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ORIGINAL ARTICLE

Study of gunshot residues from Sintox® ammunition containing marking substances

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Abstract: Two types of factory marked Sintox® ammunition were investigated from the composition of gunshot residue particles (GSR) and occurrence of marking substance points of view. The experiments were carried out with two cartridges of caliber 9 mm Luger (9 × 19 Parabellum) of two producers (Ruag Ammotec, Switzerland and Men, Germany). The first cartridge (type Action 4, Ruag Ammotec) contains gadolinium as a marking element, while the other cartridge (type PEP II, Men) is marked with gallium in gunpowder. Scanning electron microscopy equipped with EDAX analyzer (SEM/EDX) was used to detect and analyze the GSR particles in samples collected from the cartridges, barrels and shooter's hands. Besides those, particles from the hit clothes placed at different shooting distances were collected and analyzed. The spreading of GSR cloud from the gun was observed using the high-speed camera. Results obtained clearly revealed that the way of ammunition production/construction and type of marking of ammunition can significantly influence the presence and detection reliability of marking elements in GSR. The detectability is affected also by the shooting distance.

1. Introduction

Recently, increasing demands are imposed on weapons and ammunition used by the army, police and special units. In this context, special marked ammunition is introduced to be used in several European countries. This type of ammunition, utilization of which is regulated by the respective law, has generally become preferred due to its better detectability at the crime scene. Its another benefit for forensic scientists is that the bullets used in this type of ammunition are of modern construction, exhibiting the higher capability of penetration into the solid materials, together with better "stop effect" of the human body. All these factors make the marked ammunition attractive above the others.[1,2]

From all the possibilities, 9 × 19, 9 mm Luger or 9 mm Parabellum is the most widely used pistol caliber in Europe seemed to be the most suitable for police and armed force purposes. There are two main reasons of weapons with the caliber 9 × 19 popularity: they are easy to handle and their range of utilization is rather wide.

In addition to the standard technical requirements of police forces on weapons and ammunition, (e.g., powerful but limited energy transfer to the target, minimal ricochet tendency, high stopping power and defined penetration depth), environmental

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aspects are also considered carefully, i.e., primers should be constructed from materials that do not allow secondary contamination of the environment by heavy metal residues during the shooting.[1,2] Due to the last mentioned aspect, non-toxic Sintox® is considered to be the priming technology of choice, widely used e.g., in NATO-qualified cartridges.

For forensic and investigative requirements as well as in order to clearly answer the questions such as: who shot whom, with which weapon, with which ammunition and from what distance and direction, some of the ammunition producers offer the police cartridges with specific marking material. Such ammunition is now introduced in police forces of several European countries (e.g., Germany, Netherland, Italy, and Switzerland).

In connection with an expected re-armament of the Slovak police forces, chemical investigation of two types of special marked ammunition was realized as a part of the project "The Centre of Excellence of Security Research" at the Institute of Forensic Science in Bratislava, Slovakia. Scanning electron microscopy equipped with EDAX analyzer (SEM/EDX) was used to detect and analyze the gunshot (GSR) particles. Besides those, particles from the hit clothes placed at different shooting distances were collected and analyzed. The spreading of GSR cloud from the gun was observed using the high-speed camera. The aim of the investigation is to select the most proper ammunition for its possible future using by Slovak police forces.

2. Experimental

2.1. Materials

Pistols HS-9, cal. 9 × 19, Sintox® ammunition with forensic markers – 9 mm Luger, Action 4 (Ruag Ammotec, Ltd., Switzerland) and 9 mm Luger, PEP II (Men, GmbH, Germany), special SEM – stubs for the collection of gunshot residues particles (Christine Gröpl), cotton fabric, paper for chemography (Foma Bohemia, Ltd.), book-press and PVC pressure plates were used in the experiments.

2.2. Chemicals

Zincon ($C_{20}H_{15}N_4NaO_6S{\cdot}H_2O$) from Fluka and ammonium nitrate, ammonium hydroxide, rubeanic acid, and ethanol (96%), all purchased from Merck were utilized.

2.3. Methods

Gunshot residues were characterized by scanning electron microscope XL-30 (Philips) equipped with a back-scattering electron detector, secondary detector and energy – dispersive X-ray detector (EDAX). The spreading of GSR cloud from the gun was observed using the high-speed camera Olympus I-speed II.

GSR analysis was performed using GSR-XT V 3.0 software (Eastern Analytical, Concord, New Hampshire, UK). The EDX spectra were evaluated by a GSR Spectral Utility, Version 3.4m, July 2004 software (Philips) and by EDAX software "Genesis Spectrum SEM Quant ZAF, Version 3.6, November 2003".[3]

Determination of firing distances was performed using the chemographic method. Visualization of copper was performed by rubeanic acid assay[4] and visualization of zinc particles was performed by zincon reagent assay.[5]

2.4. Collection of samples

For both types of ammunition the same pistols, HS-9, cal. 9 × 19 were used. The barrels were cleaned using acetone and ethanol before each experiment and the control swab was taken in order to ensure the purity of the barrel.

For the purposes of comparison, the gunshot residues from the case and barrel were collected on special stubs.

To evaluate the presence of GSR on the shooter's hands, the traces after one and ten shootings were collected from each hand on special SEM-stubs, respectively.[6] The results are expressed as the average of ten shootings.

The presence of GSR from the short (10 cm) and long distance (25 m) was examined using the cotton fabric. The traces were collected on SEM-stubs from the surroundings of the holes. The results are expressed as the average of ten shootings.

3. Results and discussion

3.1. Analysis of primer and gunshot powder composition

GSR analysis of the primer of PEP II ammunition showed that it consists of titanium and zinc. The presence of any marking substances was not detected. SEM/EDX record of gunshot powder of PEP II ammunition and its EDAX spectrum is depicted in Figs. 1 and 2, respectively. As followed from the SEM/EDX analysis, bright particles of inorganic nature were identified inside the gunshot powder. The detailed EDAX spectral analysis revealed that the particles contain mainly gallium, copper, tin and potassium (Fig. 2). Thus, it can be partially concluded that in the case of *PEP II* ammunition, the presence of marking substance gallium was detected only in the gunshot powder. On the other hand, EDAX analysis clearly revealed that the ammunition *Action 4* contained zinc, titanium and gadolinium in the primer (Fig. 3).

Results of chemical composition analysis of gunshot residues from the cases and barrels of both types of ammunition are presented in Table 1. The analysis of GSR was performed manually because of the presence of large number of gunshot residues on the stubs. It was found that most of the GSR from the case and barrel of *PEP II* ammunition contained only

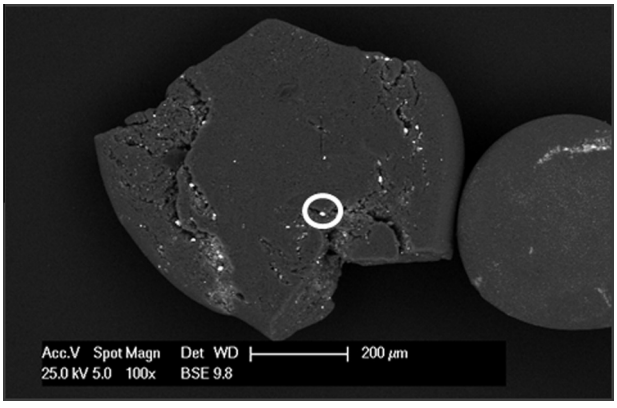

Figure 1 SEM picture of the gunshot powder of the ammunition cal. 9 × 19, PEP II (Men, Germany) with the bright particles of inorganic character (white circle).