fitted with a vacuum-tight cover are charged 70 parts of dry superfine PETN, 50 parts of "Hycar" 2601 (polyethylacrylate latex) containing about 50 percent solids, and 5 parts of plasticizer, di-2-ethylhexyladipate (Adipol DOA). The order of adding the ingredients is not critical; however, addition of the particulate high explosive last is preferred as a somewhat safer procedure. The cover is placed in position on the mixer, water at about 160° F. is circulated through the mixer jacket, and the agitator is put in motion. After the mixer has operated for about 5 minutes, vacuum is applied gradually with the agitator in motion, until a vacuum of about 29 inches or more of mercury is achieved, and this is maintained until substantially all water is removed from the charge in the mixer. The dried explosive composition is then removed from the mixer and extruded into ⅛ inch cord. The product is tough and flexible and, when initiated by a No. 6 electric blasting cap, detonates at a velocity of 8180 meters per second.

EXAMPLES 2 TO 19

Table 1 illustrates additional compositions prepared and detonated according to the procedure of Example 1.

TABLE 1

Ex:	Explosive	Parts	Polyethylacrylate rubber latex (50% solids)	Parts	Plasticizer	Parts	Det. velocity (m./s.)
2	PETN	60	"Hycar" 2600X84[1]	66	"Flexol" 360 [4]	7	8,000
3	Superfine PETN	65	"Hycar" 2601[2]	59.5	"Adipol" DOA[5]	5.25	7,940
4	PETN	70	"Hycar" 2671[3]	50	do [5]	5	8,167
5	PETN	70	do[3]	50	"Citroflex" A–4 [6]	5	7,937
6	Superfine PETN	70	do [3]	50	"Adipol" DOA [5]	5	7,940
7	PETN	70	"Hycar" 2601[2]	50	"Thiokol" TP–90B[7]	5	7,820
8	PETN	70	do [2]	50	"Flexol" 360[4]	5	8,065
9	PETN	80	do [2]	34	"Adipol" DOA [5]	3	7,940
10	Superfine PETN	80	do [2]	29.5	do [5]	5.25	8,180
11	do	84	do [2]	23.6	do [5]	4.2	8,180
12	RDX	80	"Hycar" 2671[3]	40			8,000
13	Superfine RDX	80	"Hycar" 2601[2]	40			7,700
14	do	80	"Hycar" 2671[3]	34	"Citroflex" A–4 [6]	3	7,940
15	do	80	"Hycar" 2601[2]	34	Dibutylphthalate	3	7,940
16	RDX	80	do [2]	34	"KP–90"[8]	3	7,700
17	RDX	80	do [2]	34	"Flexol" 360 [4]	5	7,940
18	RDX	80	do [2]	30	Dibutylphthalate	5	8,000
19	RDX	80	do [2]	34	"Adipol" DIDA [9]	3	7,700

[1] Terpolymer of by weight 68–72% ethylacrylate, 24–27% styrene, and 2–5% acrylonitrile; [2] Polyethylacrylate; [3] Copolymer of by weight 95–97% ethylacrylate and 5–3% acrylonitrile; [4] Triethyleneglycol di-2-ethylhexoate; [5] Di-2-ethylhexyl adipate; [6] Acetyltributyl citrate; [7] Di(butoxyethoxyethyl)formal; [8] Butylepoxy stearate; [9] Diisodecyl adipate.

What is claimed is:

1. An explosive composition consisting essentially of an intimate uniform mixture of about from 60 to 85 percent by weight cap-sensitive particulate high explosive, about from 10 to 40 percent by weight of a polyethylacrylate rubber having a Shore hardness of about from 20 to 70, wherein said polyethylacrylate rubber is polyethylacrylate or a copolymer or terpolymer of ethyl acrylate with substituted olefins selected from the group consisting of acrylic nitriles, acrylic acids, and styrene, and from 0 to about 20 percent by weight plasticizer.

2. An explosive composition of claim 1 wherein said polyethylacrylate rubber is selected from the group consisting of polyethylacrylate, copolymers of ethylacrylate with acrylonitrile, and terpolymers of ethyl acrylate with acrylonitrile and styrene.

3. An explosive composition of claim 2 wherein said high explosive is pentaerythritol tetranitrate or cyclotrimethylenetrinitramine.

4. An explosive composition of claim 3 wherein said plasticizer is selected from the group consisting of acetyltributyl citrate, triethyleneglycol di - 2 - ethylhexoate, dibutyl phthalate, di - 2 - ethylhexyl adipate, butylepoxy stearate, and di(butoxyethoxyethyl)formal.

5. An explosive composition of claim 4 wherein said polyethylacrylate rubber is selected from the group consisting of polyethylacrylate, copolymers of about from 95 to 97 percent by weight ethyl acrylate and about from 3 to 5 percent by weight acrylonitrile, and terpolymers of about from 68 to 72 percent by weight ethyl acrylate, about from 2 to 5 percent by weight acrylonitrile, and about from 24 to 27 percent by weight styrene, and said plasticizer is selected from the group consisting of dibutyl phthalate, di - 2 - ethylhexyl adipate, and triethyleneglycol di-2-ethylhexoate.

6. An explosive composition of claim 5 wherein said high explosive is pentaerythritol tetranitrate and said polyethylacrylate rubber is polyethylacrylate.

7. An explosive composition of claim 5 wherein said high explosive is cyclotrimethylenetrinitramine and said polyethylacrylate rubber is polyethylacrylate.

8. An explosive composition of claim 1 wherein said mixture comprises about from 70 to 80 percent by weight of said high explosive, about from 15 to 30 percent by weight of said polyethylacrylate rubber, and from 0 to about 10 percent by weight of said plasticizer.

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U.S. Cl. X.R.

149—20, 92, 93