

3/14/01

GSR Transfer To Paper Bag Hand Covers: A Case In Point...*Continued*

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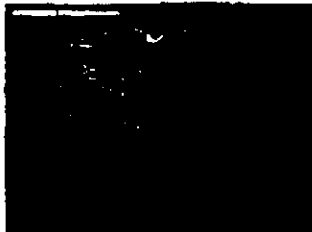
suspected shooter's hands and the subsequent analysis of the sample stubs for GSR: (1) the likelihood of transfer of GSR particles is directly related to the number of particles remaining on the hands after the post-discharge "activity" of the shooter; (2) the "masking" of GSR particles by residue (e.g. dirt, sweat) acquired prior to bagging/sampling is

possible; and (3) the need exists for a more thorough sampling of bags by "sticky lift" stubs (approx. 7% of the total surface areas for both bags was sampled in this case prior to the loss of effective "dabbing").

The instrumental parameters used were as follows: JEOL 5800 SEM/Oxford Link ISIS EDS Oxford Automated GSR package Accelerating Voltage: 20kV

Magnification(s): (400X), 800X Working distance: 10mm Backscatter threshold: Manually set (Mn, Pd standard)

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The Retention of Gunshot Residue on Clothing After Laundering

Abstract

Criminal investigators have long used the detection of gunshot residue (GSR) as evidence of an individual's association with a firearm. Previous studies have been conducted to determine the duration of time GSR is retained on a person's skin. How long gunshot residue can remain on clothing has yet to be determined. In this study, articles of clothing worn during the discharge of a firearm and then washed in a routine manner were sampled and analyzed by scanning electron microscopy with energy dispersive spectroscopy. GSR-related particles were detected on some of these laundered articles of clothing, which illustrates the difficulty in the interpretation of positive results on inanimate objects.

Introduction

The expulsion of a bullet from a firearm is initiated by the ignition of the primer compound. In center-fire ammunition this compound is contained in the primer cup located within the base of the cartridge case. Most primers contain lead styphnate as the explosive initiator, barium nitrate as the oxidizer and antimony sulfide as the fuel.^{1,2,3} Gunshot residue (GSR) particles originate from this primer compound and form as condensates from the cloud of gas which is generated when a firearm is discharged. This cloud contains vaporized components from the primer, mainly lead, barium and anti-

mony. These elements condense and coalesce to form GSR particles having a characteristic spheroidal morphology.^{4,5,6}

When a firearm is discharged, GSR particles may be deposited on nearby surfaces including the skin of the person who fires the weapon. Additionally, particles may be deposited on the skin of a person who is in the vicinity of a firearm when it is discharged. Deposition can also occur on inanimate objects, such as the weapon itself, or other objects in close proximity at the time of discharge. Contact with such an item may result in GSR deposition.

The deposition and retention of GSR particles are dependent upon many variables. The amount of residue deposited is affected by the type of ammunition, the type of firearm and the location of the shooting (indoors versus outdoors). The type of activities following deposition influence retention of residue. Previous research has shown that GSR particles deposited on the skin are easily removed in the course of normal activity.^{7,8,9} Consequently, the detection of gunshot residue on the hands or face of a living person generally indicates a fairly recent association with a firearm. It indicates the person discharged a firearm, was in close proximity when a firearm was discharged, or came in contact with an item with gunshot residue deposition.

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science of our law,--
That codeless myriad of
precedent, That
wilderness of single
instances.

Aylmer's Field.



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When GSR particles are deposited on the skin it is also possible that particles are deposited on a person's hair. Other studies have considered the retention of GSR on head hair and found that residue may be detected for up to twenty-four hours following a discharge of a firearm. It was also shown that shampooing the hair removed the residue.^{10,11}

If GSR particles can be deposited on skin and hair, it is reasonable to conclude that they can also be deposited on a person's clothing. Some research has reported with respect to GSR analysis on clothing. Zeichner, Andrasco and Wallace have reported various sampling techniques for the collection of residue from clothing.^{12,13,14} Research has also shown clothing can be contaminated with GSR. Residue was detected on a clean laboratory coat after it was hung in a closet next to a jacket previously worn while shooting.¹⁵ Although it is believed that GSR may become embedded in fabric and therefore remain on clothing for

longer periods of time, the authors found no research dealing specifically with the issue of just how long GSR can be retained on clothing.

Experimental

A variety of clothing items were selected in an effort to include different types of fabrics and items that were loosely as well as tightly woven. A list of each item and a description of the fabric is given in Table 1. In actual case samples the history of an item can never be known. For this reason, the clothing chosen for this study have unknown histories, i.e., these pieces of clothing may or may not have had GSR deposition in the past. An initial study of 5 articles of clothing was followed approximately one year later by a second study of 14 pieces of clothing. Data for all 19 items are included in this report. Each item was sampled and analyzed at three stages.

Stage I: Blanks Each item was first washed in a standard top loading washing machine using warm water and detergent.

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Table 1: Clothing Items Sampled

Item Number	Description	Fabric Type
#1	White, long-sleeved dress shirt	65% polyester-35% cotton
#2	Sheer Energy glove- right hand	81% nylon-19% spandex
#3	Sheer Energy glove- left hand	81% nylon-19% spandex
#4	Black long-sleeved sweat shirt	50% cotton-50% polyester
#5	Gore-Tex jacket	Gore-Tex
#6	Black stocking cap	100% acrylic
#7	Sheer Energy glove- left hand	81% nylon-19% spandex
#8	Sheer Energy glove- right hand	81% nylon-19% spandex
#9	Black knit stretch glove- left hand	acrylic
#10	Black knit stretch glove- right hand	acrylic
#11	Brown gardening glove- right hand	cotton
#12	Brown gardening glove- left hand	cotton
#13	White T-shirt	50% cotton-50% polyester
#14	White/grey knit glove- right hand	acrylic
#15	White/grey knit glove- left hand	acrylic
#16	Blue shaker knit sweater	100% acrylic
#17	Brown windbreaker jacket	100% nylon
#18	Grey sweatshirt	40% acrylic-30% cotton-30% polyester
#19	Plaid flannel shirt	100% cotton

Training Courses

Nanoworld's Centre for Microscopy and Microanalysis (CMM). The University of Queensland in Australia.
www.uq.edu.au/nanoworld/sem_gen.html

The Electron Microscope Unit and The Australian Key Centre for Microscopy and Microanalysis. The University of Sydney in Australia.
www.usyd.edu.au/su/emu/courses/course.html

The National Center for Electron Microscopy (NCEM). Lawrence Berkeley National Laboratory in California.
<http://ncem.lbl.gov/ncem.html>

MVA, Inc. Training in Microscopy and Microanalysis.
<http://mvainc.com/>

Geller MicroAnalytical Laboratory.
www.gellermicro.com/

Ross Electron Optics Consulting & Services (REOCS).
<http://web.missouri.edu/~geosolm/rov.html>

EVEX Analytical.
www.evex.com/

San Joaquin Delta College offers a Certificate Program in Microscopy in Stockton, California.
www.deltacollege.org/dept/electmicro/

Lehigh Microscopy School, Lehigh University in Bethlehem, Pennsylvania.
www.lehigh.edu/~inmatsci/shortcourses/Microscourses.html

The McCrone Research Institute Courses in Chicago, Illinois.
www.mcri.org/Courses_about.html

Media Cybernetics.
www.mediacy.com/training.htm

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Items #1-5 were laundered using phosphate free Amway brand detergent. Items #6-19 were laundered using Clout brand detergent. All items were dried in a dryer at low heat. Sampling was done by placing the item on a clean piece of white butcher paper and dabbing it with a 13 mm diameter aluminum scanning electron microscope (SEM) stub with double sided adhesive tape. Gloves were sampled in much the same way as arc hands. Sampling was done on the web area, back of the hand area and the cuffs. The stocking cap samples were collected from the brim, middle and top front area. All other items were sampled at the chest, collar and cuff area, if applicable. Dabbing continued until tackiness of the adhesive was minimal. Disposable gloves were worn and changed between each item sampled. These samples are designated blanks.

Stage II: Post-firing -To achieve deposition of GSR, each item was worn while firing two rounds from a Dan Wesson Arms, 357 magnum caliber revolver. For safety reasons, the barrel had been plugged and the firings were of cartridge cases with primer only. Plugging the barrel also decreased the venting of residue through the barrel and enhanced deposition of GSR. Firings were done in an indoor range. The air flow fan was off during test firings to reduce dissipation of particles and further enhance GSR deposition. One of the analysts would put on a particular article of clothing, fire two rounds, then remove the item and place it directly into a clean paper bag. The next piece of clothing would then be put on and the process repeated until each item had been worn during the discharge of two rounds. To verify that deposition had occurred, a limited area was sampled on each item in the manner described above. Only small areas were sampled to ensure that only a small amount of GSR present was being removed by the sampling process. These samples are designated post-firing.

Stage III: Post-washing -All articles of clothing were then laundered in the same manner previously described in Stage I. Each article was sampled using aluminum SEM stubs to dab the same areas indicated

in Stage I. Sampling was conducted in a room different from that where the post-firing samples were obtained. Gloves and butcher paper were again changed between each sample. These samples are designated post-washing.

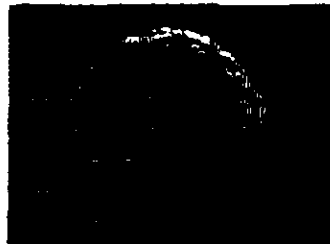
Control samples were also run. Stubs were opened and the tape surface exposed to the air for 24 hours in 3 different laboratory locations where sampling and analysis occurred. These stubs were then analyzed to establish that no airborne contamination existed within the laboratory. Butcher paper was also sampled and analyzed for GSR particles.

Analysis

Analysis was done by the scanning electron microscope and energy dispersive x-ray analysis (SEM/EDX) technique. Analysis by SEM/EDX has been widely reported as an effective technique for locating and identifying GSR particles.^{15,16} In this study a gunshot residue particle is defined as a particle containing lead, barium and antimony. Particles containing two of these three elements are considered supporting particles. These are characteristic of, but not unique to, GSR.¹⁶

In preparation for SEM analysis, the sample stubs were coated with vaporized carbon using a Denton Vacuum Desk II cold sputter etch unit with a carbon evaporation accessory. Analysis of samples was conducted on a Jeol JSM-5200 SEM equipped with a Tracor Northern Series II x-ray analyzer. Scanning of each sample was conducted manually at a magnification of 1500X, a working distance of 20 mm and an acceleration voltage set at 20 kV. The scans were conducted in the backscatter mode. In casework, laboratory protocol requires that each stub is scanned a minimum of 5 times across its diameter before an inconclusive result is reported. A random sampling procedure is followed since it is not feasible to manually scan the entire surface of a stub. Therefore, in this study as in casework, the failure to detect a GSR particle is considered inconclusive rather than negative. Scanning stops once a positive result is achieved which sometimes requires less

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the more glorious the triumph. What we obtain too cheap, we esteem too lightly; it is dearness only that gives everything its value. I love the man that can smile in trouble, that can gather strength from distress and grow brave by reflection. 'Tis the business of little minds to shrink; but he whose heart is firm, and whose conscience approves his conduct, will pursue his principles unto death.

Thomas Paine

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than 5 scans. The stubs used to sample items #1-5, (blanks and post-washings) were scanned ten times across their diameter, a protocol more stringent than the five scans generally conducted on casework. For items #6-19 (blanks and post-washings) the standards applied to casework were used, conducting 5 scans on each stub, unless a GSR-related particle was found, in which case extra scans were performed. The total number of scans on each stub is given in Table 2. The samples collected from all items after deposition (post-firing) were scanned until GSR deposition was verified. Typically less than one full scan was required.

For this study, the presence of any number of GSR or supporting particles was considered significant and is reported in our results. Results are given in Table 3.

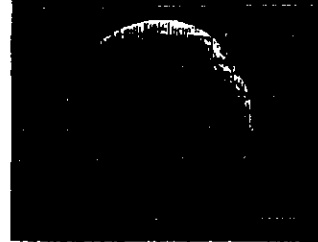
Results

No GSR-related particles were detected on the control samples collected within the laboratory or from the butcher paper. There was no evidence of GSR contamination due to airborne GSR particles.

In Stage I, the initial blanks, 3 items were found to have GSR-related particles. All

three of these items were gloves. After 10 scans on item #3, one barium/antimony particle was found. After 15 scans on item #9, one GSR particle was identified. Item #14 was examined for a total of 9 scans with identification of one lead/antimony particle. Positive results were obtained from each post-firing sample (Stage II). Items #1-5 were scanned until one GSR particle was found. Only item #3, a glove, required 2 scans to achieve this positive result. A positive result was obtained in the first scan on all other items. Items #6-19 were scanned until at least two GSR particles were identified. This was done in a single scan on all items except #6, a stocking cap, and #17, a windbreaker. Two scans were done on item #6 and four scans on item #17. After laundering, Stage III Post-washing, five items were found to have GSR-related particles remaining. A pair of gloves (#2 and #3) were found to have one GSR particle on both the right and left hand gloves. Two supporting particles were also found. On item #16, a sweater, a single GSR particle was identified. A total of 16 scans were done on this item. After 13 scans, two GSR particles were found on item #17, a wind-

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and no criminals in these days. What is the use of having brains in our profession? I know well that I have it in me to make my name famous. No man lives or has ever lived who has brought the same amount of study and of natural talent to the detection of crime which I have done. And what is the result? There is no crime to detect, or, at most, some bungling villainy with a motive so transparent that even a Scotland Yard official can see through it.

"A Study in Scarlet";
Sherlock Holmes

Table 2: Number of Scans Done on Each Stub

Item #	Item Type	Blank	Post-firing	Post-washing
#1	Shirt	10	1	10
#2	Glove-right hand	10	1	8
#3	Glove-left hand	10	1	4
#4	Sweatshirt	10	1	10
#5	Jacket	10	2	10
#6	Stocking cap	5	2	5
#7	Glove-left hand	5	1	5
#8	Glove-right hand	5	1	5
#9	Glove-left hand	15	1	5
#10	Glove-right hand	6	1	5
#11	Glove-right hand	5	1	5
#12	Glove-left hand	5	1	5
#13	Glove-right hand	5	1	5
#14	Glove-left hand	9	1	5
#15	T-shirt	5	1	5
#16	Sweater	5	1	16
#17	Jacket	5	4	13
#18	Sweatshirt	7	1	13
#19	Flannel shirt	6	1	5

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breaker. Two supporting particles, one barium/antimony particle and one lead/antimony particle, were found on item #18, a sweatshirt.

Discussion

As mentioned in the introduction, Andrasko and Pettersson reported on contamination of clothing by transfer.¹³ They detected GSR on a clean lab coat that was hung next to a jacket with GSR on it, illustrating that particles can be transferred from one item to another. Although laundering appeared to effectively remove gunshot residue from many items tested, the presence of GSR particles on some items both in Stage I (Blanks) and in Stage III (Post-washing) indicates that laundering clothing does not always completely remove gunshot residue.

Consequently, when GSR-related particles are detected on an article of clothing the possibility exists that the residue was deposited long ago or is the result of transfer.

This study raises many interesting and as yet unanswered questions demonstrating the need for additional research in this area. The clothing used here was separated as one typically separates laundry. Some GSR-contaminated items were washed with each other as well as with items that had no known exposure to gunshot residue. Samples were not collected from any of those items. It is not known whether or not a transfer of particles can occur during the actual washing and drying of clothing. Additional studies are needed to determine if this can occur. Repeating this study using a

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mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality."

Albert Einstein

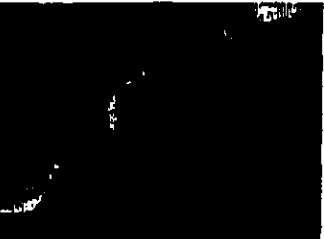


Table 3: Number and Type of GSR-Related Particles Detected**

Item #	Item Type	Stage I: Blank	Stage II: Post-firing	Stage III: Post-washing
#1	Shirt	0	Ba/Sb-1, GSR-1	0
#2	Glove-right hand	0	Ba/Sb-2, GSR-1	Pb/Ba-1, GSR-1
#3	Glove-left hand	Ba/Sb-1	Ba/Sb-1, GSR-1	Pb/Sb-1, GSR-1
#4	Sweatshirt	0	Ba/Sb-3 Pb/Ba-1, GSR-1	0
#5	Jacket	0	Ba/Sb-1 GSR-1	0
#6	Stocking cap	0	Ba/Sb-2 Pb/Sb-2, GSR-2	0
#7	Glove-left hand	0	Ba/Sb-3 GSR-2	0
#8	Glove-right hand	0	Ba/Sb-1 Pb/Sb-1, GSR-2	0
#9	Glove-left hand	GSR-1	GSR-4	0
#10	Glove-right hand	0	Ba/Sb-1, GSR-3	0
#11	Glove-right hand	0	Ba/Sb-2, GSR-2	0
#12	Glove-left hand	0	Ba/Sb-1, GSR-2	0
#13	Glove-right hand	0	Ba/Sb-1, GSR-2	0
#14	Glove-left hand	Pb/Sb-1	GSR-3	0
#15	T-shirt	0	Ba/Sb-1, GSR-2	0
#16	Sweater	0	GSR-3	GSR-1
#17	Jacket	0	Ba/Sb-5 Pb/Sb-11, GSR-3	GSR-1
#18	Sweatshirt	0	Ba/Sb-3, GSR-2	Ba/Sb-1
#19	Flannel shirt	0	Ba/Sb-1, GSR-2	0

** Key

GSR-2: Indicates 2 particles containing Pb, Ba, and Sb.

Ba/Sb-1: Indicates 1 particle containing Ba and Sb.

Pb/Sb-11: Indicates 11 particles containing Pb and Sb.

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variety of firearms and different live ammunition may also provide a more realistic situation and additional information. The instrument used by this lab for this study was, as mentioned previously, a manual search system. It has since been replaced by an SEM with an automated GSR search program, which we hope to utilize in the future for a repeat of this study.

Because GSR particles have been shown to be readily removed from skin^{7,8,9}, it is reasonable to conclude that the presence of GSR on a living person's hands or face indicates a recent association with a firearm or recent contact with an item with gunshot residue on it. This study indicates that the same is not true when analyzing clothing for GSR. No conclusions can be drawn with respect to time of deposition based on the presence of gunshot residue on clothing.

Acknowledgement

The authors wish to thank Mary Kelly Floyd and Margie K. Bopp for the many hours spent at the electron microscope.

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a new audacity of
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John Dewey

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Lead Particles from Non-Firearms Sources, J. Giacalone, IAMA Sept. 28, 2001
Pb / Sb / Sn in GSR from Yugoslavian ammunition

Retention of GSR on Clothing After Laundering, D. Chavez, C. Crowe, L. Franco IAMA, March 14, 2001 "Laundering does not always completely remove gunshot residue."

Advanced Research Instruments Corp. (personal communication)

Jozef Lebledzik

9 mm S&B: non-quantitative assesment: "Sb almost always accompanied by Sn"

SELLIER & BELLOT

J. Telecka, Sellier & Bellot

All pistol and revolver cartridges – Boxer; NMNC Mixture - Lead Stryphnate; Tetracene; Barium Nitrate, Antimony Sulfide, Calcium Silicide, Foil – Lacquer coated foil, 0.38 mm x 0.03 mm. Produce the primers they use; A dry mixture pressing and anvil assembly process
Two advantages: better moisture resistance; resistance to explosion during production
Not used to reduce barrel wear/fouling

Current Status of Tin foil use (personal communication) :

2 -3 Czech companies making Primers with tin foil.

Future : coated paper substitute; Tin foil only is requested

Pb, Ba, Sb, Sn Particles from Other Sources

K. Lueftl, Bavaria Police, Germany

Dynamite Nobel (Geco) (German) – 9, 7.65

Eidgenossische Munitionsfabrik Thun (Swiss)

Fabrique Nationale (Belgium) - 7.65 Luger +

Giulio Focchi Lecco (Italy) – 9 +

Hirtenberger (Austria) – 9

Lapuan Paruunathedas (Finland) – 9mm Browning

Norinco (China) - 9x19 Luger +

Poongsan Military cartridge (Korea) - 9x19

Priv Partizan Arsenal (Yugoslavia) - 7.65

UNIS Pobjeda (Yugoslavia) - 9 & 7.65

Winchester Western (USA) – 9 mm, 30.30

Bullets as a Source of Tin Karl Lueftl e-mail Tin bullets – Winchester Super Clean NT

Tinned Bullets, Tin coated bullets – lubricant, reduces barrel wear and tear, MEN and DAG

9x19 SX; German police using Pb free ammo Sintox Ti/Zn with no-lead primer; Bullet Jacket

coated with 5-10 u Sn; For lubrication purposes.