

Pyrotechnic Chemicals

Below are listed the most common chemicals used in modern day pyrotechnics, both consumer (1.4G) and display (1.3). Some of these, such as magnesium, are only used in display fireworks.

The chemicals are listed in the following way:

Chemical (Synonyms) **[Formula]**
Description

Acetone (2-Propanone) **[C₃H₆O]**

Flammable liquid used as a solvent in pyrotechnics (i.e., in mixtures that can't contain water). Nitrocellulose can be dissolved in it to create nitrocellulose lacquer, which can be used as an adhesive or a waterproof coating. Acetone is hard to work with because it evaporates so quickly, thus making the composition cold and causing water to condense.

Aluminum **[Al]**

Most widely used fuel in modern pyrotechnics; produces a brilliant, bright flame. The particles come in several of different shapes, such as flakes and grains.

Ammonium Chloride **[NH₃•HCl]**

Used in white smoke compositions. When burned, it decomposes into HCl and NH₃, then quickly re-combines in the air to form a fine smoke of ammonium chloride particles.

Ammonium Nitrate **[NH₄NO₃]**

Oxidizer used in high explosives (such as ANFO), but not commonly used in fireworks due to its hygroscopicity.

Ammonium Perchlorate **[NH₄ClO₄]**

Slow-burning, widely-used oxidizer. Though many rich colors can be made with it, the burn rate is too slow for use in star compositions. However, it is ideal for use in lances and torches, where slow-burning is an advantage. Since all of the decomposition products are gases, it is also used in rocket propellants (such as the Solid Rocket Boosters on the Space Shuttle).

Antimony Trisulfide (Antimony Sulfide, realgar) **[Sb₂S₃]**

A fuel sometimes used in glitter and fountain compositions to create the color white. At one point it was used in flash compositions, but it was poisonous and extremely sensitive to shock and static electricity. Comes in two forms - "Chinese Needle" and "Dark Pyro". The former is used in glitter compositions and white comets/stars. The latter is used to sharpen the report of salutes and increase the sensitivity of flash powder.

Barium Carbonate [BaCO₃]

Functions as a **green** color agent when burned with chlorine present (from the formation of BaCl⁺), burns white by itself (with oxygen, creating BaO). Can also be used to reduce acidity in chorate-based color compositions.

Barium Chlorate [BaClO₃]

Used as an oxidizer in **green** color compositions.

Barium Nitrate [Ba(NO₃)₂]

Can be used as both a **green** color agent and an oxidizer. Functions as a green color agent when burned with chlorine present (from the formation of BaCl⁺), burns white by itself (with oxygen, creating BaO)

Barium Sulfate [BaSO₄]

Used as a high-temperature oxidizer in metal-based **green** color compositions.

Benzoic Acid [C₆H₅COOH]

Used to make metallic benzoates.

Bismuth Trioxide [Bi₂O₃]

Used as a non-toxic alternative to lead tetraoxide to make crackling stars.

Bismuth Subcarbonate [(BiO)₂CO₃]

Also used as a non-toxic alternative to lead tetraoxide to make crackling stars.

Boric Acid [H₃BO₃]

Weak acid in a powder form which is added to compositions containing aluminum or magnesium and a nitrate. Metals react with nitrates to form amides, which can further react with the metal powder to create a highly exothermic reaction which could spontaneously ignite the compound. Even a few percent boric acid added to the mixture will neutralize any amides that form.

Cab-O-Sil (fumed silica, colloidal silica) [SiO₂]

Used as an anti-caking agent and to prevent hygroscopic chemicals from absorbing water from the air. Sometimes used in flash powders.

Calcium Carbonate (chalk) [CaCO₃]

[CaCO₃]

[CaCO₃]

[CaCO₃]

[CaCO₃]

Used as a color agent in **orange** star compositions, or as an acid-absorber.

Calcium Sulfate [CaSO₄• xH₂O, where x = 0, 2, 3, 5]

Calcium sulfate anhydrite (where x = 0) can be used as a high temperature oxidizer in **orange** color compositions or in strobe compositions.

Charcoal (Carbon) [C]

Charcoal is used very widely in pyrotechnics. Charcoal is the by-product of the burning of organic substances. It contains impurities which make it more reactive, and therefore is used more often than pure carbon in fireworks. It can be made from many types of wood. Charcoal from soft woods, such as grape vine or willow, is good for fast-burning compositions like black powder, whereas charcoal from hard woods like pine are used to create long-lasting spark effects. Very fine charcoal is known as *air float*. Another type of fine charcoal called *lampblack*.

Clay (bentonite, sodium aluminum silicate)

Powder used for plugs and nozzles in fountains, drivers, rockets, and other devices. Can also be made into a paste if mixed with water.

Confectioners Sugar (sucrose, table sugar) [C₁₂H₂₂O₁₁]

Can be used with an oxidizer such as potassium nitrate to create smoke devices or rocket fuel.

Copper Acetoarsenite (paris green) [Cu₃As₂O₃Cu(C₂H₃O₂)₂]

The best **blue** color agent. It is extremely poisonous, however, and is hardly ever used in modern pyrotechnics.

Copper Benzoate [Cu(C₆H₅COO)₂]

Can be used as a fuel in **blue** color compositions. Not often used because it is expensive

Copper(II) Carbonate [CuCO₃]

Light green powder used as a **blue** color agent.

Copper Chlorate (Hexahydrate) [Cu(ClO₃)₂•6H₂O]

Used as an oxidizer in **blue** color compositions.

Copper(II) Chloride (campfire blue) [CuCl₂]

Brownish-yellow compound used as a **blue** color agent.

Copper Chromite [CuCr₂O₄]

Can be used as a catalyst in rocket propellants. It is added in small quantities (1-5%) to rocket fuels and whistle compositions to increase the burn rate.

Copper(II) Oxide [CuO]

Black powder used as a **blue** color agent.

Copper Oxychloride [3CuO•CuCl₂•3.5H₂O]

Green powder used as a **blue** color agent.

Copper(II) Sulfate (Pentahydrate) [CuSO₄•5H₂O]

Anhydrous form is used as a **blue** color agent.

Copper Benzoate [Cu(C₆H₅COO)₂]

Used as a fuel and as a **blue** color agent.

Cryolite (sodium fluoaluminate) $[\text{Na}_3\text{AlF}_6]$

White powder used as a **yellow** color agent.

Dechlorane $[\text{C}_{10}\text{Cl}_{12}]$

Used as a chlorine donor.

Dextrin $[\text{C}_6\text{H}_{10}\text{O}_5]$

Commonly used, water-activated pyrotechnic binder used to hold compositions together or as a paste.

Ethanol (Ethyl Alcohol) $[\text{CH}_3\text{CH}_2\text{OH}]$

Commonly used as a solvent for compositions containing organic fuels/binders such as shellac and red gum.

Ferrotitanium [60/40 ratio of Fe and Ti]

Alloy of iron (ferrum) and titanium, used to create yellow-white sparks in fountains and star compositions.

Gallic Acid $[\text{C}_7\text{H}_6\text{O}_5 \cdot \text{H}_2\text{O}]$

White powder used to create whistles.

Gum Arabic

Vegetable gum used as a water-soluble binder

Hexachlorethane (carbon hexachloride) $[\text{C}_2\text{Cl}_6]$

White powder used as a chlorine donor and in smoke compositions

Hexamine (hexamethylenetetramine, methenamine) $[\text{C}_6\text{H}_{12}\text{N}_4]$

Used as a low reactivity fuel in blue star compositions.

Iron $[\text{Fe}]$

Gray metallic powder used to create yellow branching sparks, mainly in sparklers and fountains. Iron alloys rich in carbon work best.

Iron(II) Oxide (ferrous oxide) $[\text{FeO} \cdot \text{Fe}_2\text{O}_3 \text{ or } \text{Fe}_3\text{O}_4]$

Black powder used as a high-temperature oxidizer in thermite compositions.

Iron(III) Oxide (ferric oxide) $[\text{FeO} \cdot \text{Fe}_2\text{O}_3 \text{ or } \text{Fe}_3\text{O}_4]$

Red powder used as a catalyst in rocket compositions, as a high-temperate oxidizer in thermite compositions or ignition compositions.

Lactose (milk sugar) $[\text{C}_{12}\text{H}_{22}\text{O}_{11} \cdot 2\text{H}_2\text{O}]$

Which powder used in smoke compositions and as a low reactivity fuel in blue color compositions.

Lampblack (carbon black) $[\text{C}]$

Extremely fine form of charcoal obtained from the burning of crude oils. It is used to produce long lasting, finely dispersed orange sparks.

Lead Dioxide (lead (IV) oxide) [PbO_2]

Used as an oxidizer in friction-sensitive ignitor compositions, such as matches.

Lead Tetraoxide [Pb_3O_4]

Red powder most commonly used to make crackling stars, sometimes in high-temperature primes.

Manganese Dioxide [MnO_2]

Used as a catalyst in composite and whistling rocket propellant formulations.

Magnalium (magnesium-aluminum) [Mg/Al]

Alloy of magnesium and aluminum, with properties of both metals. Not quite as reactive as magnesium, and not as hard to ignite as aluminum. Used primarily in glitter, strobes, colored stars, and crackling stars.

Magnesium [Mg]

Highly reactive and flammable metal used to brighten flames without decreasing color quality. Coarser grades are used to produce white sparks, whereas fine magnesium is used in flare and star compositions. The by-products of the burning of magnesium are more easily vaporized than those of aluminum, making magnesium a better fuel.

Methanol [CH_3OH]

Used as a solvent (similar to ethanol) to dissolve red gum and shellac. Is often mixed with water when used in compositions in order to reduce the surface tension of the water (thus making it more "wet").

Nitrocellulose Lacquer [$\text{C}_6\text{H}_7\text{N}_3\text{O}_{11}$]

Flammable liquid used primarily as a binder in fireworks compositions, and as a water-resistant coating for fuses.

Parlon [$(\text{C}_4\text{H}_6\text{Cl}_2)_n$]

A polymer used as both a chlorine donor and binder.

Potassium Benzoate [$\text{C}_6\text{H}_5\text{COOK} \cdot (\text{C}_6\text{H}_5\text{KO}_2)$]

Used with potassium perchlorate to make whistle compositions.

Potassium Chlorate [KClO_3]

Common oxidizer used for mainly for colored star, smoke, and priming compositions.

Potassium Dichromate [$\text{K}_2\text{Cr}_2\text{O}_7$]

Carcinogenic orange crystalline powder used to treat magnesium powder in order to make it less susceptible to undesired spontaneous reactions with other chemicals.

Potassium Nitrate (saltpeter) [KNO_3]

Most commonly used oxidizer in pyrotechnics that is used for many applications, the most important being black power (a 75:15:10 ratio of potassium nitrate, charcoal, and sulfur).

Potassium Perchlorate [KClO₄]

Another common oxidizer that is much more stable than potassium chlorate. It decomposes at a higher temperature, but gives off more oxygen when it does.

Red Gum (accaroid resin) [mixture of different compounds]

A common organic fuel and binder that comes from the hardened red Kino from a certain tree native to Australia.

Saran [chlorinated polymer]

Used as a chlorine donor much like PVC and parlon. Can also be used as a binder when mixed with acetone.

Shellac [C₁₆H₂₆O₄]

A common fuel and binder that has been used for centuries; sometimes thought to be the best fuel for making colored flames. Comes from the excretions of an insect native to India.

Sodium Benzoate [NaC₇O₂H₅]

Sometimes used as a fuel, most often used to make "whistle mix" to burst shells or create whistles.

Sodium Chlorate [NaClO₃]

Not often used because of its hygroscopicity, but sometimes used in rocket propellants

Sodium Nitrate (chile saltpeter) [NaNO₃]

Also very hygroscopic, but sometimes used in flares and stars because of the bright yellow light it emits.

Sodium Oxalate [Na₂C₂O₄]

Used as a yellow color agent.

Strontium Carbonate [SrCO₃]

Used as a red color agent

Strontium Nitrate [Sr(NO₃)₂]

Oxidizer sometimes used in red color compositions.

Strontium Sulfate [SrSO₄]

Sometimes used as a high-temperature Oxidizer sometimes used in red color compositions.

Sulfur [S]

Serves as a fuel, and to reduce the ignition temperature/increase the burning rate of some mixtures.

Titanium [Ti]

Metal used to produce bright white sparks, the intensity and duration of which is affected by particle size.

Wood Meal (wood flour, sawdust) [mixture of compounds including cellulose, $C_6H_{10}O_5$]

Fine sawdust used as a fuel, mainly in lance compositions.

Zinc [Zn]

Used in rocket propellants and to create white sparks.

Zinc Oxide [ZnO]

Used to produce white smoke