



INTERNATIONAL RESEARCH JOURNAL ON ADVANCED SCIENCE HUB

e-ISSN : 2582 - 4376
Open Access

RSP SCIENCE HUB

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Available online at www.rspsciencehub.com

Special Issue of First International Conference on Information Technology, Computing & Applications (ICITCA 2021)

Testing of Safe, Barium Free Mixture for Green Flare

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Abstract

The pollution caused due to the fire work is becoming one of the major problems in both environmental safety and human health. The greenhouse gases released during the burning of crackers causes global warming and eventually increase the temperature of the Earth's atmosphere. The pollutants from burning the crackers cause health hazard in human being. The particulate matters in the dust such as PM2.5 and PM10 are easily inhaled by the human beings and affect the human health. So a new mixture which has less pollutant, particulate matter as compared with the existing mixture is formed with the help of Boron Carbide as fuel and Potassium Nitrate as the oxidizer. The newly formed mixture is completely Barium free and is much safer to handle than the Barium nitrate. The Boron carbide is implemented in the smoke flare and was found to have the performance as same as the existing composition. So the alternative for the Barium nitrate is proposed and various tests are done for the new mixture.

Keywords: Environment, safety, boron carbide, Potassium nitrate, Electrostatic discharge

1. Introduction

Fireworks are low explosive pyrotechnic used for the entertainment and for warning signals. The fireworks are classified into ground and aerial based on their performance. Various coloured flames and sparks such as green, blue, yellow, red, gold and silver can be produced using different composition in fireworks. Fireworks were first said to be invented around the year 960 AD in China. The modernisation of the fireworks occurred in European countries. The basic of fireworks consist of the fuel, oxidizer, colour producing salts and the binder. The oxidizers are the one which combines with the fuel and produce the heat required for pyrotechnic. The binder is used for holding the firework composition together in a homogenous blend, in the form of

pellets. The chemical reaction which is involved is of electron transfer or reduction or oxidation type. Usually the firework consists of the above mentioned composition filled in the paper tube. Fireworks are considered as one of the main source of air pollutions nowadays. The pyrotechnic not only causes harm to the environment but also causes adverse effect on human health. Various pollutants such as carbon monoxide, carbon dioxide, nitrous oxide, sulphur oxides etc are released into the atmosphere while burning fireworks. The particulate matter such as PM2.5 and PM10 were increased during the use of fireworks. [1-5] Governments are following strict norms to reduce the pollution caused due to the burning of the fireworks. Indian government has banned the use of Potassium perchlorate in

fireworks as an oxidizer, as these dissolves more with water and contaminates the ground water. It also causes cancer in human beings. In the month of October 2018, the central government only allowed the burning of low emission fireworks in India. These low emission crackers are named as 'Green Crackers', which are approved and developed by the scientists in CSIR-NEERI as per government norms. These green crackers have smaller shell size as compared to the previous produced crackers and less harmful raw materials are used in producing these crackers. The additives were used to suppress the dust produced during burning of the crackers. These crackers are designed to have 30% less particulate matter. About 230 companies were given permission by the NEERI to manufacture the Green Crackers. The colour producing agent such as Strontium, Barium are used as signalling device for the defence purpose. Strontium is used to produce the red colour in fireworks and Barium is used for producing green colour in fireworks. These causes harm to the atmosphere and the human using them. While using Barium with PVC (Poly Vinyl Chloride) produce toxic Poly Chlorinated Biphenyl (PCB). The use of Barium can be replaced by the alternative chemical to reduce the health and environmental hazard.[6-10].

2. Objective

The main objective of this project is to develop a smoke flare. That is

- Safe to environment
- Does not contain Barium
- Economically feasible.

3. Methodology

These are the step by step process carried out in the whole process of the project.

- Studying of the present composition for green flare.
- Proposing new composition for the green flare.
- Various test such as Friction, Impact, ESD, ICP.

4. Present composition for green flare

At present Barium is used in the green light production for pyrotechnic. The mixture consist of Barium nitrate as color producing salt, Magnesium as fuel and Poly vinyl chloride as the oxidizer. The various problems identified in the present composition are

- a. The role of the Poly vinyl chloride was to liberate chlorine while burning.

- b. This chlorine react with Barium to form metastable barium chloride, which is responsible for producing the component that produce green color.
- c. The magnesium chloride is also produced by the reaction of chlorine with magnesium oxide, which is responsible for the color purity.
- d. The PVC produces Polychlorinated Biphenyls which are toxic and causes health hazard to the human beings.
- e. Nitrous oxide, which is a greenhouse gas is evolved during burning of barium nitrate with PVC.
- f. Carbon monoxide is also evolved during the burning of Barium nitrate as a green flare.

Table1. Present composition.

Components	Weight in %
Barium Nitrate	46
Magnesium 30/50	33
Poly Vinyl Chloride	16
Laminac 4166	5

5. New composition for green flare

The propose composition consist of the following composition.

Table.2. New composition.

Components	Weight in %
Boron Carbide	10
Potassium Nitrate	70
Solvent Green 3	20



Fig. 1 Proposed composition

6. Testing of the composition

Various test such as Friction test, Impact test, Electrostatic Discharge test, Inductively Coupled Plasma test, Burning test were carried out. Impact test was carried out with the help of fall hammer test. This is used to test the sensitivity of the chemical.

Table 3. Impact test:

Height	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
0.3	X	X	X	X	X
0.4	X	X	X	X	X
0.6	X	X	X	X	X
0.8	X	X	X	X	X
1.0	X	X	X	X	X
1.1	X	X	X	X	X
1.2	X	X	X	X	X

It is found that even at the height of 1.2m there is no explosion of the chemical.

Impact energy= mgh

Where, m= Drop weight (2kg)

g= Acceleration due to gravity (9.8 m/g²)

h= Height (m)

Impact test = 2*9.81*1.2

E =23.5 J

The Impact test value, E>23.5 J. So sample is moderately sensitive explosive to impact. Friction test was carried out with the help of BAM friction test apparatus.

Table 4. Friction Test:

Load In Newton	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
360	X	X	X	X	X

Even at the weight of 360N there is no explosion or decomposition observed. So the proposed mixture is of low friction sensitive.

The ESD test is carried out to identify the voltage at which the spark occurs in the mixture. In this the mixture is placed in the nylon washer and washer is kept between the two electrodes. It is found that at the voltage range of 7.8 Kv to 8.5Kv the spark is seen in the mixture.

Table 5. ESD Discharge:

Trial	DC Voltage (kV)	AC Leakage Current (mA)
Trial 1	8.4	7.6
Trial 2	8.1	7.4

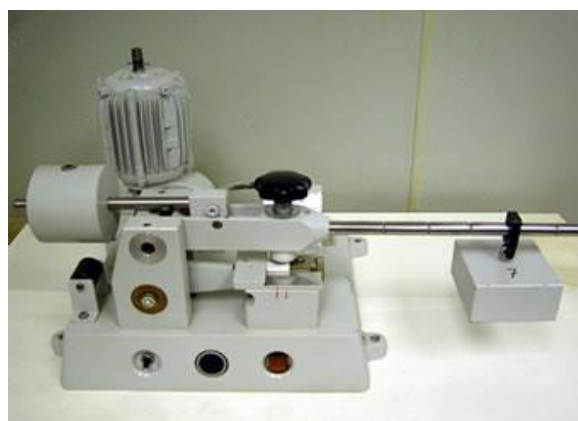


Fig.2 BAM Friction test



Fig.3 Electrostatic discharge

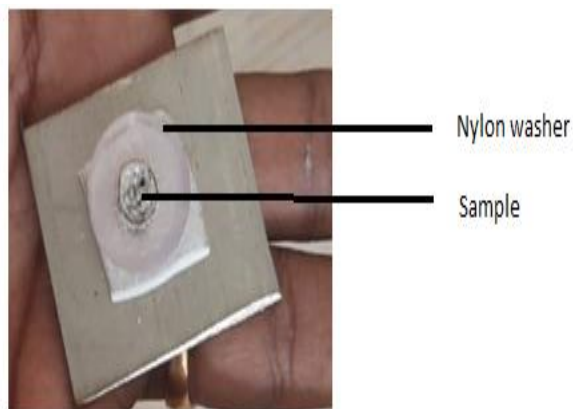


Fig.4 Nylon washer with sample

The chemical concentration of the all the elements present in the mixture can be identified by ICP test. The ICP test was mainly used to identify various metal oxides present in the residue after burning the mixture. The procedure for preparation of the sample for ICP test involves the following procedures:

- The burnt residue was weighted for 0.05g in the weight balance.
- The weighted sample are then placed in the beaker.
- 1ml of Nitric acid (HNO_3) was measured and added with the sample taken in the beaker.
- Similarly 3ml of Hydrochloric acid (HCl) was added to the sample.
- The mixture taken in the beaker is mixed thoroughly.
- Temperature of about 70°C is set in the hot splash and the solution is heated until it turns into solid state.
- 10 ml of 2% HNO_3 is added and mixed with the solution which is heated and is in the solid form.
- The mixed solution is transferred into the 50ml volumetric flask.
- Again 2% HNO_3 is added until the solution become 50ml in the volumetric flask.
- 500 micro litre of the prepared solution is measured with the help of micropipette and taken in another 50ml volumetric flask.
- The remaining volume of the smf is filled with 2% HNO_3 .
- The prepared solution is placed near the inlet of the ICP testing equipment and the test was carried out.

The amount of potassium that is left over in the residue was calculated as Amount present in the sample=0.525mg/litre

$$\text{Potassium in percentage} = (0.525/10) 100 \\ = 5.25\%$$

It is found that only little amount of potassium is left over, so the mixture does not affect the environment.

Conclusion

Boron carbide is identified as the substitution of Barium Nitrate in producing the Green colour for the flare. The Boron carbide was cost effective compared to Copper and Magnesium diboride

which also produces green colour while burning. The composition of the mixture consisting of Boron carbide and Potassium nitrate was identified. The sample is tested for sensitivity. The impact test values suggest that the mixture is moderately sensitive to the explosive, friction test also implement that the mixture is low friction sensitive. There was also green color observed during the burning of the proposed mixture. Thus it is inferred that the formed new mixture is safe to handle.

References

- [1]. Jay C. Poret and Jesse J. Sabatini. "Comparison of barium and amorphous boron pyrotechnics for green light emission". Journal of energetic material, 2012, 27-34.
- [2]. Conkling J.A. Chemistry of pyrotechnics. Boca Raton, CRC Press.
- [3]. Sabatini J and Jay C. Poret. Use of crystalline boron as a burn rate retardant toward the development of green-colored hand held signal formulation.
- [4]. Murk Pieter van roojjean, Combustion chamber for launching fire works projectiles.
- [5]. Standardisation of chamber for CO_2 , N_2O and CH_4 technique for fluxes measurement from terrestrial ecosystem by Marian Pavelkar in journal international agrophysics in 2017.
- [6]. Firecracker Emission Testing Facility for Measurement of PM and Gaseous Pollutants by NEERI.
- [7]. A review of illumination pyrotechnics by Jesse J. Sabatini in explosive pyrotechnic, 2017.
- [8]. 5-Amino-1H-Tetrazole-based Multi-Coloured Smoke Signals by Johann Gluck, Thomas M. Klapotke in 2018.
- [9]. Combustion of $\text{B}_4\text{C}/\text{KNO}_3$ binary pyrotechnic system by Jing ran xu, Chen guang yan in 2020.
- [10]. Boron Carbide as a Barium-free Green light emitter and Burn-rate modifier in Pyrotechnics by Jesse J. Sabatini and Jay C. Poret in the year 2011.