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Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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J. A. Sanchez

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

BINDER STUDY FOR HMX/TATB EXPLOSIVES

by

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ABSTRACT

Comparisons were made on Estane, Kraton G, and Kraton G with HyVac Oil for sensitivity and performance in plastic-bonded HMX/TATB formulations. Data obtained on sensitivity, performance, and processability suggest that Estane is superior, so it will be used in further studies. The goal of this study is to develop a relatively insensitive high explosive with a sensitivity between that of RX-26-AF and of PBX 9502.

I. INTRODUCTION

Several binders were investigated in formulations with TATB/HMX to select a better binder for this system. Three binders selected for this study were Estane, Kraton G, and Kraton G with HyVac Oil (Kraton/Oil). The amounts selected were 25-wt% HMX and 5-wt% binder. In each case, the PBX was made by a conventional water-slurry process.

II. BACKGROUND AND OBJECTIVES

The selection of a suitable binder for a plastic-bonded TATB explosive with 25-wt% HMX was needed to compare with TATB/HMX formulations bound with Kel-F 800. Gains in insensitivity and performance were the objective of this study. Some improvement in safety and energy tradeoff was also sought.

Selection of a binder was made based on the sensitivity and performance data in conjunction with processability. The 25-wt% level of HMX appeared to be at a transition point in sensitivity vs performance, a comparison made in previous work.

III. FORMULATION

The binder study was done using 25-wt% HMX. The three binders selected for the formulation comparison were Estane, Kraton, and Kraton/Oil. In all cases, the binder level was 5 wt%.

The formulations were first made in 5-g experimental batches. In each of the three formulations, drop-weight impact sensitivity was measured and can be found in Table I.

Larger batches of each formulation were then made for further study. Table II lists the formulation numbers assigned and used in this report to identify each formulation. All the formulations were made by standard water-slurry coating techniques. A blue and orange mottled color was chosen to identify this family of explosives (TATB/HMX/binder). Two 3-kg batches of each formulation were made of the orange color and one 3-kg batch of the blue; then these three were blended to give this mottled color.

The normal slurry process was used for all three formulations: the powdered TATB and HMX were stirred into water at room temperature with medium agitation for 30 min. The lacquer, which contained the binder, solvent, and dye, was then added to the explosive/water mixture and the temperature of the total mixture was raised to 80°C with the high agitation speed. At 80°C a vacuum air sweep at 16.88 kPa of vacuum on the gauge was maintained until agglomerates formed. The whole system was then cooled to 30°C, dumped, washed, and oven dried at 65°C overnight under vacuum. Class B HMX and standard Hercules TATB were used in these formulations. No wetting problems were encountered in the slurry preparation of the three formulations. The solvents for each of the binders are also listed in Table II.

TABLE I. Drop-Weight Impact Sensitivity

Formulation	Drop Height (cm)	
	Type 12	Type 12B
TATB/HMX/Estane	No go at 320	No go at 320
TATB/HMX/Kraton	No go at 320	No go at 320
TATB/HMX/Kraton/Oil	No go at 320	1 go at 320

TABLE II. Formulations

Experimental Explosive Formulation Number	Wt%	Components	Solvent
X-0396	70/25/5	TATB/HMX/Estane	MEK
X-0397	70/25/5	TATB/HMX/Kraton	Toluene
X-0398	70/25/2.24/2.76	TATB/HMX/Kraton/Oil	N-butyl acetate

IV. EVALUATION

A. Impact Tests

Drop-weight impact sensitivity test results indicate that X-0396 and X-0397 were less sensitive than the X-0398 formulation. The drop-weight impact test uses a 40-mg sample of material between an anvil and striker. A 2.5-kg weight is dropped from prescribed heights onto two types of surfaces. In the Type 12 drop-weight impact test, the sample is placed on sandpaper; in the Type 12B test, it is placed on the bare anvil.

B. Bullet Test

The standard HE bullet test was done on all three formulations. This test involves a right circular, mild steel cylindrical projectile fired remotely from a .30-cal Mann accuracy barrel into a 50-mm × 75-mm-high explosive sample. The results are listed in Table III. Neither X-0396 nor X-0398 showed a detonation at the highest velocity obtainable in this test. X-0397 detonated two out of three times at 1346 m/s.

C. Gap and Plate-Dent Tests

In the gap and plate-dent tests, X-0396 performed better than X-0397 and X-0398.

The gap test was a standard 25.4-mm-diameter test. The plate-dent test used 41.3-mm-diameter (1.58 in.) samples stacked to a height of 203.2 mm. Data on both tests are given in Table III.

TABLE III. Results from Gap and Plate-Dent Tests

Explosive Formulation (g/cm^3)	Gap Test Mean Gap (mm)	Plate Dent		Bullet Test (m/s)	TMD $(g/cm)^3$
		Dent (mm)	P_{CJ}(kbar)		
X-0396 (1.838)	18.97	8.05	280	No go up to 1359	1.871
X-0397 (1.789)	16.38	7.60	264	Detonation at 1346	1.826
X-0398 (1.787)	17.30	7.90	275	No go up to 1350	1.821

D. Thermal Stability

Chemical thermal stability was measured by differential thermal analysis (DTA). Data on all three formulations represent the good thermal-stability characteristics of HMX. Pyrolysis of each sample also indicated good stability. Vacuum stability was reasonable for all three formulations. Table IV lists all the results for the thermal-stability tests.

TABLE IV. Thermal Stability in DTA and Vacuum Stability

Formulation	Onset of DTA Exotherm (°C)	Vac. Stab. ($cm^3/g/120°C/48$ h)
X-0396	260	0.2
X-0397	270	0.2
X-0398	265	0.3

E. Coefficient of Thermal Expansion (CTE)

CTE values for two of the formulations, X-0396 and X-0397, are given in Table V. Average values are given for each temperature range for easy comparison. Each sample was cycled 20 times from −54 to +74°C.

TABLE V. Coefficient of Thermal Expansion (CTE) at −54 to +74°C Range

Formulation	CTE ($\times 10^6$ 1/°C)
X-0396	75.9
X-0397	83.5
X-0398	---

F. Physical Properties

The physical properties of X-0396 were measured and are given in Table VI. Tensile and compressive-strength measurements indicate reasonable physical characteristics for this formulation.

G. Pressability

A pressing evaluation was performed, varying temperature and intensification at a constant pressure of 138 MPa (20,000 psi). X-0396 (Estane formulation) was pressed to the highest density, 1.849 g/cm^3, after three intensifications at 110°C. Density changed very little, to 1.846 g/cm^3, after three intensifications at 100°C. Table VII lists densities and variables of the evaluation for all three formulations.

TABLE VII. Pressing Evaluation [At Constant Pressure of 138 MPa (20,000 psi)]

Material	Density (g/cm^3)	Intensification (cycles)	Temp (°C)
X-0396	1.841	3	85
	1.828	1	85
	1.846	3	100
	1.834	1	100
	1.849	3	110
	1.838	1	110
X-0397	1.766	3	85
	1.746	1	85
	1.784	3	100
	1.774	1	100
	1.789	3	110
	1.782	1	110
X-0398	1.785	3	85
	1.770	1	85
	1.789	3	100
	1.772	1	100
	1.787	3	110
	1.772	1	110

TABLE VI. Strength Properties of X-0396

Density (g/cm^3)	Ultimate Strength (MPa)	Ultimate Strength (psi)	Modulus (GPa)	Modulus (10^5 psi)	Elongation (%)
Tensile					
1.838	6.88	998	4.667	6.772	0.1200
Compressive					
1.836	17.14	2485	1.25	1.82	---

V. CONCLUSION AND FUTURE WORK

Based on the results of this study, X-0396 was judged to be superior to the other formulations. It was found to be less sensitive in several of our sensitivity tests and still performed better than the other two formulations. More work will be done at Los Alamos and at Pantex using the X-0396 formulation. Areas to be studied include particle size of HMX, binder level, and more in-depth evaluation of physical properties and of HMX level. The desired goal is to obtain a relatively insensitive high explosive that fits between RX-26-AF and PBX 9503 in performance.

VI. ACKNOWLEDGMENTS

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ADDITIONAL READING

T. R. Gibbs and A. Popolato, *LASL Explosive Property Data*, University of California Press, 1980.

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