Eco-Friendly Pyrotechnics

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You know it is chemistry when it stinks and goes boom—and entrances us. “No other application in the field of chemistry has such a positive association for the general population as fireworks,” says Thomas Klapötke (University of Munich, Germany).

“However, pyrotechnical applications are significant polluters of the environment.” In the journal *Angewandte Chemie*, Klapötke and his co-author Georg Steinhauser (TU Vienna, Austria) give an overview of how nitrogen-rich compounds and other new strategies could help to limit the danger to the environment.

In addition to fireworks, the field of pyrotechnics includes applications like airbags, signal flares, propellants and charges for civil and military purposes, and the production of nanoporous metal foams for catalysis, hydrogen storage, and insulation.

Pyrotechnical materials contain an oxidizer and a reducing agent; depending on the application, binding material, propellant charges, coloring agents and smoke- and sound-producing agents can be added. When a firework or other pyrotechnic is set off, it releases a whole cocktail of poisons damaging to humans and the environment: heavy metals like lead, barium and chromium, chlorates, dioxins, smoke and particulates, carbon monoxide, and nitrogen and sulfur oxides.

“For a long time, the consequences of this were not considered,” says Klapötke, “in the mean time scientists have been working on more environmentally friendly alternatives.” As usual, the main stumbling

block is price pressure because the new products must compete with the established ones. Klapötke says, “Lawmakers and other promoters must intercede to address this.”

“Modern developments in pyrotechnics are aimed at the use of nitrogen-rich compounds,” according to Klapötke. In contrast to conventional energetic substances, these do not draw their energy from the oxidation of the carbon backbone, but from their high heats of formation, which are released upon their decomposition. Interesting candidates include derivatives of tetrazoles, five-membered rings made of four nitrogen and one carbon atom, as well as tetrazines, six-membered rings made of four nitrogen and two carbon atoms. Aminotetrazole salts with the nontoxic metals lithium, sodium, potassium, rubidium and cesium result in red, orange, violet, purple, and pink colored flames. The trouble is with the color green. Intensive research is being carried out in search of barium-free green-burning salts based on copper compounds.

The class of nitrogen-rich pyrotechnics does not offer only environmentally friendly combustion products; they often offer better color quality and intensity than conventional mixtures. Nitrogen-rich propellants demonstrate improved performance and burn smoke free.

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