

PATENT SPECIFICATION

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(54) PHTHALOCYANINE COMPOUNDS

(71) We, CIBA-GEIGY AG, a body corporate organised according to the laws of Switzerland, of Basle, Switzerland, 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:—

The present invention relates to novel phthalocyanine compounds.

It is known that certain dyes, for example, eosin, Bengal Rose, methylene blue and others, have a so-called photodynamic action, i.e. on irradiation with light, they act as catalysts for the oxidation of various substrates with oxygen [see, for example, G. O. Schenck, *Angew. Chem.* 69, 579 (1957)]. Because of this property, the said dyes also have a certain antimicrobial action [see, for example, Venkataraman, *The Chemistry of Synthetic Dyes*, Volume 4 (1971) pages 502—505 and C. J. Wallis, J. L. Melnick, *J. Bacteriol.* 89, 41 (1965)].

In our Application No. 11799/78 (Serial No. 1,593,623) we describe how water-soluble phthalocyanine compounds have, in the presence of oxygen and water and on irradiation with light, a particularly good action against microorganisms, as a result of photodeactivation. In particular the Application claims a process for combating microorganisms in or on organic or inorganic substrates and for protecting the said substrates against attack by microorganisms which comprises treating the substrates with water-soluble phthalocyanine compounds, in the presence of oxygen and water and while irradiating with visible and/or infrared light. The water-soluble phthalocyanine compounds required for carrying out the process are preferably metal complexes but also phthalocyanines without a central atom.

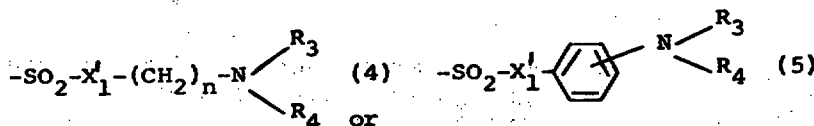
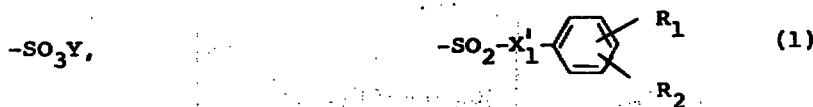
If they are to have the necessary solubility in water, the phthalocyanine compounds must be substituted on the phenyl nuclei by one or more groups conferring solubility in water, in particular sulphonic groups.

Some of the water-soluble phthalocyanine active compounds described are novel and these form the subject of the present invention.

The present invention provides phthalocyanine compounds which are free from sulphodichloride groups of the formula



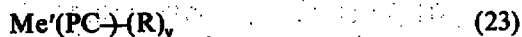
in which PC is the phthalocyanine ring system, v has a number from 1 to 4, Me' is Na, K, Ca, Mg or AlX, in which X is an anion, and R' is a group of the formula



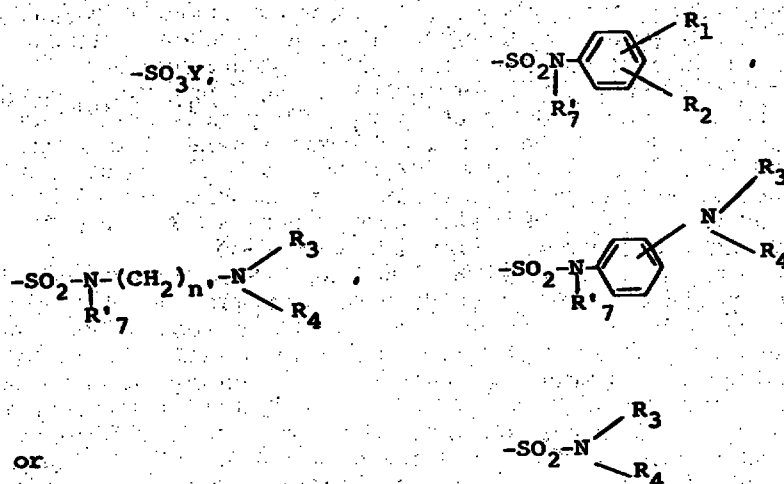
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in which Y is hydrogen or an alkali metal, ammonium or amine ion, X_1 is oxygen or a NH group, n is a number from 1 to 12, R_1 and R_2 , independently of one another are hydrogen, a sulfo group or a salt thereof, a carboxyl group or a salt thereof or a hydroxyl group with the proviso that at least one of the radicals R_1 and R_2 is a sulfo or carboxyl group or a salt thereof, and R_3 and R_4 , independently of one another are hydrogen, alkyl, hydroxyalkyl, cyanoalkyl or halogenoalkyl, all said alkyl moieties having 1 to 6 carbon atoms, or R_3 and R_4 together with the nitrogen atom to which they are bonded form a saturated 5-membered or 6-membered heterocyclic ring which additionally can contain a ring nitrogen or oxygen atom, for example a morpholine, piperidine, pyrazoline, piperazine or oxazolidine ring, and all the radicals R are bonded to the phenyl nuclei of the phthalocyanine ring system, and can be identical or different when $v > 1$. Halogen is preferably chlorine or bromine, especially chlorine.

Further compounds of the invention are those of the formula

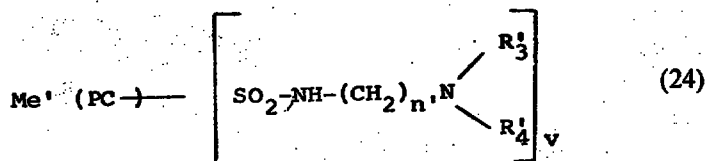


in which PC is the phthalocyanine ring system, v has any desired value between 1 and 4, Me' is Na, K, Ca, Mg or AlX, in which X is an anion, preferably a halide, sulphate, nitrate, acetate or hydroxyl ion, and R is a group of the formula



in which Y is hydrogen or an alkali metal, ammonium or amine ion, R_7 is hydrogen or alkyl having 1 to 4 carbon atoms, n is an integer from 2 to 6, R_1 and R_2 , independently of one another are hydrogen, a sulfo group and salts thereof, a carboxyl group and salts thereof or a hydroxyl group and at least one of the radicals R_1 and R_2 is a sulfo or carboxyl group or a salt thereof, and R_3 and R_4 , independently of one another are hydrogen, alkyl, hydroxyalkyl, cyanoalkyl, sulfoalkyl, carboxyalkyl or halogenoalkyl, having, in each case, 1 to 6 carbon atoms, or phenyl, or R_3 and R_4 together with the nitrogen atom to which they are bonded are a saturated 5-membered or 6-membered heterocyclic ring which additionally can also contain a nitrogen atom or oxygen atom as a ring member, and the radicals R are bonded to the phenyl nuclei of the phthalocyanine ring system and can be identical or different, when $v > 1$.

Preferred compounds of the formula (23) are those of the formula



in which PC, Me' , N' and v are as defined in formula (23) and R_3 and R_4 , independently of one another are hydrogen, phenyl, sulphonyl, carboxyphenyl or alkyl, hydroxyalkyl, cyanoalkyl, sulfoalkyl, carboxyalkyl or halogeno-

alkyl having, in each case, 1 to 6 carbon atoms, or together with the nitrogen atom form a morpholine ring.

Preferred compounds are those of the formula



in which Me', PC and Y are as defined above and v' has any desired value from 1 to 4, especially from 1.5 to 4.

Compounds of particular interest are those of the formula



in which PC, Y and v' are as defined in formula (25) and X' is an anion from the group comprising OH⁻, SO₄²⁻, Cl⁻, Br⁻ and CH₃COO⁻.

In this formula X' is preferably Cl⁻. Y is hydrogen, sodium or potassium and v' is any desired number between 1 and 4.

The phthalocyanine compounds can be prepared according to processes which are known per se.

In order to introduce substituents conferring solubility in water, the unsubstituted phthalocyanine or metal complexes thereof can be used as the starting material. Sulphonation (for example with 26% strength oleum) results in the corresponding sulphonic acids, products of different degrees of sulphonation being formed depending on the sulphonation time and temperature. Sulphonation of the unsubstituted phthalocyanine, for example at 45 to 60°C, gives the disulphonic acid. The conversion of the products into salts can be effected in a known manner.

Reaction of unsubstituted metal-free or metallised phthalocyanines with chlorosulphonic acid gives the corresponding sulphochloride compounds. Reaction of the resulting sulphochloride-phthalocyanines with correspondingly substituted aliphatic or aromatic amines or alcohols or phenols gives the phthalocyanines which are substituted by sulphonamide groups or, respectively, sulphonic acid ester groups of the formulae (1), (4), or (5). Saponification of the sulphochloride compounds results in the corresponding sulphonic acids.

The phthalocyanines can also be obtained, for example, when the correspondingly substituted phthalic anhydride or phthalodinitrile is used as the starting material and this is reacted in a known manner to give the phthalocyanine ring system. When substituted phthalodinitrile is used, this, if desired together with a metal salt, it cyclised in the melt or in solution or suspension to give the phthalocyanine ring system. When the corresponding phthalic anhydride is used, urea and, if appropriate, a catalyst, for example boric acid or ammonium molybdate, are additionally added before the reaction.

Some metal complexes of substituted phthalocyanines cannot be prepared simply by substitution (as described above) of the unsubstituted complexes or by ring synthesis. In this case, the correspondingly substituted metal-free compounds can first be prepared and these can then be reacted with a metal salt or metal alcoholate in a solvent. Solvents which can be used are, for example, mixtures of water and organic solvents, especially including tertiary amines or also anhydrous solvents, for example pyridine or chlorobenzenes. This mode of preparation is chosen, in particular, for complexes which can be hydrolysed relatively easily, for example those of the alkali metals and alkaline earth metals.

Metal complexes can, of course, also be converted into other metal complexes; these can likewise be hydrolysed to metal-free phthalocyanine compounds with the aid of acids.

The following Examples further illustrate the present invention; all percentages are by weight unless otherwise stated. The abbreviation PC represents unsubstituted phthalocyanine in all examples.

Example 1

0.67 g of metal-free phthalocyaninedisulphonic acid is dissolved in 100 ml of a mixture of pyridine/water (1:1) and 0.27 g of aluminium chloride is added. The solution is refluxed for 2 hours and evaporated in a rotary evaporator. The residue is taken up in 75 ml of water and the solution is neutralized with 1 N ammonia and evaporated again, whereupon the aluminium complex of phthalocyanine-disulphonic acid remains.

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Example 1a

2.66 g of aluminium chloride are added to a solution of 6.76 g of phthalocyanine-disulphonic acid, with an absorption maximum of 612 nm in a buffer solution of pH 7 (0.01 mol/l of sodium hydrogen phosphate/0.007 mol/l of potassium dihydrogen phosphate), in 500 ml of a 1:1 pyridine/water mixture. The solution is refluxed for 2 hours and then evaporated in a rotary evaporator. The residue is taken up in 75 ml of water and the solution is neutralised with ammonia. The aluminium complex of disulphonated phthalocyanine with an absorption maximum of 675 nm (buffer solution of pH 7) is obtained.

Example 2

The following metal complexes of phthalocyaninedisulphonic acid (S=sulphonic acid group): MgPCS_2 , MgPCS_{3-4} , CaPCS_2 , CaPCS_{3-4} , the sodium complex of phthalocyaninedisulphonic acid and the potassium complex of phthalocyaninedisulphonic acid, are obtained by the process described in Example 1 by reacting the free phthalocyanine-sulphonic acids with the equivalent amount of MgCl_2 , CaCl_2 , NaOCH_3 and KOCH_3 respectively.

Example 2a

The procedure indicated in Example 1a is repeated, but salts of Mg or Ca are used, affording the corresponding phthalocyanines listed in Table 1 below.

TABLE 1

Metal salt	Phthalocyanine derivative	λ max in H_2O , pH 9 (nm)
MgCl_2	$\text{Mg}(\text{PC})(\text{SO}_3\text{H})_2$	669
CaCl_2	$\text{Ca}(\text{PC})(\text{SO}_3\text{H})_2$	653

Example 3

a) 52.5 g of phthalic anhydride, 64 g of urea, 1 g of ammonium molybdate and 27 g of sodium m-xylenesulphonate are stirred in 175 g of trichlorobenzene and the resulting mixture is mixed with a suspension of 15 g of anhydrous aluminium chloride in 25 g of trichlorobenzene. After stirring for 6 hours at 200 to 205°C, 27 g of urea and 50 g of trichlorobenzene are added and the mixture is stirred for a further 5 hours at 200 to 205°C. The suspension is filtered cold and the residue is washed with chlorobenzene and methanol and then purified by boiling thoroughly in dilute hydrochloric acid and in dilute sodium hydroxide solution and finally in dilute hydrochloric acid again. After drying, 34 g of an aluminium complex of phthalocyanine are obtained and according to analysis this has the formula



b) 20 g of this aluminium complex of phthalocyanine are stirred in 220 ml of 30% strength oleum for 8 hours at 73 to 75°C and, after cooling to room temperature, the resulting solution is poured onto ice and 10% strength sodium chloride solution, the suspension is filtered and the residue is washed with 10% strength sodium chloride solution and then with 1 N hydrochloric acid and dried in vacuo at 90°C. Yield: 22 g.

The product has the formula



λ max=671 nm (in H_2O , pH 9).

Any other desired aluminium salt can also be employed in step a) in place of aluminium chloride. Depending on the nature of the anion, aluminium complexes of phthalocyanine derivatives in which the third valency of the aluminium is saturated by any other desired anion (for example, sulphate, acetate or hydroxyl) instead of by chlorine are obtained in this way, in this example and in the examples which follow.

Example 4

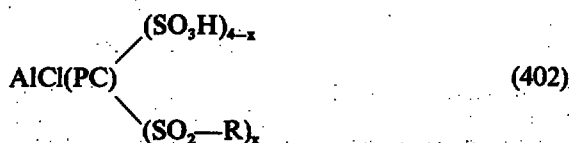
a) 20 g of the aluminium complex of phthalocyanine prepared according to Example 3a) are introduced at 20 to 25°C into 140 ml of chlorosulphonic acid and the mixture is stirred for 30 minutes. The temperature is then raised to 135 to

140°C in the course of 2 hours. After stirring for 4 hours, the reaction mixture is cooled to room temperature and poured onto ice. The suspension is filtered and the material on the filter is washed acid-free with ice-water.

b) The moist suction filter cake is stirred in 500 ml of ice-water, N,N-diethyl-ethylenediamine is added and the pH of the mixture is kept at 8 to 9 by adding 10% strength sodium hydroxide solution, with stirring. After stirring for 2 hours at 0 to 25°C, the temperature is raised to 60 to 70°C and this temperature is maintained for 5 hours. All of the product is precipitated by adding sodium chloride and is filtered off and dried in vacuo at 70 to 80°C. The compound thus obtained has the formula



If the aluminium complex of the phthalocyaninetetrasulphochloride obtained according to Example 4a) is reacted in an analogous manner with other amines, the compounds of the general formula



listed in Table 2 in which follows are obtained.

TABLE 2

Formula No.	R	x	Amine used
407	$-\text{NHCH}_2\text{CH}_2\text{CH}_2\text{N}(\text{CH}_3)_2$	4	$\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{N}(\text{CH}_3)_2$
412	$-\text{NH}-\text{C}_6\text{H}_4-\text{COOH}$	1.5	$\text{H}_2\text{N}-\text{C}_6\text{H}_4-\text{COOH}$
413	$-\text{NH}-\text{C}_6\text{H}_3(\text{SO}_3\text{H})-\text{COOH}$	1	$\text{H}_2\text{N}-\text{C}_6\text{H}_3(\text{SO}_3\text{H})-\text{COOH}$

Example 5

20 g of the aluminium complex of the phthalocyanine-tetrasulphochloride prepared according to Example 4a) are introduced into 500 ml of water and hydrolysed by adding sodium hydroxide solution, at 60 to 70°C, and the reaction mixture is then evaporated to dryness. This gives 25 g of the aluminium complex of phthalocyanine-tetrasulphonic acid (Na salt) of the formula



$\lambda_{\text{max}}=672.75 \text{ nm}$ (in H_2O , pH 9).

The same compound is also obtainable by sulphonation of the aluminium complex of the unsubstituted phthalocyanine (obtainable according to Example 3a) with 60% strength oleum at 70 to 75°C.

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Example 6

a) 20 g of the aluminium complex of phthalocyanine prepared according to Example 3a) are introduced at 25°C into 150 ml of chlorosulphonic acid and the mixture is stirred for 30 minutes. The reaction mixture is then warmed to 65 to 70°C and 32ml of thionyl chloride are added dropwise in the course of 20 minutes. The temperature is then raised to 110 to 115°C in the course of 2 hours and this temperature is maintained for 6 hours. After cooling to 25°C, the reaction mass is discharged onto ice in such a way that the temperature does not exceed 0°C. The suspension is filtered and the material on the filter is washed acid-free with ice-water.

b) The moist filter cake, consisting of the aluminium complex of phthalocyanine-trisulphochloride, is stirred in 500 ml of ice-water and 32 g of 1-amino - 3 - dimethylaminopropane are added. After stirring for 15 hours at 20 to 30°C, the temperature is raised to 60 to 70°C for a further 4 hours. The suspension is filtered and the residue is washed with 500 ml of warm water and dried in vacuo at 70 to 80°C. This gives the compound of the formula



$\lambda_{\text{max}}=675.5 \text{ nm}$ (in H_2O , pH 7).

The compounds of the formula



listed in Table 3 which follows, can be obtained in an analogous manner by reacting the aluminium complex of phthalocyanine-trisulphochloride, obtained according to Example 6a), with a corresponding amine.

TABLE 3

Formula No.	R	Starting compound HR used
603	$-\text{NH}-\text{CH}_2\text{CH}_2-\text{N}(\text{CH}_3)_2$	$\text{H}_2\text{N}-\text{CH}_2\text{CH}_2-\text{N}(\text{CH}_3)_2$
604	$-\text{NH}-\text{C}_6\text{H}_4-\text{N}(\text{CH}_3)_2$	$\text{H}_2\text{N}-\text{C}_6\text{H}_4-\text{N}(\text{CH}_3)_2$

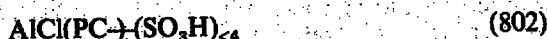
Example 7

20 g of the aluminium complex of phthalocyanine obtained according to Example 3a) are stirred in 240 ml of 33% strength oleum for 7 hours at 73 to 75°C. The reaction mixture, which has been cooled to 25°C, is discharged onto a mixture of 1,000 g of ice and 200 g of sodium chloride. The temperature is kept at 0 to 20°C by further addition of ice. The suspension is filtered and the filter residue is washed with a 10% strength sodium chloride solution until neutral. It is then also washed with 300 ml of 10% strength hydrochloric acid. The product is dried in vacuo at 80°C. The product obtained in this way has the formula



$\lambda_{\text{max}}=671 \text{ nm}$ (in H_2O , pH 9).

If the sulphonation described above is carried out using 40% strength oleum, this gives a product of the formula



$\lambda_{\text{max}}=671.75$ (in H_2O , pH 9).

WHAT WE CLAIM IS:—

1. A phthalocyanine compound which is free from sulphochloride groups, of the formula



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Example 6

a) 20 g of the aluminium complex of phthalocyanine prepared according to Example 3a) are introduced at 25°C into 150 ml of chlorosulphonic acid and the mixture is stirred for 30 minutes. The reaction mixture is then warmed to 65 to 70°C and 32ml of thionyl chloride are added dropwise in the course of 20 minutes. The temperature is then raised to 110 to 115°C in the course of 2 hours and this temperature is maintained for 6 hours. After cooling to 25°C, the reaction mass is discharged onto ice in such a way that the temperature does not exceed 0°C. The suspension is filtered and the material on the filter is washed acid-free with ice-water.

b) The moist filter cake, consisting of the aluminium complex of phthalocyanine-trisulphochloride, is stirred in 500 ml of ice-water and 32 g of 1-amino - 3 - dimethylaminopropane are added. After stirring for 15 hours at 20 to 30°C, the temperature is raised to 60 to 70°C for a further 4 hours. The suspension is filtered and the residue is washed with 500 ml of warm water and dried in vacuo at 70 to 80°C. This gives the compound of the formula



$\lambda_{\text{max}}=675.5 \text{ nm}$ (in H_2O , pH 7).

The compounds of the formula



listed in Table 3 which follows, can be obtained in an analogous manner by reacting the aluminium complex of phthalocyanine-trisulphochloride, obtained according to Example 6a), with a corresponding amine.

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Example 7

20 g of the aluminium complex of phthalocyanine obtained according to Example 3a) are stirred in 240 ml of 33% strength oleum for 7 hours at 73 to 75°C. The reaction mixture, which has been cooled to 25°C, is discharged onto a mixture of 1,000 g of ice and 200 g of sodium chloride. The temperature is kept at 0 to 20°C by further addition of ice. The suspension is filtered and the filter residue is washed with a 10% strength sodium chloride solution until neutral. It is then also washed with 300 ml of 10% strength hydrochloric acid. The product is dried in vacuo at 80°C. The product obtained in this way has the formula



$\lambda_{\text{max}}=671 \text{ nm}$ (in H_2O , pH 9).

If the sulphonation described above is carried out using 40% strength oleum, this gives a product of the formula



$\lambda_{\text{max}}=671.75$ (in H_2O , pH 9).

WHAT WE CLAIM IS:—

1. A phthalocyanine compound which is free from sulphochloride groups, of the formula

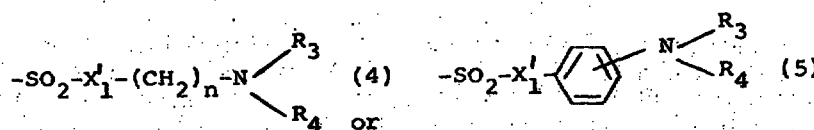
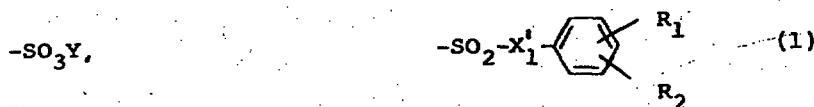




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in which PC is a phthalocyanine ring system, v has a number from 1 to 4, Me' is Na, K, Ca, Mg or AlX, in which X is an anion, and the or each R' is independently a group of the formula

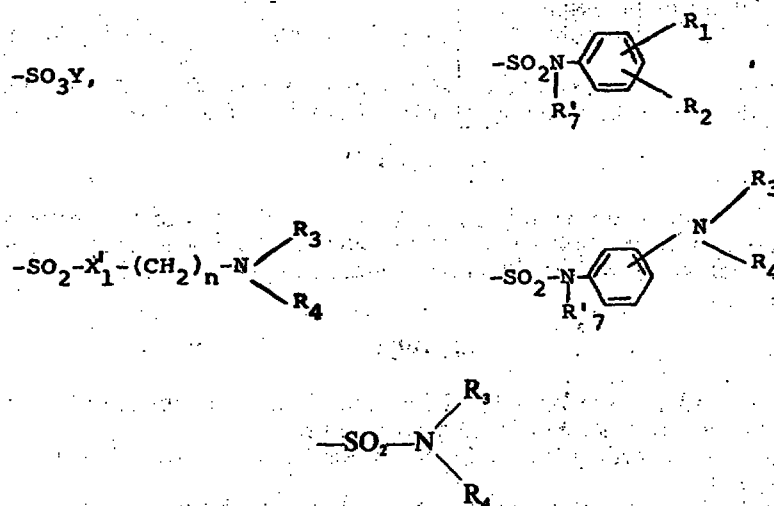


in which Y is hydrogen or an alkali metal, ammonium or amine ion, X' is oxygen or a NH group, n is a number from 1 to 12, R₁ and R₂ independently of one another are hydrogen, a sulfo group or a salt thereof, a carboxyl group or a salt thereof or a hydroxyl group with the proviso that at least one of the radicals R₁ and R₂ is a sulfo or carboxyl group or a salt thereof, and R₃ and R₄ independently of one another are hydrogen, alkyl, hydroxyalkyl, cyanoalkyl or halogenoalkyl, all said alkyl moieties having 1 to 6 carbon atoms, or R₃ and R₄ together with the nitrogen atom to which they are bonded form a saturated 5-membered or 6-membered heterocyclic ring which additionally can contain a ring nitrogen or oxygen atom, and all the R radicals are bonded to the phenyl nuclei of the phthalocyanine ring system and can be identical or different, when v > 1.

2. A phthalocyanine compound according to claim 1, of the formula



in which PC is a phthalocyanine ring system, v has a number from 1 to 4, Me' is Na, K, Ca, Mg or AlX, in which X is an anion and R is a group of the formula



in which Y is hydrogen or an alkali metal, ammonium or amine ion, R'₇ is hydrogen or alkyl having 1 to 4 carbon atoms, n' is an integer from 2 to 6, R₁ and R₂ independently of one another are hydrogen, a sulfo group or a salt thereof, a carboxyl group or a salt thereof or a hydroxyl group with the proviso that at least one of the radicals R₁ and R₂ is a sulfo or carboxyl group or a salt thereof, and R₃ and R₄ independently of one another are hydrogen, alkyl, hydroxyalkyl, cyanoalkyl, sulfoalkyl, carboxyalkyl or halogenoalkyl, having, in each case, 1 to 6 carbon atoms, or phenyl, or R₃ and R₄ together with the nitrogen atom to which they are bonded form a saturated 5-membered or 6-membered heterocyclic ring which additionally can contain a ring nitrogen or oxygen atom, and the radicals R

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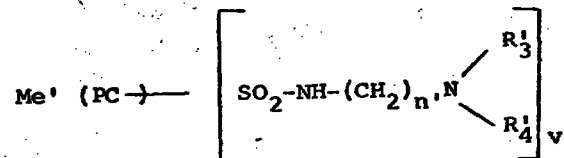
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are bonded to the phenyl nuclei of the phthalocyanine ring system and can be identical or different, when $V > 1$.

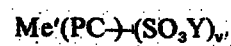
3. A phthalocyanine compound according to claim 2, of the formula



5 in which PC, Me', n' and v are as defined in claim 2 and R₃' and R₄' independently of one another are hydrogen, phenyl, sulphophenyl, carboxyphenyl or alkyl, hydroxyalkyl, cyanoalkyl, sulphoalkyl, carboxyalkyl or halogenoalkyl having, in each case, 1 to 6 carbon atoms, or together with the nitrogen atom form a morpholine ring.

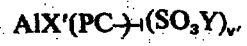
10 4. A phthalocyanine compound according to claim 2 or 3, in which Me is Al(X), in which X is as defined in claim 2.

5. A phthalocyanine compound according to claim 2, of the formula



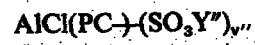
15 in which Me', PC and Y are as defined in claim 2 and v' has a number from 1 to 4.

6. A phthalocyanine compound according to claim 5, of the formula



in which PC, Y and v' are as defined in claims 5 and X' is OH⁻, SO₄²⁻, Cl⁻, Br⁻ or CH₃COO⁻.

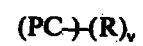
7. A phthalocyanine compound according to claim 6, of the formula



20 in which PC is as defined in claim 6, v'' is a number from 1 to 4 and Y'' is hydrogen, sodium or potassium.

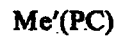
8. A phthalocyanine compound as defined in claim 1 specifically identified herein.

25 9. A process for the preparation of a phthalocyanine as defined in claim 1, which comprises reacting a metal-free phthalocyanine of the formula



in which PC, R and v are as defined in claim 1, with a salt of the metal Me'.

30 10. A process for the preparation of a sulphonated phthalocyanine as defined in claim 5, which comprises sulphonating a metal complex of a phthalocyanine, of the formula



in which Me' and PC are as defined in claim 5, with oleum and, if desired, converting the resulting sulphonic acid into a salt.

35 11. A process according to claim 9 or 10 substantially as described in any one of the Examples.

12. A phthalocyanine compound as defined in claim 1 whenever prepared by a process as claimed in any one of claims 9 to 11.

40 13. A phthalocyanine compound according to any one of claims 1 to 8 which is substantially pure.

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