

## Macroscopic Examination of Morphological Features of Propellant Powders Prevalence in Malaysia

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**ABSTRACT:** Propellant powders act as fuel to propel the bullet towards the target. The combustion of powders produces a large amount of gas, increases the pressure of the casing and detaches the projectile towards the target. The shape and geometry of powder particles, as well as the chemical composition vary among different ammunition types, affecting the burning rate of these propellant powders. Here, the morphological features of propellant powders *i.e.* shape, colour, dimensions and weight were examined. Each criterion was compared among the ammunition types. Results show only one single type of particle shape in all the ammunition analysed. Colour examination shows that one of the eight sample types analysed in triplicates had a mixture of two colours. The size and the weight of the powder particles correlate with each other where greater size particles have heavier weight and vice versa. Comparison of the morphological features allows the propellant powders to be distinguished from each other through the macroscopic examination of propellant powders.

Keywords: Macroscopic examination, morphological features, propellant powders

### Introduction

Propellant powders in cartridge case act as fuel to propel the bullet towards the target. The combustion and burning of the powders produce great amount of gas and increase the pressure rapidly inside the casing, which subsequently detach the bullet [1-4]. Smokeless powders are more commonly used nowadays compared to black powders [3-5]. Nitrocellulose forms the major component in smokeless powders. Nitroglycerine is additionally found in double base smokeless powders while nitroguanidine is also added in triple base smokeless powder. Besides explosive materials, additives such as stabilisers, plasticisers, inhibitors, coolants, moderants and lubricants are added to the composition, giving a specific formula for the propellant powders [3, 6]. The formula of each propellant varies on the basis of ballistic performance and stability characteristics [7]. The size and shape of the propellant particles also undergo optimisation by the manufacturer for desired performance of the ammunition [8].

Based on burning rate, propellant powders can be classified in three categories, namely regressive, neutral and progressive burning powders [9]. The burning surface area decreases continuously along with the consumption of propellant in the regressive powders. Generally, propellant powders in the form of flakes, or spherical and cylindrical in shapes give this characteristic. Progressive burning powders continuously increase the surface of burning as the grains burn. Examples of these powders are multi-

perforated and rosette shaped powders. Single perforated grains are categorized as neutral burning powders with the burning surface area remains approximately constant through the burning process [9]. Additional to the shape of the grains, the geometry of the powder grains and chemical treatments of the powders also affect the burning rate. Principally, smaller grains burn faster as compared to larger ones due to the exposure of greater surface area [9]. Figure 1 shows some examples of the shape of propellant powders.

Evidence must be preserved and analysed with care in all cases, as it could be the only trace left after a crime is committed and usually could not be further recovered in most circumstances. Examination of evidence always starts with non-destructive to destructive and from general to particular in the law of forensic science. During the burning process, the propellant powders in a cartridge are not totally converted into burning products, but part of them will remain unburned [4]. Besides gunshot residues, types of gunpowder particles present (e.g., flake, disc, ball and flattened ball.) at the scene on contact surface could provide useful information during examination for use in subsequent testing and interpretation. In such cases, morphological features of propellant powders shall be noted before any further examination. In this study, morphological features of propellant powders, *i.e.* shape, colour, dimensions and the weight were studied and compared with the aim to distinguish different propellant powders of different batches or manufacturers.

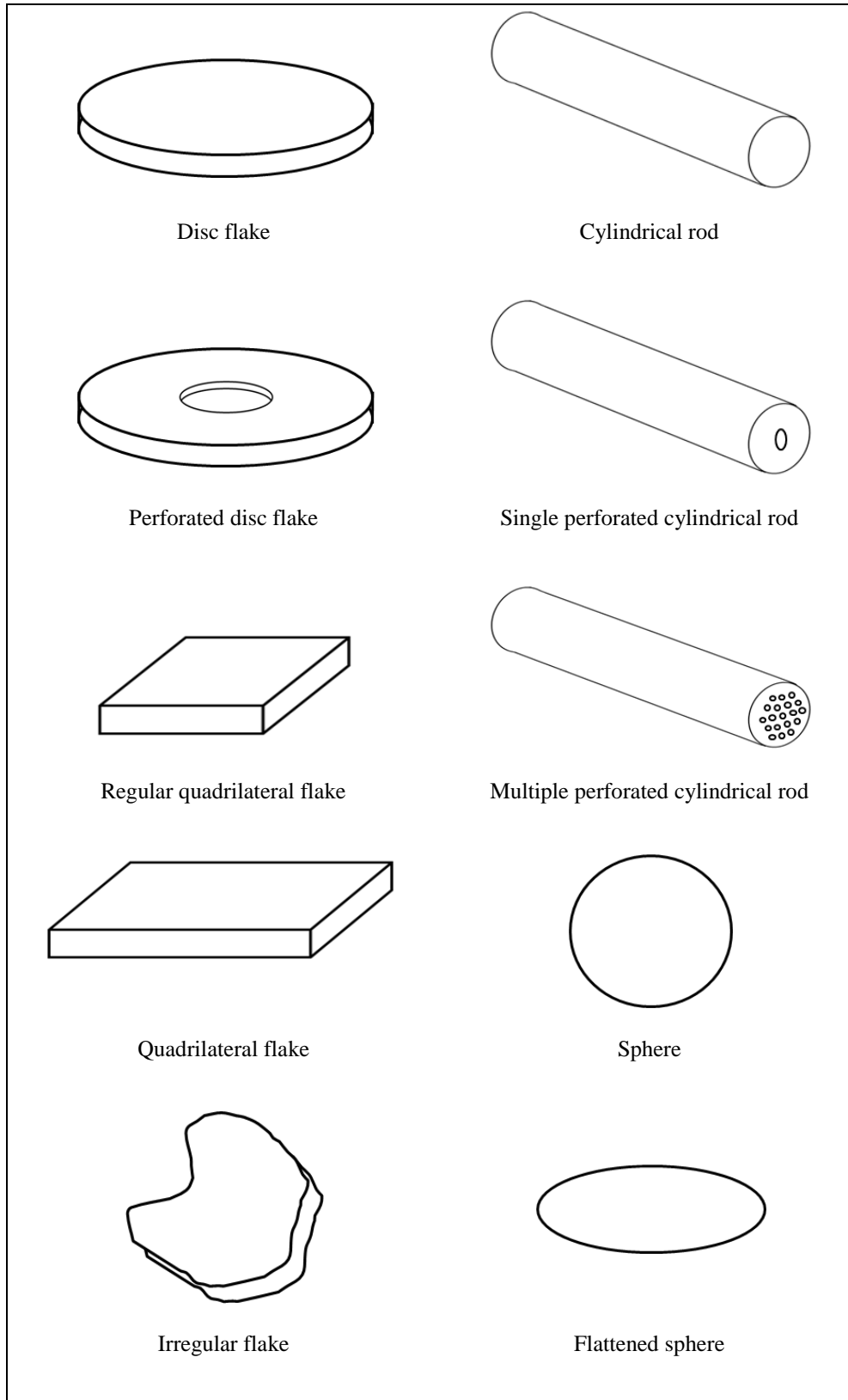


Figure 1: Shapes of unfired propellant powders [9]

**Materials and method**

*Propellant Powders*

Propellant powders from six ammunition types were supplied by Royal Malaysia Police Forensic Laboratory and SME Ordnance Ltd., *i.e.* SME 9 mm and SME .38 SPL (Malaysia), Winchester 9 mm (WCC, USA), Giulio Focchi-Leccon 9 mm (G.F.L, Italy), Sellier & Bellot 9 mm Br.C and 9×19 (S&B, Prague, Czech Republic). A Kinetic™ Bullet Puller (Quintetics, USA) was used to remove the bullets from the cartridges. Propellant powders were collected in 10 mL clear glass headspace vials (Supelco, Malaysia), sealed and labeled.

*Microscopic Examination*

A Leica Microscope MZ 16 (Switzerland) equipped with a digital camera (Leica FC 290) was used. Transmitted light base (Rottermann, TL RC 1) supplied the light source during the observation. The microscopic system was supported by Leica Application Suite software for photo capturing. Vernier caliper was used for measuring the dimensions of the propellant powders to the nearest 0.01 mm. An analytical balance (Dragon 204,

Mettler Toledo) was used for weighing the samples, to the nearest 0.01 mg.







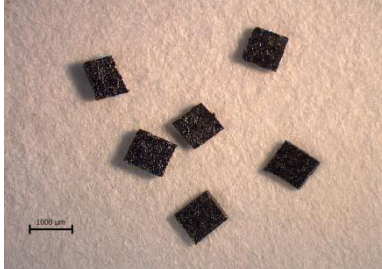
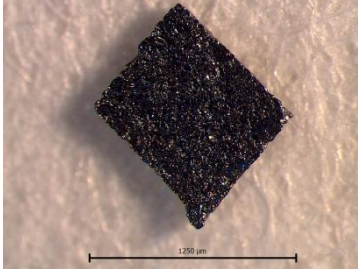
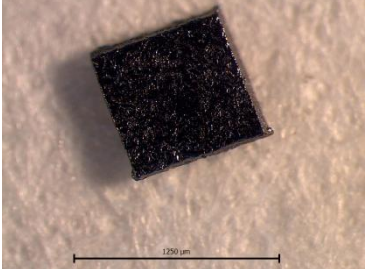
The propellant particles were magnified up to 40X during particle shape and colour examination. Photographs of each propellant particle were captured and saved as TIFF files. The dimensions of the particle were optically measured. From each propellant powders collected, seven individual particles were randomly chosen for measurement. A total of three samples from every ammunition types were examined. Mean measurements were reported with standard deviation. The intra and inter-variability of every propellant powders for different ammunition types were also analysed.

**Results and discussion**

*Shape of the propellant powders*

Among the ammunition types analysed, only one single type of particle shape was present in each sample. The shapes of powders from each ammunition type were captured in 10× and 40× magnifications (Table 1).

Table 1: Particle shape of every propellant powders studied in 10 × and 40 × magnifications

Ammunition	10 X magnification	40 X magnification	
SME (9 mm)			
WCC (9 mm)			
GFL (9 mm)			

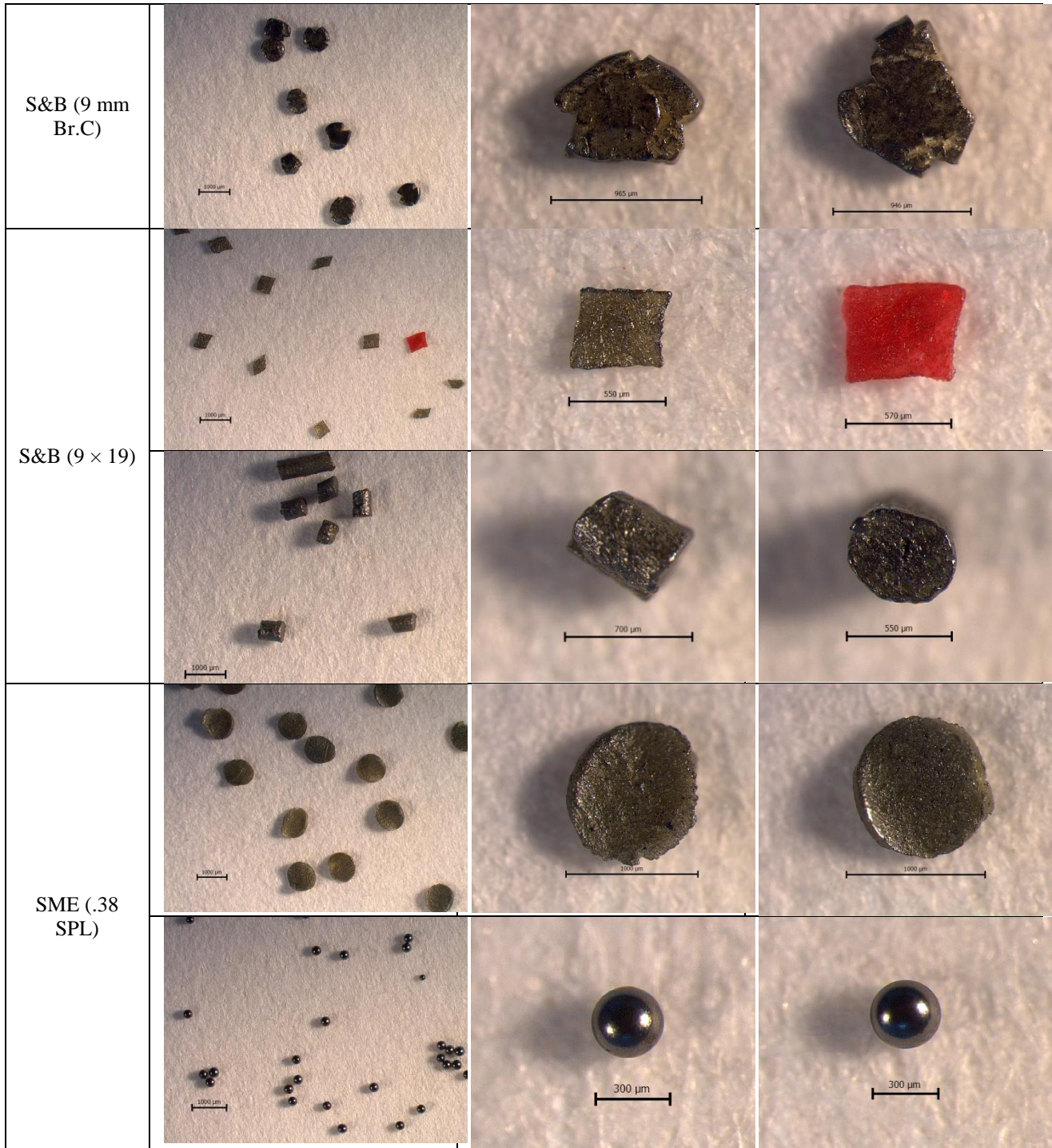


Table 2 summarises the particle shapes, colours, dimensions, and the weights of every ammunition types examined in this work. Irregular flakes were found common in propellant powders, including the SME 9 mm, WCC 9 mm and S&B 9 mm Br.C. Note

that irregular flakes refer to particles which do not pose any specific shape or configuration. Configurations such as cylindrical rod, sphere, disc and quadrilateral flakes were also observed.

Table 2: Particle type, colour, dimensions and weight of ammunition

Ammunition	Particle type	Colour	Dimensions			Weight (mg)
			Diameter (mm)	Width (mm)	Length (mm)	
SME (9 mm)	Irregular flakes	Shiny black	$0.802 \pm 0.179$	-	-	$0.125 \pm 0.036$
WCC (9 mm)	Irregular flakes	Light brown	$1.030 \pm 0.148$	-	-	$0.348 \pm 0.060$
GFL (9 mm)	Regular quadrilateral flakes	Shiny black	-	$1.021 \pm 0.040$	$1.025 \pm 0.032$	$0.428 \pm 0.115$
S&B (9 mm Br.C)	Irregular flakes	Shiny black	$0.981 \pm 0.097$	-	-	$0.130 \pm 0.033$
S&B (9 × 19)	Cylindrical rod	Grey	$0.695 \pm 0.023$	-	$0.986 \pm 0.245$	$0.374 \pm 0.089$
	Parallelogram flakes	Dark grey	-	$0.610 \pm 0.089$	$0.608 \pm 0.083$	$0.039 \pm 0.012$
		Red	-	$0.538 \pm 0.053$	$0.549 \pm 0.066$	$0.027 \pm 0.007$
SME (.38 SPL)	Disc flakes	Dark brown	$1.307 \pm 0.041$	-	-	$0.250 \pm 0.021$
	Sphere	Shiny black	$0.388 \pm 0.020$	-	-	$0.034 \pm 0.006$

Among the samples examined, two different shapes were found in SME (.38 SPL) and S&B (9 × 19) ammunition types. It was noted that these types were manufactured in different years. For instance, in SME .38 SPL ammunition types, spherical shape particles were observed in the powders collected from manufacturing year coded "02" whereas disc flakes were observed in powders from manufacturing year coded "04". In S&B 9 × 19 ammunition types, two different shapes i.e. cylindrical rods and parallelogram flakes were observed for two samples manufactured in different years. The head stamp of the cartridges could provide information to explain the difference on the particle types due to different batches or years of manufacture. In brief, examination on the shape of the propellant powders provides useful information to differentiate propellants into different groups thus aiding the subsequent identification of propellants.

#### *Colour of the propellant powders*

One of the eight sample types (all in triplicates) analysed showed a mixture of two colours. In S&B 9 mm Br.C ammunition type, majority of the parallelogram particles were dark grey but a few red flakes were observed giving a unique feature for this type of ammunition. This is an example that the variation of colours in the powder enabled them to be readily differentiated from others.

#### *Size of the propellant powders*

The size of the powders varied according to their shapes. The diameter for propellant powders with disc flakes or spherical shape was reported. Both diameter and length were reported in cylindrical

shape particles, while the width and length measurements were reported for quadrilateral flakes.

In general, the diameters of the particles were between 0.6 mm and 1.4 mm. The length of cylindrical rod particles ranged from 0.7 mm to 1.3 mm. Intra-variability of the particles from the same cartridge were observed in all types of ammunition, especially in S&B 9 × 19 powders of cylindrical rod configuration with relatively greater length being observed. The insertion and compression of the powders into the confined space of a cartridge case during manufacturing process could cause deformity or breakage of these particles. However, this intra-variability of particle size did not affect the differentiation of ammunition among types in our case as this phenomenon was seen in all the samples from the same ammunition type.

#### *Weight of the propellant powders*

The weight of propellant particles was highly dependent on the size of the particles. Smaller size particles weigh lighter than bigger ones. Cylindrical rod and quadrilateral flakes were found to be heavier than the disc flakes and spherical shape particles.

#### **Discussion**

In comparison to the variability of size and weight, intra-variability with regard to the shape and colour was very low for powders obtained from a single cartridge, and was found to be extremely low among the propellant powders from the same ammunition type. The manufacturing process of ammunition could explain these observations since the formula of

propellant powders was determined upon careful research and extensive tests to reach the intended performance intended. Consequently, frequent changes in a formula is unlikely unless with specific requirements from the users.

Stringent quality assurance during the production of propellant powders also ensures that materials used were of same quality with fairly uniform physical appearance. Nonetheless, slight deviation in size and weight is still unavoidable during production. It is important to note that the same batch of powders for the same batch of ammunition leads to low inter-variability of propellant powders among the same ammunition types, especially from the same lot. Therefore, during forensic examination, similar physical appearance or chemical composition from a same box of ammunition could be expected.

Examination of morphological features provides useful information during the preliminary examination for use in subsequent testing. Identification of propellant powders in evidential materials can provide useful information to link to the types ammunition used especially when both the cartridge and projectile are absent. Although the chemical composition of propellant powders was the target of interest of forensic investigation, the morphological features should be carefully noted before any chemical tests are attempted.

### Conclusion

Propellant powders showed low intra-variability in shape and colour, compared to their size and weight. Relatively low inter-variability was observed in the morphological features of propellant powders from all types of ammunition examined. Macroscopic examination of these propellant powders suggests the possibility of distinguishing different ammunition types in a simpler and quicker manner.

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