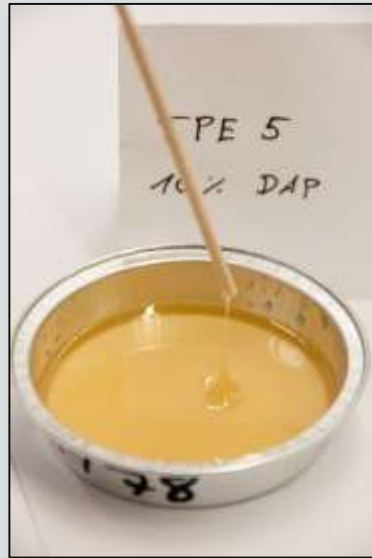


# DAP: A promising chain extender for energetic thermoplastic elastomers



Marcel Holler

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# Content

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- Introduction
- Synthesis and Characterization of new energetic chain extenders
- Synthesis of ETPEs
- Development and testing of new ETPE-based PBX
- Outlook

# Introduction

- Most explosives are embedded in a matrix for optimum processability and safe handling
- A variety of binder/softener combinations is in use
- Using inert material dilutes explosive power



Semtex RAZOR™



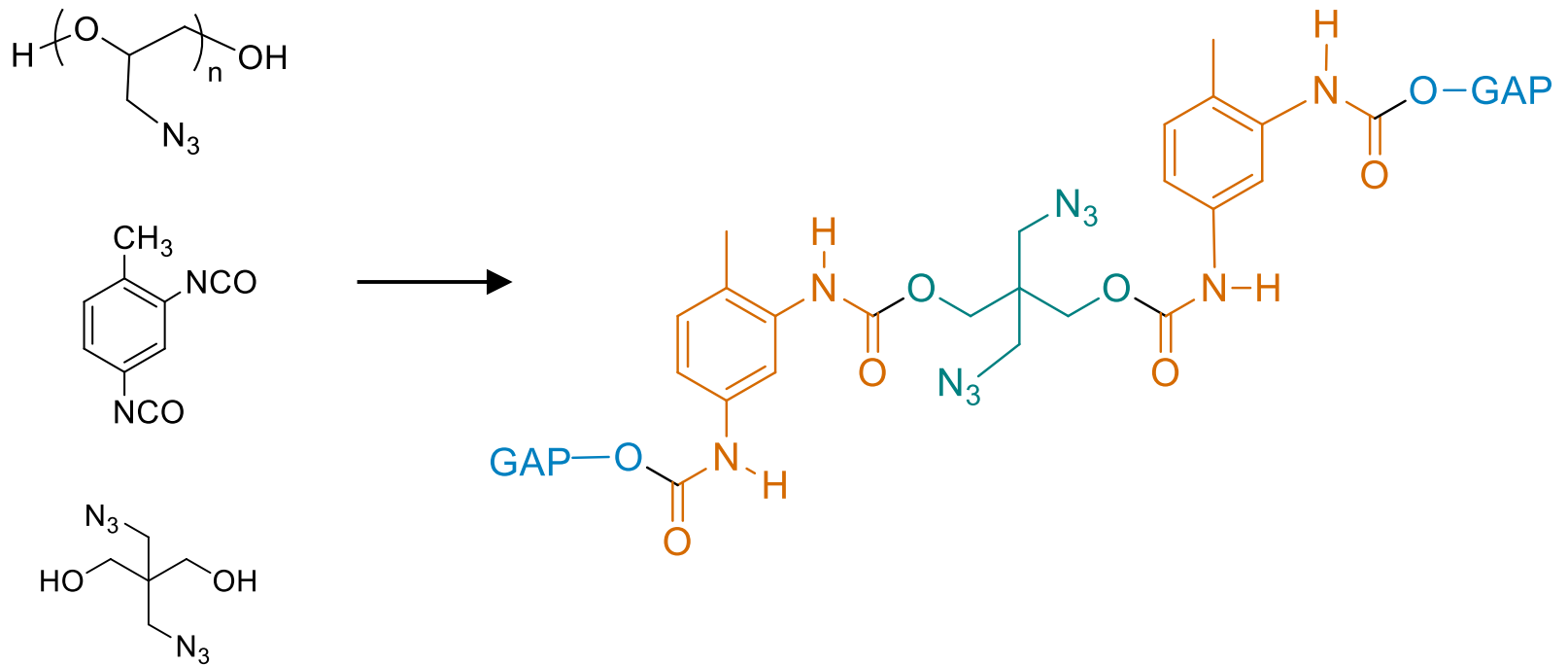
Mk. 82 General Purpose Bomb

Component	m-%
RDX	64
Al	20
HTPB	8.5
DOA	2.5

Formulation of PBXN-109

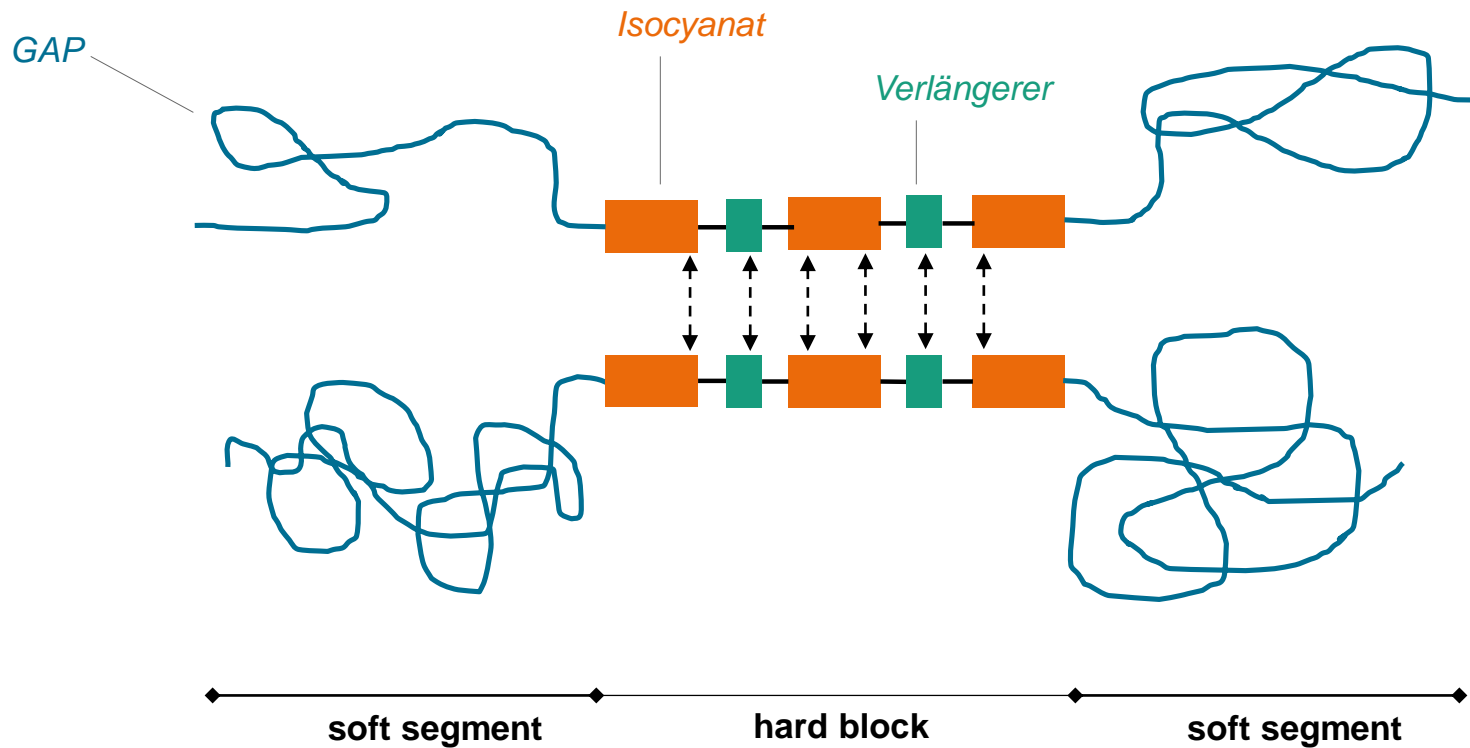
# Introduction

- Better performance by using energetic thermoplastic elastomers (ETPEs)



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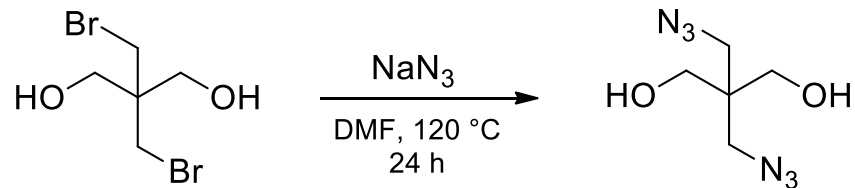


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# DAP (Diazidopentaerythritol)

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- Classic azidation in polar aprotic solvent, e.g. DMF

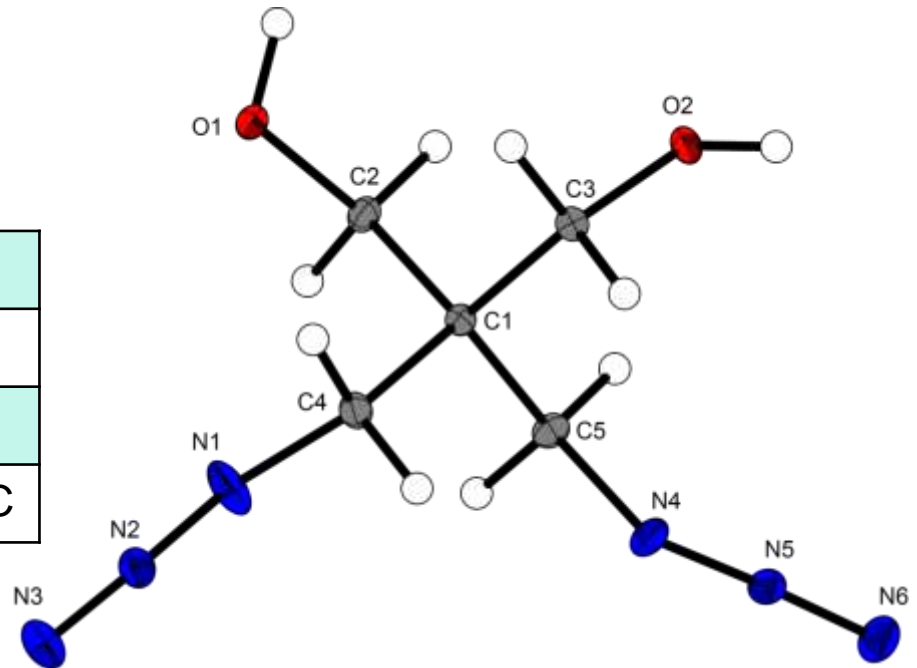


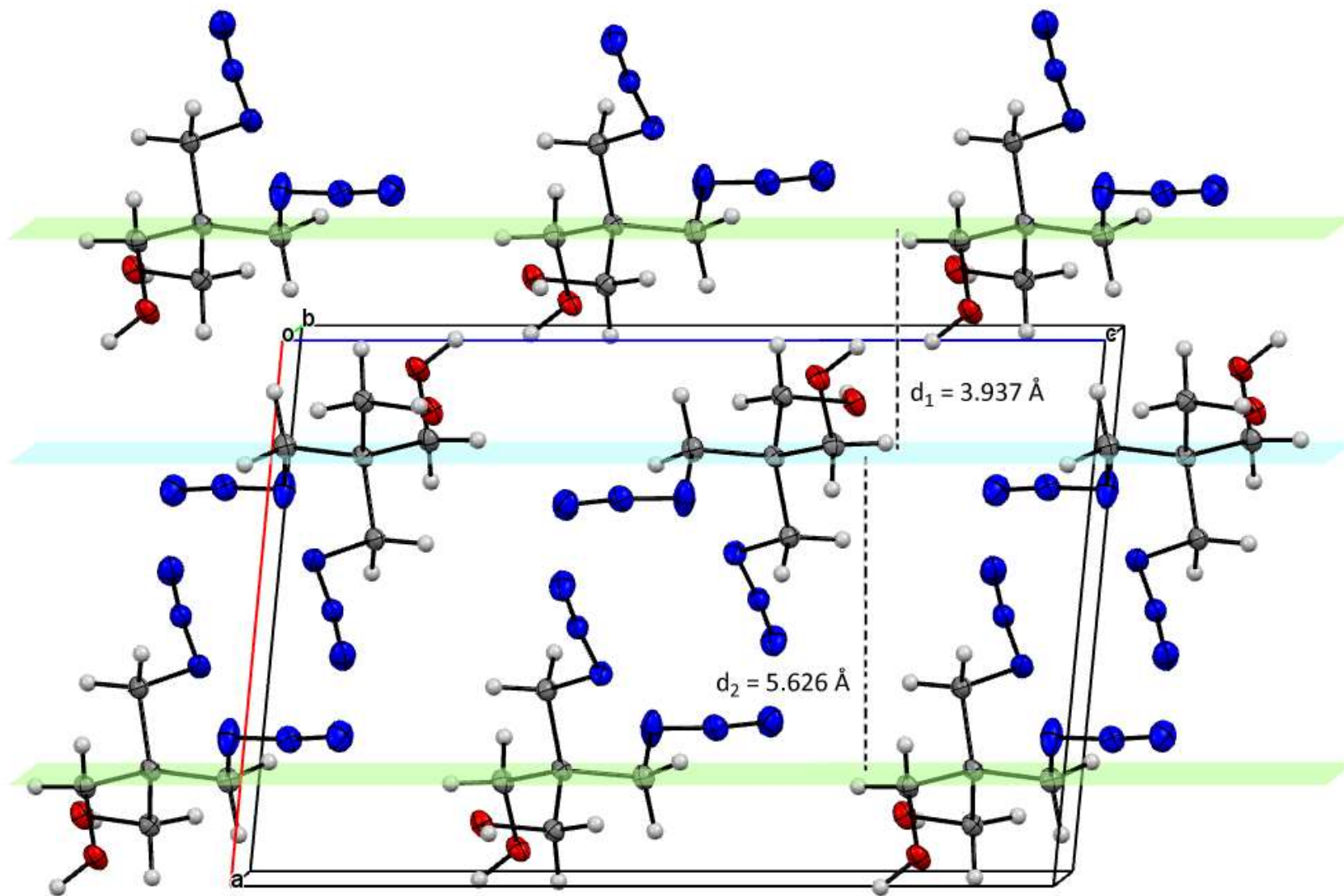
- For the first time: synthesis and characterization of pure target substance
- Current focus: alternative, **green** synthesis methods

# DAP (Diazidopentaerythritol)

- crystal structure from single crystal X-Ray
- Extensive characterization (IR, Raman, NMR, mass spectrometry, DSC, TGA, sensitivity)

Friction sensitivity	324 N
Impact sensitivity	25 J
Melting point	32.0 °C
Thermal stability (DSC onset)	198.2 °C

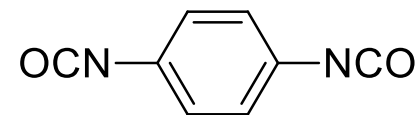
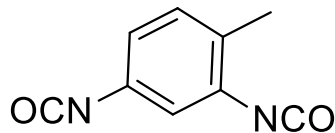
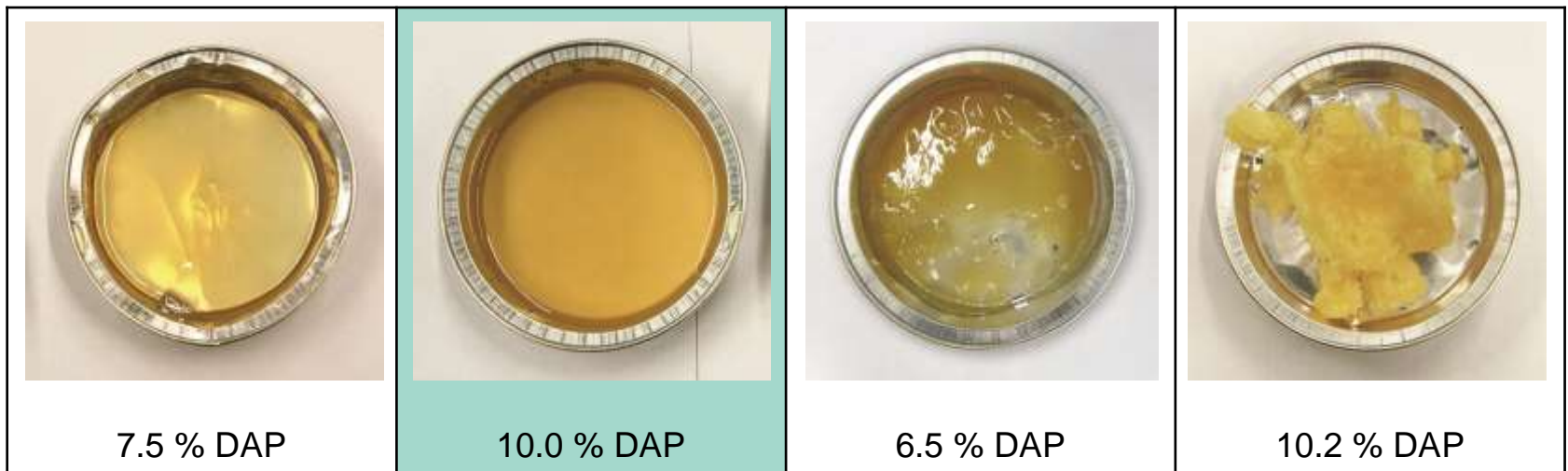






# Synthesis of DAP-based ETPEs

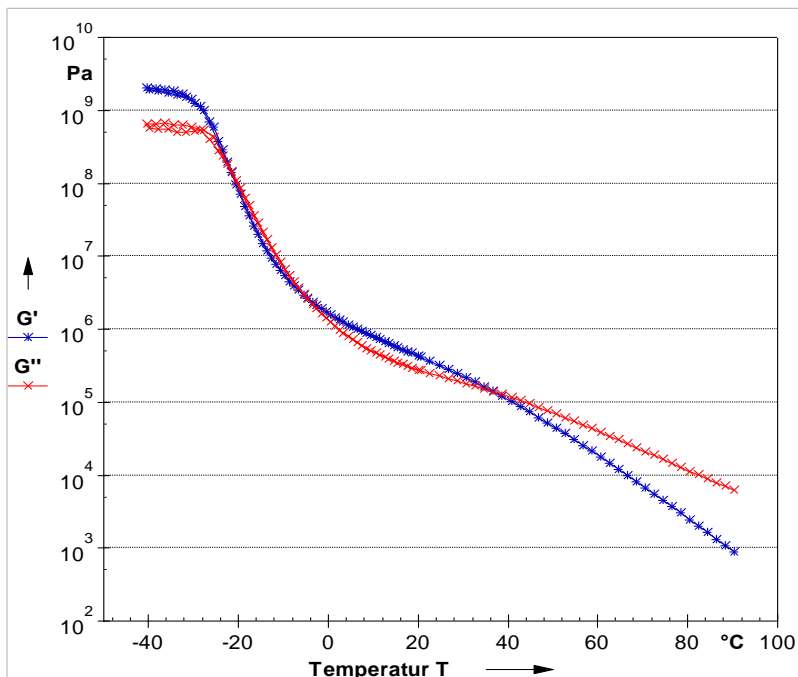
- Main compound: GAP-diol
- Variation of composition and choice of isocyanate
- A broad variety of consistencies is available



# Synthesis of DAP-based ETPEs

## ETPE 5

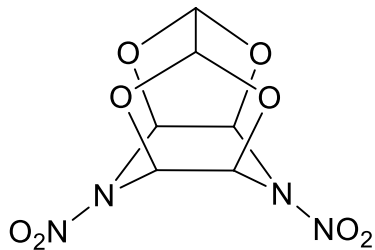
75 % GAP, 10 % DAP, 15 % TDI



Friction sensitivity	> 360 N
Impact sensitivity	25 J
Glass transition point	-34.5 °C
Thermal decomposition	214.5 °C
$\Delta H_c^\circ$	-20.68 kJ/g
$M_w$	44620

# Development of new PBX

- Main ingredients: HMX and TEX
- 2 PBX were manufactured and tested: one with ETPE 5 and one with inert binder (paraffin)



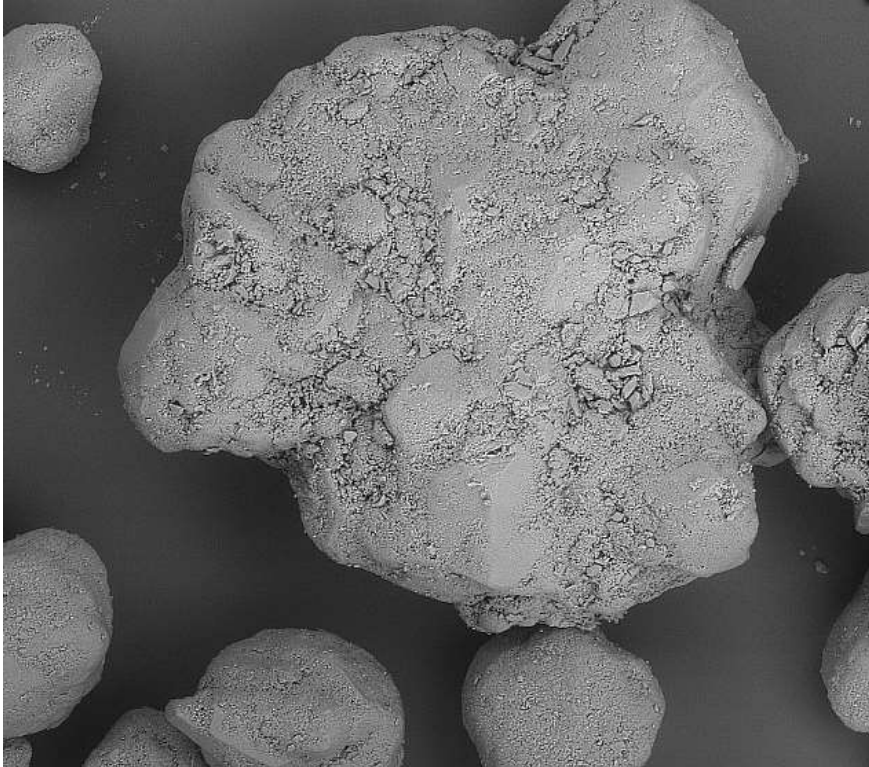
component	m-[%]
HMX (340 μm)	68.6
HMX (17 μm)	22.1
TEX	4.8
Graphite	0.5
Binder	4



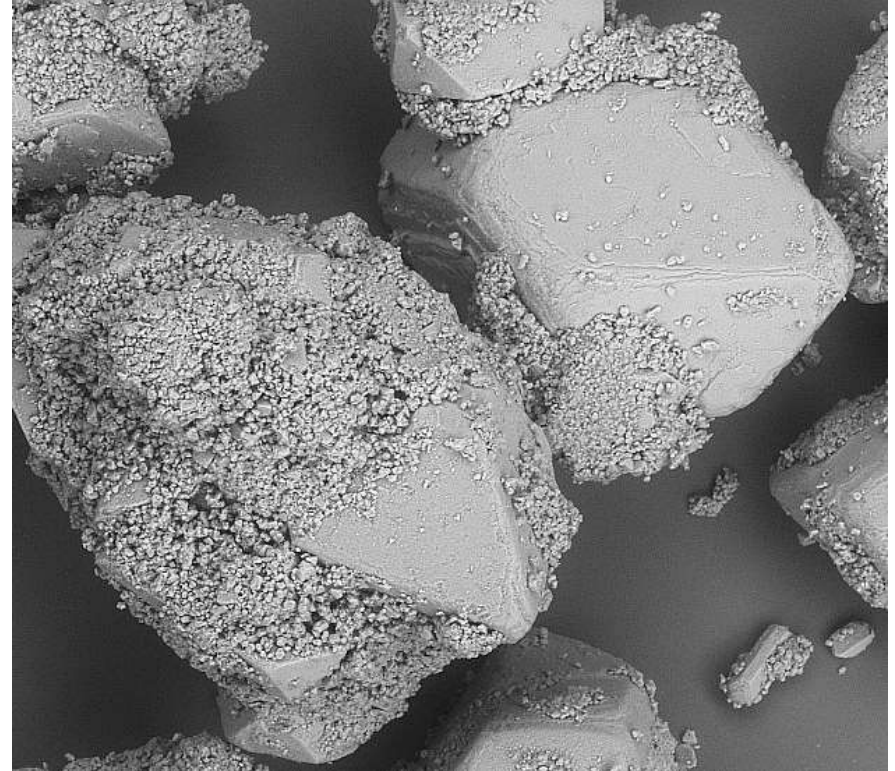
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# Development of new PBX

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**ETPE**



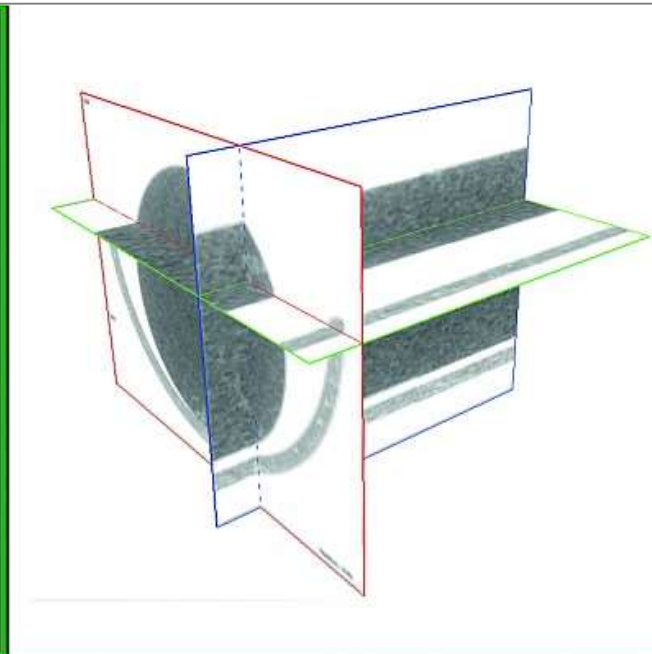
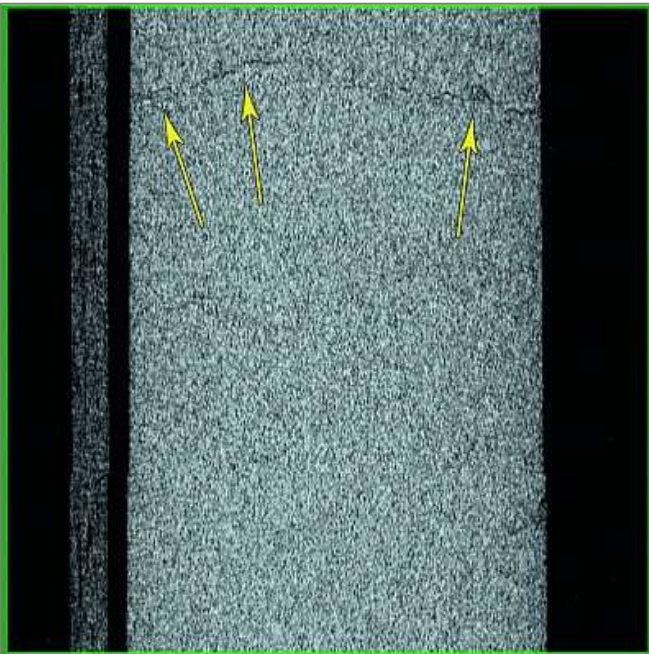
**Paraffin**

# Processing

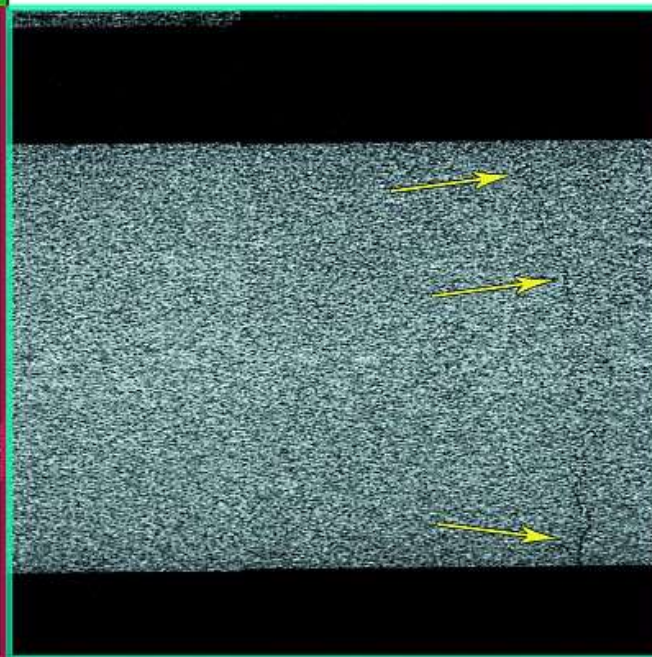
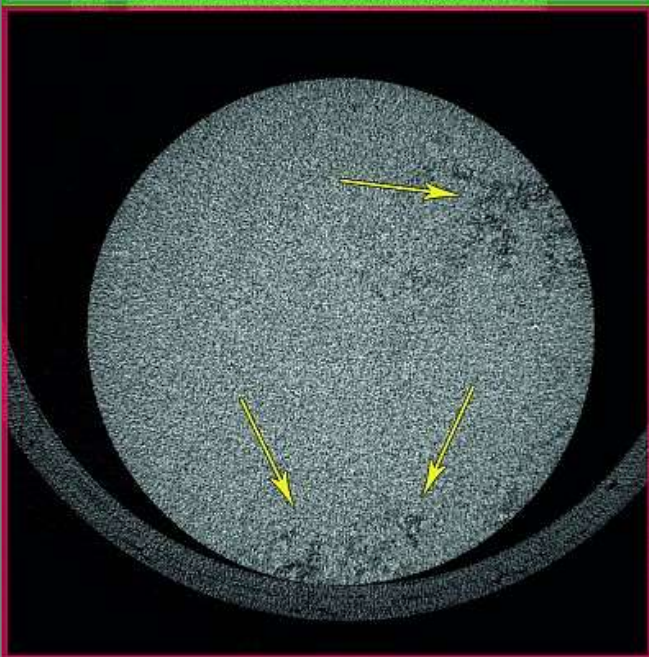


- compacts  $\varnothing$  21 mm x 21 mm
- dual side pressing, 69 kN or 87 kN
- ETPE: 97.4 % TMD
- Paraffin: 99.3 % TMD



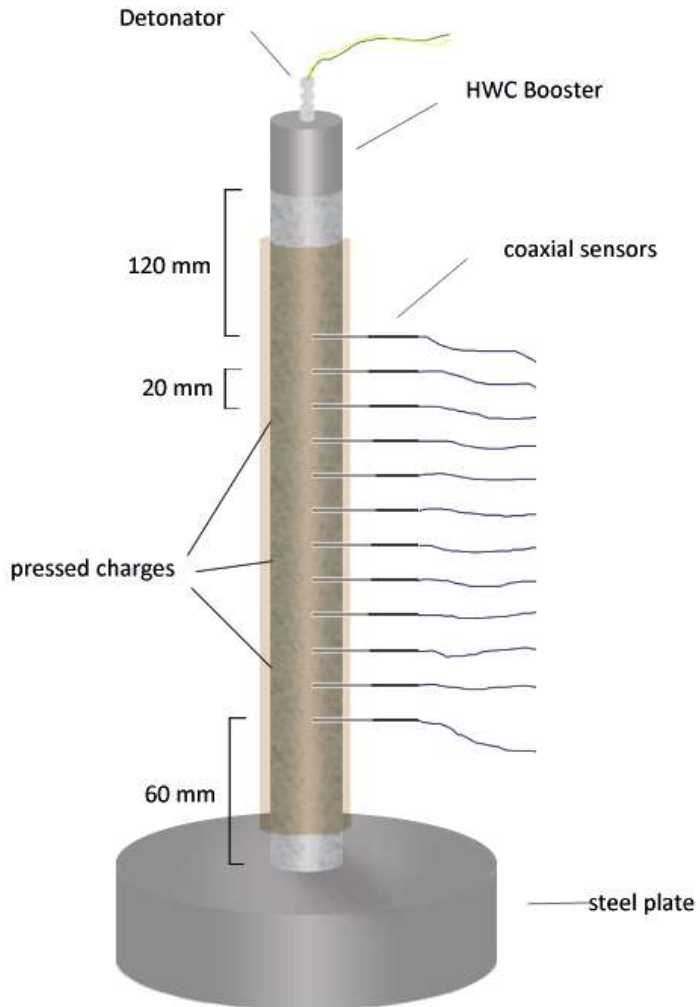


- cracks and voids in paraffin-bound compacts



- ETPE-bound compacts: clean and uniform density

# Detonics



- Configuration for VoD and plate-dent measurement (20 compacts)

	PBX 1	PBX 2
<b>VOD [m/s]</b>	8704.2 ± 8.2	8694.8 ± 10.5
<b>Plate-dent [mm]</b>	4.67 ± 0.03	5.25 ± 0.03
<b>GAP-test GO</b>	18 mm (20.4 kbar)	
<b>GAP-test No-GO</b>	19 mm (17.2 kbar)	



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# Summary

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- Synthesis and characterization of pure DAP
- DAP ensures ETPEs with consistency from viscous gel to stiff, rubbery flakes
- Proof of concept: DAP-based ETPEs as binder for pressed charges
- Excellent coating and adhesive properties
- Considerably improved detonation pressure
- Improvement towards IM characteristics with higher binder content possible



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# Outlook

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- Systematic analysis of GAP-DAP ETPEs, build-up of binder library
- Current work exploring the use of DAP-based ETPEs in gun / rocket propellants and pyrotechnics
- Optimizing pressed charges towards IM properties

## Thank you:

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