

# GREEN PYROTECHNICS AND THEIR APPLICATIONS

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***Abstract:** Pyrotechnic compositions are a mixture of compounds that when ignited, undergo an energetic chemical reaction called combustion, at a controlled rate, releasing gas, liquid or solid reaction products, at attended pressure and temperature, to produce on demand and in various combinations, quantities of heat, visible or IR radiation, noise, smoke for screening or for signaling, specific time delays.*

*Today there are many trends for the development of pyrotechnic devices or pyrotechnic applications. The pyrotechnic munitions are in use for all the military forces: land, air and navy. The goal of this paper is to find solutions for green pyrotechnics.*

## **1. Introduction. What is the meaning of “green pyrotechnic”?**

The pyrotechnics are an array of two or many pyrotechnic compositions, charged in mechanical elements. After the ignition of prime composition, the pyrotechnic train will suffer the combustion, at a controlled rate, releasing gas, liquid or solid reaction products, at attended pressure and temperature, necessary to produce on demand and in various combinations, quantities of heat, visible or IR radiation, noise, smoke for screening or for signaling, specific time delays.

According Jesse J. Sabatini (US Army RDECOM-ARDEC) “green” pyrotechnic formulations should consist of environmentally acceptable ingredients, have equal or enhanced performances, and have identical or reduced sensitivities to ignition stimuli (i.e., impact, friction, and electrostatic discharge) compared to the environmentally questionable pyrotechnic munitions that are in existence today.

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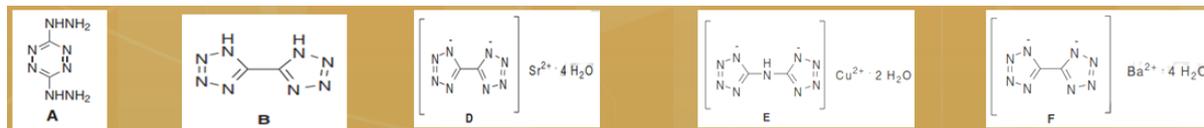
In their military or civil applications, during the production stage, operations or demilitarization, a “green pyrotechnics” must interact friendly humans or to the environment, releasing nontoxic substances, remaining safe and suitable for service.

## 2. Solutions for “Green” Pyrotechnics

### Synthesis of a new compounds

The first efforts to “green” pyrotechnics comes from the use of high-nitrogen compounds in pyrotechnic illuminating compositions. The particular advantages of employing high-nitrogen compounds in pyrotechnic mixtures involves their gaseous and ashless combustion which typically results in a larger flame plume, more brilliant colors in the form of a better dominant wavelength, and a higher spectral purity. Douda developed the first known high-nitrogen pyrotechnic material, tris (glycine) strontium perchlorate. This compound is unique because it contains its own fuel, oxidizer, and coloring agent.

Tetrazole and tetrazine - based fuels have been explored the most for pyrotechnic applications. The low carbon content of these fuel types ensures that soot production is kept to a minimum. Despite their high-nitrogen contents, the aromatic and hydrated nature of these fuels tends to increase their stabilities toward thermal conditions and various ignition stimuli.



**Figure 1.** dihydrazino tetrazine and bis-(1(2)H-tetrazol-5-yl) amine monohydrate (C) and some of their metal salts (D-F)

Another area of concern to the “green” pyrotechnics is the presence of heavy metals in many currently used pyrotechnic formulations.

Today, the most common heavy metals used in various pyrotechnic munitions include barium, lead, and hexavalent chromium (Cr(VI)). Although many barium compounds are not mobile in soil, and are readily converted to the relatively nontoxic and insoluble barium carbonate (BaCO<sub>3</sub>) and barium sulfate (BaSO<sub>4</sub>). Many barium compounds and barium-based combustion products are believed to be cardiotoxic and are believed to be occupational health hazards.

Lead is a known poisonous material, adversely affects the nervous system, and its neurotoxicity is known. Lead is known to cause disorders of the brain, blood,

cardiovascular system, and kidneys, and can bioaccumulate in the bones and soft tissues of the human body.

### **3. Conclusion**

For a green pyrotechnic composition the selection of oxidizers agents, fuels, binder or other pyrotechnic components is crucial. The theoretical and experimental studies must prove the fulfillment of qualification requirements for military or civil applications.