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Primer composition and memory effect of weapons—Some trends from a systematic approach in casework

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A B S T R A C T

Since 2008, our laboratory has adopted a systematic approach to the examination of gunshot residues (GSR) in casework by analysing, whenever possible, the inorganic composition present in ammunition (cartridge cases and unused ammunition). By compiling the results of these analyses in a database, it is possible to observe some trends during the period of interest: on the one hand, the prevalence of primers containing lead, barium and antimony is about 50%, and even as high as 70% when including lead–barium–antimony based primers also containing tin; on the other hand, the prevalence of non-toxic primers is for the time being very low. Still using the same approach, test firings were performed with recovered weapons and litigious ammunition whenever possible in order to estimate the influence of the well known "memory effect" of the weapons on the GSR analysis results. The first results show a quite strong memory effect for the .22 and the .32 caliber, unlike the .38 caliber. This is probably due to a high prevalence of lead–barium–antimony based primers for the latter caliber.

1. Introduction

When a shooting incident occurs, gunshot residues (GSR) are produced and deposited in the vicinity of the shooter. The field of investigation related to this characteristic has recently been reviewed by Dalby et al. [1]. The method of choice for analysing GSR is use of the scanning electron microscope, combined with X-ray microanalysis (SEM/EDX), following the ASTM norm [2] or the ENFSI guide [3]. At the beginning of the development of this field and even until the early 2000, the analytical strategy consisted in priority of looking to evidence for lead–barium–antimony particles (on samples from hands or clothes of suspects), since these elements are present in a large number of primers and are considered to be characteristic of GSR [2,4]. However, it is well known that some primers do not contain one or more of these three elements, leading to the production of GSR particles without lead, barium and/or antimony, and thus resulting in possible false negative cases. Considering this issue, a case-by-case approach is nowadays highly recommended whenever possible [5]. The analytical strategy consists of examining the cartridge case when available, in order to determine the inorganic composition in the cartridge case, and by doing so to define the type of GSR that would be produced in the specific shooting incident under investigation. Several papers [6–8] have shown that due to extreme conditions inside the gun during the shooting, the population of GSR particles can greatly vary between different sampling locations (e.g. hands of shooter vs. cartridge case). However, analysing the inorganic composition in the cartridge case can at least give a valuable idea about the expected GSR particles that have to be identified. Since 2008, it has been decided to apply this strategy in our laboratory in a more systematic way, leading to the building of a database of elemental compositions of the cartridge cases pertaining to real criminal cases.

The first part of the present article introduces the prevalence of elemental composition in cartridge cases during the period of interest (2008–2010). This database, which is still continuously supplied with incoming data, gives an idea of the actual prevalence of different ammunitions used in criminal cases in Belgium, leading to a better knowledge of the future challenges in the domain of inorganic GSR analysis.

However, the memory effect of the weapon can play an important role and should sometimes be taken into account. This well-known effect is related to the production of GSR particles with a composition that is not compatible with the composition of the primer of the ammunition of interest, but with primers of ammunition which was previously fired from the weapon [9–11]. Therefore, it was decided in casework to also perform systematically, whenever possible, test firings with the litigious

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weapon and associated ammunition of interest recovered from the crime scene. This would lead to a better knowledge of the type of GSR that was produced during the shooting incident, trying in a second step to search specifically for these particles on the pieces of evidence submitted to analysis. It is of course evident that in some cases it must be assumed that for several reasons (e.g. ambient conditions or post-firing activities of the shooters), reconstruction in the shooting range can lead to sizeable variations between GSR populations recovered from the hands of suspects and reference shooters.

The second part of the article shows the results of more than twenty experiments of this type conducted between 2009 and 2010. Beside the interest for particular cases, the collection of these data leads to a better understanding of the problem of the memory effect in real casework, and can be useful when, in the absence of any weapon submitted for analysis, the probability of the origin (through memory effect or another weapon environment) of cartridge-case-incompatible GSR has to be evaluated.

2. Materials and methods

2.1. Cartridge case analysis

Each cartridge case received was treated as follows: the internal part of the cartridge case was scratched with a fresh toothpick; the cartridge case was then put upside down on a .5 in. carbon tab-covered stub and the headstamp was softly tapped several times. The stub was subsequently analysed using a Cambridge Stereoscan 360 scanning electron microscope, equipped with a SiLi nitrogen-cooled EDX detector, coupled to a PGT Avalon X-ray analyser, using the PGT acquisition and treatment software. A bulk analysis spectrum acquisition at 50 times magnification, with a count rate of 1000 cps was performed during 150 s.

2.2. Test firings

In order to avoid heavy contaminations, the individuals selected for the test firings were chosen among the lab employees that do not belong to the Firearms Laboratory. For each test firing the following procedure was applied: after having washed his hands, the shooter takes the weapon (previously loaded) and fires one time using his two hands. He immediately exits the shooting range and performs administrative work for a period of 1 h. After this time period, a hand sample is collected following the same procedure as the one used within the European ''AGIS'' framework study [12]. The stub is then analysed with an ASPEX 3025 or PSEM75, following the internal routine analysis procedures. The particles of interest are automatically sorted according to their elemental composition into six classes: 1/PbBaSbSn, 2/PbBaSb, 3/PbBa(Sn), 4/PbSb(Sn), 5/BaSb(Sn) and 6/BaAl. These particles are manually reviewed for confirmation. When possible (sufficient available ammunition), the test firing was performed twice.

3. Results and discussion

3.1. Cartridge case analysis

During the period of interest, 210 cartridge cases were submitted for analysis, corresponding to 49 criminal cases. Not only the spent cartridge cases, but also the unused cartridges were submitted for investigation, explaining the high number (ca. 5) of ammunition samples per case. Table 1 shows the different types of ammunition received pertaining to criminal cases within the period of interest. For each type of ammunition the composition of the inorganic elements present in the cartridge case was determined and sorted into five classes: 1/PbBaSb, 2/PbBaSbSn, 3/PbBa, 4/Sb (without Ba) and class 5/other. Sixty-nine different types of ammunitions were encountered during this period.

Fig. 1 illustrates the prevalence in our crime cases of the inorganic composition in cartridge cases. The prevalence of primers containing lead, barium and antimony is approximately 50%, and even as high as 70% when including these types of primers also containing tin (generally used as a sealing foil of the primer

Table 1
Types, inorganic composition (in the cartridge case) and occurrence of ammunition received from criminal cases during the period of interest (2008–2010).

Nominal caliber	Ammunition used (inscriptions on headstamp)	Inorganic composition	Occurrence	Class
.22	A	PbBaSi	2	3
	C	PbBaSi	7	3
	F	PbBaSi	5	3
	REM	PbBaSbSi	1	1
	U	PbSi	1	5
.25	*FN	PbBaSbSn	3	2
	GECO	PbBaSb	3	1
	S&B Br	PbBaSnCaSi	3	3
	WIN 25 AUTO	PbBaSb	5	1
.30	10 91	SbSnKFeClS	1	4
	13 88	PbBaSbKSi	1	1
	19 83	SbSnKFeClS	3	4
	321 91	SbSnKFeClS	1	4
	323 88	SbSnKFeClS	1	4
	60 57	SbSnKFeClSSi	1	4
	90 05	SbSnKFeClSSi	1	4
	90 05	HgSbFe	2	4
	IK 86	SbSnKClS	1	4
	IK 87	SbSnKClS	6	4
	IK 91	SbSnKClSSiAl	1	4
	ППУ 1985	SbSnKClS	1	4
	ИK 1977	SbSnKClS	1	4
	ИK 1980	SbSnKClSSiAl	1	4
	ИK 1983	SbSnKClSSiAl	1	4
	S&B	PbBaSb	8	1
	S&B	PbBaCaSi	2	3
	VAPEX	PbBaSbSn	3	2
.32	*FN	PbBaSbSnHg	1	2
	*FN	PbHgSbKCl	7	4
	FN	PbBaSbSn	2	2
	GECO	PbBaSb	1	1
	GFL	PbBaSb	10	1
	RP S&W L.32	PbBaSbAlSi	1	1
	S&B Br	PbBaSbSn	9	2
	S&B Br	PbBaSb	1	1
	SBP	PbBaSnCaSi	1	3
	WW 32 AUTO	PbBaSb	7	1
	WW S&W LONG .32	PbBaSbAl	1	1
8 mm	GFL	PbBaSb	1	1
.38	CBC AUTO 380	PbBaSbAl	5	1
	FC LUGER	PbBaSb	6	1
	F	PbBaSb	3	1
	GFL 9M34 08	PbBaSb	2	1
	GFL LUGER	PbBaSb	10	1
	GFL 38 SPECIAL	PbBaSb	3	1
	MEN GI .38SP	KSSiAl	6	5
	MFS	PbBaSbSn	6	2
	MRP LUGER	PbBa	7	3
	NEVINS LUGER	PbBaSb	7	1
	NORMA 38 SPL 1985	PbBaSb	5	1
	RP AUTO .380	PbBaSbAl	5	1
	RP LUGER	PbBaSbCaSiAl	1	1
	RPP .38 SPL	PbBaSbAl	1	1
	RP 357 MAGNUM	PbBaSbAl	2	1
	S&B LUGER	PbBaSnCaSi	1	3
	S&B PARA	PbBaCaSi	1	3
	S&B SPECIAL 38	PbBaSbSn	7	2
	SPEER 38 SPECIAL	PbBaSb	1	1
	SPL 38	PbBaCaSi	1	3
	WW S&W 38	PbBaSb	1	1
	WW SUPER .357M	PbBaSbAl	1	1
.45	IMI 45 ACP	PbBaSbSe	1	1
.41	GFL FIOCCHI 410	PbBaSbAl	2	1
12	CHEDDITE FUN-TIR 12	PbBaSbMgAlSiKFe	7	1
	LEGIA BROWNING FN 12	PbBaSbSi	4	1
	RC4 SPECIAL	PbBaSbAl	1	1
	REMINGTON 12 GA PETERS	PbBaSbSiAlMg	2	1
	ROTTWEIL EXPRESS	PbBaSbKAl	2	1
	SOLOGNAC	PbBaSbAl	1	1