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PREPARATION AND CHARACTERIZATION OF THIN SHEETS OF ENERGETIC MATERIALS BASED ON POLYISOPRENE

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ABSTRACT

Thin sheets of highly energetic materials based on polyisoprene (PI) as high elastomeric material and cyclo-trimethylene trinitamine (RDX) as high brisant explosive were prepared by rolling of the prepared beads of the RDX coated by PI. These beads were prepared by employing the slurry technique and the sheet explosives were cured in oven at 60^{o}C for two days. The measured explosive properties of the prepared sheets were discussed and compared with that based on RDX and polyisobutylene (PIB).

The sensitivity to impact and friction of the prepared formulation containing 86% RDX were markedly decreased when compared with that of pure RDX, but the ignition point was close to that of pure RDX.

The measured detonation velocity of the prepared formulation (8100 m/s) was slightly less than that of pure RDX. The prepared sheet explosive, after curing, behaves as an elastomer with very good stress-strain values.

KEY WORDS

Plastic bonded explosives, Sheet explosives, RDX, Polyisoprene.

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INTRODUCTION

Thin sheets of energetic materials are usually called sheet explosives may be considered as special type of plastic bonded explosives (PBXs) which are based on highly flexible elastomeric binders as polyisoprene, polyisobutylene, polyurethane and others (1-3). The flexibility of these formulations is utilized in some important applications as in explosive reactive armors (ERA) (3-6). Many recent researches were focused on the preparation, characterization and applications of PBXs including sheet explosives to achieve lower vulnerability, high physical and mechanical properties without sacrificing explosive and energetic properties of these formulations (7-15).

In general PBXs are mainly consisting of a polymeric binder, explosive filler and other minor ingredients as plasticizers, curing and bonding agents. In this work Cyclotrimethylene-trinitramine (RDX) was selected to be the explosive filler since it is considered as one of the most brisant high explosives. Polyisprene (PI) was selected as the high flexible binder because it, either natural or synthetic, forms after mastication process and sulfur vulcanization, the model for the ideal elastomeric properties including rapid extensibility to great elongation, high stiffness and strength when stretched and also rapid and complete retraction on release of external stress (16).

EXPERIMENTAL

MATERIALS

All the chemicals used in this work; RDX, PI, Dioctylazelate (DOZ) plasticizer, dichloroethane (DCE) solvent, and Teflon (PTFE) as solid lubricant were of high purity.

Preparation of PBX Beads Based on RDX and PI

The preparation was carried out using the slurry technique (17-18). PI was completely dissolved in DCE and RDX was slowly added to the laquer. After 20- 30 minutes about 400 ml, more than the volume of DCE, of distilled water was poured drop-wise and stirring was continued for 30 minutes. Temperature was increased to evaporate DCE and the formed beads were filtered off, washed with water and dried at 70^{o}C. Teflon as a solid lubricant, DOZ as plasticizer and small amount of distilled water as wetting agent were added and thoroughly mixed with the RDX beads coated with PI to be ready for the rolling process.

The final composition by weight percent of this formulation was 86% RDX, 8.5% PI, 3.5% DOZ and 2% Teflon. Water is not considered here because it will be evaporated during the rolling process.

Rolling and Curing of PBX Beads to Produce the Sheet Explosives

The explosive beads were introduced between two heavy duty calendars which produce a sheet of thickness 4 mm and the rolling process was repeated ten times at 25°C. In the first run Sulfur as vulcanizing agent was added with some minor additives as accelerator and activator. The produced sheets were cured at 60°C for about 48 hours.

Sensitivity of Prepared Formulations

Sensitivity to impact was determined by employing Julius Peters KG (Germany made) apparatus, using 2 Kg falling weight according to the standard technique (19). Sensitivity to friction was determined using Julius Peters KG apparatus**.** The test was conducted in such a way that the loading on the pistil was increasing and the percentage of initiation was determined. The load at which 100% initiation was determined and thus the force in Newton could be estimated (19). The sensitivity to heat was obtained by measuring the ignition temperature for the prepared PBX samples (19) using Julius Peters apparatus. To determine the ignition temperature, the temperature was uniformly increased [5°C/min] until the explosion conversion was occurred.

Detonation Velocity of the Prepared PBX Formulations

Three sheets of the prepared PBX formulations were used together to form a sheet of 12 mm thickness. This sheet was employed to determine the detonation velocity of the prepared formulation and pure RDX as a booster was used. The Exploment -Fo-Multi Channel, Supplied by Kontiniro AG. (Swiss made) was used to measure the detonation velocity of this formulation. The time interval for a detonation wave to travel a known distance between the two fiber optic probes in microseconds was displayed with the calculated detonation velocity in m/s.

Stress-Strain Characteristics of the Prepared Sheet Explosives

The values of the stress and strain of the prepared sheet explosive was determined for the sheet before and after curing employing LRX-5K material testing machine supplied by Lloyd Instrument, UK. The dumbbell shape samples had the American standard dimensions.

RESULTS AND DISCUSSION

All the results of different explosive characteristics obtained for the prepared sheet explosive were compared with that obtained for pure RDX and also with that obtained for a similar sheet explosive based on polyisobutylene and RDX of close weight percent composition(1). All these results are listed in Table (1).

Table (1) Results of Different Explosive Characteristics
for the Prepared Sheet Explosive

Explosive Characteristics	**Pure RDX**	**Sheet Explosive Based on RDX and Polyisobutylene**	**Sheet Explosive Based on RDX and Polyisoprene**
Sensitivity to Impact (J)	7.5	37.5	45
Sensitivity to Friction (N)	120	>360	324
Sensitivity to Heat (Ignition Point) ^{O}C	222	204	235
Detonation Velocity (m/s)	8750	7930	8100

It is obvious from Table (1) that the sensitivity to impact was markedly decreased when the RDX crystals were coated by the polyisoprene thin layers. The sensitivity to impact of the prepared sheets was decreased by 600% when compared with that of pure RDX. The obtained value of the sensitivity to impact was also much less than that for the similar composition based on RDX and polyisoprene.

The sensitivity to friction of the prepared sheets was also markedly decreased when compared with that of pure RDX. The values of the sensitivity to friction of both sheet explosives based on polyisoprene or polyisobutylene are close to each other.

The sensitivity to heat expressed by the values of the ignition point of the prepared sheet was also slightly decreased when compared with that of pure RDX or with that of sheet explosive based on polyisobutylene.
From the values of sensitivity to different initial impulses of the prepared sheet explosive, we can come to a conclusion that, the prepared sheet may be classified as low vulnerability explosive which is highly safe during rolling, storing and application.

The obtained value of the detonation velocity for the prepared sheet explosive which represents the explosive performance was slightly decreased than the value obtained for pure RDX by 7.4% only. The slight decrease in the value of the detonation velocity of the prepared sheet explosive means that in spite of the markedly decrease in the sensitivity of this sheet, the explosive characteristics were approximately not affected.

The stress-strain characteristics of the prepared sheet explosive were measured to emphasize the flexibility, ductility and high mechanical properties of this sheet after curing. The stress-strain values before and after curing are listed in Table (2).

It is clear from this table that the values of the stress and strain were greatly improved after curing and the obtained sheet has excellent flexibility and ductility properties (20).

Table (2) Stress Strain Characteristics of the Prepared Sheet Explosives

Characteristics	Before Curing	After Curing
Maximum Stress (N/cm^2)	5.78	8.58
Maximum Strain (%)	43	144

CONCLUSION

Thin sheet of highly energetic material based on polyisoprene as a polymeric elastomer and RDX as high energetic explosive was successfully prepared and showed high ductility after curing, stress of 8.58 N/cm^2 and strain of 144%. In the same time this sheet has high energetic properties which are close to that of pure RDX, detonation velocity of 8110 m/s. The sensitivity to impact and friction of the prepared sheet was markedly decreased when compared with that of pure RDX which decrease the vulnerability during application, while the sensitivity to heat was also decrease but with a less extend than that of pure RDX.

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