United States Patent Office

3,102,833
Patented Sept. 3, 1963

3,102,833

PROCESS FOR PRODUCING A FIBROUS EXPLOSIVE HAVING VARIABLE DENSITY

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No Drawing. Filed Mar. 7, 1961, Ser. No. 93,852
9 Claims. (Cl. 149—19)

The present invention relates to a novel, self-supporting explosive composition whose density and velocity of detonation may be readily varied by mechanical means, and to a method of fabricating the composition. More particularly, the present invention relates to a deformable self-supporting explosive composition in fibrous form of controllable density and velocity of detonation comprising an intimate mixture of a cap-sensitive crystalline high-explosive with an elastomeric composition.

Recent developments in the art of utilizing explosively generated pressures for constructive purposes, such as in the fields of metal-treating and working, require a deformable self-supporting high explosive composition, preferably in sheet form, which detonates at a velocity most suitable for the specfic application. Depending on the application, the detonation velocity desired may be as low as 2000 meters per second, as high as 7000 meters per second, or some specific value between these limits. The composition should be capable of sustaining a detonation without confinement even in relatively thin cross sections. For convenience and economy in fabrication and use, the mechanism for regulating the velocity of detonation of the composition should be one which does not require changes in the formulation of the composition itself.

According to the present invention, a novel, fibrous self-supporting explosive composition in which the detonation velocity may be regulated by mechanical means may be formulated from an intimate mixture of 50 to 85% of a cap-sensitive crystalline high-explosive compound with 15 to 50% of an elastomer. The compositions of this invention may be prepared conveniently and safely by forming a solution of the explosive and the elastomer in a suitable solvent, precipitating the mixture of explosive and elastomer in fibrous form by introducing the solution into a liquid which is miscible with the solvent but is not a solvent for either the explosive or the elastomer, separating and drying the fibrous precipitate, and mechanically cutting and pressing the composition to the requisite configuration and density. In a preferred embodiment, a normally fibrous material, such as paper pulp, strands, or fibers, is suspended in the precipitating liquid so that the explosive-elastomer mixture precipitates as a deposit on the normally fibrous material. The composition thus formed tends to have a higher tensile strength than does the fibrous explosive-elastomer composition without the supporting fiber matrix. The amount of extraneous fibrous material may constitute up to about 30% by weight of the final composition. Also, the suspension of extraneous fibrous material may contain a substantial quantity of finely-divided explosive to impart increased explosive content in the precipitated explosive-elastomer composition.

The fibrous compositions thus obtained may be mechanically formed, for example by felting techniques, into useful shapes, such as sheets and tubes, and will be self-supporting in any shape or configuration into which they are formed. The resultant forms have the cohesiveness, flexibility, and degree of resilience as well as the requisite explosive strength and other properties for use as an explosive. The novel explosive compositions are relatively water-resistant and stable under normal storage conditions. They are especially convenient for use in connection with recently developed explosive specialty techniques, such as explosive forming, steel hardening, etc.

The cap-sensitive high explosive constitutes 50–85% of the final composition. If greater amounts of the explosive component are utilized, the final compositions lack the desired degree of cohesiveness and have a tendency to crack, whereas the use of lesser amounts of the high explosive results in products which have unreliable detonation characteristics. When the proper proportions of high explosive and elastomer (and fibrous material) are used, the compositions of the present invention can be initiated in sheet form, or otherwise, by commercially available blasting caps and will detonate at velocities which may be varied from 1500 to 7500 meters per second. The velocity of the composition will vary directly with the density of the fibrous material, which can be regulated by mechanical means. PETN (pentaerythritol tetranitrate) and RDX (cyclotrimethylenetrinitramine), which are representative of cap-sensitive crystalline high-explosive compounds, are particularly suitable for use in the composition as the high explosive component. However, other cap-sensitive crystalline explosives, such as other organic nitrates, e.g., nitromannite, and other nitramines, e.g., HMX (cyclotetramethylenenitramine), tetryl, and ethylenedinitramine, also can be used. Moreover, a mixture containing such compounds, e.g., a mixture of PETN and TNT or RDX, or a mixture of PETN and a less sensitive compound such as ammonium nitrate, are suitable.

A portion or all of the cap-sensitive explosive used in preparing the fibrous composition of the present invention may be added as a suspension in the precipitating liquid in a superfine state, i.e., the maximum dimension of the particles are within the range of 0.1–100 microns, the average maximum crystalline dimension being within the range of 0.1 and 2 microns. The use of the superfine material increases the impact and cap sensitivity of the fibrous mass, for example, as determined by the standard drop test with a 5-kg. weight or the minimum primer test.

The non-explosive binding material consists of the elastomer and, if desired, the extraneous fibrous material. Increasing the proportion of elastomer within certain limits increases the resilience of the explosive composition. However, if the elastomer constitutes more than 50% by weight of the composition, the product mass will not reliably propagate a detonation. On the other hand, the use of less than 15% of the binding materials gives a composition which is difficult to form and lacks the desired strength and cohesiveness.

Any elastomeric material such as natural or synthetic rubbers, rubbery plastics and polymers and the like which are chemically inert with the system and soluble in a solvent for the explosive and insoluble in the solvent-miscible precipitating liquid may be used in preparing the composition of the present invention. The elastomer must not contain elements or compounds, such as alkaline constituents, aliphatic or aromatic amines, or strong mineral acids, which will react with the explosive composition to effect a degradation thereof nor must it be of a nature to react with the solvent medium at the expense of its elastomeric properties so that a friable or hard precipitate is formed by the reaction. Ketone, e.g., acetone, soluble elastomeric materials are especially convenient and represent a much preferred embodiment. Exemplary elastomeric materials include butadiene-acrylonitrile copolymers available as "Hycar" (manufactured by the B. F. Goodrich Co.) or as "Paracril" (manufactured by the Naugatuck Chemical Division of the U. S. Rubber Co.); copolymers of vinylidene fluoride and hexafluoropropylene (commercially available as "Viton," manufactured by E. I. du Pont de Nemours and Co.); chloroprene polymers (commercially available as "neoprene," manufactured by E. I. du Pont de Nemours and Co.); and methacrylonitrile-butadiene copolymers (manufactured by the method of U.S. 2,459,126), all of which are ketone soluble. These particular elastomers are economical, readily available, convenient to work with and yield an explosive composition of the type described having excellent workability and other physical and explosive properties in line with the objectives of this invention. The use of these particular elastomers is by no means critical to the invention, however, and the novel compositions of the present invention may be prepared with any elastomeric material which is soluble in a suitable solvent, such as a ketone, and inert to the system. The elastomeric material is used for its rubbery nature and not because of any chemical property or characteristic. So long as the elastomeric material is substantially chemically inert to the system (i.e., will not react with the explosive to desensitize it, will not degenerate or degrade in solution, etc.), it is satisfactory for purposes of the present invention regardless of its chemical structure.

If desired, various plasticizers or modifiers such as cellulose acetate, vinyl chloride-vinyl acetate copolymers and the like may be added to the composition to the extent that the additive is chemically inert with the system.

The incorporation of a normally fibrous material, which may constitute 0.5–30% by weight of the fully formulated composition, usually enhances the tensile strength of the composition. When the concentration of the normally fibrous material is more than 30%, the detonation characteristics of the composition may deteriorate. In addition, increasing the content of extraneous fibrous material in the composition, while improving the composition's tensile strength, may reduce its flexibility until, at an amount in excess of 30%, the loss of flexibility may curtail the utility of compositions for some industrial applications.

Paper pulp is a preferred fibrous material, considering especially its low cost. However, other natural or synthetic substances composed of strands or fibers may be used, e.g., cotton, rayon, nylon, polyesters, or acrylic resins, etc.

Any solvent which will dissolve both the explosive component and the elastomeric component and which is miscible with a non-solvent for these components may be used to form these unique explosive compositions. The water-miscible solvents such as acetone, methyl ethyl ketone, or dimethyl formamide are especially convenient. Sufficient solvent must be used to completely dissolve all of the explosive and all of the elastomer to be precipitated. More than the minimum amount may be used to modify the physical nature of the precipitate, if desired.

As the precipitating liquid, any non-solvent for the explosive and the elastomer which also is miscible with the solvent used may be employed. Because of its low cost, water is preferred if the solvent is water-miscible. The quantity required is that which will dilute the solvent sufficiently to precipitate out essentially all of the explosive and the elastomer.

The fibrous precipitate may be recovered from the slurry by conventional means, such as filtration, and dried. The dry fibrous composition can be used without further treatment. In this loose, unpressed state, the composition has its lowest density and its minimum (or initial) detonation velocity. Compressing the composition to densify it increases the velocity of detonation of the composition. The velocity of detonation obtained by detonating an unpressed fibrous composition containing PETN as the high explosive is in the vicinity of 1500 meters per second when the density is approximately 0.20 gram per cubic centimeter, and the velocity is about 7300 meters per second when the fibrous sheets are compacted to a density of 1.6 grams percubic centimeter. The mechanical method by which the composition is densified forms no part of the present invention, any suitable techniques being satisfactory, e.g., pressing with a mechanical or hydraulic press or rolling, etc.

Although various methods can be used to prepare sheets of the novel fibrous explosive composition, the method described in the examples is simple and reliable, i.e., precipitating a fibrous mass comprised of the high explosive, an elastomer, and, if desired, a fibrous material, collecting the fibrous mass on a filter to produce the desired explosive weight per unit area, drying the filter cake to a desired moisture content ("bone" dry or slightly moist to minimize springback), and compacting the fibrous mass to a desired density, e.g., by pressing with a mechanical or hydraulic press or by rolling. Although this represents a preferred method in a number of respects, the invention is not limited to this technique.

An attendant advantage of the use of water as the precipitating liquid in preparing the explosive composition of the present invention resides in the fact that the diluted organic solvent separates out of the mixture and can be removed by decantation or filtration, residual quantities of water and solvent being removed by evaporation during the drying of the mixture. In addition, there is the advantage of working the high explosive in a wet state, which is inherently safer than working with the dry form.

A thin layer of a pressure-sensitive adhesive may be applied to the surface of the finished product, e.g. the sheet, so that the sheet will adhere readily to the surface of another object. Such treatment is especially advantageous for applications where intimate contact is desired, as in metal-working processes. For example, sheets may be formed from the composition, the sheets dried, and a layer of adhesive placed on one surface of the sheet, and then a layer of crepe release paper placed upon the adhesive. When one of these sheets is to be used, the release paper is removed and the adhesive surface of the sheet pressed against the metal surface to be worked to give a strong, close bond between the sheet and metal. Such an arrangement is especially convenient, for example, in connection with the explosive austenitic steel hardening process described in U.S. Patent No. 2,703,297 to N. A. MacLeod.

Auxiliary agents such as reinforcing agents, pigments, dyes, and the like may be incorporated in the explosive compositions of this invention to the extent that the composition is not unduly impaired with respect to its density or detonation velocity.

The following examples serve to illustrate specific embodiments of the explosive composition of the present invention. However, they will be understood to be illustrative only and not as limiting the invention in any way. Unless designated otherwise, the parts in the examples are parts by weight.

EXAMPLE 1

A solution of 70 parts PETN and 30 parts of a white, translucent linear vinylidene fluoride-hexafluoropropylene copolymer containing about 65% fluorine by weight, and having a specific gravity of 1.82 and a Mooney viscosity at 212° F. of 67 (commercially available as "Viton" A) in 150 parts of acetone was poured into a beaker containing 400 parts of water with stirring. Upon mixing of the acetone solution into the water, the PETN and "Viton" were co-precipitated to form a flocculent, off-white precipitate which was filtered onto a 4½ inch diameter Büchner funnel, excess solvent removed by suction, and the filter cake dried at 100° F. The dried filter cake had a density of 0.27 gram per cubic centimeter and in appearance was an off-white fibrous mass which was strong and flexible. The sheet could be initiated by a No. 6 electric blasting cap and the velocity of detonation was 2020 meters per second. When a portion of the sheet was pressed to a density of 1.6 grams per cuibc centimeter and then initiated by a conventional No. 6

electric blasting cap, the velocity of detonation was 7260 meters per second.

EXAMPLE 2

The procedure of Example 1 was repeated with the exception that the wet precipitate on the filter cake was lightly pressed, sucked dry, and subsequently air dried at 100° F., the dry filter cake was a white fibrous sheet in which the fibers were more closely bound than the unpressed cake initially prepared in Example 1. The sheet had a density of 0.58 gram per cubic centimeter. The sheet was initiated by a No. 6 electric blasting cap and had a detonation velocity of 3815 meters per second.

EXAMPLE 3

A solution of 19.8 parts of the vinylidene fluoride-hexafluoropropylene copolymer of Example 1 and 46 parts of PETN in 198 parts of acetone was poured into a beaker containing 350 parts water with stirring. The flocculent precipitate which formed was collected on a 9¼ inch diameter Büchner funnel and the precipitate air dried at 100° F. The fibrous dry sheet was approximately 0.6 centimeter thick, weighed 0.94 gram per square inch, and had a density of 0.24 gram per cubic centimeter. When a portion of the sheet was initiated by a conventional No. 6 electric blasting cap, the velocity of detonation was 2160 meters per second. When another portion of the above cake was pressed by a hand press to a thickness of 0.1 centimeter (density, 1.4 grams/cubic centimeter) and this sheet initiated by a No. 6 electric blasing cap, the velocity of detonation was 4620 meters per second.

EXAMPLE 4

A fibrous sheet comprising a 50/50 mixture of PETN and the vinylidene fluoride-hexafluoropropylene copolymer of Example 1 was prepared by the method described in Example 1. The dry, unpressed sheet had a density of 0.26 gram per cubic centimeter and detonated at a velocity of 1560 meters per second.

EXAMPLE 5

A mixture of 80 parts PETN, 15 parts butadiene-acrylonitrile copolymer having an intermediate acrylonitrile content (approximately 25%), a specific gravity of 0.97 and a Mooney viscosity of 50–60 ("Paracril" BJ) and 5 parts cellulose acetate was dissolved in acetone, and the resulting solution was jetted through a capillary tube into a Waring Blendor containing 400 parts water revolving at low speed. The precipitate which formed was filtered onto a 4½ inch diameter Büchner funnel and the filter cake dried at 100° F. to form a sheet which weighed 1 gram per square inch and had a density of 0.22 gram per cubic centimeter. The sheet was strong and flexible and detonated at 2350 meters per second.

EXAMPLE 6

A solution of 27.8 parts of PETN and 12.85 parts of a low-temperature polymerized acrylonitrile-butadiene elastomer containing a high percentage (approximately 40%) of acrylonitrile and having a specific gravity of 1.00, Mooney viscosity of 70–95 ("Hycar" 1041) in 700 parts acetone was jetted into a suspension of 27.8 parts suerfine PETN and 5.55 parts paper pulp in 300 parts water with agitation. Upon mixing of the acetone solution into the aqueous dispersion, the PETN and "Hycar" were co-precipitated and the elastomer enmeshed the suspended material to form a flocculent off-white precipitate. The precipitate was filtered onto a Büchner funnel, excess liquid removed by suction and the filter cake lightly pressed to even the top surface, removed from the Büchner funnel, and dried at 100° F. The dry filter cake was approximately 0.165 inch in thickness, had a density of 0.38 gram per cubic centimeter and had an impact sensitiveness, as determined by the standard drop test (5-kg. weight), of greater than 30 inches (50% detonation point). In appearance, the sheets were strong and flexible and could be bent around a pipe of ½ inch radius without breaking. The sheet could be initiated by a No. 6 electric blasting cap, and the velocity of detonation was 2615 meters per second.

EXAMPLE 7

A number of compositions were prepared by the method of Example 6 from PETN, a low-temperature polymerized acrylonitrilebutadiene elastomer of Example 6 ("Hycar 1041") and the paper pulp. In these compositions the proportion of paper pulp was varied while the ratio of PETN to elastomer was maintained at 12/3.6. The following table summarizes the properties of the sheets prepared from these mixes.

Table I

Percent pulp	Percent PETN	Percent elastomer	Density (g./cc.)	Velocity of detonation
4.88	73.2	21.92	0.42	2,746
7.6	71.2	21.3	0.35	2.478
9.3	69.8	20.9	0.39	2,495
11.8	67.9	20.3	0.36	2,229
14.0	66.2	19.8	0.40	2,532
17.0	63.8	19.2	0.34	2,328
23.5	58.8	17.7	0.34	2,015
26.4	56.7	16.9	0.36	1,905
29.1	54.6	16.3	0.34	1,770
31.6	52.6	15.8	0.34	1,740
33.9	50.8	15.3	0.29	Failed
35.5	49.7	14.8	0.32	1,610
37.1	48.4	14.5	0.30	Failed

EXAMPLE 8

A fibrous composition comprising a 70/33.5/7.5 mixture of PETN/low-temperature polymerized acrylonitrile-butadiene elastomer containing 35–40% acrylonitrile ("Hycar" 1041)/paper pulp was prepared by the method of Example 6. The mixture was dried to form a sheet weighing 2 grams per square inch, having a density of 0.35 gram per cubic centimeter and a detonation velocity of 2083 meters per second. Portions of the original sheet were compressed to various predetermined densities by pressing with a hydraulic press to a thickness corresponding to the desired density. The properties of the compressed sheets formed are listed in the following table.

Table II

Density (g./cc.):	Velocity (m./sec.)
0.35 (original)	2083
0.42	2190
0.50	2220
0.58	2403
0.73	2747
0.82	3530
0.88	4120

All of these sheets could be initiated by a No. 6 cap.

EXAMPLE 9

A solution containing 24 parts PETN and 5.6 parts of a low-temperature polymerized acrylonitrile-butadiene elastomer containing 35–40% acrylonitrile ("Hycar" 1041) in 400 parts acetone was allowed to drip into a stirred suspension of 2.4 parts paper pulp in 2 liters of water. The precipitated fibrous mass was collected on a 4½ inch diameter Büchner funnel and the filter cake dried at 100° F. The fibrous sheet formed weighed 2 grams per square inch and had a density of 0.33 gram per cubic centimeter. The sheet was cut into five segments and four of these segments were compressed by using a conventional mechanical press (an Arbor press) to thicknesses corresponding to the densities shown in the following table. Each of the five segments was initiated by a No. 6 cap and the velocity of detonation measured.

Table III

Density (g./cc.):	Velocity (m./sec.)
0.33 (original)	2670
0.46	3000
0.49	3100
0.62	3500
1.15	6280

EXAMPLE 10

A solution of 2.4 parts PETN, 2.4 parts of a butadiene-acrylonitrile copolymer of Example 5 ("Paracril" BJ) and 0.8 part cellulose acetate in acetone was poured slowly into a water suspension of 0.8 part paper pulp in a Waring Blendor revolving at slow speed. The fibrous material which precipitated was filtered onto a 4½ inch diameter Büchner funnel, and the filter cake obtained was dried at 100° F. to form a sheet. The density of the dried sheet was 0.26 gram per cubic centimeter. The sheet was somewhat rigid but could be flexed slightly without breaking. This sheet was divided into two portions and tested for explosive properties. In the standard drop test (5 kg. weight), the 50% detonation point of the sheet was 44 inches. The detonation velocity of the sheet was 2480 meters per second, and the sheet could be initiated by a No. 6 cap.

EXAMPLE 11

An acetone solution of 12 parts PETN, 2.4 parts of the acrylonitrile-butadiene copolymer of Example 5 ("Paracril" BJ) and 0.8 part of a vinyl chloride-vinyl acetate copolymer was poured into an aqueous dispersion of 0.8 part paper pulp in a Waring Blendor revolving at slow speed. The fibrous precipitate was filtered onto a 4½ inch diameter Büchner funnel and dried at ambient temperature. The dried cake had a density of 0.23 gram per cubic centimeter and detonated at a velocity of 2160 meters per second.

EXAMPLE 12

An acetone solution of 2.0 parts of the acrylonitrile-butadiene copolymer of Example 5 ("Paracril" BJ) and 0.8 part cellulose acetate was jetted into an aqueous dispersion of 12 parts superfine PETN and 1.2 parts paper pulp stirred at high speed, and the fibrous precipitate formed was filtered onto a Büchner funnel and dried at ambient temperature to give a felt-like sheet which had a density of 0.39 gram per cubic centimeter. In the standard drop test (5 kg. weight), the 50% detonation point of the sheet was 6 inches. The detonation velocity of the sheet was 2670 meters per second and the sheet could be initiated by a No. 6 cap.

EXAMPLE 13

A number of mixes were prepared by the method described in Example 12 from PETN and a mixture of paper pulp, the acrylonitrile-butadiene copolymer of Example 5 ("Paracril" BJ), and cellulose acetate. In these mixes, the proportions of superfine PETN (suspended in water slurry) to PETN in acetone solution were varied as shown in the following table which summarizes the properties of the sheets prepared from these mixes.

Table IV

Mix	Suspended superfine PETN/ PETN dissolved in acetone (parts by weight)	Density (g./cc.)	Impact sensitivity (drop test in inches)	Velocity of detonation (m./sec.)
A	12/0	0.39	6	2,670
B	9/3	0.32	23	2,399
C	6/6	0.24	32	2,200
D	3/9	0.24	36	2,076

EXAMPLE 14

A number of mixes were prepared by jetting an acetone solution of PETN and the acrylonitrile-butadiene elastomer of high acrylonitrile content as described in Example 6 ("Hycar" 1041) into a water slurry of superfine PETN stirred in a Waring Blendor, collecting the precipitate on a Büchner funnel, and drying at 100° F. to remove solvent and water. In these mixes, the proportions of PETN, superfine PETN and the acrylonitrile-butadiene elastomer were varied as shown in the following table which summarizes the initial properties of the sheets prepared from these mixes and of sheets prepared by rolling a portion of the initial sheet between two rollers to compress it to a thickness corresponding to various desired densities.

Table V

Mix	Superfine PETN/ PETN/ elastomer (parts by wt.)	Initial thickness (inches)	Density (g./cc.)	Velocity of detonation (m./sec.)	Thickness after pressing (inches)	Approximate density after pressing (g./cc.)	Velocity of detonation of pressed sheet (m./sec.)	Impact sensitivity (inches), 5 kg. wt.
A	40/40/20	0.20	0.30	3,530	0.10	.60	4,680	Failed at 56.
B	35/35/30	0.15	0.38	2,820	0.075	.76	3,860	Do.
C	30/30/40	0.175	0.36	2,520	0.085	.72	3,300	Do.

All of the sheets were strong and flexible and could be initiated by No. 6 caps. However, mixtures of high elastomer content, i.e., mixes of Table V, were difficult to prepare as fibrous precipitates because of tendency to form agglomerated precipitates.

EXAMPLE 15

A slurry of 6 parts superfine PETN and 1.2 parts paper pulp in 70 parts water was mixed with an acetone solution of 6 parts PETN, 2.7 parts of the acrylonitrile/butadiene elastomer of Example 6 ("Hycar" 1041) and 1 part of a polyether plasticizer, dibutoxyethoxyethyl formal (commercially available as TP-90-B, manufactured by Thiokol Chemicals) in a Waring Blendor at slow speed. The precipitate obtained was collected on a 4½ inch Büchner funnel and dried at 100° F. The sheet prepared had a density of 0.44 gram per cubic centimeter and had an impact sensitiveness as determined by the standard drop test (5 kg. weight) of greater than 56 inches. The sheet could be initiated by a No. 6 electric blasting cap, and the velocity of detonation was 2820 meters/second. When a portion of the sheet was rolled to a density of 1.2 grams per cubic centimeter, the velocity of detonation when the sheet was initiated by a No. 6 cap was 6350 meters per second. The sheet was flexible even at temperatures as low as −15° F.

EXAMPLE 16

A solution of 30 parts PETN in 70 parts of a low-molecular weight stabilized, polymerized chloroprene having a specific gravity of 1.23 and viscosity at 122° F. of 800,000 cps. ("neoprene" FB) in 400 parts of acetone fitted into a dispersion of 12 parts paper pulp in 2000 parts of water contained in a Waring Blendor rotating at low speed forms a flocculent precipitate when collected on a 9¼ inch diameter Büchner funnel and dried at 100° F. to form a felt-like mass, a strong and flexible sheet is obtained which detonates uniformly when actuated by a No. 6 electric blasting cap.

EXAMPLE 17

In a variation of the procedures previously described and illustrated, water was added incrementally to a solution of 52.5 parts PETN and 12.25 parts of the elastomer of Example 6 in 1000 parts of acetone. Upon addition of the two 25-part portions of water, localized precipitation occurred which redissolved upon stirring. With the addition of an additional 10 parts of water the solution became turbid, whereas with the addition of another 25 part portion the elastomer precipitated as a gel and was redissolved by the addition of acetone. The solution so formed was added to 5000 parts water with agitation and the simultaneous addition of 5.25 parts paper pulp in 2000 parts water. The precipitate was collected on a 9¼ inch Büchner funnel and the filter cake dried at 100° F. The dry cake was 0.35 inch thick and weighed 1.05 grams per square inch. The density of the cake was 0.47 gram per cubic centimeter. When the sheet was initiated by a No. 6 electric blasting cap, the velocity of detonation was 3570 meters per second.

EXAMPLE 18

A solution of 52.5 parts RDX and 12.25 parts of the acrylonitrile-butadiene elastomer of Example 6 in 1000 parts acetone was jetted into a suspension of 5.25 parts paper pulp dispersed in 2000 parts of water with agitation. The precipitate was filtered onto a 9¼ inch Büchner funnel, excess liquid removed by suction and the filter cake dried at 100° F. The dry filter cake was approximately 0.12 inch in thickness, had a density of 0.52 gram per cubic centimeter and weighed 1.005 grams per square inch. The sheet was strong and flexible and detonated at 2810 meters per second when it was initiated by a No. 6 electric blasting cap.

EXAMPLE 19

A solution of 52.5 parts HMX and 12.25 parts of the elastomer of Example 6 in 2670 parts acetone was added in a small stream to 5000 parts water with stirring simultaneously with a dispersion of 5.25 parts paper pulp in 2000 parts water. The flocculent precipitate was collected on a Büchner funnel and dried at 100° F. The resulting filter cake was 0.31 cm. thick and had a density of 0.48 gram per cubic centimeter. The sheet was strong and flexible. When the sheet was initiated by a No. 6 electric blasting cap, the velocity of detonation was 3030 meters per second.

EXAMPLE 20

An acetone solution of 37.5 parts PETN, 37.5 parts of a mixture of 60 percent RDX and 40 percent TNT (commercially available as composition B), and 17.5 parts of the acrylonitrile-butadiene elastomer of Example 6 was jetted onto an aqueous dispersion of 7.5 parts paper pulp. The flocculent precipitate was collected on a Büchner funnel and dried overnight. The strong, flexible sheet weighed 1 gram per square inch, and had a density of 0.36 gram per cubic centimeter and detonated at a velocity of 2400 meters per second.

EXAMPLE 21

A solution of 52.5 parts PETN and 12.25 parts of a low temperature polymerized acrylonitrile-butadiene elastomer of Example 6 in 1000 parts acetone was dripped into 5000 parts of water with stirring. While simultaneously, a parallel stream of a suspension of 5.25 grams of unbleached kraft paper pulp in 2000 parts of water was added to the water. Approximately one-third of the flocculent precipitate formed was poured onto a 24-cm. diameter Büchner funnel, suction was applied, and the solvent removed to produce a soft solid mass. A layer of cheesecloth having a diameter approximately that of the funnel was laid on top of the mass, and one-half of the remaining flocculent-precipitate was poured on top of the cheesecloth and the solvent removed. Another layer of cheesecloth was placed on top of the partially dried mass and the remaining portion of the flocculent precipitate was poured onto the funnel. Suction was again applied to remove the solvents and the filter cake was dried at 100° F. overnight.

The dry filter cake weighed 1.06 grams per square inch, was approximately 0.177 inch in thickness and had a density of 0.37 gram per cubic centimeter. The tensile strength of the sheet was excellent. When initiated by a No. 6 electric blasting cap the sheet detonated at a velocity 2456 meters per second.

EXAMPLE 22

A solution of 70 parts PETN, 20 parts of the acrylonitrile-butadiene elastomer of Example 6, 6 parts cellulose acetate and 4 parts of ¼-inch strands of "Dacron" in 400 parts of acetone was poured into water in a Waring Blendor. The resulting precipitate was collected on a Büchner funnel and dried overnight at 100° F. The filter cake was strong and had a density of 0.215 gram per cubic centimeter and a velocity of detonation of 2480 meters per second.

Although the invention has been described in detail in the foregoing, it will be apparent to those skilled in the art that many variations in composition and procedures are possible without deviating from the spirit and scope of the invention. It is intended, therefore, to be limited only by the following claims.

I claim:

1. A fibrous, felt-like explosive compressible composition having a variable density and detonation velocity comprising about from 50 to 85% by weight of cap-sensitive, crystalline high explosive selected from the group consisting of organic nitrates and nitramines and about from 15 to 50% by weight of rubbery elastomeric polymeric binding material therefor in fibrous form, said binding material being soluble in a water-miscible solvent and chemically inert with the system.

2. A fibrous, felt-like explosive composition comprising about from 50 to 85% by weight of cap-sensitive, crystalline high explosive seleced from the group consisting of organic nitrates and nitramines and about from 15 to 50% by weight of elastomeric polymeric binding material therefor in fibrous form, said binding material being chemically inert with the system, soluble in water miscible solvent and selected from the group consisting of natural rubber, butadiene-acrylo-nitrile copolymers, vinylidene fluoride-hexafluoropropylene copolymers, chloroprene polymers and methacrylonitrile-butadiene copolymers.

3. An explosive composition of claim 2 wherein said cap-sensitive, crystalline high explosive comprises pentaerythritol tetranitrate.

4. An explosive composition of claim 2 wherein said cap-sensitive, crystalline high explosive comprises cyclotrimethylenetrinitramine.

5. A non-woven, felt-like sheet of an explosive composition of claim 2 containing additionally about from 0.5 to 30% by weight of a normally fibrous substance selected from the group consisting of natural and synthetic fibers.

6. A non-woven, felt-like sheet of claim 5 wherein said fibrous substance is paper pulp.

7. A method of preparing an explosive composition in sheet form which comprises dissolving about from 50 to 85 parts by weight of cap-sensitive, crystalline high explosive selected from the group consisting of organic nitrates and nitramines and about from 15 to 50 parts by weight of elastomeric polymeric binding material therefor in a mutual solvent miscible with water, said binding material being chemically inert with the system and selected from the group consisting of natural rubber, butadiene-acrylonitrile copolymers, vinylidene fluoride-

hexafluoropropylene copolymers, chloroprene polymers and methacrylonitrile-butadiene copolymers, dispersing the resulting solution in water to coprecipitate said explosive and elastomeric binding material as a fibrous mass, collecting the fibrous precipitate and compressing said fibrous precipitate into a sheet.

8. A method of claim 7 wherein said water contains about from 0.5 to 30% by weight of a dispersed, water-insoluble, fibrous substance selected from the group consisting of natural and synthetic fibers.

9. A method of claim 8 wherein the water contains a finely dispersed mixture of said fibrous substance and

cap-sensitive, crystalline high explosive having maximum crystallite dimensions in the range of 0.1 to 100 microns, the average thereof being within the range of 0.1 to 2 microns.

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