CHAPTER 9

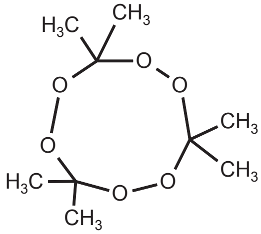
# HEMs: Concerns of Security

## 9.1 HEMs: Concerns of Security

Palpably, terrorism is the number one menace and threat to global peace today. The most common tools that the terrorists use today are high explosives, although the world should be ready to prevent and combat terrorism based on more disastrous tools like nuclear, biological, and chemical weapons. The very survival of humanity today depends on the human will, technological advancement, and judicious strategies in this direction.

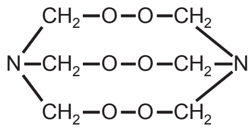
We are witnesses to the use of high explosives in terrorist attacks in versatile ways right from the crude lumps containing simple mixture of ammonium nitrate and nails (intended to be high-velocity projectiles on the initiation of AN) and a detonator to sophisticated, remote-operated explosive devices. When the terrorists fail to get stolen ammunition or relatively costly and strategic explosives like RDX, the option of easily accessible civil explosives (mostly AN-based and some times NG/dynamite-based) is always open to them. The explosive devices used in unconventional warfare by terrorists are referred as **Improvised Explosive Devices (IEDs)** and they can take any form like letter bombs, pipe bombs, or explosive devices kept in a radio transistor/ suitcases/lunch boxes/toys, etc. Some of the commonly used explosives in IEDs are given in Table 9.1.

The use of innocuous materials as explosives for terrorist activity is a cause of worry. Recent approaches to use CHO materials (free from nitro and nitrato groups to escape detection) are an alarming trend. For example, it is reported that triacetone triperoxide (TATP) was about to be used in the terrorist attempt foiled a few years back in London. It was intended to blast the aircrafts in midair. It can be obtained in crude state from polish remover. Hexamethylene triperoxide diamine (HMTD) is another compound of this class, which was captured from Algerian terrorists entering into the United States from Canada.




TATP

Demystifying Explosives: Concepts in High Energy Materials. http://dx.doi.org/10.1016/B978-0-12-801576-6.00009-4



HMTD

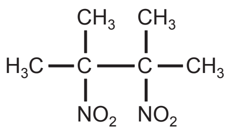
**Table 9.1: Some improvised explosive devices (IED) compositions.**

| Conventional/Military Explosives used in IEDs | Commercial Explosives used in IEDs |
|---|---|
| **RDX-based IEDs**<br><br>*SEMTEX*<br>(RDX, styrene-butadiene copolymer & additives (plastic explosive used in 1988 Pan Am aircraft blast))<br>*SEMTEX-H*<br>(RDX, PETN, styrene-butadiene copolymer, motor oil, & additives<br>C-2: RDX, TNT, DNT,[a] MNT, & NC<br>C-3: RDX, TNT, DNT, Tetryl, & NC<br>C-4: RDX, Polyisobutylene, & Fuel oil) | **Ammonium nitrate–based IEDs**<br>*Red diamond*: Ammonium nitrate, Sodium nitrate, Nitroglycerine, & additives<br>*ANFO*: Ammonium nitrate & fuel oil<br>*Prillex*: Ammonium nitrate & diesel oil<br>*Sigmagel Titagel*: Ammonium nitrate, Sodium nitrate, & Calcium nitrate<br>*Lovex*: Ammonium nitrate, mono-methyl ammonium nitrate, & gelling agent<br>Emulsion explosives<br>*Nipak*: Ammonium nitrate, Sodium nitrate, polyurethane, & additives |
| **TNT based IEDs**<br>*Cyclotol*: RDX & TNT<br>*Tetryol*: TNT & Tetryl<br>**PETN based IEDs**<br>Detsheet: PETN & Plasticizer<br>*Pentolite*: PETN & TNT | **Miscellaneous**<br>Petrogel: Nitroglycerin, Ethylene Glycol Dinitrate, Nitrocellulose, sodium nitrate, & additives<br>*Dynamite*: NG + Keiselgur<br>Slurry and water gel explosives |

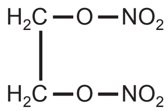
[a]DNT, Dinitro toluene.

## 9.2 Detection of Explosives

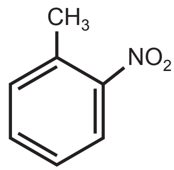
The detection of hidden explosives and prevention of a disaster is one of the major technological challenges today. Although a huge amount of work has been and is being done in this direction, different devices designed and manufactured for this purpose have their own advantages and disadvantages. One of the earliest methods adopted was to make it a statutory obligation on the part of an explosives manufacturer to add certain chemicals in a small percentage to the explosives at the time of processing. The said chemicals (called taggants) have a low vapor pressure, but their vapors are easily detectable by devices such as Electron Capture Detector (ECD). However, if the IED is thoroughly sealed, hardly allowing any vapor of that chemical to effuse out, this method will be of no use. Some such taggant chemicals are given below:



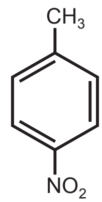
2,3-Dimethyl-2,3-dinitrobutane



Ethylene glycol dinitrate



*Ortho* mononitro toluene



*para* mononitro toluene

(*Note*: Most of the explosives themselves have very low vapor pressures. For example, the vapor pressures of RDX and PETN (in mm of Hg at 25 °C) are $8.0 \times 10^{-8}$ and $7.0 \times 10^{-9}$, respectively. In case these explosives are embedded in a polymeric matrix as a plastic explosive, the vapor emission will go down further drastically).

In the detection of explosives, sniffer dogs have application since as long as mobile detectors have been around. It is reported that they have about 90% reliability. However, major problems are their deployment in public places, need for continuous training, and proper handlers. Law enforcing agencies are increasingly dependent on conventional X-ray detectors at entry points like airports, seaports, and other important public places. Although such heavy X-ray detectors have been doing a good job in scanning the baggages to detect any explosive devices, their immobility limits their use in detecting hidden explosives elsewhere. At times, it may be required to detect hidden explosive at a stand-off distance in view point of safety. For such purposes, stand-off detectors are designed to detect explosives at a distance of 10 m or more. Different devices have been and are still being developed for the purpose of detection of explosives, and each of them is based on a specific principle such as electron capture (Electron capture detector (ECD)), chemiluminescence (CL Detector), ion mobility (Ion mobility spectrometer (IMS)), diamagnetism of materials, fast neutron activation, etc., and a few of them are described below:

### 9.2.1 Electron Capture Detector

**Principle**: It records changes in current due to absorption of electrons by certain electron-absorbing groups (e.g., $NO_2$) present in explosives molecules. The ECD is used for detecting electron-absorbing components of high electronegativity such as halogenated compounds in the output stream of a gas chromatograph.

| Advantages | Disadvantages |
|---|---|
| Highly selective | Only usable for a few constituents |
| High sensitivity (<1 pg detection limit) | Radioactive detector is used |
| Nondestructive | Smaller linear range & response factors vary considerably |

### 9.2.2 Ion Mobility Spectrometer

**Principle**: It records the mobility of the explosive molecular ions that is characteristic of an explosive. IMS is a spectrometry technique capable of detecting very low concentrations of chemicals based upon the differential migration of gas phase ions through a homogeneous electric field.

| Advantages | Disadvantages |
|---|---|
| Detects the presence or absence of an energetic material in seconds | Low resolution |
| (Can detect quantities from 0.1 to 10 nanograms) | Susceptible to atmospheric changes |

### 9.2.3 Thermoredox Detector

**Principle**: It records the electrochemical reduction of $-NO_2$ group present in the explosives. This technology is based on decomposition of explosive substance followed by the reduction of the $NO_2$ groups.

| Advantages | Disadvantages |
|---|---|
| This technique does not require a carrier gas other than ambient air | Sensitivity is fairly low |
| System is portable, lightweight, and powered by rechargeable batteries | Harmless nitro compounds often create false alarms |
| Low consumable cost, requires very limited operator training, and user friendly | Suitable only for compounds with high vapor pressure |

### 9.2.4 Field Ion Spectrometer

**Principle**: The principle is based on filtering ion species according to the functional dependence of their mobilities with electric field strength.

Field ion spectrometer, also known as transverse field compensation IMS, is a new technique for trace gas analysis that can be applied to the detection of explosives and narcotics. It eliminates the gating electrodes needed in conventional IMS to pulse ions into the spectrometer; instead, ions are injected into the spectrometer and reach the detector continuously, resulting in improved sensitivity. The technique enables analyses that are difficult with conventional, constant field-strength IMS.

### 9.2.5 Diamagnetism-Based Magnetic Field Detector

**Principle**: The detection is based on the principle that every material has a characteristic magnetic property and can be detected accordingly.

Magnetometers have a wide range of potential applications, and where there is an electrical current, there is a magnetic field. Measurements of magnetic fields can reveal information about the electrical activity, the chemical identity of a spinning atom, or simply the presence or absence of metal. This consists of a laser, a cell containing vaporized metal atoms, and a light detector. When the metal atoms are illuminated by the laser, they align such that they don't absorb any of the light. The presence of even a very weak magnetic field, however, disrupts their alignment, and they absorb some of the light. This change is recorded by the detector.

With small size and sensitivity, the new sensors promise to improve detection of bombs and could be incorporated into future magnetic resonance imaging (MRI) scanners. It is small and cheap, and uses very little power. For the detection of IED or unexploded ordnance in minefields, the small size and low power consumption of the sensors could make a big difference. The sensors could be grouped in arrays, making it possible to gain more data in a given amount of time.

### 9.2.6 Nuclear Quadrupole Resonance Detector

Nuclear Quadrupole Resonance (NQR) is a sensor technology related to nuclear magnetic resonance (NMR). Any nucleus with more than one unpaired nuclear particle (protons or neutrons) will have a charge distribution that results in an electric quadrupole moment. NQR measures a signature unique to the explosive contained in the hidden objects, thus providing a means of efficiently detecting land mines.

NQR can detect even small quantities of explosives. NQR signature is independent of the shape of the explosive. The signature emanates directly from the condensed phase, and NQR does not have the shortcomings that plague vapor-phase chemical detectors. It provides the chemical specificity of NMR and the volume capacity of MRI without the need for expensive and cumbersome DC magnets.

### 9.2.7 Micro Electro Mechanical Systems

Micro Electro Mechanical Systems (MEMs) is a recent technology and it consists of integrated mechanical elements, sensors, actuators, and electronics on a silicon substrate using a process technology called microfabrication. The sensors gather information by measuring mechanical, thermal, biological, chemical, magnetic, and optical signals from the environment. The microelectronic integrated circuits (ICs) act as the decision-making piece of the system by processing the information given by the sensors. Finally, the actuators help the system respond by moving, pumping, filtering, or somehow controlling the surrounding environment to achieve its purpose. Research and development efforts are in progress to develop a viable and general purpose explosives detection system based on MEMs.

A number of explosive vapor detection devices based on other spectroscopic techniques like photoluminescence, Resonance enhanced multi-photo ionization, Cavity ring down spectroscopy, Laser induced breakdown spectroscopy, Raman Scattering and Laser imaging detection and ranging, etc., are emerging on the scene. The technologies receiving major attention are described below.

1. Biosensors
2. Surface Acoustic Wave
3. Micro cantilever—based mine detection system
4. Amplifying fluorescent polymers
5. Detector-based on diamagnetism

During recent times, the miniaturization of analytical instruments has resulted in the availability of UV—VIS, Near infra red (IR), fluorescence, Raman spectrophotometers for field applications. The literature reports also indicate that the miniaturization of mass spectrometers has also been mastered and they may become available in near future for field analysis.

The trace explosive detectors require the operator to approach the IED to close distances, of the order of a few centimeters, unless some robot or unmanned ground/aerial vehicle is employed. The detection of an IED in large area like residential area or ground/stadium becomes a laborious and time-consuming task.

In view of the unabated use of different explosives by terrorists with varying degrees of innovation and sophistication, huge sums of money are being spent toward the development of detectors with better accuracy and reliability, portability, very low probability of setting false alarms, and safety features.

## Suggested Reading


[1] J. Yinon, Forensic and Environmental Detection of Explosives, John Wiley & Sons, Inc, 1999.

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[3] J. Yinon, Counterterrorist Detection Techniques of Explosives, Elsevier, 2007.

[4] J. Gardner, Y.J. Jehuda, Electronic noses and sensors for the detection of explosives, in: Proceedings of the NATO Advanced Research Workshop, Held in Warwick, Coventry, U.K, 2003.

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[6] H. Schubert, A. Kuznetsov, Detection of explosives and landmines methods and field experiences methods and field experience, in: Proceedings of the NATO Advanced Research Workshop, Petersburg, Russia, 2001.

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[8] H. Schubert, A. Kuznetsov, Detection of liquid explosives and flammable agents in connection with terrorism, in: Proceedings of the NATO Advanced Research Workshop on Detection of Liquid Explosives and Flammable Agents in Connection with Terrorism, NATO Science for Peace and Security Series B, Petersburg, Russia, 2007.


## Questions

1. What is meant by IEDs?
2. Why are IEDs difficult to be detected?
3. What are taggants? Name any two taggants used for military explosives.
4. How does an ECD work?
5. What are MEMs? How are they fabricated?
6. Are there any common methods of detection of explosives?