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Variations of Dispersion Pattern of Gun Shot Residue on Cloth Target - a Review

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Abstract

Determination of range between the muzzle end and the target is important and is requirement to solve the cases related to firearm. Test firing is done by the firearm for this purpose at different distances and then analyzing the GSR dispersion pattern with that of the victim and target [1]. Analysis of GSR can be done by various methods. When bullet hits the target, examination of target is important as large portion of the GSR is trapped by the target. So, dispersion of GSR on target can be use in determining the range of firing [1]. The purpose of this study is to determine the dispersion pattern of 7.65mm calibre on cotton cloth at different range [4,8,12] to establish the exact range of fire.

Keywords: GSR dispersion pattern; Cotton substrate; 7.65 calibre; Muzzle to target distance; Country made firearms

Introduction

An ammunition basically consist of components which are: a cartridge case composed of brass, a primer cap which contains lead, antimony and barium, a propellant which is mainly consist of potassium nitrate, nitrocellulose and nitroglycerine and a projectile made from lead alloy with tin or antimony [2]. With the firing of gun various matter leaves the barrel which is called Gun Shot Residue. The matter consists of burnt, partly burnt and unburnt combustion product combine with additional residues from the surface of primers, bullet, cartridge case or firearm itself [3]. Because of different designs of arms and ammunitions and different firing process, there is a variation in GSR composition. So, each shot will have unique composition which results in unique GSR cloud. Comparing and measuring these compositions may be useful in forensic casework [4].

During firing, gunshots hit different body parts covered by cloth. In these cases, cloth examination is important as that of the body, because most of the soot and powder, including GSR are trapped in the clothing and do not reach the skin. So, studying the GSR pattern on the clothing itself is very important [5].

Standard firearms

These are the firearms which are manufactured in factories and these firearms have defined firing range, muzzle length, rifling characteristics etc. and their manufacturing is authorized by government.

Country made firearms

Country made firearms are randomly made firearms. Each such firearm is unique in itself. The barrels of these firearms are often made of pipes used for water lines. These firearms are made to fire cartridges of shotgun, pistol, and revolver and rifle which are easily available. In India, almost crime like murder, poaching, riot etc are committed by using country made firearms [6]

Examination of GSR

Different methods are available for the study of GSR and they are as follow:

Walker test: This test detects nitrites in the residue using desensitized photo bromide paper. The cloth carrying the residues is kept over the bromide paper. It is covered with a towel moistened with 20% acetic acid and the setup is pressed with a hot electric iron for 5-10 mins. Dark red spot on bromide paper indicate GSR.

Harrison Gilroy's test: Harrison and Gilroy introduced a method through which metal-containing components of GSR can be examined. The components that are taken care of are

led, antimony, and barium that are generated from the primer and the bullet. Spot test is done in which the residues are taken from suspect's hand through swabbing with cotton cloth with 0.1M hydrochloric acid. After drying the swab, it is then tested with one or two drops of a 10% alcohol solution of triphenyl methylarsonium iodide. The presence of antimony was indicated by the formation of orange dye. When the orange dye get dried then by putting two drops of sodium rhodizonate solution (5%), red color development inside the ring indicates lead barium or both.

Dermal nitrate test: Dermal Nitrate test is frequently used to identify the shooter. In this test the nitrate are picked up on a paraffin wax cast and are treated with diphenylamine dissolved in strong Sulphur acid. Nitrate is indicated by the appearance of blue color spots and hence the indication of presence of GSR.

Review Literature

In 2019, Jason Berger et al. [7] visualize the nitrite residue which is necessary in gunshot range determination. Earlier it was done by Modified Griess Test which only allows the recognition of free nitrites and will not react with the unburnt gunpowder particles which typically travel further than partially burned gunpowder. This will likely limit the distance at which significant nitrite residues are observed when using the traditional MGT. So, an improved method referred to as TNV (Total Nitrite Pattern Visualization) is prefer in which there is an addition of alkaline hydrolysis step prior to MGT which converts nitrates to nitrites. The introduction of TNV methods has allowed the substantial increase in the quality of GSR analysis sacrificing results from subsequent test [7].

In 2018, Oriana Ovide et al. [8] study the application of Laser Induced breakdown Spectrometry to calculate the distance between muzzle end and the target and to detect GSR around bullet holes. He classifies the distance between muzzle end and the target on the basis of inorganic gunshot residue distributions. He considers 79 cotton textile of different fabrics and shot them using 9mm pistol and Rossi revolver with different ammunition. 45 shots were made at a known distance to create a training set while remaining 28 were shot at unknown distance to check the exactness of the method. Result shows that LIBS is more selective and sensitive method as compared to color tests. The technique is reagent free and does not require sample preparations and can detect GSR at low levels (0.2 ng to 440 ng) [8].

In 2016, Chiara Giraudo et al. [5] present a study where he analyze firearm wound covered by textile on human skin experimentally. He performed the firing trails on human calves, in almost 60 sections covered by a layer of fabric and 15 sections of bare calves. The firing is done at different distances (5,15 and 30 cm) using a .32 ACP pistol and are analyze by Micro-CT. There are different pattern of GSR distribution on bare skin as well as on fabrics. Micro-CT analysis reveals that on all entrance wound there is an existence of radio opaque material which differentiate between exit and entry wound [5].

In 2015, Kah Haw Chang et al. [9] presented a paper where they detect and analyze organic compounds by Gas chromatography-flame ionization detection technique. Organic compounds includes naphthalene, 2,6-dinitrotoluene, 2,4-dinitrotoluene, diphenylamine, and dibutyl phthalate and evaluation of chromatograms for diphenylamine, dibutyl phthalate, and naphthalene and these compounds indicates the period after a gunshot was discharged, whether it was 1 days, 2–4 days, less than 5 days,10 days, 20 days, or more than 30 days ago.

The time of discharge of cartridge is affected by the environmental factor, so environmental condition should be taken care of while examining the crime scene [9]. In 2014, Julia Plolovkova et al. [10] investigated the GSR composition and marking substance of two cartridges of calibre 9mm (type action 4 and type PEP II). It was found that gadolinium is the marking element in first cartridge and GSR analysis results that it consists of Titanium and Zinc and second cartridge (type PEP II) has gallium in gunpowder and GSR consist of Titanium and Zinc. The introduction of special marked ammunition and marking substance to the primer is important for forensic investigation and is proved by this analysis. So, the type of marking of ammunition can significantly influence the presence and detection reliability of marking elements in GSR [10].

In 2012, James Arndt et al. [11] presented a paper in which he study the organic component of GSR, and their persistence are estimated using diphenylamine (DPA). He collects the samples from the shooter's hand by swabbing and analyzes those using Ion Mobility Spectrometry (IMS). Here the sample is volatilized by thermal desorption and it was noticed that GSR has a persistence time of 4h on shooter's hand and with the passage of time, particle present on shooter's hand will decrease [11].

In 2010, Macro R. Rijnders et al. [4] presented a paper where he compares GSR composition of four different ammunition from different location in and around the firearm and analyze them by scanning electron microscopy/energy dispersive X-ray. While using different ammunition, the correlation between them was very low and when ammunition of similar type was used, high correlations was found indicating that they belongs to the same source. The combinations of standard samples from the chamber and the barrel are mostly dissimilar from the samples which are associated from other locations. The samples taken from the cartridge case were not correlated with the other samples, especially when lead-free ammunition was used. So, while taking samples from shooter's hand or cartridge case care must be taken [4].

In 2008, Stanley Keith Hodges [1] published result where he determine if there is any difference if firing is done with different firearms and different ammunition from different distance. He uses three brands of ammunition (CCI ammunition, the Winchester and Remington ammunition). The finding indicates that no notable differences occur with different firearm but there

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were significant differences with different brand of ammunition. The CCI ammunition uses a flake powder and showed a tighter GSR pattern. Winchester uses ball powder and showed the greatest dispersal of GSR pattern. Remington uses a pellet type of powder. The differences in such pattern is due to the weight of the powder i.e. Ball Powder>Pallet Powder > Flake Powder [1].

In 2006, Ka-Man Pun and Alain Gallusser [12] study the morphological characteristics (size, shape and color) of powder before and after the shot to establish the ammunition used. 181 cartridges are fired and analyzed. Among the fired cartridges, two different shapes are present: balls and flattened ones. Five cartridges present a combination of two colors and the cartridge of three different colors. The particle size varies between 0.2mm to 3mm. They also observed the morphology of unfired gunpowder grains to establish the starting shape and as the combustion is progressing the color of the powder is changing, the longer a gunpowder grain is burnt, more its color change [12].

In 1992, Arie Zeichner et al. [13] work on ammunition based on mercury fulminate-based primer and observe the existence of mercury fulminate GSR particles on shooters hand, cartridge case and burnt cartridge case. Test firing were carried out with Egyptian and Russian 7.62 mm ammunition and with Italian and Egyptian 9mm Parabellum ammunition. GSR from the cartridge cases and shooter hand were sampled and are analyze using SEM/EDX and it was observed that mercury containing GSR particle was found more in cartridge case as compare to the samples taken from the hand of the shooter. This is due to the increase in temperature from the ignition of propellant which evaporate the mercury and hence burning propellant will undergo more heat damage as compare to the GSR in cartridge case.

Methodology

The main objective of test firing is to calculate exactly the range from which the firearm is shot. For test firing, we will take 7.65 calibre firearms and fix it on a stand tightly. We will place our target i.e. cotton cloth over the cardboard and then attached it to the bullet recovery box. The target is placed at different distances i.e. 10cm, 20cm and 30cm from the firearm. After the firing we will observe the GSR pattern on the cloth [14].

Result

This study will be helpful in determining the exact range of firing and calibre from different distances i.e. 10cm, 20cm and 30cm in case of country made firearms which help the forensic expert for the easy disposal of cases where range of firing is to be ascertain.

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