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PATENT SPECIFICATION

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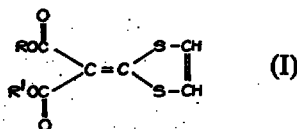
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(54) 1,3-DITHIOL-2-YLIDENE MALONIC ESTERS, PROCESS FOR PREPARING THE SAME, AND USE OF SAID ESTERS

(71) We, NIHON NOHYAKU CO. LTD., a corporation organised under the laws of Japan, of 1-2-5, Nihonbashi, Chuo-Ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a compound represented by the general formula (I),

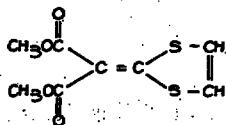


wherein R₁, which may be same or different, are individually an alkyl group having 1 to 4 carbon atoms, and to a process for preparing the same. Further, the present invention is concerned with an agricultural and horticultural fungicide containing as active ingredient a compound represented by the general formula (I).

The compounds represented by the above-mentioned general formula (I) are useful as agricultural and horticultural fungicides since they are excellent in action of controlling such diseases of agricultural and horticultural crops as, for example, rice diseases such as rice bacterial leaf blight, rice blast and rice brown spot; fruit tree diseases such as citrus canker and apple alternaria leaf spot; and vegetable diseases such as cucumber anthracnose.

Typical examples of the compounds represented by the above-mentioned general formula (I) are as follows:

1.



m.p. 134.5—135°C.

Dimethyl 1,3-dithiol-2-ylidene malonate

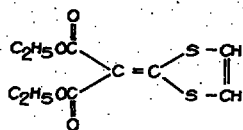
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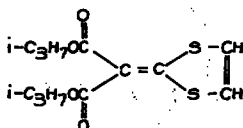
2.



m.p. 113°C.

Diethyl 1,3-dithiol-2-ylidene malonate

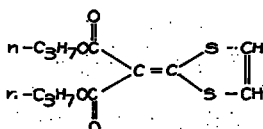
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m.p. 59—60°C.

Di-i-propyl 1,3-dithiol-2-ylidene malonate

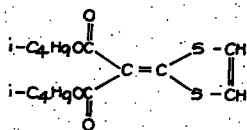
4.



m.p. 73—75°C.

Di-n-propyl 1,3-dithiol-2-ylidene malonate

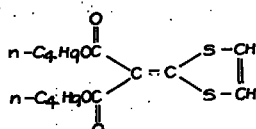
5.



m.p. 76—78°C.

Di-i-butyl 1,3-dithiol-2-ylidene malonate

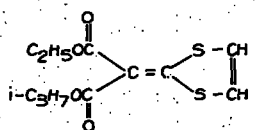
6.



m.p. 55—57°C.

Di-n-butyl 1,3-dithiol-2-ylidene malonate

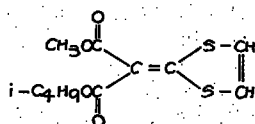
7.



m.p. 57—58°C.

Ethyl i-propyl 1,3-dithiol-2-ylidene malonate

8.



n_D^{20} 1.5928

Methyl i-butyl 1,3-dithiol-2-ylidene malonate.

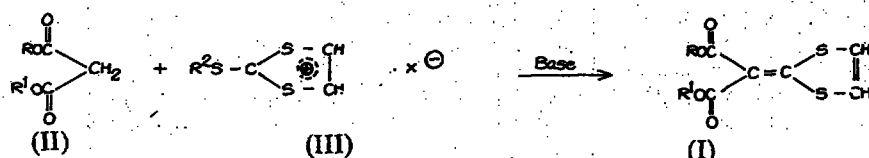
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Typical processes for synthesizing the compounds represented by the general formula (I) are the below-mentioned processes A, B and C. The malonic esters used as starting materials in the present invention further include esters of the asymmetric type.

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Process A:

This process comprises reacting a malonic ester represented by the general formula (II) with a 1,3-dithiolium salt represented by the general formula (III) in an inert solvent and in the presence of a suitable base. The said reaction may diagrammatically be shown by the following reaction scheme:



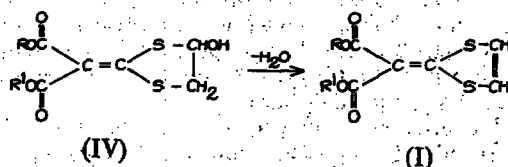
wherein R and R¹ are as defined previously; R² is an alkyl group having from 1 to 4 carbon atoms or a benzyl group; and X is an anion residue.

The 1,3-dithiolium salt represented by the general formula (III) may be synthesized by treating 1,3-dithiol-2-thion with an alkylating agent such as, for example, dimethylsulfuric acid, iodomethyl or bromoethyl, or with an aralkylating agent such as benzyl chloride. Alternatively, the said 1,3-dithiolium salt may be synthesized by alkylating 1,3-dithiol-2-thion-4,5-dicarboxylic acid simultaneously with decarboxylation. Further, anion residue of the resulting dithiolium salt may be replaced by the anion residue of another salt forming agent, e.g. perchlorate.

Thus, the compound represented by the general formula (I) can be synthesized by reacting a malonic ester represented by the general formula (II) with a dithiolium salt represented by the general formula (III) in an inert solvent in the presence of a base. Examples of the inert solvent include alcohols, acetic acid, dimethylformamide, dimethyl sulfoxide, tetrahydrofuran and dioxane. Particularly, the use of alcohols, tetrahydrofuran and dioxane is advantageous. The base used in the present invention is preferably an inorganic base such as metallic sodium, sodium hydride, sodium alcoholate, sodium hydroxide or potassium hydroxide. The amounts of said malonic ester and the dithiolium salt are generally used in the reaction in substantially equimolar amounts though a slight excess of the malonic acid is preferred. The amount of base used is preferably from 1.0 to 1.5 moles per one mole of the dithiolium salt. The reaction may practically be conducted at a temperature in the vicinity of the boiling point of the solvent used.

Process B:

This process comprises dehydrating a 4-hydroxy-1,3-dithiolan-2-ylidene malonate represented by the general formula (IV) by use of a suitable dehydrating agent, e.g. sulfuric acid. The said reaction may diagrammatically be shown by the following reaction scheme:



wherein R and R₁ are as defined previously.

The dithiolan represented by the general formula (IV) may be obtained by hydrolyzing, according to an ordinary procedure, a 4-alkylcarboxy-1,3-dithiolan-2-ylidene malonate such as 4-acetoxy-1,3-dithiolan-2-ylidene malonate with a hydrolyzing agent such as sulfuric acid or, phosphoric acid.

Thus, the compound represented by the general formula (I) can be synthesized by dehydrating a dithiolan represented by the general formula (IV) with a dehydrating agent, either directly or in an inert solvent. The dehydrating agent is a substance which can effectively form a double bond, and includes, for example, concentrated sulfuric acid and sulfonic acid chlorides. Examples of the sulfonic acid chlorides include chlorosulfonic acid, methanesulfonic acid chloride and benzenesulfonic acid chloride. Particularly, the use of chlorosulfonic acid is advantageous.

In a preferred embodiment of this process the above-mentioned dithiolan is contacted directly with the dehydrating agent. A typical example of the preferred embodiments is where the dithiolan is contacted with concentrated sulfuric acid.

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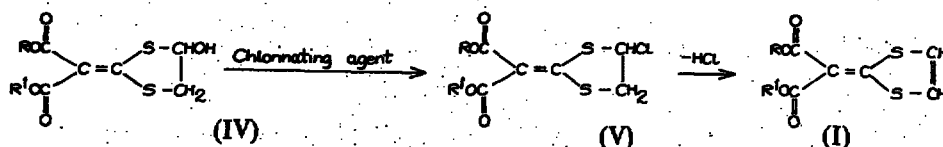
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When concentrated sulfuric acid is used as the dehydrating agent, the said acid is preferably used in a proportion of 0.5 to 50 parts by weight, particularly 10 to 20 parts by weight, per part by weight of the compound (IV). In this case, the reaction proceeds at room temperature.

When a sulfonic acid chloride is used as the dehydrating agent, the reaction is generally carried out in an inert solvent. Examples of the solvent are chlorinated paraffins such as carbon tetrachloride, though these are not limitative. The sulfonic acid chloride and the compound of formula (IV) are generally used in the reaction in substantially equimolar amounts though a slight excess of the acid chloride is preferred. The reaction may be conducted at a temperature in the range from room temperature to the boiling point of the solvent used.

Process C:

This process comprises chlorinating the hydroxyl group of a 4-hydroxy-1,3-dithiolan-2-ylidene malonic ester, and the subjecting the resulting chlorination product to a dehydrochlorination reaction. The said reaction may diagrammatically be shown by the following reaction scheme:



wherein R and R' are as defined previously.

According to the method the compound represented by the general formula (I) can be synthesized by reacting the compound represented by the general formula (IV) with a chlorinating agent such as thionyl chloride, phosphorus trichloride, phosphorus oxychloride and phosphorus pentachloride in an inert solvent, and then subjecting the resulting chlorination product (V), either as it is or after isolation, to a dehydrochlorination reaction in the presence of a base.

In this process, the reaction may be carried out by reacting one mole of the compound (IV) with from 1/3 to 1 mole of a chlorinating agent in an inert solvent, e.g. an aromatic hydrocarbon such as benzene or toluene, or an ether such as diethyl ether, tetrahydrofuran or dioxane, though a slight excess of the chlorinating agent may be preferred. The reaction temperature may be in the range from room temperature to a temperature of 5°C. The resulting compound (V) is not always required to be isolated. Subsequently, the resulting chlorination product is treated as it is or after being isolated with a base, whereby a dehydrochlorination reaction proceeds. In this case, the reaction temperature may be in the range from 5°C to the boiling point of the solvent used, but the reaction usually proceeds at a satisfactory rate at room temperature. Examples of the base used in the above-mentioned reaction include inorganic bases such as sodium hydroxide and potassium, and organic bases such as pyridine, triethylamine, dimethylaniline diethylaniline and 1,8-diazabicyclo-(5,4,0)undecene-7. The amount of the base to be used in the reaction is preferably 1—2 moles per one mole of the starting 4-hydroxy-1,3-dithiolan-2-ylidene malonate.

The compound represented by the general formula (I) is effective as an agricultural and horticultural fungicide, since it has prominent effects in controlling plant diseases such as rice bacterial leaf blight, cucumber anthracnose and apple alternaria leaf spot. In application, the said compound is ordinarily diluted with a diluent, and formulated into a composition of a suitable form according to an ordinary procedure adopted in the art of the formulation of agricultural chemicals.

Particularly, the composition of the present invention has a prominent action in controlling rice blast, which is a rice disease. Accordingly, the present invention involves such mode that the composition is used for preventive and/or curative purposes by applying the same directly to the plants to be protected or onto the ground, or is applied through paddy field water or soil. The amount of the present composition to be used varies depending on various factors, e.g. the kind of disease to be controlled, the extent of damage, the tendency of occurrence of disease, the weather, the environmental conditions and the form of the composition. For example, in case the composition is finally used in the form of liquid like an emulsifiable concentrate or a wettable powder, it is practical that the composition is diluted or suspended to that the final concentration of active ingredient becomes 0.001% or more, in general. Further, the composition in the form of dust

or granular preparation is ordinarily used in a proportion of 1 to 10 kg. per 10 ares. These, however, do not limit the scope of the present invention.

It is also possible to use the present composition in admixture or combination with at least one of other agricultural chemicals, fertilizers, plant nutriment, etc. which are used in the same manner as in the case of the present composition. For example, in controlling rice blast by application of the present composition, the composition may be mixed with an agent for controlling insects injurious to rice (or may be mixed with a fungicide in some cases), thereby preparing a multipurpose composition. Typical agricultural chemicals used for the above-mentioned purpose are such fungicides and insecticides as mentioned below. As the fungicides, there are used antibiotics such as blasticidins and its derivatives, kasugamycin and polyoxin, and synthetic fungicides such as O,O-diisopropyl S-benzylthiophosphate and 2,4,5-trichloro-phenyl O-ethyl O-phenylphosphate; and as the insecticides there are used organo-phosphorus type insecticides such as O,O-dimethyl O-(3-methyl-4-nitrophenyl)thiophosphate, O-ethyl O-p-nitrophenylthionobenzenephosphonate and Malathion (Trade Mark), carbamate type insecticides such as 1-naphthyl N-methylcarbamate and m-tolyl N-methylcarbamate, and formamidine type insecticides such as chlorophenamide.

Procedures for synthesizing the compounds of the present invention are explained below with reference to examples, but the examples do not limit the scope of the invention. In the examples, the numbers attached to the compounds correspond to those of the compounds exemplified previously.

Example 1.

Synthesis of diisopropyl 1,3-dithiol-2-ylidene malonate (the compound 3):

1.1 Grams (0.03 mole) of 69% purity sodium hydride was suspended in 30 ml. of dry tetrahydrofuran. Into the resulting suspension, 5.6 g (0.03 mole) of diisopropyl malonate was gradually dropped with ice-cooling. After completion of the generation of hydrogen gas, 8.2 g (0.03 mole) of 2-methylthio-1,3-dithiolium iodide was added. The resulting mixture was heated under reflux for 1 hour, and then the reaction product was poured into a large amount of ice water to deposit crystals. The crystals were recovered by filtration, dried and then recrystallized from n-hexane to obtain 6.7 g of white crystals, m.p. 59—60°C., yield 77.5%.

The 2-methylthio-1,3-dithiolium iodide used as starting material was synthesized in the following manner:

44.4 Grams (0.2 mole) of 1,3-dithiol-2-thion-4,5-dicarboxylic acid was dissolved in 240 ml of nitromethane, and the resulting solution was heated to 80°C. Into this solution, 100 ml of methyl iodide was gradually dropped, and the resulting mixture was refluxed for 6 hours. After completion of the reaction, the formed crystals were recovered by filtration, washed with 100 ml of ether and then air-dried to obtain 48.4 g of the desired compound, m.p. 114—116°C. (decomp.), yield 87.0%.

Example 2.

Synthesis of diethyl 1,3-dithiol-2-ylidene malonate (the compound 2):

1.7 Grams (0.073 atom) of metallic sodium was dissolved in 50 ml of ethanol to form an ethyl alcoholate. To this alcoholate, 8.0 g (0.05 mole) of diethyl malonate was gradually added. Subsequently, 14 g (0.05 mole) of the 2-methylthio-1,3-dithiolium iodide prepared in Example 1 was added little by little, and the resulting mixture was heated under reflux for 2 hours. After completion of the reaction, the reaction product was poured into ice water to deposit crystals. The crystals were recovered by filtration and then recrystallized from ethanol to obtain 3.3 g of white crystals, m.p. 113°C, yield 42%.

Example 3.

Synthesis of 2-methylthio-1,3-dithiolium perchlorate:

A mixture comprising 26.8 g (0.2 mole) of 1,3-dithiol-2-thion and 25.2 g (0.2 mole) of dimethylsulfuric acid was reacted at 60°C for 30 minutes and then at 90°C for 30 minutes. After cooling, the reaction product was poured into 150 ml of a saturated aqueous sodium perchlorate solution to deposit crystals. The crystals were recovered by filtration, washed with ether, dried and then recrystallized from methanol to obtain 42.5 g of yellow crystals, m.p. 42—46°C, yield 85.8%.

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Synthesis of diisobutyl 1,3-dithiol-2-ylidene malonate
(the compound 5):

1.1 Grams (0.03 mole) of 69% purity sodium hydride was suspended in 30 ml of dry tetrahydrofuran. To the resulting suspension, 6.5 g (0.03 mole) of diisobutyl malonate was added little by little with ice-cooling, and the resulting mixture was reacted as 60°C for 30 minutes. Subsequently, 7.5 g (0.03 mole) of the 2-methylthio-1,3-dithiolium perchlorate prepared in the aforesaid manner was added, and the mixture was heated under reflux for 2 hours. After completion of the reaction, the reaction product was poured into a large amount of ice water to deposit crystals. The crystals were recovered by filtration and then recrystallized from acetone to obtain 3 g of white crystals, m.p. 76—78°C, yield 32.0%.

Example 4.

Synthesis of diisopropyl 1,3-dithiol-2-ylidene malonate
(the compound 3):

11 Grams (0.3 mole) of 69% purity sodium hydride was suspended in 100 ml of dry tetrahydrofuran. Into the resulting suspension, 56.5 g (0.3 mole) of diisopropyl malonate was gradually dropped with cooling. Finally, 75 g (0.3 mole) of 2-methylthio-1,3-dithiolium perchlorate was added little by little. The resulting mixture was heated under reflux for 2 hours, allowed to cool and then poured into ice water to deposit crystals. The crystals were recovered by filtration and then recrystallized from a mixture comprising n-hexane and ethyl ether to obtain 55.5 g of white crystals, m.p. 59—60°C, yield 65%.

Example 5.

Example 3 was repeated, except that the diisobutyl malonate was replaced by dimethyl malonate, to obtain dimethyl 1,3-dithiol-2-ylidene malonate (the compound 1) as pale yellow crystals, m.p. 134.5—135°C, yield 45.5%.

Example 6.

Synthesis of diethyl-1,3-dithiol-2-ylidene malonate
(the compound 2):

A solution of 2 g of diethyl 4-hydroxy-1,3-dithiolan-2-ylidene malonate in 40 ml of concentrated sulfuric acid was allowed to stand at room temperature for 1 hour. Thereafter, the reaction product was poured into ground ice to deposit crystals. The crystals were recovered by filtration, washed with water and then recrystallized from ethanol to obtain 1.9 g of the desired compound as white crystals, m.p. 113°C, yield 95%.

Example 7.

Synthesis of diisopropyl 1,3-dithiol-2-ylidene malonate
(the compound 3):

A solution of 3 g of diisopropyl 4-hydroxy-1,3-dithiolan-2-ylidene malonate in 50 ml of carbon tetrachloride was incorporated with 1.2 g of chlorosulfonic acid, and then stirred at room temperature for 2 hours. After completion of the reaction, the reaction product was charged with water, and the carbon tetrachloride layer was separated. The aqueous layer was extracted with diethyl ether and then combined with the carbon tetrachloride layer. The resulting mixture was dried and the freed from the solvent by distillation to form crystals. The crystals were recovered and the dried to obtain 2.5 g of the desired compound as white crystals, m.p. 59—60°C, yield 86%.

Example 8.

Synthesis of diisobutyl 1,3-dithiol-2-ylidene malonate
(the compound 5):

Into a solution of 3.5 g of diisobutyl 4-hydroxy-1,3-dithiolan-2-ylidene malonate in 50 ml of ether was dropped at below 15°C 1.8 g of phosphorus oxychloride. Subsequently, 1.8 g of triethylamine was added, and the resulting mixture was reacted with stirring at room temperature for 4 hours to deposit triethylamine hydrochloride. This hydrochloride was removed, and the ether layer was washed with a dilute aqueous sodium hydroxide solution and the freed from the ether by distillation to deposit 2.2 g of the desired compound as white crystals, m.p. 76—78°C, yield 73%.

Example 9.

Synthesis of di-n-propyl 1,3-dithiol-2-ylidene malonate
(the compound 4):

A solution of 3 g of di-n-propyl 4-hydroxy-1,3-dithiolan-2-ylidene malonate in

50 ml of concentrated sulfuric acid was allowed to stand at room temperature for 2 hours. Thereafter, the reaction product was poured into ice water to deposit crystals. The crystals were recovered by filtration, washed with water and then recrystallized from n-hexane to obtain 2.8 g of the desired compound as white crystals, m.p. 73—75°C, yield 93%.

Example 10.

Example 9 was repeated, except that the di-n-propyl 4-hydroxy-1,3-dithiolan-2-ylidene malonate was replaced by dimethyl-4-hydroxy-1,3-dithiolan-2-ylidene malonate, to obtain dimethyl 1,3-dithiol-2-ylidene malonate (the compound 1) as white crystals, m.p. 134.5—135°C, yield 66.7%.

Example 11.

Synthesis of di-i-propyl 1,3-dithiol-2-ylidene malonate (the compound 3):

To a solution of 30.6 g of 4-hydroxy-1,3-dithiolan-2-ylidene malonate in 60 ml of benzene was added 13 g of thionyl chloride, and the resulting mixture was stirred at room temperature for 1.5 hours. About 30 minutes after addition of the thionyl chloride, hydrogen chloride and sulfurous acid gas generated, but the reaction terminated after 1.5 hours. After completion of the reaction, 50 ml of benzene was added to the reaction product, and the resulting mixture was dried over sodium sulfate. Into this mixture, 15.3 g of 1,8-diaza-bicyclo(5,4,0)undecene-7 was dropped at a liquid temperature of 5° to 15°C. After the dropping, the mixture was heated with stirring at room temperature for 30 minutes and then under benzene reflux for 1 hour. After completion of the reaction, the benzene was removed by distillation to obtain 32 g of a crude product. The crude product was recrystallized from n-hexane to obtain 25 g of the desired compound as white crystals, m.p. 59—60°C, yield 87%.

The above-mentioned operation was repeated, except that the thionyl chloride was replaced by each of phosphorus trichloride and phosphorus oxychloride, to obtain the desired compound in a high yield.

In order to substantiate the effectiveness of the present fungicides, several test examples are shown below. In the test examples, the numbers attached to the compounds correspond to those of the compounds exemplified previously.

Test Example 1.

Tests of antimicrobial and antifungal activities against various pathogenic fungi:

(1) Antimicrobial activity test method:

A bouillon liquid medium in a given amount was charged into a test tube, and a definite amount of a solution of each test compound (represented by the number) at a given concentration was poured into the test tube by use of a messpipette to dilute the medium to 5 times the original volume thereof. This dilution was inoculated with one platinum loop amount of a plant pathogenic microbe cultured in a slant medium in a test tube, and was allowed to stand in a thermostat at 28°C for 5 days. Subsequently, the turbidity of the medium was measured to calculate the minimum inhibitory concentration (MIC in ppm) of the compound against the pathogenic microbe. The results obtained were as shown in Table 1.

(2) Antifungal activity test method:

In a watch glass, a solution of each test compound at a given concentration was mixed with spores of a pathogenic fungus, and was allowed to stand in a thermostat at 25°C for 24 hours. Thereafter, the state of germination of the spores was microscopically observed to calculate the MIC of the compound. The results obtained were as shown in Table 1.

(3) Tested microbes:

- A. Rice bacterial leaf blight (*Xanthomonas oryzae*)
- B. Citrus canker (*Xanthomonas citri*)
- C. Rice blast (*Piricularia oryzae*)
- D. Rice brown spot (*Cochliobolus miyabeanus*)
- E. Cucumber anthracnose (*Colletotrichum lagenarium*)
- F. Apple alterinaria leaf spot (*Altenaria mali*)

TABLE 1

Test compound	A	B	C	D	E	F
1	125	625	25	25	25	125
2	125	125	5-25	25	5-25	125
3	625	625	5	25-125	5	625
4	625	>625	1	5	5	>625
5	>625	625	5	25	25	125
6	625	625	125	25	125	>625
7	125	125	5	25-125	5	625
8	125	125-625	25	125	5-25	625

Test Example 2.

Test of curative effect on rice blast (pot test):

Paddy-rice seedlings (variety "Jikkoku"; height 20 cm) grown in a greenhouse were inoculated with rice blast fungus. One day after the inoculation, the seedlings were sprayed on a turn table by use of a spray gun (1.5 kg/cm²) with a solution of each test compound at a given concentration, and then stored in a greenhouse. 4 Days after the spraying, the number of spots developed was counted to calculate the curative value (%) of the compound.

$$\text{Curative value (\%)} = \frac{\left(\frac{\text{Number of spots per leaf in non-treated area}}{\text{Number of spots per leaf in treated area}} - 1 \right) \times 100}{\left(\frac{\text{Number of spots per leaf in non-treated area}}{\text{Number of spots per leaf in treated area}} \right)}$$

The results obtained were as shown in Table 2.

TABLE 2

Test compound	Concentration (p.p.m.)	Number of spots per leaf	Curative value (%)	Phyto-toxicity
1	500	0.5	98.4	None
2	"	2.1	93.5	None
3	"	5.2	89.5	None
4	"	6.4	80.2	None
5	"	4.8	85.1	None
IBP emulsion (Commercially available product)	480	1.8	94.4	None
Non-treatment	—	32.4	—	

Note) The IBP emulsion contains O,O-diisopropyl-S-benzyl thiophosphate as active ingredient.

Test Example 3.

Test of preventive effect on rice blast (pot test):

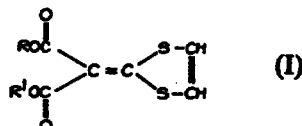
Paddy-rice seedlings (variety "Jikkoku"; height 20 cm) grown in a greenhouse were sprayed on a turn table by use of a spray gun (1.5 kg/cm²) with 10 ml per pot of a solution of each test compound at a given concentration. After 1 day, the seedlings were sprayed and inoculated with spores suspension of rice blast fungus cultured on rice straw, allowed to stand still in a greenhouse at 24°C for 24 hours, and then allowed to stand in a vinyl chamber in the greenhouse. 4 Days after the inoculation, the number of spots per leaf was counted to calculate the preventive value (%) of the compound. The results obtained were as shown in Table 3.

TABLE 3

Test Compound	Concentration (p.p.m.)	Number of spots per leaf	Preventive value (%)	Phyto-toxicity
1	500	2.5	90.4	None
2	"	2.2	91.6	None
3	"	0.5	98.0	None
4	"	1.6	93.8	None
5	"	5.2	80.1	None
IBP emulsion	480	3.4	87.0	None
Non-treatment	—	26.2	—	—

WHAT WE CLAIM IS:—

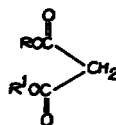
1. A 1,3-dithiol-2-ylidene malonate derivative represented by the general formula (I)



wherein R and R¹, which may be same or different, are individually an alkyl group having 1 to 4 carbon atoms.

2. Dimethyl 1,3-dithiol-2-ylidene malonate.
3. Diethyl 1,3-dithiol-2-ylidene malonate.
4. Diisopropyl 1,3-dithiol-2-ylidene malonate.
5. Di-n-propyl 1,3-dithiol-2-ylidene malonate.
6. Diisobutyl 1,3-dithiol-2-ylidene malonate.
7. Di-n-butyl 1,3-dithiol-2-ylidene malonate.
8. Ethyl isopropyl 1,3-dithiol-2-ylidene malonate.
9. Methyl isobutyl 1,3-dithiol-2-ylidene malonate.

10. A process for preparing a 1,3-dithiol-2-ylidene malonate derivative as claimed in claim 1, which comprises reacting a malonic ester represented by the general formula,



wherein R and R¹ are as defined in claim 1, with a dithiolium salt represented by the general formula,



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Test Example 3.

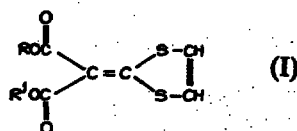
Test of preventive effect on rice blast (pot test):
Paddy-rice seedlings (variety "Jikkoku"; height 20 cm) grown in a greenhouse were sprayed on a turn table by use of a spray gun (1.5 kg/cm²) with 10 ml per pot of a solution of each test compound at a given concentration. After 1 day, the seedlings were sprayed and inoculated with spores suspension of rice blast fungus cultured on rice straw, allowed to stand still in a greenhouse at 24°C for 24 hours, and then allowed to stand in a vinyl chamber in the greenhouse. 4 Days after the inoculation, the number of spots per leaf was counted to calculate the preventive value (%) of the compound. The results obtained were as shown in Table 3.

TABLE 3

Test Compound	Concentration (p.p.m.)	Number of spots per leaf	Preventive value (%)	Phyto-toxicity
1	500	2.5	90.4	None
2	"	2.2	91.6	None
3	"	0.5	98.0	None
4	"	1.6	93.8	None
5	"	5.2	80.1	None
IBP emulsion	480	3.4	87.0	None
Non-treatment	—	26.2	—	

WHAT WE CLAIM IS:—

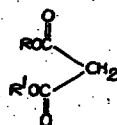
1. A 1,3-dithiol-2-ylidene malonate derivative represented by the general formula (I)



wherein R and R', which may be same or different, are individually an alkyl group having 1 to 4 carbon atoms.

2. Dimethyl 1,3-dithiol-2-ylidene malonate.
3. Diethyl 1,3-dithiol-2-ylidene malonate.
4. Diisopropyl 1,3-dithiol-2-ylidene malonate.
5. Di-n-propyl 1,3-dithiol-2-ylidene malonate.
6. Diisobutyl 1,3-dithiol-2-ylidene malonate.
7. Di-n-butyl 1,3-dithiol-2-ylidene malonate.
8. Ethyl isopropyl 1,3-dithiol-2-ylidene malonate.
9. Methyl isobutyl 1,3-dithiol-2-ylidene malonate.

10. A process for preparing a 1,3-dithiol-2-ylidene malonate derivative as claimed in claim 1, which comprises reacting a malonic ester represented by the general formula,



wherein R and R' are as defined in claim 1, with a dithiolium salt represented by the general formula,

(18)

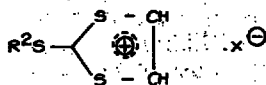


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wherein R^2 is an alkyl group having 1 to 4 carbon atoms or a benzyl group; and X is an anion residue, in an inert solvent in the presence of a base.

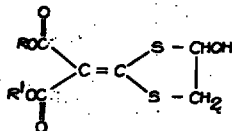
11. A process according to claim 10, wherein the inert solvent is an alcohol, acetic acid, dimethyl-formamide, dimethyl sulfoxide, tetrahydrofuran or dioxane.

12. A process according to claim 10 or claim 11 wherein the base is an inorganic base.

13. A process as claimed in claim 12 wherein the base is metallic sodium, sodium hydride, sodium alcoholate, sodium hydroxide or potassium hydroxide.

14. A process according to any of claims 10 to 13 wherein substantially equimolar amounts of said malonic ester and the dithiolium salt are used, and wherein from 1.0 to 1.5 moles of the base are used per one mole of the dithiolium salt.

15. A process for preparing a 1,3-dithiol-2-ylidene malonate derivative as claimed in claim 1 which comprises dehydrating a compound represented by the general formula,



wherein R and R' are as defined in claim 1, with a dehydrating agent, either directly or in an inert solvent.

16. A process according to claim 15 wherein the dehydrating agent is a sulfonic acid chloride.

17. A process according to claim 16 wherein the sulfonic acid chloride is chlorosulfonic acid, methane-sulfonic acid chloride or benzenesulfonic acid chloride.

18. A process according to claim 17, wherein substantially equimolar amounts of the sulfonic acid chloride and the 4-hydroxy-1,3-dithiolan-2-ylidene malonate are used.

19. A process according to claim 15 wherein the dehydrating agent is concentrated sulfuric acid.

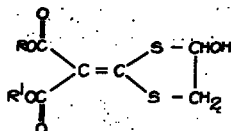
20. A process according to claim 19 wherein the amount of concentrated sulfuric acid is 0.5 to 50 parts by weight per part by weight of the 4-hydroxy-1,3-dithiolan-2-ylidene malonate.

21. A process according to claim 20 wherein the amount of the concentrated sulfuric acid is 10 to 20 parts by weight per part by weight of the 4-hydroxy-1,3-dithiolan-2-ylidene malonate.

22. A process according to any of claims 15 to 21 wherein the inert solvent is a chlorinated paraffin.

23. A process as claimed in claim 22 wherein the chlorinated paraffin is carbon tetrachloride.

24. A process for preparing a 1,3-dithiol-2-ylidene malonate derivative as claimed in claim 1 which comprises reacting a compound represented by the general formula,



wherein R and R' are as defined in claim 1, with a chlorinating agent in an inert solvent, and then subjecting the reaction product, either as it is or after isolation, to a dehydrochlorination reaction in the presence of a base.

25. A process according to claim 24, wherein the chlorinating agent is thionyl chloride, phosphorus trichloride, phosphorus oxychloride or phosphorus pentachloride.



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26. A process as claimed in claim 24 or claim 25 wherein the inert solvent is an aromatic hydrocarbon or an ether.
27. A process as claimed in claim 26 wherein the ether is diethyl ether, tetrahydrofuran or dioxane.
- 5 28. A process as claimed in claim 26 wherein the aromatic hydrocarbon is benzene or toluene.
29. A process as claimed in any of claims 24 to 28 wherein the base is an inorganic base or an organic base.
- 10 30. A process as claimed in claim 29 wherein the organic base is pyridine, triethylamine, dimethylaniline, diethylaniline or 1,8-diaza-bicyclo(5,4,0)undecene-7.
31. A process as claimed in claim 29 wherein the inorganic base is sodium or potassium hydroxide.
32. A process as claimed in any of claims 24 to 31 wherein the amount of the chlorinating agent is $1/3$ to 1 mole per mole of the 4-hydroxy-1,3-dithiolan-2-ylidene malonate.
- 15 33. A process as claimed in any of claims 24 to 32 wherein the amount of the base is from 1 to 2 moles per one mole of the 4-hydroxy-1,3-dithiolan-2-ylidene malonate.
34. A process as claimed in claim 14 wherein the amount of the malonic ester used is slightly in excess of the equimolar amount.
- 20 35. A process as claimed in claim 18 wherein the amount of the sulfonic acid chloride used is slightly in excess of the equimolar amount.
36. A process as claimed in any of claims 24 to 31 wherein the amount of the chlorinating agent used is slightly in excess of the equimolar amount.
- 25 37. An agricultural and horticultural fungicidal composition comprising an effective amount of a compound according to any claims of 1 to 9 and an inert diluent or carrier.
38. A 1,3-dithiol-2-ylidene malonate derivative as claimed in any of claims 1 to 9 when prepared by a process according to any of claims 10 to 36.
- 30 39. A method of treatment and/or prophylaxis of plant microbial or fungal diseases comprising the application of a compound as claimed in any of claims 1 to 9 to the plants and/or the surrounding ground.
40. A method of treatment and/or prophylaxis of rice blast comprising the application of a compound as claimed in any of claims 1 to 9 to the rice plants and/or onto the surrounding ground.
- 35 41. A method as claimed in claim 40 wherein the compound is applied through the paddy field water and/or soil.
42. A 1,3-dithiol-2-ylidene malonate derivative substantially as described hereinbefore with particular reference to Examples 1 to 11.
- 40 43. A process of preparing a 1,3-dithiol-2-ylidene malonate derivative substantially as described hereinbefore with reference to Examples 1 to 11.
44. An agricultural and horticultural fungicidal composition according to claim 37 and substantially as described hereinbefore.

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