

[54] **EXPLOSIVE COMPOSITION CONTAINING
MONOCELLULAR THERMOPLASTIC
GLOBULES AND METHOD OF PREPARING
SAME**

[75] Inventor: **Thomas E. Slykhouse**, Midland,
Mich.

[73] Assignee: **The Dow Chemical Company**,
Midland, Mich.

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[56] **References Cited**
UNITED STATES PATENTS

3,671,342 6/1972 Slawinski 149/2

3,101,288	8/1963	Coursen et al.....	149/21
3,409,484	11/1968	Minnick.....	149/21
3,456,589	7/1969	Thomison et al.....	149/21 X
3,457,126	7/1969	Travers et al.....	149/2
3,419,444	12/1968	Minnick.....	149/2
3,409,485	11/1968	Minnick.....	149/21

Primary Examiner—Benjamin R. Padgett
Attorney—Griswold and Burdick, Bruce M. Kanuch
and Lloyd S. Jowanovitz

[57] **ABSTRACT**

A blasting agent containing a continuous phase and a plurality of discrete gas-containing globules dispersed therein is improved by incorporating into the blasting agent, as a source of such globules, hollow essentially monocellular thermoplastic particles.

14 Claims, No Drawings

EXPLOSIVE COMPOSITION CONTAINING MONOCELLULAR THERMOPLASTIC GLOBULES AND METHOD OF PREPARING SAME

BACKGROUND OF THE INVENTION

Various benefits and advantages are obtained by incorporating within explosive compositions, containing a continuous liquid and/or solid phase, minute gaseous bubbles. These gaseous bubbles presently are being incorporated into the explosive compositions by intimately mixing particulate void containing materials into the explosive composition; by whipping gaseous bubbles into the explosive composition; and/or by incorporating a gas releasing compound within the composition.

In the past both monocellular and multicellular particulate materials, composed of various clays, thermosetting plastics, foams, glass, metals and natural occurring substances such as ground corn stalks, walnut shells and the like, have been employed in explosives. For background information on the use of some of these materials, reference may be had to the following U.S. Pat. Nos.: 3,456,589; 2,671,400; 3,101,288; 3,453,158; 3,382,117 and 3,457,129.

It has now been discovered that certain unexpected beneficial results are obtained by employing essentially monocellular hollow particles composed of a thermoplastic resin as the source of gaseous-containing voids. Some of the advantages include, excellent reproducibility of desired densities from one batch of explosives to the next, better sensitivity at higher densities, greater reductions in densities with less weight per cent of particles and others.

SUMMARY OF THE INVENTION

The present invention concerns an improved explosive composition and the method for preparing the same. It has been discovered that by incorporating essentially monocellular gas filled hollow particles composed of a thermoplastic resin into an explosive composition containing a continuous phase, i.e., liquid and/or solid, improved explosive characteristics are achieved.

Explosive compositions which are improved by the practice of the present invention are those which contain a continuous liquid and/or solid phase, i.e., those commonly known in the art as slurries, liquid and cast explosives. The latter explosive is typical of the type containing a continuous solid phase. The former are illustrative of those containing a continuous liquid phase. The invention is applicable to ammonium nitrate and other inorganic oxidizing salt based explosives; explosives based on organic nitrogen containing compounds; dynamite type explosives; and various cast mixes as more fully described hereinafter.

In all of these types of explosives it is known that a certain amount of discrete, gaseous bubbles or globules are desirable to ensure ready and full propagation and detonation of the explosive and efficient release of the explosion energy. It has been found that these explosives can be improved by employing as the gas containing discrete particles, gas filled hollow essentially monocellular particles composed of a thermoplastic resin.

PREFERRED EMBODIMENTS OF THE INVENTION

Gas filled hollow monocellular thermoplastic parti-

cles which can be employed in the practice of the present invention can be prepared by methods well known in the art of manufacturing discrete hollow particles.

The gas filled hollow monocellular thermoplastic particles employed in the practice of the present invention can be prepared from any suitable thermoplastic polymer material. The particles are preferably prepared by the limited coalescence polymerization technique. This polymerization technique involves the use of a polymerizable monomer and a volatile blowing agent which has a limited solubility in the polymer. Particles of the type illustrated in FIG. 2 of Canadian Pat. No. 752,451 and prepared by the method and from polymer materials described at page 2 (lines 15-31), page 3 (lines 1-20) and from page 5, line 4 through page 12a, line 19, can be employed in the practice of the present invention. The teachings cited above are specifically incorporated herein by reference. Further, thermoplastic particles prepared in accordance with the method taught in U.S. Pat. No. 2,797,201, column 1, line 48 through column 6, line 8 and Examples 5 to 7, 11 and 12 can be used.

An illustrative technique for preparing the hollow particles involves charging a polymerization reactor with about 100 parts by weight di-ionized water and about 15 parts by weight of a 30 weight per cent colloidal silica dispersion in water. The reactor is then charged with about 2.5 parts by weight of a 10 weight per cent aqueous solution of a separately prepared copolymer of diethanolamine and adipic acid prepared from equimolar proportions by carrying out a condensation polymerization reaction to yield a polymer having a viscosity of about 100 centipoises at 25° C. The reactor is then charged with about 1 part by weight of an aqueous solution containing about 2.5 weight per cent potassium dichromate. Hydrochloric acid is then added to the aqueous solution in the reactor until a pH of 4 is reached.

An oil phase mixture is then prepared by mixing about 100 parts by weight methyl methacrylate which contains 20 weight per cent neopentane and 0.1 part by weight of benzoyl peroxide as a catalyst. The oil phase mixture is added to the water phase in the reactor with agitation supplied by a blade rotating in the reactor. The mixture is maintained in the reactor at a temperature of about 80° C for a period of about 24 hours. At the end of this period, the temperature of the reaction mass is lowered and a white, milky liquid is recovered. A portion of the reaction mixture is filtered to recover particles which are air-dried in an oven at a temperature of about 30° C. Microscopic examination of a representative number of the particles indicate that they have a diameter of between about 2 and about 10 microns. The particles are of hollow, spherical configuration and appear to contain a liquid and a small vapor space. A portion of the dried particles are then heated in an air oven to a temperature of about 150° C for a period of about 3 minutes. The heated particles have diameters which range between about two times and about five times the diameters of the particles before they are heated. The particles have a relatively thin, transparent wall and a gaseous center.

While the foregoing illustration of one technique for producing hollow synthetic thermoplastic particles which can be used in this invention, it is evident that other techniques can be employed with monomers other than methyl methacrylate. Similarly, expanding

agents other than neopentane can be used if desired. Thus, for example, a copolymer of methyl methacrylate and acrylonitrile can be used in fabricating the hollow particles. The hollow particles can also be prepared by the technique outlined above from a copolymer containing 75 per cent by weight combined vinylidene chloride and 25 per cent by weight combined acrylonitrile by employing isobutane as the blowing agent. A polymer of styrene containing up to about 40 per cent by weight combined acrylonitrile can be used to fabricate the hollow particles, if desired.

Other exemplary materials which may be employed in the practice of the present invention include a copolymer of 80 percent by weight methyl methacrylate and 20 percent by weight styrene; a copolymer of between about 10 percent and about 90 percent by weight methyl methacrylate and between about 10 percent and about 90 percent by weight ethyl acrylate; a copolymer of between about 10 percent and about 90 percent by weight methyl methacrylate and between about 10 percent and about 90 percent by weight ortho-chlorostyrene; poly(orthochlorostyrene); poly(vinylbenzyl chloride); a copolymer of between about 10 percent and about 90 percent by weight acrylonitrile and between about 10 percent and about 90 percent by weight vinylidene chloride; a copolymer of between about 10 percent and about 90 percent methyl methacrylate and between about 10 percent and about 90 percent by weight acrylonitrile; a copolymer of methyl methacrylate and para-tertiary-butylstyrene; a copolymer of methyl methacrylate and vinyl acetate; a copolymer methyl methacrylate and butyl acrylate; and the like. It is evident that any suitable thermoplastic material in addition to those enumerated above can be used if desired in the practice of the invention.

Expanded particles of vinylidene chloride acrylonitrile copolymers such as those described in Modern Plastics, August, 1969, are suitable for use in practicing the invention.

One particular type of particle which upon being expanded was found particularly effective in the practice of the present invention comprises particles having a generally spherical liquid-containing space therein, the synthetic resinous particles comprising a copolymer of from about 65 to 90 weight percent vinylidene chloride and from about 35 to 10 weight percent acrylonitrile, and beneficially a polymer of 65 to 75 weight percent vinylidene chloride and 25 to 35 weight percent acrylonitrile, the liquid being a volatile fluid foaming agent which is a non-solvent for the polymer, such a blowing agent advantageously is isobutane present from about 10 to 25 parts by weight, the particles being expandable to hollow gas-filled monocellular spheres by heating to a temperature within the range of from about 85° to 100° C. The spheres may be expanded prior to being incorporated into the explosive or in instances where the temperature at which the explosive is prepared is about equal to the blowing temperature of the particles, they may be incorporated into the explosive in an unexpanded form and expanded in situ.

In practice of the present invention, monocellular particles having a size such that a substantial portion thereof are smaller than about 200 microns in diameter can be employed. Preferably, the particles range in size from about 2 to 100 microns in diameter. It has been discovered that the smallness of the particles, i.e., smaller than 200 microns, is not critical to the practice

of the invention and even may be beneficial thereto. However, it has been found that larger particles have an undesirable affect upon some of the normally desirable characteristics of the individual explosive compositions, e.g., upon sensitivity and the like. The particles which can be employed have a particle density of less than about 0.1 gm/cc. Preferably a particle density of between about 0.05 and 0.005 gm/cc is desired.

The amount of particles which are employed depends upon the particular explosive composition employed, upon the desired density of the composition, on the propagation and detonation velocity desired and other similar characteristics. One may readily ascertain the optimal amount of these discrete particles to be employed in the individual explosive composition by merely preparing several samples of the explosive and testing the same. Normally, however, not more than about five percent by weight and preferably not more than about two percent by weight of the discrete particles are necessary.

Further, it is appreciated that some thermoplastics may not be compatible with certain explosive systems, e.g., those containing nitric acid and the like. One may readily determine the compatibility of certain thermoplastics with individual explosive compositions by providing a sample of the particles in the composition and determining the compatibility thereof. Likewise, certain particles may not be stable at the temperature required to prepare certain explosives. Again compatibility may be easily ascertained by simple experimental techniques.

Various explosives which may be improved by the practice of the present invention include, by way of example, those which are generally liquid (or a thickened or gelled liquid) such as disclosed in U.S. Pat. No. 3,419,443; those commonly described as slurry explosives such as disclosed in U.S. Pat. No. 3,307,986; cast explosives such as those disclosed in U.S. Pat. No. 3,326,734, and dynamites which can be fairly thick slurries such as those disclosed in U.S. Pat. No. 3,101,288. As indicated the blasting agents which may be improved by the practice of the present invention are those which contain a continuous phase (liquid or solid) and a plurality of discrete gaseous globules dispersed therein.

The explosive compositions may range from readily flowable mixes, i.e., those which can be poured from a container into the borehole to very stiff or hard set mixes. As indicated previously, the exact explosive composition is not critical to the practice of the present invention. It has been discovered that certain unexpected favorable results are obtained when the necessary discrete gaseous bubbles are provided in such explosive compositions by employing the thermoplastic monocellular particles as described fully herein.

Exemplary of cast or set mixes are those presently prepared by one of four general methods. "Melt" blasting agents are prepared by melting one or more inorganic oxidizing salts, or self-explosives, e.g., TNT, and while molten, adding thereto, if desired, other constituents required to make an effective blasting agent, e.g., fuels, air voids, etc., the resultant mixture thereafter being allowed to cool to solidify in shaped or cast form. Exemplary of a "melt" blasting agent is that taught in Canadian Pat. No. 803,945, issued Jan. 14, 1969. Other blasting agents falling within this class are those normally associated with military uses and include, for

example, cast mixes — both of melt, solidification and chemical reaction type, including such compositions as:

Amatol (a mixture of TNT and ammonium nitrate which is prepared by admixing the ingredients at a sufficient temperature that TNT melts to provide a semi to fluid system which can be molded, etc., Tetrytol (a mixture of Tetryl and TNT); Picrotol (a mixture of ammonium picrate and TNT); Pentolite (a mixture of PETN and TNT); Cyclotol (cyclonite and TNT); Composition B (cyclotol and one percent wax); Tritonal (TNT and aluminum flake); Torpex (cyclonite, TNT and aluminum); and Ammonal (TNT-ammonium nitrate particulate aluminum).

Another method for preparing a solidified blasting agent comprises preparing a mixture containing particulate and liquid phases and incorporating therein a setting agent which sets the mixture agent to a solid shaped or cast blasting agent. Exemplary of such a method and blasting agent is taught in U.S. Pat. No. 3,326,734.

A third method for preparing such a set or cast blasting agent is to employ a sufficient quantity of a suitable polymeric material, e.g., thermosetting resin or the like, in a liquid containing blasting agent to form an essentially solid or rigid blasting agent.

Still another method for preparing this type of blasting agent comprises saturating a suitable liquid with at least one inorganic oxidizing salt at an elevated temperature to provide a fluid or mobile system, optionally mixing other constituents into the fluid system, and cooling the mixture, whereupon reprecipitation of a portion of the dissolved salt from solution produces a solidified mass. Exemplary of such a blasting agent is taught in U.S. Pat. No. 3,390,029.

The second general class of blasting agents to which the present invention pertains are those containing an essentially continuous liquid phase (said phase may or may not be thickened or gelled). This class of explosives includes those commonly referred to as dynamites such as disclosed in U.S. Pat. No. 3,101,288, wherein the continuous liquid phase consists essentially of a liquid explosive, e.g., nitroglycerin or the like.

A major group of blasting agents having a continuous liquid phase are those commonly referred to as slurries. These blasting agents generally comprise as the continuous liquid phase an aqueous solution containing dissolved or dispersed therein, for example, an inorganic oxidizing salt, soluble or dispersible organic materials, dispersants, inhibitors, acids and the like. These blasting agents also usually contain a particulate inorganic oxidizing salt and a fuel which may be a particulate metal, a particulate or liquid carbonaceous fuel and optionally a thickening or gelling agent to render the blasting agent more water resistant, and more stable to settling of particulate materials, e.g., metals, organic

oxidizing salts, solid organic explosives (TNT), and void containing materials and the like. Slurry blasting agents are disclosed, for example, in U.S. Pat. Nos. 3,307,987; 3,264,151 and 3,462,324.

Blasting agents which are essentially liquids (or thickened or gelled liquids) are also included within the scope of the present invention. Exemplary of these blasting agents are those disclosed in, for example, U.S. Pat. Nos. 3,242,022 and 3,419,443.

The following examples will facilitate a more complete understanding of the present invention.

Example 1

In this example three slurry blasting agents were tested employing various cellular particles. The basic compositions (excluding the cellular materials) contain the constituents set forth in the following Table I.

TABLE I

Constituent	Parts by Weight in Explosive Composition		
	A	B	C
Ammonium Nitrate (ground prills)	1070	270	162.9
Sodium Nitrate (ground prills)	270	23.5	41.2
H ₂ O	300	22.5	45.7
Formamide	190	36.0	38.4
Particulate Aluminum (substantially all + 150 mesh)	270		
Thickening Agent	4	3	12.2

To samples of Composition A were added certain cellular particles dispersed in formamide.

To samples of Composition B were added varying amounts of cellular particles dispersed in ethylene glycol.

To samples of Composition C various amounts of different cellular particles were added prior to the thickening agent.

These samples are then tested in a standard lead block test employing essentially an equal volume of explosive in each test. The deformation of a different lead block upon detonation of each sample was measured. This type of test method is described, for example, in U.S. Pat. No. 3,326,734, column 4, lines 1-18.

The cellular material added to each sample, the amount added, the resulting density of the sample, the deformation of the lead block (ΔH in millimeters) and a numerical value (X) computed by dividing the deformation (ΔH) by the density of the sample is set forth in the following Table II. The numerical value X is employed to compare the performance of the different samples where the density of the comparative samples differed. Since essentially equal volumes of each sample were tested but the density of each sample varied there was more explosive (mass) in the higher density mixes. If all other things are equal one would expect a greater mass to give a greater deformation ΔH .

TABLE II

Compo- sition	Cellular additive	Percent by wt. of cellular additive	Density of com- position. gm./cc.	ΔH	X
Test number:					
1.....A	Glass balloons (1).....	2.04	1.33	24.5	18.4
2.....A	do.....	4.0	1.25	21.8	17.4
3.....A	Expanded perlite.....	2.04	1.24	30.3	24.4
4.....A	do.....	4.00	1.15	32.7	28.4
5.....A	Thermosetting resin balloons.....	2.04	1.30	25.3	19.4
6.....A	do.....	4.00	1.20	33.8	28.2
7.....A	Thermoplastic balloons.....	2.04	1.12	36.2	32.3
8.....A	do.....	4.00	0.88	25.7	29.2
9.....B	Expanded perlite.....	0.67	1.42	0.3	0.21

TABLE II—Continued

Compo- sition	Cellular additive	Percent by wt. of cellular additive	Density of com- position. gm./cc.	ΔH	X
10.....	B.....do.....	1.33	1.37	0.3	0.22
11.....	B.....do.....	2.00	1.32	0.3	0.23
12.....	B.....do.....	2.67	1.19	1.7	1.43
13.....	B.....Thermosetting resin balloons.....	0.67	1.41	0.1	0.07
14.....	B.....Thermosetting resin balloons.....	1.00	1.42	0.1	0.07
15.....	B.....do.....	2.00	1.34	0.3	0.22
16.....	B.....do.....	3.00	1.30	0.3	0.23
17.....	B.....Glass balloons (1).....	1.33	1.42	0.1	0.07
18.....	B.....do.....	2.67	1.35	0.2	0.15
19.....	B.....do.....	4.00	1.29	0.3	0.23
20.....	B.....Glass balloons (2).....	1.33	1.44	0.0	0.0
21.....	B.....do.....	2.66	1.36	0.4	0.29
22.....	B.....do.....	4.00	1.32	0.2	0.15
23.....	B.....Thermoplastic balloons.....	0.33	1.27	1.4	1.10
24.....	B.....do.....	0.50	1.20	15.9	13.2
25.....	B.....do.....	0.17	1.38	0.0	0.0
26.....	C.....Glass (2).....	1.33	1.38	0.3	0.2
27.....	C.....do.....	2.66	1.30	0.2	0.15
28.....	C.....do.....	4.00	1.29	0.2	0.15
29.....	C.....do.....	12.00	1.06	0.9	0.85
30.....	C.....Glass (1).....	1.33	1.36	0.1	0.1
31.....	C.....do.....	2.66	1.33	0.0	0.0
32.....	C.....do.....	4.00	1.26	0.1	0.1
33.....	C.....do.....	12.00	0.99	0.9	0.9
34.....	C.....Glass (3).....	1.33	1.38	0.2	0.2
35.....	C.....do.....	2.66	1.33	0.1	0.1
36.....	C.....do.....	4.00	1.28	0.3	0.3
37.....	C.....do.....	12.00	1.02	2.2	2.8
38.....	C.....Thermosetting resin.....	1.33	1.35	0.1	0.1
39.....	C.....do.....	2.66	1.27	0.1	0.1
40.....	C.....do.....	4.00	1.21	0.1	0.1
41.....	C.....do.....	10.00	0.97	0.6	0.6
42.....	C.....Expanded perlite.....	1.33	1.30	0.2	0.2
43.....	C.....do.....	2.66	1.20	0.8	0.8
44.....	C.....do.....	4.00	1.14	2.5	2.2
45.....	C.....do.....	5.33	1.00	14.6	14.6
46.....	C.....Thermoplastic resin.....	0.167	1.34	0.1	0.1
47.....	C.....do.....	0.33	1.24	1.2	1.0
48.....	C.....do.....	0.50	1.17	19.0	16.2

* The different cellular particles had the following characteristics:

Glass (1): These particles (composed of silicate glass) were essentially monocellular and had an average particle density of about 0.325 gm/cc, a bulk density of about 13 pounds/cu. ft. and a particle size such that about 90 per cent by count are between about 20 and 80 microns.

Glass (2): These particles (composed of glass) were essentially monocellular and had an average particle density of about 0.375 gm/cc, a bulk density of about 15 lb/cu. ft. and a particle size similar to Glass (1).

Glass (3): These particles were similar to Glass (1) and Glass (2) but had an average particle density of about 0.38 gm/cc and a bulk density of about 14.5 lbs/cu. ft. Thermosetting Resin: These balloons were composed of individual microscopic hollow spheres of phenolic resin. They had a size range of from about 2 microns to about 200 microns and an average particle size of about 16 microns. They have a bulk density ranging from about 7.0–9.6 lbs/cu. ft. and a particle density ranging from about 0.25 to 0.35 gm/cc. They are commercially available from Union Carbide Corporation under the trademark BAKELITE.

Expanded Perlite: This material is commercially available under the tradename Tensile No. 50 from Chemrock. It has a packed density of about 4 lbs/cu. ft. It is essentially composed of perlite rock which is heated to form a light fluffy material similar to pumice and crushed to form vitreous multicellular particles. They ranged in size from about 50 to 1,000 microns.

Thermoplastic Balloons: These balloons are composed of a copolymer containing about 75 per cent vinylidene chloride and 25 per cent acrylonitrile. There were manufactured essentially by the limited coalescence polymerization technique which was taught hereinbefore. The balloons have a particle size ranging from about 5 to about 100 microns and an average size of about

30–40 microns. They have a particle density of less than about 2 pounds per cubic foot.

The data generated in this Example illustrates several unexpected characteristics possessed by explosive compositions containing certain monocellular thermoplastic hollow particles as the source of gaseous globules.

First, in each explosive system tested in Example 1 greater X values (indicating greater power) could be obtained when compared with other hollow particles in explosives having similar density values. This means that (1) the use of thermoplastic particles allows for greater work to be achieved from a like volume of an explosive; or (2) a given amount (weight) of an explosive which contains the thermoplastic particles will give more work than the same weight of a similar explosive containing another type of particle. The practical and economic consequences of this are evident. Since explosive compositions are traditionally sold by the pound for mining purposes (e.g., open pit) there is obviously an economic advantage to be able to obtain more work from an equal weight of explosive or equal work with less explosive.

Secondly, this data illustrates that less weight per cent of the thermoplastic particles are required to give equivalent densities than the other cellular materials tested. This not only has economic significance but it also means the explosive is diluted less by the sometimes non-reactive material of construction of the cellular materials.

Example 2

An explosive composition containing the constituents as per cent by weight set forth in the following Table III is pourable from a container into a borehole without the use of pumping pressure. It is water resis-

tant and will detonate with a high order of energy release.

TABLE III

Constituent	Parts by Weight about 61
Crushed Fertilizer Grade Ammonium Nitrate	" 12
Water	" 4
Formamide	" 8
Sodium Nitrate	" 3
Ethylene Glycol	" 9
Particulate Aluminum	" .5
A Dispersant, Thickening Agent	" .25
Crosslinking Agent and Inhibitor	" 1.25 gm/cc
*Thermoplastic Balloons	" 1.25 gm/cc
Density	" 1.25 gm/cc

*These have the same characteristics as those set forth in Example 1

Example 3

To samples of a base composition similar to that of Composition C (Example 1) were added various amounts of a multicellular foamed particle made essentially of foamed polystyrene and commercially available as beads under the trademark Pelaspan. These beads ranged in size from about 700 to 400 microns and had a particle density of about 1.5 lbs/cu. ft. These beads are typical of the foamed polystyrene particles taught and claimed in U.S. Pat. No. 3,457,126. The samples were then tested as in Example 1 in a standard lead block test. The exact composition contained the following constituents as parts by weight: 66 parts ammonium nitrate, 10 parts sodium nitrate, 7 parts H₂O, 14 parts formamide, 1 part thickening agent and 2 parts propylene glycol.

The amount of foamed particles added to each sample, the resulting density, the deformation of the lead block (ΔH in millimeters) and the numerical value X are set forth in the following Table IV.

TABLE IV

Test number:	Percent by wt. of foamed particle	Density, gm./cc.	ΔH , milli- meters	X , mm./ gm./cc.
1-----	0.784	1.11	.825	.75
2-----	1.0	1.05	1.07	1.03
3-----	1.84	0.889	2.86	2.70
4-----	2.3	0.812	5.13	6.35
5-----	3.4	0.70	2.91	4.25

Compared to Test Nos. 46 to 48 of Example 1 the compositions containing thermoplastic beads demonstrated better performance.

Example 4

A metallized slurry explosive was prepared containing the following constituents as part by weight, thickener 30 parts, water 150 parts, formamide 150 parts, sodium nitrate 150 parts, aluminum (particulate) 150 parts, and crushed ammonium nitrate 580 parts. To samples of the composition were added various amounts of foamed polystyrene beads as employed in Example 3. The samples were then detonated in a standard lead block test as defined hereinbefore. The percent by weight of foamed particles present in each sample, the resulting density, the deformation of the lead block (ΔH in millimeters) and the value X are listed in the following Table V. To illustrate the unexpected advantage of the present invention, to a sample of the same base mix was added about 1 per cent by weight of monocellular thermoplastic balloons composed of methylmethacrylate resin. These particles had an average particle size of about 30 microns and a bulk density

of about 1 lb/cu. ft. The resulting mix had a density of about 1.30 gm/cc, and provided a ΔH and X value of about 17.3 mm and 13.3 respectively when detonated in the standard lead block test. The composition containing the foamed particles only approached such power when the density was lowered to at least 1.07 gm/cc, thus showing the unexpected sensitizing effect of the thermoplastic balloons. In Example 1 greater than 2 percent by weight of glass balloons had to be added to obtain a similar density.

TABLE V

Test number:	Percent by wt. of foam particles	Density	ΔH	X
1-----	1.0	1.277	3.31	2.40
2-----	2.0	1.212	2.9	2.44
3-----	3.0	1.07	16.0	15.0
4-----	4.0	1.00	17.15	17.15
5-----	5.0	0.88	16.71	19.0

Example 5

In this example an explosive was prepared containing the following constituents as parts by weight.

TABLE VI

Ammonium Nitrate	3780
Sodium Nitrate	900
Water	894
Formamide	1194
Guar Gum	135
*Thermoplastic Balloons	28.5

*Same as employed in Example 1

Specific gravity: about 1.20

This mix was detonated in a 3/4 inch inside diameter steel pipe at 60° F with a 5 gram pentolite booster. It was also detonated in a 1/2 inch diameter steel pipe with a 2 gram pentolite booster at 60° F. It has an unconfined critical diameter of about 2.4 inches at 60° F and 1.25 inches at 75° F.

The minimum amount of a pentolite booster required to initiate a 4 inch diameter by 15 inch long cylinder of the explosive at 60° F is about 10–20 grams, and at 75° F is about 5–10 grams.

Explosive compositions having characteristics similar to that described in Example 5 can be prepared containing as per cent by weight, from about 12 to 22 percent formamide, about 9 to 18 percent water, about 1 to 25 percent sodium nitrate, about 0.2 to 6.0 percent guar gum, about 0.1 to 2.0 percent of the gas containing hollow monocellular thermoplastic particles and the balance ammonium nitrate. In addition, other fuel-oxidizers systems (essentially oxygen balanced) and sensitizers (e.g., organic and/or inorganic, such as TNT, particulate metals, etc.) can be added to the basic mix.

What is claimed is:

1. In an explosive composition containing a continuous liquid or solid phase having dispersed therein a plurality of discrete gas containing hollow particles as a sensitizer and a density control agent the improvement which comprises: providing as the hollow particles hollow monocellular thermoplastic resin particles the particles being less than about 200 microns in diameter and having a particle density of less than about 0.1 gm/cc.

2. The composition as defined in claim 1 wherein the

particles are composed of a copolymer of vinylidene chloride and acrylonitrile.

3. The composition as defined in claim 1 wherein the continuous phase is a liquid.

4. The composition as defined in claim 3 wherein the normal viscosity of the continuous liquid phase is increased.

5. The composition as defined in claim 1 wherein the continuous phase is solid.

6. In an explosive composition containing a continuous liquid phase, solid particles of an inorganic oxidizing salt and a plurality of discrete gaseous globules dispersed in said continuous phase, the improvement which comprises: as the gaseous globules discrete gas containing hollow monocellular particles composed of a thermoplastic resin.

7. The composition as defined in claim 6 wherein said particles are less than about 200 microns in diameter and have a particle density of less than about 0.1 gm/cc.

8. The composition as defined in claim 7 wherein said continuous liquid phase is aqueous and said solid particles comprise an inorganic oxidizing salt.

9. The composition as defined in claim 8 wherein said solid particles include in addition a particulate oxidizable metallic fuel.

10. The composition as defined in claim 6 wherein said liquid phase is an aqueous solution, said particles comprise at least one particulate inorganic oxidizing salt and at least one particulate oxidizable metallic fuel and said thermoplastic particles are less than about 200 microns in size and have a particle density ranging from

about 0.05 to about 0.005 gm/cc.

11. In a solid explosive composition containing an essentially solid continuous phase and a plurality of discrete gaseous globules dispersed in said continuous solid phase the improvement which comprises: as said plurality of gaseous globules discrete gas containing essentially monocellular hollow particles composed of a thermoplastic resin having a size less than about 200 microns in diameter and having a particle density of less than about 0.1 gm/cc.

12. In a slurry explosive comprising a continuous aqueous phase having dispersed therein a particulate inorganic oxidizing salt at least a portion thereof comprising ammonium nitrate, and a particulate oxidizable metal fuel, said explosive also containing an effective amount of a thickening agent to stabilize the dispersed particles, and also containing a plurality of discrete gaseous globules dispersed in said continuous liquid phase, the improvement which comprises: as said gaseous globules a plurality of discrete essentially monocellular gas containing hollow particles composed of a thermoplastic resin said particles being less than about 200 microns in diameter and having a particle density of less than about 0.1 gm/cc.

13. The composition as defined in claim 12 wherein the thermoplastic resin is a copolymer of vinylidene chloride and acrylonitrile.

14. The composition as defined in claim 12 wherein the gas containing monocellular particles have a density ranging from about 0.05 to about 0.005 gm/cc.

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