

Ecofriendly/Green Firecrackers In Comparison With the Old Firecrackers

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Abstract

Firework is a small object that burns or explodes with colored light and loud sounds, use for entertainment. But it affect air quality by emmiting pollutants on large scale. It's observed that it leads health effects like skin, respiratory, nervous system cause of presence of heavy metals in air due to pollution. Traditionally in all firework barium(Ba) and potassium nitrates, sulfur lead are used. Bariumcompounds are used as oxidizers and also to impart green colour flame. Combustion products of barium compounds are water soluble and readily absorbed by the body affecting human health.

To reduce the ambient air pollution caused due to burning of conventional firecrackers, CSIR NEERI has developed reduced emission firecrackers (green crackers). This is achieved by reducing the amount of chemicals, barium nitrate, shell size and addition of additives such as zeolite and iron oxide. Four types of conventional and reduced emission firecrackers were selected and tested inside a firecracker emission testing facility to check the levels of barium in PM₁₀ and PM_{2.5}. The measured mean concentrations of all types of green crackers provided by fireworks manufacturers show significantly reduced barium concentration by 30–60% compared to conventional crackers.

Keywords:-Barium, PM (2.5), PM (10), Reduced emission, use Green-Crakers.

Introduction

Firework are any composition or device designed to produce a visible or audible effect by combustion. They are enclosed in heavy paper casing so that it contains explosive compound. Firecracker, along with fireworks were originated in China.

Firework product are combination of both fule and oxidizing agent.the primary component used

in manufacturing of firecrackers pollutants. In which common propellant used was groundpowder or black powder(barium nitrate, potassium nitrate as oxidizer, sulfur as stabilizer,and charcoal as fuel), emitters being iron, aluminium, carbon, steel, magnesium/aluminium additives are used to promote visual effects and to cheaper the composition.

Science the workers are continuously expose to the chemicals, this also cause fumes, fire and explosion which cause serious injuries. Also emits pollutants which are harmful to health like SO₂, CO₂, CO, NO_x and etc [11]. Short term firecracker bursting alerts physical and chemical properties of particular matter (PM) leads adverse health effect [11]. Firework is high-intensity man made activities that causes short term air quality degradation. It mostly causes dense smoke clouds which is full of PM₁₀, PM_{2.5}[4].

Research has been carried out to minimize the toxic emission released after the bursting of fireworks. Aluminum in flash powder is replaced by boron to minimize workplace accidents (Azhagurajan et al., 2019); use of energetic compounds rich in nitrogen, such as tetrazole and tetrazine (Zhang and Shreeve, 2016; Sabatini et al., 2013; Steinhauser and Klapötke, 2008) and reactive metals pyrotechnic formulation have been reported (Yen and Wang, 2012). Few studies have shown that the reduction of PM, SO₂ and NO_x is in the range of 30–40% using zeolite, iron oxide and boric acid hydrogel as an additive in green crackers such as light emitting firecrackers and reduced emission sound crackers (Junghare et al., 2022a, Junghare et al., 2022b, Nagababu et al., 2022).

Traditional/old fire-crackers

The chemistry of fireworks is based on the combustive features of its ingredients used and the lighting effects that they generate. Based on the literature survey the key ingredients that are used in the manufacturing of firecrackers are:

1. Fuel: Charcoal i.e., black powder is the most common fuel used in fireworks.
2. Oxidizing Agent: It produces oxygen needed to burn the mixture within the fireworks. E.g. Nitrates, chlorates or perchlorates etc.
3. Reducing agents: It burns the oxygen provided by the oxidizing agents. The most common reducing agents are sulphur and

charcoal which reacts with oxygen to form sulphur dioxide

4. 4.Regulators: These are metals (like aluminum titanium, copper, strontium, barium etc.) that are added to regulate the speed of the reaction and the coloring agent.
5. Binders: These are used to hold the mixture of the fireworks together in a paste like mixture. The most commonly used binder is dextrin
6. Coloring Agents: Different chemicals are used for the production of different colors in firecrackers.

Ecofriendly/Green fire-crackers

These firecrackers are produced using less harmful raw materials and additives which reduce emissions by suppressing dust. The new formulations have reduced the emission of light and sound named as SWAS, SAFAL and STAR; have 30% reduction in particular matter using potassium nitrate (KNO₃) as oxidant. The approval for the production of new or improved formulation crackers was given to NEERI and PESO. The key Features of ecofriendly/green firecrackers in comparison with the old firecrackers (CSIR-NEERI).

Compound used in green firecracker

Zeolites

[11] Synthetic Zeolites 4A for Firework is used as a substitute for barium nitrate in manufacturing green firework as mandated by Supreme Court.

Zeolites are crystalline aluminosilicates which consist of three-dimensional frameworks of SiO₄ and AlO₄ tetrahedra linked through oxygen bridges (Dessalegne et al., al., 2016). These zeolites have a porous structure which can accommodate a wide variety of cations, such as Na, K, Ca, Mg and others. They are considered as irritant dusts which may evoke pulmonary changes leading to irritation of the respiratory tract. Pulmonary inflammatory responses,

particularly those caused by naturally occurring zeolites, can lead to fibrosis.

Synthetic zeolite structures, usually cuboidal, produce irritation of the eyes and mucous membranes, but there is no evidence of significant pathologic changes in the lungs. Few non-pulmonary toxic changes are produced by either the natural or synthetic zeolites.

Clays

Clay minerals can have an adverse effect on human health when they are inhaled over a very long period. Inside the lung, clay minerals can cause diverse pathologies include cancer or pneumoconiosis, but the toxicity of these minerals is generally related to both the presence of quartz or asbestos from mining works, or with the geological conditions of formation.

Silica gel

Silica gel is a colloidal form of silicon dioxide (SiO₂) which is made by partial dehydration of metasilicic acid (H₂O Si). Silica gel is most commonly used in everyday life as beads in a small paper packet. It is used as a drying agent to control local humidity to avoid spoilage or degradation of some goods.

Iron (III) oxide or Ferric Oxide (Fe₂O₃): The experimental results show that iron oxide catalyzed the thermal decomposition of potassium perchlorate [6]. The thermal decomposition of potassium perchlorate was studied by Differential scanning calorimetry.

Key Features of Ecofriendly/Green firecrackers in comparison with the old firecrackers

1. A minimum PM reduction of 30%.
2. A minimum PM reduction of 20% and the rest 10% of gaseous omission (mass of gases emitted based on composition) or more reduction of gaseous emission (mass of gases emitted based on composition) In light emitting

firecracker Fe₂O₃, is used as an additive in place of Barium (used in the old firecracker) Knowhow based on novel concept of exploiting exothermic heat of materials (zeolite, clays, silica gel, lime and AD for bursting of crackers).

3. Overcome issues of particulate and gaseous emissions PM reduction by more than 80% for peroxidase based crackers.
4. PM reduction by 30% for water based crackers Significant NO_x and SO_x reduction is anticipated,
5. Reduction in cost due to reduction of KNO₃, and S.
6. They release water vapor and don't allow the dust particles to rise.

Methods

Firecrackers from different manufactures were randomly selected, and the detailed sample designation are provided in ST1.

Search Strategy

We used Pub Med, MEDLINE, Google Scholar and Cochrane library and concerned national sites upto October 2021 to identify the relevant citations. The searched keywords were 'firecrackers', 'ecofriendly or green firecrackers', 'human health impacts and hazards'. All the data related to ecofriendly firecrackers was extracted from national government site. The search topics were "firecrackers". We also extracted information on selected keywords like manufacturing, transportation, air quality issues related to firecrackers.

Methodological issues

No studies are available that can differentiate between the old firecrackers and the ecofriendly firecrackers. Hence, to draw a concrete difference between their formulations and their health effects is challenging. All the data related to ecofriendly firecrackers is extracted

from CSIR-NEERI. Reduction in the usage of potassium nitrate (KNO) and sulphur (S) leads to the reduction in overall cost.

Result

Studies showed the major health concerns related to the manufacturing and bursting of firecrackers as they cause permanent hearing loss, contact dermatitis and accidents/ incidents because of human error. Short term effects include allergy, skin irritation, eye irritation and inflammation, headaches, fever, chills, chest tightness, coughing, etc. Long term health effects include permanent hearing loss, bio-accumulation (specific to organ system) which can lead to prolonged problems. Reduction in SO, NO, in green firecrackers can help in regulating the air quality during Diwali.

Percentage reduction

The percentage reduction of the particulate matter and barium in PM₁₀ and PM_{2.5} of conventional and reduced emission firecrackers was calculated by the formula as given below,

$$\% \text{Reduction in emission} = \left(\frac{\text{Baseline value} - \text{Calculated value}}{\text{Baseline value}} \right) \times 100$$

Where calculated value is the emission from REF cracker in mg/m³ and baseline value is the emission value of commercial cracker in mg/m³.

Conclusion

Traditionally used heavy metal-based compounds are the major source of fireworks pollution which causes health and environmental concern. Reduced emission fireworks (Green firecrackers) developed provides solution to control emission with usage of multifunctional additives like zeolite and iron oxide along with reduced usage of chemicals in the manufacturing of chemicals[8].

To investigate the effect of these multifunctional additives, testing of conventional and improved type of fireworks.

This review identifies the difference between the traditional/old and ecofriendly (green) firecrackers with respect to their formulations and their health effects respectively. Scant data is available related to the formulations of ecofriendly firecrackers and no studies are available related to its use and outcomes.

Due to the reduction in the amount of chemicals used in the ecofriendly firecrackers there is expected reduction in the emissions of particulate matter. According to all the data from all the search engines and the national government sites related to old firecrackers and the ecofriendly (green) firecrackers it can be concluded that the ecofriendly/green firecrackers can be a better substitute for the old firecrackers as their composition is less harmful to human beings.

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