Crossing Forensic Borders
CLHC kick-off event
2 December 2020

# Going beyond detection and identification in forensic explosives investigations

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# Explosives incidents

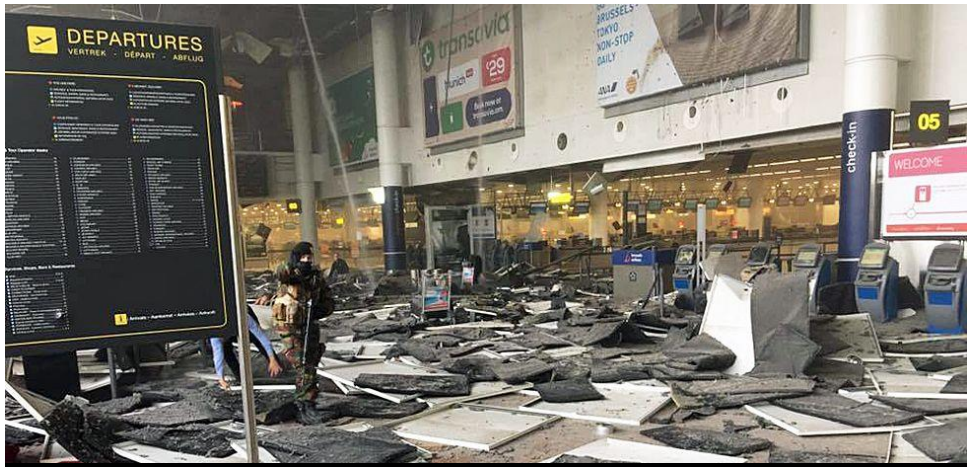
Disaster

2020 Beirut

# Explosives incidents

2011 Oslo

**Terrorist attacks**




2016 Brussels

2005 London

# ATM attacks

NOS NIEUWS • BINNENLAND • ECONOMIE • 28-11-2019, 21:42

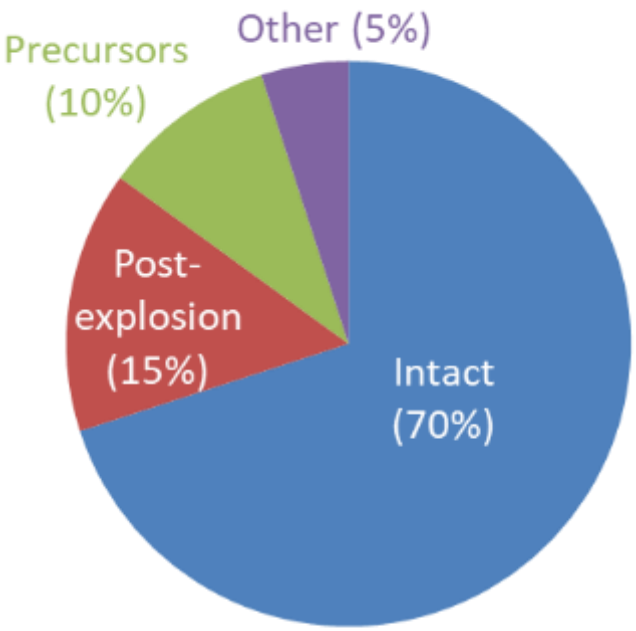
## 'Plofkraakschade is enorm, en veel ondernemers draaien er zelf voor op'

**‘Damage caused by ATM Raids is enormous and many entrepreneurs have to face the costs themselves.’**

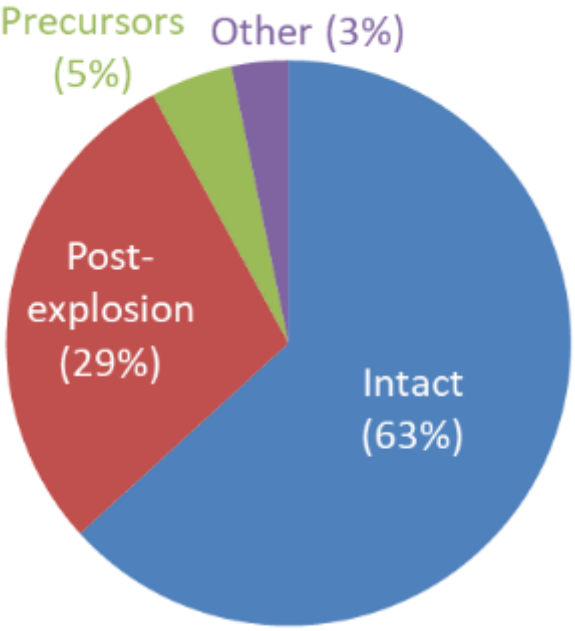
# ATM attacks

# Trend in NL: ATM attacks and Handgrenades

# Forensic explosives casework in the Netherlands




2009 – 2013
(n = ± 1000 cases)




2014 – 2018
(n = 815 cases)

# Chemical analysis

***Detection and Identification***
*Is an explosive present?*
*If so: what explosive are we dealing with?*

Unknown explosive

- Bulk
  - Organic
    - IR spectroscopy
    - XRD
  - Raman Spectroscopy
  - Inorganic
    - XRD
    - XRF
- Trace
  - Organic
    - LC-MS
  - Inorganic
    - IC/IC-MS

# Beyond detection…

**FEXIN**
**Forensic Explosives Intelligence**

*Go beyond detection and chemical identification and provide valuable information to solve and maybe even prevent crimes with explosives!*

# Misuse of fireworks

## Illegal use and trade of professional fireworks

→ Many incidents involve powerful flash bangers (Cobra 6)


Irresponsible and risky adolescent behavior

Criminal activities

Terrorist threats

# Misuse of fireworks

## Illegal use and trade of professional fireworks

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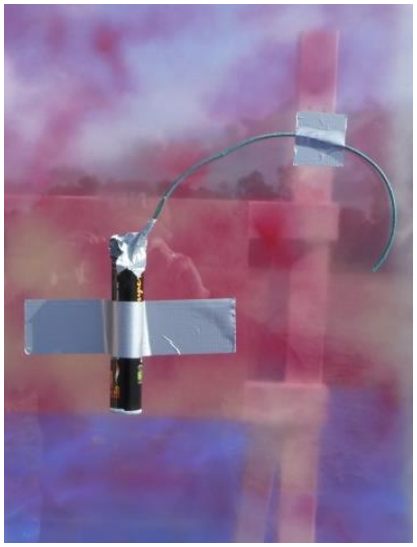
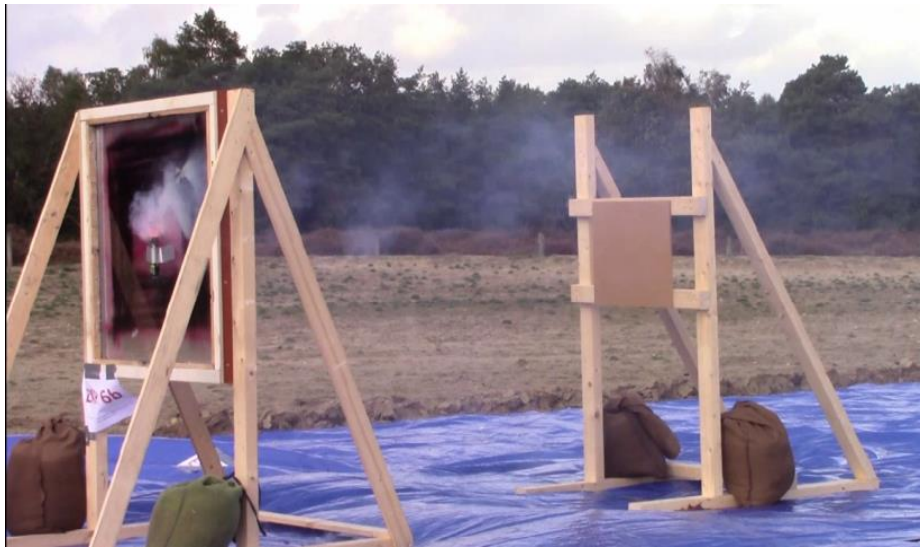
Irresponsible and risky adolescent behavior

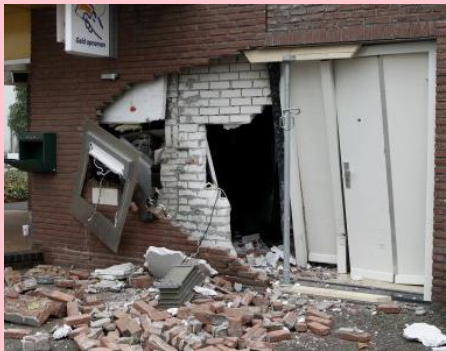
Criminal activities

Terrorist threats





# From identification to individualisation




**FEXIN**
Forensic Explosives Intelligence

***Can we differentiate between different batches of explosives?***

***Can we link explosive materials from crime scenes and suspects?***

# Cobra 6 sample collection


**Cobra 6 (2016):**
**22000 items confiscated**

**1800 items collected**



**200 items disassembled**

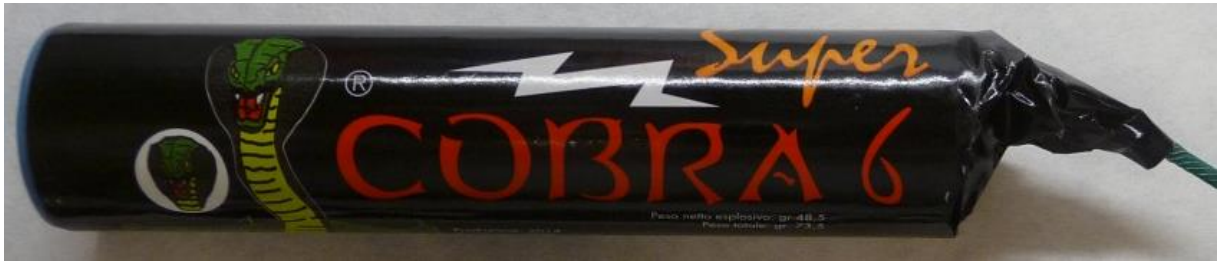
# Profiling of Cobra 6 fireworks

*Visual examination*

**Cobra 6 2G**


**Cobra 6 imitation**


**Cobra 6**



# Profiling of Cobra 6 fireworks

***Visual examination***

**Cobra 6 2G**

**Cobra 6 imitation**


**Cobra 6**

# Profiling of Cobra 6 fireworks

*Visual examination*

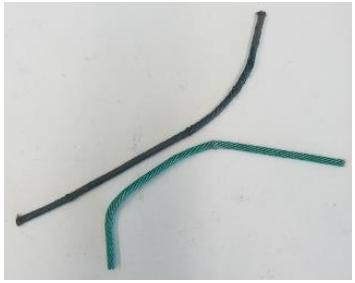
**Cobra 6 2G**

**Cobra 6 imitation**

**Cobra 6**

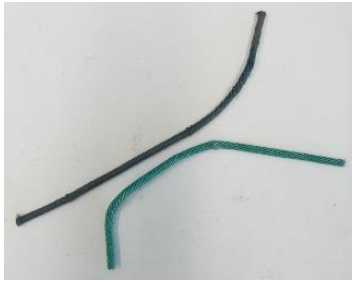
# Profiling of Cobra 6 fireworks

*Visual examination*




# Profiling of Cobra 6 fireworks

*Visual examination*

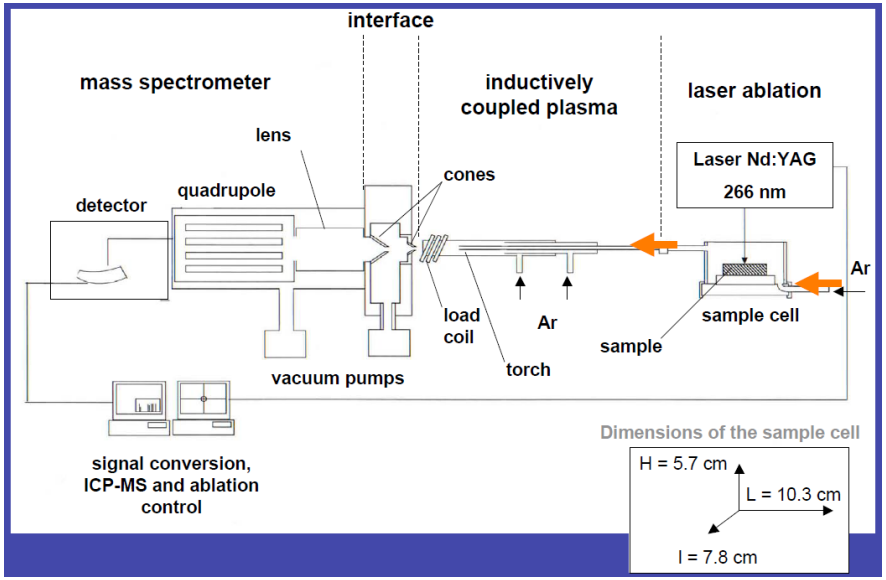



*But what about post-explosive… Can we link an intact item to post-explosive residues?*

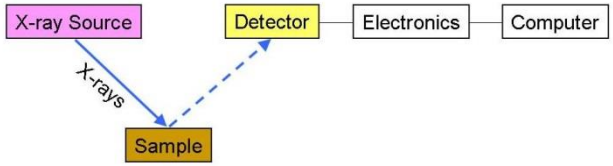
# Profiling of Cobra 6 fireworks

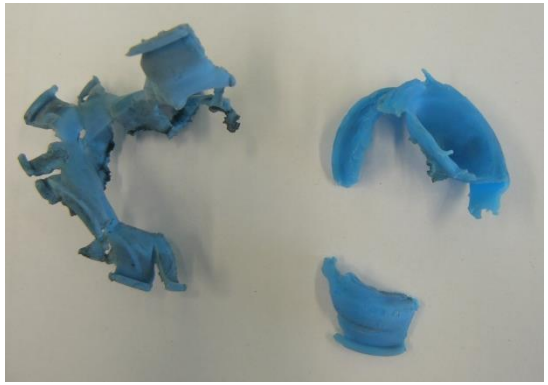
*Elemental analysis of plastic caps*

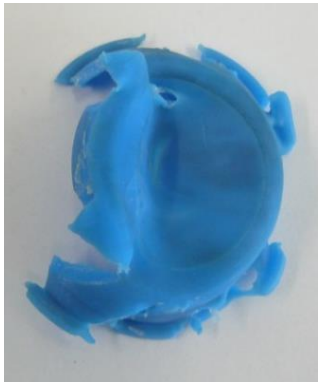
## Laser Ablation – Inductively Coupled Plasma – Mass Spectrometry (LA-ICP-MS)

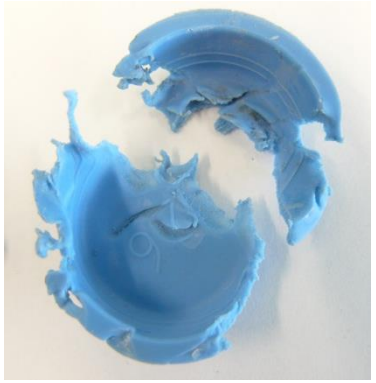



## X-ray fluorescence (XRF)



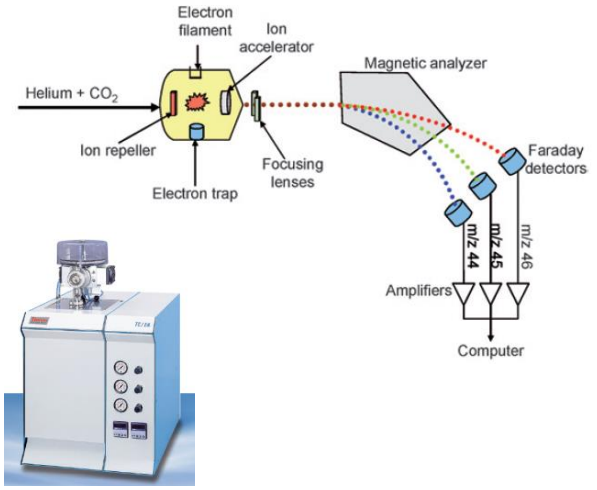


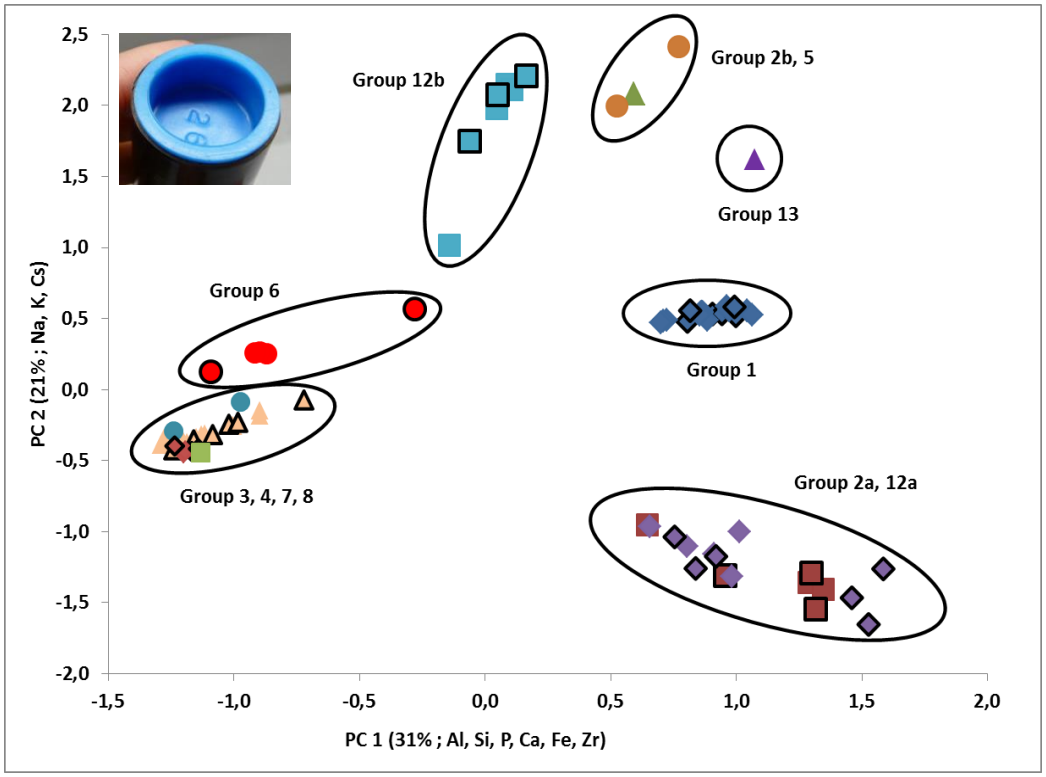


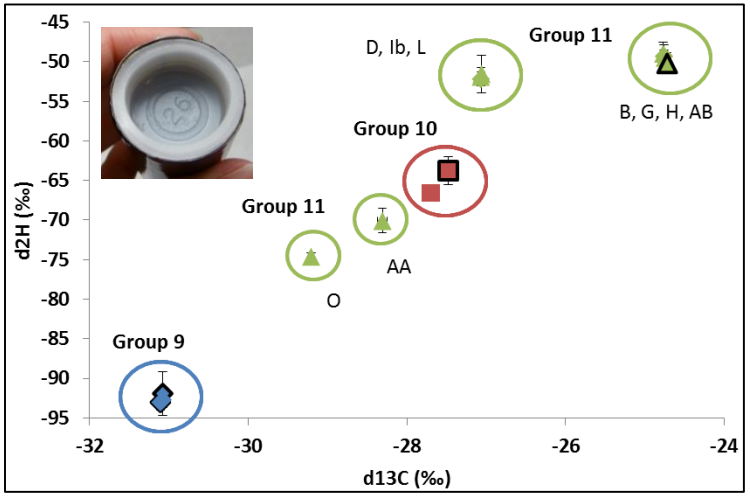
# Profiling of Cobra 6 fireworks

*Elemental analysis of plastic caps*

*Isotope analysis of plastic caps*



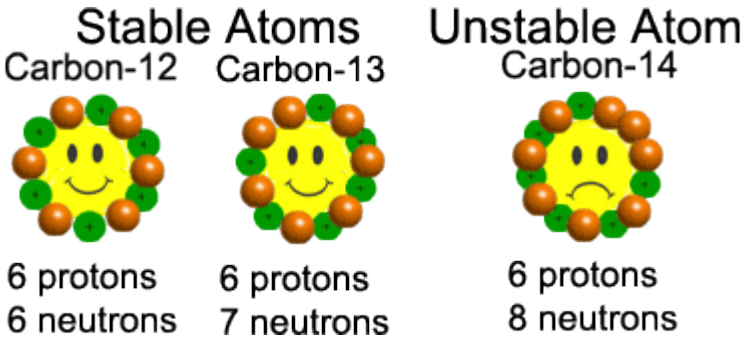



# One slide on isotopes

Natural abundance stable isotopes

| $^{12}C$ | $^{13}C$ | $^{14}C$ |
|---|---|---|
| 12.00000<br>98.89% | 13.00335<br>1.11% | 14.0<br>$t_{1/2}$ = 5715yrs |
| Stable | Stable | Radioactive<br>Cosmogenic/<br>anthropogenic |




$$\text{Ratio (R)} = \frac{\text{abundance of the heavy isotope}}{\text{abundance of the light isotope}}$$

## Definition of Isotopes

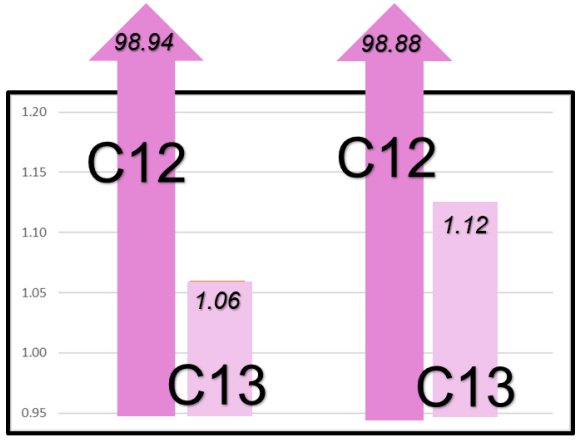
Atoms of the same element that contain an equal number of protons, but differ in their number of neutrons

## Isotopic composition of substance: Isotope ratios

→ e.g. $^{2}H/^{1}H$, $^{13}C/^{12}C$, $^{18}O/^{16}O$, $^{15}N/^{14}N$

→ Relative variations related to a reference scale

→ Expressed in ‰



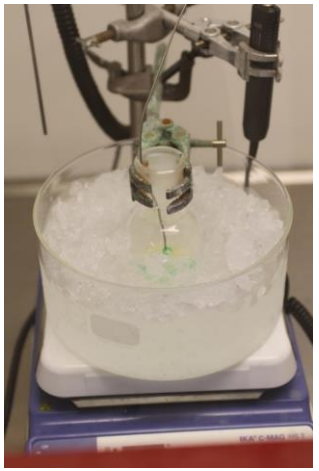
# From identification to individualisation

FEXIN
Forensic Explosives Intelligence

***Can we provide tactical information about production and origin of explosives?***

***Can we prevent an attack with explosives?***

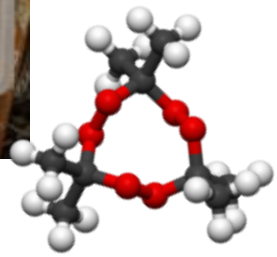
TATP



ETN

# Homemade explosives (HME)

**TATP**

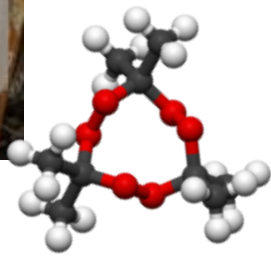


Tien jaar gevangenisstraf voor afpersing Jumbo supermarkten

***10 year sentence for extortion of Jumbo Supermarket***


# Homemade explosives (HME)

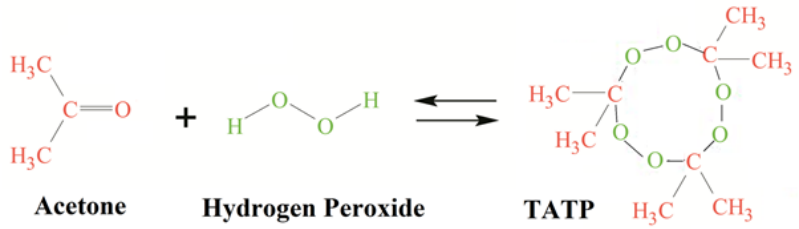
**TATP**



**'Explosie in flat Groningen veroorzaakt door springstof TATP'**

***'Explosion in Groningen apartment caused by explosive TATP'***

# TATP

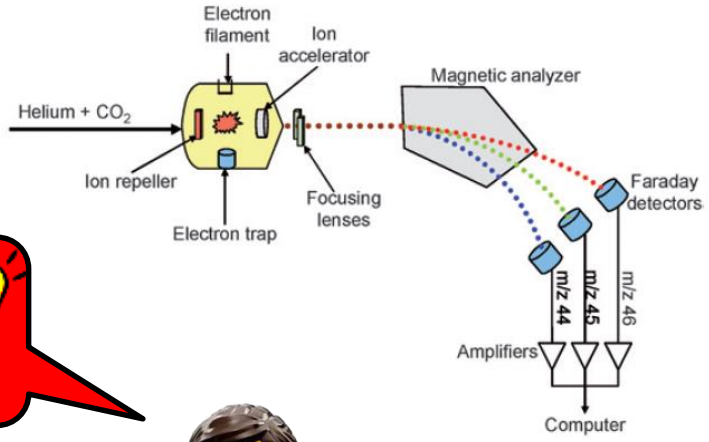




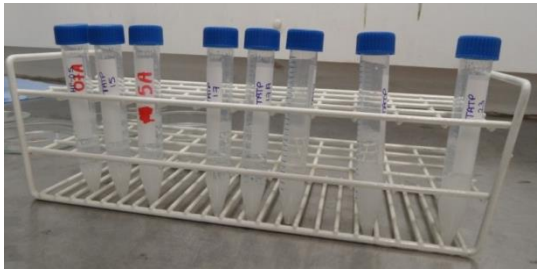

*We found an intact IED made of TATP at crime-scene.*

*We found acetone at the suspect's place.*

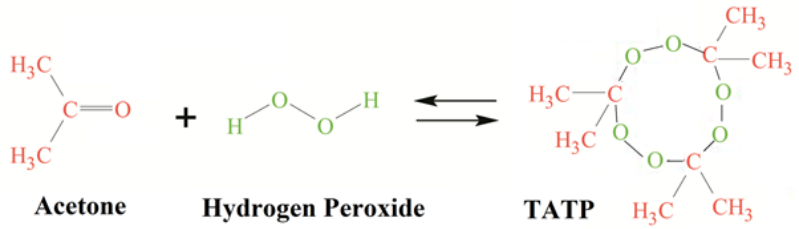
*Can we link these items?*




*IRMS analysis*



# TATP



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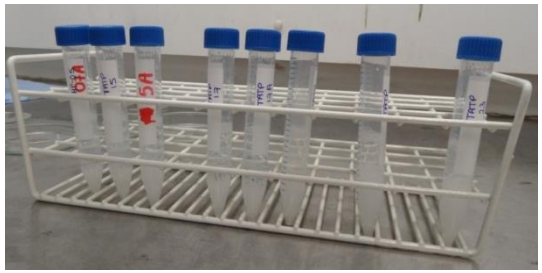
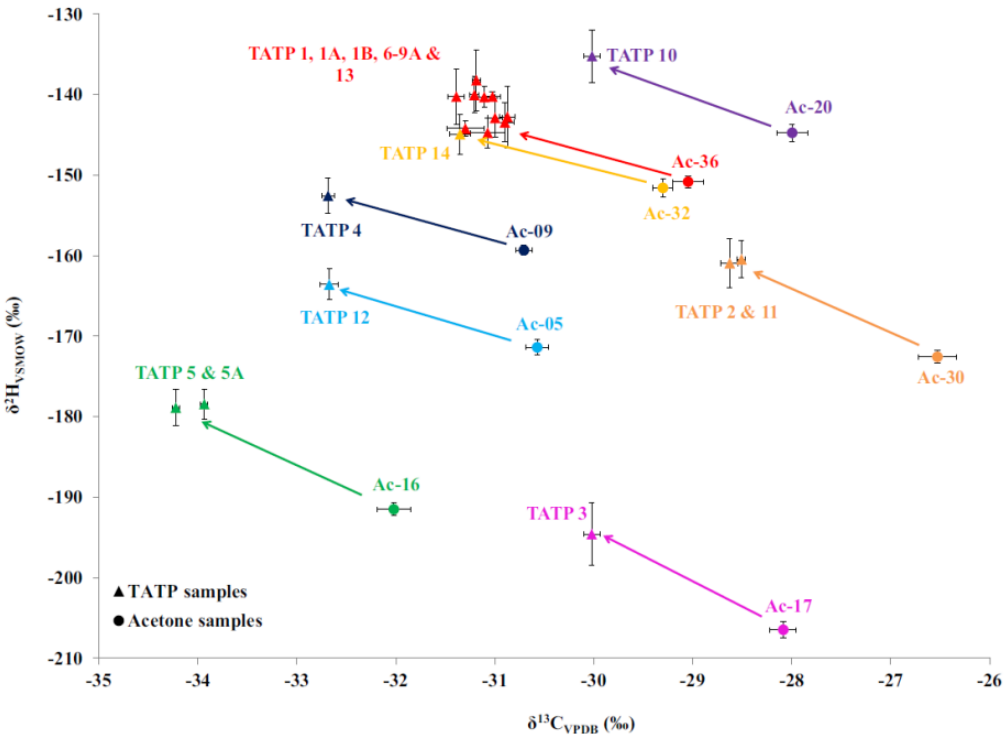
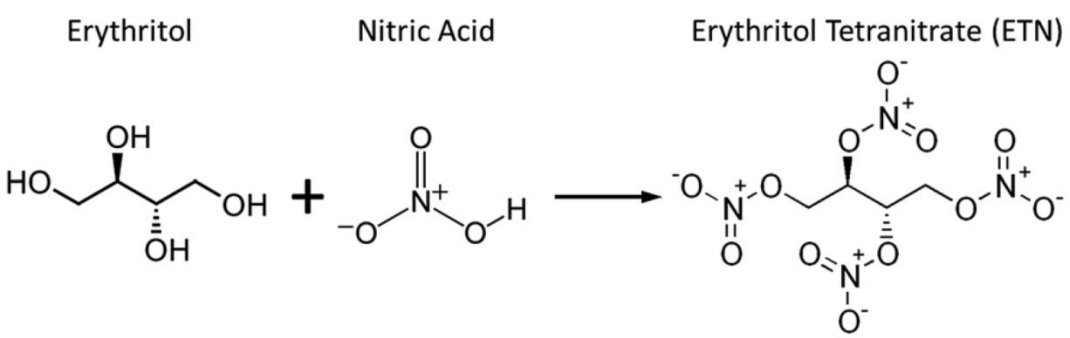
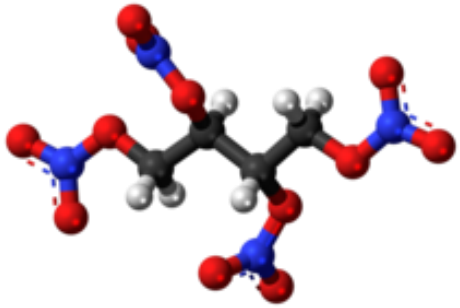




# ETN



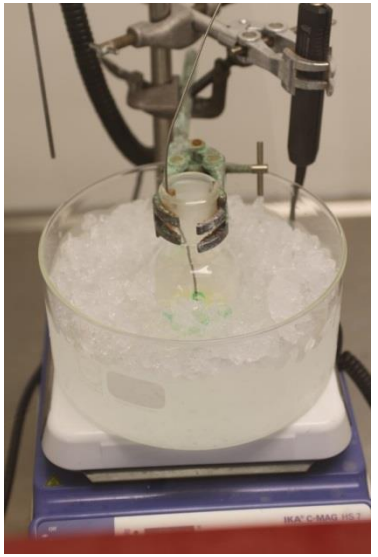
*Relatively stable explosive*

*Easy synthesis method*

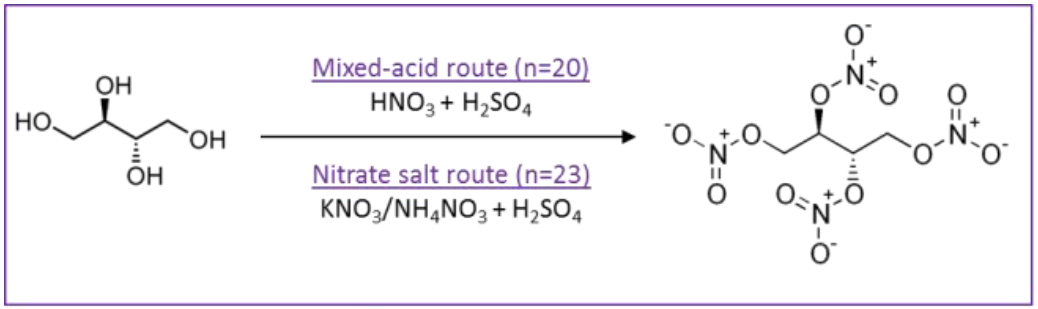
*Precursors readily available*







# ETN

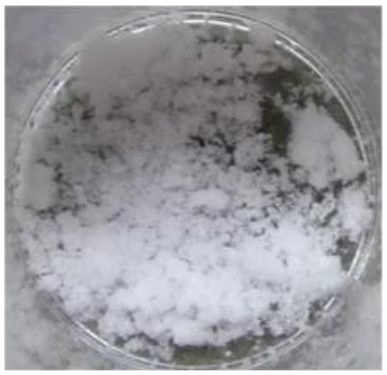



Parameters
- Synthesis route
- Time
- Temperature
- Concentrations
- Nitrate salt
- Sulfuric acid
- Wash step
- Recrystallization solvent

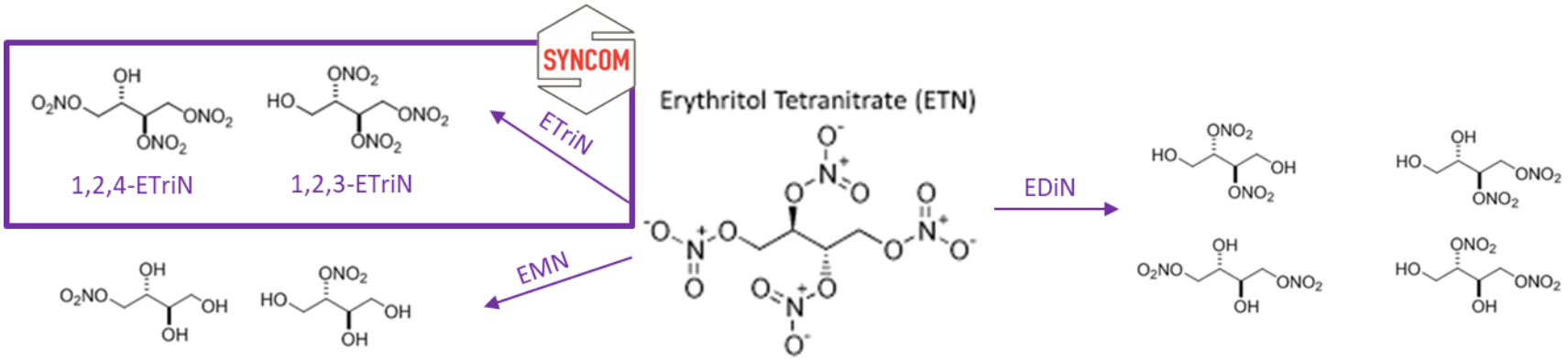
***Can we determine raw material use and synthesis conditions from a crime scene ETN sample without any reference material?***

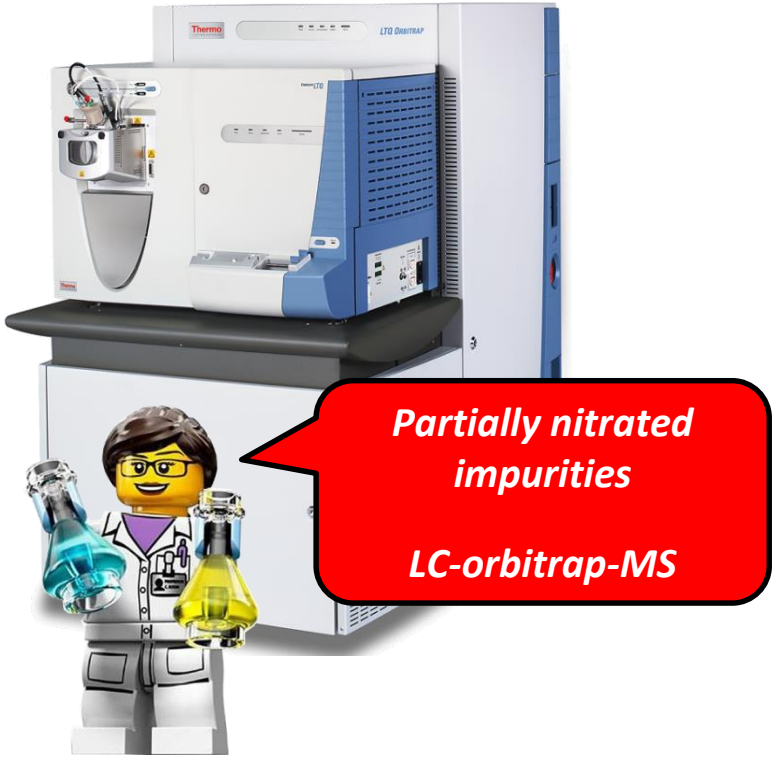
Erythritol precursor → Synthesis → ETN "crude product" → Washing → ETN product → Recrystallization → ETN "recrystallized product"

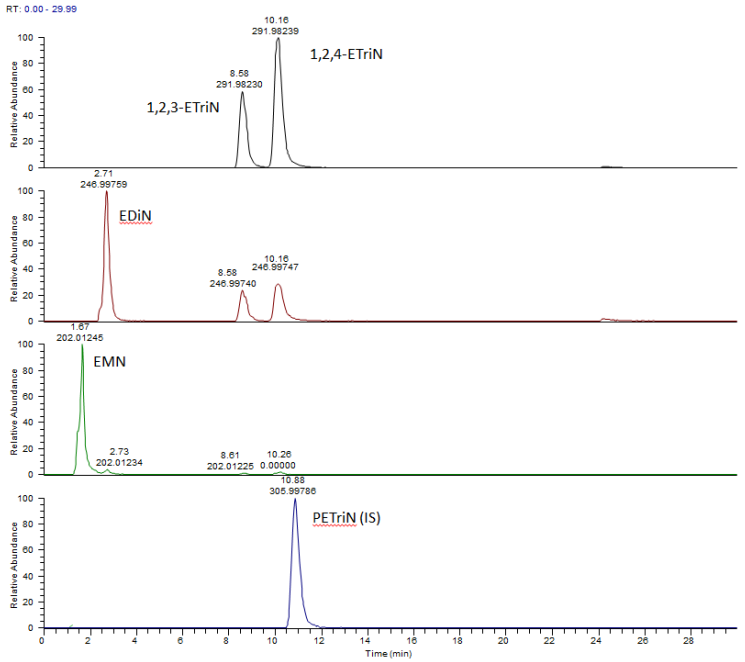
Erythritol precursor (n=10)

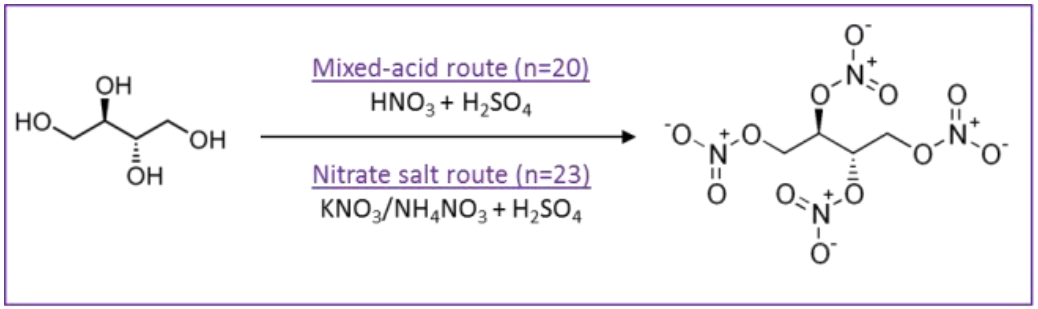
# ETN


SYNCOM
1,2,4-ETriN
1,2,3-ETriN
ETriN
Erythritol Tetranitrate (ETN)
EDiN
EMN

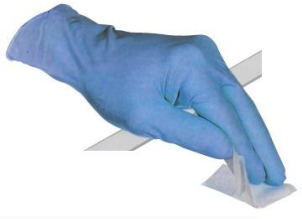

Partially nitrated impurities
LC-orbitrap-MS


RT: 0.00 - 29.99
1,2,4-ETriN
1,2,3-ETriN
EDiN
EMN
PETriN (IS)
Relative Abundance
Time (min)

# ETN



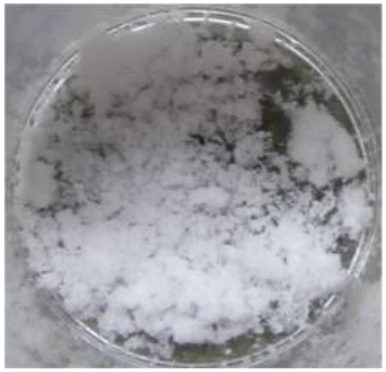

Parameters
- Synthesis route
- Time
- Temperature
- Concentrations
- Nitrate salt
- Sulfuric acid
- Wash step
- Recrystallization solvent



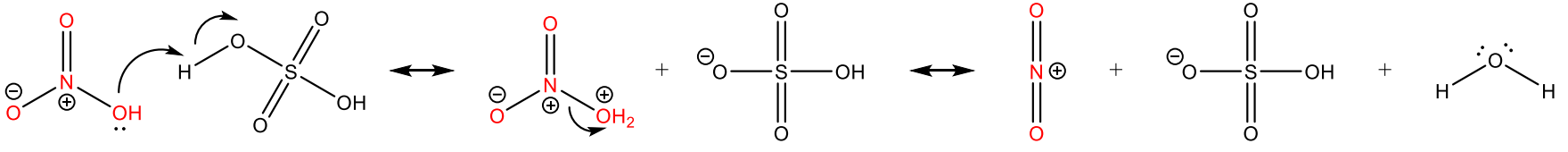
Intact vs. Post-explosive traces

Erythritol precursor → Synthesis → ETN "crude product" → Washing → ETN product → Recrystallization → ETN "recrystallized product"

Erythritol precursor (n=10)

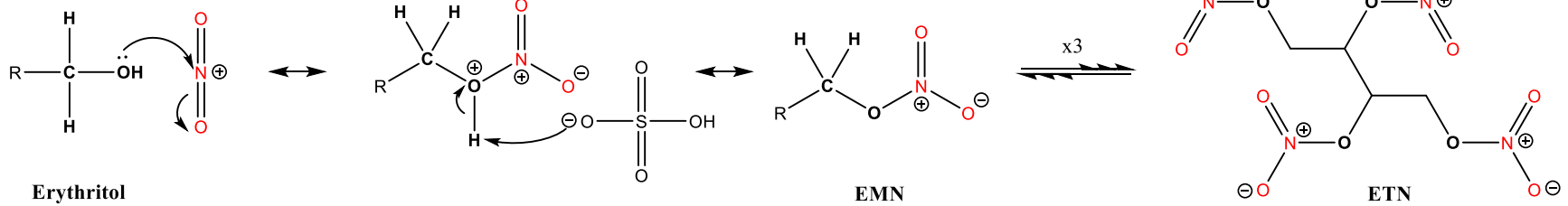
# ETN



(a)

**Nitrocidium cation**
($H_2CHN_2^+$)

**Nitronium cation**
($NO_2^+$)

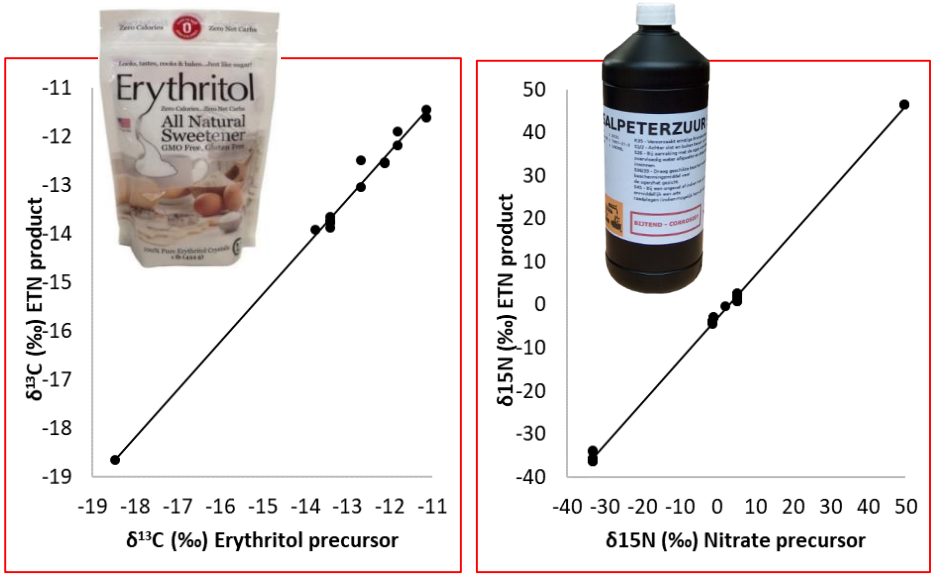



**Erythritol**

**EMN**
(erythritol mononitrate)

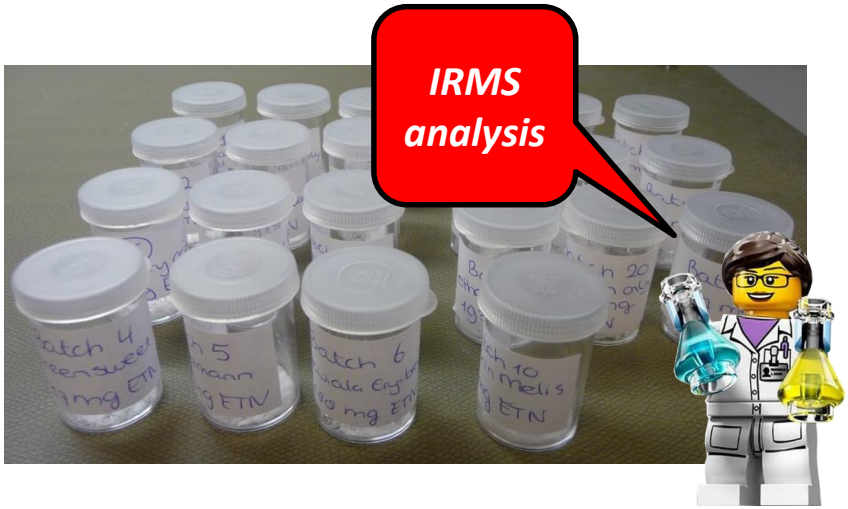
**ETN**
(erythritol tetranitrate)

(b)

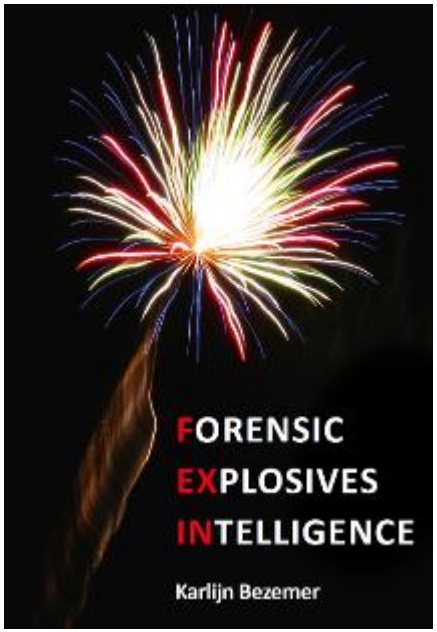








# PhD Defence – September 2nd 2020




JOURNAL OF FORENSIC SCIENCES

*J Forensic Sci*, September 2016, Vol. 61, No. 5
doi: 10.1111/1556-4029.13135
Available online at: onlinelibrary.wiley.com

PAPER

CRIMINALISTICS

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## The Potential of Isotope Ratio Mass Spectrometry (IRMS) and Gas Chromatography-IRMS Analysis of Triacetone Triperoxide in Forensic Explosives Investigations

ELSEVIER

Forensic Science International
Volume 290, September 2018, Pages 327-335

## Multicomponent characterization and differentiation of flash bangers — Part I: Sample collection and visual examination

Karlijn Bezemer [a, b], Rikus Woortmeijer [b], Mattijs Koeberg [b], Peter Schoenmakers [a], Arian van Asten [a, b, c]

Forensic Science International 307 (2020) 110102

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/forsciint

## Chemical attribution of the home-made explosive ETN – Part I: Liquid chromatography-mass spectrometry analysis of partially nitrated erythritol impurities

Karlijn Bezemer[a,b,*], Lindsay McLennan[c], Lara van Duin[a], Chris-Jan Kuijpers[b], Mattijs Koeberg[b], Jos van den Elshout[d], Antoine van der Heijden[d], Taylor Busby[c], Alexander Yevdokimov[c], Peter Schoenmakers[a], James Smith[c], Jimmie Oxley[c], Arian van Asten[a,e]

Forensic Chemistry 16 (2019) 100187

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## Rapid forensic chemical classification of confiscated flash banger fireworks using capillary electrophoresis

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Forensic Science International 290 (2018) 336–348

Contents lists available at ScienceDirect

Forensic Science International

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## Multicomponent characterization and differentiation of flash bangers — Part II: Elemental profiling of plastic caps

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Forensic Science International 313 (2020) 110344

Contents lists available at ScienceDirect

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## Chemical attribution of the homemade explosive ETN - Part II: Isotope ratio mass spectrometry analysis of ETN and its precursors

Karlijn Bezemer[a,b,*], Lindsay McLennan[c], Rosanne Hessels[a], Jorien Schoorl[d], Jos van den Elshout[e], Antoine van der Heijden[e], Annemieke Hulsbergen[b], Mattijs Koeberg[b], Taylor Busby[c], Alexander Yevdokimov[c], Eva de Rijke[d], Peter Schoenmakers[a], James Smith[c], Jimmie Oxley[c], Arian van Asten[a,f]

ELSEVIER

Forensic Science International
Volume 308, March 2020, 110160

## Emerging techniques for the detection of pyrotechnic residues from seized postal packages containing fireworks

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# Thank you!

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2 December 2020

# Going beyond detection and identification in forensic explosives investigations

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