By use of an appropriate thermoplastic rubber as the binder, the thermal stability and thermal stress characteristics of plastic-bonded explosives may be greatly improved. In particular, an HMX-based explosive composition using an oil-extended styrene-ethylenebutylene-styrene block copolymer as the binder exhibits high explosive energy and thermal stability and good handling safety and physical properties.

6 Claims, 1 Drawing Figure
THERMALLY STABLE, PLASTIC-BONDED EXPLOSIVES

BACKGROUND OF THE INVENTION

The invention described herein relates to high explosives and more particularly to thermally-stable, plastic-bonded explosives.

New requirements for high explosives have appeared in many applications of modern ordnance. In particular, there are various modern ordnance applications that require the explosive to see extended service at elevated temperatures. Accordingly, explosive compositions having a reasonable explosive performance and a high degree of thermal stability are desired. Additionally, such a heat-resistant explosive should be capable of being readily formed into the varied shapes required in modern ordnance and should have a sufficient strength to retain its structural integrity under rather severe thermal conditions.

Plastic-bonded explosives represent a class of explosives which can be made into pressings from which can be fabricated—usually by machining—desired shapes. These explosives are pressed from so-called molding powders which are typically prepared by the slurry technique. Powdered explosive and water are mixed in a kettle equipped with a condenser and agitator. A lacquer composed of the plastic (together with a plasticizer, if necessary) dissolved in a suitable solvent is added to the slurry. The solvent is removed by distillation, causing the plastic phase to precipitate out on the explosive. The plastic-explosive agglomerates into “beads” as the stirring and solvent removal continues. Finally, water is removed from the beads by filtration and drying; the resultant product is the molding powder. The powder is then pressed into shape by either compression molding or hydrostatic or isostatic pressing under vacuum. The pressing may readily be machined into a desired shape for actual use.

Plastic-bonded, HMX-based explosives normally use energetic binder systems, such as nitroaliphatic compounds or nitrate esters, to maximize their explosive power. High-density, halogenated resins are also used for this purpose. Unfortunately, both of these binder types introduce problems. The thermal stability of energetic binder materials is less than that of the HMX filler. This property limits the life of the explosive in high temperature applications. Although the halogenated resin binders are thermally stable, they are undesirable in that they cause the explosive to be unduly sensitive in the skid test, an important measure of handling safety.

DEFINITION OF TERMS

As used within this application, HMX is an explosive having the chemical name 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane, also designated as cyclotetramethylene-tetranitramine; Kraton G-6500 is a tradename for a thermoplastic rubber which is a styrene-ethylenebutylene-styrene block copolymer thermoplastic rubber manufactured by Shell Chemical Co.; Hyvac 93-50-3 is a paraffinic oil sold by Central Scientific Co.; TATB is an explosive having the chemical name sym-triamino-trinitrobenzene; RDX is an explosive having the chemical name hexahydro-trinitro-triazine, also known as cyclotrimethylene-trinitramine.

SUMMARY OF THE INVENTION

I have found that plastic-bonded explosives having excellent thermal stability, good handling safety, and good physical properties may readily be produced using as the binder a styrene-ethylenebutylene-styrene block copolymer thermoplastic rubber which is manufactured and sold under the tradename Kraton G-6500. The thermal stress properties of these explosives may be further improved through use of an appropriate extender. A preferred embodiment of my invention is a plastic-bonded explosive containing 97.5 wt % HMX, 1.12 wt % Kraton G-6500, and 1.38 wt % paraffinic oil.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE is a bar chart comparing the tensile properties of the plastic-bonded explosive which is the preferred embodiment of the invention to that of a standard plastic-bonded explosive, PBX 9404.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Kraton G-6500 is an unusual polymer in that it acts as a cross-linked (vulcanized) rubber at temperatures below the glass point of styrene (100° C.) through an association of the styrene blocks or domains. At higher temperatures, these bonds are broken, and the polymer acts as a thermoplastic in forming operations such as compression molding. It reverts, however, to its original cross-linked structure upon cooling. Certain solvents also weaken these bonds and dissolve the polymer, thus allowing the use of the slurry process with this polymer in the manufacture of plastic-bonded explosives.

The properties of Kraton G-6500 may readily be varied by extending it with a pure paraffinic oil such as Hyvac 93050-3. Such extension, while producing a low modulus and high elasticity, does not destroy the attractive cross-linking feature of the polymer. As indicated by the following data, a binder composed of 45 wt % Kraton G-6500 and 55 wt % pure paraffinic oil has remarkable elasticity while its properties remain relatively constant over a wide temperature range.

Exudation test: none
Elongation, elastic (%): 900
Elongation, break (%): >900
Shore durometer (A-2):
+74° C.: 15
+24° C.: 21
-23° C.: 30
Glass point, Tg (°C.): -63

Kraton G-6500 may be used as a binder in plastic-bonded explosives with a variety of explosive compounds. As will become apparent later in this specification, it is thermally stable and does not degrade even when kept at 90° C. for long periods. Thus, the thermal stability of plastic-bonded explosives using it as a binder is largely predicated on the thermal stability of the explosive compound incorporated therein as the filler. A preferred explosive compound for use with the Kraton G-6500 is HMX which has good thermal stability and excellent explosive characteristics. Examples of other explosive compounds which may readily be used with the Kraton G-6500 binder include RDX and TATB.

Depending on the properties desired, plastic-bonded explosives using Kraton G-6500 as the binder may contain as much as 10 wt % of the binder. As used here, the
The term "binder" may include the use of certain additives to obtain desired physical properties. A preferred binder to provide low modulus and excellent elasticity is the paraffinic oil extender noted earlier in this specification. Alternatively, a microcrystalline petroleum wax may readily be used as the extender. The extender may be added in any desired ratio, however, when paraffinic oil is used and the fraction of the oil in the binder approaches 65 wt %, the oil begins to exude from the binder.

A preferred embodiment of the plastic-bonded explosive of this invention contains 97.5 wt % HMX, 1.12 wt % Kraton G-6500 and 1.38 wt % paraffinic oil. Hereinafter in this specification this composition will be referred to as X-0298.

As the following data show, X-0298 is quite stable in the conventional short-term tests.

**TABLE I-continued**

<table>
<thead>
<tr>
<th>Performance</th>
<th>X-0298 Explosive Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detonation velocity (m/s)</td>
<td>8833 (1.817 g/cm³)</td>
</tr>
<tr>
<td>Calculated PE (kgb)</td>
<td>366 (1.817 g/cm³)</td>
</tr>
<tr>
<td>Plate Dent PE (kgb)</td>
<td>363 (1.817 g/cm³)</td>
</tr>
</tbody>
</table>

**TABLE II**

<table>
<thead>
<tr>
<th>Strength Properties of X-0298</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile</td>
</tr>
<tr>
<td>+74° C</td>
</tr>
<tr>
<td>+24°</td>
</tr>
<tr>
<td>-54°</td>
</tr>
</tbody>
</table>

**Compressional**

| +74° | 391 | 447 | 0.41 |
| +24° | 1518 | 2068 | 1.53 |
| -54° | 2525 | 4059 | 2.90 |

Shear

| +74° | 351 | 418 |
| +24° | 828 | 930 |
| -54° | 1650 | 1878 |

Creep

| C.T.E., -54° to +74° C, °C⁻¹ x 10⁶ | 0.30 |
| Thermal Expansion | 48.4 |

**TABLE II-continued**

To prepare X-0298, a slurry of 12.68 kg of Class A HMX (coarse) and 6.82 kg of Class B (fine) HMX in 60 liters of water is prepared in an agitated, heated vessel. A lacquer consisting of 224 g of Kraton G-6500, 276 g of paraffinic oil (Hyvac 9305-L), and 2.4 liters of n-butylacetate solvent is added to the vessel, which is at 75° C. Strong agitation, the temperature is raised to 80°-83° C. The agitation is then reduced to a low level, and heat is applied to drive off the solvent by azetropic distillation. Cooling is then applied, and the coated agglomerated HMX particles are recovered by filtration. After drying in trays in a forced-draft oven, the 20 kg of product is suitable for use as a molding powder in the formation of desired explosive shapes.

The foregoing description of X-0298 and the means of making it are supplied to comply with the best mode requirement of 35 U.S.C. 112. The invention is not in any way limited to this preferred embodiment but rather is as set forth in the Summary of the Invention and encompassed by the broad claims appended hereto.

What I claim is:

1. In a plastic-bonded explosive which comprises an explosive compound filler and a plastic binder in a desired ratio, the improvement comprising use of a thermoplastic rubber which is a styrene-ethylene-butylene-styrene block copolymer as the plastic binder.

2. The plastic-bonded explosive of claim 1 wherein said thermoplastic rubber binder has an extender incorporated therein in a desired ratio.

3. The plastic-bonded explosive of claims 1 or 2 wherein said explosive compound is cyclotetramethy-
Iene-tetranitramine, cyclotrimethylene-trinitramine, or sym-triamino-trinitrobenzene.

4. The plastic-bonded explosive of claim 2 wherein said explosive compound is cyclo tetramethylene-tetranitramine and said extender is paraffinic oil.

5. The plastic-bonded explosive of claim 4 containing 97.5 wt % cyclo tetramethylene-tetranitramine, 1.12 wt % of said thermoplastic rubber, and 1.38 wt % paraffinic oil.

6. A plastic-bonded explosive having excellent thermal stability which comprises in a desired ratio (a) cyclo tetramethylene-tetranitramine, cyclo trimethylene-trinitramine, or sym-triamino-trinitrobenzene, (b) a styrene-ethylene-butylene-styrene block copolymer thermoplastic rubber, and (c) paraffinic oil or a microcrystalline petroleum wax.