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QUALIFY AN ALTERNATE POLYISOBUTYLENE (PIB) BINDER FOR COMPOSITION C-4

QUALIFY AN ALTERNATE POLYISOBUTYLENE (PIB) BINDER FOR COMPOSITION C-4

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2009 Insensitive Munitions & Energetic Materials Technology Symposium

Tucson, AZ

11-14 May 2009

OUTLINE

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- Background
- Qualification Status
  - Specification
  - Sensitivity
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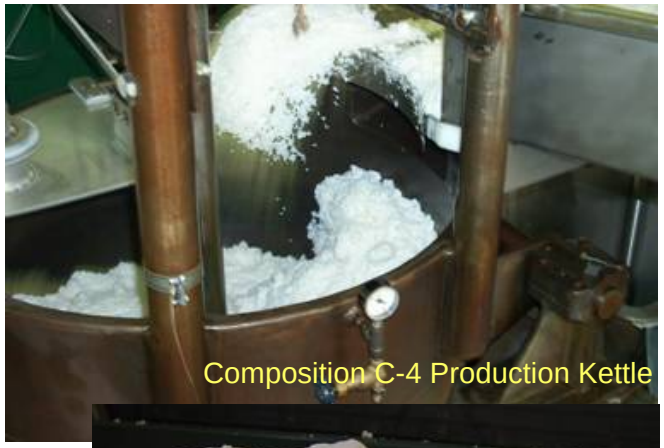
  - Compatibility
  - Extrudability
- Summary

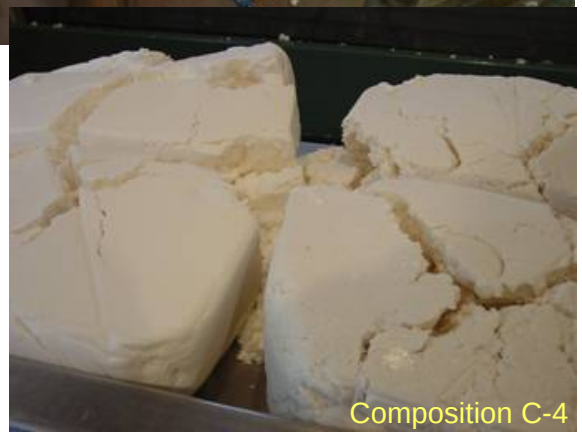
ACKNOWLEDGEMENT

- **PM Close Combat Systems**
  - Mr. Felix Costa
- **BAE Systems, Holston Army Ammunition Plant**
  - Mr. Curtis Teague
  - Mr. Brad Smythe
- **RDECOM-ARDEC**
  - Mr. Greg Tremarco
  - Mr. Paul Vinh
  - Mr. Sanjeev Singh
  - Ms. Maria Bukowska
  - Mr. Mike Mauriello
  - Mr. Drew Smith
- **Milan Army Ammunition Plant**
  - Mr. Dave Duncan
- **Crane Army Ammunition Activity**
  - Mr. Stacy Vanhoy

BACKGROUND

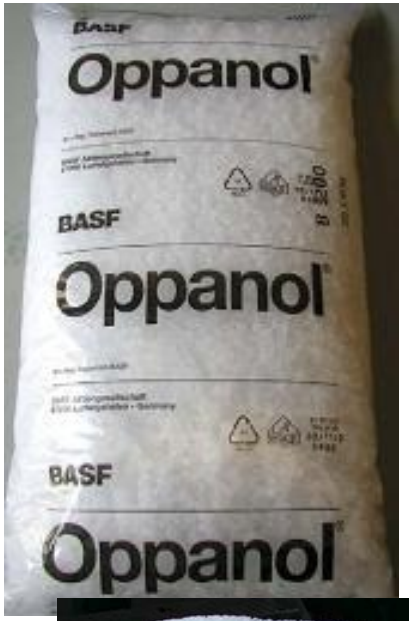
- **Composition C-4, Class 3 is produced by BAE Systems at Holston Army Ammunition Plant**
  - **88.9% RDX Explosive**
  - **9.9% Plastic Binder**
  - **1.2% DMDNB Taggant**
- **Composition C-4 is mainly used for demolition purposes**
  - **M112 Demolition Charge**
  - **M183 Demo Kit**
  - **MICLIC**
  - **M18A1 Claymore Mine**

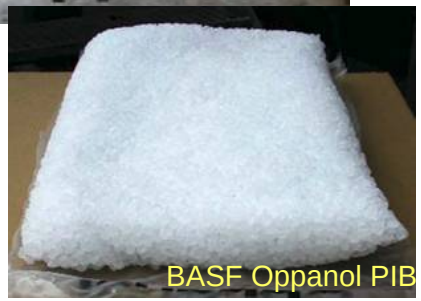

Composition C-4 Production Kettle


Composition C-4

BACKGROUND

- **Approximately 23% Polyisobutylene (PIB) in the plastic binder**
- **ExxonMobil sole qualified PIB producer**
  - **Vistanex MML-120**
  - **ExxonMobil ceased all PIB production**
- **BASF markets its own PIB, called Oppanol**
- **PM-CCS initiated effort to qualify BASF Oppanol PIB**
- **Market survey confirmed BASF sole supplier of CONUS PIB similar to qualified Vistanex**
  - **BASF Oppanol PIB grades B-100, B-150, and B-200**




BASF Oppanol PIB

BACKGROUND

- **BASF PIB grades were tested for specification compliance and further evaluated in Composition C-4 lab-scale batches**
- **Oppanol B-150 and B-200 were down-selected for scale-up production and qualification testing based on:**
  - **Rheological characterization**
  - **B-100 does not meet 2 specification requirements**
  - **B-150 and B-200 meets all but the intrinsic viscosity specification requirement (higher intrinsic viscosity)**
    - **Intrinsic viscosity affects flow, i.e. higher value the more viscous**
    - **Higher molecular weight PIB to coat RDX particles**


Polyisobutylene


Polyisobutylene (PIB)

QUALIFICATION STATUS
Specification Compliance

- PIB grades used in scale-up C-4 production analyzed for specification compliance, MIL-P-13298


Ground Polyisobutylene

Specification	*MIL-P-13298 PolyIsoButylene Specification*		BASF Oppanol B-150			BASF Oppanol B-200			Vistanex MML-120 (control)
	Min.	*Max.*	Lot #: 0804	Lot #: 0805	Lot #: 0806	Lot #: 0807	Lot #: 0808	Lot #: 0809	
Intrinsic Viscosity	*3.15*	*3.72*	4.621*	5.012*	3.996*	6.237*	4.763*	5.236*	3.62
Iodine No.		*1.32*	0.9123	0.5963	0.7261	1.0120	0.8763	0.6973	0.89
Chlorine, %		*0.10*	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acidity, % AS HCL		*0.01*	0.002	0.003	0.001	0.001	0.003	0.004	0.000
Insoluble Matter		*0.20*	0.03	0.09	0.08	0.02	0.04	0.07	< 0.20
Color	*</= standard*		< std	< std	< std	< std	< std	< std	< std

** Failed Specification*

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QUALIFICATION STATUS
Specification Compliance

- All 6 scale-up Composition C-4 batches (4,000 lb/batch) produced with Oppanol PIBs are MIL-C-45010A specification compliant

Specification	*MIL-C-45010A Comp C-4, Class 3*		Comp C-4 with B-150			Comp C-4 with B-200		
			Batch #: R7577	Batch #: R7578	Batch #: R7579	Batch #: R7580	Batch #: R7581	Batch #: R7582
	Min.	*Max.*	(PIB Lot#: 0805)	(PIB Lot#: 0804)	(PIB Lot#: 0806)	(PIB Lot#: 0807)	(PIB Lot#: 0808)	(PIB Lot#: 0809)
% RDX	*89.8*	*91.2*	90.6	90.5	90.6	90.2	90.2	90.2
% Binder	*8.8*	*10.2*	9.4	9.5	9.4	9.8	9.8	9.8
% DMDNB	*1.00*	*1.50*	1.14	1.30	1.40	1.38	1.18	1.16
% Moisture		*0.25*	0.03	0.02	0.01	0.07	0.04	0.05
USSS 40		*0*	0	0	0	0	0	0
USSS 60		*5*	0	0	0	0	0	0
Plasticity	*0.018*		0.176	0.131	0.142	0.140	0.167	0.117

QUALIFICATION STATUS
Sensitivity and Performance

- Sensitivity and performance of Composition C-4 with Oppanol B-150 PIB comparable to the control

	C403-R7576 (Control)	C403-R7577 (#1, B-150)	C403-R7578 (#2, B-150)	C403-R7579 (#3, B-150)
ERL, Type 12 Impact Test	*87.4 ± 1.4 cm*	75.7 ± 2.0 cm	60.7 ± 0.7 cm	60.7 ± 0.9 cm
BOE Impact Test	*1/10 (4" Height)*	0/10 (4" Height)	0/10 (4" Height)	1/10 (4" Height)
ABL Friction Sensitivity Test, (1800 psi)	*0/20 Trials*	0/20 Trials	0/20 Trials	0/20 Trials
Electrostatic Sensitivity (ESD), (0.25J)	*0/20 Trials*	0/20 Trials	0/20 Trials	0/20 Trials
Large Scale Gap Test (LSGT)	*1.645"*		1.925"	1.805"
Ignition & Unconfined Burning, (Seconds)	*Trial 1: 93* *Trial 2: 106* *Trial 3: 92*	Trial 1: 94 Trial 2: 89 Trial 3: 110	Trial 1: 108 Trial 2: 102 Trial 3: 117	Trial 1: 133 Trial 2: 106 Trial 3: 137
Detonation Velocity & Plate Dent	*V = 7.86 km/s* *Dent = 0.118"*		V = 7.96 km/s Dent = 0.118"	V = 7.90 km/s Dent = 0.113"

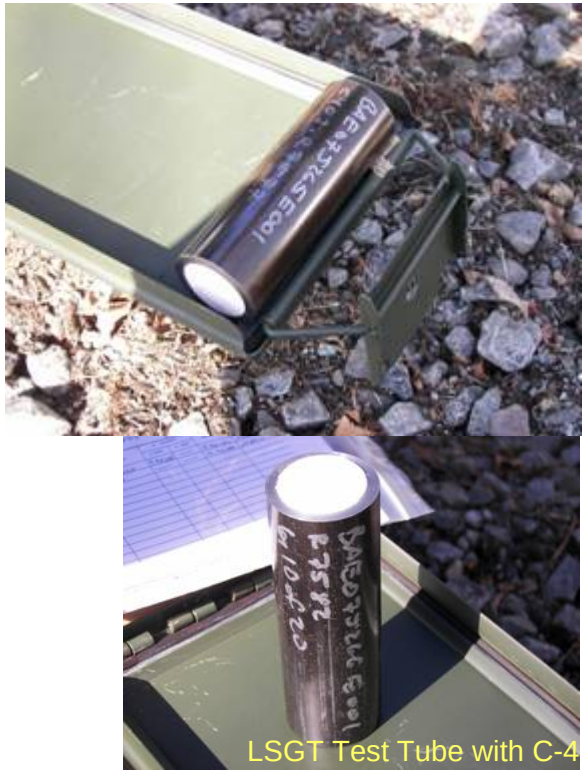
QUALIFICATION STATUS
Sensitivity and Performance

- Sensitivity and performance of Composition C-4 with Oppanol B-200 PIB comparable to the control

	C403-R7576 (Control)	C403-R7580 (#1, B-200)	C403-R7581 (#2, B-200)	C403-R7582 (#3, B-200)
ERL, Type 12 Impact Test	*87.4 ± 1.4 cm*	94.4 ± 1.4 cm	48.3 ± 1.1 cm	55.2 ± 1.9 cm
BOE Impact Test	*1/10 (4" Height)*	0/10 (4" Height)	0/10 (4" Height)	0/10 (4" Height)
ABL Friction Sensitivity Test, (1800 psi)	*0/20 Trials*	0/20 Trials	0/20 Trials	0/20 Trials
Electrostatic Sensitivity (ESD), (0.25J)	*0/20 Trials*	0/20 Trials	0/20 Trials	0/20 Trials
Large Scale Gap Test (LSGT)	*1.645"*	1.875"	1.700"	
Ignition & Unconfined Burning, (Seconds)	*Trial 1: 93* *Trial 2: 106* *Trial 3: 92*	Trial 1: 120 Trial 2: 115 Trial 3: 93	Trial 1: 111 Trial 2: 133 Trial 3: 136	Trial 1: 114 Trial 2: 117 Trial 3: 137
Detonation Velocity & Plate Dent	*V = 7.86 km/s* *Dent = 0.118"*	V = 7.74 km/s Dent = 0.108"	V = 7.98 km/s Dent = 0.117"	

QUALIFICATION STATUS
Sensitivity, Performance, & Aging

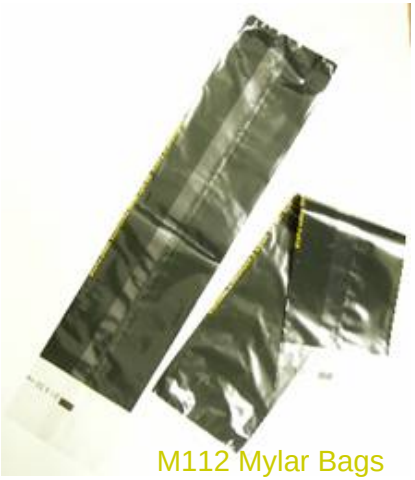
- Composition C-4 batches made with Oppanol B-150 and B-200 PIB, tested for impact, friction, electrostatic, shock sensitivity, and performance properties are comparable to the control batch made with Vistanex PIB
- No significant problems or anomalies during testing evaluation
- Accelerated aging of test batches with sensitivity and performance properties to be compared to the control batch
  - Impact, friction, and rheology testing every 1, 2, 4, 6, 8 months
  - LSGT and detonation velocity at 0 & 8 month
  - Second month completed to date



LSGT Test Tube with C-4

QUALIFICATION STATUS
Compatibility

- Composition C-4 produced with Oppanol B-150 and B-200 PIB passes compatibility testing with Mylar bag (Mylar bag used in wrapping C-4 block in M112 demolition charge)
  - Differential Scanning Calorimetry (DSC) used to measure enthalpy changes of material for compatibility

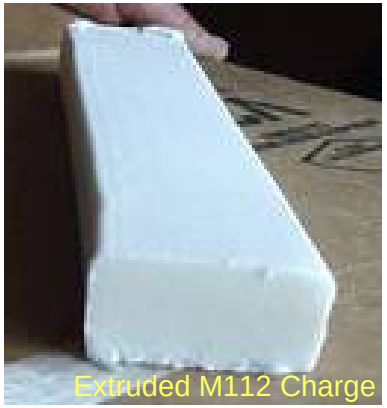


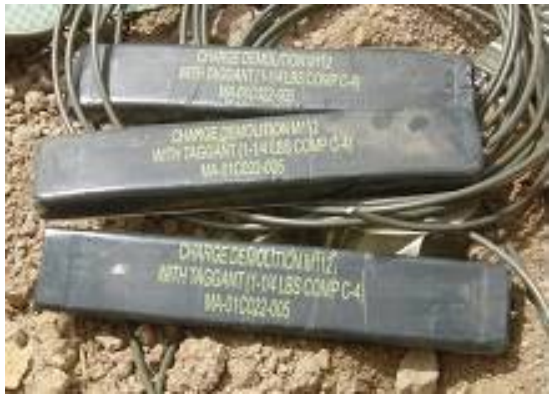
M112 Mylar Bags

	Test Sample	DSC Exotherm, Peak Temperature	Criteria	Result
Control	C-4 (B-150 PIB)	234.54°C		
Control	C-4 (B-200 PIB)	236.08°C		
Test #1	C-4 (B-150) & Mylar bag-a	232.87°C	Within 4°C of control	Pass
Test #2	C-4 (B-150) & Mylar bag-b	234.72°C	Within 4°C of control	Pass
Test #1	C-4 (B-200) & Mylar bag-a	236.98°C	Within 4°C of control	Pass
Test #2	C-4 (B-200) & Mylar bag-b	234.88°C	Within 4°C of control	Pass

QUALIFICATION STATUS
Extrudability

- Composition C-4 made with Oppanol B-150 and B-200 PIB successfully extruded into M112 demolition charges at Milan Army Ammunition Plant (American Ordnance) and at Crane Army Ammunition Activity without any significant problems
- Extrudability, i.e. process control parameters, of the 6 batches/lots (2,000 lbs each) made with Oppanol comparable to the control batch/lot
- All lots pass LAT at Milan AAP (Lot Acceptance):
  - Three lots with Oppanol B-150
  - Three lots with Oppanol B-200
  - One control lot with Vistanex MML-120
- All C-4 batches/lots, made with Oppanol PIB, extruded into M112 demolition charges pass extrusion evaluation


Extruded M112 Charge



SUMMARY

- **Vistanex MML-120, sole qualified polyisobutylene (PIB) for use in Composition C-4, is no longer produced by ExxonMobil and Vistanex tradename was sold to BASF**
- **BASF produces a similar product with various grades, called Oppanol (no other CONUS producers of similar PIB as determined by market survey)**
- **Three BASF Oppanol PIB grades (B-100, B-150, & B-200) tested and B-150 & B-200 selected for scale-up evaluation qualification**
- **Composition C-4 batches produced with Oppanol B-150 & B-200 were tested for impact, friction, electrostatic, shock sensitivity, performance properties, and extrudability which are all comparable to the control batch made with qualified Vistanex PIB**
- **Final qualification of Oppanol B-150 & B-200 to be completed in Fall 2009 pending completion of aging evaluation**