Going beyond detection and identification in forensic explosives investigations

Crossing Forensic Borders
CLHC kick-off event
2 December 2020

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Explosives incidents

Disaster

2020 Beirut
Explosives incidents

2011 Oslo

2016 Brussels

Terrorist attacks

2005 London
ATM attacks

‘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
- Raman Spectroscopy
- Inorganic
  - XRD

Trace
- Organic
  - LC-MS
- Inorganic
  - IC/IC-MS
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

→ Many incidents involve powerful flash bangers (Cobra 6)

Irresponsible and risky adolescent behavior

Criminal activities

Terrorist threats
From identification to individualisation

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
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

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

Can we prevent an attack with explosives?

TATP

ETN
Homemade explosives (HME)

Tien jaar gevangenisstraf voor afpersing Jumbo supermarkten

10 year sentence for extortion of Jumbo Supermarket
Homemade explosives (HME)

'Explosion in Groningen apartment caused by explosive 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
We found an intact IED made of TATP at crime-scene. We found acetone at the suspect’s place. Can we link these items?
ETN

Erythritol + Nitric Acid → Erythritol Tetranitrate (ETN)

- Relatively stable explosive
- Easy synthesis method
- Precursors readily available
Can we determine raw material use and synthesis conditions from a crime scene ETN sample without any reference material?
ETN

Partially nitrated impurities

LC-orbitrap-MS
ETN

Mixed-acid route (n=20)
HNO₃ + H₂SO₄

Nitrate salt route (n=23)
KNO₃/NH₄NO₃ + H₂SO₄

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

Erythritol precursor
Synthesis
ETN “crude product”
Washing
ETN “crude product”
Recrystallization
ETN “recrystallized product”

Erythritol precursor (n=10)
ETN

(a) Nitrocidium cation \((\text{H}_2\text{CHN}_2^+)\)  
Nitronium cation \((\text{NO}_2^-)\)

(b) Erythritol  
EMN (erythritol mononitrate)  
ETN (erythritol tetranitrate)

**IRMS analysis**

- \(\delta^{13}C\) (‰) Erythritol precursor
- \(\delta^{15}N\) (‰) Nitrate precursor
The Potential of Isotope Ratio Mass Spectrometry (IRMS) and Gas Chromatography-IRMS Analysis of Triacetone Triperoxide in Forensic Explosives Investigations

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

Rapid forensic chemical classification of confiscated flash bang fireworks using capillary electrophoresis

Emerging techniques for the detection of pyrotechnic residues from seized postal packages containing fireworks
Thank you!

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