TECHNICAL NOTE

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One-Pot Processing of Swabs for Organic Explosives and Firearms Residue Traces

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ABSTRACT: By the procedure described, swabs may be extracted and the cleanup of the extracts continued, by solid phase extraction, in the containers issued for the return of the used swabs to the laboratory. Thus, problems associated with techniques that involve transfer between containers of the swabs or their extracts are avoided. The procedure is designed for work with explosives and firearm traces and residues but is in principle applicable to any trace material that can be taken into solution.

KEYWORDS: criminalistics, gunshot residues, swab processing, trace analysis, explosives

Obvious advantages are obtained if swabs taken from skin surfaces for the detection of contact traces can be processed in the containers in which they are collected and returned to the laboratory. Thus, the possibilities of error that might occur because of mislabeling and contamination are minimized, transference losses are reduced, and economies may be made in the time and expense of the processing. This approach, used in the detection of explosives and firearms residue traces, is made possible now by the swabbing kits provided to the police forces served by the U.K. Home Office forensic science laboratories. In principle, the technique is applicable to the retrieval of any trace material that can be taken into solution.

Experimental Materials and Procedures

Materials

The swabbing kits issued for police use include the nonwoven cotton cloth swabs (Litex-10, 4 by 6 cm, from LIC Medical, Sweden) introduced into criminalistics work by Russell [*1*]. The swabs, prewetted with 1 ml of isopropanol/water (8:2 v/v), are issued in heat-

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sealed foil packets. In use, a swab is rubbed over the relevant surface (a hand or facial area) [2]. Usually approximately half of the original volume of solvent is left on the swab. Labeled disposable 15-mL polypropylene centrifuge tubes fitted with needle-penetrable caps (Alpha Laboratories, U.K., Ltd.) are provided for the return of the used swabs.

Procedure

If necessary, the swab is shaken into the top of the capped centrifuge tube. The point of a disposable hypodermic needle (25 mm, 19-gauge, thin walled) is pressed onto a glass surface to form the point into a small hook, with the point reversed away from the bevel of the needle. The hook is pushed through the cap into a position between the wall of the tube and the swab, and the needle hub projecting out of the cap is rotated to entrain the swab firmly on the needle. Hence, when subsequently centrifuged, the swab is supported by the needle's hub pressing on the exterior of the cap. By means of a microsyringe inserted through the hypodermic needle, any internal standard required (for example, 20 ng of *m*-dinitrobenzene in 10 μL of isopropanol) may be transferred to the swab. The fluid contents of the swab are centrifuged into the bottom of the tube at 250 *g* for 5 min; 1.5 mL of water is syringed through the needle into the swab; and the tube is again centrifuged.

The cleanup of the extract is continued, in the same tube, essentially according to the solid-phase extraction procedures already described in detail elsewhere (See Ref *3* and references mentioned therein) [*3*]. In brief: the cap with the attached swab is removed, and 10 mg of 125 to 150-μm Chromosorb-104 (Johns-Manville), an acrylonitrile copolymer, is dispensed into the extract and maintained in suspension for not less than 5 min. After removal of the spent supernatant, the Chromosorb is drawn into a disposable microcolumn (with a 1-mm inside diameter and a final effective length of 60 mm) prepacked with 3.5 mg of <100-μm Amberlite XAD-4 (Rohm & Haas), a styrene copolymer. The column is eluted with acetonitrile/water (25:12 v/v) at 1 μL s^{-1}, and the fraction collecting between 35 and 90 s (55 μL) is retained for the analysis of a diluted aliquot by high-performance liquid chromatography (HPLC) with electrochemical reductive detection [*3*]. Organic explosives and the similar components of firearm residues are detected and may be quantitated against spiked control swabs or reported as the absolute amounts recovered in the microcolumn eluates. Peaks of interest may be trapped from the chromatograms for thermal energy analyzer (TEA) and mass spectrometric (MS) examination [*4*]. The spent extract and the swab remain available, if required, for examinations for soluble ionic species and insoluble particulates such as inorganic firearm discharge residues.

Results and Discussion

Particular attention was given to the development of a technique robust enough to handle the considerable variations that occur among swabs, for example, in their soiling and degree of solvent depletion, and among the properties of explosives and also of firearm propellant components. Since the introduction of the technique, well in excess of 500 hand swabs have all been smoothly processed. The net manipulation time per swab is 5 to 6 min.

Some results from recovery experiments conducted on ten used swabs (from five subjects), spiked 24 h earlier with 20-ng amounts of the indicated compounds, are given in Table 1. The compounds were chosen to represent those most likely to be encountered in explosives and firearms work at the present time. Their mean recoveries varied reproducibly over the range 63 to 75%. Similar values were obtained for up to the maximum amounts examined (200 ng per swab) and down to the region of the detection limits.

TABLE 1—*Recovery of 20-ng amounts of explosives spiked into used hand swabs.*

Explosive	Mean Recovery, % (standard deviation)[a]
Cyclotrimethylenetrinitramine (RDX)	67.2 (5.3)
2,4-Dinitrotoluene (DNT)	62.8 (4.2)
Nitroglycerin (NG)	73.3 (5.4)
Pentaerythritol tetranitrate (PETN)	75.2 (5.4)
2,4,6-Trinitrotoluene (TNT)	63.2 (4.3)

[a] $n = 10$.

These are of the order 0.1 to 1.0 ng per swab, depending on the state of the swab and on the actual compound. If necessary, the initially unrecovered material can be largely retrieved by a reextraction of the swab with the spent extract in the original tube, the standard procedure then being followed afterward.

The response obtained by HPLC at the completion of the procedure is illustrated in Fig. 1, where Chromatogram A is from a hand swab collected after three days of unrestricted activity following a transfer to the hand of 50 μg of the explosive Semtex. The cyclotrimethylenetrinitramine (RDX) peak corresponds to 29 ng of RDX on the swab. The other explosive component of Semtex, pentaerythritol tetranitrate (PETN), is less persistent than RDX on skin surfaces [*4*] and was not apparent in this chromatogram.

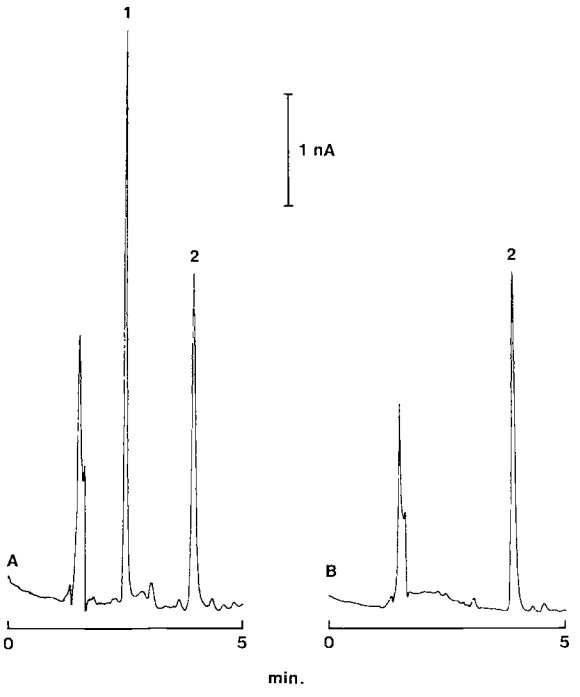

FIG. 1—*Results of HPLC on ODS-Hypersil in methanol/aqueous phosphate (pH 3), 100:89 v/v, with electrochemical reductive detection at −1.0 V versus Ag/AgCl:* (a) *extract of a hand swab collected three days after contact with Semtex,:* (b) *a negative hand swab extract. Peak 1 = RDX; Peak 2 = internal standard* (m-*dinitrobenzene). Each chromatogram represents 5% of the material recovered from the swab. Further details are given in the text.*

By the techniques employed here, Semtex traces may be detected as long as a week or more following the initial contact [*4*]. Chromatogram B (Fig. 1) shows the results from a swab containing no explosives-related compounds apart from the internal standard (*m*-dinitrobenzene).

No modification to the procedure is necessary for the detection of nitroglycerin or 2,4-dinitrotoluene from firearm residue traces on the swabs. The nitrocellulose in such residues is of limited significance as evidence [*2,3*], but if necessary, the solubility in, for example, acetonitrile could be applied in conjunction with previously published techniques for the detection of this component [*3*]. Inorganic firearm residue particulates remain on the extracted swabs, from which they may be recovered for characterization by scanning electron microscopy (SEM) in the usual way, that is, by sonication of the swab in an organic solvent and then membrane filtration of the extract.

References

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