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TECHNICAL NOTE

CRIMINALISTICS

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Stubs Versus Swabs? A Comparison of Gunshot Residue Collection Techniques

ABSTRACT: The collection efficiency of two widely used gunshot residue (GSR) collection techniques—carbon-coated adhesive stubs and alcohol swabs—has been compared by counting the number of characteristic GSR particles collected from the firing hand of a shooter after firing one round. Samples were analyzed with both scanning electron microscopy and energy dispersive X-rays by an experienced GSR analyst, and the number of particles on each sample containing Pb, Ba, and Sb counted. The adhesive stubs showed a greater collection efficiency as all 24 samples gave positive results for GSR particles whereas the swabs gave only positive results for half of the 24 samples. Results showed a statistically significant collection efficiency for the stub collection method and likely reasons for this are considered.

KEYWORDS: forensic science, fired cartridge cases, gun shot residue, XRF, imaging, spectroscopy

The recovery and analysis of gunshot residue (GSR) may be significant in criminal investigations as it can provide supporting evidence of whether or not a suspect was involved in a firearm-related incident, by discharging, handling, or possession of a firearm. Collection of residue is normally from hands, face, hair, and clothing by a variety of techniques such as swabbing, vacuuming, and tape-lifting (1,2). The need for a quick and simple collection technique is paramount as it has been shown that the persistence of GSR is affected by activity such as wiping the hands, putting hands in pockets, and activity during arrest (3). Examination of the efficiency of tape-lifting and cotton swabs (plastic shafted) has been carried out by Goleb and Midkiff (4) who found that both techniques showed comparable efficiency, with residue detection frequencies of 90% and 80%, respectively (4).

The collection efficiency of the tape-lift technique with respect to glue lifting has also been examined, with tape-lifting shown to have superior collection efficiency (5). Further examinations into the collection efficiency of adhesive tapes and tabs have been carried out (6,7). The collection efficiency of adhesive tape for collecting GSR from hair showed no significant difference with respect to swabbing (6).

When comparing the effectiveness of adhesives, using adhesive tape, tabs, and liquids which were applied to aluminum scanning electron microscopy (SEM) stubs for sampling, it was found that the adhesion strength of tapes and tabs was far superior to liquid. Adhesive strength is important as the number of particles collected is directly related to how sticky the adhesive is (7). It is also important that the adhesive remains sticky for some length of time as a large area may be sampled. The liquid was found to be only a weak adhesive when applied wet to the aluminum stub and used for sampling. When allowed to dry before sampling, the liquid showed virtually no adhesive quality. To use the liquid in the field, it would have to be applied to an aluminum stub immediately before sampling (7). Further, the adhesive layer of the liquid is thin which gives less surface area with which the particles may come into contact, affecting the particle retention. It is clear from these results that adhesive tapes and tabs offer a superior level of adhesion and particle retention relative to liquids (7).

There has been little published work on the collection efficiency of swabs; rather, research in this area has focused on the identification of particles once they have been collected by swabs, using different organic solvents to moisten the swabs (8).

The stub collection method involves dabbing an adhesive coated aluminum stub over the area of interest, until the tackiness has gone (*c.* 30 dabs) as shown in Fig. 1.

For swabbing, an alcohol-moistened swab is wiped over the area of interest, placed in a plastic tube and sealed in a bag (Fig. 2).

Some UK Police Forces are moving toward the use of adhesive-coated aluminum stubs for the collection of GSR, without prior examination of collection efficiency. The current research was conducted to examine systematically the collection efficiency of swabs and stubs, under identical conditions, to examine whether there was a statistically significant difference in GSR collection efficiency.

Materials and Methods

Residue Collection

Stub and swab samples were taken using collection kits supplied by Forensic Science Northern Ireland, UK and LGC Forensics, UK.

GSR was collected from the firing hand of eight shooters after firing one round from a Glock 17 using Federal

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FIG. 1—*Example of a stub used for GSR collection.*

FIG. 2—*Example of a swab used for GSR collection.*

full-metal-jacketed ammunition. Before any sampling took place, all shooters were asked to thoroughly wash their hands, and a control stub was taken from Shooter #1 before any shots were fired. Each shooter then fired one round, and their hands were immediately sampled using a stub collection kit. The shooters then washed their hands and the process was repeated twice, giving a total of 24 stub samples, with two more controls taken from Shooters #2 and #3, respectively.

Following the stub collection, all shooters were asked to wash their hands thoroughly and the shooting exercise was repeated using a swab collection kit for sampling. In total, 24 swab samples and three controls were taken. The washing of hands was overseen to check each shooter washed their hands to the same standard between each firing round.

The sample collection took place at Northamptonshire Police Firearms Training Unit, Northampton, UK, and all samples were taken on the firing range located at this site.

Sample Preparation and Analysis

The swab samples were prepared following a standard operator procedure (SOP) supplied by Key Forensic Services Limited. The swabs were placed in glass jars, and approximately 50 mL petroleum ether added. The jars were sonicated for 30 min, then the supernatant liquid was filtered through a Swinnex dual-filter system —a 20-μm filter to remove debris and a 1-μm filter to collect particles of interest. The 1-μm filter was then allowed to dry, mounted on an aluminum stub and sealed around the edge with conductive carbon cement. These samples were then carbon coated prior to analysis.

The stub samples were simply carbon coated before analysis was carried out; no other preparation was necessary for the samples.

Analysis of all the samples (including controls) was carried out at Key Forensic Services Limited, Coventry, UK, using a LEO 435VP Scanning Electron Microscope (SEM) with INCA GSR software (Oxford Instruments, Buckinghamshire, UK).

Results and Discussion

In these experiments, major GSR particles are defined as those being composed of lead (Pb), barium (Ba), and antimony (Sb) in various combinations.

Table 1 shows that for the stub collection method, all 24 samples and three controls gave positive results for GSR. The number of major GSR particles detected ranged from 1 to 34. The swab collection method gave positive results for only 12 of the 24 samples and one control, with the number of major GSR particles detected generally no more than 10. Sample 33 shows a heavy level of GSR, with 47 major particles identified. We believe this to be an anomalous result because of contamination perhaps from the shooter wiping their hands on heavily contaminated clothing.

The significance of the collection efficiency was examined using a Chi-Square statistic (9). It was found that the difference in the

TABLE 1—*List of samples with the number of major GSR particles and the GSR level.* C_x *denotes control sample x.*

Stubs			Swabs		
Sample No.	No. Major Particles	GSR Level	Sample No.	No. Major Particles	GSR Level
1	10	Moderate	25	10	Moderate
2	14	Moderate	26	0	None
3	9	Moderate	27	0	None
4	16	Heavy	28	0	None
5	20	Heavy	29	4	Low
6	34	Heavy	30	7	Moderate
7	7	Moderate	31	0	None
8	7	Moderate	32	1	Very Low
9	23	Heavy	33	47	Heavy
10	9	Moderate	34	5	Low
11	1	Very Low	35	0	None
12	2	Low	36	0	None
13	8	Moderate	37	0	None
14	11	Moderate	38	1	Very Low
15	15	Moderate	39	7	Moderate
16	15	Moderate	40	1	Very Low
17	6	Moderate	41	0	None
18	1	Very Low	42	2	Low
19	1	Very Low	43	4	Low
20	21	Heavy	44	2	Low
21	20	Heavy	45	0	None
22	2	Low	46	0	None
23	11	Moderate	47	0	None
24	16	Heavy	48	0	None
C_1	5	Low	C_4	1	Very Low
C_2	4	Low	C_5	0	None
C_3	2	Low	C_6	0	None

number of stub samples that revealed any trace of GSR, compared with the number of swab samples, was statistically significant at the 99% confidence level ($p < 0.01$). Further, the GSR count on the control samples for the stubs is statistically significantly different from (and less than) the count on the test fire samples using a Chi-Square statistic (9).

The level of GSR shown in Table 1 was classified as follows:

- 1 particle: Very low level and of little significance
- 2–5 particles: Low level of GSR
- 6–15 particles: Moderate level of GSR
- 16–50: Heavy level of GSR
- 50+: Very high level of GSR

The above is a general guide used at Key Forensic Services Limited when determining the levels and significance of GSR detected and interpreting the findings in a case. However, it should be noted that the levels of GSR detected should be interpreted within each case circumstance. This will take into account witness statements, case scenarios, whether the shooting took place inside or outside, contamination issues, type of firearm used, how quickly the items have been recovered for analysis, and many other factors.

A considerable difference in collection efficiency has been identified in the comparison of these two GSR collection techniques. Although particles were recovered using the swab method, only half of the samples gave positive results, which, considering that the samples were taken in a heavily contaminated environment, is surprising.

The ease of use of the swab method in the field is questioned within this investigation. The swabs required removal from vacuum-sealed foil packs (Fig. 2), which proved rather difficult because of the lack of manual dexterity as a result of wearing the gloves provided within the kit. Furthermore, once sampling was complete, each swab was placed in a slim plastic tube. This again required a large degree of manipulation, potentially removing some of the collected particulate.

It is also believed that the extraction process was not thorough enough to remove all the particles that had been collected from the swab. The swabs used were a very fibrous, lint-like material, good for the retention of particulate, but clearly requiring a more vigorous method of particle removal. The dual filter system used to remove debris and collect particles of interest had a tendency to leak as well as removing large conglomerate particles (over 20 μm in size). Conglomerates are made up of a number of smaller GSR particles that have fused together (Fig. 3). With these particles remaining on the 20-μm filter, the number of GSR particles likely to be identified will be lower. It should be noted that in this investigation, the 20-μm filter was not examined; as in casework circumstances, the general size of particles detected is between 1 and 10 μm.

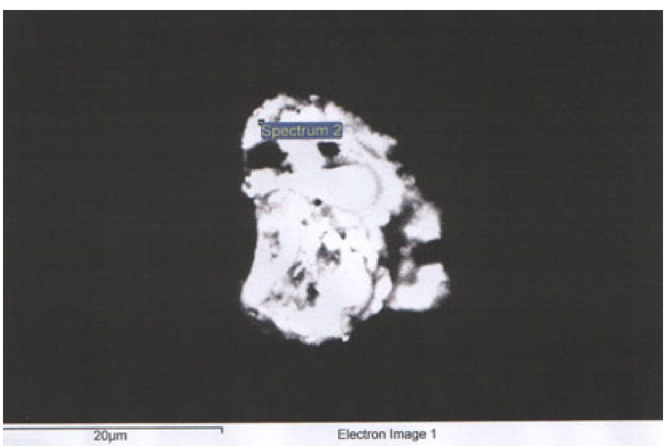

FIG. 3—*An example of a conglomerate particle. Spectrum 2 indicates the area selected for elemental analysis.*

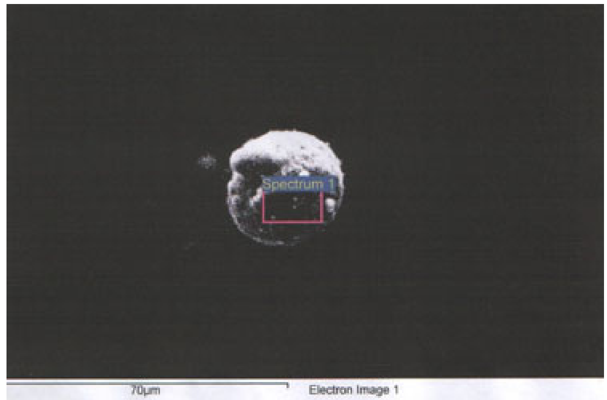

FIG. 4—*10 -μm GSR particle from stub sample. The red box indicates the area selected for elemental analysis. This is labelled Spectrum 1.*

Stub collection is a much quicker and easier method to use in every aspect. Sampling is quick and simple, and the stubs require minimal sample preparation prior to analysis. This means the likelihood of particulate loss is minimal and, as a result of the little sample preparation required, the overall analysis time is less than that required for swabs.

Examples of GSR particles found on some of the stub samples are shown below (Figs. 3 and 4). Examples of elemental spectra produced during analysis of GSR particles are shown in Figs. 5 and 6.

Conclusions

We have shown that the stub collection method is more effective for the collection and subsequent analysis of primer GSR. However, the swab collection method should not be ruled out as a GSR collection method especially for smooth surfaces and if propellant analysis is required. Currently there are no known nondestructive methods for analyzing stubs for propellant residue. Moreover, this investigation is limited to one type of swab collection kit. Other swab collection kits are available, and further work is needed to examine the efficiency of these types of swabs against the stub technique.

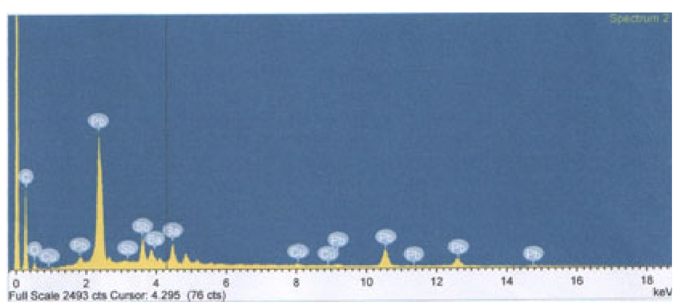

FIG. 5—*EDX spectrum of conglomerate particle in Fig. 3 showing the presence of lead, barium, and antimony, classifying this as a major GSR particle.*

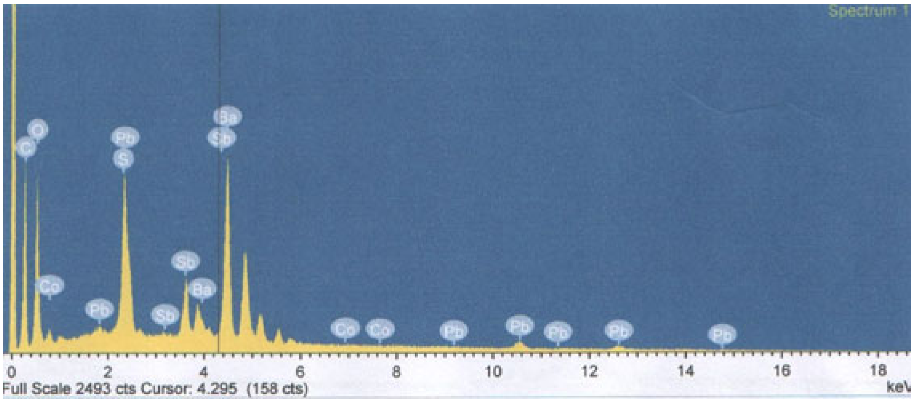

FIG. 6—*EDX spectrum of the particle in Fig. 4 showing the presence of lead, barium, and antimony, the three major components of primer residue.*

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