Research Article
Volume 11:3,2020
DOI: 10.37421/2157-7145.11.458

Journal of Forensic Research

ISSN: 2157-7145 Open Access

Identification of GSR on the Shooter's Hands Using Energy Dispersive Experiments

Mishra RK[1], Jain P[1], Anil Budania[1], Mukesh Sharma[1*] and Tiwari RS[2]

[1]*Physics Division, State Forensic Science Laboratory, Rajasthan, India*

[2]*Physics Division, University of Rajasthan, Jaipur, India*

Abstract

Background: Gunshot residues are collected after shooting incident or firearms used, using to determine the composition of the GSR reference by various techniques to choose methods and techniques most suitable for this type of analysis, such as SEM-EDX, NAA, LBIS and etc.

Objectives: Our proposed study is to determine the elemental analysis of GSR using EDX – 8000 set-up. All the GSR constituents lead-barium-antimony (Pb-Ba-Sb) are verified in the Indian made ammunition.

Methods: Samples of metallic powder residue were realized after several shoots by different kind of weapons (country made firearms) with local ammunitions. So, this study was undertaken to develop chemical ballistic specialty in order to improve forensic investigations and drive benefit to Indian police and forensic experts.

Results: Our results reveals that the non-destructive - EDX method is quite adequate to analysis the proposed investigation.

Keywords: Forensic ballistics • GSR • EDX–8000

Introduction

The detection of gunshot residue (GSR) ejected from a gun during its discharge is of great importance in various criminal investigations involving the use of firearms. The analysis of gunshot residue in human tissues and clothing in suicide, homicide or suspicious death provides to the forensic expert valuable information to interpret and reconstruction the scene of occurrences [1]. Forensic analysis has improved significantly over the past few years, mainly owing to the continued increase in the requirement for more reliable results in order to diminish erroneous convictions. GSRs are residues from firearm discharge, and they consist of vapors and particulate materials that are deposited onto the hands (mainly the index fingers and thumbs), face, and clothes of the shooters. If these particles are collected and reliably analyzed, the suspect can be successfully identified. GSRs have three main inorganic elements: lead, barium, and antimony [2]. The analysis of lead from GSRs can be used as an indicator of the presence of the residues. For the assessment of the value of a GSR is linking a suspect and a crime, it is importance to compare two hypotheses: the first can be that of the evidence if the suspect has been shooting in as specific situation, the second that of the evidence if the suspect was not involved in the shooting [3]. Analysis of GSR, Bolck and Stamouli [4] has reported a two level multinomial model for the calculation of the likelihood ratio in order to have a tool to discriminate between same-ammunition-type GSR compositions and different-ammunition-type compositions. Using the two-level multinomial model they reported the conclusion that this model can indeed be applied on such experimental data. Interpretation of GSR data in suspected suicide cases is a difficult task since the victim, who was for sure present in the surroundings of the shooting, may be highly contaminated. On the other hand, the occurrence of false negatives is also quite large. Conducting a follow-up of the study by Molina et al. published earlier [5], Lucas N, et al. [6] have examined the presence of IGSR on the hands of victims of undisputed suicide cases by firearms: 59 cases that occurred in Australia were investigated. About 50% of these cases presented no or very few (less than four) Lead-Barium-Antimony particles, confirming the results of the study conducted by Molina K, et al. [5]. However, most of the cases presenting such low level of characteristic particles were related to the use of 0.22 calibre rifles (the most popular firearm in Australia), for which the primer of the ammunition usually does not contain Antimony. Not surprisingly, this leads to the production of GSR particles with no (or very little) Antimony. Taking such particles into account in the statistics, the number of the cases presenting no or very few (less than four) particles of interest falls down to less than 15%. The article presents other interesting statistics, such as the difference of GSR production as a function of weapon model (i.e. a higher number of GSR particles are produced by revolvers, compared to rifles). Zeichner commented this article, with a discussion about the possible memory effects of the weapon to the contribution of Antimony in IGSR particles [7].

Dona-Fernandez et al. [8] performed an extended comparative study of SEM/EDS and portable laser-induced breakdown spectroscopy. By performing a comparison between data collected from shooters and non-shooters, the authors concluded that even when only one single Lead-Barium-Antimony GSR particle was found by SEM/EDS, the laser-induced breakdown spectroscopy sy.

***Address for Correspondence:** Mukesh Sharma, Physics Division, State Forensic Science Laboratory, Rajasthan, India, Tel: +91-8209791580; E-mail: mksphy@gmail.com*

Received: 25 May, 2020; **Accepted:** 25 July, 2020; **Published:** 3 August, 2020

In a recent study, McKenzie-Coe et al. [9] have presented a novel workflow for the detection of both elemental and organic constituents of the firearm discharge residue from skin swabs using electrospray trapped ion mobility spectrometry coupled to mass spectrometry.

Experimental Set-up

We have used EDX method all samples collected (on cotton, gauze and filter paper) were kept separate and covered with non-conducting material paper foil. The samples were analyzed with an Energy dispersive X-rays Fluorescence instrument – EDX – 8000 (Shimadzu, Germany) equipped with high-performance SDD detector using the simple analysis software (pcedx-navi)
general analysis software (pcedx-pro) software provided with the equipment. This software automatically searches all particles that have one of the selected elemental compositions typical of GSR required by ASTM [10]. Though the unit is compact, it is equipped with a large, vacuum-compatible sample chamber. During analysis, the blue led on top is lit, so the instrument status can be checked even from another location. In the system set up bottom irradiation type optical system, in which X-rays are emitted from below the analysis sample [11]. The primary filters, collimators, and sample observation camera are included as standard. When studying the persistence of the GSR population with the EDX analysis by automated search, the primer elements of three new class residues were added to the software program to detect the non-classic GSR on the shooters' hands resulting from our own research. The control cotton, gauze and filter paper were analyzed with the same automatic procedure adopted to discriminate the background particles from the GSRs collected from hands.

Measurement parameters are tabulated in Table 1, the elemental profile was recorded for any particle by using X-ray spectra with a live time of 360 s for each sample [11].

Table 1: EDX – Setup measurement specifications.

Items	Specification for measurement
X- ray tube	Max.: 50 kV, 1 mA, air-cooled, Rh target
Detector	High-performance SDD detector (liquid nitrogen not required)
Elemental measurement range	EDX-8000: ^{6}C to ^{92}U
Primary filters	5 types + OPEN, with automatic switching
Collimators	4 types, with automatic switching (1, 3, 5, and 10 mm dia.)
Sample observation mechanism	CMOS camera
Sample chamber dimensions (W×D×H)	300×275 mm × approx. 100 mm (radius excluded)
Software	Simple analysis software (PCEDX-Navi) General analysis software (PCEDX-Pro)
Sample exposure size	10 mm

Sample preparation

The sample preparation phase of present study comprised three experimental scenarios. The decision was taken to simulate contacts and transfers immediately after the firearm discharges had taken place. In the absence of comprehensive studies on the extent and rates of GSR transfer, on hand using country made firearms (pistol and revolver) it was deemed important to ensure that the maximum quantity of GSR available for transfer at the time of contact.

Firearm → Shooter → Cotton Swab/Gauze piece/Filter paper (Buttman)

Across the experimental scenarios, three different materials have been used to pick GSR deposition and transfer were simulated in each sample collection we adopted three different chemically treated cotton swab, gauze piece and filter paper a) with HNO3; b) with Dil. HCl and c) with distilled water, which gives us 09 sample for each study total 21 sample have been analyzed.

Results and Discussion

Table 2: Collection of GSR sample of 7.65 mm KF ammunition fired from 7.65 mm country made pistol (No. of sample 09).

Sample collection on material		GSR elements detected under EDX measurements
Cotton	HNO_3	Ba, Pb
	HCl	Ba, Pb
	Distilled water	Ba, Pb
Gauze	HNO_3	Ba, Pb
	HCl	Ba, Pb
	Distilled water	Ba, Pb
Filter Paper	HNO_3	Ba, Pb
	HCl	Ba, Pb
	Distilled water	Ba, Pb

Table 3: Collection of GSR sample of 8 mm KF ammunition fired from 8 mm country made pistol (No. of sample 09).

Sample collection on material		GSR elements detected under EDX measurements
Cotton	HNO_3	Ba, Pb
	HCl	Ba, Pb
	Distilled water	Ba, Pb
Gauze	HNO_3	Ba
	HCl	Ba
	Distilled water	Ba, Pb (very less quantity)
Filter Paper	HNO_3	Ba, Pb
	HCl	Pb, Sb
	Distilled water	Pb

After the collection of the sample, the lead content of the GSRs was determined using both the proposed method EDX measurement. It is

important to note that the lead determination by using chemical treatment, but here we have performed first ever measurement of GSR on human (shooter hand), while using country made firearms (pistol and revolver) in India.

The authors have tested and applied to the samples reported in the Tables 2-5, by using EDX. The results of the examination are reported and summarized in the Tables 2-5. Through our study, it can be concluded that the proposed strategy is reliable and can be successfully applied to lead determination in GSR analysis using EDX – 8000 instruments.

Some interesting aspects can be highlighted from our analysis of the results in the present study: a) it can easily be seen that lead (Pb) present in almost 20 samples out of 21 samples in the collected samples, in the GSR from the country made pistol and country made revolver which indicate that Pb is the prominent GSR in Indian scenario in Country Made firearms; b) the antimony (Sb) is detected along with Pb in KF ammunition is only one sample, depicts that Sb is not a major constituent in the Indian scenario [12] and the last c) almost all sample under EDX analysis reveals that lead (Pb) and Barium (Ba).

Table 4: Collection of GSR sample of 0.32" SNWL ammunition fired from 0.32" country made Revolver (No. of sample 03).

Sample collection on material		GSR elements detected under EDX measurements
Cotton	HNO_3	Ba, Pb
	HCl	Ba, Pb
	Distilled water	Ba, Pb

Table 5: For background and environmental.

Sample collection on material	Analysis on EDX instrument
Cotton	No significant peaks for Pb, Sb, and Ba have been detected. This indicates our sample preparation was quite proper and adequate in nature.
Guaze	
Filter paper	

Conclusion

The present study provide as specific study of the Country made firearms (Pistol and revolver) particularly found in Indian crime scene. The specific study on GSR for Indian ammunition using country made firearms has not been reported yet. Through our report, the first ever statistics and analysis the GSR using EDX measurement reported in this, which conclude that the main constituents of GSR is consist of Pb-Ba-Sb is verified.

GSR evidence is one of the most common trace evidence examined in crime investigation. GSR examination is done is Forensic Science Laboratory in India with very high accuracy and modern analytical techniques. This study will provide a comparable data to the scientist to take as reference in Indian contest. Significant development in the EDX techniques, the forensic science expert has to be up-to-date with the advancement of the techniques, like SEM-EDX [13], milli-XRF [14] and Synchrotron radiation facility [15]. Now a day's India is also developing the Synchrotron based source, at CAT, Indore, which will provide the forensic community to analyse trace materials using these facilities.

References

1. Lewey, Heather. "Examining significant differences of gunshot residue patterns using same make and model of firearms in forensic distance determination tests." East Tennessee State University, Tennessee, USA, 2007.
2. Romolo, F Saverio and P Margot. "Identification of gunshot residue: A critical review." *Forensic Sci Int* 119 (2001): 195–211.
3. Schwoeble, Skip A J and David L Exlin. "Current Methods in Forensic Gunshot Residue Analysis." CRC Press, New York, NY, USA, 2000.
4. Bolck, Annabel, and Stamouli Amalia. "Likelihood Ratios for categorical evidence; Comparison of LR models applied to gunshot residue data." *Law Probab Risk* 16 (2017): 71-90.
5. Molina, Kimberley D, Michael Martinez, James Garcia, Vincent JM DiMaio. "Gunshot residue testing in suicides: Part I: Analysis by scanning electron microscopy with energy-dispersive X-ray." *Am J Forensic Med Pathol* 28 (2007): 187-90.
6. Lucas, Nick, Michael Cook, James Wallace, K Paul Kirkbride, Hilton Kobus. "Quantifying gunshot residues in cases of suicide: Implications for evaluation of suicides and criminal shootings." *Forensic Sci Int* 266 (2016): 289-298.
7. Zeichner, Arie. "Antimony content of inorganic gunshot residue (IGSR) produced by 0.22 caliber rimfire ammunition having free-antimony primer." *Forensic Sci Int* 270 (2017): e26-27.
8. Dona-Fernandez, Alicia, Israel de Andres-Gimeno, Pilar Santiago-Toribio, Eduardo Valtuille-Fernández, et al. "Real-time detection of GSR particles from crime scene: A comparative study of SEM/EDX and portable LIBS system." *Forensic Sci Int* 292 (2018): 167-175.
9. McKenzie-Coe, Alan, Suzanne Bell, Francisco Fernandez-Lima. "Detection of firearm discharge residue from skin swabs using trapped ion mobility spectrometry coupled to mass spectrometry." *Anal Methods* 10 (2018): 4219-4224.
10. "Standard guide for gunshot residue analysis by scanning electron microscopy/Energy dispersive X-ray spectrometry." Active Standard ASTM E1588–17, West Conshohocken, USA, 2018.
11. https://www.ssi.shimadzu.com/sites/ssi.shimadzu.com/files/Products/literature/xray/c142e-044a.pdf
12. Dalby, Oliver, David Butler, Jason W Birkett. "Analysis of gunshot residue and associated materials—a review" *J Forensic Sci* 55 (2010): 924–943.
13. Zeichner, Arie, Henry A Foner, Phil M, Michael Dvorachek, et al. "Concentration techniques for the detection of gunshot residues by scanning electron microscopy/energy dispersive X-ray analysis (SEM/EDX)." *J Forensic Sci* 34 (1989): 312–320.
14. Berendes, Antje, Dieter Neimke, Rudiger Schumacher, Martin Barth. "A versatile technique for the investigation of gunshot residue patterns: On fabric and other surfaces: m-XRF." *J Forensic Sci* 51 (2006): 1085–1090.
15. Carrato, Sergio, Cervelli F, Mattei A, Jerian M, et al. "Imaging using synchrotron radiation for forensic science." *SPIE Proc* 7870 (2011): 1-9.

How to cite this article: Mishra RK, Jain P, Anil Budania, Mukesh Sharma and Tiwari RS. "Identification of GSR on the Shooter's Hands Using Energy Dispersive Experiments". J Forensic Res 11 (2020) doi: 10.37421/2157-7145.11.458