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Study of Ignition and Burning Pattern of Propellant from Various Rimfire Cartridges

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Abstract

The propellant is the complex organic compound. Basically it contains nitrocellulose and nitroglycerine. They are classified into two categories namely black powder and smokeless powder. All smokeless powders contain nitrocellulose however; powder contains nitroglycerine known as double base cordite. Propellant used in cartridges is made of variety of sizes, shapes, color and modification made on their surface. This propellant burns with flame having different nature and color, which depends on the various ingredients of propellant. In the present work, we describe the ignition and burning pattern of propellant in respect of their color and nature of flame on burning. For this purpose seven different types of rimfire cartridges are selected.

Keywords: Rimfire cartridges, Propellants, Ignition and Burning.

Introduction

In recent years, public interest in forensic sciences gained popularity in the India as well as in world. Ballistics and firearms is one of them areas of the forensic sciences. Scientist in firearms identification units are generally asked to match a suspect firearm with discharged bullets or cartridge cases[1]. The basic components of the cartridge are primer, propellant and bullet. When propellant ignite, quantity of gas generated will depends on the type of propellant used either single organic compound or mixture of organic compound[2-3]. Now a day's nitrocellulose and nitroglycerine or mixture of both is generally used as a propellant in the firearm cartridges. In the firing process, the burning of propellant is necessary to propel the projectiles from fired cartridge to outside the barrel. The muzzle velocity of these projectiles depends on the many factors such as condition of firearm, weight and size of projectiles and nature of propellant etc. The nature and color of the propellant depends on its ingredients. Generally propellants are grey, greenish black, olive green and shiny black in color[4--5]. Material used as propellant can be produced great heat and also large volume of gas. Tiny propellant powders in shell / cartridge case act as fuel to propel the bullet / projectile towards the target / object[1]. The combustion and burning of tiny powders produce large amount of gas and developed the pressure rapidly inside the casing, which subsequently detach the bullet / projectile. Nitrocellulose or smokeless propellants are more common used now days compared to low explosives i.e. gunpowder or black powder Nitrocellulose is prepared by treating cellulose and bark with HNO_3 and H_2SO_4. Tiny nitrocellulose forms the major component in low explosive as a smokeless powder. Besides low explosive materials, the graphite coating employed on it, so shining black or grey color formed. The preparation of each propellant varies on the basis of Forensic Ballistics performance and stability characteristics. The nature of the propellant powders also undergo optimization by the ammunitions manufacturer for performance of the .22" rimfire ammunition on the basis of burning rate of nitrocellulose propellant classified *viz* regressive, neutral and burning powders. In this paper we study the ignition and burning nature of propellant present in seven various types of rimfire .22" cartridges.

Methodology

For this study, seven types rimfire (type 10) cartridges were selected, these cartridges are differentiated on the basis of their head stamp markings. The physical parameters like weight and length of these cartridges were noted. These cartridges were dismantled in the laboratory to separate the propellant and collected propellant from each cartridge taken for analysis. Then the color, weight, shape and size of these samples of propellant were recorded. The burning / ignition tests for all the samples of propellant were carried out by burning a pinch of each type propellant on spatula and also igniting entire quantity of propellant with matchsticks. The burnt residue was analyzed for nitrite test. Freshly prepared solutions of sulphanilic acid and alpha naphthyl amine are used for nitrite test and found that nitrite test were positive for all.

Results and Discussions

In nineteenth century, highly flammable material is developed its nothing but nitrocellulose. Now a day's nitrocellulose is used in variety of application viz. propellant, explosive and lacquer for finishing guitars and vehicles[6]. The combustion can occur when heat, oxygen and fuel in right proportion are come

together. The combustion reaction is highly exothermic and produces heat and light depending upon amount of propellant[7]. For this combustion study, we dismantled seven cartridges and shown in Figure-1. The weights of these cartridges were found to be about 3.418 g. The head stamp marking of type 10 rimfire cartridges are shown in the Table-1. These cartridges were dismantled and each found to contain nitrocellulose propellants of various shape with different color. The weight of each propellant was about 60-70 mg.

Table-1 shows the different colors imparted to the flames on burning the each samples of propellant. Every propellant burns and suddenly produces a large volume of gas. The gas pressure depends upon the quality of propellant. The quality of these propellants can be determined from the color of flame, nature of flame and chemical composition. It is seen that fast burning propellant gave poor results for nitrite where as slow burning propellant gave the strong nitrite in the residue. Thus quality of propellant can be helpful in examination of GSR in the forensic case work. This study indicate that, all type of propellant burn in different rate and also different in color. It may be due to aging of propellant and quality as well as ingredients of propellants. Some propellant burn with brick red flame and smoke while some propellant burn with yellow flame without smoke. The rate propellant to burn depends on their shape.

The propellant with compact mass will take longer time to burn while, cylindrical elongated shaped propellant burn comparatively faster[8]. The smokeless or minimum smoke propellant has fast burning time. The catalyst such as lead or copper salts has been added to decrease burning rate of smokeless propellant to control Ballistic behavior[8]. In our study, propellant present in the sample number 3, 4 and 7 burns rapidly as compared with the others.

Table-1
Properties of propellant present in various brands of cartridges

Country	Nature/shape of propellant	Color of propellant	Color of flame imparted on burning propellant on gas burner	Color of flame burnt with sparking matchstick
India	Circular thick	Greenish	Yellow Orange	Whitish Yellow
U.S.A	Sandy/tiny	Grey	Yellow Orange	Yellowish
U.S.A	Sandy/Tiny	Shiny Black	Yellowish White	Orange Yellow
U.K.	Small circular thick	Olive green	Yellowish White	Orange Yellow
U.K.	Small circular thick	Blackish	Whitish	Brownish White
Germany	Sandy/tiny thick	Shiny Black	Yellow Orange	White Yellowish
U.S.A.	Sandy/tiny thick	Shiny Black	Yellowish White	Yellow Orange

Figure-1
Various brands of dismantled cartridges with their head stamp marking

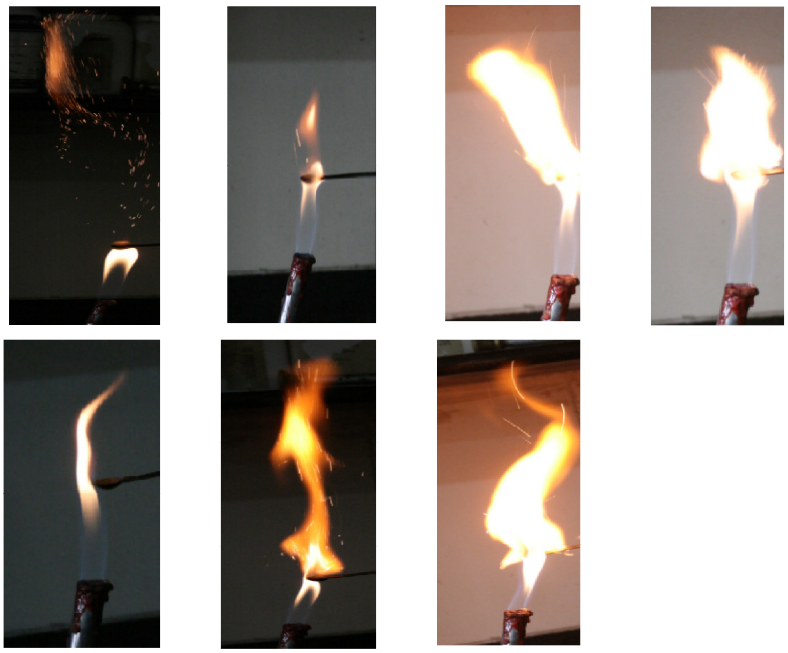

Figure-2
Color of flame when propellant burnt on gas burner

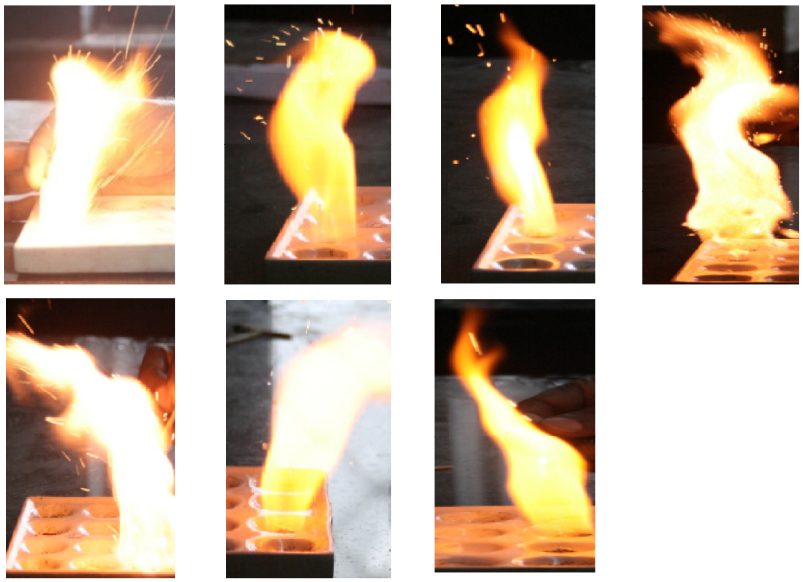

Figure-3
Color of flame when propellant burnt by matchstick

Conclusion

In this article we studied the ignition and burning pattern of seven different .22" rimfire cartridges. It shows that color of propellant different propellant for different brands. The ignition and burning pattern of propellant present in .22" rimfire cartridges showed yellow orange, yellow whitish and brick red. Ignition of propellant on gas burner gives rapid flame. Some propellant burns fast while other burns slow. The quality and chemical composition of the propellant can be determined from color and nature of the flame. The propellant present in the sample number 3, 4 and 7 burns rapidly as compared with the others.

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