Determining the firing distance from the pattern of gunshot residue on fabric using color test

Jinjuta Sangsawang[1], Thitichaya Thattiwong[2], Pitchaya Mungkornasawakul[1]
[1]Department of Chemistry Faculty of Science, Chiangmai University, Chiang Mai 50200, Thailand
[2]Firearms and Ammunition Identification Subdivision, Police Forensic Science Center 5, Lampang 52000, Thailand

Abstract

This study focuses on developing a method to estimate shooting distances based on the distribution of gunshot residue found on fabric surfaces. Test firings were conducted at distances of 2, 5, 10, 15, 20, 40, 60, 80, 100, 150, and 200 centimeters from the muzzle to the target. The study utilized physical examination to observe burned and unburned particles, chemical examination using the Modified Griess Test to detect nitrite residues, and the Sodium Rhodizonate Test to detect lead from the bullet. These methods were used to analyze the radius and pattern of gunshot residue distribution. The results showed that physical examination could estimate the shooting distance from the distribution of gunshot residue within the range of 2 to 40 centimeters from the muzzle to the target, with the residue distribution radius ranging from approximately 3.83 to 2.67 centimeters. The lowest coefficient of variation in the data set was 3.8%. The chemical examination using the Modified Griess Test could estimate the shooting distance from the residue distribution within the range of 5 to 80 centimeters, with a distribution radius ranging from 1.57 to 10.7 centimeters. The lowest coefficient of variation in the data set was 2.4%. The Sodium Rhodizonate Test could estimate the shooting distance within the range of 2 to 40 centimeters, with a distribution radius ranging from 3.67 to 2.3 centimeters. The lowest coefficient of variation in the data set was 0%. Combining these methods to examine the gunshot residue distribution can yield accurate estimates of the shooting distance, providing reliable scientific evidence that is crucial for legal considerations.

Introduction

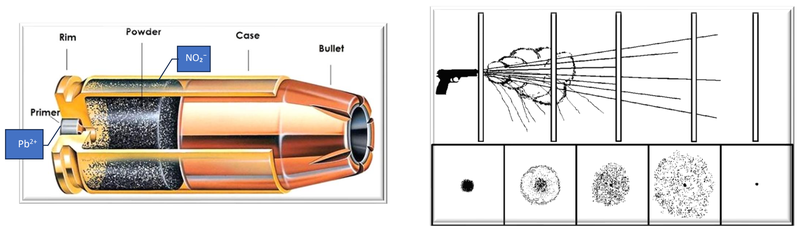

Fig.1 Bullet components and the relationship between shooting distance and gunshot residue dispersion radius

Crime in Thailand has been steadily increasing, with studies showing that guns are the most commonly used weapons in criminal cases, leaving behind significant evidence. Nowadays, scientific evidence is widely accepted in the justice system, and gunshot residue (GSR) is one of the key types of evidence found after firearm use. GSR contains nitrates and nitrites produced by the combustion of gunpowder, along with lead particles dispersed around the bullet hole on fabric surfaces. Examining this evidence can help determine the shooting distance, which is crucial in court proceedings, as it can be used to analyze the offender's intent. The data obtained from experiments will be used to create a database that will assist forensic investigators in more accurately determining the shooting distance, providing valuable evidence to support legal proceedings in court

Objectives

- To study the dispersion radius of gunpowder residue fired from a 9 mm semi-automatic pistol. (Glock 19 Gen 3)
- To analyze NO_2^- using physical examination and the Modified Griess Test.
- To analyze Pb^{2+} using the Sodium Rhodizonate Test.
- To estimate the shooting distance through physical and chemical examination.

Methodology

➢ Modified Griess Test

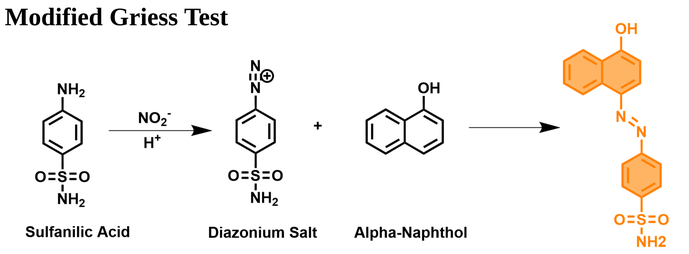

Fig.2 Reaction equation of the Modified Griess Test

➢ Sodium Rhodizonate Test

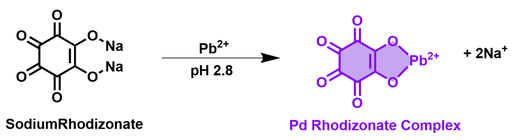

Fig.3 Reaction equation of the Sodium Rhodizonate Test

Experimental

➢ Modified Griess Test

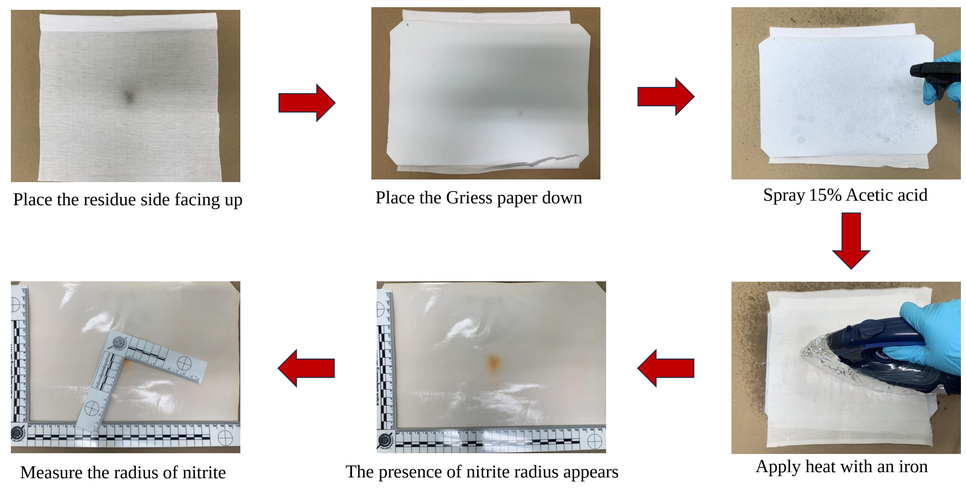

Fig. 4 Experimental procedure for the Modified Griess Test

➢ Sodium Rhodizonate Test

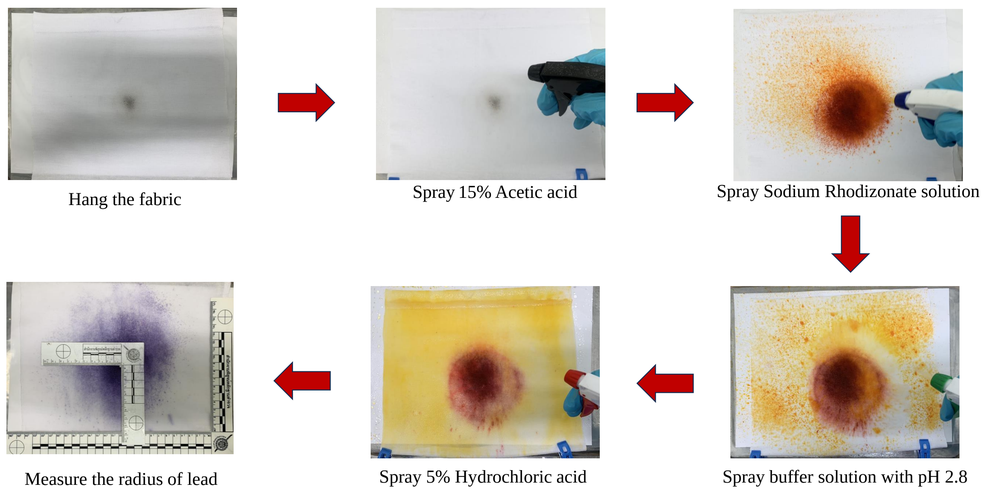

Fig. 5 Experimental procedure for the Sodium Rhodizonate Test

Results and Discussion

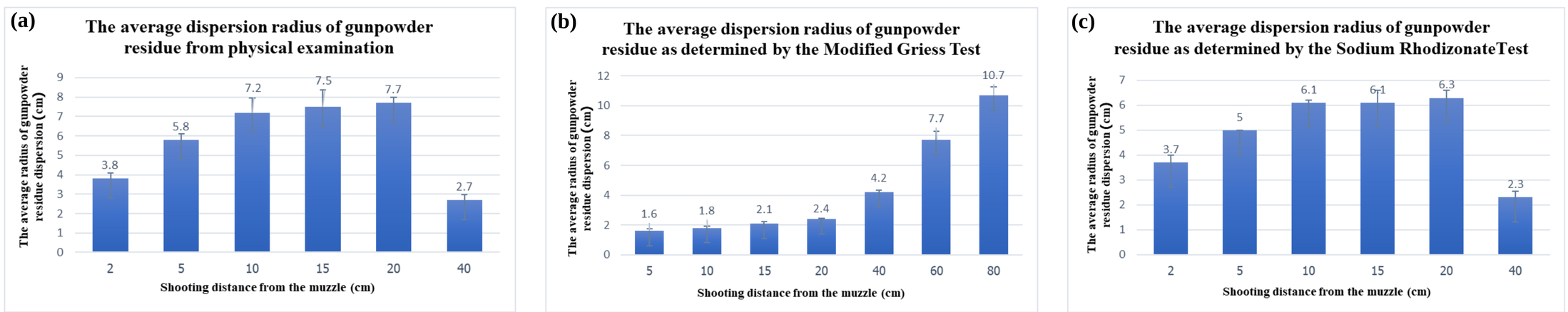

Fig.6 Statistical analysis results of the dispersion of gunshot residue at various distances, based on (a) physical examination, (b) the Modified Griess Test, and (c) the Sodium Rhodizonate Test

Based on observations of gunshot residue dispersion, different methods yield varying maximum shooting distances. Physical examination can estimate a shooting distance of up to 40 cm from the muzzle, but it cannot detect residues between 60 and 200 cm (Fig. 6a). The Modified Griess Test increases the detectable range to 80 cm, though it fails to identify residue between 100 and 200 cm (Fig. 6b). Likewise, the Sodium Rhodizonate Test can estimate shooting distances up to 40 cm, with no detection possible between 60 and 200 cm (Fig. 6c)

Conclusions

- The database on the dispersion radius of gunshot residue indicated that the farthest distance for an accurate estimate of the firing distance was 80 cm.
- Nitrite Detection
  - Physical analysis of GSR detected residue at a maximum distance of 40 cm, with a dispersion radius of 10.7 cm.
  - Modified Griess Test detected GSR at a maximum distance of 80 cm, with a dispersion radius of 10.8 cm.
- Lead Detection
  - Sodium Rhodizonate Test detected GSR at a maximum distance of 10 cm, with a dispersion radius of 11.5 cm.
- The firing distance can be evaluated by combining both physical and chemical analyses.

References

1. Jaluddin, S. N. et al. Preliminary Evaluation of Gunshot Residue (GSR) Using 3-Aminophenol in Modified Griess Test. Indonesian J. Chem. 2021, 21(6), 1550-1559.
2. Wongpakdee, T., et al. (2021). Simple gunshot residue analyses for estimating firing distance: Investigation with four types of fabrics. Forensic Science International, 329, 111084.

Acknowledgement

I would like to express my heartfelt gratitude to Assoc. Prof. Dr. Pithchaya Munggornassawakul for providing valuable guidance and advice throughout this research project. I am also sincerely thankful to Pol. Maj. Thitichaya Thattiwong and the mentors in the department for their knowledge, and support during the research process. Finally, I would like to extend my deepest appreciation to the Firearms and Ammunition Identification Subdivision, Police Forensic Science Center 5, for allowing me to participate in the cooperative education program and conduct this research.