

Novel Plasticizer for IM Compliant Solid Propellants

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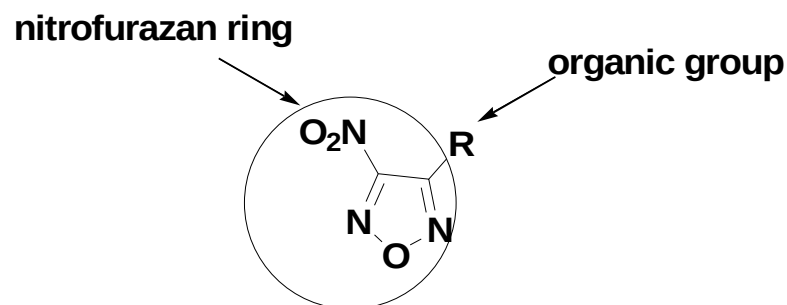
- **36 year-old company of 180 talented scientists, and engineers**
- **We work in headquarters in Andover, MA, with five satellite locations in the United States**
- **Acoustics**
- **Electro-magnetics**
- **Fluid physics**
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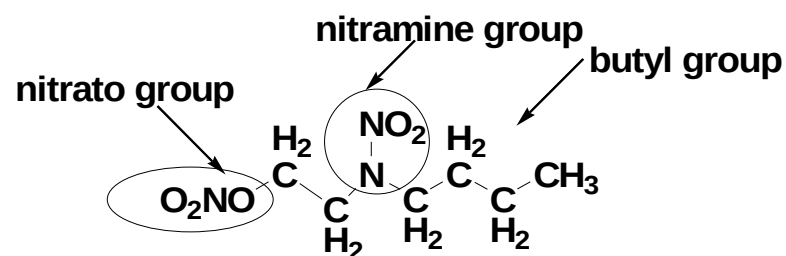
Nitrofurazan Plasticizers (NF)

VG09-052-2

- Nitrofurazan family offers promise as high energy, good thermal behavior, high density and low sensitivity plasticizers



NF plasticizers



Butyl NENA plasticizer

- NF core: heterocyclic ring with high thermal stability, good density
- Organic Group R: capability to functionalize the nitrofurazanic core
- R group variation may generate various categories of NF plasticizers

Background: NF1

- **PSI synthesized and characterized NF1 from low cost precursors (30% yield)**
- **Aerojet performed the energetic and thermal properties testing: promising plasticizer with good energy and good density**

	Density Gm/cc	Decomposition Temperature, °C	ΔH_f, Kcal/mol
NF1 theor	1.620	180	69.5
NF1 exp.	1.467	180	58.8
Butyl NENA	1.211	165	-45.55
TMETN	1.488	158	-105.8
BTTN	1.520	154	-92.6

Background: NF1 Cont'd

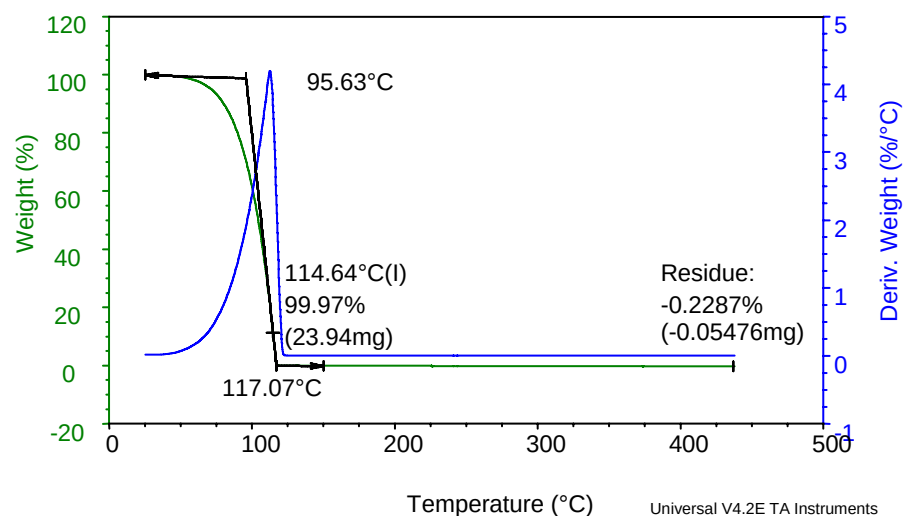
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- **NF1 properties**
 - Low viscosity fluid
 - Moderate volatility
- **Measurements show it is insensitive**
 - Category “Green” [normal]

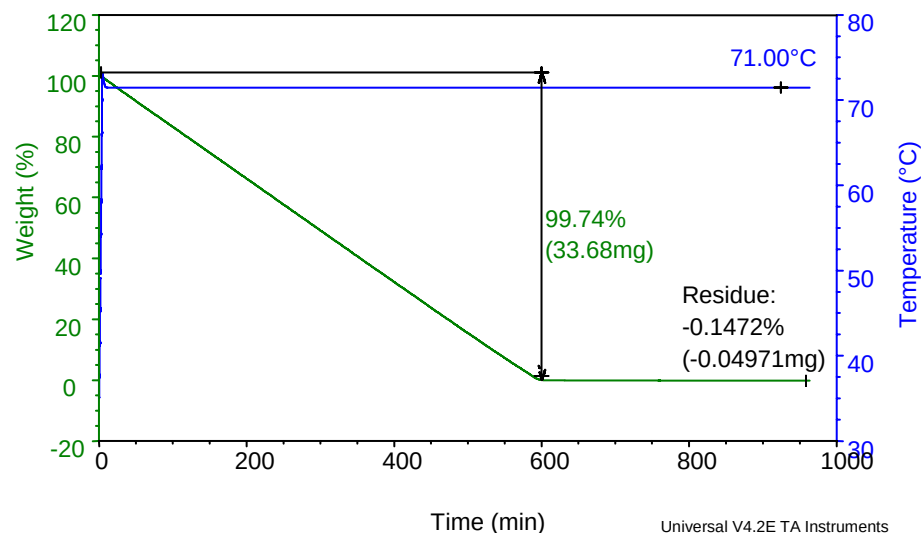
Hazard	NF1	RDX
Impact, kg-cm	145	49
Friction, psi @ drop angle, °	1800 @ 90°	1200@90°
ESD, J @ 5kv	6.0	0.38

Background: NF1 Cont'd

VG09-052-5



Onset of weight loss in TGA occurs at a low temperature

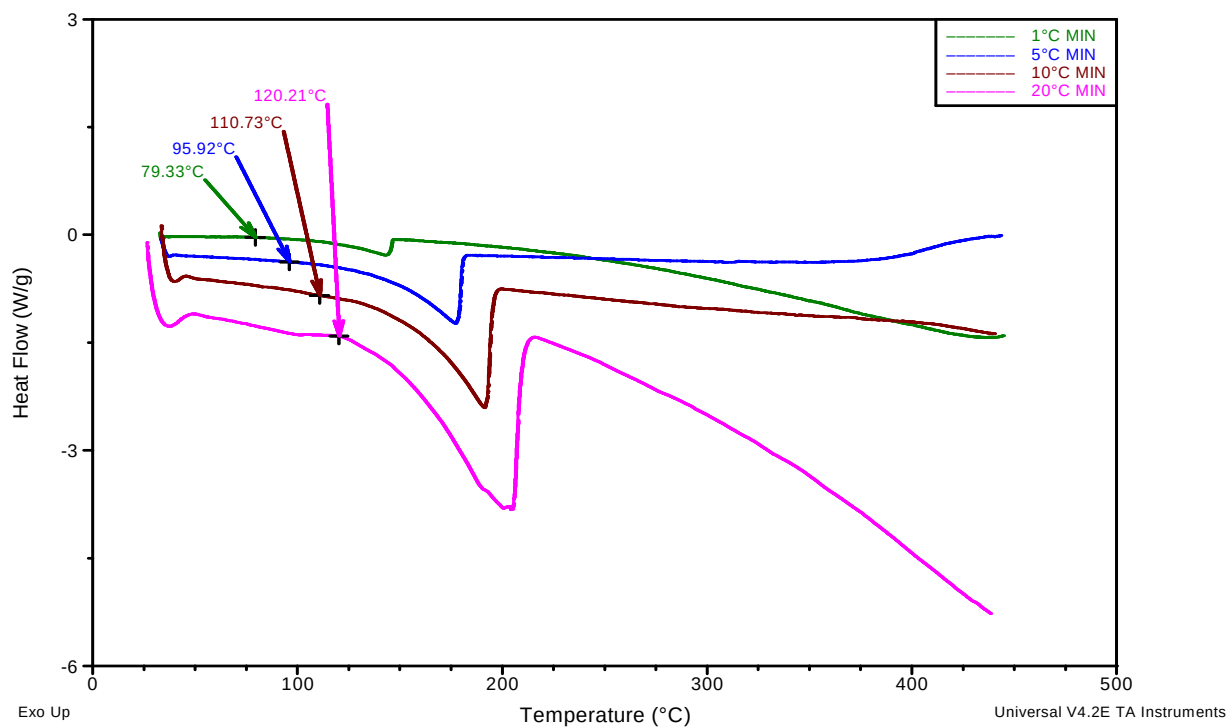


Isothermal TGA shows material evaporates after 10 hr at 70°C

Chemical modification to NF1 was required to eliminate volatility

NF1: Background Cont'd

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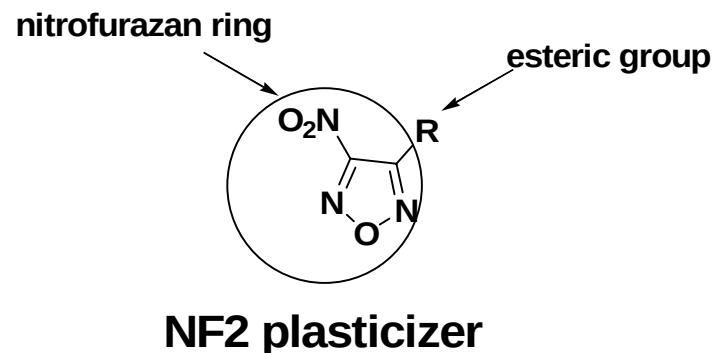
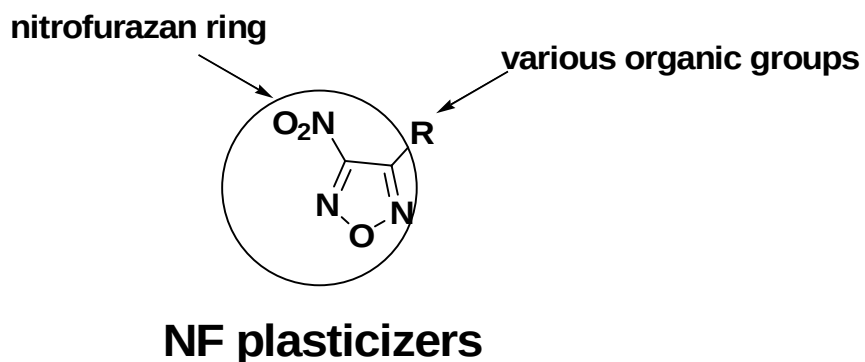


In Differential Scanning Calorimetry (DSC)
only endotherms noted due to vaporization – no exotherms

Novel Nitrofurazan Plasticizer: NF2

VG09-052-7

- Variation of the R group generated various NF classes of nitrofurazanic plasticizers
- R = esteric group: Esteric NF Plasticizers Candidates
- NF2 showed good energy, good density and acceptable volatility





Novel Nitrofurazan Plasticizer: NF2 Cont'd

VG09-052-8

	Density G/cm ³	Decomposition Temperature, °C	ΔHf, Kcal/mol
NF2 exp.	1.264	176.4	-62
NF1 exp.	1.467	180	58.8
Butyl NENA	1.211	165	-45.55
TMETN	1.488	158	-105.8
BTTN	1.520	154	-92.6

NF2 has good sensitivity and good thermal properties

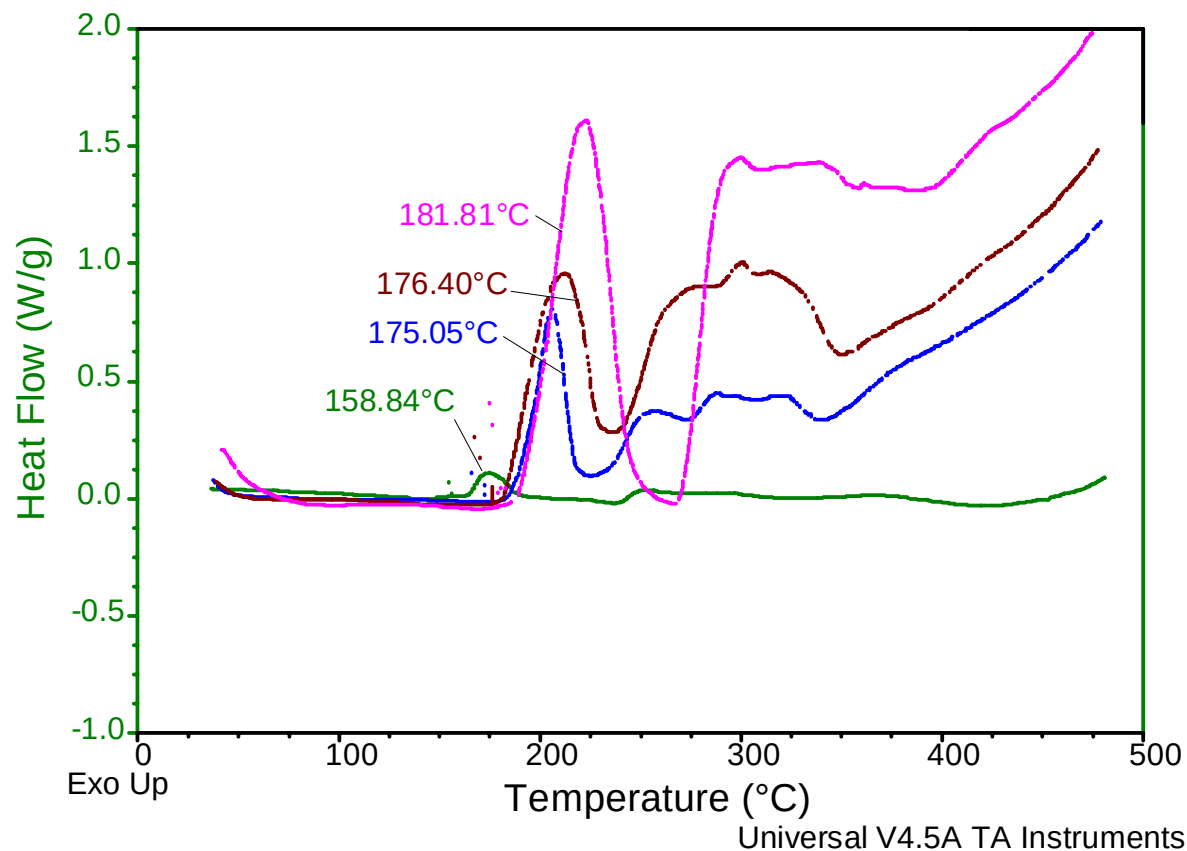
Hazard	NF2	RDX
Impact, kg-cm	300	49
Friction, psi @ drop angle, °	1800 @ 90°	1200@90°
ESD, J @ 5kv	6.0	0.38



Novel Nitrofurazan Plasticizer: NF2 Cont'd

VG09-052-9

DSC Overlay: 1 °C/min., 5 °C/min., 10 °C/min., 20 °C/min.



In Differential Scanning Calorimetry (DSC)
only exotherms were noted: low volatility of NF2

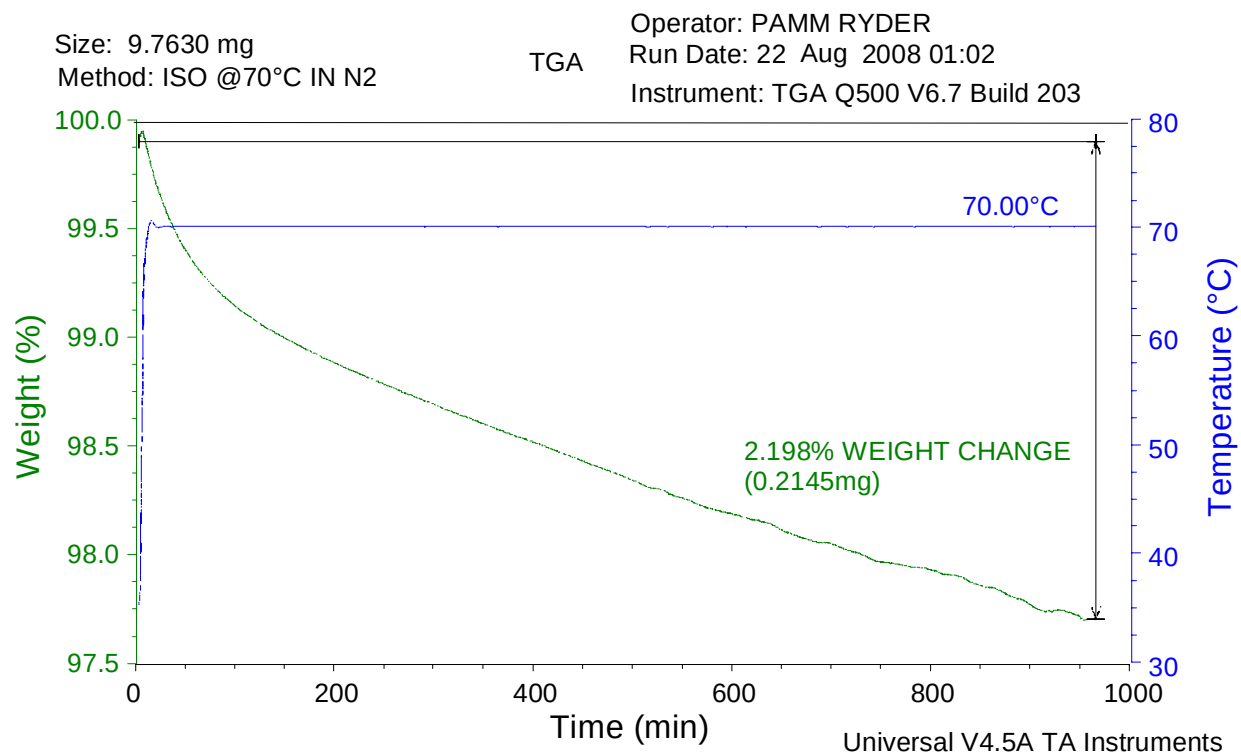


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Novel Nitrofurazan Plasticizer: NF2 Cont'd

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TGA ISO @ 70°C FOR 16 HRS



NF2 has low volatility: 2% loss in weight at 70 °C for 16 hrs



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Novel Nitrofurazan Plasticizer: NF2 Cont'd

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Thermal Gravimetric Analysis 1°C MIN

Size: 10.6370 mg

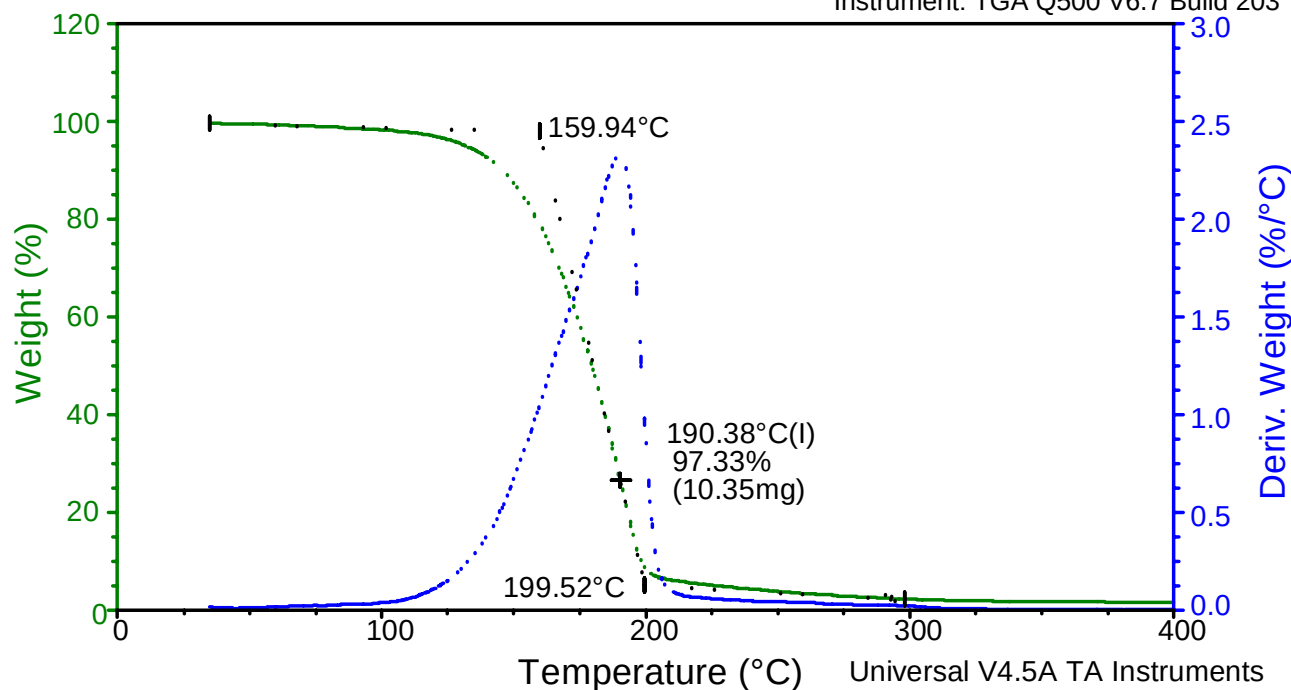
Method: 1°C MIN TO 600°C IN N2

TGA

Operator: PAMM RYDER

Run Date: 21-Aug-2008 13:57

Instrument: TGA Q500 V6.7 Build 203



Onset in the weight loss for NF2 starts above 100 °C



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Conclusions

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- **NF2 has been successfully synthesized and characterized in a 40% overall yield**
- **NF2 synthesis used low cost precursors and was produced in high purity (>98%)**
- **NF2 Testing Results: insensitive (“green” category material)**
- **NF2 showed good thermal properties: it has good decomposition temperature and low volatility**
- **Additional work will be conducted - NF2 will be incorporated in propellant samples (work in progress at Aerojet)**

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