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# EVALUATION OF SOME ARTIFICIAL AEROSOLS FOR ANTI-INFRARED ROLES

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## ABSTRACT :

This paper describes the experimental setup for estimation of pyrotechnic smoke composition for anti-infrared roles using thermal imager operating in the wavelength range of 8-12 μ . Several pyrotechnic compositions based on thoroughly mixed maleic acid, potassium chlorate, calcium silicide, calcium carbonate, sodium carbonate, naphthalene, anthracene, ammonium chloride and commercial boiled oil have been tested. Hot plate of temperature ranging between 101 °C and 120 °C was used to represent the source of emitted infrared radiation. The temperature of the hot source was traced during the generation of the pyrotechnic smoke inside a specially designed smoke testing laboratory tunnel. The effect of both the pyrotechnic composition and the amount of each sample on the attenuation of the hot source temperature was shown and discussed. The experimental work was done in an ambient temperature of 38 °C during June month in the afternoon period.

## KEY WORDS

Smoke, camouflag, IR roles, obscuring.

## INTRODUCTION :

On the modern battle field, military forces have become dependent on electro-optical systems and weapons which are highly advanced, sensitive and accurate in both imaging and aiming. These include night-vision devices, near infrared weapons and systems, infrared aiming and imaging systems(FLIR), laser designated weapons and other advanced systems. In the future conflicts there will be even more effective and sophisticated electro-optical systems in use. [1,2].

When technically developed and used properly, smoke can be highly effective against such systems and can be capable to change the yield of the battles. Smoke mixtures, as other systems, need to be continuously improved in order to face the expected advances in the last mentioned weapons and systems. Tactically, smoke is considered as a key ingredient in maneuver operations, obscuring the forces and targets and preventing the enemy's weapons to be accurately aimed. Quality of the smoke and the proper coverage are essential to mission success. Smoke, on the other hand, can be considered as "two-edge" sword if it makes confusion during the operations on both sides. So the planning for how and when the smoke must be used as an effective factor [3,4].

In this paper, selected pyrotechnic compositions were formulated, thermally ignited, and the generated smoke screens are evaluated by a thermal imager.

## EXPERIMENTAL:

a) Chemicals:

All the chemicals used in the formulation of the proposed pyrotechnic compositions were selected of the laboratory pure grade. They are used directly without any additive purification processes.

b) Apparatus:

The thermal imager coupled with data processing system for analyzing the results is used in these experiments. It operates in the wavelength range of 8-12 $\mu$ with sensitivity of 0.1 °C.

c) Smoke tunnel:

It is metallic laboratory structure of length 5 m. and squared cross sectional area of 1 $m^2$ . It is equipped with a ventilation systems and air curtains to prevent smoke from escaping to the laboratory space. There is at one end of the tunnel an electric hot source that represent the infrared radiation emission and on the other side, the thermal imaging system is installed. There is an accompanied fume cupboard inside through which the smoke screen is withdrawn with a fan system into the tunnel body between the hot source and the thermal imager.

d) Procedurure

The selected chemicals with the calculated and designed proportions were thoroughly mixed in a mortar for about 20 minutes. The blended mixture was placed in a commercially available plastic cup of height 10 cm. and diameter of 7 cm. The mixture was roughly pressed by hand and placed in the fume cupboard. An igniting mixture based on black powder was placed on the surface of the composition and thermally ignited by a match. The initial impulse generated from the black powder initiated the main pyrotechnic smoke mixture. A gray to black smoke screen associated with a flame is generated. The anti-infrared role of this smoke is estimated by the thermal camera.

## RESULTS AND DISCUSSION:

The results shown in table(1) indicate the variation of temperature of the hot source with the time from the start of smoke generation up to the arrival of constant value. Eight samples of weight 40 g were investigated.

The exact compositions of these formulations are not mentioned due to security reasons. The main ingredients in these compositions are : maleic acid, potassium chlorate, naphthalene and boiled oil. Some of them are mixed with ammonium chloride and others are mixed with calcium carbonate, sodium carbonate or calcium silicide. The initial source temperature varied between 101°C up to 120°C. The temperature was measured each 15 seconds. During the measurement, the temperature started to decrease till it attained minimum value at the maximum intensity of smoke, then started to increase again. The best results were obtained with a sample that was able to attenuate the source temperature from 116 °C to 71 °C. This decrease of 45 °C occurred within 90 seconds from the start of smoke generation. Other compositions gave a decrease in the source temperature ranged between 17 °C and 20 °C within periods of time ranged between 75 to 165 seconds. This attenuation of thermal radiation can be attributed to both absorption, and scattering of the thermal radiation by the particles of the smoke screen. These particles can be proposed to be likely containing KCl, carbon and other sublimable constituents, in addition to the possible formation of $CaCl_2$, NaCl, $SiCl_4$ and their hydrolysis products formed under the effect of atmospheric humidity. It was clear that the sample contained ammonium chloride gave better results compared with those contained calcium carbonate, sodium carbonate or calcium silicide. This could be due to the higher cooling effect of ammonium chloride compared with the last mentioned others on the infrared power of the composition.

Table (2) indicate the results obtained by increasing the weight of the best sample to 60 and 80 gm. This was expected to increase the amount of generated smoke, thus leading to an appreciable increase in the smoke intensity inside the tunnel . The initial source temperature in the experiment with the sample weighing 60 gm. was 122 °C and the room temperature was 39 °C. The source temperature decreased by 26°C within a period of 165 seconds. This value of the temperature attenuation is lower than that described before with the sample weighing 40 gm. The same behavior was observed with the second sample weighing 80 gm. The source temperature decreased by a value of 28 °C starting from 125 °C to 96 °C. These unexpected results may be due to the variation in relative humidity during the measurement. Since these two groups of experiments were carried out in separated dates: the first being carried out on Sunday 8th June and the second on Sunday 22nd June. It is also well established that the relative humidity plays a vital role in the quality and properties of the smoke screen [4].

The best composition was now under further investigation to improve its ant-infrared role.

## CONCLUSIONS:

The proposed pyrotechnic mixtures generated gray to black smoke screens that succeeded to attenuate the hot source temperature. The best estimated sample made a decrease in temperature of 45 °C within 90 seconds. This ensures the anti- best estimated sample made a decrease in temperature of 45 °C within 90 seconds. This ensures the anti-infrared role of these smoke generating mixture that is needed to be improved.

## REFERENCES:

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Table (1) : Effect of the different pyrotechnic mixtures on the attenuation of the hot source temperature from the moment of ignition in °C.

| N°. | Time in second from the moment of ignition | | | | | | | | | | Tem. diff. °C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | |
| 1 | 119 | 117 | 114 | 112 | 111 | 109 | 108 | 105 | 104 | 102 | 17 |
| 2 | 116 | 110 | 106 | 90.1 | 75 | 71.1 | 71 | | | | 45 |
| 3 | 107 | 106 | 104 | 102 | 100 | 97.3 | 95.1 | 92 | 90.9 | 89 | 18 |
| 4 | 120 | 116 | 112 | 109 | 106 | 104 | 103 | 102 | 102 | | 18 |
| 5 | 111 | 109 | 107 | 102 | 101 | 99.2 | 97.2 | 95.5 | 93.7 | 91 | 20 |
| 6 | 108 | 105 | 103 | 101 | 98.8 | 95.1 | 92 | 89.3 | 87.4 | 87 | 21 |
| 7 | 101 | 99.9 | 95.4 | 89.8 | 85.1 | 82 | 81 | 81 | -- | -- | 20 |
| 8 | 104 | 100 | 92 | 87 | 83 | 83 | -- | -- | -- | -- | 21 |

Table (2) : Effect of weight of sample number (2) on the attenuation of the hot source temperature in °C.

| Wt. of the sam. in.gm | Time in second from the moment of ignition | | | | | | | | | | Temp. diff. in °C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | |
| 40 | 116 | 110 | 106 | 90.1 | 75 | 71.1 | 71 | | | | 45 |
| 60 | 122 | 121 | 120 | 116 | 108 | 105 | 103 | 100 | 98 | 96 | 26 |
| 80 | 125 | 123 | 120 | 117 | 114 | 110 | 105 | 102 | 99 | 97 | 28 |