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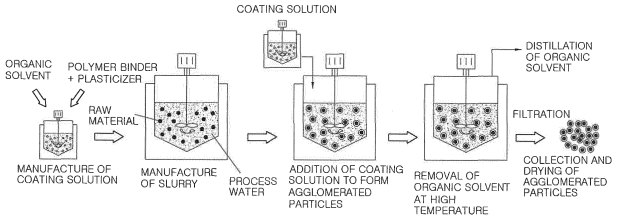
(54) METHOD FOR MANUFACTURING COMPRESSED COMPOSITE GUNPOWDER USING POLYMER EMULSION, AND COMPRESSED COMPOSITE GUNPOWDER MANUFACTURED THEREBY

(57) Disclosed is a method of manufacturing a press polymer-bonded explosive, in which a polymer emulsion is used to maximize the efficiency of a process, and a press polymer-bonded explosive manufactured using the same. The method includes a polymer-emulsion-manufacturing step of mixing a monomer of a polymer binder and an emulsifier with a process water and then adding an initiator to thus manufacture a polymer emulsion using a polymerization reaction, a slurry-manufacturing step of mixing a raw material including an explosive and an emulsion breaker with fresh process water to thus manufacture a slurry, an agglomerated-particle-forming step of adding the manufactured polymer emulsion to the manufactured slurry to thus form agglomerated particles in which a surface of the raw material is coated with the polymer binder, and an agglomerated-particle-obtaining step of collecting the agglomerated particles using filtration and drying the collected agglomerated particles.

FIG.1



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Description

BACKGROUND OF THE INVENTION

1. Technical Field

[0001] The present invention relates to a press polymer-bonded explosive and, more particularly, to a method of manufacturing a press polymer-bonded explosive, in which a polymer emulsion is used to maximize the efficiency of a process, and a press polymer-bonded explosive manufactured using the same.

2. Description of the Related Art

[0002] Explosions of explosives cause extensive loss of life and tremendous property damage once they occur because there is no time to evacuate. For this reason, there has been a need for an insensitive explosive, which is an explosive not causing an explosion reaction in response to unexpected external stimuli such as heat and shocks, and the demand thereof has also increased. Therefore, studies have been made on the manufacture of a polymer-bonded explosive in which a raw material explosive is desensitized or in which explosive particles are coated with a polymer binder to reduce sensitivity.

[0003] Of the various types of polymer-bonded explosives, a press polymer-bonded explosive (hereinafter, also referred to as pressable polymer-bonded explosive or Press-PBXs or P-PBXs) is a granular powder polymer-bonded explosive manufactured by adding a solvent, containing a polymer binder dissolved therein, to a suspension in which explosive particles are dispersed in water, thus agglomerating the explosive particles and the polymer binder. The press polymer-bonded explosive is compression molded to be used as a main charge or a booster charge for a weapon system. Moreover, the press polymer-bonded explosive is mainly applied to ammunition and warheads which require the fragmentation performance and the jet performance of a shaped charge, because the content ratio of the explosive particles is the highest.

[0004] Generally, such a press polymer-bonded explosive is manufactured by applying a water-slurry (hereinafter, also referred to as WS) process. The WS process includes adding a coating solution, in which a plasticizer and a polymer binder are dissolved in an organic solvent, to a suspension, in which raw materials containing explosive particles are dispersed and agitated in water at a temperature of about 60°C, to thus perform coating and agglomeration of the raw materials, and then removing the organic solvent using distillation at a high temperature of about 100°C or more, thereby ultimately obtaining a granular powder (molding powder) of a press polymer-bonded explosive.

[0005] However, the WS process is disadvantageous in that a distillation process at a high temperature of 100°C or more is inevitable for removing the organic solvent after coating and agglomeration of the raw materials. Moreover, there is a danger in terms of handling safety of the organic solvent, as well as the problem of environmental harm.

[0006] The above-mentioned background arts are intended to aid understanding of the background of the invention, and may include matters other than conventional technologies previously known to those skilled in the art.

SUMMARY OF THE INVENTION

[0007] Accordingly, the present invention has been made keeping in mind the above problems encountered in the related art, and it is an object of the present invention to provide a method of manufacturing a press polymer-bonded explosive, in which a polymer emulsion is used instead of an organic solvent to maximize the efficiency of a process, and a press polymer-bonded explosive manufactured using the same.

[0008] In order to accomplish the above object, the present invention provides a method of manufacturing a press polymer-bonded explosive using a polymer emulsion. The method includes a polymer-emulsion-manufacturing step of mixing a monomer of a polymer binder and an emulsifier with process water and then adding an initiator to thus manufacture a polymer emulsion using a polymerization reaction (S110), a slurry-manufacturing step of mixing a raw material including an explosive and an emulsion breaker with fresh process water to thus manufacture a slurry (S120), an agglomerated-particle-forming step of adding the manufactured polymer emulsion to the manufactured slurry to thus form agglomerated particles in which a surface of the raw material is coated with the polymer binder (S130), and an agglomerated-particle-obtaining step of collecting the agglomerated particles using filtration and drying the collected agglomerated particles (S140).

[0009] Further, during the polymer-emulsion-manufacturing step (S110), the monomer forms the polymer binder of one or more among a styrene butadiene rubber (SBR), neoprene, a nitrile butadiene rubber (NBR), an acrylic rubber, a fluorine-based rubber, and polyisobutylene using the polymerization reaction.

[0010] Further, during the polymer-emulsion-manufacturing step (S110), the emulsifier is one or more among sodium dodecyl sulfonate (SDS), sodium dodecyl benzene sulfonate (SDBS), sodium dioctyl sulfosuccinate, acetyl dimethyl

benzyl ammonium chloride, and hexadecyl trimethyl ammonium bromide.

[0011] Further, during the polymer-emulsion-manufacturing step (S110), the emulsifier is added in an amount of 0.1 to 5 wt% based on a weight of the process water.

[0012] Further, during the slurry-manufacturing step (S120), the explosive is one or more among trimethylenetrinitroamine (RDX), tetramethylenetetranitroamine (HMX), and hexanitrohexaazaisowurtzitane (HNIW), and is dispersed in an amount of 5 to 30 wt% based on a weight of the process water.

[0013] Further, during the slurry-manufacturing step (S120), the emulsion breaker is one or more among calcium chloride (calcium dichloride), sodium chloride, potassium chloride, magnesium chloride, sodium nitrate, sodium carbonate, sodium iodide, and potassium iodide as an inorganic salt.

[0014] Further, during the slurry-manufacturing step (SI20), the raw material further includes one or more metals among aluminum, magnesium, and boron.

[0015] Further, the method further includes, after the agglomerated-particle-forming step (S130), a process-water-exchanging step of collecting the agglomerated particles using filtration and adding again the collected agglomerated particles to new process water (S131), and a plasticizer addition step of adding a plasticizer, thus agglomerating the agglomerated particles and the plasticizer (S132).

[0016] Further, during the plasticizer addition step (S132), the plasticizer is one or more among dioctyl adipate (DOA), dioctyl sebacate, dioctyl phthalate (DOP), and isododecyl pelargonate (IDP).

[0017] In addition, a press polymer-bonded explosive of the present invention manufactured using the above-described manufacturing method includes 50 to 98 wt% of an explosive, 0 to 40 wt% of a metal, 0.5 to 5 wt% of a polymer binder, and 0 to 10 wt% of a plasticizer.

[0018] In the present invention, since a polymer emulsion is used instead of an organic solvent, a distillation process at a high temperature of 100°C or more is not required. Accordingly, the manufacturing time is shortened to thus reduce costs, thereby maximizing the efficiency of the process.

[0019] Further, since the process of distilling the organic solvent is not required, there is no need to allocate dead volume in a reactor, which corresponds to about 1/2 of the total volume of the reactor, to prevent the slurry from overflowing when the organic solvent is distilled. Therefore, the production amount per reactor is increased by about 200%. As a result, the production amount per unit time and per reactor is increased by about 1000%.

[0020] Moreover, since an organic solvent is not used, safety and eco-friendliness of the process are high.

[0021] In addition, since energy metal particles (aluminum, magnesium, and boron), which have not been used as the composition of the polymer-bonded explosive due to a hydration reaction with water at a high distillation temperature, are capable of being used, it is possible to greatly improve the explosion energy of the press polymer-bonded explosive that is ultimately manufactured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

FIG. 1 is a mimetic diagram showing a conventional method of manufacturing a press polymer-bonded explosive;
FIG. 2 is a flowchart showing a method of manufacturing a press polymer-bonded explosive according to the present invention;
FIG. 3 is a mimetic diagram showing the method of manufacturing the press polymer-bonded explosive according to the present invention;
FIGS. 4 and 5 show the SEM results of agglomerated particles manufactured using the conventional method of manufacturing the press polymer-bonded explosive; and
FIGS. 6 and 7 show the SEM results of agglomerated particles manufactured using the method of manufacturing the press polymer-bonded explosive according to the present invention.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

[0023] The technical terms used in the present specification should be interpreted in a sense generally understood by those skilled in the art to which the present invention belongs, and should not be construed in an overly broad sense or an overly narrow sense, unless defined otherwise in the present invention. In addition, the general terms used in the present invention should be interpreted according to definitions in a dictionary or according to the context.

[0024] Further, the singular forms used in the present specification include plural referents unless the context clearly dictates otherwise. That is, the terms 'constituting', 'comprising', or 'including', as used herein, should not be construed as necessarily including the various elements or steps described in the specification, but it is to be understood that some components or some steps may not be included, or that additional components or steps may be included therein.

[0025] FIG. 1 is a mimetic diagram showing a conventional method of manufacturing a press polymer-bonded explosive.

As shown in FIG. 1, the press polymer-bonded explosive is manufactured according to a WS (water-slurry) process using a coating solution manufactured by mixing a polymer binder and a plasticizer with an organic solvent. However, the WS process is disadvantageous in that a distillation process at a high temperature of 100°C or more is inevitable for removing the organic solvent after coating and agglomeration of raw materials. Moreover, there is a danger in terms of handling safety of the organic solvent, as well as the problem of environmental harm. Further, the use of metal particles, which contribute to improvement of the explosion energy of the polymer-bonded explosive, is limited because the hydration reaction of metal is accelerated at high temperatures.

[0026] Accordingly, the present invention is directed to solve the above-described problems, and relates to a method of manufacturing a press polymer-bonded explosive, in which a polymer emulsion is used instead of an organic solvent to maximize the efficiency of a process, and a press polymer-bonded explosive manufactured using the same.

[0027] FIG. 2 is a flowchart showing a method of manufacturing a press polymer-bonded explosive according to the present invention, and FIG. 3 is a mimetic diagram showing the method of manufacturing the press polymer-bonded explosive according to the present invention. Hereinafter, the present invention will be described with reference to FIGS. 2 and 3.

[0028] As shown in FIG. 2, the present invention includes, in sequence, a polymer-emulsion-manufacturing step of adding a monomer of a polymer binder and an emulsifier to process water, mixing them, and then adding an initiator to thus manufacture a polymer emulsion using a polymerization reaction (S110), a slurry-manufacturing step of dispersing a raw material including an explosive and an emulsion breaker in fresh process water to thus manufacture a slurry (S120), an agglomerated-particle-forming step of adding the manufactured polymer emulsion to the manufactured slurry to thus form agglomerated particles in which the surface of the raw material is coated with the polymer binder (S130), and an agglomerated-particle-obtaining step of collecting the agglomerated particles using filtration and drying the collected agglomerated particles (S140).

[0029] In addition, the present invention further includes, after the agglomerated-particle-forming step (S130), a process-water-exchanging step of filtering the slurry, in which the agglomerated particles are formed, to thus collect the agglomerated particles and re-dispersing the collected agglomerated particles in new process water (S131), and a plasticizer addition step of adding a plasticizer and performing mixing (S132).

[0030] Hereinafter, each step will be described in more detail.

[0031] The polymer-emulsion-manufacturing step (S110) is a step of manufacturing a water-based polymer emulsion in which the polymer binder is surrounded by the emulsifier in the process water. In this step, first, the emulsifier at a critical micelle concentration (CMC) or higher and the monomer of the polymer binder are added to the process water, followed by mixing, thus arranging the emulsifier to form a micelle structure. The monomer of the polymer binder is present in the micelle.

[0032] Thereafter, the initiator is added to thus cause a polymerization reaction of the monomer, and the polymer binder is formed using the polymerization reaction. In addition, the water-based polymer emulsion in which the polymer binder is surrounded by the emulsifier in the process water is ultimately manufactured.

[0033] The polymer binder is applied on the surface of the explosive particle during the agglomerated-particle-forming step (S130). As described above, the polymer binder is formed using the polymerization reaction of the monomer, and is preferably one or more among a styrene butadiene rubber (SBR), neoprene, a nitrile butadiene rubber (NBR), an acrylic rubber, a fluorine-based rubber, and polyisobutylene.

[0034] Accordingly, the monomer of the polymer binder is preferably a monomer which is capable of forming one or more polymer binders among a styrene butadiene rubber (SBR), neoprene, a nitrile butadiene rubber (NBR), an acrylic rubber, a fluorine-based rubber, and polyisobutylene using the polymerization reaction. It is preferable to add the monomer of the polymer binder in an amount of 10 to 50 wt% based on the weight of the process water.

[0035] In addition, the emulsifier is added in order to manufacture the polymer emulsion in which the polymer binder is surrounded by the emulsifier. Preferably, the emulsifier is one or more among an anionic emulsifier, including sodium dodecyl sulfonate (SDS), sodium dodecyl benzene sulfonate (SDBS), and sodium dioctyl sulfosuccinate, and a cationic emulsifier, including acetyl dimethyl benzyl ammonium chloride and hexadecyl trimethyl ammonium bromide.

[0036] It is preferable to add the emulsifier in an amount of 0.1 to 5 wt% based on the weight of the process water. The reason for this is based on the following. When the amount of the emulsifier is less than 0.1 wt%, since a micelle structure is not formed, the monomer of the polymer binder cannot be polymerized. As a result, the polymer emulsion is not manufactured. When the amount of the emulsifier is more than 5 wt%, the emulsifier is expressed in a complicated nanostructure rather than a micelle structure, which hinders the formation of a spherical polymer emulsion.

[0037] The initiator is added to initiate the polymerization reaction of the monomer, and is preferably one or more among potassium persulfate, sodium persulfate, ammonium persulfate, and hydrogen peroxide, but is not particularly limited thereto.

[0038] In addition to the initiator, a cross-linking agent such as divinyl benzene (DVB) or a chain transfer agent such as tetra-dodecylmercaptan (tert-dodecylmercaptan) may be added during the polymerization reaction, and the amount thereof is preferably less than 1% of the molar ratio of the monomer of the polymer binder.

[0039] The slurry-manufacturing step (S120) is a step of manufacturing a slurry in which an explosive is dispersed, and the raw material containing the explosive is added to the process water and then sufficiently dispersed, thus manufacturing the slurry.

[0040] The explosive is preferably one or more among trimethylenetrinitroamine (RDX), tetramethylenetetranitroamine (HMX), and hexanitrohexaazaisowurtzitane (HNIW), and is preferably added in an amount of 5 to 30 wt% based on the weight of the process water.

[0041] The reason for this is based on the following. When the amount of the explosive is less than 5 wt%, since the amount (yield) of the ultimately obtained agglomerated particles is very small, the efficiency of the process is reduced. When the amount of the explosive is more than 30 wt%, since the concentration of the slurry is high, it is difficult to sufficiently disperse the raw material in the process water, so great agglomeration of the explosive particles may occur.

[0042] Meanwhile, the explosive and a metal in a powder state may be further included in the raw material, and the metal is preferably one or more among aluminum, magnesium, and boron, which are energy metals capable of improving the explosion performance of the press polymer-bonded explosive that is ultimately manufactured.

[0043] In addition, the slurry is manufactured by mixing a raw material (an explosive or an explosive and a metal) and an emulsion breaker (or a demulsifier), and the emulsion breaker serves to precipitate the polymer binder emulsified by the emulsifier in the polymer emulsion that is added during the agglomerated-particle-forming step (S130).

[0044] The emulsion breaker is preferably one or more among calcium chloride (calcium dichloride, $CaCl_2$), sodium chloride (NaCl), potassium chloride (KCl), magnesium chloride ($MgCl_2$), sodium nitrate ($NaNO_3$), sodium carbonate ($NaCO_3$), sodium iodide (NaI), and potassium iodide (KI) as an inorganic salt.

[0045] In addition, preferably, the emulsion breaker is sufficiently added in such an amount as to be able to precipitate the entire amount of the polymer binder emulsified in the polymer emulsion added during the agglomerated-particle-forming step (S130). More specifically, the emulsion breaker may be added in an amount equal to or greater than the weight of the polymer binder contained in the polymer emulsion.

[0046] The reason for this is that, when the polymer binder that is not be precipitated is present in a large amount, a raw material (an explosive or an explosive and a metal) that is not coated with the polymer binder may be present. In addition, the emulsion breaker has no effect on the manufacturing process because it is removed during the process-water-exchanging step (S131), even when a large amount of the emulsion breaker has been added.

[0047] Meanwhile, during the slurry-manufacturing step (S120), a dispersant such as IPA (isopropyl alcohol) may be added, or a dispersing device such as a sonicator may be used for a predetermined time, so that a raw material (an explosive or an explosive and a metal) is sufficiently dispersed in the process water.

[0048] Further, in consideration of the characteristics of the metal, which accelerates a hydration reaction with a heat-sensitive explosive at high temperatures, the slurry-manufacturing step (S120) is preferably performed at room temperature. More specifically, the slurry-manufacturing step (S120) is preferably performed at a temperature of 20 to 40°C.

[0049] The agglomerated-particle-forming step (S130) is a step of forming agglomerated particles in which the surface of the raw material, that is, the explosive or the explosive and the metal, is coated with the polymer binder and agglomerated therewith. The polymer emulsion manufactured during the polymer-emulsion-manufacturing step (S110) is added in a predetermined amount to the slurry manufactured during the slurry-manufacturing step (S120) and is agitated. In consideration of the characteristics of the metal, which accelerates a hydration reaction with a heat-sensitive explosive at high temperatures, the agglomerated-particle-forming step is preferably performed at room temperature. More specifically, the agglomerated-particle-forming step is preferably performed at a temperature of 20 to 40°C.

[0050] When the polymer emulsion containing the polymer binder emulsified by the emulsifier is added to the slurry containing the raw material (the explosive or the explosive and the metal) and the emulsion breaker, the polymer binder emulsified by the emulsifier is precipitated due to the emulsion breaker, and the precipitated polymer binder is applied on the surface of the explosive or the explosive and the metal and agglomerated therewith, thus forming the agglomerated particles.

[0051] The weight of the polymer emulsion added to the slurry is preferably adjusted depending on the chemical composition of the agglomerated particles ultimately obtained during the subsequent agglomerated-particle-obtaining step (S140). More specifically, it is preferable to determine the addition amount depending on the weight percentage of the polymer binder, which is to be included, based on the total weight of the agglomerated particles that are ultimately obtained.

[0052] In this connection, in the present invention, the agglomerated particles manufactured using the manufacturing method of the present invention preferably include 50 to 98 wt% of the explosive, 0 to 40 wt% of the metal, and 0.5 to 5 wt% of the polymer binder based on the total weight of agglomerated particles. The reason for this is based on the following. When the amount of the polymer binder is less than 0.5 wt%, since explosive particles that are not coated with the polymer binder and not agglomerated are present in a large amount, they may be susceptible to unexpected external stimuli such as heat and impact. When the amount of the polymer binder is more than 5 wt%, the physical properties of the polymer-bonded explosive may be reduced.

[0053] Therefore, the weight of the polymer emulsion added to the slurry during the agglomerated-particle-forming

step (S130) is calculated so that the agglomerated particles ultimately obtained include 0.5 to 5 wt% of the polymer binder based on the total weight of agglomerated particles, in consideration of the weights of the explosive and the metal used during the manufacture of the slurry (S120) and the weight of the polymer binder precipitated by the emulsion breaker, and the polymer emulsion is then added.

[0054] Meanwhile, during the agglomerated-particle-forming step (S130), the slurry may be aged for a predetermined time after the agglomerated particles are formed, thus adjusting the size and the shape of the agglomerated particles. During the aging process, the agglomerated particles are coated with the polymer binder and are agglomerated to gradually grow. The aging time may be about 10 minutes or more, but is not limited thereto, and may be adjusted depending on the desired size and shape of the agglomerated particles.

[0055] Meanwhile, after the agglomerated-particle-forming step (S130), a process-water-exchanging step (S131) is performed, in which the slurry having the agglomerated particles formed therein is filtered using a filtration apparatus to thus collect the agglomerated particles and the collected agglomerated particles are added again to new process water.

[0056] Thereby, residues such as inorganic salts formed by the emulsifier and the emulsion breaker remaining in the slurry may be removed, so that the agglomerated particles ultimately obtained during the agglomerated-particle-obtaining step (S140) can be free from impurities.

[0057] Meanwhile, after the process-water-exchanging step (S131), a plasticizer addition step (S132) is performed, in which a plasticizer is added to the process water containing the agglomerated particles added again thereto and is then mixed so that the plasticizer is agglomerated with the agglomerated particles. The plasticizer is preferably one or more among dioctyl adipate (DOA), dioctyl sebacate, dioctyl phthalate (DOP), and isododecyl pelargonate (IDP).

[0058] The weight of the added plasticizer is preferably adjusted depending on the chemical composition of the agglomerated particles ultimately obtained during the subsequent agglomerated-particle-obtaining step (S140). More specifically, it is preferable to determine the addition amount depending on the weight percentage of the plasticizer, which is to be included, based on the total weight of the agglomerated particles that is ultimately obtained.

[0059] In this connection, in the present invention, the agglomerated particles manufactured using the manufacturing method of the present invention preferably include 50 to 98 wt% of the explosive, 0 to 40 wt% of the metal, 0.5 to 5 wt% of the polymer binder, and 0 to 10 wt% of the plasticizer based on the total weight of agglomerated particles. The reason for this is that when the amount of the plasticizer is more than 10 wt%, the physical properties of the polymer-bonded explosive may be deteriorated.

[0060] Therefore, the weight of the plasticizer added during the plasticizer addition step (S132) is calculated so that the agglomerated particles ultimately obtained include 0 to 10 wt% of the plasticizer based on the total weight of agglomerated particles, in consideration of the weights of the explosive and the metal used during the manufacture of the slurry (S120), and the plasticizer is then added.

[0061] Meanwhile, after the plasticizer addition step (S132), filtration is performed using a filtration apparatus to thus collect the agglomerated particles, and the collected agglomerated particles are placed in an oven capable of circulating air and are dried so as to have a water content of about 0.5% or less, thereby obtaining final agglomerated particles (S140).

[0062] The agglomerated particles that are ultimately obtained include 50 to 98 wt% of the explosive, 0 to 40 wt% of the metal, 0.5 to 5 wt% of the polymer binder, and 0 to 10 wt% of the plasticizer based on the total weight of agglomerated particles. The agglomerated particles are compression molded, thus manufacturing a press polymer-bonded explosive. In addition, the press polymer-bonded explosive manufactured according to the present invention has the same chemical composition as the chemical composition of the agglomerated particles.

[0063] Hereinafter, the present invention will be described in more detail with reference to a Comparative Example and an Example. However, the following Comparative Example and Example are for illustrative purposes only and are not intended to limit the scope of the present invention.

Comparative Example

[0064] 26 g of an acrylic rubber (HYTEMP), which was a commercial polymer binder, and 78 g of dioctyl adipate (DOA), which was a plasticizer, were added to 520 g of ethyl acetate, which was an organic solvent, and were sufficiently dissolved at a temperature of 60°C for about 2 to 8 hours, thus manufacturing a coating solution. Thereafter, 1196 g of RDX (Hanwha Co., Ltd.) was added to 6500 g of a process water in a 25-liter reactor, and was agitated and dispersed at a temperature of 60°C for 10 minutes, thus manufacturing a slurry. Thereafter, the manufactured coating solution was added to the manufactured slurry to thus form agglomerated particles. Then, aging was performed for about 10 minutes, enabling the agglomerated particles to grow. Thereafter, 3120 g of the process water was added, thus terminating the growth of the agglomerated particles. After heating to about 100°C, the temperature was maintained for about 30 to 50 minutes, thus removing the organic solvent by distillation. Thereafter, 1300 g of agglomerated particles was ultimately obtained using filtration and drying processes.

Example

[0065] 1.24 g (0.0043 mol) of sodium dodecyl sulfonate, which was an emulsifier, 156 g (1.217 mol) of butyl acrylate, which was a monomer of a polymer binder, and 52 g (0.52 mol) of ethyl acrylate were added to 800 g of a process water on the basis of a 25-liter batch, and were agitated for 1 hour. Thereafter, 0.52 g (0.0019 mol) of potassium persulfate, which was an initiator, was added at a temperature of about 80 to 90°C, and a polymerization reaction was then performed at a temperature of 75°C for 5 to 10 hours, thus manufacturing a polymer emulsion (S110). Thereafter, 3600 g of RDX (Hanwha Co., Ltd.) and 80 g of calcium chloride ($CaCl_2$), which was an emulsion breaker, were added to 20000 g of process water in a 25-liter reactor, and were agitated at a temperature of 25°C for 10 minutes, thus manufacturing a slurry. Thereafter, 400 g of the manufactured polymer emulsion (the amount of the included polymer binder was 80 g) was added to the manufactured slurry to thus form agglomerated particles. Then, aging was performed for about 10 minutes, enabling the agglomerated particles to grow. Thereafter, the agglomerated particles were collected by filtration, and the collected agglomerated particles were added again to new process water, thus removing the residue. Thereafter, 240 g of dioctyl adipate (DOA), which was a plasticizer, was added and agitated. Thereafter, 4000 g of agglomerated particles were ultimately obtained using filtration and drying processes.

[Table 1]

	Explosive (RDX)	Polymer binder	Plasticizer (DOA)
Composition (wt%)	92.10 wt%	1.96 wt%	5.94 wt%

[0066] Table 1 shows the result obtained by confirming the composition using a weight difference before and after extraction, after the agglomerated particles manufactured in the Example are dissolved in hexane, which is a solvent for dissolving dioctyl adipate, which is the plasticizer, and in acetone, which is a solvent for dissolving RDX, which is the explosive, followed by extraction. The final residue after the extraction of dioctyl adipate and RDX has the composition of the polymer binder.

[Table 2]

Manufacturing method	Sensitivity			
	Impact [J]	Friction [Kg•f]	Static electricity [J]	Shock [kbar]
Comparative Example	40.18	26.80	>25	38.16 sheets (150.38 kbar)
Example	38.73	26.92	>25	37.90 sheets (151.88 kbar)

[0067] Table 2 shows the results of the sensitivity tests of impact, friction, static electricity, and shock of the agglomerated particles manufactured in the Comparative Example and the Example. FIGS. 4 and 5 show the SEM results of the agglomerated particles manufactured using the conventional method of manufacturing the press polymer-bonded explosive, and FIGS. 6 and 7 show the SEM results of the agglomerated particles manufactured using the method of manufacturing the press polymer-bonded explosive according to the present invention.

[0068] In the impact sensitivity test, the weight was allowed to free-fall while the weight and height thereof were changed to measure the energy when an explosion reaction of a sample occurred with a probability of 50%. In the friction sensitivity test, the weight of the weight provided on the equidistant groove formed in a long lever and the position of the equidistant groove were changed to measure the energy when the explosion reaction of a sample fastened to the front bottom of the long lever occurred at a probability of 50%. In the static-electricity sensitivity test, electrical energy was applied to measure whether or not the sample reacted. In the shock sensitivity test, an attenuator (gap) was placed between a shock pressure source (a donor explosive) and the sample, and the shock pressure source was detonated to measure the thickness of the attenuator when the explosion reaction of the sample occurred with a probability of 50%.

[0069] As seen from Table 2 and FIG. 4, the impact sensitivity, friction sensitivity, static-electricity sensitivity, shock sensitivity and shape of the agglomerated particles manufactured according to the manufacturing method of the present invention are almost the same as those of the agglomerated particles manufactured according to a conventional manufacturing method using an organic solvent. This result shows that the manufacturing method of the present invention has the excellent efficiency of a process from the aspects of time, costs, and production amounts (agglomerated particles weighing about three times or more are obtained based on the same volume of reactor (25 liters)) and that even the agglomerated particles having the same characteristics can be manufactured.

[0070] In the method of manufacturing the press polymer-bonded explosive using the polymer emulsion and the press polymer-bonded explosive manufactured using the same, which are the present invention, the polymer emulsion is used

instead of the organic solvent, which maximizes the efficiency of a process from the aspects of time, costs, and production amounts. Moreover, since an organic solvent is not used, safety and eco-friendliness of the process are secured.

[0071] The embodiments of a method of manufacturing a press polymer-bonded explosive using a polymer emulsion and a press polymer-bonded explosive manufactured using the same, which are the present invention, are only preferable embodiments provided so that the present invention can be easily carried out by those skilled in the art to which the present invention belongs, but are not limited to the disclosed Examples and the accompanying drawings, and thus the scope of the present invention is not limited thereto. Accordingly, the true scope of the present invention should be determined by the technical idea of the appended claims. It will be apparent to those skilled in the art that various substitutions, modifications, and variations are possible without departing from the technical idea of the present invention, and it is obvious that those parts easily changeable by those skilled in the art are included in the scope of the present invention.

Claims

1. A method of manufacturing a compressed composite gunpowder using a polymer emulsion, the method comprising:

   a polymer-emulsion-manufacturing step of mixing a monomer of a polymer binder and an emulsifier with a process water and then adding an initiator to thus manufacture a polymer emulsion using a polymerization reaction;
   a slurry-manufacturing step of mixing a raw material including an explosive and an emulsion breaker with fresh process water to thus manufacture a slurry;
   an agglomerated-particle-forming step of adding the manufactured polymer emulsion to the manufactured slurry to thus form agglomerated particles in which a surface of the raw material is coated with the polymer binder; and
   an agglomerated-particle-obtaining step of collecting the agglomerated particles using filtration and drying the collected agglomerated particles.

2. The method of claim 1, wherein, during the polymer-emulsion-manufacturing step, the monomer forms the polymer binder of one or more among a styrene butadiene rubber (SBR), neoprene, a nitrile butadiene rubber (NBR), an acrylic rubber, a fluorine-based rubber, and polyisobutylene using the polymerization reaction.

3. The method of claim 1, wherein during the polymer-emulsion-manufacturing step, the emulsifier is one or more among sodium dodecyl sulfonate (SDS), sodium dodecyl benzene sulfonate (SDBS), sodium dioctyl sulfosuccinate, acetyl dimethyl benzyl ammonium chloride, and hexadecyl trimethyl ammonium bromide.

4. The method of claim 1, wherein during the polymer-emulsion-manufacturing step, the emulsifier is added in an amount of 0.1 to 5 wt% based on a weight of the process water.

5. The method of claim 1, wherein during the slurry-manufacturing step, the explosive is one or more among trimethylenetrinitroamine (RDX), tetramethylenetetranitroamine (HMX), and hexanitrohexaazaisowurtzitane (HNIW), and is dispersed in an amount of 5 to 30 wt% based on a weight of the process water.

6. The method of claim 1, wherein during the slurry-manufacturing step, the emulsion breaker is one or more among calcium chloride (calcium dichloride), sodium chloride, potassium chloride, magnesium chloride, sodium nitrate, sodium carbonate, sodium iodide, and potassium iodide as an inorganic salt.

7. The method of claim 1, wherein during the slurry-manufacturing step, the raw material further includes one or more metals among aluminum, magnesium, and boron.

8. The method of claim 1, further comprising:

   after the agglomerated-particle-forming step,
   a process-water-exchanging step of collecting the agglomerated particles using filtration and adding again the collected agglomerated particles to a new process water; and
   a plasticizer addition step of adding a plasticizer, thus agglomerating the agglomerated particles and the plasticizer.

9. The method of claim 8, wherein the plasticizer is one or more among dioctyl adipate (DOA), dioctyl sebacate, dioctyl

phthalate (DOP), and isododecyl pelargonate (IDP).

10. A compressed composite gunpowder comprising:

50 to 98 wt% of an explosive;
0 to 40 wt% of a metal;
0.5 to 5 wt% of a polymer binder; and
0 to 10 wt% of a plasticizer.

11. The compressed composite gunpowder of claim 10, wherein the explosive is one or more among trimethylenetrinitroamine (RDX), tetramethylenetetranitroamine (HMX), and hexanitrohexaazaisowurtzitane (HNIW).

12. The compressed composite gunpowder of claim 10, wherein the metal is one or more among aluminum, magnesium, and boron.

13. The compressed composite gunpowder of claim 10, wherein the polymer binder is one or more among a styrene butadiene rubber (SBR), neoprene, a nitrile butadiene rubber (NBR), an acrylic rubber, a fluorine-based rubber, and polyisobutylene.

14. The compressed composite gunpowder of claim 10, wherein the plasticizer is one or more among dioctyl adipate (DOA), dioctyl sebacate, dioctyl phthalate (DOP), and isododecyl pelargonate (IDP).

FIG.1

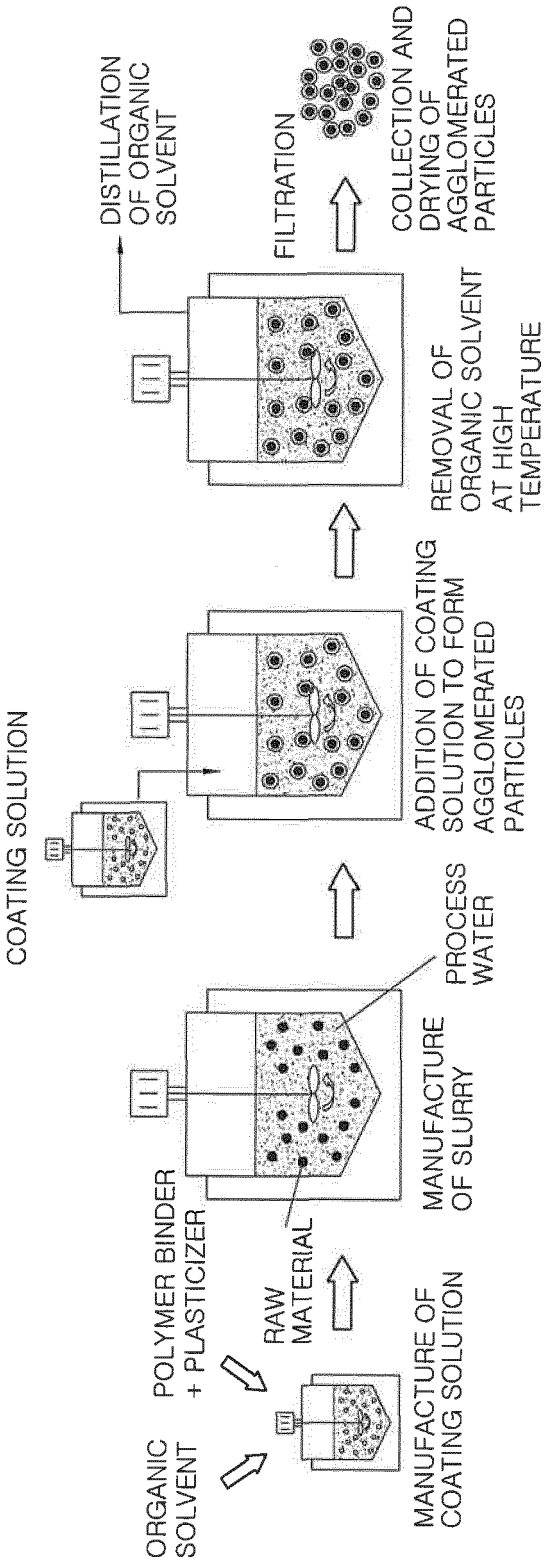

ORGANIC SOLVENT
POLYMER BINDER + PLASTICIZER
RAW MATERIAL
MANUFACTURE OF COATING SOLUTION
MANUFACTURE OF SLURRY
PROCESS WATER
COATING SOLUTION
ADDITION OF COATING SOLUTION TO FORM AGGLOMERATED PARTICLES
REMOVAL OF ORGANIC SOLVENT AT HIGH TEMPERATURE
DISTILLATION OF ORGANIC SOLVENT
FILTRATION
COLLECTION AND DRYING OF AGGLOMERATED PARTICLES

FIG.2

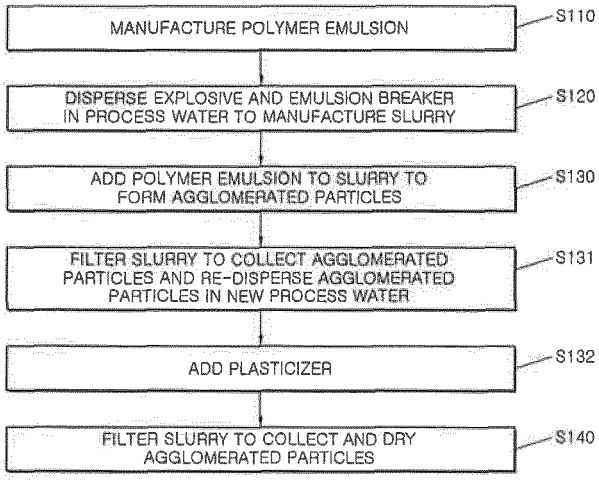

MANUFACTURE POLYMER EMULSION
S110
DISPERSE EXPLOSIVE AND EMULSION BREAKER IN PROCESS WATER TO MANUFACTURE SLURRY
S120
ADD POLYMER EMULSION TO SLURRY TO FORM AGGLOMERATED PARTICLES
S130
FILTER SLURRY TO COLLECT AGGLOMERATED PARTICLES AND RE-DISPERSE AGGLOMERATED PARTICLES IN NEW PROCESS WATER
S131
ADD PLASTICIZER
S132
FILTER SLURRY TO COLLECT AND DRY AGGLOMERATED PARTICLES
S140

FIG.3

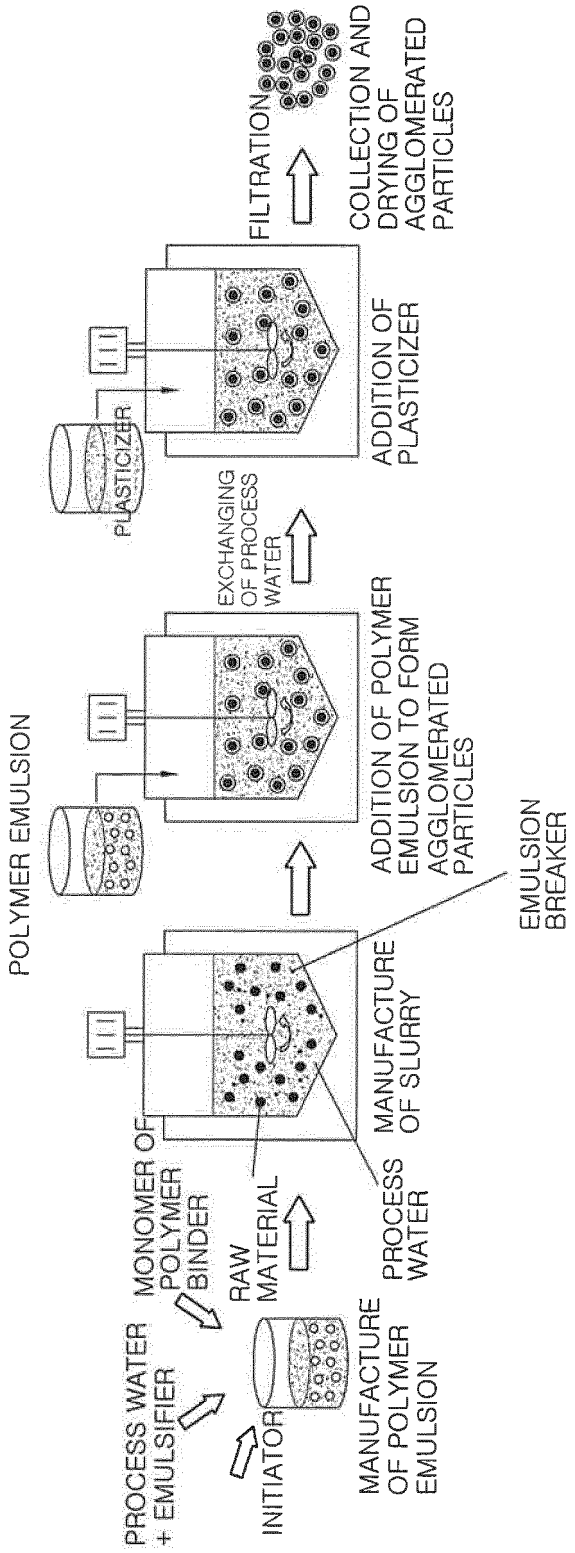

PROCESS WATER + EMULSIFIER
INITIATOR
MANUFACTURE OF POLYMER EMULSION
MONOMER OF POLYMER BINDER
RAW MATERIAL
PROCESS WATER
MANUFACTURE OF SLURRY
EMULSION BREAKER
POLYMER EMULSION
ADDITION OF POLYMER EMULSION TO FORM AGGLOMERATED PARTICLES
EXCHANGING OF PROCESS WATER
PLASTICIZER
ADDITION OF PLASTICIZER
FILTRATION
COLLECTION AND DRYING OF AGGLOMERATED PARTICLES

FIG.4

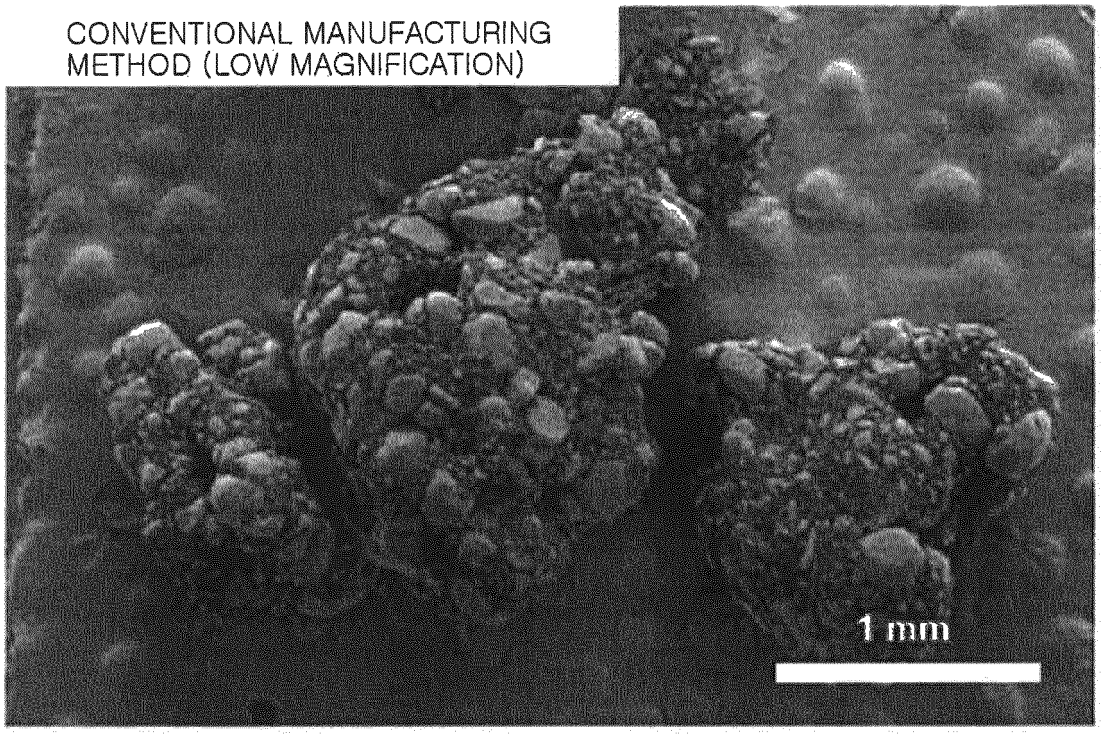

CONVENTIONAL MANUFACTURING METHOD (LOW MAGNIFICATION)
1 mm

FIG.5

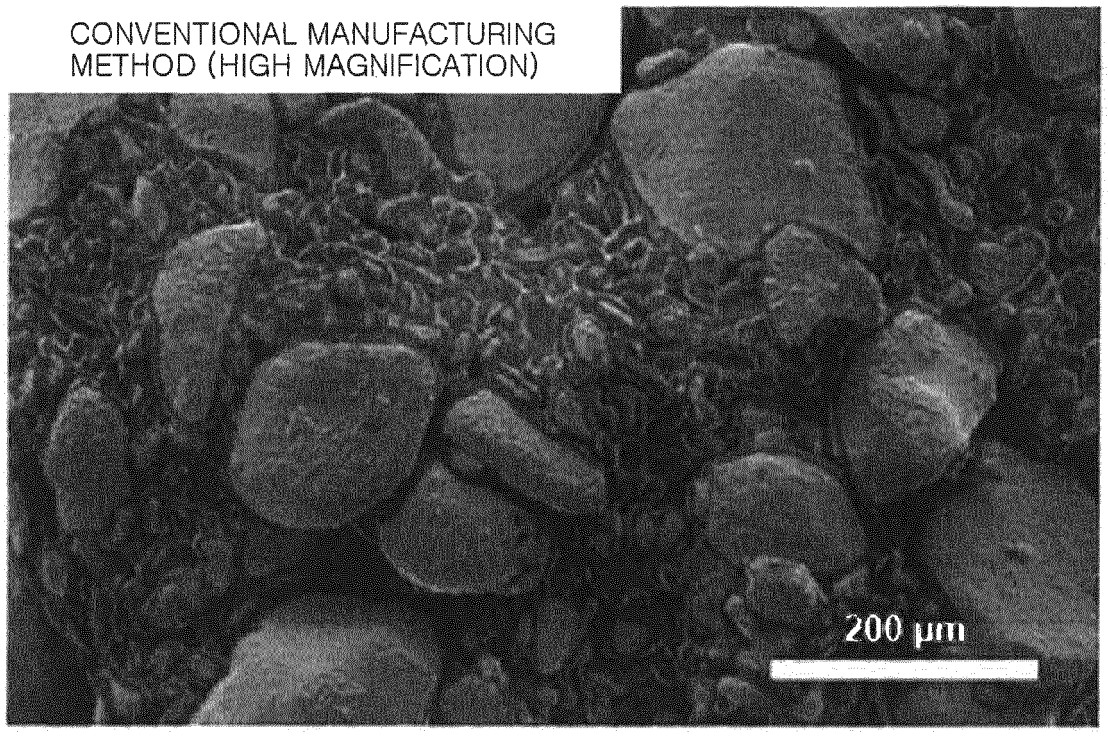

CONVENTIONAL MANUFACTURING METHOD (HIGH MAGNIFICATION)
200 μm

FIG.6

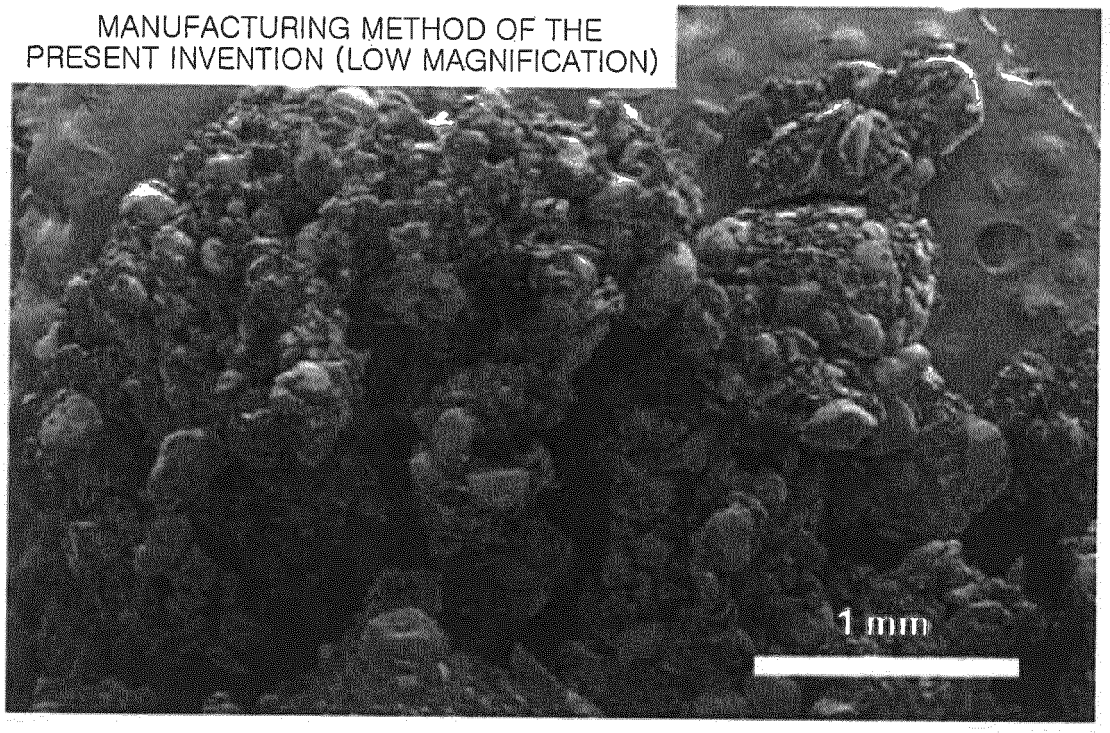
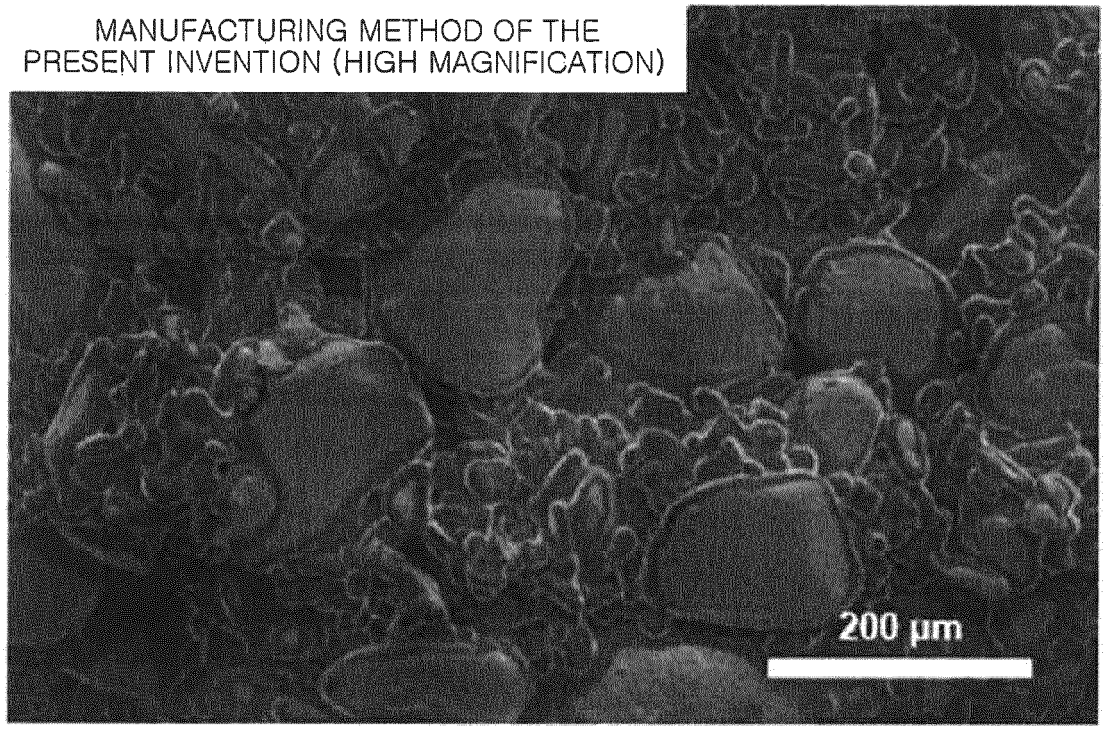

MANUFACTURING METHOD OF THE
PRESENT INVENTION (LOW MAGNIFICATION)
1 mm

FIG.7


MANUFACTURING METHOD OF THE
PRESENT INVENTION (HIGH MAGNIFICATION)
200 μm

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2018/004340

A. CLASSIFICATION OF SUBJECT MATTER

C06B 45/22(2006.01)i, C06B 25/20(2006.01)i, C06B 21/00(2006.01)i, C06B 47/14(2006.01)i, C06B 33/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C06B 45/22; C06B 25/34; C06B 45/18; C06B 25/06; C06B 31/12; C08F 236/06; C08F 236/12; C06B 25/20; C06B 21/00; C06B 47/14; C06B 33/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & Keywords: explosives, polymer bonding agent, emulsion, emulsion breaker, emulsifying agent, initiator, metal, bonded explosives

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	YU, Lan et al., "A Novel ε-HNIW-based Insensitive High Explosive Incorporated with Reduced Graphene Oxide", Journal of Thermal Analysis and Calorimetry, 20 July 2014 (online), vol. 117, pages 1187-1199 See abstract; pages 1187, 1188; and emulsion polymerization coating section.	1-9
Y	KR 10-2010-0122183 A (LG CHEM, LTD.) 22 November 2010 See paragraphs [0027], [0029], [0037].	1-9
X	KR 10-1444658 B1 (AGENCY FOR DEFENSE DEVELOPMENT) 28 October 2014 See paragraphs [0003], [0027], [0028], [0034], [0039]; and claims 4, 5.	10-14
Y		7-9
A	KR 10-2012-0017328 A (AGENCY FOR DEFENSE DEVELOPMENT) 28 February 2012 See the entire document.	1-14
A	KR 10-1999-0054990 A (AGENCY FOR DEFENSE DEVELOPMENT) 15 July 1999 See the entire document.	1-14

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 AUGUST 2018 (10.08.2018)	**10 AUGUST 2018 (10.08.2018)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. +82-42-481-8578	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2018/004340

Patent document cited in search report	Publication date	Patent family member	Publication date
KR 10-2010-0122183 A	22/11/2010	KR 10-1225915 B1	24/01/2013
KR 10-1444658 B1	28/10/2014	NONE	
KR 10-2012-0017328 A	28/02/2012	KR 10-1182328 B1	20/09/2012
KR 10-1999-0054990 A	15/07/1999	KR 10-0255359 B1	01/05/2000

Form PCT/ISA/210 (patent family annex) (January 2015)