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The enhancement of friction ridge detail on brass ammunition casings using cold patination fluid

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ABSTRACT

Brass ammunition is commonly found at firearms related crime scenes. For this reason, many studies have focused on evidence that can be obtained from brass ammunition such as DNA, gunshot residue and fingerprints. Latent fingerprints on ammunition can provide good forensic evidence, however; fingerprint development on ammunition casings has proven to be difficult. A method using cold patination fluid is described as a potential tool to enhance friction ridge detail on brass ammunition casings. Current latent fingerprint development methods for brass ammunition have either failed to provide the necessary quality of friction ridge detail or can be very time consuming and require expensive equipment. In this study, the enhancement of fingerprints on live ammunition has been achieved with a good level of detail whilst the development on spent casings has to an extent also been possible. Development with cold patination fluid has proven to be a quick, simple and cost-effective method for fingerprint development on brass ammunition that can be easily implemented for routine police work.

1. Introduction

Although a great deal of research focuses on advancements in DNA profiling for identification, fingerprints are also an excellent identification tool. The uniqueness of the ridges on the skin allows fingerprint residue to form an identifiable pattern (print) on surfaces that come into contact with the skin. Eccrine fingerprint residue consists of water and other secretions such as sodium chloride and potassium, sulphide, calcium and magnesium. Sebaceous gland secretions consist of fatty substances including glycerides and phospholipids. Friction ridge contact with sebaceous rich surfaces (i.e. face) prior to deposition results in sebaceous rich fingerprints [1].

Despite the various components of fingerprint secretions, finger marks are described as latent because they are naturally colourless making them difficult to detect. Such prints are visualised using fingerprint development techniques that have been well documented and validated over the years, the UK Home Office Centre for Applied Science and Technology (CAST) provide comprehensive details and guidance on techniques in the Fingermark Visualisation Manual [2].

Specific fingerprint development techniques are designed for use on certain types of surfaces or conditions that are encountered. For instance, fingerprints on porous surfaces that become wet lose the water soluble components and can be developed using the technique physical developer which reacts with other non-water-soluble components of the fingerprint. Physical developer is also used in sequential treatment after the application of other fingerprint development techniques such as DFO and Ninhydrin for visual enhancement [3]. The development of friction ridge detail on ammunition casings has been attempted in several recent studies [4–6]. Gun bluing (GB) is one such technique that can be applied to brass ammunition casings in order to develop fingerprints. The "Gun Blue" solution is a mixture of copper sulfate and selenous acid that causes selenium and copper to react with the metal surface. The parts that are free of the fatty substances, such as those found in sebaceous fingerprints, change colour and this leads to the development of the fingerprints [7]. Gun bluing was also used in combination with cyanoacrylate fuming (CNA) and brilliant yellow dye (BY40) to enhance fingermarks even further [8]. Palladium deposition is a similar technique that is based on the deposition of palladium on the metal

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surface of a cartridge case. CNA and palladium deposition has similar enhancement results to the CNA-GB-BY40 combination [8]. Due to low recovery rates of fingerprints from ammunition casings more current studies targeted this area of research. Recently, Bond studied the effects of high temperature on brass disks with fingerprint deposits and concluded that even after attempting to remove fingermarks from metallic surfaces, the 'aggressive' ions such as Cl^{-} in the salt component of the fingerprint residue would have readily reacted with metals to form metal salts [9]. Conclusions from Williams and McMurray were consistent with those of Bond where they used a Scanning Kelvin Probe (SKP) and were able to visualise fingerprints on ammunition to a certain extent. The Scanning Kelvin Probe measures the difference between the work function of the corroded and the uncorroded brass. The corrosion is a result of the reactions between the fingerprint and the metal surface; therefore, the SKP can map out the areas with different work function and ultimately visualise the fingerprint deposit [6]. Considering the theory behind the SKP technique Bond designed a new fingerprint development technique called cartridge electrostatic recovery analysis (CERA) that uses a conducting carbon powder in combination with an electrostatic charge (~2500 V) [9]. In theory the charge causes the powder to preferentially adhere to the metallic areas corroded by the fingerprint residue. In collaboration with Bond, Consolite Forensics developed the CERA LT, which is an optical system which can be used to capture and enhance the image of fingerprints on cylindrical items without the use of carbon powder [10]. Upon production of CERA LT, Bond has suggested that this technique "provides superior imaging" to the electrostatic charge method of fingerprint development [10].

Many different types of firearms evidence are presented in a forensic case. This includes weapons, magazines, silencers, live ammunition, cartridge cases, bullets and gunshot residue. Ammunition and cartridge case analysis allows forensic examiners to acquire information on the cartridge type, manufacturer, approximate date of manufacture, the type of weapon used as well as potentially provide a link to a weapon.

Additional evidential value can be obtained from ammunition and ammunition casings through fingerprint development techniques. Such techniques will greatly increase the forensic value of the casings as it may link an individual to the ammunition and potentially a firearm. Data from the Metropolitan Police has shown that by using conventional techniques for the recovery of fingermarks on ammunition the success rates achieved are very low, this has formed part of the rationale for this research.

This study seeks to present cold patination fluid as a potential candidate for forensic use in the visualisation of friction ridge detail on brass ammunition. In addition, the selectivity of the technique will be tested by treating other metals widely used in ammunition casing manufacture: steel and aluminium. Patination fluid reacts with brass and visualises friction ridge detail through a colour change. Patination fluid, otherwise known as 'antiquing fluid' is used as a metal colouring technique which has the ability to change the surface colour of brass to give it an antique like finish. A thin layer of patina is formed on the surface of the metal, produced by oxidation, the metal is tarnished and corroded by the chemical reaction. The patination fluid is composed of two main components: selenium dioxide and nitric acid. The selenium dioxide component allows the development of black patina on the surface of brass and other metals. Due to the oxidative characteristics of selenium, it is easy to manipulate for application. The nitric acid component acts as a corrosive medium to allow the colour to etch onto the surface of the metal. The application of this solution is a simple, safe and low cost method to blacken the surface of brass [11]. However, the selenium dioxide component dissolves in water to form selenious acid which is toxic by inhalation, therefore all work with patination fluid should be carried out in a fume cupboard while wearing personal protection equipment. Jade oil is used, as recommended by the manufacturer, on all samples after treatment to ensure that the development is halted and fixed.

2. Material and methods

2.1. Reagents

Cold patination fluid black (selenium dioxide and nitric acid) was obtained from Priory Polishes, UK. Jade oil was obtained from Liberon, UK. 0.7 mm thick 300 mm × 100 mm brass (63% copper, 37% zinc) sheets were purchased from Macc Models Engineers Supplies Ltd. 0.9 mm thick 150 mm × 300 mm aluminium sheets and 60 mm diameter brass disks were obtained from the online retailer Hardware Outlet UK. 0.9 mm thick 250 mm × 250 mm mild steel sheets were obtained from Smiths Metal Company. Superglue (CNA) provided by the Metropolitan Police Service was obtained from Tetra Scene of Crime. 9 mm Luger rounds of ammunition and variable spent brass cartridge cases were provided by the Metropolitan Police Service. Sixty spent cartridge cases were used to optimise the method using patination fluid and 165 live ammunition samples were used for the experimentation.

2.2. Brass ammunition

Five batches of live ammunition were prepared using one donor to minimise the variables that could affect the study such as age, race, genetics and sex [12]. Further to this, as a proof of concept study to assess the potential of the technique it was deemed suitable to use only one donor at this time. A further, larger pool of donors would be required for validation trials. Each batch comprised of 30 samples that were stored in cylindrical tubes. Firstly, the ammunition was rinsed with distilled water and wiped using paper towels. Afterwards, the donor was asked to wash their hands with water and soap to remove any greasy substances that may interfere with the quality of the fingerprint. The donor was asked to separately place sebaceous and eccrine fingerprints on the ammunition casings. The sebaceous prints were taken by asking the donor to wipe their forehead with his fingers and eccrine sweat was generated by wearing nitrile gloves for ~5 min. The fingerprints were deposited by rolling the sample between the index finger and the thumb. This would allow the fingerprint to be placed all around the brass casings metal surface. After depositing fingerprints, 15 samples from each batch were fired using a SIG Sauer P226 pistol within 24 h and the spent casings placed back into the tubes. The remaining 15 'live' samples were stored immediately as they were. For the 15 samples that were fired and the 15 'live' that were stored, 8 samples had sebaceous finger marks on them and 7 had eccrine finger marks (illustrated in Fig. 1). Four batches were stored for 1, 2, 3 and 4 weeks after finger mark deposition and one batch was treated on the day of deposition. All 5 batches were treated with the cold patination fluid.

2.2.1. Patination fluid

A 3% solution of cold patination fluid was prepared using distilled water in a beaker. The samples were taken out of the tubes and then immersed in the patination fluid for 90 s. During this time, the surface of the sample changed colour and the friction ridge detail started to develop. The samples were then dried by gently rolling the cartridge case/ammunition on a paper towel. Then Jade oil was applied by slightly dampening a paper towel with the oil and then wiping the surface of the cartridge, this allowed the developed colouring to become fixed. To avoid hazards