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Experiences with Zincon, A useful Reagent for the Determination of Firing Range with Respect to Leadfree Ammunition

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ABSTRACT: In the Dutch Forensic Laboratory firing range is determined by means of a chemographical method. The applied method produces colors with the elements lead and barium in conventional ammunition. This method cannot be applied for the determination of the firing range of leadfree ammunition. Because of developments in the eighties and the increasing use of leadfree ammunition, a new method with another coloring reagent has been developed.

Elements present in the gunshot residues of, for example, 9 mm para Action-3 Sintox ammunition used by the Dutch police forces, are copper, zinc and titanium. Our contribution to the method for the determination of the firing range is a combination of the material cellophane film, the coloring reagent zincon and the design of a simple stretching device.

Dependent on weapon, ammunition and clothing a firing range up to about 1.5 m can be determined by means of this method. To conclude, a survey is given of the shoot-outs investigated in The Netherlands in which leadfree ammunition was used.

KEYWORDS: forensic science, firing range determination, gunshot residues, leadfree ammunition, chemographical method, zincon

Within the investigation of a shoot-out, a forensic laboratory will receive a short description of the incident as well as relevant pieces of evidence such as clothing, weapon(s) and parts of ammunition.

The firing range (distance weapon-victim) provides important information for the reconstruction of a criminal offence involving firearms. Reconstruction with the results of the method described herein will contribute to the technical evidence and will help the examining magistrate to distinguish murder from suicide or accident.

When a fired bullet hits a piece of clothing, this will usually cause damage to the clothing, dependent on the energy and the distance. Apart from damage, as a result of the shooting, residues can also be deposited on the clothing. These residues (gunshot residues) are caused as follows. During firing combustion of the powder produces a gas cloud containing, among others, combustion products of powder (smut), unburned powder and metallic particles (Fig. 1).

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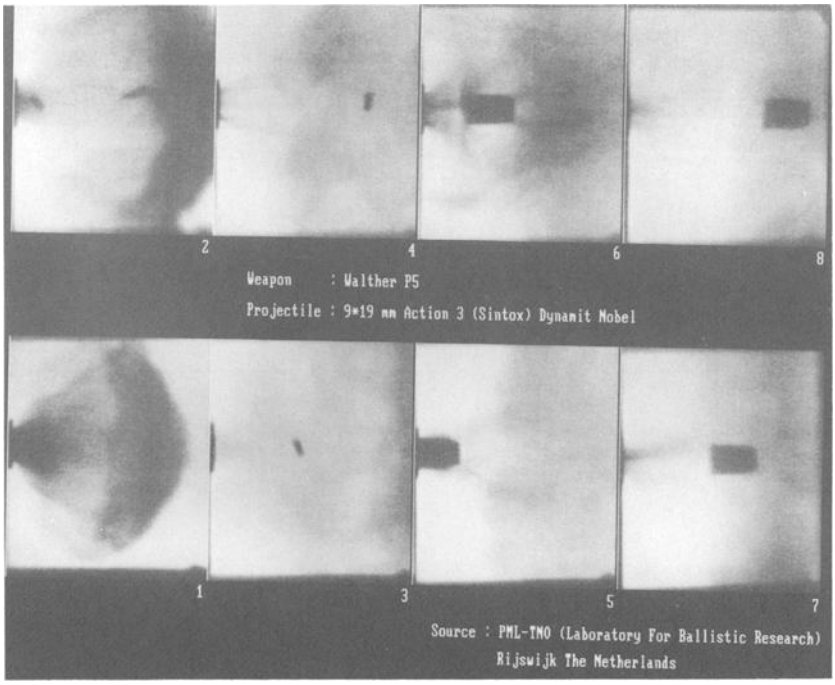

FIG. 1—*A series of high-speed photos of a 9*19 Action-3 bullet fired with a Walther P5 pistol. Time of interval is 40 microseconds.*

The metallic particles are mostly from:

1. the primer mixture. The primer mixture contains metallic compounds such as lead styphnate, barium nitrate and antimony sulphide.
2. the surface of the bullet. Due to the friction between the bullet and the barrel of a firearm, metal particles are scraped off the bullet. These metal particles may contain copper, zinc, nickel, iron, lead and/or antimony;

All these metallic particles, metallic compounds and partially combusted and unburned powder particles are of vital importance for the determination of the firing range.

In the combustion of the powder charge gasses are given off at high pressure and temperature. The pressure causes the ejection of the bullet from the cartridge and the barrel of the firearm. Because of the high gas pressure, the inertia of the bullet and the small space between bullet and wall of the barrel, a part of the gas (including particles of gunshot residues) will leave the barrel of the firearm before the bullet. A part of the combustion residues from the gas cloud will settle on the inner wall of the barrel. On its way through the barrel, the bullet will partially wipe these residues from the barrel wall (note: These residues can be from previous firings, perhaps with a different type of ammunition). Just outside the barrel the bullet penetrates the gas cloud again, causing particles from the cloud to settle on the surface of the bullet. All these accumulated species are now transported to the target by the bullet.

When the bullet penetrates the clothing of the victim, the fibres of the clothing wipe the surface of the bullet, leaving traces on the clothing in the shape of a dark circular mark, the so-called "bullet wipe ring."

These marks depend, among other things, on the diameter of the bullet, but not on the firing range. After having left the barrel of the weapon, the gas cloud expands and moves at a decreasing speed and density. When and if, this cloud hits the victim, a more or less circular deposit of (extremely) small particles and condensed gasses is created around the point of impact of the bullet. The diameter of this circular deposit depends on the distance between the weapon and the victim: the firing range [*1*]. The cloud with gunshot residues generally has a range of about 1.5 m.

To determine the firing range a reference set is made by firing at sheets of clean cotton cloth with the same weapon and ammunition (or using a similar weapon and/or ammunition if the originals are not available). Usually a reference set of 0, 2.5, 5, 10, 25, 50, 75, 100, 150 and 200 cm is made. By means of a chemographical method a color print is made of the clothing of the victim and of the reference set to visualize the circular deposit. This method was described by Suchenwirth for conventional lead containing ammunition [*2*]. By comparing the color prints of the victims clothing with the color prints of the reference set, a judgement can be made on the firing range. The three criteria used for this judgement are: pattern diameter, pattern intensity and pattern homogeneity. To make a color print of the impact damage, advantage is taken of the presence of the gunshot residue element lead, which forms a pink complex with the rhodizonate reagent. As an additional reaction barium containing compounds are colored orange.

In consequence of the environmental legislation enacted by the Dutch government, today Dutch police forces use leadfree ammunition (9 × 19 mm cartridges, type Action-3 Sintox of which the bullet consists of brass with a green plastic nose cap).

Sintox is the name of a leadfree primer mixture developed by Dynamit Nobel. This primer mixture contains zinc peroxide and metallic titanium [*3*]. The sodium rhodizonate method mentioned above is not applicable for visualization of zinc and titanium.

Lichtenberg has published a method for making visible gunshot residues from leadfree ammunition by means of the reagent Chlorindazone DS [*4*]. Because this reagent is not available in The Netherlands, another coloring reagent for zinc and titanium was sought. This article describes a method in which the coloring reagent 2-Carboxy-2′-hydroxy-5′-sulfoformazylbenzene (zincon) [*5*] is used.

The coloring reagent zincon forms a blue-colored complex with the elements zinc and titanium. As a side-reaction the element copper, which among others comes from the projectiles or cases themselves, also forms a blue-colored complex with this reagent.

As the filter paper used in Suchenwirth's method often contains zinc and/or titanium itself, cellophane film is used as in Leszczynski's method [*6*].

Chemicals and Appliances

- zincon ($C_{20}H_{15}N_4NaO_6S.H_2O$, Merck Art. 8739, Germany)
- ammonium nitrate (NH_4NO_3, Merck Art. 1188, Germany)
- ammonium hydroxide-solution (25% NH_4OH, Merck Art. 5432, Germany)
- photo developing tray
- cellophane film (50 micrometer, A-4 format, manufacturer Kalle, type P600, Germany)
- book-press
- stretching device
- hair-drier
- light-box
- plastic kitchen film
- foam pressure pads

- PVC pressure plates
- adhesive film (A-4 format, manufacturer Schwartz, type MIPO P Germany)

Ammonium nitrate buffer: dissolve 8 grams of NH4NO3 in 1 liter of H2O. Bring the solution to pH 9 with 25% NH4OH. Zincon-solution: dissolve 0.13 grams of zincon in 1 liter of ammonium nitrate buffer.

Method

Preliminary Investigation

During the examination of the clothing, first it has to be determined if the damage was caused by a shot rather than, for example, a stabbing. This investigation is carried out by means of visual, microscopical inspection and microchemical test reactions. Thus a distinction can also be made between damage from impact and exit bullets. Sometimes differences between primary and secondary impact damage can be seen. Here the bullet wipe ring can also give a decisive answer. Each of the microchemical tests is based on filter paper with a coloring reagent, which reacts with the elements lead or copper respectively and shows the bullet wipe ring, which is often not readily discernible.

Dependent on the information about the type of ammunition used and/or the results of this preliminary investigation, the conventional or the leadfree investigation method is applied for the determination of the firing range.

Here, the chemographical method for leadfree ammunition is described.

Firing Range

Cellophane film (A4) is soaked in the zincon solution for 15 minutes.

The wet cellophane is placed on the clothing on top of the impact damage. The piece of clothing with the cellophane is then placed between plastic kitchen film; foam pressure pads; PVC pressure plates.

To improve the contact, this sandwich is pressed in a book-press for 20 minutes.

Then the cellophane film is taken to the improvised stretching device (Fig. 2). Stretching prevents the film from shrinking as a result from the drying-process. The cellophane film is dried with a hair-drier. After drying and cooling, the film is cut out and examined visually

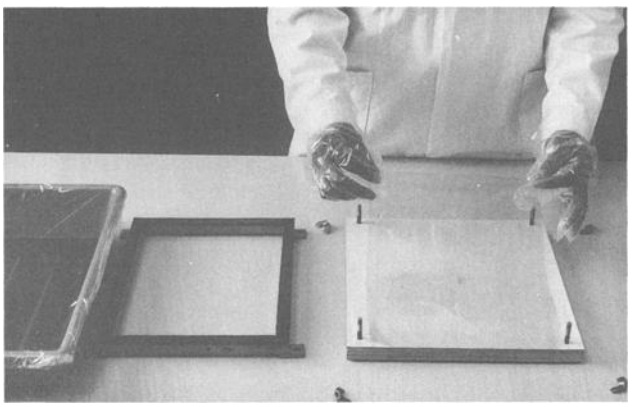

FIG. 2—*The mounting of the cellophane film on the improvised stretching device.*

for blue discolorations by means of a light-box. Samplers with the test shots are treated in the same way, thus giving a series of colored cellophane as a reference set (Fig. 3).

So a conclusion can be drawn about the firing range with a maximum distance of about 1.5 meters. Not only the coloring pictures but also the visible powder remnants are used to determine the firing range. At ranges up to about 5 meters fragments of the green plastic nose cap on the Action-3 bullet can be found on the target. This can provide additional information about the firing range.

Survey of the Leadfree Shoot-outs

In the period from November 1989 until September 1993 the Dutch Forensic Science Laboratory has investigated about 1200 shoot-outs, where in approximately 500 incidents the firing range was investigated. In 31 incidents leadfree ammunition was used.

Most of the investigations have led to a conclusion about a firing range greater than 150 cm (Fig. 4).

Discussion

The advantages of the method described above, which includes the use of cellophane film, zincon coloring reagent and an improvised stretching device are

1. The method is practicable for the determination of firing ranges between 0 and about 150 cm.
2. The fine distribution of the gunshot residue elements Ti and Zn of leadfree ammunition around a point of impact is clearly visualized.
3. The element Cu, among others from copper containing bullets or cases, reacts with zincon also.

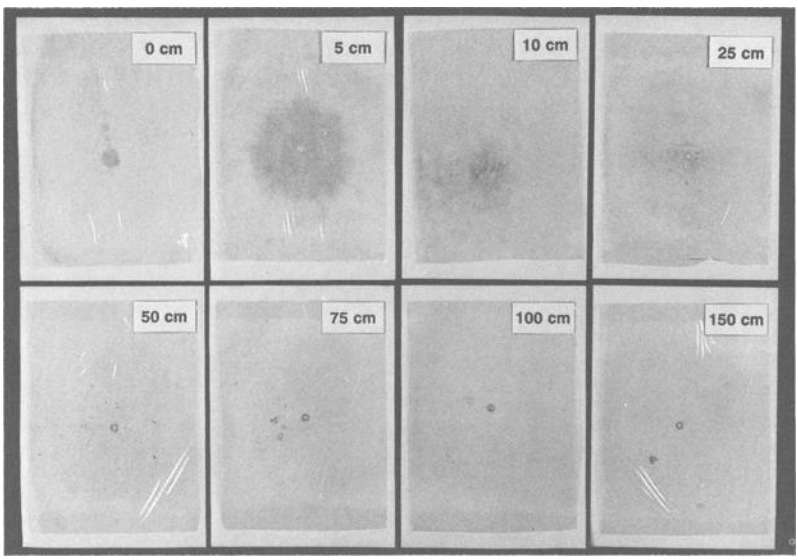

FIG. 3—*A series of treated cellophane film representing firing distances from 0 to 200 cm (selection). The dark spots around the point of impact are remnants of the plastic cap on the Action-3 bullet.*

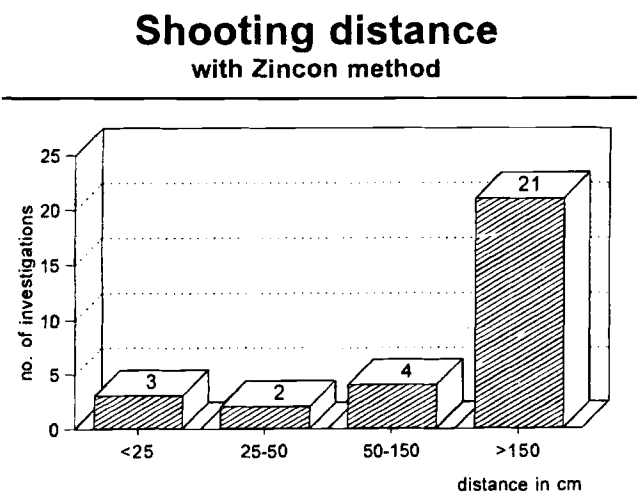

FIG. 4—*Survey of investigated shoot-outs with firing range conclusions as far as leadfree ammunition is used.*

4. The use of the improvised stretching device is simple and cheap.
5. The method is simple and can be easily reproduced.

The disadvantages of this method are:

1. The element lanthanum interferes with zincon, but in practice this element is not frequently found in the environment;
2. Copper clothing accessories, such as brass buttons and zips or tannin in leather clothing interfere with the determination.

The impact damage on objects such as doors, windows, etc. can be examined in this way as well. In similar cases the gunshot residues around the impact opening in the object are recovered by means of adhesive film. The adhesive film is then treated in the way described above to determine the firing range.

Acknowledgment

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