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Navy Case No. 71,769

BINDERS FOR MELT CASTABLE PLASTIC BONDED EXPLOSIVES

Background of the Invention

The present invention relates in general to binders for melt castable plastic bonded explosives, and more particularly, to a binder system which desensitizes the explosive fill and which can be used in filling ordnance without the need for a baking step at elevated temperatures.

Prior Art

In conventional melt castable explosives, a mixture containing an explosive such as trinitrotoluene (TNT), a fuel filler of aluminum powder, and optionally cyclotrimethylene trinitromine (RDX) is poured into the casing of the ordnance such as a bomb casing. This explosive charge solidifies and becomes very hard. This type of explosive fill is relatively sensitive to shock and does not pass insensitive munitions requirements such as resistance to thermal cook-off and sympathetic detonation.

To reduce the sensitivity of the bomb fill, plastic bonded explosives have been used. A polybutadiene prepolymer (HTPB) with hydroxyl groups on the terminal carbon atom and having a molecular weight of about 3,000 has been used as a flexible binder for bomb fills. To effect curing of the HTPB, it is necessary to add diisocyanate and a metal catalyst and then heat the filled ordnance in an oven at about 60°C to effect reaction between the diisocyanate and the hydroxyl groups on

the HTPB. The advantage of using polybutadiene prepolymers is its relatively low viscosity (60 poises) at temperatures below about 100°C which facilitates ease of mixing with the explosive filler. The plastic bonded explosives have the disadvantage that curing at elevated temperatures in ovens requires an additional processing step, entailing handling of the filled ordnance.

Commercially available thermoplastic elastomers normally melt at relatively high temperatures, i.e., above 150°C. These elevated temperatures would cause the decomposition of the explosive fillers, leading to hazardous mixing conditions. Also, the viscosity of these commercially available thermoplastic elastomers was believed to be too high to use with an explosive filler because it would not be possible to form a uniform blend of explosive particles of aluminum powder and RDX.

It is desirable to have an explosive fill for ordnance which is relatively insensitive to shock and impact and which includes a binder system which need not be cured at elevated temperatures. It is also desirable to have a binder system which can be melted at temperatures lower than the thermal safety limits of the explosive fillers, thereby facilitating the safe incorporation of RDX into the explosive mixture. It is also desirable to have a thermoplastic/thermoplastic elastomeric binder system having a relatively low melting temperature which has a sufficiently low viscosity at the

melting temperature to facilitate the formation of a uniform blend containing explosive particles.

Summary of the Invention

A melt castable plastic bonded explosive composition is provided for use in ordnance casings which has a melting temperature of below about 105°C and comprises a tackifier, at least one thermoplastic elastomer, a process meltable solid, and, optionally, an anti-stick agent, an anti-oxidant, and a plasticizer.

As a result of the incorporation of a process-meltable solid, the various binder compositions of the present invention possess a characteristic temperature referred to herein as the "blend melt temperature" which is measurable by differential scanning calorimetry. This is the temperature at which the binder system becomes a solid phase as the binder cools from the processing temperature of approximately 100°C. This blend melt temperature is found in compositions containing a process meltable solid.

Upon cooling, the molten plastic bonded explosive composition of the present invention solidifies and needs no further curing as in the case of conventional plastic bonded explosives. The composition of the present invention is particularly advantageous in that it has sufficient wettability, elasticity, and flexibility to desensitize the explosive filler contained therein. Moreover, the melting temperature of the composition of the present invention is sufficiently low that RDX can safely be incorporated into the

mixture, and its viscosity in the molten state is sufficiently low to facilitate uniform mixing of explosive particles with the binder system in subsequent explosive mixture casting. Low temperature elasticity is important in desensitizing explosive fills under cold weather conditions. The binder system of the present invention is particularly advantageous because is elastic at temperatures as low as -20°C.

At the processing temperature, the binder system of the present invention has a relatively low viscosity. It also has a blend melt temperature of from about 60-105°C. Also, a processing temperature of approximately 90-100°C can be used, and the explosives in the binder system are both castable and extrudable. Further, the binder system of the present invention has a lower ratio of solids to binder, better impact sensitivity properties, better cook-off properties, and the use of higher energy materials in advanced applications.

It has been found that the binder system of the present invention can be used where higher energy levels are required. The binders of the present invention are compatible with various explosives, fillers, and metallic fuels. Suitable explosive fillers are RDX, HMX, ammonium perchlorate, nitroguanidine, and nitrotriazole-5-one (NTO). Also, the binder system of the present invention is inert, non-hazardous, non-toxic, and the ingredients thereof are off-the-shelf commercial items. In addition, many of the off-the-shelf solids loading ingredients can now be used, and the aluminum powder does not fall out of the binder formulations of the

present invention. Also, in formulations prepared in the laboratory, no air bubbles were found and, advantageously, the mixing equipment can be cleaned with hot water, provided an anti-stick agent is present.

According to the present invention, the thermo-plastic elastomer can comprise any block polymer having a first polymer segment which is hard (glassy, crystalline, amorphous) and at least one other second polymer segment which is elastomeric at service temperatures. A suitable first thermoplastic polymer segment is, for example, polystyrene, polyethylene, polypropylene, saturated polybutadiene, etc. The second elastomeric polymer segment is, for example, polyisoprene, polybutadiene, polyisobutylene, polyacrylates, etc. A preferred thermoplastic elastomer is STEREON 840A, manufactured by Firestone Tire and Rubber Company, Akron, Ohio, which is a stereospecific multiblock copolymer rubber of butadiene and styrene. This material contains bound styrene of 43% by weight and has a molecular weight of about 85,000.

The weight ratio of the thermoplastic polymer segment to the elastomeric polymer segment can be from about 0.1-0.8. In a preferred embodiment, a styrene-polybutadiene polymer contains about 43% of styrene.

Preferred thermoplastic elastomeric polymers have a molecular weight of from about 10,000 to 800,000, more preferably from about 10,000 to 100,000, and most preferably from about 50,000 to 100,000. The function of the

thermoplastic elastomer in the composition of the present invention is to provide elasticity and tensile strength to the overall composition.

The tackifier used in the binder system of the present invention preferably comprises a polyterpene to reduce viscosity and provide adhesion between the explosive solids and binder and walls of the ordnance. Thus, the tackifier serves as a wetting agent for explosive particles in the binder system. A preferred tackifier is ZONATAC 105, manufactured by Arizona Chemical Company, Fair Lawn, New Jersey, which is a thermoplastic modified terpene hydrocarbon resin. Also preferred is ZONESTER 85 rosin ester of ACINTOL R type tall oil rosin, also manufactured by Arizona Chemical Company. Also suitable are other esters of tall oil rosin.

The melt castable binder system of the present invention also includes a plasticizer to reduce the viscosity during mixing and casting and improve low temperature mechanical properties. Suitable plasticizers include mineral oil. A preferred plasticizer is DRAKEOL-10B light mineral oil manufactured by Penreco, Butler, Pennsylvania, which has a viscosity, SUS at 100°F of 103 and a specific gravity at 60/60°F of 0.875. This material is manufactured from a napthenic base stock. In some applications it is possible to replace the plasticizer with additional tackifier.

The binder system of the present invention includes a process meltable solid to reduce viscosity during mixing and casting.

Suitable process meltable solids includes hydrogenated castor oil, the principle ingredient of which is the glycerol triester of 12-hydroxystearic acid. This material is described in "Industrial Waxes", Vol. I, by H. Bennett, Chemical Publishing Company, Inc., New York, New York, at pp. 276-279. A specific example of a suitable hydrogenated castor oil is CENWAX G which is produced by Union Camp Co., Wayne, New Jersey. Other microcrystalline waxes can also be used.

The binder system of the present invention preferably has a narrow melting range of from about 60 to 105°C. Below 60°C the system is a flexible elastomeric solid. The process meltable solid has a melting temperature within the melting range of the binder system. For example, Cenwax G has a melting temperature of about 86°C. The process meltable solid performs a number of functions in the binder system. First the process meltable solid is a crystalline solid melting between about 60 to 105°C. Second, it provides a narrowing of the mechanical strength transition between a pourable liquid and a rubbery solid. Third, above its melting point, it is soluble or partially soluble in the mixture making up the binder system. At a process temperature of from about 90 to 105°C, the binder system of the present invention forms a single liquid phase or liquid emulsion.

To fine-tune the adhesiveness of the binder, an anti-stick agent can be incorporated in the binder system of the present invention. Suitable anti-stick agents include fatty acid amides having fatty acids containing from 1 to 100 carbon

atoms. A preferred anti-stick agent are KEMAMIDE E, which is a fatty acid monoamide derived from erucic acid and produced by Witco Chemical Corp., Memphis, TN.

To reduce aging and increase the useful life of the binder system, it is preferred to incorporate an anti-oxidant such as a sterically hindered phenol or phosphited phenols. A preferred antioxidant is IRGANOX 1010 produced by Ciba-Geigy Corp., Ardsley, NY, which inhibits discoloration of thermoplastic SBR block copolymer, and comprises 2,2-bis[[3-[3,5-bis(1,1- dimethylethyl)-4-hydroxyphenyl]-1-oxypropoxy]methyl]- 1,3-propanediyl 3,5-bis(1,1-dimethyl-ethyl)-4- hydroxybenzene propanoate.

According to the present invention, the thermoplastic elastomer comprises from about 1 to 35, preferably from about 2 to 25, more preferably from about 5 to 20 weight percent of the binder system. The tackifier comprises from about 20 to 80, preferably from about 30 to 70, more preferably from about 40 to 65 weight percent of the binder system. The plasticizer comprises from about 0 to 60, preferably from about 1 to 50, more preferably from about 1 to 40 weight percent of the binder system.

The process meltable solid comprises from more than 0 to 15, preferably from about 1 to 10, more preferably from about 1 to 5 weight percent of the melt castable system. In addition, the anti-stick agent can comprise from about 0 to 15 weight percent, preferably from about 0 to 10 weight percent, more

preferably from about 0 to 5 weight percent of the melt castable system. Advantageously, the anti-oxidant can comprise from about 0 to 3, preferably from about 0 to 2, more preferably from about 0 to 1 weight percent of the melt castable system.

Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever.

In the following, all parts and percentages are by weight.

Two exemplary melt castable binder systems according to the present invention were prepared by mixing the ingredients at the melting temperature. These binder systems are described below in Table I.

TABLE I

MELT CASTABLE BINDER SYSTEM

FORMULATION NO.	1	2
INGREDIENT (wt. %)		
Zonatac 105	64.0	59.0
Stereon 840A	15.0	20.0
Drakeol 10B	15.0	15.0
Cenwax G	05.0	05.0
Kemamide E	00.5	00.5
Irganox 1010	00.5	00.5

The preceding example can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

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ABSTRACT OF THE DISCLOSURE

A melt castable plastic bonded explosive composition for use in ordnance which contains an explosive and a thermoplastic/thermoplastic elastomer binder system, the binder system comprises a tackifier, at least one thermoplastic elastomer, and a process meltable solid, and, optionally, an anti-stick agent, an antioxidant, and plasticizer.