

## **Uses of Copper Compounds**

CDA Technical Note TN11, 1972

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CDA Technical Note TN11

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## Acknowledgements

To the Technical Department, McKechnie Chemicals Ltd.

## Copper Development Association

Copper Development Association is a non-trading organisation sponsored by the copper producers and fabricators to encourage the use of copper and copper alloys and to promote their correct and efficient application. Its services, which include the provision of technical advice and information, are available to those interested in the utilisation of copper in all its aspects. The Association also provides a link between research and user industries and maintains close contact with other copper development associations throughout the world.

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## Contents

Acknowledgements.....	2
Copper Development Association.....	2
Contents.....	1
Tables.....	1
Introduction.....	2
General uses of copper compounds.....	2
Agricultural uses of copper compounds.....	3
Copper sulphate.....	4
Manufacture.....	4
Uses.....	4
Copper sulphate's role in agriculture.....	5
Preparation of Bordeaux and Burgundy mixtures on the farm.....	5
Dissolving copper sulphate.....	5
Preparation of Bordeaux mixture.....	5
Preparation of a 1% Burgundy mixture.....	5
Control of fungus diseases.....	6
Correction of copper deficiency in soils.....	6
Correction of copper deficiency in animals.....	6
Stimulation of growth for fattening pigs and broiler chickens.....	6
A molluscicide for the destruction of slugs and snails, particularly the snail host of the liver fluke.....	7
Other copper compounds.....	10
Copper acetates.....	10
Cuprous oxide.....	10
Cupric oxide (black copper oxide).....	11
Cupric chloride.....	11
Copper oxychloride.....	11
Cuprous chloride.....	11
Cupric nitrate.....	11
Copper cyanide.....	11
Copper soaps.....	11
Copper naphthenate.....	12
Anhydrous and monohydrated copper sulphate.....	12

## Tables

Table A – Uses of copper sulphate

Table B – Plant diseases amenable to control by copper fungicides

## **Introduction**

In addition to their many uses in agriculture and biology, copper salts have an astonishing variety of industrial uses, chiefly of a specialised nature, and there is hardly an industry which does not have some small use for them. The following pages briefly describe a few of the more important copper compounds and list some of their uses with particular reference to copper sulphate.

It is worth noting that copper is an indispensable constituent of all living tissues and is essential for the normal growth and well being of plants and animals. Where it is lacking it has to be supplied. The minute quantities of copper needed for human health are usually obtained through the normal intake of food and water.

Copper and its compounds are not toxic like some other metals, such as lead or mercury. There are no records of any occupational diseases attributable to copper among people who have worked for any years with the metal or its salts. Indeed it has sometimes been said that such people often appear healthier and generally suffer less from colds and other ailments. Copper bangles and other adornments are reputed to relieve and prevent rheumatic pains. Copper water storage vessels, copper kettles and copper cooking pans have been used for generations.

## **General uses of copper compounds**

To trace the history of copper compounds it would be necessary to go back much further than the fourth millennium BC. Records found in the tombs of the early Egyptians suggest that, at least, this ancient civilisation employed copper sulphate as a mordant in their dyeing process. Today, more than 5,000 years later, copper sulphate is still employed by the world's dyeing industry in the after treatment of certain dyes to improve their fastness to light and washing.

Another equally early recorded use for copper compounds was for the making of ointments and other medical preparations. Later, the Greek civilisation of the pre-Christian era of Hypocrates (circa. 400 BC) saw the prescribing of copper sulphate for pulmonary diseases and by the 18th century AD it had come into wide clinical use in the western world being employed for the treatment of mental disorders and afflictions of the lungs. It is noteworthy that copper sulphate has lost none of its effectiveness over the centuries, neither have any harmful side effects been reported. Copper sulphate is still, however, highly prized by some inhabitants of Africa and Asia for healing sores and skin diseases. In the West it is widely used in baby foods and in mineral and vitamin tonics and pills.

Copper has a wide spectrum of effectiveness against the many biological agents of timber and fabric decay. It renders them unpalatable to insects and protects them from fungus attack. Copper sulphate has been in use since 1838 for preserving timber and is today the base for any proprietary wood preservatives. The discovery more than 80 years ago that any algae are highly susceptible to copper, led to the use of copper salts by water engineers to prevent the development of algae in potable water reservoirs. They are also employed to control green slime and similar algal scums in farm ponds, rice fields, irrigation and drainage canals, rivers, lakes and swimming pools. Another well known use for copper compounds is as a molluscicide for the control of slugs and snails. Less than one part of copper per million parts of water can control disease-transmitting aquatic snails, which are responsible for schistosomiasis or bilharzia in humans in tropical countries and fascioliasis or liver fluke of animals in both tropical and temperate climates.

## **Agricultural uses of copper compounds**

Copper compounds have their most extensive employment in agriculture where the first recorded use was in 1761 when it was discovered that seed grains soaked in a weak solution of copper sulphate inhibited seed-borne fungi. By 1807 the steeping of cereal seeds in a copper sulphate solution for a limited time and then drying them with hydrated lime became the standard farming practice for controlling stinking smut or bunt of wheat, which by then was endemic wherever wheat was grown. Flour milled from bunted wheat had to be fed to animals or sold cheaply to ginger bread makers who had found a way of masking its bad taste and colour with ginger and treacle. Within a few decades, so general and effective had become the practice of treating seed grains with copper sulphate that the appearance of more than a few bunted ears in a field of wheat was looked upon as a sign of neglect on the part of the farmer. So well have copper compounds controlled bunt that today this seed-borne disease is no longer of any economic importance.

The greatest breakthrough for copper salts undoubtedly came in the 1880's when the French scientist Millardet, while looking for a cure for downy mildew disease of vines in the Bordeaux district of France, chanced to notice that those vines, bordering the highways and which had been daubed with a paste of copper sulphate and lime in water in order to make the grapes unattractive to passers-by, appeared free of downy mildew. This chance observation led to experiments with mixtures of copper sulphate, lime and water and in 1885 Millardet announced to the world that he had found a cure for the dreaded mildew. This mixture became known as Bordeaux mixture and saw the commencement of protective crop spraying.

Within a year or two of the discovery of Bordeaux mixture, Burgundy mixture, which also takes its name from the district of France in which it was first used, appeared on the scene. Burgundy mixture is prepared from copper sulphate and sodium carbonate (soda crystals) and is analogous to Bordeaux mixture.

Trials with Bordeaux and Burgundy mixtures against various fungus diseases of plants soon established that many plant diseases could be prevented with small amounts of copper applied at the right time and in the correct manner. From then onwards copper fungicides have been indispensable and many thousands of tonnes are used annually all over the world to prevent plant diseases.

As a generalisation, soils would be considered copper deficient if they contain less than two parts per million available copper in the context of plant health. However, where the soil contains less than five parts per million available copper, symptoms of copper deficiency may be expected in animals. The increasing use of chemical fertilisers which contain little or no copper are denuding soils of readily available copper and creating a deficiency of the element in plants and through them in animals. Copper compounds are now being added to the ever increasing copper deficient soils either direct or in combination with commercial fertilisers. This is particularly the case where the fertilisers are rich in nitrogen and phosphorus. Animals grazing on copper deficient pastures or obtaining an inadequate amount of copper through their normal diet will benefit from mineral supplements containing copper.

Copper sulphate, because of its fungicidal and bactericidal properties, has been employed as a disinfectant on farms against storage rots and for the control and prevention of certain animal diseases, such as foot rot of sheep and cattle.

## Copper sulphate

Copper sulphate, blue stone, blue vitriol are all common names for pentahydrated cupric sulphate,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , which is the best known and the most widely used of the copper salts. Indeed it is often the starting raw material for the production of many of the other copper salts. Today in the world there are more than 100 manufacturers and the world's consumption is around 200,000 tonnes per annum of which it is estimated that approximately three-quarters is used in agriculture, principally as a fungicide.

## Manufacture

In the production of copper sulphate virgin copper is seldom, if ever, used as the starting raw material. Copper ores are used in countries where these are mined. For the bulk of the world's production non-ferrous scrap is the general source. The scrap is refined and the molten metal poured into water to produce roughly spherical porous pieces about the size of marbles which are termed "shot". This shot is dissolved in dilute sulphuric acid in the presence of air to produce a hot saturated liquor which, if the traditional large crystals of copper sulphate are required, is allowed to cool slowly in large cooling vats into which strips of lead are hung to provide a surface for the crystals to grow on. If the granulated (snow) crystal grades are desired, the cooling process is accelerated by agitating the liquor in water cooled vessels. Other methods of production are:

1. By heating copper scrap with sulphur to produce copper sulphide which is then oxidised to form copper sulphate.
2. By heating copper sulphide ores to produce copper oxide which is then treated with sulphuric acid to form copper sulphate.
3. By slow leaching in air of piles of low grade ore. Bacterial action is sometimes employed to hasten the process. A solution of copper sulphate drains away from such heaps.

Commercially copper sulphate contains 25% metallic copper and is sold with a guaranteed minimum purity of 98% copper sulphate. It is produced in a number of grades varying from large crystal lumps, of 25 mm or more in diameter from which it appropriately derives the name bluestone, to very fine powders of almost the fineness of talcum powder. The four commonest grades, based on crystal diameter sizes, are:

1. Large crystals (from 10 mm to 40 mm)
2. Small crystals (from 2 mm to 10 mm)
3. Granulated or snow crystals (less than 2 mm)
4. Windswept powder (less than 0.15 mm)

## Uses

Copper sulphate is a very versatile chemical with as extensive a range of uses in industry as it has in agriculture. Its principal employment is in agriculture, and this role is described in some detail in the next section.

Up to a generation or so ago about its only uses in industry were as a mordant for dyeing and for electroplating, but today it is being employed in many industrial processes. The synthetic fibre industry has found an application for it in the production of their raw material. The metal industry uses large quantities of copper sulphate as an electrolyte in copper refining, for copper coating steel wire prior to wire drawing and in various copper plating processes. The mining industry employs it as an activator in the concentration by froth flotation of lead, zinc, cobalt and gold ores. The printing trade takes it as an electrolyte in the production of electrotype and

as an etching agent for process engraving. The paint industry uses it in anti-fouling paints and it plays a part in the colouring of glass. Indeed, today there is hardly an industry which does not have some small use for copper sulphate. In Table A some of the many uses of copper sulphate are listed.

## **Copper sulphate's role in agriculture**

Copper sulphate has many agricultural uses (see Table A) but the following are the more important ones:

### **Preparation of Bordeaux and Burgundy mixtures on the farm**

Because of their importance to farmers, instructions concerning the dissolving of copper sulphate and the preparation of both Bordeaux and Burgundy mixtures have been included in the text.

#### **Dissolving copper sulphate**

Iron or galvanised vessels must not be used for the preparation of copper sulphate solutions. Plastic vessels are light and very convenient. To make a strong solution, hang a jute sack of copper sulphate so that the bottom of it dips a few inches only in the water. The copper sulphate will dissolve overnight. Copper sulphate dissolves in cold water to the extent of about 3 kg per 10 litres. If more than this is placed in the sack described above, then a saturated solution will be obtained and it may be used without serious error on the basis that it contains 3 kg copper sulphate per 10 litres.

#### **Preparation of Bordeaux mixture**

Bordeaux mixture is prepared in various strengths from copper sulphate, hydrated lime (calcium hydroxide) and water. The conventional method of describing its composition is to give the weight of copper sulphate, the weight of hydrated lime and the volume of water in that order. The percentage of the weight of copper sulphate to the weight of water employed determines the concentration of the Bordeaux mixture. Thus a 1% Bordeaux mixture, which is the normal, would have the formula 1:1:100, the first 1 representing 1 kg copper sulphate, the second representing 1 kg hydrated lime, and the 100 representing 100 litres (100 kg) water. As copper sulphate contains 25% copper metal, the copper content of a 1% Bordeaux mixture would be 0.25% copper. The quantity of lime used can be reduced considerably. Actually 1 kg copper sulphate requires only 0.225 kg of chemically pure hydrated lime to precipitate all the copper. Good proprietary brands of hydrated lime are available but, as even these deteriorate in storage, it is safest not to exceed a ratio of 2:1 i.e. a 1.05:100 mixture.

In preparing Bordeaux mixture, the copper sulphate is dissolved in half the required amount of water in a wooden or plastic vessel. The hydrated lime is mixed with the balance of the water in another vessel. The two "solutions" are then poured together through a strainer into a third vessel or spray tank.

#### **Preparation of a 1% Burgundy mixture**

Dissolve separately 1 kg copper sulphate in 50 litres water and 1.25 kg washing soda (or 0.475 kg soda ash) in 50 litres water and slowly add the soda solution to the copper sulphate solution with stirring.

## **Control of fungus diseases**

Bordeaux and Burgundy mixtures have been found effective in controlling a whole host of fungus diseases of plants. Normally a 0.5% to 1.0% Bordeaux or Burgundy mixture applied at 2 to 3 week intervals suffices to control most copper-susceptible fungi.

Generally once the fungus spores have alighted on the host plant and penetrated the tissues it is difficult to control them. The principle of control must in most cases depend on protection, i.e. preventing the fungus spores from entering the host tissues. Copper fungicides are noted for their tenacity and for this reason are much to be preferred in areas of high rainfall. The simplest method of control is to apply a protective coating of Bordeaux or Burgundy mixture (or other copper fungicide) to the susceptible parts of the plant, so that spores alighting on them come in contact with the protective film of copper and are killed instantly. It is thus important to remember that the first spraying must ideally be made just before the disease is expected and continued at intervals throughout the susceptible period. For this reason it is important to take advantage of the early warning schemes which are in operation to ensure greater accuracy of the timing of the first spraying. It must also be remembered that fungi are plants and that control measures that will kill them may not always leave the host plant unaffected. The use of too concentrated a fungicide mixture must therefore be guarded against, particularly for the early sprays.

Copper fungicides have been reported effective against numerous plant diseases. A list, by no means exhaustive, of some 300 diseases that have been found amenable to control by copper fungicides, appears in Table B.

## **Correction of copper deficiency in soils**

Where copper deficiency has been confirmed by soil analysis or field diagnosis, whether in plants or animals, it can be corrected very simply either by applying 50 kg copper sulphate per hectare in the form of a fertiliser before sowing or by spraying the foliage of the young cereal plants, when they are about 150 mm high, with 750 grams copper sulphate (dissolved in from 400 to 2,000 litres water) per hectare. The soil application has generally given the better results and has the advantage that it may have a residual effect for more than ten years. The foliar application has to be given annually to each crop. An alternative is to add a copper containing slag (normally about 1% to 2% copper) at a rate of a tonne to the hectare.

## **Correction of copper deficiency in animals**

A method of correcting copper deficiency in livestock is to treat the soil on which animals graze. For example, in Australia and New Zealand swayback in lambs is being prevented by top dressing copper deficient pastures with 5 to 10 kg copper sulphate per hectare before lambing begins. Other methods include drenching periodically with a copper sulphate solution; incorporating copper sulphate in salt and other animal licks; or by what is probably the most general method, incorporating copper sulphate along with other minerals and vitamins in the form of carefully blended supplements in the feeding stuffs.

## **Stimulation of growth for fattening pigs and broiler chickens**

The inclusion of up to as much as 0.1% copper sulphate in the diet of bacon and pork pigs and broiler chickens stimulates appetite and produces increased growth rate with a marked improvement in feed conversion.

## A molluscicide for the destruction of slugs and snails, particularly the snail host of the liver fluke

All likely habitats of the liver fluke snail should be treated with copper sulphate at the rate of 25 kg to the hectare at least twice a year in June and August (northern hemisphere) or December and February (southern hemisphere).

*Table A – Uses of copper sulphate*

<b>Classification</b>	<b>Application</b>
<b>Agriculture</b>	
Major uses	Preparation of Bordeaux and Burgundy mixtures for use as fungicides
	Manufacture of other copper fungicides such as copper-lime dust, tribasic copper sulphate, copper carbonate and cuprous oxide
	Manufacture of insecticides such as copper arsenite and Paris green
	Control of fungus diseases (see Table B)
	Correction of copper deficiency in soils
	Correction of copper deficiency in animals
	Growth stimulant for fattening pigs and broiler chickens
	Molluscicide for the destruction of slugs and snails, particularly the snail host of the liver fluke
Other uses	Seed dressing
	Soil steriliser, e.g. Cheshunt compound (a mixture of copper sulphate and ammonium carbonate) to prevent "damping-off" disease of tomato, etc.
	Control and prevention of foot rot in sheep and cattle
	Bacteriostat for addition to sheep dips
	Disinfectant in prevention of the spread of swine erysepelas and white scours in calves
	Control of scum in farm ponds
	Plant nutrient in rice fields
	Preservative for wooden posts, wooden buildings, etc.
	Preservative for wooden fruit boxes, planting baskets and other containers
	Ingredient of vermin repellents, e.g. for application to bark of trees against rabbits
	Stimulant of latex yield on rubber plantations
	Protection against algal growths on flower pots

<b>Public health and medicine</b>	
	Destruction of algal blooms in reservoirs and swimming pools
	Prevention of the spread of athlete's foot in warm climates, by incorporation in the flooring mixture of swimming baths
	Control of bilharzia in tropical countries, as a molluscicide
	Prevention of malaria, in the preparation of Paris green for use against mosquito larvae
	Antiseptic and germicide against fungus infections
	Catalyst or raw material for the preparation of copper catalysts used in the manufacture of pharmaceutical products
<b>Industry</b>	
Adhesives	Preservative in casein and other glues
	Additive to book binding pastes and glues, for insecticidal purposes
	Additive to animal and silicate glues to give water resistance
Building	Timber preservative and in the preparation of other wood preservatives, e.g. oil based copper naphthenates and water based copper/chrome/arsenic for the prevention of woodworms and wood rots
	Ingredient of plaster to prevent fungus infection, e.g. to prevent the spread of dry rot
	Ingredient of concrete, both as a colouring matter and as an antiseptic, e.g. for use in and around swimming pools
	Modification of the setting of concrete
	Protection against lichens, moulds and similar growths on asbestos cement roofing and other building materials
	Control of the growth of tree roots in sewers
Chemical	Preparation of catalysts for use in many industries
	Purification of gases, e.g. removal of hydrogen chloride and hydrogen sulphide
	Precipitation promoter in purifying zinc sulphate solutions
	Precipitation of alkaloids as double salts from crude extracts
	Source of other copper compounds such as copper carbonate silicate/arsenite/aceto-arsenite/resinate/stearate/tartrate/oleate naphthenate/chromate/chlorate/alginate/fluoride/hydroxide, cuprous oxide/chloride/cyanide and cuprammonium compounds
Decorative trades	Colouring glass
	Colouring cement and plaster
	Colouring ceramic wares
	Alteration of metal colours, e.g. darkening of zinc, colouring aluminium
Dyestuffs	Reagent in the preparation of dyestuffs intermediates
	Catalyst or raw material for the preparation of copper catalysts, e.g. preparation of phenols from diazo compounds, preparation of phthalocyanine dyes

Leather and fur	Mordant in dyeing
	Reagent in tanning processes
Metal and electrical	Electrolyte in copper refining
	Electrolyte in copper plating and electro forming
	Electrolytic manufacture of cuprous compounds, e.g. cuprous oxide
	Constituent of the electrodes and electrolytes in batteries
	Electrolyte in the manufacture of copper powder
	Electrolyte in aluminium plating and anodising
	Copper coating steel wire, prior to wire drawing
	Pickling copper wire, etc., prior to enamelling
	Providing a suitable surface for marking out iron and steel
Mining	Flotation reagent in the concentration of ores, e.g. zinc blende
Paint	Raw material for the manufacture of copper naphthenate and other copper compounds for use in anti-fouling paints
	Preparation of certain varnish or paint dryers, e.g. copper oleate, copper stearate
	Preparation of certain pigments, e.g. copper chromate, copper ferrocyanide, copper phthalocyanine
Printing	Etching agent for process engraving
	Electrolyte in the preparation of electrotype
	Ingredient of printing inks
Synthetic rubber and petroleum	Preparation of catalysts used in cracking certain gaseous and liquid petroleum
	Fractions
	Preparation of cuprous chloride, used in the purification of butadiene and in the separation of acetylene derivatives
	Preparation of catalysts used in chlorinating rubber latex
	Purification of petroleum oils
Textiles	Preparation of copper compounds for rot-proofing canvas and other fabrics
	Rot-proofing sandbags
	Mordant, especially in calico printing
	Cuprammonium process for the production of rayon
	Production of aniline black and diazo colours for dyeing
	"After coppering" to increase the fastness of dyes
	Catalyst in the manufacture of cellulose ethers and in cellulose acetylation

Miscellaneous	Improving the burning qualities of coke
	Laboratory analytical work
	Ingredient of laundry marking ink
	Dyeing of hair and horn
	Ingredient of hair dyes of the phenylene diamine or pyrogallol type
	Preparation of chlorophyll as a colouring material for food stuffs
	Imparting a green colour in fireworks
	Activator in the preparation of active carbons
	Preservative for wood pulp
	Preservation of fishing nets and hides on trawls
	Obtaining a blue-black finish on steel
	Treatment of carbon brushes
	Ingredient of the solution used for preserving plant specimens in their natural colours
Impregnation in fruit wrapping papers to prevent storage rots	

## Other copper compounds

### Copper acetates

Basic copper acetate (verdigris) was at one time made in France by interleaving copper metal sheets with fermented grape skins and dregs left after wine manufacture. After some time when the copper sheets had become coated with verdigris they were removed, exposed to the air for a few days and then replaced. This process was repeated until the whole sheet had become corroded. The resulting product was known as blue verdigris and was used as a fungicide at 1 kg basic copper acetate in 500 litres water.

Present manufacture is based on the action of acetic acid on copper metal, copper oxide or copper carbonate. They can also be prepared by treating a copper sulphate solution with lead acetate. Copper acetates are used as an intermediate in the manufacture of Paris green (cupric aceto-arsenite); as a catalyst in a number of organic reactions including rubber ageing; as a chemical in textile dyeing; and as a pigment for ceramics. Copper acetates have also been used for impregnating kraft paper to produce an anti-tarnish wrapping paper for high grade silver ware.

### Cuprous oxide

Can be produced either electrolytically from copper or by the action of alkaline reducing agents on copper sulphate solutions. Formulated proprietary brands of cuprous oxide are extensively employed as fungicides and seed dressings. Another important application is in anti-fouling paints. Other uses include the colouring of porcelain and glass.

## **Cupric oxide (black copper oxide)**

Can be produced either by adding caustic soda to hot copper sulphate solutions or by treating copper scale with nitric acid and heating to redness. Cupric oxide is used in the ceramic industry for imparting blue, green or red tints in glasses, glazes and enamels. It is occasionally employed for incorporation in mineral supplements for insuring against an insufficiency of copper in the diet of animals. Among its other uses is the preparation of cuprammonium hydroxide solutions for the rayon industry.

## **Cupric chloride**

Obtained either by dissolving cupric oxide in hydrochloric acid or by the action of chlorine on copper. Its principal use is in the petroleum industry for sweetening (catalytic oxidation of the mercaptans) and as an ingredient of catalysts for other chemical processes. It is also used as a mordant in calico printing and dyeing.

## **Copper oxychloride**

Is a basic copper chloride and is usually manufactured either by the action of hydrochloric acid on copper metal or by the air oxidation of cuprous chloride suspensions. It has a number of applications, by far the most important being as an agricultural fungicide for which purpose it is extensively employed in formulated form as dusts, wettable powders and pastes.

## **Cuprous chloride**

Prepared either by heating a solution of cupric chloride with copper turnings or by the action of a reducing agent such as sulphur dioxide, on a mixture of common salt and copper sulphate solution. The petroleum industry uses cuprous chloride in their "oil sweetening" process. Ammoniacal solutions of cuprous chloride are employed for the absorption of any carbon monoxide which may be present in a gas as an impurity.

## **Cupric nitrate**

Produced either by dissolving copper carbonate in nitric acid or direct from copper and nitric acid. It has a number of small uses, such as in ceramics, dyeing as a mordant, in fireworks and in photography.

## **Copper cyanide**

Manufactured from sodium cyanide and copper sulphate. It is mainly used for copper electroplating.

## **Copper soaps**

Usually made by the inter-action of the corresponding soap with copper sulphate solution. Small quantities of these, such as copper stearate, copper oleate and copper abietate (from resins), are employed mainly for rot-proofing textiles, ropes, etc. They are also used in paints as they are soluble in oils, white spirits, etc.

## Copper naphthenate

Usually manufactured either from copper sulphate and naphthenic acid in combination with an alkali or by heating naphthenic acid and copper oxide. It is widely used as an oil-based wood preservative and as a rot-proofing agent.

## Anhydrous and monohydrated copper sulphate

Obtained by heating copper sulphate pentahydrate - when four molecules of water of crystallisation are removed the product becomes copper sulphate monohydrate which is green in colour. At a higher temperature all the water of crystallization is removed and anhydrous copper sulphate is the white powder which results. They can also be obtained by crystallisation from copper sulphate pentahydrate in boiling sulphuric acid. The main applications are in the production of proprietary wood preservatives and agricultural fungicides as well as for the production of a number of copper compounds. Sometimes they are utilised to detect the presence of moisture.

*Table B -Plant diseases amenable to control by copper fungicides*

Plant	Disease	
	Common name	Pathogen
Almond	Shot hole	Clasterosporium carpophilum
	Rust	Puccinia pruni-spinosae
	Blossom wilt	Sclerotinia laxa and Sclerotinia fructigena
	Leaf curl	Taphrina deformans
Aloe	Anthraxnose	Colletotrichum agaves
Antirrhinum	Rust	Puccinia antirrhini
Apple	Pink disease	Corticium salmonicolor
	Fireblight	Erwinia amylovora
	Bitter rot	Glomerella cingulata
	Canker	Nectria galligena
	Blotch	Phyllosticta solitaria
	Black rot	Physalospora obtusa
	Blossom wilt	Sclerotinia laxa
	Scab	Venturia inaequalis
Apricot	Shot hole	Clasterosporium carpophilum
	Rust	Puccinia pruni-spinosae
	Blossom wilt	Sclerotinia laxa and Sclerotinia fructigena
Areca Nut	Thread blight	Corticium koleroga
Arrowroot	Banded leaf blight	Corticium solani
Artichoke (Globe)		Ramularia cynarae
Asparagus	Rust	Puccinia asparagi

Plant	Disease	
	Common name	Pathogen
Avocado	Fruit spot	<i>Cercospora purpurea</i>
	Anthracnose (Black spot)	<i>Glomerella cingulata</i>
	Bacterial rot	<i>Pseudomonas syringae</i>
	Scab	<i>Sphaceloma perseae</i>
Azalea	Flower spot	<i>Ovulinia azaleae</i>
Banana	Black rot (Die back)	<i>Botryodiplodia theobromae</i>
	Helminthosporiosis	<i>Helminthosporium</i> sp.
	Sigatoka disease (Leaf spot)	<i>Mycosphaerella musicola</i>
Barley	Snow damage	<i>Typhula itoana</i>
	Covered smut	<i>Ustilago hordei</i>
Bean (Broad)	Leaf spot	<i>Asochyta pisi</i>
	Chocolate spot	<i>Botrytis cinerea</i>
	Rust	<i>Uromyces fabae</i>
Bean (French and Runner)	Anthracnose	<i>Colletotrichum lindemuthianum</i>
	Powdery mildew	<i>Erysiphe polygoni</i>
	Halo blight	<i>Pseudomonas medicaginis</i> var <i>phaseolicola</i>
	Rust	<i>Uromyces appendiculatus</i>
	Common blight	<i>Xanthomonas phaseoli</i>
Begonia	Mildew	<i>Oidium begoniae</i>
Betel	Leaf spot	<i>Bacterium betle</i>
	Leaf spot	<i>Glomeralla cingulata</i>
	Foot rot	<i>Phytophthora colocasiae</i>
	Leaf rot	<i>Phytophthora parasitica</i>
Blackberry	Cane spot	<i>Elsinoe veneta</i>
Blueberry	Powdery mildew	<i>Microsphaera alni</i> var. <i>vaccinii</i>
	Leaf rust	<i>Pucciniastrum myrtilli</i>
	Fruit rot	<i>Sclerotinia vaccinii-corymbosi</i>
Brassicas	Damping off	<i>Oipidium brassicae</i>
	Downy mildew	<i>Peronospora parasitica</i>
	Black leg (Canker)	<i>Phoma lingam</i>
	Black rot	<i>Xanthomonas campestris</i>
Cacao	Brown pod rot (Die back)	<i>Botryodiplodia theobromae</i>
	Witches' broom	<i>Marasmius perniciosus</i>
	Black pod rot	<i>Phytophthora palmivora</i>
Calendula	Leaf spot	<i>Cercospora calendulae</i>

Plant	Disease	
	Common name	Pathogen
Carnation	Ring spot	Didymellina dianthi
	Leaf spot	Septoria dianthi
	Rust	Uromyces dianthi
Carrot	Blight	Alternaria dauci
	Bacterial soft rot	Bacterium carotovorum
	Leaf spot	Cercospora carotae
Cassava	Leaf spot	Cercospora henningsii
Castor oil	Leaf spot	Phyllosticta bosensis
Cattleya	Black rot	Phythium ultimum
Celery	Blight	Cercospora apii
	Leaf spot	Septoria apii and Septoria apii graveolentis
Cherry	Shot hole	Clasterosporium carpophilum
	Leaf spot	Coccomyces hiemalis
	Bitter rot	Glomerella cingulata
	Leaf scorch	Gnomonia erythrostoma
	Bacterial canker	Pseudomonas mors-prunorum
	Brown rot (Blossom wilt)	Sclerotinia laxa and Sclerotinia fructigena
	Scab	Venturia cerasi
Chestnut	Blight	Endothia parasitica
	Ink disease	Phytophthora cambivora
Chilli	Blight (Leaf spot)	Cercospora capsici
	Blight (Collar rot)	Phytophthora capsici
	Bacterial spot	Xanthomonas vesicatoria
Chrysanthemum	Mildew	Oidium chrysanthemi
	Rust	Puccinia chrysanthemi
	Leaf spot	Septoria chrysanthemella
Cinchona	Damping off	Pythium vexans
Cineraria		Alternaria senecionis
Citronella	Collar rot	
Citrus	Sooty mould	Aithaloderma citri
	Thread blight	Corticium koleroga
	Melanose	Diaporthe citri
	Mal secco	Deuterophoma tracheiphila
	Scab	Elsinoe fawcetti
	Anthraxnose (Wither tip)	Gloeosporium limeticola

Plant	Disease	
	Common name	Pathogen
Citrus (continued)	Sooty blotch	Leptothyrium pomi
	Black spot	Phoma citricarpa
	Brown rot	Phytophthora spp.
	Black pit	Pseudomonas syringae
	Septoria spot	Septoria depressa
	Canker	Xanthomonas citri
Coffee	Brown eyespot	Cercospora coffeicola
	Thread blight (Black rot)	Corticium koleroga
	Anthracnose (Die back)	Glomerella cingulata
	Rust	Hemileia vastatrix
	Berry disease	Colletotrichum coffeanum
Conifers	Blight	Cercospora thujina
	Coryneum blight	Coryneum berckmanii
	Canker	Coryneum cardinale
	Fusiform rust	Cronartium fusiforme
	Blister rust	Cronartium ribicola
	Leaf cast (of Kauri Pine)	Hendersonula agathi
	Needle cast (of Scots Pine)	Lophodermium pinastri
	Phomopsis blight	Phomopsis juniperovora
	Needle cast (of Douglas Fir)	Rhabdocline pseudotsugae
	Root rot	Rhizoctonia crocorum
Cotton	Alternarii disease	Alternaria gossypii and Alternaria
	macrospora	
	Sore shin	Corticium solani
Cowpea	Scab	Cladosporium vignae
Cucurbits	Leaf blight	Alternaria cucumerina
	Wet rot	Choanephora cucurbitarum
	Anthracnose	Colletotrichum lagenarium
	Wilt	Erwinia tracheiphila
	Powdery mildew	Erysiphe cichoracearum
	Black rot	Mycosphaerella citrullina
	Stem end rot	Physalospora rhodina
Currant (Ribes)	Downy mildew	Pseudoperonospora cubensis
	Leaf spot	Mycosphaerella grossulariae and Mycosphaerella ribis
	Leaf spot	Pseudopeziza ribis

Plant	Disease	
	Common name	Pathogen
Cytisus	Die back	Ceratophorum setosum
Daffodil	White mould	Ramularia vallisumbrosae
	Fire	Sclerotinia polyblastis
Dahlia	Leaf spot	Phyllosticta dahliicola and Entyloma dahliae
Dalo	Leaf spot	Phytophthora colocasiae
Delphinium	Mildew	Erysiphe polygoni
Derris	Leaf spot	Colletotrichum derridis
Dogwood (Cornus)	Spot anthracnose	Elsinoe corni
Egg Plant	Leaf spot	Ascochyta melongenae
	Damping off	Corticium solani
Fig	Leaf fall and Fruit rot	Cercospora bolleana
	Rust	Cerotelium fici
	Thread blight	Corticium koleroga
	Canker	Phomopsis cinerescens
	Blight	Phizoctonia microsclerotia
Filbert	Bud blight	Xanthomonas corylina
Fruit trees	Crown gall	Bacterium tumefaciens
Gambier	White root rot	Fomes lignosus
Gardenia	Canker	Phomopsis gardenia
Gerbera	Leaf spot	Cercospora sp.
Ginseng	Blight	Alternaria panax
Gladiolus	Corm rot	Botrytis gladiolorum
Gooseberry	Die back	Botrytis cinerea
	Leaf spot	Mycosphaerella grossulariae
	Cluster cup rust	Puccinia pringshemiana
	American mildew	Sphaerotheca mors-uvae
Grasses	Snow mould	Calonectria graminicola
	Red thread	Corticium fusiforme
	Brown patch of lawns	Rhizoctonia and Holminthosporium spp.
	Stripe smut	Ustilago striiformis
Ground nut	Leaf spot	Cercospora arachidicola and Cercospora personate
	Stem rot (Southern blight)	Sclerotium rolfsii
Guava	Leaf spot	Cephaleuros mycoidea
	Thread blight	Corticium koleroga
	Rust	Puccinia psidii
Hellebore		Coniothyrium hellebori

Plant	Disease	
	Common name	Pathogen
Hollyhock	Rust	<i>Puccinia malvacearum</i>
Hop	Downy mildew	<i>Pseudoperonospora humuli</i>
	Powdery mildew	<i>Sphaerotheca humuli</i>
Hydrangea	Mildew	<i>Oidium hortensiae</i>
Leek	Mildew	<i>Peronospora destructor</i>
	White tip	<i>Phytophthora porri</i>
Lettuce	Downy mildew	<i>Bremia lactucae</i>
	Ring spot	<i>Marssonina panattoniana</i>
Lily	Blight	<i>Botrytis elliptica</i>
Maize	Downy mildew	<i>Sclerospora philippinensis</i>
Mango	Red rust	<i>Cephaleuros virescens</i>
	Anthracnose	<i>Colletotrichum gloeosporioides</i>
	Scab	<i>Elsinoe mangiferae</i>
	Bacterial black spot	<i>Erwinia mangiferae</i>
	Anthracnose	<i>Gloeosporium mangiferae</i>
	Powdery mildew	<i>Oidium mangiferae</i>
Medlar	Scab	<i>Venturia eriobotryae</i>
Millet (Italian)	Smut	<i>Ustilago crameri</i>
Mushroom	White mould	<i>Mycogone perniciosa</i>
	Bacterial blotch(Brown blotch)	<i>Pseudomonas tolaasi</i>
Nectarine	Shot hole	<i>Clasterosporium carpophilum</i>
	Rust	<i>Puccinia pruni-spinosae</i>
	Blossom wilt	<i>Sclerotinia laxa</i> and <i>Sclerotinia fructigena</i>
	Leaf curl	<i>Taphrina deformans</i>
Oats	Loose smut	<i>Ustilago avenae</i>
Olive	Leaf spot	<i>Cycloconium oleaginum</i>
Onion	Downy mildew	<i>Peronospora destructor</i>
Orchids	Fusarium	<i>Macrophoma</i> and <i>Diplodia</i> spp.
Paeony	Blight	<i>Botrytis peoniae</i>
	Bud death	<i>Sphaeropsis paeonia</i>
Palm (Palmyra)	Leaf spot	<i>Pestalotia palmarum</i>
Passion fruit	Brown spot	<i>Alternaria passiflorae</i>
	Grease spot	<i>Pseudomonas passiflorae</i>

Plant	Disease	
	Common name	Pathogen
Pawpaw	Leaf spot	Ascochyta caricae
	Anthraco nose (Fruit rot)	Colletotrichum gloeosporioides
	Powdery mildew	Oidium caricae
	Hard rot	Phytophthora parasitica
Peach	Shot hole	Clasterosporium carpophilum
	Rust	Puccinia pruni-spinosae
	Blossom wilt	Sclerotinia laxa and Sclerotinia fructigena
	Leaf curl	Taphrina deformans
Pear	Scab (America)	Cladosporium effusum
	Thread blight	Corticium koleroga
	Firebiiglit	Erwinia amylovora
	Bitter rot	Glomerella cingulata
	Leaf spot (Leaf speck)	Mycosphaerella sentina
	Scab	Venturia pirina
Pecan	Scab	Cladosporium effusum
	Thread blight	Corticium koleroga
	Vein spot	Gnomonia nerviseda
	Liver spot	Gnomonia caryae var. pecanae
Pepper(Red)	(See Chilli)	
Persimmon	Canker	Phomopsis diospyri
Pineapple	Heart or stern rot	Phytophthora parasitica
Piper betle	(See Betel)	
Plantain	Black tip	Helminthosporium torulosum
Plum	Shot hole	Clasterosporium carpophilum
	Black rot	Dibotryon morbosum
	Bacterial canker	Pseudomonas mors-prunorum
	Wilt	Pseudomonas prunicola
	Rust	Puccinia pruni-spinosae
	Brown rot	Sclerotinia fructigena
	Blossom wilt	Sclerotinia laxa
	Watery rot (Pocket plums)	Taphrina pruni
Bacterial spot	Xanthomonas pruni	
Poplar		Septogloeum populiperdun
Poppy	Downy mildew	Peronospora arborescens

Plant	Disease	
	Common name	Pathogen
Potato	Early blight	Alternaria solani
	Grey mould	Botrytis cinerea
	Blight (Late blight)	Phytophthora infestans
	Dry rot	Sclerotium rolfsii
Quince	Brown rot	Sclerotinia fructigena
	Shot hole	Clasterosporium carpophilum
Raspberry	Spur blight	Didymella applanata
	Cane spot (Anthracnose)	Elsinoe veneta
	Cane wilt	Leptosphaeria coniothyrium
Rhododendron	Leaf scorch (Bud blast)	Pycnostysanus azaleae
Rhubarb	Downy mildew	Peronospora jaapiana
Rice	Brown spot	Ophiobolus miyabeanus
	(Helminthosporiosis)	
	Blast	Piricularia oryzae
Rose	Black spot	Diplocarpon rosae
	Downy mildew	Peronospora sparsa
	Rust	Phragmidium mucronatum
	Leaf spot (Anthracnose)	Sphaceloma rosarum
	Mildew	Sphaerotheca pannosa
Rubber	American leaf disease	Dothidella ulei
	White root rot	Fomes lignosus
	Leaf disease	Helminthosporium heveae
	Stem disease	Pestalotia palmarum
	Abnormal leaf fall	Phytophthora palmivora
Rye grass	Blind seed	Phialea temulenta
Safflower	Rust	Puccinia carthami
Seedlings	Damping off	Pythium debaryanum, Pythium and Rhizoctonia spp, Sclerotinia sclerotiorum,etc
Sorghum	Covered smut	Sphacelotheca sorghi
Spinach	Leaf spot	Heterosporium variabile
	Downy mildew	Peronospora effusa
Spindle tree	Mildew	Oidium euonymi-japonicae
Stock	Leaf spot	Alternaria raphani
Strawberry	Leaf spot	Mycosphaerella fragariae
Sugar beet	Leaf spot	Cercospora beticola
	Downy mildew	Peronospora schactii

Plant	Disease	
	Common name	Pathogen
Sunflower	Rust	<i>Puccinia helianthi</i>
	Wilt	<i>Sclerotinia sclerotiorum</i>
Sweet potato	Wilt	<i>Fusarium</i> spp.
Taro	Leaf spot	<i>Phytophthora colocasiae</i>
Tea	Black rot (Die back)	<i>Botryodiplodia theobromae</i>
	Red rust	<i>Cephaleuros nycoidea</i>
	Blister blight	<i>Exobasidium vexans</i>
	Grey blight	<i>Pestalotia theae</i>
Tobacco	Brown spot (Red rust)	<i>Alternaria longipes</i>
	Leaf spot	<i>Ascochyta nicotianae</i>
	Frog eye	<i>Cercospora nicotianae</i>
	Blue mould (Downy mildew)	<i>Peronospora tabacina</i>
	Wildfire	<i>Pseudomonas tabacum</i>
Tomato	Early blight	<i>Alternaria solani</i>
	Leaf mould	<i>Cladosporium fulvum</i>
	Anthracnose	<i>Colletotrichum phomoides</i>
	Fruit rot	<i>Didymella lycopersici</i>
	Mildew	<i>Leveilluia taurica</i>
	Fruit rot	<i>Phytophthora capsici</i>
	Foot rot	<i>Phytophthora cryptogea</i>
	Blight (Late blight)	<i>Phytophthora infestans</i>
	Leaf spot	<i>Septoria lycopersici</i>
	Grey leaf spot	<i>Stemphylium solani</i>
	Bacterial spot	<i>Xanthomonas vesicatoria</i>
Tuberose	Blight	<i>Botrytis elliptica</i>
Tung	Thread blight	<i>Corticium koleroga</i>
Veronica		<i>Septoria exotici</i>
Vine (Grape)	"Coitre"	<i>Coniothyrium diplodiella</i>
	Anthracnose	<i>Elsinoe ampelina</i>
	Black rot	<i>Guignardia bidwellii</i>
	Leaf spot	<i>Isariopsis fuckelli</i>
	Bitter rot	<i>Melanconium fuligineum</i>
	Angular leaf spot	<i>Mycosphaerella angulata</i>
	Downy mildew	<i>Plasmopara viticola</i>
	Totbrenner	<i>Pseudopeziza tracheiphila</i>
	Powdery mildew	<i>Uncinula necator</i>

<b>Plant</b>	<b>Disease</b>	
	<b>Common name</b>	<b>Pathogen</b>
Vine (Sultana)	Sooty dew	Exosporium sultanae
Viola	Leaf spot	Centrospora acerina
Violet	Scab	Sphaceloma violae
Walnut	Ring spot	Ascochyta juglandis
	Anthracnose (Blotch)	Gnomonia leptostyla
	Downy leaf spot	Microstroma juglandis
	Blight	Xanthomonas juglandis
Wheat	Root rot	Gibberella zeae
	Rust	Puccinia spp.
	Snow damage	Pythium sp.
	Bunt	Tilletia caries and Tilletia faetida
Willow	Black canker	Physalospora miyabeana
	Scab	Venturia chlorospora
Zinnia	Wilt	Sclerotinia sclerotiorum

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