Abstract #13851

Development of Electrically Controlled Energetic Materials for 120mm Tank Igniters

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Background

Electrically ***C***ontrolled ***E***nergetic ***M***aterials (ECEMs)

POWER ON

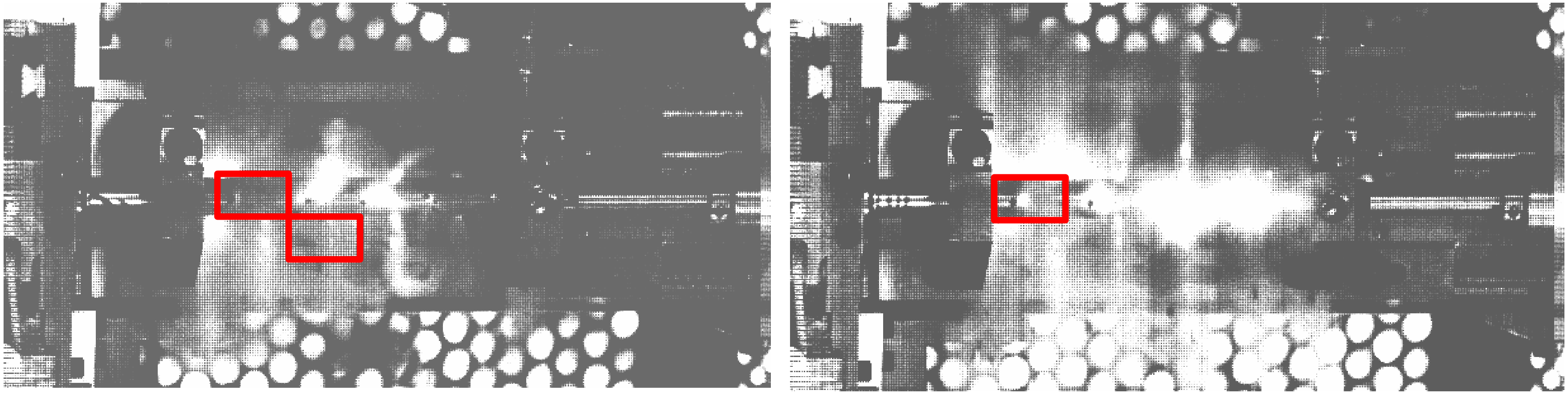
POWER OFF

POWER UP

- Hydroxylammonium nitrate (HAN) based plastisol
    - Formulations developed by Digital Solid State Propulsion (DSSP)
- Developed as a replacement for ammonium perchlorate
- Generates relatively non-toxic gases
- Burn rate controlled through electrical parameters

Motivation

- Benite – Inconsistent ignition, inconsistent performance



High speed video stills from static test firing of 120mm M865 tank igniters*

- Future igniter materials
  - Performance – Consistent ignition with the ability to throttle
  - IM – Ability to avoid violent reaction due to external stimuli

*Reproduced from Rozumov 56th JPM

Target Item

120mm M865 & M1002 Tank Training Rounds

- Electrically initiated through multi-step ignition train
- Main energetic fill of igniter is benite
- Requirements:
  - Propellant must function at extreme temperatures
    - Hot: 145°F
    - Cold: - 46°F
  - No changes to current ballistic firing tables
  - Compatibility with all current energetics
  - Must meet current ignition times

Objective

- Evaluate current DSSP formulations in 120mm tank igniters
  - Multiple formulations available for demonstration
    - Down selecting best suited formulation and optimizing to meet ARDEC requirements
- Design electrodes to optimize ignition
  - Can control where and when propellant ignites
- Improve understanding of propellant reaction mechanism
  - How and why does it burn?
  - What can be done to improve how it burns?

Design Considerations – Propellant Types

HIPEP

- Non metalized high performance propellant
- Flame insensitive
- Reactions stops with removal of electrical power
- Burn Rate: Tailorable, from 0.5 to > 10ips*, $0.4 < \eta < 0.9$

BADB

- Metalized propellant (Boron)
- Flame sensitive
- Lower flame temperature
- Continues to burn once ignited
- Burn Rate: Tailorable, from 0.4 to >15ips*, $0.4 < \eta < 0.9$

Compatibilities

- Incompatible with many metals (Iron, Nickel, Copper, etc.)
- Compatible with common polymers (Conventional engineering plastics)

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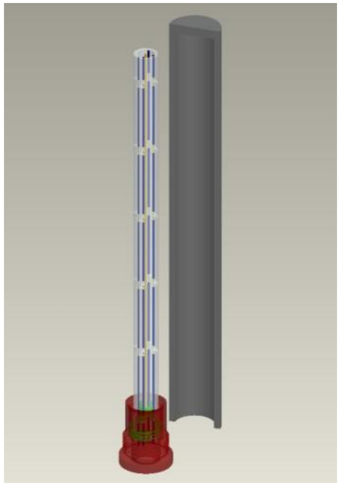
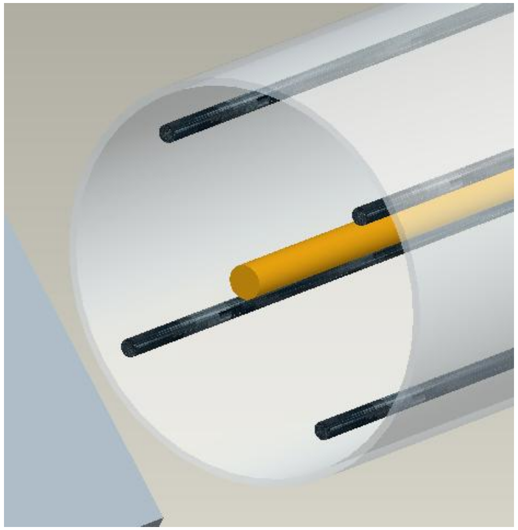
* *Cured strand burning rates, 1000psi*

Design Considerations – Electrode Configuration

FIVE ELECTRODE CONCEPT

Four – Outer Electrodes
One – Inner Electrode



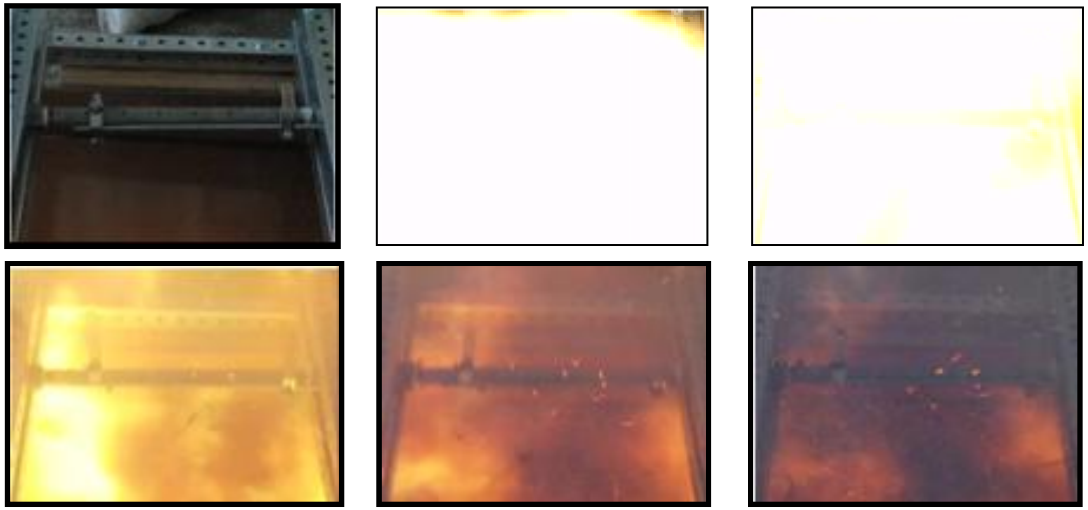


Cathode

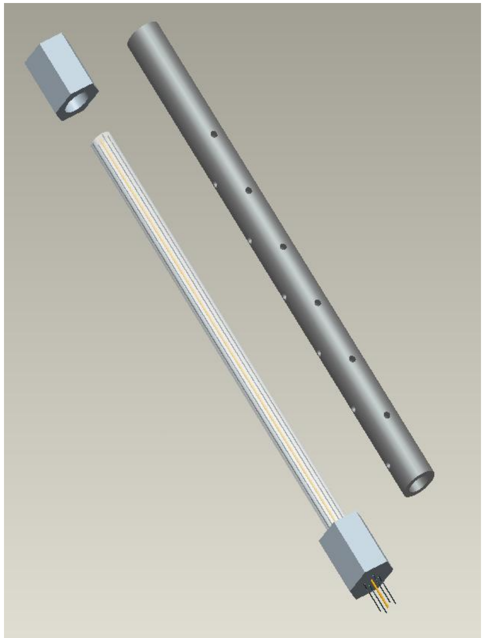
Anode

- Stainless steel electrodes
- Ignition at cathode or anode

Proof of Concept Testing



First prototype - Stainless steel simulated igniter tube



- Performed at DSSP
- Two propellant candidates
  - ***HIPEP***
  - ***BADB***
- Test voltage – 300V
- Single electrical pulse

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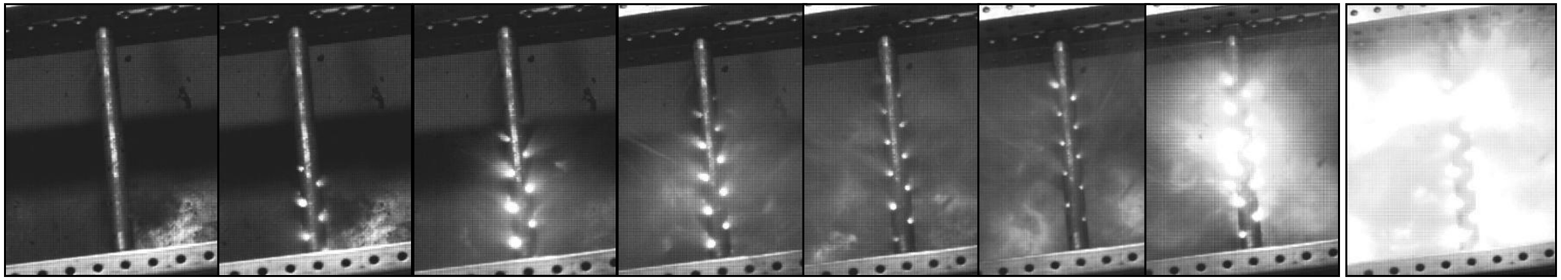
Proof of Concept Testing

Success!

- Perforations on polyethylene liner in alignment with igniter tube holes
  - All holes opened – Current system does not see consistent burn through all igniter holes
  - Polyethylene tube part of igniter enhancement effort separately supported by PM MAS due to issues with current purple lacquer
- Some propellant unconsumed
  - Phase II will look at what quantity of material is actually required – current firing maximized all available space in the primer tube
- Electrodes were twisted and broken – design optimization work still needed

Ignition

HIPEP Propellant



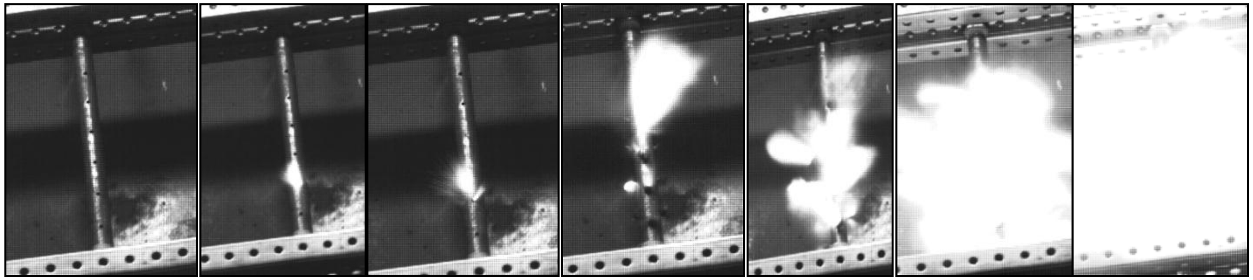
Stills are in 172µs intervals

- Additional tests performed at DSSP with high speed camera
- Sequential ignition along primer body
- Total action time* = 24.6ms
- Igniter perforations open after ~ 1ms

**Total action time is defined as the time from observed smoke to dissipation of flames*

Ignition

BADB Propellant



Stills are in 173µs - 316µs intervals

- Uneven ignition - igniter holes skipped as reaction spreads
- Intense fireball generated
- Lower power requirement than HIPEP
- Total action time* = 19.5ms

**Total action time is defined as the time from observed smoke to dissipation of flames*

Safety Tests

UN Series 3 Tests – Classification for New Substances

Formulation	Igniter Sensitivity		
	Impact ERL (cm)	Friction (GO / No GO) (N)	ESD (J)
HIPEP	>158.5	No GO	>0.25
BADB	>158.5	No GO	>0.25
Class 3 PETN	18.8	288 / 252	>0.25
Class 1 Type 2 RDX	23.2	>360	>0.25

Both ECEM formulations did not react at under the maximum loads for impact, friction, and ESD tests.

Thermal Stability

Uninstrumented Thermal Stability

Sample	Weight Loss (%)
HIPEP	>1.00
BADB	>1.00
Propellant, Passing	<1.00

- Possible moisture problem – propellants are hygroscopic
- Follow on testing to be performed
    - Instrumented thermal stability (mass spec)
- Discovered formulation and processing issue at ARDEC

Cut up pre-test samples

Future Work

- Investigate ingredients and alternative formulations to improve performance, moisture absorption and stability at hot and cold temperatures
- Conduct static igniter firing tests to collect pressure data at the primer holes
- Evaluate the propellants in a ballistic simulator
    - Will give insight as to whether or not enough hot particles are being generated to light a bed of propellant in 120mm tank rounds
- Start adapting this technology for explosives and thrusters applications

Summary

- Completed safety and proof of concept testing
- Optimize
    - Propellant formulation
    - Electrode design
    - Mass of propellant
- Test performance in a ballistic simulator
- Adapt technology for other energetic applications

Acknowledgements

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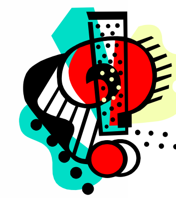
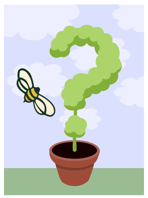
- Alma Valdivia
- Tim Manship

Questions?



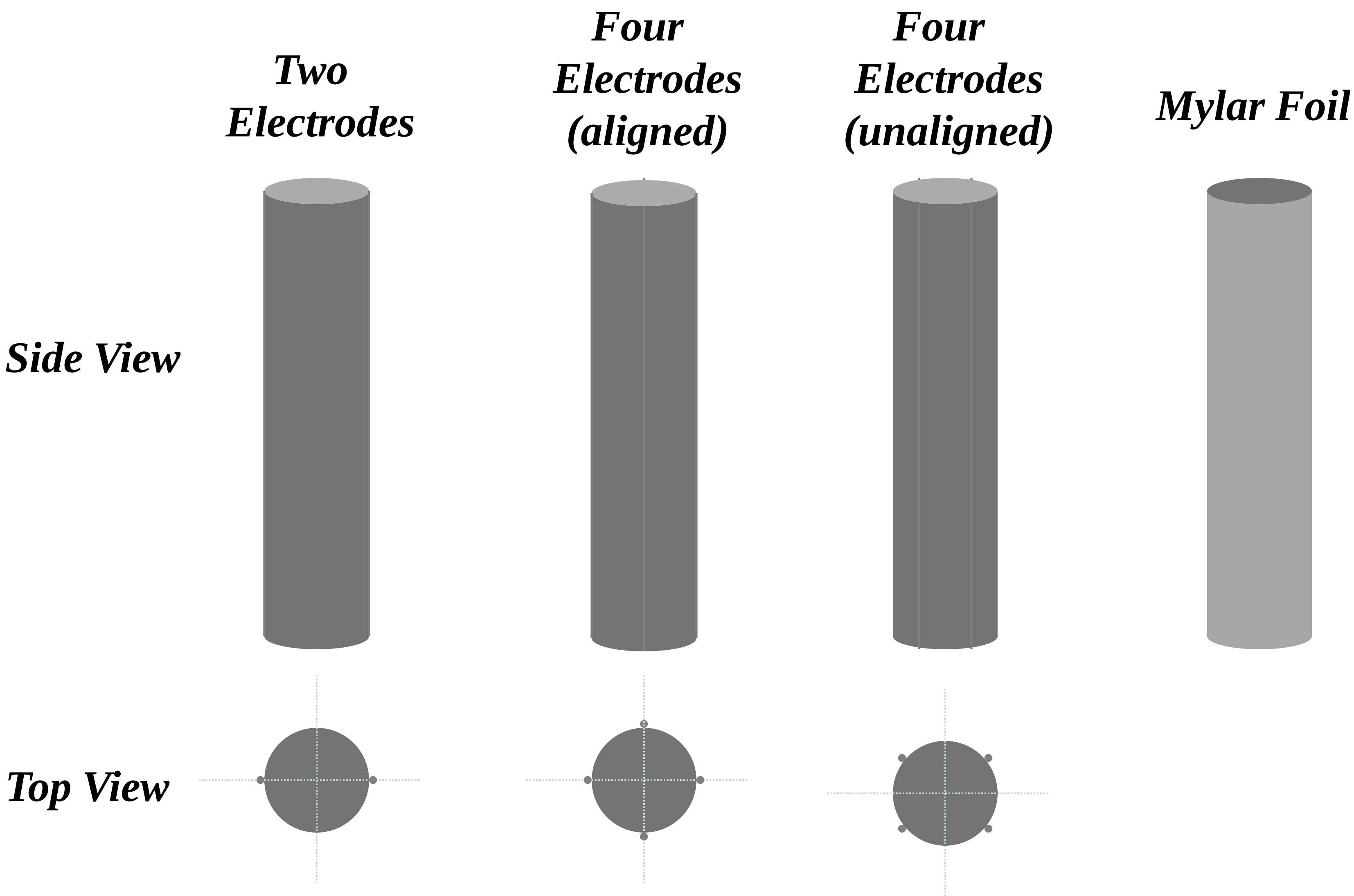







Back Up Slides

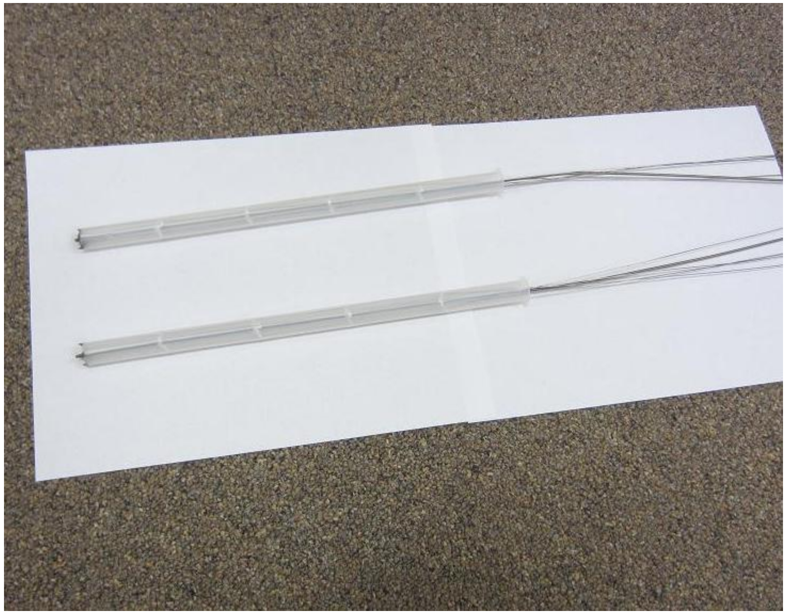
Electrode Designs

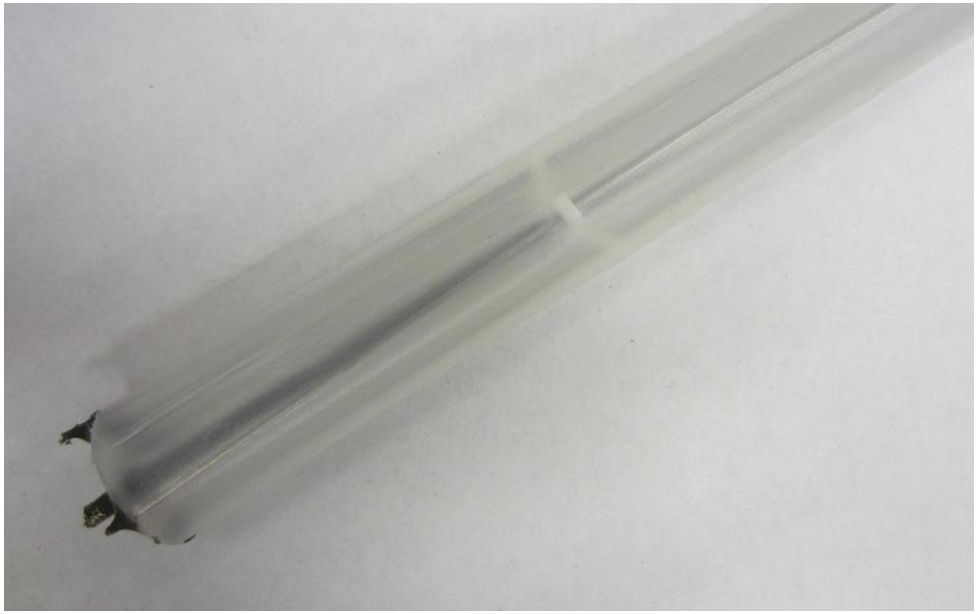


BADB Propellant

Bad Propellant

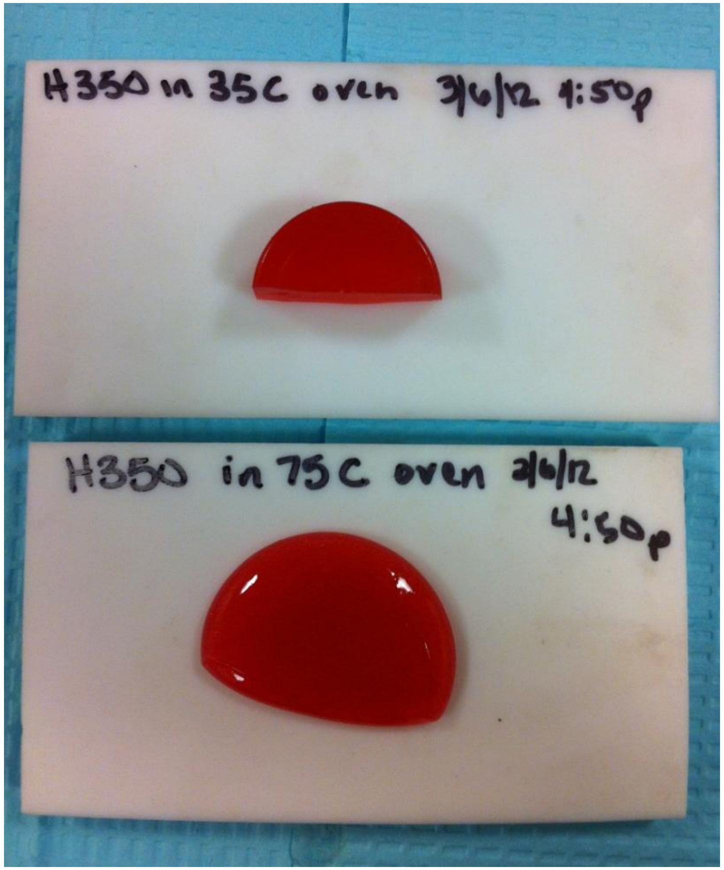
Liner/Electrode Preparation





Thermal Stability Update - HIPEP

- New material tested at DSSP
- Samples made with stoichiometric HAN slumped at 75ºC , weight loss noted
- Sample weight reverted back to original value under ambient conditions



Initial Formulation Problems

- Stabilized HAN was found to contain excess hydroxylamine
- Hydroxylamine decomposes at 58ºC

Proof of Concept Video Stills

BADB Propellant

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