TECHNICAL NOTE

Lawrence Gunaratnam,[1] *M.Sc. (Eng.) and*
Kimmo Himberg,[1] *M.Sc.*

The Identification of Gunshot Residue Particles from Lead-Free Sintox Ammunition

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ABSTRACT: Scanning electron microscopy combined with energy dispersive X-ray analysis (SEM/EDX) was used to identify the gunshot residue (GSR) particles discharged by lead-free Sintox ammunition. Sintox GSR particles are characterized by spheroidal particles mainly consisting of titanium (Ti) and zinc (Zn). The results obtained in this study are in agreement with the hypothesis that GSR particles are formed by rapid condensation and solidification of vaporized and molten primer and bullet materials as a result of sudden temperature quench. The surface morphology of Ti-Zn particles is an essential criterion for their identification as gunshot residue particles and for discrimination against Ti-Zn environmental particles.

KEYWORDS: criminalistics, gunshot residue, ammunition, SEM, Sintox

Analysis of gunshot residue particles (GSR) originating from cartridge primers has become a widely accepted technique in the investigation of shooting cases. The analysis is classically performed by scanning electron microscopy with energy dispersive X-ray analysis (SEM/EDX). The most widely used primer compositions contain a mixture of lead, antimony, and barium compounds. The formation mechanism and classification of conventional Pb-Sb-Ba GSR particles have been extensively studied and presented in numerous articles [*1–5*].

In firing practice, mainly in indoor shooting ranges, considerable amounts of toxic gases are produced by this type of primer compositions. Inhaling these gases increases the level of lead in the blood and is a health hazard to the shooters. Therefore, a new type of non-toxic Sintox ammunition was developed by Dynamite Nobel AG to avoid the evolvement of toxic gases from the primer compositions. The availability and use of this type of ammunition introduces new problems in characterizing gunshot residue particles that do not have the unique composition of lead, antimony, and barium.

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[1]Forensic Scientist, and Director, respectively, National Bureau of Investigation, Crime Laboratory, Suvilahdenkatu, Helsinki, Finland.

The aim of this study was to establish criteria for the identification of gunshot residues discharged by lead-free Sintox cartridges.

Experimental

Test Firing

Sintox cartridges (cal .357 Magnum) manufactured by Geco and a Smith and Wesson revolver were used. A typical Sintox primer composition contains 15% diazodinitrophenol (DDNP) and 3% tetracene as primary explosives, 50% zinc peroxide as oxidizer, 5% 40 micron size titanium metal powder, and 27% nitrocellulose as propellant powder [*6*]. Tests were made by firing with a cleaned gun in order to avoid residues from previous firing with lead-containing cartridges.

Test samples were collected immediately after firing with pieces of adhesive tape attached to aluminum stub. The tape was coated with carbon in a Balzer CED 030 carbon evaporator device for particle analysis in the scanning electron microscope. Particle analyses was performed manually using backscattered electron imaging.

SEM Instrumentation

The scanning electron microscope used in this study consisted of Jeol JSM-6400 with Winsem software, equipped with Link Tetra solid state backscattered electron detector and a Link eXL X-ray microanalysis system.

Results and Discussion

Gunshot residue particles are formed by two mechanisms: rapid condensation of vaporized primer and bullet materials, where the vaporized elements condense to form GSR particles; and rapid solidification of molten primer and bullet materials, where these materials are driven out of the gun in molten state to form mainly spheroidal particles as a result of sudden temperature quench. This is analogous to the gas atomization process

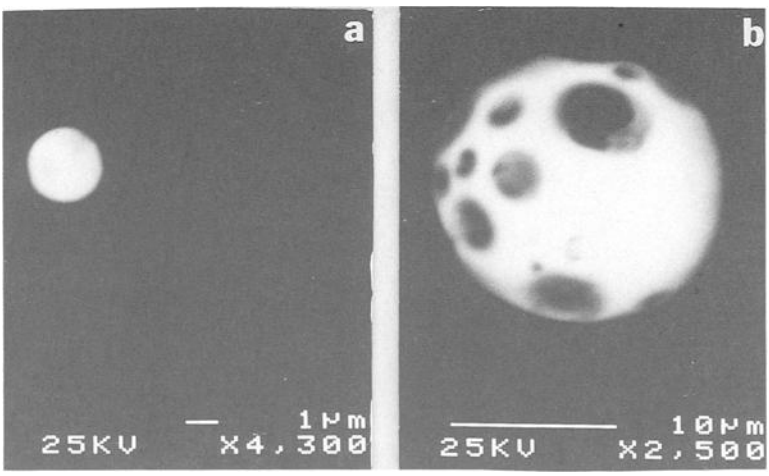

FIG. 1(a *and* b)—*Backscattered electron micrographs of typical Sintox GSR particles.*

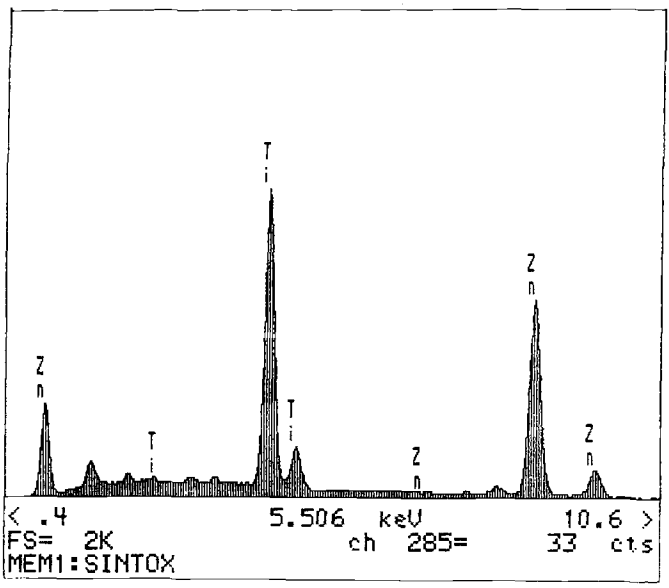

FIG. 2—*EDX spectrum of Sintox GSR particles.*

employed in metallurgy to produce fine superalloy powders from molten metals. The metal powder particles produced by the gas atomization process are also generally spheroids.

The formation mechanisms have been described by Basu [*5*] and Walton et al. [*1,3,4*].

The results obtained in this study indicate that the discharge residues of Sintox ammunition are mainly composed of titanium (Ti) and zinc (Zn) and characterized by their spheroidal shape (Figs. 1*a*, *b* and 2). However, the number of spheroidal particles found

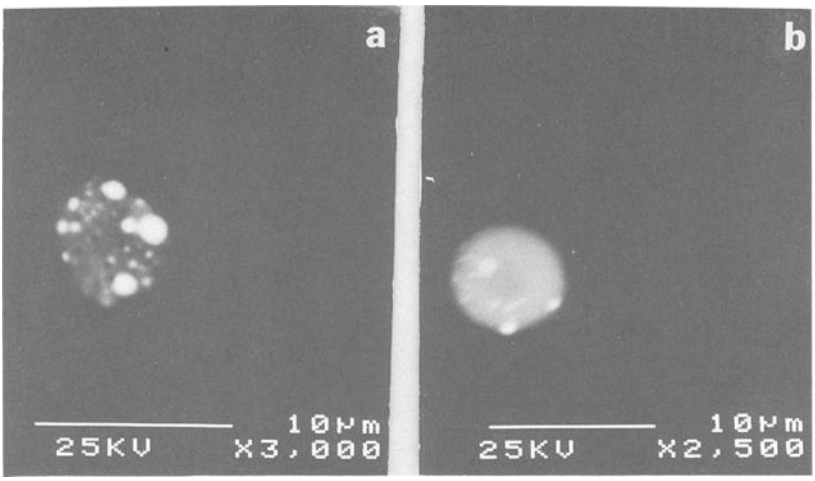

FIG. 3(a *and* b)—*Backscattered electron micrographs of Sintox GSR particles. Small lead particles are deposited on the surface of Sintox GSR particles.*

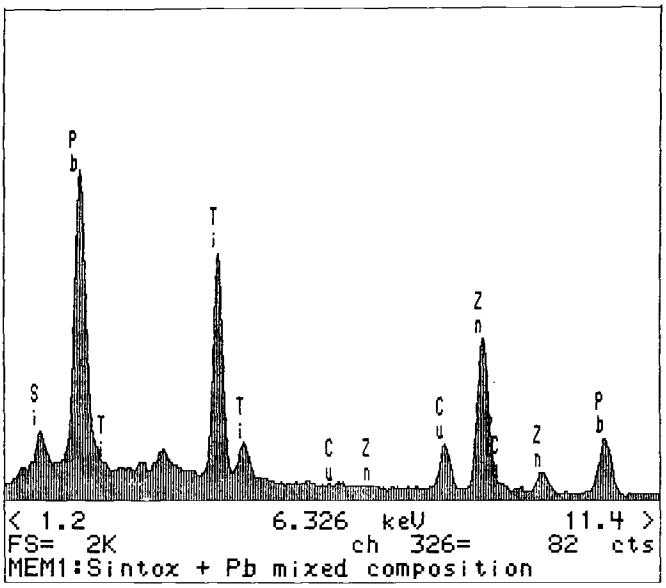

FIG. 4—*EDX spectrum of Sintox GSR particles (mixed composition of Ti, Zn and Pb).*

in the test samples is distinctly smaller compared to the number of spheroidal particles (Pb-Sb-Ba) discharged by lead-containing cartridges.

A potential source for misinterpretation of observations lies in the fact that titanium and zinc are commonly used as pigments in paints. However, experience with SEM paint analyses carried out in this laboratory indicates that Ti and Zn are never present in paint particles as major elements; additionally, spheroidal particles having that composition have not been encountered but rather the paint particles are irregular in shape. It remains possible after this preliminary study that interfering particles are formed in burning Ti-Zn pigment paints. This hypothesis will be further investigated. Although case work on conventional Pb-Sb-Ba GSR particles shows that not only spheroidal but also irregular particles can be identified as gunshot residues owing to their unique elemental composition, this is not the case in Sintox residues where the morphology becomes an essential identification criterion.

Even though the revolver used in this study was thoroughly cleaned before test firing, a few spheroidal particles were found in test samples which had the compositions of Ti-Zn-Pb and Ti-Zn-Pb-Ba. In some of these particles small lead particles were deposited on the surface of a Ti-Zn particle (Figs. 3*a*, *b* and 4). The formation of this type of mixed composition particles have been described by Zeichner et al. [*7*]. In practical case work these type of particles would probably often be encountered.

Conclusion

The lead-free Sintox GSR particles are characterized by spheroidal particles composed mainly of titanium and zinc. The morphological information, along with their elemental composition, can be used as a means of identifying GSR particles discharged by Sintox cartridges.

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Address requests for reprints or additional information to
Lawrence Gunaratnam
National Bureau of Investigation, Crime Lab
Suvilahdenkatu, 10A
SF-00580 Helsinki
Finland