The science of fireworks

Fireworks have a history going back to ancient China where they were used to scare away evil spirits, and their dazzling arrays of patterns, vibrant colours and sounds have been captivating us ever since. But what gives fireworks that sensational sound and sparkle? Let's illuminate these bangs and bursts of brightly coloured light.

BRILLIANT BLASTS

Essentially, a firework is a missile, specially designed to explode in a controlled way. A two-step process – the first explosion sends the firework up into the air. Once there, more gunpowder inside the shell causes it to explode with a BANG! A small tube called an aerial shell contains all the explosive chemicals (usually gunpowder) needed to propel the firework into the sky. These chemicals are responsible for all the lights, colours and sounds of a firework. In the first explosion, the lifting charge of gunpowder below the shell is ignited using a fast-acting fuse. The gunpowder explodes – creating lots of heat and gas. The build-up of pressure shoots the aerial shell skyward. After a few seconds, when the aerial shell is high above the ground, a second fuse inside the aerial shell ignites, causing the bursting charge to explode. This ignites the gunpowder and other chemicals inside the shell, rapidly producing lots of gas and heat, causing the shell to burst open, propelling light and colour in every direction.

A CACOPHONY OF COLOUR

Also known as pyrotechnics, from the Greek pyro ('fire') and Tekhnikos ('made by art'), fireworks have us mesmerised by their colours. The colours are formed in two ways: luminescence and incandescence. Incandescent light is produced when a substance is heated to such high temperatures that it begins to glow. The hot explosion and burning of the explosive charge produces reds, oranges, yellows and white that we see in many fireworks.

The wavelength (or colour) of light from a firework also depends on the metal salts contained within it. This is luminescence – the intense heat from the explosion excites the metal atoms in the metal salts to a higher energy stage. When the atoms relax back to a more stable state they emit colours. Different metal salts produce different colours. For example, to obtain a red, white and blue display for July Fourth celebrations, lithium or strontium can be used to create red, magnesium for white and chemicals containing copper for the blue.

Chemists are constantly looking for new chemicals to produce more impressive colours. Blue fireworks are especially challenging because the copper salt needs precise temperatures to be excited to the energy state that emits blue light. Burning too hot or too cool washes out the colour into a light blue hue. Known as 'painting' in the fireworks trade, just as artists mix primary colours to create other colours, the chemical combos of metal salts within fireworks keep audiences awed with more and more impressive technicolour displays.

SIZZLING STUFF

Progress in pyrotechnics hasn't just produced exciting colours, firework patterns just keep getting better and better. To create different shapes, the aerial shells are carefully constructed. Studs of chemicals are arranged on a piece of cardboard in the desired configuration. To create a star shape, the chemical studs will be arranged in a star pattern on the cardboard, causing them to explode into a star shape in the sky. With shaped fireworks, pyrotechnicians often set off several at the same instant to ensure the shape can be seen from all angles.

The next time you watch a fireworks display – whatever you're celebrating – also take a moment to celebrate the amazing chemistry and physics occurring above you.

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