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Gunshot Residue Particles Formed by Using Different Types of Ammunition in the Same Firearm

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ABSTRACT: Examples of some exceptional compositions of gunshot residue particles, formed by using different types of ammunition in the same firearm, are presented. The composition that may be encountered in casework may differ appreciably from the "classic" criteria for identification of gunshot residues. This fact must therefore be taken into account by the expert when interpreting case results, and thus, every case has to be dealt with on an individual basis.

KEYWORDS: forensic science, gunshot residues, ballistics, ammunition

The detection and identification of gunshot residue (GSR) particles by scanning electron microscopy/energy-dispersive X-ray (SEM/EDX) analysis is now a well-established technique and is applied in many forensic science laboratories. The mechanism of formation and the criteria for identification of such particles have been described in numerous articles [*1–7*]. It has been stated that gunshot residues are formed by the condensation of vaporized bullet and primer materials which segregate into metallic and compound particles. It has also been mentioned that, to characterize a particular cartridge, it is essential to start with a clean gun, or else residues from previous firings may be mixed with the residues from the current firing [*2*]. It is therefore reasonable to assume that, through the use of different types of ammunition in the same firearm, producing different compositions of discharge particles, we may expect, in principle, to find discharge particles having combinations of all possible compositions. In practice, there may be limitations in forming all possible combinations because of the limited mutual solubilities in the liquid and solid states of the elements involved [*3*].

The purpose of this work is to report on GSR compositions that, to the best of our knowledge, have not been mentioned so far in the literature. These compositions were encountered in a real case, and it was difficult to reconcile them with the cartridge cases found at the scene of the shooting.

Simulated test shots were carried out to aid interpretation of the results. Since the use of unleaded ammunition such as Sintox is expected to increase, it was also interesting to examine preliminarily the GSR compositions that may be formed by firing Sintox ammunition in combination with ammunition forming lead, antimony, and barium GSR particles.

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The Case

At the scene of an attempted murder by shooting, five cartridge cases of 7.65-mm LV Geco ammunition were found. The investigators were told by witnesses that the suspect fired his weapon from inside a vehicle. The suspect was apprehended 3 h after the incident and his hands were sampled for GSR. The seat covers from the two front seats of the car were also brought to the laboratory to be sampled for GSR.

Case Examination—Experimental Procedure

The suspect's hands were sampled using a kit consisting of 1-in. (2.54-cm)-diameter aluminum stubs coated with 3M double-sided adhesive [*8*]. The seat covers were also sampled for particles using double-sided adhesive-coated aluminum stubs. SEM/EDX analysis for GSR particles was carried out using an automated search system attached to a CamScan IV scanning electron microscope (SEM) with a motorized stage drive and a four-sample holder, combined with a Tracor-Northern TN5500 energy-dispersive X-ray (EDX) system [*9–11*]. GSR from the cartridge cases found at the crime scene was sampled using wood sticks and then transferred on aluminum double-sided adhesive-coated stubs. The composition of Geco GSR particles is lead (Pb), antimony (Sb), and barium (Ba), accompanied sometimes by small amounts of aluminum (Al), silicon (Si), iron (Fe), copper (Cu), and zinc (Zn) (Fig. 1). In the samples from the suspect's hand, one particle of this composition was found. In the samples from the seat covers, many particles of this composition were found. However, many particles containing tin (Sn) or nickel (Ni), or both, in addition to the Pb, Ba, and Sb, were also found (Fig. 2). In the following discussion, we will call these particles "particles of exceptional composition." Such compositions are inconsistent with the GSR composition resulting from the firing of Geco ammunition, and we had not previously encountered such a composition either in our casework or in the literature.

Shooting Experiments with Sellier Bellot, Prague (SBP) and Geco Ammunition

SBP ammunition (Sellier Bellot of Prague, Czechoslovakia) is quite widely found in Israel. Tin is characteristic for the composition of SBP GSR, which usually contains Pb,

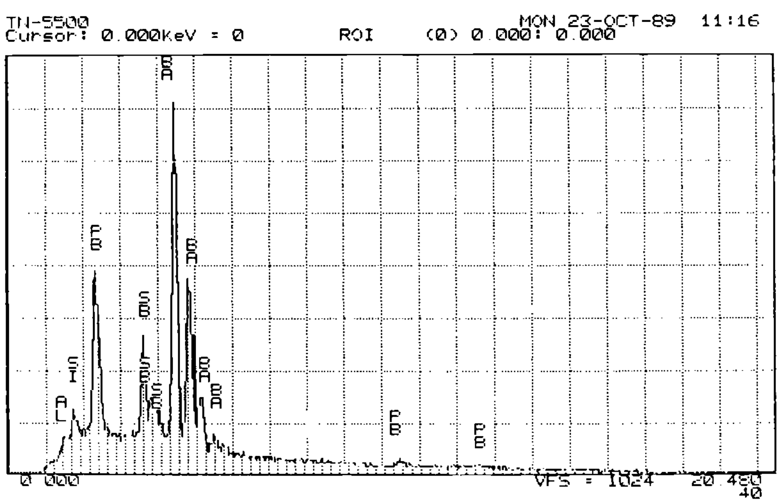

FIG. 1—*EDX spectrum of a GSR particle from 7.65-mm Geco ammunition, in the sample from a cartridge case.*

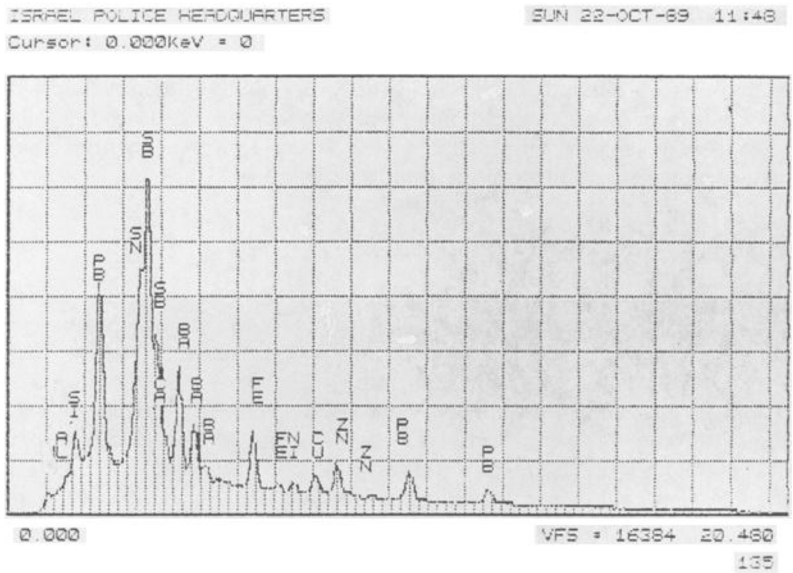

FIG. 2—*EDX spectrum of a GSR particle in the sample from the seat covers.*

calcium (Ca), Ba, and Sn (Fig. 3), or sometimes Pb, Ca, Si, and Ba; therefore, it seemed to us quite reasonable that a possible explanation for the "exceptional composition" received could stem from using SBP and Geco ammunition in the same firearm.

To confirm this hypothesis, five test firings were carried out. First, a 7.65-mm Beretta semiautomatic pistol was thoroughly cleaned and a person with uncontaminated hands fired two rounds of 7.65-mm Geco LV ammunition. The person's hands were then sampled for GSR immediately after the firing. The gun and the shooter's hands were

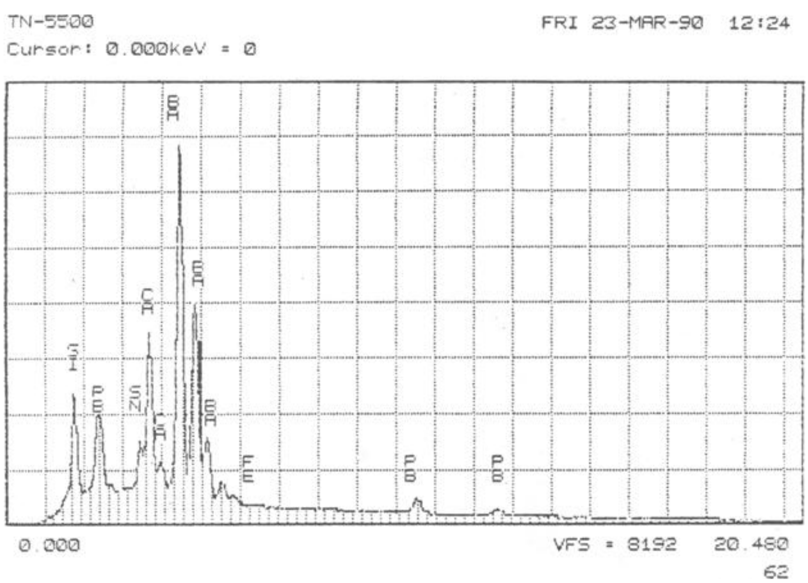

FIG. 3—*EDX spectrum of a GSR particle from 7.65-mm SBP ammunition, in the sample from a cartridge case.*

then again thoroughly cleaned and two rounds of 7.65-mm SBP ammunition were fired. Again, the shooter's hands were sampled for GSR. Following this, the person cleaned his hands and fired one round of 7.65-mm Geco LV ammunition from the same gun without cleaning it. Again, the person's hands were sampled for GSR. In the fourth and fifth tests, the weapon was again thoroughly cleaned, the sequence of Geco and SBP ammunition was reversed from that used in the second and third test, and the hands of the shooter were again sampled.

Results

In the samples from the first test, particles with a composition characteristic of 7.65-mm Geco LV ammunition were found. Most of the particles were without Cu and Zn, and a very few had small amounts of Ni.

In the samples from the second test, GSR particles with a composition characteristic of 7.65-mm SBP ammunition were found. No nickel was observed in any of these particles.

In the samples from the third test (one round of Geco after two rounds of SBP ammunition), GSR particles similar in composition to those found on the seat covers (Geco with Sn or Ni or both) were found (Fig. 4).

In the samples from the fifth test, the particles found were similar in composition to those found in the third test.

It is interesting to note that, besides the formation of "mixed" GSR composition particles stemming from the two types of ammunition, many more particles containing nickel were found in the third and fifth tests than in the first test. In addition, the nickel concentrations in the particles from these tests were often higher than those in those particles containing nickel from the first test. When the concentration of nickel was high, cobalt was also detected in the GSR composition (Fig. 5). This finding is consistent with the composition of a 7.65-mm Geco jacketed projectile (Fig. 6).

From these results, it seems that SBP GSR particles somehow enhance the formation of a much larger proportion of GSR particles containing nickel than that found when using Geco ammunition alone.

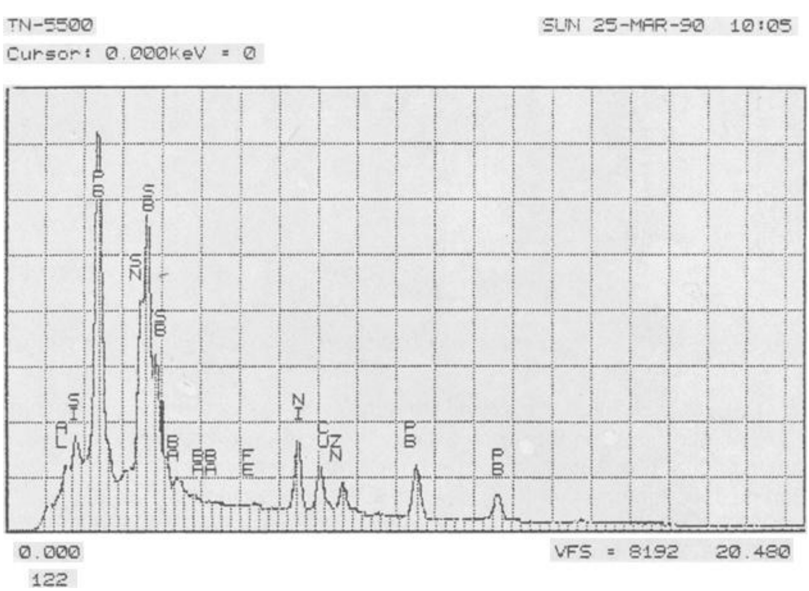

FIG. 4—*EDX spectrum of a GSR particle from the third shooting test, in the sample from the shooter's hands.*

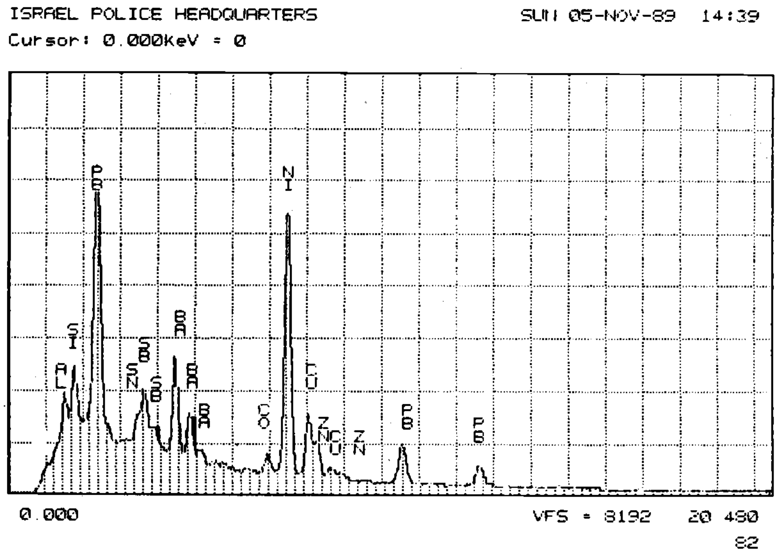

FIG. 5—*EDX spectrum of a GSR particle from the third shooting test, containing high nickel, accompanied by a small amount of cobalt.*

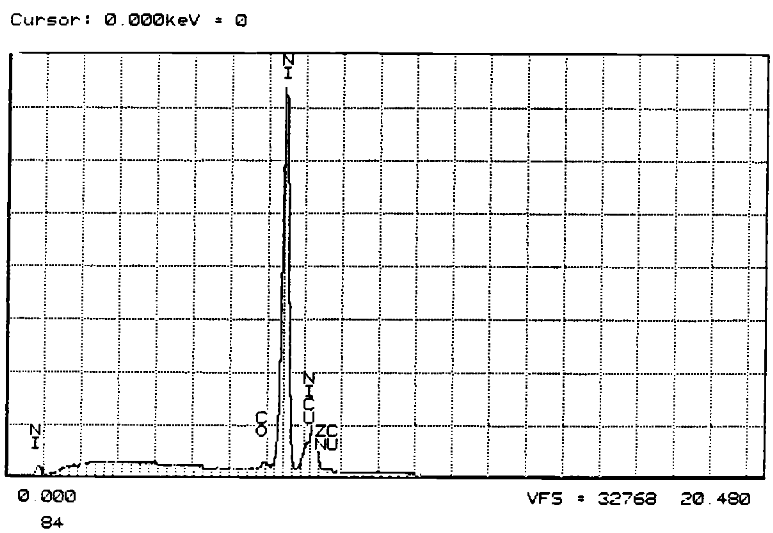

FIG. 6—*EDX spectrum of the outer coating of a 7.65-mm Geco jacketed projectile.*

It is apparent from the real case and from the tests carried out that mixed compositions exist and should be taken into consideration when interpreting GSR results.

Similar preliminary tests were carried out with a combination of 9-mm Sintox and 9-mm Israeli TZZ ammunition using a 9-mm FN semiautomatic pistol.

GSR from 9-mm Sintox is characterized by particles consisting mainly of titanium (Ti) and Zn (Fig. 7). GSR from 9-mm TZZ ammunition is characterized by particles containing Pb, Ba, and Sb. Samples taken after the firing of these two ammunitions in succession were analyzed. The GSR particles found were mainly Sintox and TZZ, with some "mixed composition" particles. The composition of these particles is shown in Figs. 8 and 9.

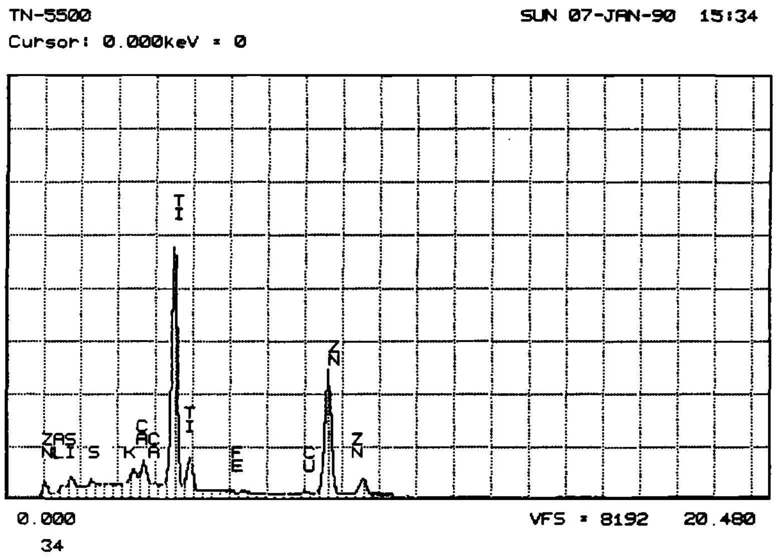

FIG. 7—*EDX spectrum of a GSR particle from 9-mm Sintox ammunition, in the sample from a cartridge case.*

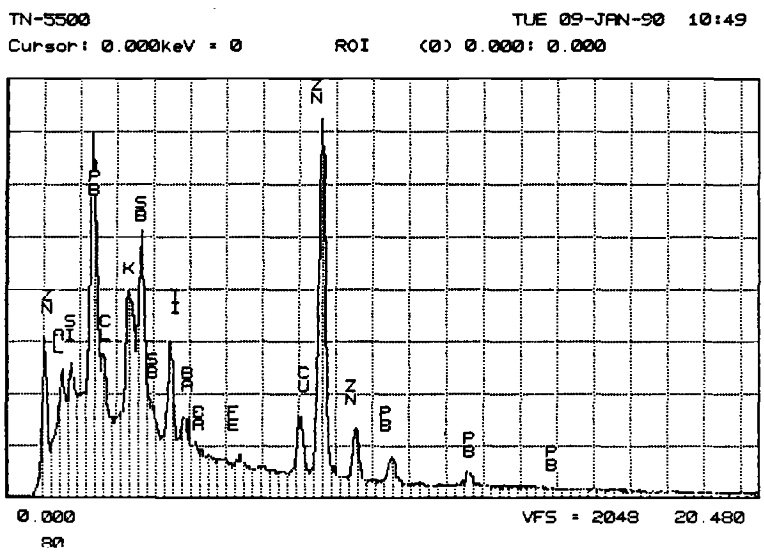

FIG. 8—*EDX spectrum of a GSR particle from a shooting test in which 9-mm Sintox and 9-mm TZZ ammunitions were fired in succession, in the sample from the shooter's hand.*

Conclusions

This study has shown, from a real case and tests that were later performed, that "mixed" GSR compositions can be easily formed. These compositions are a result of the firing of different types of ammunition in the same weapon. It is therefore possible to find discharge particles on a suspect that differ in composition from those from the ammunition used at the scene of the crime. It is important that this fact be taken into account by the expert when interpreting GSR case results.

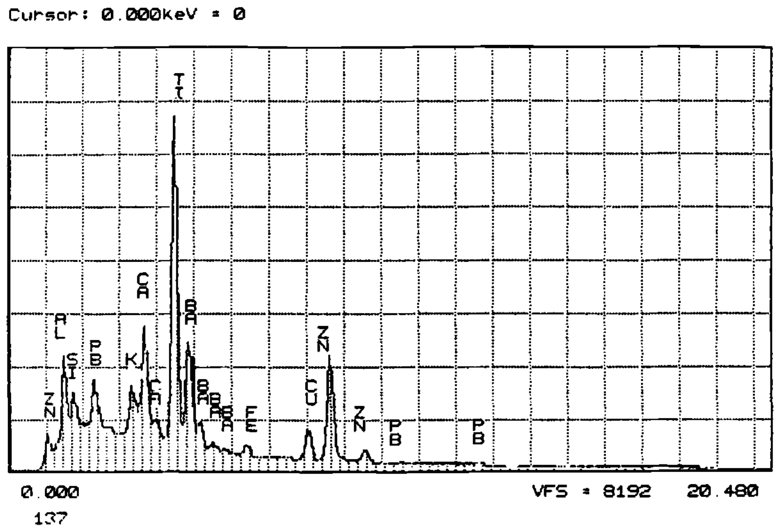

FIG. 9—*EDX spectrum (different from the one in Fig. 8) of another GSR particle from a snooting test in which 9-mm Sintox and 9-mm TZZ ammunitions were fired in succession, in the sample from the shooter's hand.*

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