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Investigating airborne GSR particles by the application of impactor technology

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ABSTRACT

Gunshot residues (GSR) are of interest when firearms are used in criminal cases. GSR analyses are usually based upon the elemental composition and morphological appearance of very minute particles by means of SEM-EDS. Based on these two parameters, GSR particles are divided into specified classes. The amount of detected GSR particles depends on the time since discharge of the weapon and the sampling position relative to the location of discharge. In this paper, the influence of time on the local concentration and the distribution of airborne GSR particles were investigated with impactor technology. The particle concentration is constant in the still room; changes in concentration are only related to the emission of GSR particles by the discharge of a firearm. Here we showed that large quantities (50% of max. concentration) of airborne GSR particles can be detected several hours after discharge and contamination can take place as much as three hours after discharge. This study is a first approach to describe the propagation and sedimentation of GSR particles. With respect to statistical confirmation further experiments are already projected in order to comprehend the well-known variability of GSR emission and behavior.

1. Introduction

Gunshot residues (GSR) are often investigated when firearms are used in a criminal case. GSR consists of small particles in the submicron to 10 μm range, which can be inorganic or organic [1–3]. These particles originate from the primer and the propellant, as well as material that was re-condensed from formerly evaporated material from the bullet, the cartridge case, and previous residues in the barrel, as well as abrasion particles from the same sources. Lead, antimony, and barium mainly originate from the primer in contemporary ammunition where they are used in the form of lead styphnate, antimony trisulphide, and barium nitrate, e.g. in Sinoxid ammunition by Dynamit Nobel, and many other ammunition manufacturers [4].

GSR is classified according to the ENFSI (European Network of Forensic Science Institutes) and ASTM (American Society for Testing and Materials) guidelines: *characteristic of* GSR and *consistent with* GSR [5,6]. Characteristic particles are at least three-component particles (with characteristic morphology), which are normally only found when a firearm has been discharged. *Consistent with* particles are two-component particles that, although uncommon, can also have their origin in the environment.

The main topic in this article is the variation in concentration of GSR particles versus time in a closed, still room after discharge of a firearm. The particle concentration is constant in such a still room prior to the discharge of a firearm. It can be reasonably assumed that concentration changes are only related to the emission of GSR particles by this discharge.

A time model of the behavior of GSR in this situation would be desirable, but is difficult to create as there are many different effects that influence the concentration of airborne GSR. Fojtásek and Kmjec (2005) tried to develop a time model when looking at the sedimentation of GSR particles [7]. Their results show that the main sedimentation process comes to an end after 8 min for the investigated size classes. Our study works on the principle of collected airborne GSR instead of sedimented GSR.

The most common method to sample and analyse GSR is tape-lifting and the use of a scanning electron microscope coupled with an energy dispersive X-ray spectrometer (SEM/EDS) [1,8]. Tape-lifting is done on clothing or the hands of the shooter and cannot be used to collect airborne particles. However, Andrasko and Pettersson (1991) reported the use of a double filtration system in combination with an ordinary vacuum cleaner for the collection of GSR [9]. Here, two filters of 20 and 0.8 μm pore size

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Fig. 1. Overview of the shooting range.

were used for the separation of particles. The calculated flow rate in the vacuuming system was around 6 L/min.

In the present study an impactor was used with a triple separation system with cut off sizes at 10, 2.5 and 0.4 μm [10–12]. This flow rate in this system was 33 L/min. The flow rate is six times greater than that of Andrasko and Pettersson [9]. The impactor was used in combination with a pump with a controlled volume passing through the system instead of an ordinary vacuum cleaner. In this way the particle concentration can be related to a volume of the environmental air, and the particle density can be calculated. This will aid significantly in understanding the distribution of particles.

Additionally, semi-continuous measurements were performed with a particle counter because the only source of particle emission is the discharge of the firearm. The particle counter is not able to distinguish between GSR-related and not-related particle concentrations. However, if the formerly measured background is subtracted the particle concentration can be observed over time.

2. Experimental – materials and methods

The experiments were conducted in a closed shooting range of 6.6 × 4.3 × 2.3 m (L × W × H, V ≈ 65 m^3). This shooting range was especially designed for shooting distance tests (Fig. 1). It is not used for any ballistic investigations and firearms identification tests. The air conditioning was switched off at least 10 min before shooting, the lights were turned off after the shot had been fired, so the only turbulence inside the room came from the shooter walking out at a slow pace. A Glock 19 pistol (barrel length of 102 mm) with Geco 9 mm Luger ammunition (a full metal jacket lead projectile with an open base, 8.0 g) was used for all the experiments. In all experiments the shooter was the same person, firing the pistol with both hands in three different experimental setups.

Setup 1, shooter stands in the middle of the room and the two suction tubes, one for impactor and one for the particle counter are behind the shooter in the corner of the room at 1 m height (Fig. 2). This corresponds to a distance of 3.25 m between the shooter and the suction tubes.

Setup 2, two suction tubes, one for impactor and one for particle counter are 20 cm to the right and 80 cm to the front of the shooter (Fig. 2).

Setup 3 uses the same position as in setup 1; however, here at 4 different heights (0.5 m, 1 m, 1.45 m and 1.9 m) samples were only taken with the particle counter.

2.1. Equipment

2.1.1. Particle counter

An ACS-Plus 228 from KM OptoElectronic GmbH (Leonberg, Germany) with detection sizes from: 0.2 μm to 1.0 μm with steps of 0.1 μm; 1.0 to 4.0 μm with steps of 0.5 μm; and 5 μm was used during the experiments [13].

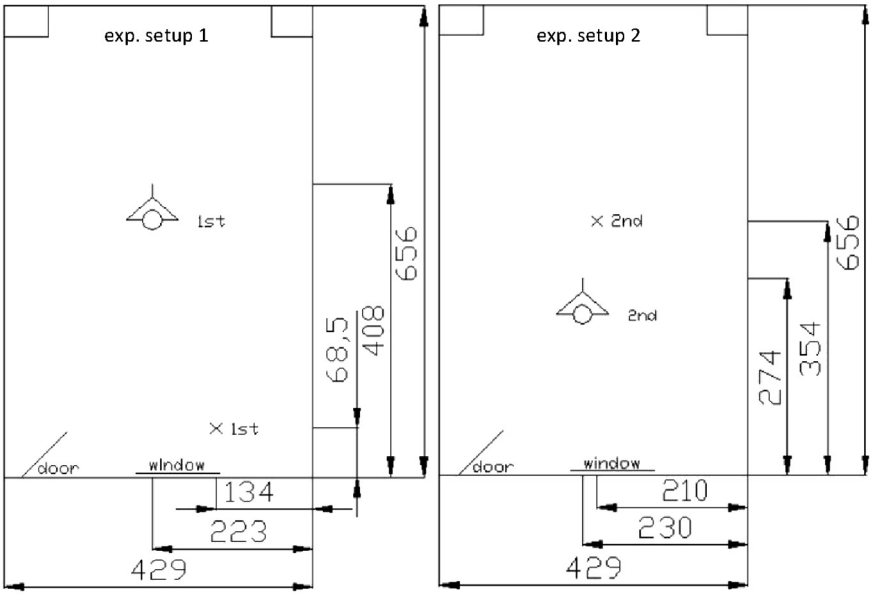

Fig. 2. Setups of the experiments in the shooting range, X is the position of the suction tubes. Experimental setup 3 uses the position of setup 2.