The present invention is directed to an explosive composition comprising a paste comprised of hexogen and octogen and in inert binder comprised of dioctyl adipate and polyacrylate elastomer, the binder being present in an amount ranging from about 2% to about 10% by weight, where the weight of dioctyl adipate to polyacrylate of about 1:1 to about 5:1 and whereas the hexogen is present in an amount ranging from about 86% to about 92%, by weight and the octogen is present in an amount ranging from about 4% to about 6% by weight of the composition. It is also directed to the process of preparing said composition.
INSENSITIVE HEXOGEN EXPLOSIVE RELATED APPLICATIONS

[0001] This application is a Continuation-In-Part of copending U.S. application of Ser. No. 10/253,083, filed on Sep. 24, 2002.

FIELD OF THE INVENTION

[0002] The present invention relates to a new composition for the manufacture of desensitized high energy explosives, comprised of hexogen and octogen and to the process of preparing same.

BACKGROUND OF THE INVENTION

[0003] A new type of hexogen (insensitive RDX) has been found which possesses a crystal structure, which lies close to the ideal form for explosives. The shockwave sensitivity and the thermal sensitivity are lower than those of heretofore known hexogens (RDX). However, these aforementioned hexogens do not fulfill the requirements for thermal insensitivity in accordance with the technical delivery requirements of the Bundesamt für Wehrtechnik und Beschaffung (Federal Office for Defense Technology and Procurement) in Germany, TL. 1376-0800, STANAG 4170. These delivery requirements demand that an explosive, which is enclosed in a container, such as a projectile body, will not tear open or disintegrate upon being fired on or under thermal conditions such as fire or other thermal radiation. The only reactions permitted are those culminating in a steady burning of the explosive. The container cannot contain fissures under those conditions like fire or other thermal radiation. The cylindrical container must remain intact under these conditions.

[0004] The present invention solves this problem.

[0005] Accordingly, it is an object of the present invention to provide a composition for the manufacture of an insensitive explosive composition comprising predominately composition hexogen, which fulfills the abovementioned requirements.

[0006] More specifically, this composition, in a surprising manner, is overall more insensitive, and more powerful with the addition of octogen, as described herein. However, at the same time, the explosive composition is made more manageable with the inclusion of the inert binder composition defined hereinbelow.

SUMMARY OF THE PRESENT INVENTION

[0007] The present invention is directed to a composition comprised of a paste comprised of hexogen (RDX) and octogen (HMX) associated with a binder comprised of a mixture of dioctyl adipate and polycrylate elastomer in a weight ratio ranging from about 1:1 to about 5:1, respectively, said binder being present in a range of about 2 to about 10% by weight and the said hexogen being present in a range of about 86% to about 92% by weight and the octogen being present in an amount of at least about 4% and at most about 6% by weight of the composition.

[0008] The present invention is also directed to a process for the manufacture of an explosive composition comprised of hexogen and octogen in a binder system comprised of a mixture of dioctyl adipate and polycrylate elastomer said hexogen being present in an amount ranging from about 86% to 92% by weight and said octogen being present at least about 4% and at most about 6% and said binder being present in an amount ranging from about 2% to about 10% by weight, and said dioctyl adipate and polycrylate elastomer being present in a weight ratio ranging from about 1:1 to about 5:1, which process comprises

[0009] (a) forming a slurry comprised of octogen, hexogen and a binder composition comprised of dioctyl adipate and polycrylate elastomer

[0010] (b) mixing the slurry formed in (a) with a solvent comprised of a mixture of ethyl acetate and acetone in a molar ratio ranging from about 1:3 to about 3:1 under vacuum under conditions sufficient to form a paste and

[0011] (c) removing the solvent therefrom, thereby forming said composition.

DETAILED DESCRIPTION OF THE INVENTION

[0012] The present invention is directed to an explosive composition comprising a mixture of hexogen and octogen in association with a binder system comprised of dioctyl adipate and as polycrylate elastomer. The crystalline heterocyclic nitramines, e.g., hexogen and octogen, are the energetic fillers used in the composition of the present invention. They have very high energy densities and have been used in ammunitions and munitions for over fifty years. Both have been type classified and described with military specifications by virtually every country in the world. Hexogen has a higher energy density than octogen. Both are available in the form of fine powders, with different usually Gaussian distributed gram size.

[0013] As used herein, the term “hexogen” is cyclotrimethylene trinitramine (also known as RDX). The hexogen used herein is substantially pure preferably. It contains no more than about 10% by weight impurities and more preferably less than about 5% by weight impurities. It is also substantially free of octogen, that is, the octogen concentration is less than about 1% by weight of the hexogen.

[0014] The second component is octogen. The term “octogen” as employed in the present invention is understood to mean, 1,3,5,7-tetranitro-1,3,5,7-tetranitramine. This compound is also known under the name of HMX (“high melting explosive of His Majesty’s explosive”). There are four crystalline modifications of the compound, namely the orthorhombic alpha form, the monoclinic beta form, the monoclinic gamma form and the hexagonally crystallizing delta form, and all of these can be used in the composition of the present invention. However, the preferred octogen is the beta form. Further, the beta form comes in two purity grades, viz., A and B. Either grade can be used in the present composition. The most preferred is the beta HMX, class 5, which has been described in military specifications. The octogen utilized in the present composition is substantially pure. Preferably, it contains less than 10% by weight impurities and more preferably less than 5% by weight impurities. It is substantially free of hexogen, containing less than about 1% of hexogen.

[0015] The octogen in the composition of the present invention is present in at least about 4% by weight and at most about 6% by weight. Preferably, it is present within a range of about 4.5% to about 5.5% by weight.
The composition also contains an inert binder. The binder is comprised of dioctyl adipate and a polyacrylate elastomer. Preferably the polyacrylate polymer is an adhesive polyacrylate polymer. It preferably has a specific gravity of about 1.10. In addition, it exhibits a Mooney viscosity, as measured in accordance with the standard procedure of ASTM D1646, of 25-40 in Mooney linear viscosity units.

The binder is present in an amount sufficient to desensitize the hexogen and octogen. It is preferred that the composition contains from about 2% to about 10% by weight binder and more preferably from about 2% to about 8% by weight and most preferably from about 4% and about 6% by weight.

An example of the polyacrylate elastomers that is useful in the present invention include, for example, products sold under the trademark HYTEMP®, by Zeon Chemicals L.P., 4100 bells lane, Louisville, Ky. 40211. The preferred polyacrylate polymer is HYTEMP® 44.51. It is an adhesive compounding material comprised of a polyacrylate polymer. It has the following characteristics according to the manufacturer:

(a) Specific gravity of about 1.10

(b) Mooney viscosity, measured in accordance with the industry standard ASTM D1646, of 25-40 in Mooney Linear Viscosity Unit.

It is preferred that the polyacrylate elastomer is substantially pure, preferably, it contains greater than about 90% and more preferably greater than 95% acrylic polymer.

The dioctyl adipate and polyacrylate elastomer are present in the binder in an amount sufficient to solubilize the hexogen and octogen. Preferably the weight ratio of the dioctyl adipate to acrylate polymer ranges from about 1:1 to about 5:1 and more preferably from about 1:1 to about 4:1, even more preferably from about 1:1 to about 3:1 and most preferably at about 1.5:1, respectively.

The explosive composition of the present invention is prepared as follows using techniques known in the art.

The first phase of the process is to form a slurry comprised of hexogen, octogen and binder.

The hexogen and octogen are mixed together in water under conditions sufficient to form a suspension. It is preferred that the weight ratio of the hexogen to octogen ranges from about 15:1 to about 24:1 respectively. The suspension is turbid. Preferably the suspension is formed at a temperature between the ambient temperature and the boiling point of water. More preferably, the temperature ranges from about 60°C to about 80°C. and more preferably at about 70°C.

The mixture of dioctyl adipate and polyacrylate elastomer is dissolved in an inert organic solvent. The solvent used is one in which both dioctyl adipate and polyacrylate, are soluble. Moreover, the solvent does not react with either the hexogen, octogen, dioctyl adipate, or polyacrylate elastomer. Further, the solvent should have a boiling point of less than 100°C, so that it could be easily removed under vacuum. The preferred inert organic solvent is ethyl acetate. It is preferred that the weight ratio of dioctyl adipate to polyacrylate elastomer in the solvent ranges from about 1:1 to about 5:1 and more preferably at about 2:1 to about 4:1 and most preferably at about 3:1. The solvent may contain a dilute concentration of the dioctyl adipate and polyacrylate elastomer or it may be concentrated. However, the more dilute the concentration the longer it take and the more volume that is required to reach the end point when the turbidity in the water disappears, as described hereinbelow. It is preferable that the total amount of the dioctyl adipate and polyacrylate elastomer in the inert organic solvent be as concentrated as possible to minimize the amount of the solution of dioctyl adipate and polyacrylate added.

The resulting solution comprising the inert solvent, dioctyl adipate and polyacrylate elastomer is added drop wise to the aforementioned suspension until the turbidity of the water is eliminated. Preferably the solution of dioctyl adipate and polyacrylate elastomer are added sufficiently slowly such as dropwise so that the addition thereof can be stopped immediately when the turbidity is eliminated. Thereafter, the water is removed by processes known to one of ordinary skill in the art. For example, the water may be separated from the slurry by filtering the product through a filter known to one of ordinary skill in the art. Alternatively, the water may be removed by evaporation. Alternatively, the water may be removed by a combination of both.

Sufficient water is removed to form a slurry.

The slurry is then concentrated to form a paste by mixing the slurry with an inert solvent comprised of ethyl acetate and acetone in a molar ratio ranging from about 3:1 to about 1:3 and more preferably from about 2:1 to about 1:2 and most preferably at about 1:1 in an evacuated mixer under conditions sufficient to increase the viscosity and form a paste. The mixing is preferably effected at ambient temperatures to temperatures slightly above thereof, e.g., up to about 55°C. Preferably the mixing is effected at temperatures of about 30°C to about 50°C and more preferably at about 40°C. The mixing continues until a paste is formed, which preferably takes about an hour.

After the paste is formed, the solvent is removed from the composition using techniques known to one of ordinary skill in the art. Preferably, it is evaporated under vacuum at slightly elevated temperatures above ambient temperature i.e., from about 30°C to about 55°C, and more preferably at about 40°C. The evaporation preferably continues until the solvent is substantially removed. Preferably, the removal of the solvent occurs in several steps. In an embodiment, it is removed at slightly elevated temperatures ranging from about 25°C to about 55°C and more preferably at about 40°C until the partial pressure of the solvent is reduced to about 240 mbar. Then the temperature is increased to a temperature ranging from 60°C to about 70°C and the solvent system is continued to be removed until its partial pressure is less than about 1 mbar.

The use of the techniques described hereinabove in preparing the explosive composition of the present invention imparts unique characteristics and advantages to the explosive composition of the present invention that have not been realized heretofore.

The explosive composition of the present process is quite useful. The reaction at high thermal conditions resulting from the use of the composition of the present invention
is quiet and is not intense. Without wishing to be bound, it is believed that when the octogen is present in at least 4% by weight as defined herein, the octogen undergoes a phase change at a temperature of about 190°C, which temperature is less than the temperature to which the explosive composition is normally subjected. As a result, there is an increase in volume and thus a reduction of density thereof. This increase in volume loosens the cover of the container in which the explosive composition is placed and permits the gases formed to escape, resulting in a mild burning of the high explosive load only.

[0033] Other advantages are also realized by the present invention. For example, during the process of preparing the paste, there is absolutely avoided an eutectic mixture of hexogen and octogen crystals is avoided. To the contrary, throughout the process the crystals remain separate from each other as a result of the presence of the binder.

[0034] Furthermore, the density of the composition of the present invention consists of more than 98% of the TMD (Theoretical Maximum Density).

[0035] Moreover, the compacting step of the present process results in a significant savings in cost in that the compacting pressures lie at about 30%-50% below the compacting pressures normally used in preparing this explosive composition of HMX and RDX. Usually, for a load cross-section of 100 mm, in accordance with the state of the technology, there is provided a compacting pressure of 1.5 kbar. However, in accordance with the present process for that type of load diameter, there is required only a low compacting pressure, e.g., of less than about 0.5 kbar. Consequently, there is no requirement for any heavy and thereby more expensive compacting work tools. To the contrary, it is adequate to use thin-walled pressure work tools in the present process. Thus, there is no requirement for any support along the sides of the explosive charge casing.

[0036] A further advantage is also provided in that the explosive composition, which is produced in accordance with the present process, can be removed from the container in which it is stored and thereafter can again be almost completely reused, without any complicated preparation process as it is completely dissolved in the binder. This is unlike typical explosive charges comprised of hexogen used in the prior art in which during the mechanical removal of the explosive charge, the crystal structure of hexogen and octogen is destroyed.

[0037] A further advantage obtained is the reusability of the solvent and its capability for recycling. Furthermore, during the process of forming the paste, the microstructure errors along the crystal surfaces of the explosives crystals are smoothed out, thereby increasing the surface area. Also, small crystals which otherwise would adhere to the surface of the crystals are removed due to the effect of the solvent medium on the binder.

[0038] Unless indicated to the contrary, the percentages are by weight.

[0039] Moreover, it is to be understood that the singular denotes the plural and vice versa.

[0040] The above description illustrates the scope and spirit of the present invention. This description will make apparent to those skilled in the art other embodiments. These other embodiments are within the contemplation of the present invention. Therefore, the present invention should be limited only by the appended claims.

1. An explosive composition comprising a paste comprised of hexogen and octogen and an inert binder comprised of dioctyl adipate and polyacrylate elastomer, the binder being present in an amount ranging from about 2% to about 10% by weight, where the weight ratio of dioctyl adipate to polyacrylate in the binder ranges from about 1:1 to about 5:1 and whereas the hexogen is present in an amount ranging from about 86% to about 92% by weight and the octogen is present in an amount ranging from about 4% to about 6% by weight of the composition.

2. The explosive composition according to claim 1 wherein the octogen is present in an amount ranging from about 4.5% to about 5.5%.

3. The explosive composition according to claim 1 wherein the binder is present in an amount ranging from about 4% to about 6% by weight of the composition.

4. The explosive composition according to claim 1 wherein the binder is present in an amount ranging from about 4% to about 6% by weight of the composition.

5. The explosive composition according to claim 4 wherein said weight ratio of dioctyl adipate to polyacrylate ranges from about 1:1 to about 3:1.

6. The explosive composition according to claim 5 wherein the weight ratio of dioctyl adipate to polyacrylate is about 1.5:1.

7. A process for the preparation of the explosive composition of claim 1 which comprises:

(a) forming a slurry comprised of octogen, hexogen and binder comprised of dioctyl adipate and polyacrylate elastomer,

(b) mixing the slurry formed in (a) with a solvent comprised of a mixture of ethyl acetate and acetone in a molar ratio ranging from about 1:3 to about 3:1 in a vacuum under conditions sufficient to form a paste and

(c) removing the solvent therefrom, thereby forming said explosive composition.

8. The process according to claim 7 wherein the solvent is removed by evaporation while stirring the paste.

9. The process according to claim 7 wherein the slurry is prepared by mixing the octogen and hexogen in water until it becomes a suspension;

(b) adding the binder to the product of (a) in an inert solvent in amount sufficient to cause the turbidity of the water to disappear; and

(c) removing the water.

10. The process according to claim 7 wherein the solvent is removed by heating the product of (b) at about 40°C under vacuum until the partial pressure of the solvent is reduced to about 240 mbar and then removing the remaining solvent by raising the temperature to a range of about 60°C to about 110°C under vacuum until the partial pressure of the solvent present is less than about 1 mbar.

11. The process according to claim 7 wherein the octogen is present in an amount ranging from about 4.5% to about 5.5% by weight of the composition.

12. The process according to claim 7 wherein the binder is present in an amount ranging from about 4% to about 6% by weight of the composition.
13. The process according to claim 7 wherein the weight ratio of dioctyl adipate to polyacrylate elastomer in the binder ranges from about 1:1 to about 4:1.

14. The process according to claim 13 wherein said weight ratio of dioctyl adipate to polyacrylate elastomer ranges from about 3:1.

15. The process according to claim 14 wherein the weight ratio of dioctyl adipate to polyacrylate elastomer is about 1.5:1.