

**Explosive Residue Analysis:
Evaluation and Optimisation of
Sampling, Storage and
Cleanup Protocols**

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ABSTRACT

For the detection and identification of explosive residues, surfaces of interest are typically sampled by swabbing or solvent wash. The current use of sequential swabbing protocols that separately target organic and inorganic compounds is under threat due to the increased use of improvised organic/inorganic explosive mixtures. An optimised swabbing procedure, using commercially available skin cleansing alcohol wipes, was developed to maximize the collection of both organic and inorganic explosive residues in a single step. Using six representative compounds (TNT, RDX, PETN, TATP, ammonium nitrate, and sodium chlorate) and four different substrates (glass, plastic, aluminium foil and laminate), the collection efficiency of the alcohol wipes was compared to the results obtained using conventional cotton swabs, polyester swabs, and a direct solvent wash (used as a control). The alcohol wipes demonstrated better overall performance in the recovery of both the organic and inorganic compounds from all test surfaces.

The compositions of a mixture of three organic solvents (acetone, acetonitrile and methanol) and water for a single-step solvent extraction of both organic and inorganic representative compounds from the alcohol wipes was investigated. In addition, the study included the evaluation and optimisation of a subsequent solid-phase extraction (SPE) clean-up procedure for the wipes extracts utilising several solid-phase extraction cartridges (both commercially available and prepared in-house).

The application of a polyester alcohol wipe as a universal swab, followed by extraction with 60% v/v methanol/water and clean-up with a Nexus SPE cartridge, was proposed as the final optimised protocol for the combined recovery and clean-up of organic and inorganic explosive residues.

The stability of the six representative compounds on polyester wipes and in 60% v/v methanol/water extracts, stored over 30 days in clear and amber glass vials at three different temperatures, was assessed in order to establish storage recommendations in conjunction with the final proposed protocol. The retention of all six target compounds on a glass surface at two different storage temperatures was included for an estimation of the maximum time that the explosive material could still be detected and recovered from a stored exhibit.

The results from the stability study suggested that, after sampling, the wipes should be stored in a dark and low temperature environment. Also, after processing using the proposed protocol, the extracts should be stored in a similar fashion. The results from the retention study of the six target compounds on the glass substrate suggested that exhibits should be stored at the lowest temperature possible to minimise the loss of any TNT or TATP (or similar target compounds) that might be contained within the sample.

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LIST OF ABBREVIATIONS

AN	Ammonium nitrate
BGE	Background electrolyte
CE	Capillary electrophoresis
DFLEX	Diffusive flammable liquid extraction device
DNB	m-Dinitrobenzene
DNN	1,3-Dinitronaphthalene
DSTL	Defence Science and Technology Laboratory, UK
EGDN	Ethyleneglycol dinitrate
FINEX	Forensic International Network for Explosives Investigation
FT-IR	Fourier transform infrared spectroscopy
GC-ECD	Gas chromatography/electron capture detector
GC-MS	Gas chromatography/mass spectrometry
GC-TEA	Gas chromatography/thermal energy analyser detector
HMTD	Hexamethylene triperoxide diamine
HMX	High melting explosive or Her Majesty's Explosive (1,3,5,7-tetranitro-1,3,5,7-tetraazacyclooctane or octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)
HPLC	High performance liquid chromatography
IC	Ion chromatography
IMS	Ion mobility spectrometry
IR	Infrared spectroscopy
IS	Internal standard
NATA	National Association of Testing Authorities
NG	Nitroglycerine
NMR	Nuclear magnetic resonance spectrometry
NT	Nitrotoluene
PETN	Pentaerythritol tetranitrate
PTFE	Poly(tetrafluoroethylene)
RCMP	Royal Canadian Mounted Police
RDX	Research Department Explosive or Royal Demolition Explosive (1,3,5-trinitro-1,3,5-triazacyclohexane or hexahydro-1,3,5-trinitro-1,3,5-triazine)
SEM-EDX	Scanning electron microscopy/energy dispersive X-ray analysis
SFE	Supercritical fluid extraction
SPE	Solid phase extraction

SPME	Solid phase microextraction
TATP	Triacetone triperoxide
TLC	Thin-layer chromatography
TNT	2,4,6-Trinitrotoluene
TRIS	Tris(hydroxymethyl)aminomethane
XRD	X-ray diffraction
XRF	X-ray fluorescence