TECHNICAL NOTE

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Officers, Their Weapons and Their Hands: An Empirical Study of GSR on the Hands of Non-Shooting Police Officers

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ABSTRACT: To help determine the potential of secondary gunshot residue (GSR) transfer from officers onto subjects to be tested for GSR, the presence of GSR on non-shooting patrol officers' hands were evaluated. Forty-three officers were sampled with adhesive-lift discs, which were subsequently concentrated and analyzed by scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS) microanalysis. GSR levels on the officers' hands were lower than expected considering that a firearm was carried and handled by all officers. Only three of the 43 officers had unique GSR particles. No officer had more than one unique GSR particle. Twenty-five of the 43 officers had no particles of GSR on their hands. Although the potential for secondary transfer contamination from an arresting officer to a subject exists, the low empirical numbers of GSR particles found on these non-shooting officers suggest that the potential for this occurrence is relatively low.

KEYWORDS: forensic science, criminalistics, gunshot residue (GSR), scanning electromicroscopy-energy dispersive X-ray analysis, empirical study, gunshot residue transfer, gunshot residue contamination, police officers' hands

In Memoriam

One of the authors, E. F. Rhodes, did not see the fruition of this, his last work, due to his early and very untimely demise. The surviving authors wish to dedicate this article to their mentor, colleague and good friend, Dr. Edward Franklin Rhodes, III.

When a suspected shooter is apprehended, often a gunshot residue (GSR) kit is collected. If these GSR kits contain adhesive- or tape-lift sampling devices, they may be analyzed by scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS) microanalysis [*1–6*]. Concentration procedures exist which allow the criminalist to characterize the elemental composition and morphology of the dense particles collected by searching a minimal surface area [*7–10*]. While the detection of unique particles can provide absolute confirmation of gunshot residue on a subject's hands, it cannot provide the mechanism of deposit. Although handling and/or firing a gun is the primary means of deposition, transfer from a secondary source is possible [*5,11*]. In law enforcement situations where police officers take samples from subjects, the arresting officer's hands represent a theoretical source of secondary transfer contamination. To help evaluate the potential for this condition, adhesive-lifts were taken from non-shooting patrol officers and analyzed by the SEM/EDS technique for gunshot residue.

Methods

Collection

Twenty-nine (29) Orange County Sheriff's Department (OCSD) deputies and 14 San Diego Police Department (SDPD) officers were sampled. The participation and sampling was completely voluntary. A single one-inch diameter adhesive-lift disc was used to collect samples from both of the officers' hands. Sampling was done at the conclusion of the patrol shift when officers dropped off paperwork. The officers were asked to refrain from washing

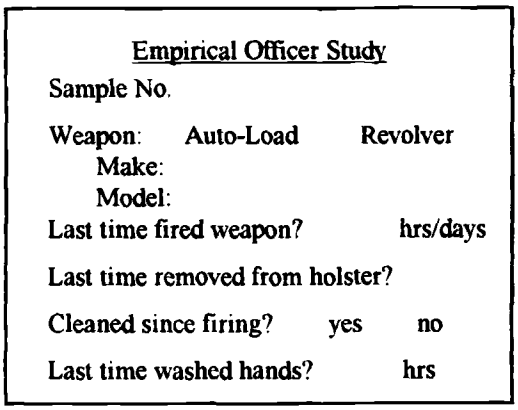

FIG. 1—*Example questions.*

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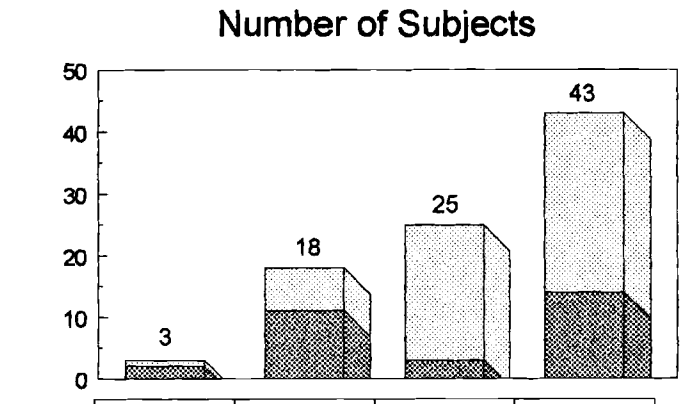
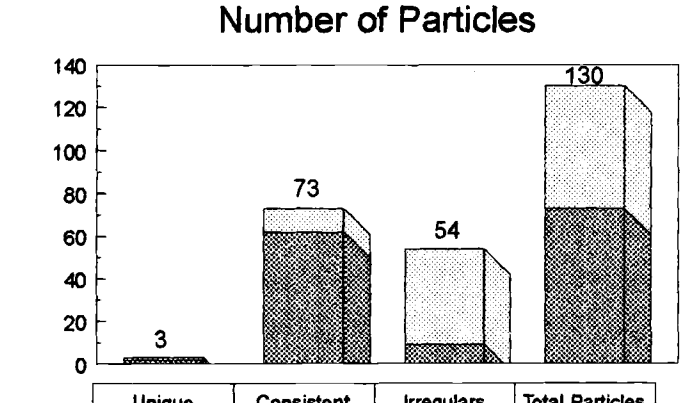


	Unique	Consistent	No GSR	Total Subjects
SDPD	2	11	3	14
OCSD	1	7	22	29

FIG. 2—*Number of subjects within each particle class used in the study. SDPD: San Diego Police Dept., OCSD, Orange County Sheriff's Dept.*



	Unique	Consistent	Irregulars	Total Particles
SDPD	2	62	9	73
OCSD	1	11	45	57

FIG. 3—*Total number of particles found on officers' hands for each particle class used in the study.*

their hands when they returned to the station until they had been sampled. Following sampling, the officers answered a brief questionnaire regarding recent use and handling of their weapon (see Fig. 1). For the purposes of this study, handling a firearm was defined to be removing the firearm from the holster and holding it; placing or resting one's hand on the sidearm was not considered

TABLE 1—*Operating conditions for SEM/EDX.*

Condition	Setting
Accelerating voltage	25 kV
Working distance	35 mm
Specimen tilt	10 degrees
Magnification	1800×
Specimen current	0.5 nA
EDX acquisition energy	1–20 keV

TABLE 2—*Particle Classification Scheme.*

Type	Element(s)	Morphology
Unique	Pb, Sb, Ba	Spherical or non-spherical
	Ba, Sb	Spherical or non-spherical
Consistent	Pb, Sb	Spherical
	Pb, Ba	Spherical
	Ba	Spherical
	Sb	Spherical
	Pb	Spherical
Irregulars	Pb, Sb	Non-spherical/irregular
	Pb, Ba	Non-spherical/irregular
	Ba	Non-spherical/irregular
	Sb	Non-spherical/irregular
	Pb	Non-spherical/irregular

NOTE: Trace elements allowed as in Aerospace Report [*1*].

TABLE 3A—*Officer information.*

Sample Number	PI-Autoloader PR-Revolver Caliber and General Description	Days Since Last Fired	Hours Since Handled	Cleaned After Last Use	Hours Since HandWash
1	PI 9mm	10	24	Y	8
2	PR 357 Mag. S&W	15	3	Y	2
3	PI 9mm	0.5	unk	N	3
4	PI 9mm S&W 5904	21	3	Y	0.2
5	PI 9mm S&W 5904	21	5	N	8
6	PI 9mm S&W 5904	25	9	Y	3
7	PI 9mm S&W	1.1	9	Y	4
8	PI 9mm S&W	30	3	N	3
9	PI 9mm S&W	30	1.5	Y	3.5
10	PI 9mm Beretta	5	24	Y	3
11	PI 9mm S&W 5904	3.5	8	Y	10
12	PI 9mm S&W	30	8	Y	3
13	PI 9mm S&W	1	6	Y	5.5
14	PI 9mm S&W	30	6	N	2
15	PI 9mm S&W	7	4	Y	1
16	PR 38 Spl S&W	14	4	Y	8
17	PI 9mm S&W	20	8	N	8
18	PI 9mm S&W	30	48	N	10
19	PI 9mm S&W	30	8	Y	1.5
20	PI 9mm S&W	1	24	N	12
21	PI 9mm S&W	30	4	N	2
22	PI 9mm S&W	21	72	Y	3
23	PR 38 Spl S&W	30	3	Y	5
24	PI 9mm S&W	13	96	Y	8
25	PI 9mm S&W	20	8.5	N	3
26	PI 9mm S&W	17	168	Y	5
27	PI 9mm S&W	30	7	Y	1
28	PI 9mm S&W	30	0.1	N	1
29	PR 38 Spl S&W	30	24	Y	10
30	PI 9mm Sig 226	30	9.5	Y	2.5
31	PI 9mm Sig 226	60	3	Y	1.5
32	PI 9mmRuger	60	5	Y	2
33	PI 9mm Sig	14	11	Y	1.5
34	PI 9mm S&W	1	4.5	Y	2.5
35	PI 9mm Sig 226	7	1	Y	2.5
36	PI 9mm S&W	45	5.5	Y	1.75
37	PI 9mm S&W 5903	8	10.5	Y	1
38	PI 9mm S&W 5904	60	0.2	Y	1
39	PI 9mm S&W 669	90	10	Y	3
40	PI 9mm Ruger P85	7	10.5	Y	4
41	PI 9mm Ruger P85	14	4	Y	3
42	PI 9mm S&W	90	8	Y	5
43	PI 9mm Ruger	2	9.5	Y	2

TABLE 3B—*Author-table title?*

Sample Number	Unique	Consistent	Irregulars (Total)	Comments
1			Pb/Fe(2), Pb/Si	At firing range, No firing
2				
3			Pb(3)	Night Shoot Training
4		Pb/Sb		Washed Hands 10 min.prior
5				
6			Pb	
7		Pb		
8				
9		Pb/Sb	Pb(2), Pb/Sb(2)	Handled Shotgun
10		Pb/Ca/Fe(3),Pb,Pb/Ca	Pb(7)	
11			Pb, Pb/Si	Cleaned Gun Prior Shift
12				
13		Pb	Pb, Pb/Sb(8)	Cleaned Gun During Shift
14				
15				
16		Pb/Sb	Pb/Sb(2)	Cu/Zn
17				
18			Pb/Sb	
19				
20			Pb/Si/Al/Sb	
21				
22			Pb(2)	
23			Pb/Si/Ca(3), Pb, Pb/Sb	
24			Pb, Pb/Ca	At firing range, No firing
25	Pb/Ba/Sb	Pb	Pb/Sb	Unique particle 40u flake
26				Cu/Zn
27			Pb(2)	
28				
29				
30		Ba(6), Pb/Sb(2), Pb	Sb	Cu/Zn, Cu/Ni
31		Ba	Sb	Cu/Zn, Cu/Ni
32				
33		Sb/Pb(1), Ba(4)		Cu/Zn, Cu/Ni
34		Ba(7),Pb	Sb(2)	Cu, Cu/Zn
35		Ba(15), Pb(3)	Sb(2), Ba	Cu/Zn, Cu/Ni
36		Pb(3), Ba(4)	Sb	Cu/Zn, Cu/Ni
37		Ba(7), Pb	Sb	Cu/Zn, Cu/Ni
38		Ba(3)		Cu/Zn, Cu/Ni
39	Pb/Sb/Ba	Ba		Cu/Zn, Cu/Ni
40		Pb/Sb		
41				Cu/Ni
42	Pb/Sb/Ba	Ba		Cu/Ni
43				Cu/Zn

handling. All officers carried ammunition containing lead, antimony, and barium in the primer.

Analysis

The lifts were extracted and concentrated onto polyester membranes with 0.6 μm pore size using the technique described previously by one of the authors [*7*]. Four "Blank" samples were also prepared to ensure no contamination was introduced during the adhesive-lift preparation, the concentration procedure, or the analysis. There was one "Blank" for each group of samples concentrated. The collected particles were analyzed for GSR using a CamScan Series IV (S4) Scanning Electron Microscope (SEM) with a Robinson backscatter detector, motorized stage drives, and an EDAX 9800 Plus Energy Dispersive X-Ray spectrometer. The automated searching was operated by CamScan GSR automation software. Automated search conditions are listed in Table 1.

Automation of SEM/EDS gunshot residue analysis has been used by several laboratories nationwide and its application to casework has been reported previously [*12–14*]. Calibration for the automated searching system was achieved using a disc with a previously determined number of 1.0 μm size GSR particles. The sensitivity of the system was calibrated such that it would "hit" on all the 1.0 μm size GSR particles at least 95% of the time during replicate calibration checks. GSR particles less than 1.0 μm in size may be missed, however, using the automated search analysis. All particle "hits" were manually reviewed by one of the authors (DMG or EFR) for the presence of GSR particles.

Particle Classification

The particle classification scheme used is a modification of that developed by the Aerospace Group [*1*]. The barium, calcium, and silicon particles that the Aerospace Report considers "Unique" (or "Characteristic") were classified in this study as "Consistent." This modified scheme was incorporated to avoid any confusion of whether Ba,Ca,Si particles should be considered unique or consistent. Some authors have reported that they do not consider these particles unique [*15*]. Table 2 outlines the classification scheme used for the analysis. Trace elements may accompany the

major components of gunshot residue particles; trace elements were allowed as noted in the Aerospace Report [see Ref. 1, pp. 15].

Any particles elementally consistent with gunshot residue based on EDS but inconsistent with gunshot residue based on morphology were classified as "Irregulars." Particles that were clearly non-GSR (such as Pb/Sn) were not included in this group.

Results

Table 3 lists the empirical data collected during the analysis. Results of all the pertinent questions are in tabular form for the reader. Sample numbers 1–29 are from Orange County Sheriff's Department deputies while sample numbers 30–43 are from San Diego Police Department officers. The firearm carried by the officer is noted with the FBI's Crime Lab Information System (CLIS) File listing format. The "Hours Since Handled" column in Table 3A is the answer to the question from Fig. 1 "Last time removed from the holster?" The elements listed under the particle classifications are listed in order of descending abundance (for example, Pb/Sb means that a lead-antimony particle with lead in greater abundance than antimony based on EDS). The numbers following the elements indicate the actual numbers of particles found; particles without a number indicate one particle found. Blank cells in the chart indicate no particles found. The "Comments" column lists any important or interesting notes about the officer sampled (for example, unusual activity of the officer or an abundance of certain particles). Although not listed, the "Blanks" were devoid of any GSR (unique or consistent) particles and devoid of any "Irregular" (Pb/Sb/Ba non-spherical/irregular) particles.

Figure 2 and Figure 3 display some of the tabular information about the analysis graphically. Figure 2 shows the number of subjects within each particle class used in this study. Officers with no particles unique to or consistent with GSR were considered to have "No GSR" regardless of the presence of or absence of "Irregular" particles. Figure 3 displays the total number of particles found on the officers' hands from each particle class used in this study (that is, Unique, Consistent, Irregular).

Conclusions

Of the 43 officers sampled, only three had unique GSR particles (approximately 7% of the sampled officers). No officer had more than one unique GSR particle. Twenty-five (25) of the 43 officers had no GSR particles on their hand surfaces (approximately 58% of the sampled officers). Considering that a firearm is carried and handled routinely, only a small fraction of the sampled officers had unique GSR collected from their hands. Furthermore, slightly more than half of the sampled officers had no gunshot residue particles collected from their hands. The low number of GSR particles collected from the officers' hands[4] indicates a lessened likelihood of transfer to sampled subjects. Although the potential for secondary transfer contamination from an arresting officer to a subject exists, the low empirical numbers of GSR particles found on these non-shooting officers suggests that the potential for this occurrence is relatively low.

[4] Referring to Figure 3: There were 76 total GSR particles amongst the 43 officers.

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