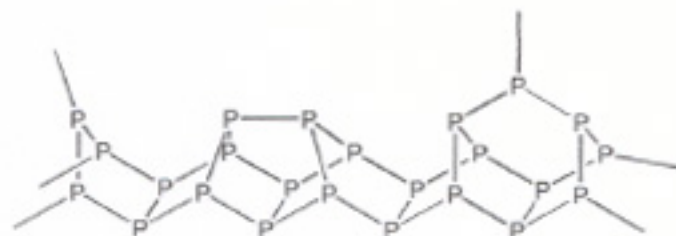


FLAME RETARDANTS FACT SHEET

Red Phosphorus (RP)

SUMMARY PROFILE

Red Phosphorus is an amorphous polymeric modification of the chemical element phosphorus. Elemental phosphorus is readily oxidized and this high reactivity results in hazardous properties of the material. However, red phosphorus is much less reactive and even more less toxic than yellow (also called white) phosphorus¹ (see [appendix](#)). Since red phosphorus is a polymer, an exact molecular formula does not exist. The following structure serves as an example to illustrate how each phosphorus atom is bonded to three others:



APPLICATIONS

- Red Phosphorus is active as sole additive in polymers like polyamides, polyesters, polyurethanes, polyisocyanates and epoxy resins while in polymers like polyolefins, styrenics and rubbers it has to be applied in combination with spumific and carbonific coagents;
- typical required concentrations are 2 ... 10 %

BENEFITS

- Red Phosphorus is the more concentrate source of phosphorus therefore it is an effective flame retardant at low concentration.

¹ Although red and white phosphorus are totally different chemicals they do share the same EINECS-number (231-768-7, European inventory of existing chemical substances) so that care has to be taken when data are extracted from sources based on the EINECS-number.

- Red Phosphorus does not affect the mechanical properties of polymer articles and usually retains or even improves good electrical properties of the polymers (e.g. high current tracking index, CTI).
- Red Phosphorus is endowed with high thermal stability therefore can overcome drastic processing conditions up to 300°C.
- Red Phosphorus avoids the formation of greater amounts of toxic smoke and heat.
- The flame retarding effect of Red Phosphorus prevents the outbreak of large fires from small ignition sources, so that substantial harm to human beings, buildings, etc. can be prevented.

Mode of action:

Phosphorus containing flame retardants mainly influence the reactions taking place in the solid phase. They are particularly effective in materials with high oxygen content, such as cellulose and oxygen containing plastics. The flame retardant is converted by thermal decomposition to phosphoric acid, which in the condensed phase extracts water from the pyrolysing substrate, causing it to form a protective char layer on the surface of the burning item.

ENVIRONMENTAL / HEALTH ASPECTS

Health:

Red Phosphorus has a very low acute toxicity to mammals, e.g. the LC₅₀ for rats by oral application is greater than 15 000 mg per kg bodyweight. Moreover, when applied as a flame retardant, red phosphorus is usually completely embedded into a polymer matrix so that it cannot react with air or water. Due to its own polymeric nature it will not migrate or evaporate from the final product.

Environment:

Recent toxicological studies revealed an aquatic toxicity (LC₅₀ or EC₅₀) in the range of 10 to 100 mg/L for fish, Daphnia and algae². In the environment red phosphorus will slowly degrade by disproportionating and hydrolysis to phosphine (PH₃) and phosphorus acids (oxidation levels of I, III, V). Although the intermediate phosphine is toxic, it is also quite reactive and will be oxidized. The final products will be phosphates which are ubiquitous and harmless. From wastewater, red phosphorus is eliminated mainly by adsorption to sewage sludge. In an accidental fire or waste incineration the phosphorus will be oxidized to phosphorus oxides which are properly removed in flue gas treatment systems of state of the art incinerators or which will remain as polymeric phosphoric acid or phosphates in the bottom ash.

² Clariant GmbH, 2000, submitted to the European Chemicals Bureau, which recommended a resulting labelling as R52 = harmful to aquatic organisms, to be published in a forthcoming Adaptation to Technical Progress to the Dangerous Substances Directive (67/548/EC)

ISSUES

In a study on environmental properties of flame retardants, the German Environmental Protection Agency (Umweltbundesamt, 2001) has assigned red phosphorus to the category »use is unproblematic«.

SAFETY

Hazardous substance data and risk symbols (European classification and labeling):

- sign »F« highly flammable
- R 11 Highly flammable
- R 16 Explosive when mixed with oxidizing substances
- (R 52 harmful to aquatic organisms, probably as of 2002, see ²)
- S 7 Keep container tightly closed
- S 43.1 In case of fire, use Wasser

Red phosphorus is very sensitive to mechanical forces like friction or impact when dry and concentrated. The safety of handling Red Phosphorus in the workplace can be increased by adding stabilisers, dust suppressants, and coating the surface by microencapsulation.

The safest and most convenient way of processing Red Phosphorus is the use of concentrates available in a wide variety of polymer carriers covering almost all the applications.

Red Phosphorus in this form is NOT flammable, NOT classified as a hazardous product for transportation, NOT hazardous for handling and industrial safety (unless carrier material is).

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REFERENCES:

Umweltbundesamt 2001: Research project on "Substituting Environmentally Relevant Flame Retardants: Assessment Fundamentals". Berlin, Umweltbundesamt, UBA-FB 000171/1-3

APPENDIX: Comparison of white and red phosphorus

	white phosphorus	red phosphorus
CAS-number	12185-10-3	7723-14-0
EINECS-number	231-768-7 !	
structure	discrete P ₄ molecules	highly polymeric P _n
appearance	crystalline, waxy, translucent	amorphous or crystalline, opaque, dark red or brownish
melting point	44 °C	585 – 610 °C
vapour pressure	high	very low
density	1.83 g/cc	2.0 ... 2.4 g/cc
solubility: in organic solvents: in water:	yes only ~3 mg / L	no no (very slow hydrolysis)
toxicity	highly toxic	very low toxicity
toxicity LC ₅₀ 48 h, fish LD ₅₀ , oral, rat	highly toxic low µg/L levels 3 mg/kg body weight	very low toxicity > 100 mg/L (nominal loading) > 15 000 mg/kg body weight
heat of sublimation	13.4 k cal/mol	30.0 k cal/mol
chemiluminescence	yes	no
ignitability	- spontaneous ignition in air at room temperature - spontaneously ignites in chlorine	- ignites only above 260 °C - heat necessary for ignition in chlorine
smell	characteristic	no smell
reaction with aqueous alkali	produces phosphine	none

DISCLAIMER

This information was compiled with great care and scrutiny – it reflects the current knowledge about this product at the time of completion of this record. This fact sheet is meant to provide users of the product and all interested parties information on health, environmental and regulatory issues. However, this is no replacement for a safety data sheet or any other legally required document. Furthermore, these data do not represent a specification of any commercial product.