A new blue-light-emitter for fireworks

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Conventional fireworks and signal flares that emit a blue flame utilize toxic chemicals as a source of chlorine. Chemists at LMU have now developed the first chlorine-free formulation that emits blue light upon combustion.

The fascination exerted by fireworks isn't often dulled by reflections on the composition of the chemical formulations used to produce the dazzling kaleidoscope of colors we enjoy against the backdrop of the night sky. Mixtures that generate blue light present a particular problem. "Blue flames are especially difficult to produce. They have traditionally been generated using copper or copper-containing compounds in combination with a source of chlorine. At high combustion temperatures, the chlorine reacts with the copper to yield copper(I) chloride (CuCl)," says Professor Thomas M. Klapötke, holder of the

Chair of Inorganic Chemistry and Energetic Materials at LMU Munich. "Moreover, it was long thought that CuCl was the only suitable source of blue light for this purpose," he adds. Now he and his colleagues have proven otherwise. In collaboration with Dr. Jesse Sabatini of the Pyrotechnics Technology and Prototyping Division of the US Army (ARDEC), his group has developed a chlorine-free mixture of chemicals, which emits blue light upon combustion, and offers a practical alternative to conventional formulations used in fireworks. The researchers report on the work in the latest issue of the journal *Angewandte Chemie*.

Blue-emitting fireworks normally use ammonium perchlorate or potassium perchlorate, or chlorine-containing organic compounds as their source of chlorine. "But these perchlorates are highly toxic because they disrupt the function of the thyroid gland. In addition, combustion of polychlorinated organic materials, such as polyvinylchloride (PVC), results in the formation of polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). These substances are extremely toxic and carcinogenic," says Klapötke.

A purer hue

He and his associates in the project have identified an environmentally benign substitute for perchlorate salts and organochlorine compounds for pyrotechnical applications. "We have been able to dispense with perchlorates altogether. Our approach is based on the generation of copper(I) iodide (CuI), which is a strong emitter of light in the blue region of the visible spectrum," Klapötke explains. Furthermore, the light produced by the new mixture is of a spectrally purer quality than that obtainable using the traditional combination of chemicals.

"The new mixture is also less sensitive to shock and is easy to handle,"

Klapötke avers. However, it is not totally innocuous. "Under extreme conditions, combustion of the new mixture is expected to give rise to polyiodated biphenyls. But from a toxicological point of view, these compounds are far less hazardous than chlorine. They are employed as contrast agents in medical radiology, for instance."

Formulations that generate blue flames for pyrotechnical applications are primarily of interest for use in fireworks. "Our new chlorine-free coloring agent could revolutionize the manufacture of fireworks and blue-emitting signal flares for the US Army and Navy, because it enables production of fireworks that are more environmentally friendly than those that are currently in use," Klapötke concludes.

More information: Klapötke, T. M., Rusan, M. and Sabatini, J. J. (2014), "Chlorine-Free Pyrotechnics: Copper(I) Iodide as a "Green" Blue-Light Emitter." *Angew. Chem. Int. Ed.*.
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