

MELT CAST ELASTOMERIC PBX - PROCESSING AND PROPERTIES OVERVIEW

N. C. Johnson, C. Gotzmer, and R. C. Gill
Synthesis and Formulations Branch, R11
Naval Surface Weapons Center
Silver Spring, Maryland 20910

ABSTRACT

Thermoplastic, rubbery binder systems are being developed for melt cast plastic bonded explosives. These materials are tailored for the existing Navy industrial base for melt cast explosives.

In the event of rapid mobilization, present-day curable PBX's could not be processed in-house in large volume. Production would revert to older melt cast TNT formulations for bomb fills and, therefore, the improved safety characteristics of the rubbery PBX's would be sacrificed. This work has directed formulation efforts specifically toward compositions that exhibit the rubbery characteristics of present-day curable PBX's such as PBXW-108 or PBXW-109 but with processing characteristics appropriate to existing melt cast production equipment.

Melt cast binder systems will be described and the processability and physical properties of the PBX compositions will be presented.

INTRODUCTION

Review of the Navy explosive production plant at NWS, Yorktown, VA, which has facilities typical of present-day explosive processing plants, shows the following capability: plant #1, four 2000 lb capacity melt cast kettles with no vacuum; plant #2, two 2000 lb capacity melt cast kettles, only one with vacuum; plant #3, three 2000 lb capacity melt cast kettles, only one with vacuum, and two Baker-Perkins mixers (one 150- and one 300-gallon).

In the event of any rapid mobilization, present-day curable elastomeric PBX's (which can only be prepared in the high shear Baker-Perkins mixers) could not be processed in-house in sufficient volume and production would revert to the older melt cast formulations which are based on crystalline TNT. Thus the improved safety characteristics we have realized in the present-day rubbery PBX's would be sacrificed. Even if the melt cast elastomeric PBX is manufactured in peacetime at low levels, a savings in operational costs would be gained from the simplicity of the operation. The melt cast PBX does not require the use of curing agents, crosslinking agents, cure catalysts, curing ovens, and Baker-Perkins mixer processing. However, the elastomeric binder network would still be maintained. In addition, precise control of chemical crosslinking and sensitivity to moisture would be avoided by use of the thermoplastic elastomeric binder system.

The intent of the Melt Cast Elastomeric PBX program is to develop an explosive composition that exhibits the rubbery characteristics of present-day curable PBX's such as PBXW-108 or PBXW-109 but which has processing characteristics suitable for existing melt cast equipment.

BINDER AND PBX DEVELOPMENT

Multiblock-multiphase polymers of the A-B-A type provide a suitable binder network for the rubbery melt cast systems. These polymers differ fundamentally in molecular structure from the typical plastic or commercial rubber (homopolymers or copolymers) in that they consist of individual chains of three blocks: an elastomeric block in the center and the thermoplastic block on each end. This unique structure allows the polymer to soften and flow when heated to the melt and when cooled, to recover its structure and elastomeric properties by forming physical crosslinks via the endblock domains. The domains are characterized as crystalline or thermoplastic in nature.

Since the crosslinking mechanism for the melt cast binder system is a physical interaction rather than a chemical reaction, crosslinking agents and cure catalysts would not be used. Also, the binder system is insensitive to moisture during the physical crosslinking process (cool down) whereas chemical crosslinking via present-day isocyanates would be detrimentally affected both during processing and crosslinking by moisture.

Formulation and tailoring of an inert thermoplastic rubbery binder system is underway. The binder is based on Kraton^R G1652 (Shell Chemical Company), a block copolymer with polystyrene endblocks and a saturated ethylene-butylene midblock. Although the thermoplastic styrene domains soften at temperatures above 100°C unlocking the physical crosslinking mechanism, the polymer will not flow even at temperatures of 120° to 150°C unless high shear energy is applied. This kind of high shear cannot be obtained in existing melt cast kettles. However, exceptions have been found whereby the Kraton^R rubber has been plasticized with certain low viscosity naphthenic, paraffinic, and olefinic oils and with certain hot melt resins to yield binder compositions that could be processed in conjunction with energetic fillers in the 90° to 100°C temperature range under a low shear condition.

Formulation, viscosity, and physical properties data for the Kraton^R based melt cast binders are listed below in Table 1. All of the binder compositions could be processed at 90-100°C. No evidence of plasticizer oil exuding from the compositions has been observed.

A plastic bonded explosive composition (formulated from binder composition no. 1 in Table 1) that would be typical of PBXW-108 in both solids loading and energy is listed in Table 2. This composition processed well in the 2-gallon Anchor mixer; it had an end-of-mix viscosity of 3.5 kilopoise at 93°C and cast well. The mechanical properties of this explosive composition are comparable to those of PBXW-108 at 25°C and can be found in Table 3.

CONCLUSIONS

The melt cast elastomeric PBX is a new type of plastic bonded explosive that would exhibit the improved safety characteristics of elastomeric curable PBX's but would be processed in the present-day melt cast production equipment.

FUTURE PLANS

Additional plans for the melt cast elastomeric PBX program include new binder and explosive development using the inert and energetic ABA polymers synthesized in the Office of Naval Research program.

ACKNOWLEDGMENTS

The melt cast elastomeric PBX project is supported by the Naval Sea Systems Command Explosive Development, Effects, and Safety Block Program monitored by L. A. Roslund (R10C) of the Naval Surface Weapons Center.

The authors extend their thanks to H. T. Fillman (R11) and J. F. Leahy (R11) of NSWC for processing the energetic compositions.

TABLE 1

Compositions and Properties of Melt Cast Binders

	Mix #						
	1	2	3	4	5	6	7
<u>Formulation, Wt. %</u>							
Kraton G1652	20	25	20	20	22	22	20
Tufflo 6016 Oil	80	75	0	0	0	0	0
Shellflex 371 Oil	0	0	80	45	45	58	55
Foral 85 Resin	0	0	0	35	33	14	0
Piccofyn A100 Resin	0	0	0	0	0	0	25
Pentalyn H Resin	0	0	0	0	0	0	0
Piccotex 100 Resin	0	0	0	0	0	6	0
<u>Viscosity, Poise (100°C)</u>	73	390	83	150	300	200	120
<u>Physical Property (25°C)</u>							
Stress, psi	6	50	12	240	530	140	94
Strain, %	210	340	360	1530	2110	990	1030
<u>Glass Transition Temp., °C</u>	-78	-	-89	-100	-	-	-

TABLE 1 (CONT)

Compositions and Properties of Melt Cast Binders

	Mix #						
	8	9	10	11	12	13	14
<u>Formulation, Wt. %</u>							
Kraton G1652	20	20	20	22	20	20	20
Tufflo 6016 Oil	0	0	0	0	0	0	0
Shellflex 371 Oil	53	50	45	53	60	55	45
Foral 85 Resin	0	0	0	0	0	0	0
Piccofyn A100 Resin	27	30	35	25	14	0	0
Pentalyn H Resin	0	0	0	0	0	25	35
Piccotex 100 Resin	0	0	0	0	6	0	0
<u>Viscosity, Poise (100°C)</u>	150	170	300	230	130	110	200
<u>Physical Property (25°C)</u>							
Stress, psi	190	280	190	190	110	98	230
Strain, %	1490	1730	1230	1480	990	990	1540
<u>Glass Transition Temp., °C</u>	-	-	-	-	-	-	-

TABLE 2

Melt Cast Plastic Bonded Explosive Composition

<u>Ingredients</u>	<u>Wt. %</u>
Kraton G1652	3.0
Tufflo 6016	12.0
RDX C	59.5
RDX E	25.5
End of mix viscosity at 93°C (KP)	3.5

TABLE 3

Mechanical Properties of Melt Cast Plastic Bonded Explosive Composition from Table 2 Versus PBXW-108E at 25°C

Composition	Sm (psi)	Sr (psi)	Em (%)	Er (%)	Shore A Hardness
PBX From Table 2	30	29	16	16	24
PBXW-108E	34	34	19	19	28

Note: Sm: Stress at maximum
 Sr: Stress at rupture
 Em: Strain (elongation) at maximum
 Er: Strain (elongation) at rupture