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Explosives Identification

The use of gas chromatography to test for traces of explosives

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Dubai Police uses TEA by Ellutia for explosives identification

Dubai Police Science and Criminology Laboratory has been praised as one of the best in the world, with around 520 technicians and support staff and 200 forensic experts. In 2016, the force unveiled its $100 million Forensic Science and Criminology building.

The new building includes classic forensic departments, such as: Forensic Biology and DNA, Chemistry, Toxicology, Trace Evidence, Explosives, Firearms and Tool-marks, Questioned Documents, Digital Forensics, Fire Investigation, and Fingerprint Recovery and Comparison, together with the Crime Scene and Criminology Departments.
Nine laboratories focus on providing high-tech backup to police investigations and include testing of DNA, toxicology, firearms, fingerprints, fire debris and document analysis. Lisa Dunn was employed in this department as a Consultant for six years, alongside Senior Expert, Hamda Ali Sultan Al Obaidly.

> **"Traces of high explosives aren't commonly found in the everyday environment and therefore, can have forensic significance if identified"**

Lisa, with over 15 years' experience as an analytical chemist with particular regard to the use, examination and analysis of explosives and explosives-related paraphernalia, was responsible for the development of the department's forensic explosives investigation capability. Specifically, to develop methods for the analysis of bulk quantities of explosives and to identify traces of explosives that were not visible to the naked eye.

Hamda Ali Sultan is Head of the Forensic Explosives Section in the General Department of Forensic Science and Criminology, with over 15 years' experience as an analytical chemist. Her specialties are the forensic examination and chemical analysis of drugs of abuse and explosives, and she explains the importance of explosives analysis: "Undertaking explosives analysis is necessary for Dubai Police as it helps to provide key evidence on the cause of an explosion at a crime scene. Traces of high explosives aren't commonly found in the everyday environment and can therefore, have forensic significance if identified."

The department has introduced the latest types of scientific disciplines and specialised research in the field of crime, to provide concrete evidence to the judiciary.

The Need for Testing

Chromatography can be an extremely valuable tool in the detection of explosives. It is important to note that not all explosions are caused by explosive material – they can be caused by non-explosive compounds, such as propane or butane gas. Lisa Dunn adds:

> **"it is crucial to a police investigation to identify whether an explosive was used and, if so, what type"**

"Following an explosion, it is crucial to a police investigation to identify whether an explosive was used and, if so, what type. Finding traces of explosives on a suspect's clothing or belongings, such as a mobile phone or a car, can be useful in linking that suspect to a case."

Typically, trace samples are collected by washing, swabbing or vacuuming a surface. Samples are extracted into a suitable solvent, cleaned-up using solid phase extraction to remove contaminants and to pre-concentrate the sample, and then analysed using a suitable technique. The amount of explosives in the samples can be in the low nanogram range. One nanogram can be considered to be comparable to one millionth of a grain of sugar.

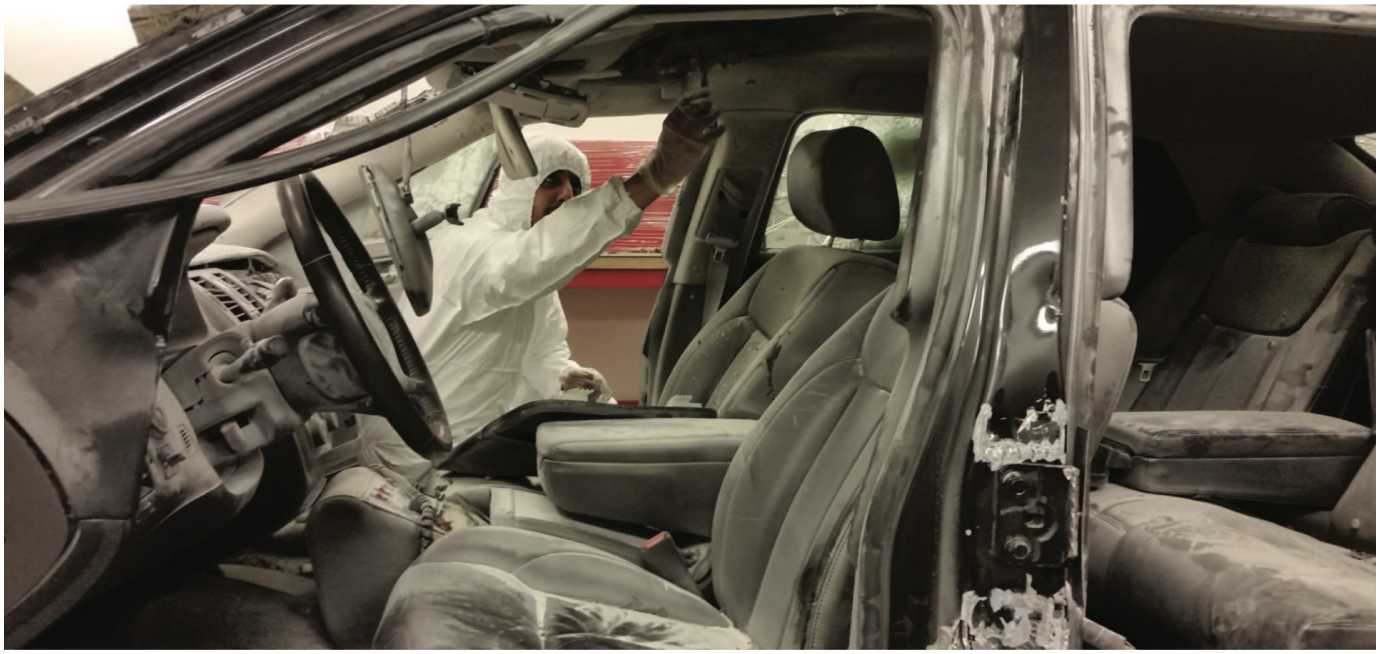
Gas chromatography offers the advantages of quick instrument set-up and high resolving power, the latter being particularly important for the trace analysis of explosives. Efficient GC separation using capillary columns allows the analysis and separation of various nitrate esters, nitrobenzene isomers and mono, di and tri-nitroaromatic isomers. The gas chromatography/ thermal energy analyser (GC/TEA) method developed by Dubai Police utilises the 800 Series TEA and screens for the presence of 25 explosives and degradation products, contained within two different mixed standards.

The Explosives Analysis Process

Dubai Police Forensic Department has a Trace Explosives Suite; this is a series of laboratories with access restricted to dedicated, trained personnel. Before entering the Trace Explosives Suite, personnel are required to wear clean disposable gloves, laboratory coats and shoe covers, and to screen themselves for explosives contamination. The Trace Explosives Suite is regularly subjected to quality assurance testing to ensure that it has not become contaminated with explosives.

> **"The GC/TEA offers a high degree of selectivity."**

One of the laboratories has two GC/TEA systems installed; one system is fitted with a CP-SIL 19 column, whilst the second system has dual injection ports and is fitted with both DB-1 and DB-5 columns (only 1 column is in use at any one time). Each of the three columns has a different polarity and thus analytes are retained on the column differently. Two standards are analysed at the beginning of the sequence and then up to three samples are analysed before the standards are reanalysed; this is done to monitor system performance.



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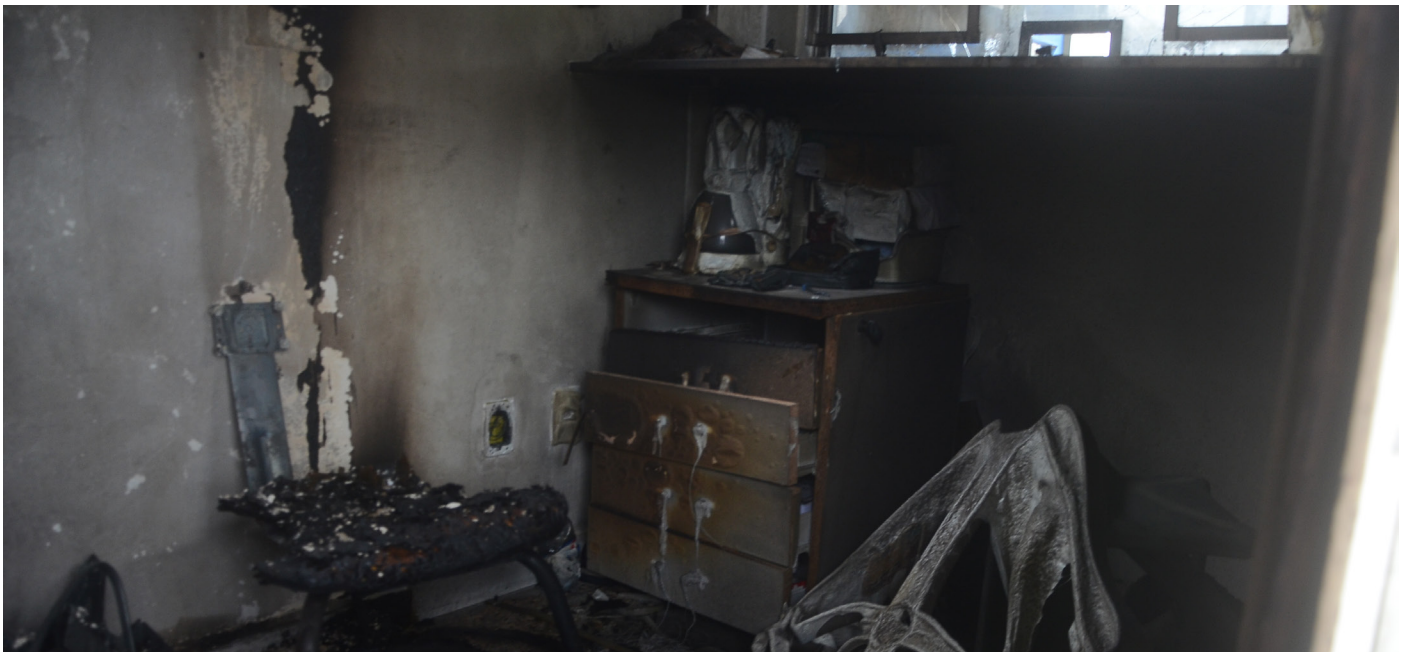
Samples are initially screened using one GC/TEA system. Retention times of peaks (with a signal/noise ratio >3) observed in the chromatogram are compared to the retention times of the analytes in the standard solutions. If the retention time for a peak is within ± 1.0 % of the retention time of the standard, then the sample is analysed using another GC column. Identification of an analyte relies on the retention time of the analyte falling within ± 1.0 % on all three columns.

Furthermore, as Lisa explains: "The GC/TEA offers a high degree of selectivity; it is more selective than GC/ECD (electron capture detector), but offers similar sensitivity. TEA detectors only detect compounds which on pyrolysis give nitrogen oxide (NO); this makes them well-suited for the analysis of nitrogen containing explosives. Additionally, this makes the GC/TEA more suitable than other techniques such as GC/MS (mass spectrometry), because most non-explosive contaminants will not give a response."

Analytical challenges in testing explosives

There are a number of analytical challenges associated with the testing of explosives materials. Firstly, some analytes decompose during analysis, e.g. tetryl decomposes by hydrolysis to N-methylpicramide. Certain analytes such as, hexamethylene triperoxide diamine (HMTD) can even degrade expensive analytical columns, and other analytes, such as 3,5-dinitroaniline, can cause degradation of other explosive analytes (e.g. TNT and ETN) so cannot be included in the standard solutions. The technique is also not suitable for explosives that do not contain nitroso or nitro groups (e.g. TATP), and the explosives need to be sufficiently volatile to be analysed.

GC Conditions	LOD/ ng		
	DB1	DB5	CPSIL
Propylene glycol dinitrate (PGDN)	0.10	0.10	0.07
3-nitrotoluene (3-NT)	0.10	0.10	0.08
1,3-dinitroglycerine (1,3 DNG)	0.10	0.10	0.10
Diethylene glycol dinitrate (DEGDN)	0.07	0.07	0.05
1,3-Dinitrobenzene (1,3-DNB)	0.07	0.05	0.05
1,2-Dinitrobenzene (1,2 DNB)	0.07	0.07	0.05
3,5-Dinitrotoluene (3,5-DNT)	0.07	0.05	0.05
Triethylene glycol dinitrate (TEGDN)	0.10	0.13	0.10
1,3,5-trinitrobenzene (TNB)	0.20	0.20	0.16
Cyclotrimethylenetrinitramine (RDX)	0.13	0.10	0.08
2,4-diamino-6-nitrotoluene (2,4-D-6-NT)	0.50	1.00	0.25
4-amino-2,4-dinitrotoluene (4A-2,6-DNT)	0.13	0.10	0.10
Ethylene glycol dinitrate (EGDN)	0.05	0.05	0.07
Nitrobenzene (NB)	0.10	0.10	0.08
2-nitrotoluene (2-NT)	0.10	0.10	0.13
4-nitrotoluene (4-NT)	0.10	0.10	0.13
1,2-dinitroglycerine (1,2-DNG)	0.05	0.07	0.07
Trinitroglycerine (TNG)	0.04	0.05	0.04
2,6-dinitrotoluene (2,6-DNT)	0.04	0.04	0.04
2,4-dinitrotoluene (2,4-DNT)	0.04	0.50	0.04
3,4-dinitrotoluene (3,4-DNT)	0.04	0.04	0.04
Erythritol tetranitrate (ETN)	0.08	0.10	0.10
2,4,6-trinitrotolune (TNT)	0.08	0.08	0.08
Pentaerythritol tetranitrate (PETN)	0.08	0.10	0.20
2,6-diamino-4-nitrotoluene (2,6-D-4-NT)	0.40	0.27	0.40



Injection port liners are a particularly important component of analysis as it helps in the volatilisation of the sample. However, if dirty, the response of some analytes, particularly PETN, can be significantly affected. Some form of sample clean-up is required as the presence of contaminants can affect the quality of the chromatography, such as altering peak shapes and retention times. The responses for PETN and RDX can be significantly affected by the presence of contamination especially if highly polar compounds contaminate the inner surface of the column at the entry point and catalyse thermal decomposition of the analytes.

"Ellutia is widely known to be a leader in this field and we received strong recommendations regarding the robustness of the instrument and quality of customer service it provides."

Why the 800 Series TEA?

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"Ellutia is very knowledgeable about the system and is always there to assist."

vDubai Police has collaborated with Ellutia since 2014, with the TEA installation being finalised in August 2016. The experience Ellutia has gained over the years from its work with other forensic laboratories means that the company has an excellent understanding of customer requirements and experience in this field, as Hamda explains further:

"We have been extremely satisfied with the service and support received from Ellutia. The TEA detectors are very user friendly; Ellutia was able to connect the TEA to our existing GCs quickly and simply. Ellutia is very knowledgeable about the system and is always there to assist from the installation of TEA systems, to remote troubleshooting of any minor problems we have encountered."

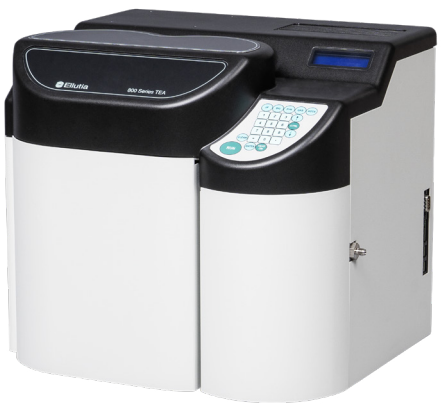
Hamda adds: "We have found the detectors to be remarkably reliable. We particularly like using GC/TEA because, aside from its selectivity and sensitivity for compounds that interest us and the relatively short run time, it's very robust, simple to use and doesn't require much preparation compared with other instruments, such as LC/MS."

The system can also be utilised in other investigations. Dubai Police has utilised the TEA for the analysis of an unusual drug in one particular case, and are not ruling out scope to investigate its use in such a way in the future.

To learn more about the Dubai Police, please visit:
https://www.dubaipolice.gov.ae/

To learn more about Ellutia, visit:
https://www.ellutia.com/

To learn more about the 800 Series TEA, visit:
https://www.ellutia.com/800-series-tea-detector



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To learn more about the Ellutia TEA Detector, please scan the QR code below or visit https://www.ellutia.com/800-series-tea-detector

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