TATB PBX DEVELOPMENT
LOW PERCENT BINDER SURVEY

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T. L. Stallings

DEVELOPMENT DIVISION

JULY - SEPTEMBER 1976

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ABSTRACT

A preliminary survey of nine plastic binders with TATB, screened by the indirect tensile test, indicates that Kel-F 800 is the most promising candidate to be considered as a low percent binder for TATB.

INTRODUCTION

Various combinations of TATB with single organic binders were formulated and subjected to preliminary safety tests (e.g., drop hammer and DTA) and physical property testing. Small quantities (about 0.1 kg) were formulated and tested for compression and indirect tensile properties. This screening experiment was conducted to select a promising binder to be evaluated for TATB booster applications.

The indirect tensile⁽¹⁾ test is a unique method for evaluating and comparing small quantities of material. Results reported here cannot be compared to standard tensile test results. The compression specimens used here are also different from the standard compression specimen; i.e., the specimens are much smaller with an L/D ratio of approximately 1.

DISCUSSION

A total of nine different binders were screened. A list of these binders and a brief description of each are included in Table I. Each of the binders listed were formulated with TATB (1,3,5-triamino-2,4,6-trinitrobenzene), in most cases using a solvent, at 1 and 2% (by weight) binder. As a matter of interest some additional samples were prepared at a 5% binder level. A sample of the Kel-F 800 was tested at 7.5% (by weight) binder level for comparison.

Each of the lots were mechanically pressed into several compression (20.3 mm diameter x 19.1 mm high) and indirect tensile (20.3 mm diameter x 6.4 mm high) specimens. Physical strength and density data are recorded in Tables II through IV. A single lot of pure TATB powder pressed at the same pressure as the formulations is included for reference (lot 5123-135-01, the first lot listed in each table). All of the indirect tensile specimens were tested at a constant crosshead speed of 0.0021 mm/s. The compression specimens were tested at two crosshead speeds—0.001 mm/s and 0.021 mm/s. The different conditions are footnoted for each lot on each of the tables. Table II presents the results for the 1% binder, Table III presents results for the 2% binder level, and Table IV presents the results for the 5% and 7.5% Kel-F level. These data are graphically illustrated in Figs. 1 and 2 for comparison of the tensile and the compression data, respectively.

(1) L. C. Myers and H. D. Johnson, "An Evaluation of a Mechanical Property Test for Small Samples of Plastic Bonded Explosives," MHSMP-76-30P, April - June 1976.

As shown in the results all specimens exhibited good pressability with most pressing exceeding 96% of TMD; the higher binder percentage lots listed in Table IV exhibited a wider range of densities. The uncured monoepoxy results are included in Table IV to illustrate the difference between cured and uncured materials. The uncured data are not included in the figures.

The indirect tensile data plotted in Fig. 1 show that Kel-F 800 is essentially as strong as the other binders. Some of the binders were stronger than pure TATB while others were not. However, all formulations exhibited higher strain than pure TATB. These data show that no binder was significantly better than Kel-F at the 1 and 2% level. The Kraton G is an interesting material because of its high strain at 5%; note however, that because of its low density, its volume percentage is higher than that of Kel-F 800.

The compression data in Fig. 2 show some interesting trends. The monoepoxy was the only binder which was notably stronger than pure TATB with essentially the same elongation. The polyester 750051 gave the highest elongation at the 5% by weight level; however, it also is a low density binder.

FUTURE WORK, COMMENTS AND CONCLUSIONS

The results indicate that several of the binders offer some improvement in tensile stress and strain over pure TATB. However, none are significantly stronger than pure TATB or TATB containing a low percent Kel-F 800. These screening tests were performed not to evaluate a particular binder, but rather to select the most promising binder to be evaluated at the low percent level. The Kel-F 800 appears to be the most promising candidate for further evaluation. One of its primary advantages is the large amount of extant data and experience with TATB/Kel-F formulations. Larger batches are required with the low percentage Kel-F 800 to thoroughly evaluate strength response. Another area to be evaluated is the amount of Kel-F 800 required to produce a moisture resistant pellet.

Table I. Organic Binder Properties

Polymer	TMD (Mg/m ³)	$\sim T_m$ (C)	$\sim T_g$ (C)	Tensile Strength (MPa)	Elongation (%)	Shore Hardness	Manufacturer	Description
Kel-F 800	2.02	97.0	+27-30	10.34	350	D64	3M Corp St. Paul, MI	A copolymer of vinylidene fluoride and chlorotrifluoroethylene
Viton A	1.815	NA ^b	-27	NA	NA	NA	EI du Pont de Nemours Deepwater, NJ	A copolymer of vinylidene fluoride and perfluoropropylene in a 2:1 ratio
Estane 5702 F1	1.18	NA	-31	24.13	625	A70	B.F. Goodrich Chemical Co. Cleveland, OH	A polyester urethane
Vistanex L-120	0.92	NA	NA	> 13.79	1000	NA	Exxon Chemical Co. New York, NY	Polyisobutylene; MW ~ 120000
Kraton GX-6500	> 0.91	176.7	NA	41.37 ^a	500	NA	Shell Chemical Co. Torrance, CA	A block-type polymer, A-B-4 where A represents a polystyrene endblock and B represents a polyolefin midblock
Polyester 750051	1.00	+150.0	-80	29.65	1100	D30	3M Corp. St. Paul, MI	Polyester resin
Polyester 750052	1.318	+90.0	-80	17.24	650	D35	3M Corp. St. Paul, MI	Polyester resin
Polyester 750053	1.143	+120.0	-80	24.13	700	D30	3M Corp. St. Paul, MI	Polyester resin
Monoepoxy XL 7690	1.185	NA	NA	^c	NA	NA	Hardman, Inc. Belleville, NJ	Elevated temperature cure system

^aInstron jaw separation rate 4.23 mm/s @ 23 C (tensile strength of film cast from toluene)

^bNot available

^cCure temperature 100 C, cure time 20 minutes, lap shear strength 5.52 MPa

Table II. Properties of Formulations Containing One Percent Binder

Lot No. and Binder	Density (Mg/m ³)	% TMD	Compression			Indirect Tensile ^c	
			Maximum Stress (MPa)	Failure Strain (%)	Rupture Strain (%)	Maximum Stress (MPa)	Ultimate Strain (%)
5123-135-01 ^a Pure TATB	1.862	96.06	18.92	1.41	2.14	2.46	0.10
6014-154-01 ^a Vistanex L-120	1.853	96.68	12.96	2.87	4.71	1.35	0.18
6014-161-01 ^a Estane 5702-F1	1.861	96.65	17.61	2.86	4.62	2.65	0.20
6015-160-01 ^a Viton A	1.867	96.38	17.06	5.86	8.32	2.03	0.19
6016-155-01 ^a Polyester 750051	1.865	97.14	18.26	3.75	5.43	2.63	0.29
6016-157-01 ^a Polyester 750052	1.860	96.43	15.19	3.14	4.62	2.05	0.13
6016-158-01 ^a Polyester 750053	1.863	96.80	17.47	1.96	3.03	2.11	0.14
6019-159-01 ^a Kraton GX-6500	1.856	96.85	19.00	2.60	3.51	2.69	0.16
5349-151B-01 ^{b, d} Monoepoxy XL 7690	1.856	96.39	20.90	1.90	2.31	1.97	0.24
5350-153-01 ^{b, d} Kel-F 800	1.874	96.68	19.60	2.00	2.94	2.60	0.22

^aCompression test run at constant crosshead speed of 0.021 mm/s^bCompression test run at constant crosshead speed of 0.001 mm/s^cAll indirect tensile tests run with constant crosshead speed of 0.002 mm/s^dCured at 120 C for 16 hours

Table III. Properties of Formulations Containing Two Percent Binder

Lot No. and Binder	Density (Mg/m ³)	% TMD	Compression			Indirect Tensile ^c	
			Maximum Stress (MPa)	Failure Strain (%)	Rupture Strain (%)	Maximum Stress (MPa)	Ultimate Strain (%)
5123-135-01 ^a Pure TATB	1.862	96.06	18.92	1.41	2.14	2.46	0.10
6014-154A-01 ^a Vistanex L-120	1.838	96.94	10.14	5.85	13.40	1.39	0.20
6014-161A-01 ^a Estane 5702 F1	1.855	96.95	16.74	3.52	6.30	2.73	0.27
6015-160A-01 ^a Viton A	1.867	96.43	15.89	4.64	7.40	2.65	0.21
6016-155A-01 ^a Polyester 750051	1.859	97.72	17.88	4.78	7.07	2.88	0.21
6016-157A-01 ^a Polyester 750052	1.849	96.36	14.13	3.85	5.80	2.14	0.15
6016-158A-01 ^a Polyester 750053	1.849	96.74	16.13	2.43	3.55	2.31	0.17
6019-159A-01 ^a Kraton GX-6500	1.844	97.30	19.00	3.84	5.22	3.10	0.30
5349-151A-01 ^{b,d} Monoepoxy XL 7690	1.847	96.53	24.20	2.10	2.39	2.95	0.41
5350-153A-01 ^{b,d} Kel-F 800	1.884	97.13	19.50	2.10	3.34	2.93	0.33

^aCompression tests run at a constant crosshead speed of 0.021 mm/s

^bCompression tests run at a constant crosshead speed of 0.001 mm/s

^cAll indirect tensile tests run at a constant crosshead speed of 0.002 mm/s

^dCured at 120 C for 16 hours

Table IV. Properties of Formulation Containing Five Percent Binder

Lot No. and Binder	Density (Mg/m ³)	% TMD	Compression			Indirect Tensile ^c	
			Maximum Stress (MPa)	Failure Strain (%)	Rupture Strain (%)	Maximum Stress (MPa)	Ultimate Strain (%)
5123-135-01 ^a Pure TATB	1.862	96.06	18.92	1.41	2.14	2.46	0.10
6019-155B-02 ^a Polyester 750051	1.826	98.64	15.23	11.40	20.2 ^e	3.07	0.46
6019-157B-01 ^a Polyester 750052	1.810	95.59	11.33	7.73	13.03	1.89	0.20
6019-158B-01 ^a Polyester 750053	1.816	96.96	12.52	3.25	5.50	2.39	0.31
6019-159B-01 ^a Kraton GX-6500	1.796	97.91	15.75	9.04	14.50	3.31	0.91
5303-151-01 Cured Monoepoxy XL 7690	C 1.746 T 1.723	92.98 91.71	28.80 ^b	2.50	2.84	3.77	0.43
Uncured Monoepoxy XL 7690	C 1.805 T 1.749	96.12 93.13	4.00 ^b	3.80	4.78	0.24	0.32
5315-145-04 ^d Kel-F 800 Heated @ 250 F	C 1.877 T 1.858	96.53 95.56	18.11 ^b	2.40	3.38	4.28	0.67

^aCompression tests run at a constant crosshead speed of 0.021 mm/s^bCompression test run at a constant crosshead speed of 0.001 mm/s^cAll indirect tensile tests run at a constant crosshead speed of 0.002 mm/s^d7.5% (by weight) binder^eOff Scale - Exceed instrument range

Fig. 1. Indirect Tensile Test

↑
 Vistanex L-120
 ↓
 ↑
 Polyester 750052
 ↓
 ↑
 Polyester 750053
 ↓
 ↑
 Viton A
 ↓
 ↑
 Ionomer XL 7690
 ↓
 ↑
 Estane 5702-F1
 ↓
 ↑
 Polyester 750051
 ↓
 ↑
 Kraton 6500
 ↓
 ↑
 Kel-F 300
 ↓

Fig. 2. Compression Test