

Forensic Science Laboratory
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Forensic Analysis of C-4 Explosives for Possible Discrimination

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Introduction

- Security authorities in Bahrain have seized an exceptional amount of Plastic bonded explosive called Composition 4 (C-4).
- Forensic investigators are concerned with determining:
 - i. The source of material used or origin of the explosive
 - ii. The responsible party (or parties), whether they were involved in other events
 - iii. Making a link between the same kind of explosives seized from different location.

Objectives

- Chemical Profiling of C-4 Explosives.
- Discrimination between same kind of explosives.
- Creating link between the cases.





C-4 Explosive?

C = Composition

4 = 4 Constituents

- 1. 91% of RDX (Research Department explosive)**
2. 5.3% plasticizer (DOA, DOS or Phthalate)
3. 2.1% binder (Polyisobutylene)
4. 1.6% processing oil (Process Oil)

Some Countries Adding:

- Taggant (physical or chemical)
- Dyes

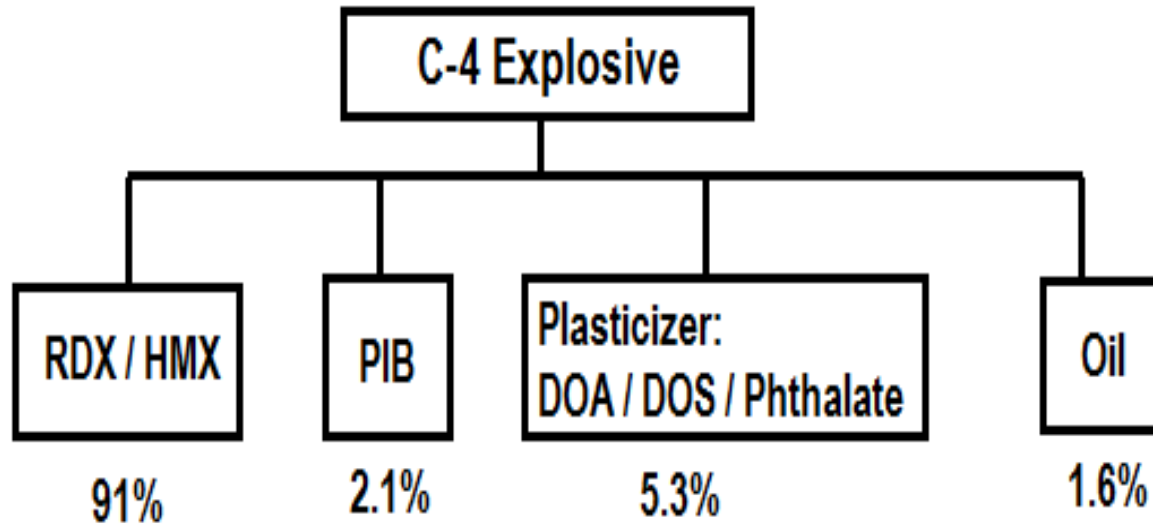


Methodologies

1. Extraction of all constituents present in C-4 explosives.
2. Techniques used to measure the chemical characteristics of C-4.
 - Gas chromatography coupled with Mass Spectrometer, GC/MS
 - Gas chromatography coupled with Thermal Energy Analyzer, GC/TEA
 - High Performance Liquid Chromatography, HPLC
 - Vibrational Spectroscopy i.e. FTIR and Raman



Extraction hierarchy for a single C-4 sample



Acetone	→	Soluble	Insoluble	Soluble	Soluble
Hexane	→	Insoluble	—	Soluble	Soluble

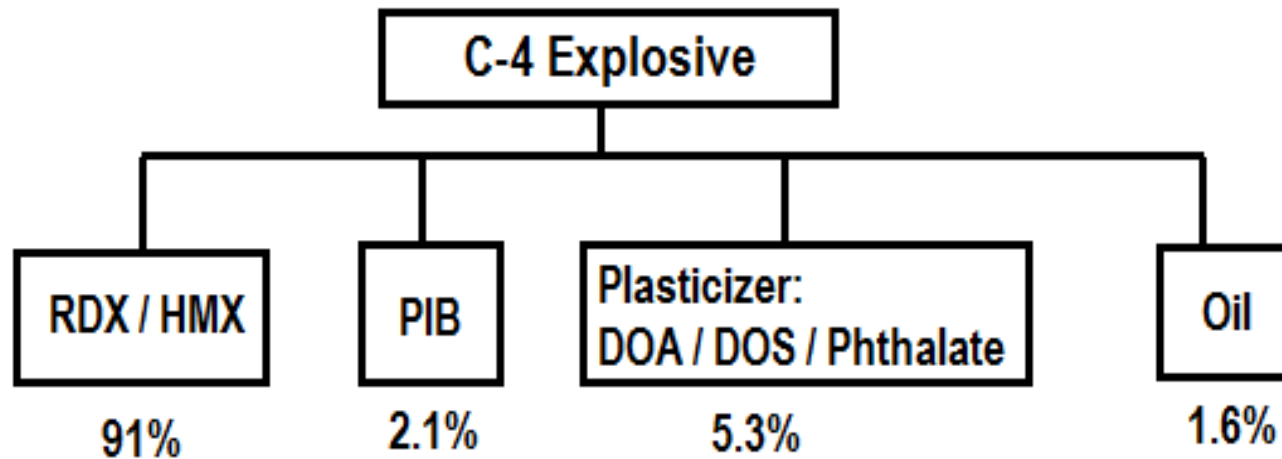


Separation of Plasticizer & Oil from the Mixture





Approaches used for C-4 Discrimination



1. Ratio of RDX & HMX
2. Type of Binder
3. Type of Plasticizer
4. Type of Oil



Synthesis of RDX

- Production of RDX on industrial scale.
1. **Hale and Woolwich Process:** involve direct nitration of hexamine, where the **HMX** generates less than 5%.
 2. **Bachmann process**, where the impurity (HMX) contains are significantly higher (8-12 %) and also a trace amount of acetyl products formed.
 3. **Brockman process**, which yield the pure RDX without any impurities



Results

Ratio of RDX & HMX

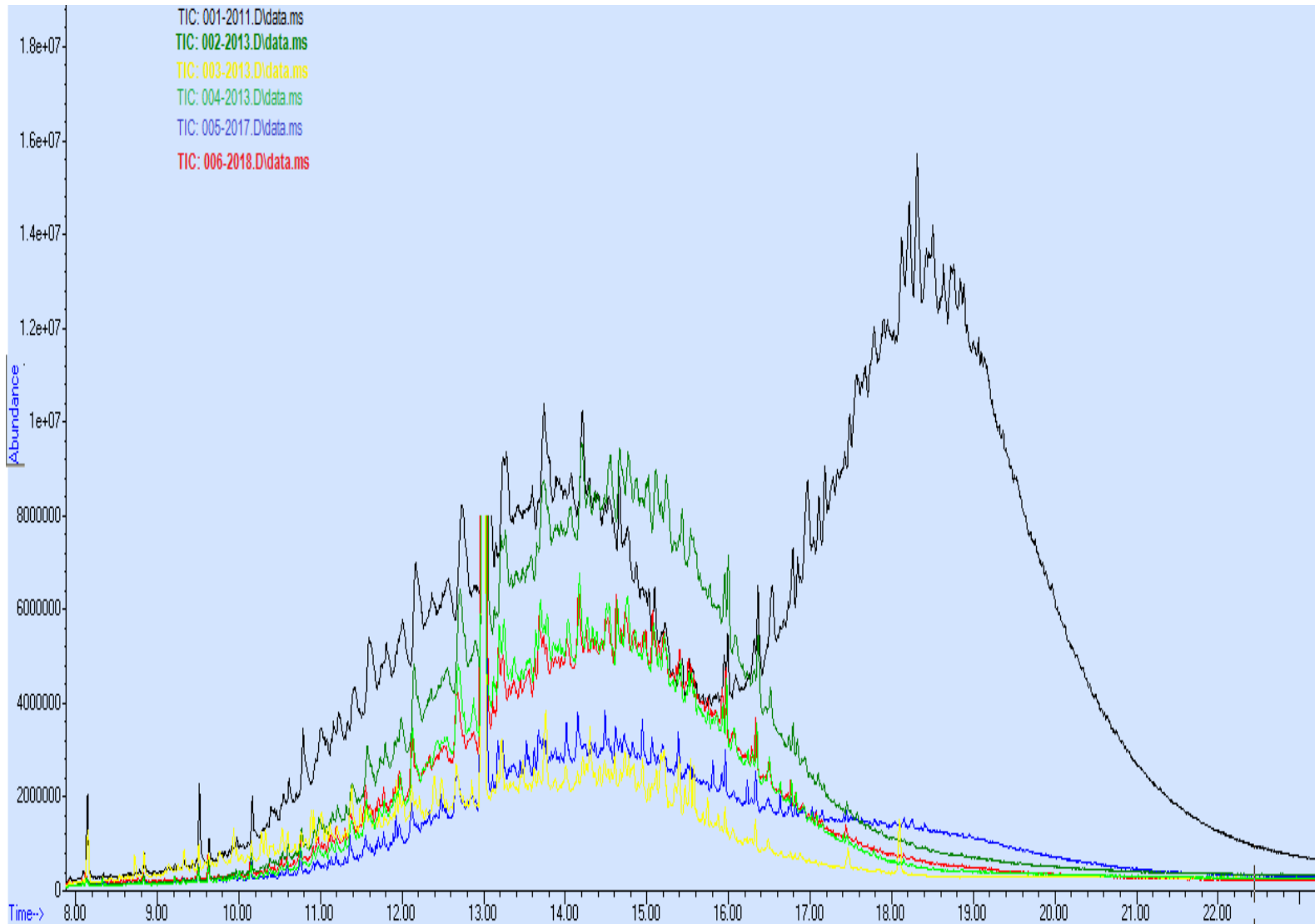
S. No.	Case Number (imaginary)	% RDX + % HMX	% age of HMX	Possible route of RDX synthesis
1	001-2011	90.36	4.31	Woolwich process
2	002-2013	89.72	4.03	Woolwich process
3	003-2013	90.20	3.44	Woolwich process
4	004-2013	90.25	3.25	Woolwich process
5	005-2017	89.20	3.86	Woolwich process
6	006-2018	88.90	7.99	Bachmann process



Type of Binder and Plasticizer

S. No.	Case Number (imaginary)	Type of Binder	Type of Plasticizer
1	001-2011	PIB	Diethyl adipate (DOA)
2	002-2013	PIB	Diethyl sebacate (DOS)
3	003-2013	PIB	Diethyl sebacate (DOS)
4	004-2013	PIB	Diethyl sebacate (DOS)
5	005-2017	PIB	Diethyl adipate (DOA)
6	006-2018	PIB	Diethyl adipate (DOA)

The Overlaid total Ion Chromatogram (TIC) of all six oils extracted from C4 explosives



Oil analysis



Case Number	Hydrocarbon (HC) Range	Antioxidant	polycyclic aromatic hydrocarbon (PAH)
001-2011	C16 – C35	2,4-Di-tert-butylphenol	Naphthalene, Phenanthrene
002-2013	C16 – C33	2,4-Di-tert-butylphenol	Naphthalene, Phenanthrene
003-2013	C15 – C35	2,4-Di-tert-butylphenol	Naphthalene, Phenanthrene
004-2013	C18-C35	2,4-Di-tert-butylphenol	Naphthalene, Phenanthrene
005-2017	C16-C33	2,4-Di-tert-butylphenol	Naphthalene, Phenanthrene
006-2018	C16 – C32	2,4-Di-tert-butylphenol	Naphthalene, Phenanthrene



Conclusion

6 Cases were studied for the possible discrimination b/w them.

- On the basis of plasticizer analysis, studied cases can be categorized into two groups.
- RDX present in 5 cases were synthesized by Woolwich Process (Direct Nitration process) and one case Bachmann Process (Combination Process) was involved.
- No Evidence of detection taggant found
- Oil Analysis shows very similar results for all six cases.



Limitation and Future work

- Origin of all samples (C4 explosives) were unknown.
- Fewer samples have been analyzed.
- Utilization of Isotope Mass Spectrometer (IRMS)
- Future work includes: utilizing this project on known C4 explosives (as controls) from different countries i.e. USA, UK, Iran etc.



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Thank You