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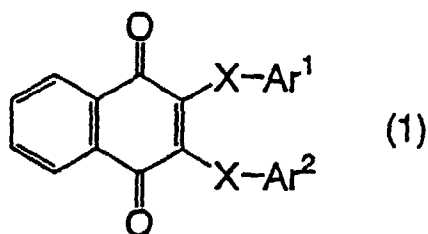
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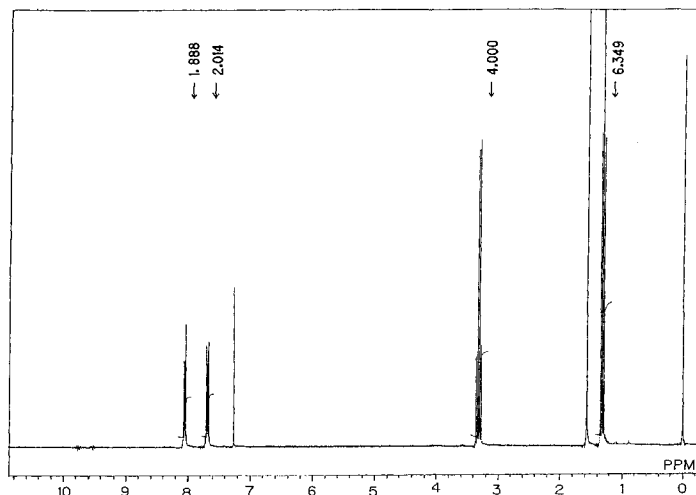
(54) **Naphthoquinone derivative and electrophotosensitive material using the same**

(57) A naphthoquinone derivative represented by the general formula (1):



wherein X represents a sulfur atom or an oxygen atom; and Ar¹ and Ar² are the same or different and represent an alkyl group, or a phenyl group which may have a substituent. An electrophotosensitive material comprising a conductive substrate and a photosensitive layer provided on the conductive substrate, the photosensitive layer containing the naphthoquinone derivative (1).

FIG. 2



Description

BACKGROUND OF THE INVENTION

The present invention relates to a naphthoquinone derivative having excellent electric charge transferring capability, and an electrophotosensitive material containing this naphthoquinone derivative, which is used in image forming apparatuses such as electrostatic copying machines, facsimile machines, laser beam printers and the like.

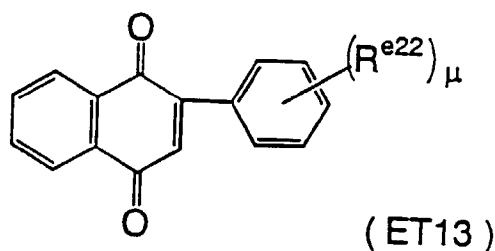
In the above image forming apparatuses, various photoconductors having a sensitivity at the wavelength range of a light source used in said apparatuses have recently been used. One type is an inorganic photoconductor using an inorganic material such as selenium in a photosensitive layer and another type is an organic photoconductor (OPC) using an organic material in a photosensitive layer. The organic photoconductor has widely been studied because of easy production in comparison with the inorganic photoconductor, various selective photosensitive materials (e.g. electric charge transferring material, electric charge generating material, binding resin, etc.) and high functional design freedom.

Examples of the organic photoconductor include a multi-layer type photoconductor comprising an electric charge generating layer containing an electric charge generating material and an electric charge transferring layer containing an electric charge transferring material, which are mutually laminated, and a single-layer type photoconductor wherein an electric charge generating material and an electric charge transferring material are dispersed in a single photosensitive layer. Among them, the photoconductor put into practical use is generally a multi-layer type, and a multi-layer type photoconductor provided with an electric charge transferring layer having a film thickness larger than that of an electric charge generating layer as an outer-most layer is more general in view of mechanical strength.

Electric charge transferring materials having high carrier mobility are used in these photoconductors. However, the majority of electric charge transferring materials having high carrier mobility show hole transferring properties. Therefore, the multi-layer type photoconductor provided with the electric charge transferring layer at the outermost layer becomes a negative charging type.

However, since the negative charging type organic photoconductor must be charged by negative-polarity corona discharge which causes generation of a large amount of ozone, problems arise, such as the effect of ozone on the environment, deterioration of the photoconductor, etc.

Therefore, in order to solve these problems, the use of an electron transferring material as the electric charge transferring material has been studied. In Japanese Laid-Open Patent Publication No. 206349/1989, it is suggested that a compound having a diphenoquinone structure or a benzoquinone structure is used as the electron transferring material. In Japanese Laid-Open Patent Publication No. 110227/1994, it is suggested that a naphthoquinone derivative represented by the general formula (ET13):



(wherein R^{e22} represents a halogen atom, an alkyl group which have a substituent, a phenyl group which may have a substituent, an alkoxy carbonyl group, a N-alkylcarbamoyl group, a cyano group or a nitro group; and μ represents any one of integers 0 to 3; provided that each R^{e22} may be different when μ is 2 or more) is used as an electron transferring material.

However, since it is difficult to match conventional electron transferring materials such as a compound having the above diphenoquinone structure or benzoquinone derivative, a naphthoquinone derivative represented by the above general formula (ET13), etc. and the electric charge generating material, the injection of electrons from the electric charge generating material into the electron transferring material is insufficient. Furthermore, since the electron transferring material has poor compatibility with a binding resin and is not uniformly dispersed in the photosensitive layer, the hopping distance of electrons becomes longer and electron movement at low electric field hardly arises.

Accordingly, a photoconductor containing a conventional electron transferring material has problems such as high residual potential and insufficient sensitivity, as is apparent from an electric characteristics test described in the following

Examples.

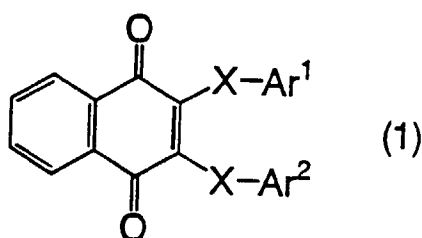
The single-layer type photoconductor has an advantage that one photoconductor can be used in both positive charging and negative charging types by using the electron transferring material in combination with the hole transferring material. However, when using the above diphenoquinone derivative or naphthoquinone derivative (ET13) as the electron transferring material, there arises a problem that a charge-transfer complex is formed by the interaction with the hole transferring material, thereby inhibiting the transferring of electrons and holes.

SUMMARY OF THE INVENTION

The present invention seeks to solve the above technical problems and to provide a novel compound which is suitable as an electron transferring material in an electrophotosensitive material.

The present invention also seeks to provide an electrophotosensitive material whose sensitivity is improved in comparison with a conventional one.

The present inventors have studied intensively in order to solve the above problems. As a result, the present inventors have found that a naphthoquinone derivative represented by the general formula (1):



(wherein X represents a sulfur atom or an oxygen atom; and Ar¹ and Ar² are the same or different and represent an alkyl group, or a substituted or unsubstituted phenyl group has an electron transferring capability higher than that of a conventional electron transferring material, such as a compound having a diphenoquinone structure or benzoquinone structure, a naphthoquinone derivative represented by the above general formula (ET13), etc., and is superior in compatibility with a binding resin. Thus, according to the present invention, there is provided a naphthoquinone derivative represented by the general formula (1).

The naphthoquinone derivative (1) is superior in electron acceptance properties because the sulfur atom or oxygen atom is substituted on the naphthoquinone ring, and is also superior in compatibility with a binding resin because of an action of an alkyl group or phenyl group substituted on the above sulfur atom or oxygen atom and, therefore, the naphthoquinone derivative is uniformly dispersed in the photosensitive layer. Since the naphthoquinone derivative is superior in matching with the electric charge generating material, the injection of electrons from the electric charge generating material is smoothly performed. Accordingly, the naphthoquinone (1) shows excellent electric charge transferring properties even at low electric field, and can be suitably used as the electron transferring material in the electrophotosensitive material.

Furthermore, since the above naphthoquinone derivative (1) does not form a charge-transfer complex, together with the hole transferring material, it can be suitably used in the single-layer type photosensitive layer using the electron transferring material in combination with the hole transferring material.

On the other hand, the electrophotosensitive material of the present invention is characterized by comprising a conductive substrate and a photosensitive layer provided on the conductive substrate, the photosensitive layer comprising the naphthoquinone derivative represented by the above general formula (1).

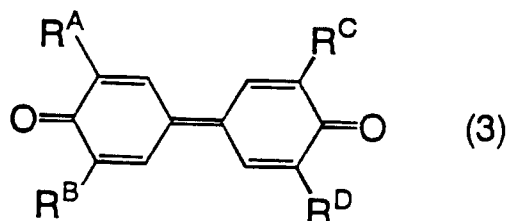
Such an electrophotosensitive material is superior in electron transferring properties at low electric fields because the naphthoquinone derivative (1) has excellent characteristics in the photosensitive layer, as described above. Furthermore, since the probability of recombination between electrons and holes in the photosensitive layer is low, an apparent electric charge generation efficiency approaches a practical value of the electric charge generation efficiency. As a result, the electrophotosensitive material of the present invention has a residual potential lower than that of an electrophotosensitive material containing a conventional electron transferring material, and has high sensitivity. Furthermore, stability and durability are improved when performing repeated exposures.

Since the above naphthoquinone derivative (1) does not form a charge-transfer complex, together with the hole transferring material, as described above, a photosensitive material having higher sensitivity can be obtained by using an electron transferring material and a hole transferring material in the same photosensitive layer in a single-layer type photosensitive layer.

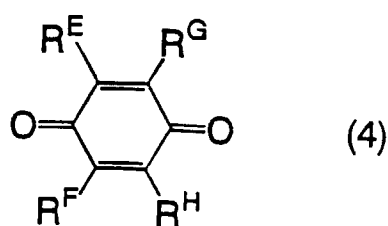
Furthermore, when the photosensitive layer contains a compound having a redox potential of -0.8 to -1.4 V as the

other electron transferring material, together with the naphthoquinone derivative (1) (electron transferring material), the sensitivity of the photosensitive material is further improved. This reason is believed to be as follows. Since the other electron transferring material has the function of drawing electrons from the electric charge generating material to transmit them to the naphthoquinone derivative (1) as the main electron transferring material, the injection of electrons from the electric charge generating material into the naphthoquinone derivative (1) becomes smoother.

Particularly considering the combination with the naphthoquinone derivative (1) as a main electron transferring material, the other electron transferring material is preferably a diphenoquinone derivative represented by the general formula (3):



wherein R^A , R^B , R^C and R^D are the same or different and represent a hydrogen atom, an alkyl group, an aryl group, an aralkyl group, a cycloalkyl group, an alkoxy group, or a substituted or unsubstituted amino group, or a benzoquinone derivative represented by the general formula (4):



wherein R^E , R^F , R^G and R^H are the same or different and represent a hydrogen atom, an alkyl group, an aryl group, an aralkyl group, a cycloalkyl group, an alkoxy group, or a substituted or unsubstituted amino group.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph illustrating a relation between a tractive voltage (V) and the current (μ A) for obtaining a redox potential.

Fig. 2 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (11-1).

Fig. 3 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (11-2).

Fig. 4 is a graph illustrating an infrared absorption spectrum of the naphthoquinone derivative (11-3).

Fig. 5 is a graph illustrating an infrared absorption spectrum of the naphthoquinone derivative (11-4).

Fig. 6 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-1).

Fig. 7 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-2).

Fig. 8 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-3).

Fig. 9 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-4).

Fig. 10 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-5).

Fig. 11 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-6).

Fig. 12 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-7).

Fig. 13 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-8).

Fig. 14 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-9).

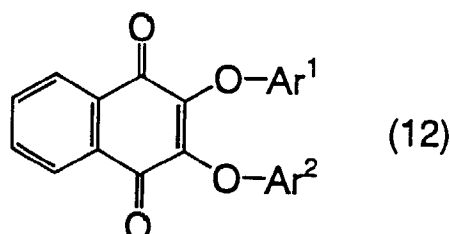
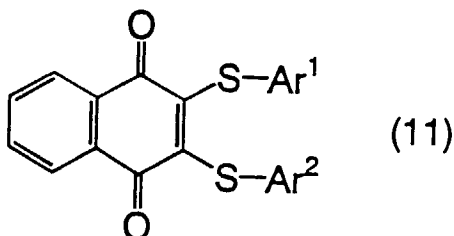
Fig. 15 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-10).

Fig. 16 is a graph illustrating a $^1\text{H-NMR}$ spectrum of the naphthoquinone derivative (12-11).

DETAILED DESCRIPTION OF THE INVENTION

First, the naphthoquinone derivative (1) of the present invention will be described in detail.

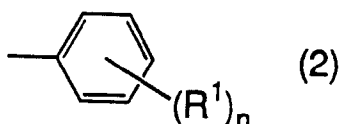
The naphthoquinone derivative (1) of the present invention is, more specifically, represented by the general formulas (11) and (12):



wherein Ar¹ and Ar² are as defined above.

In the above general formula (1), examples of the alkyl group corresponding to the substituents Ar¹ and Ar² include groups having 1 to 6 carbon atoms, such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, s-butyl, t-butyl, n-pentyl, n-hexyl and the like.

In the above general formula (1), examples of the phenyl group which may have a substituent, corresponding to the substituents Ar¹ and Ar², include phenyl groups represented by the group (2):



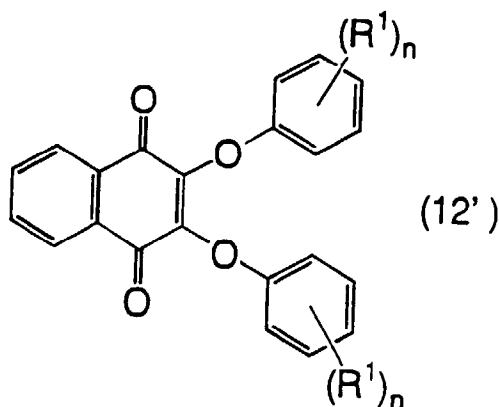
wherein R¹ represents an alkyl group, a halogenated alkyl group, an aryl group, an aralkyl group, an alkoxy group, an aryloxy group, an aralkyloxy group, an acyl group, an alkoxycarbonyl group, an aryloxycarbonyl group, an aralkyloxycarbonyl group or a nitro group; and n represents any one of integers 0 to 3.

Among the groups corresponding to the above group R¹, examples of the alkyl group include the same alkyl groups as described above. Examples of the halogenated alkyl group include groups wherein a halogen atom such as fluorine, chlorine, bromine, iodine, etc. is substituted on any position of the above alkyl group. Examples of the aryl group include groups such as phenyl, tolyl, xylol, naphthyl, anthryl, phenanthryl, fluorenyl, biphenyl, o-terphenyl and the like. Examples of the aralkyl group include groups such as benzyl, benzydryl, trityl, phenethyl and the like. Examples of the alkoxy group include groups having 1 to 6 carbon atoms, such as methoxy, ethoxy, n-propoxy, isopropoxy, t-butoxy, n-pentyloxy, n-hexyloxy and the like. Examples of the aryloxy group include groups such as phenoxy and the like. Examples of the aralkyloxy group include groups such as benzyloxy and the like. Examples of the acyl group include groups having 1 to 6 carbon atoms (alkanoyl group), such as acetyl, propionyl, butyryl, isobutyryl, valeryl, pivaloyl, hexanoyl, etc. and groups such as benzoyl, naphthoyl, toluoyl, benzylcarbonyl, etc. Examples of the alkoxycarbonyl include groups such as methoxycarbonyl and the like. Examples of the aryloxycarbonyl group include groups such as

phenoxy carbonyl and the like. Examples of the aralkyloxycarbonyl group include groups such as benzyloxycarbonyl and the like. Examples of the alkoxy portion in the above alkoxy carbonyl group include the same groups as those for alkoxy group. Examples of the aryl portion in the above aryloxy group and aryloxycarbonyl group include the same groups as those for aryl group. Examples of the aralkyl portion in the above aralkyloxy group and aralkyloxycarbonyl group include the same groups as those for aralkyl group.

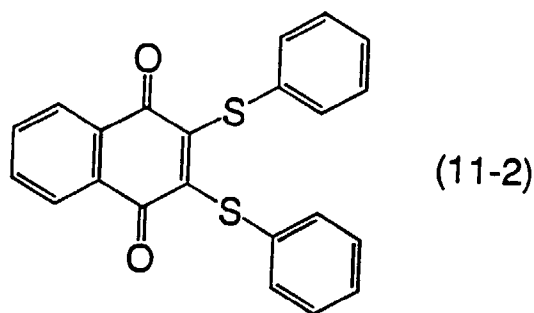
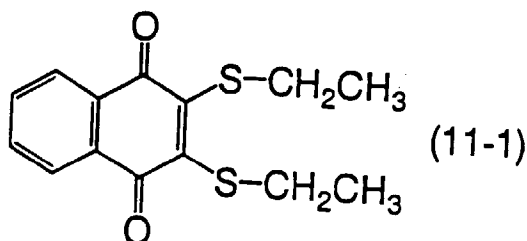
In the above formula (2), n represents an integer of 0 to 3, preferably 0 to 2.

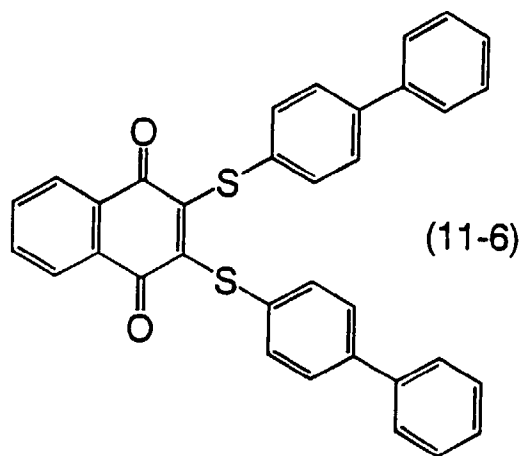
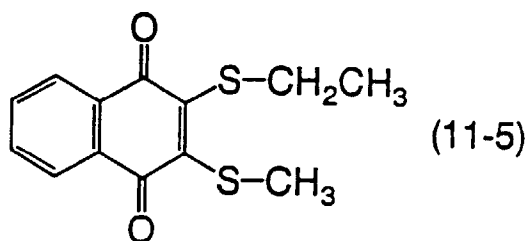
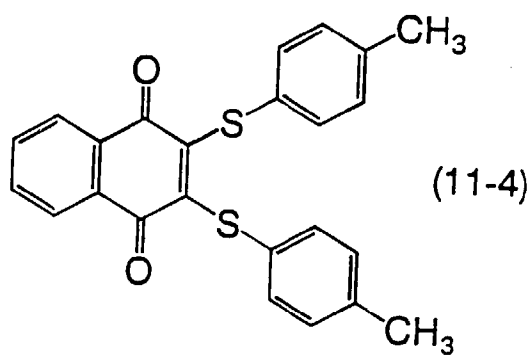
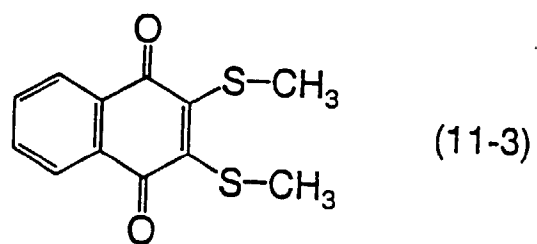
The naphthoquinone derivative represented by the above general formula (12) is preferably a phenyl group which may have a substituent, wherein the group Ar¹ and Ar² are represented by the above formula (2), as represented by the following general formula (12'):

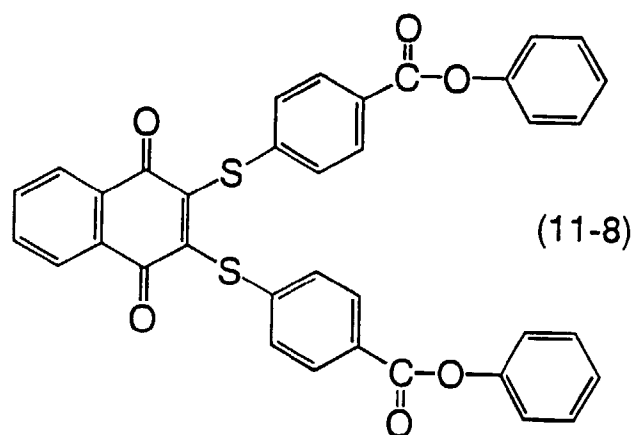
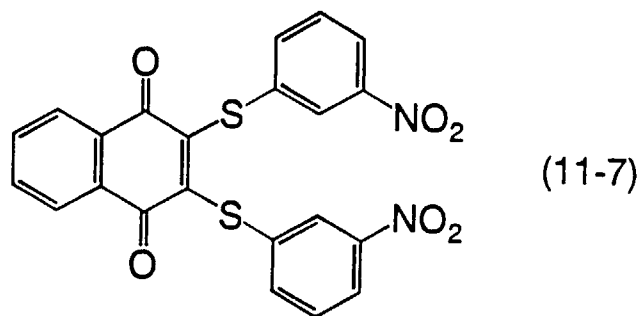


wherein R¹ and n are as defined above.

Among the naphthoquinone derivative (1) of the present invention, specific examples of the naphthoquinone derivative represented by the general formula (11) include compounds represented by the formulas (11-1) to (11-8).



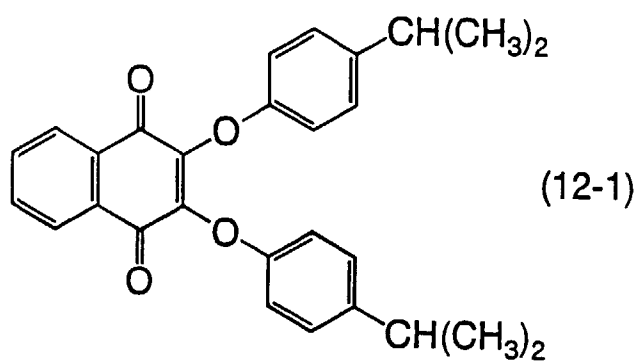


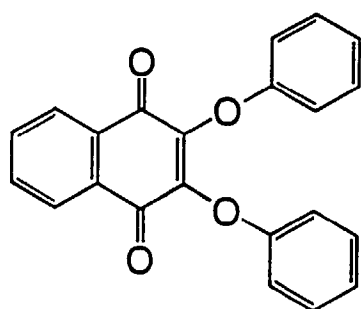


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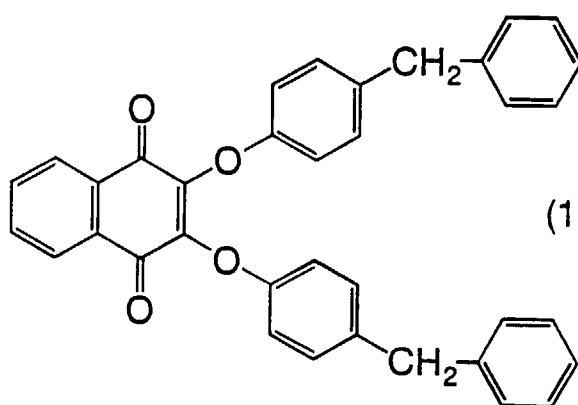
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On the other hand, specific examples of the naphthoquinone derivative represented by the general formula (12) include compound represented by the formulas (12-1) to (12-15).

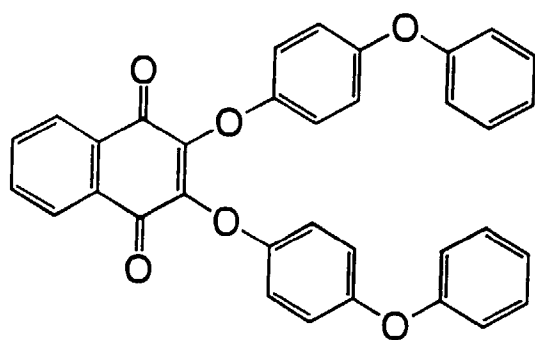




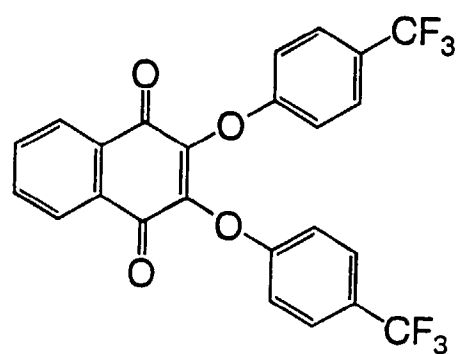
(12-2)



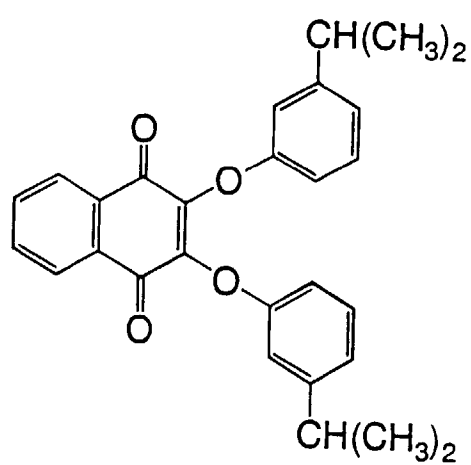
(12-3)



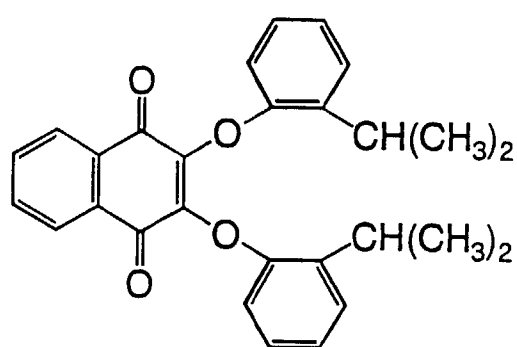
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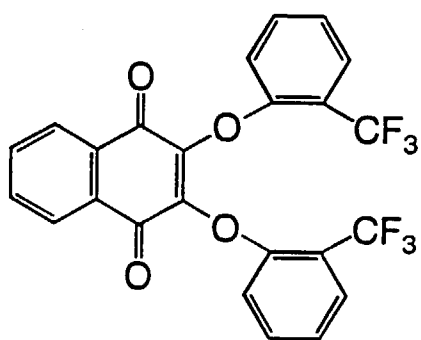
(12-5)



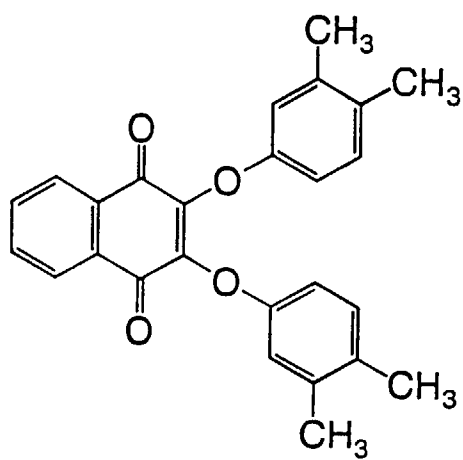
(12-6)



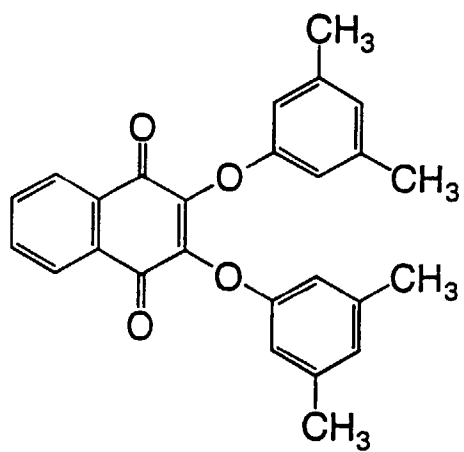
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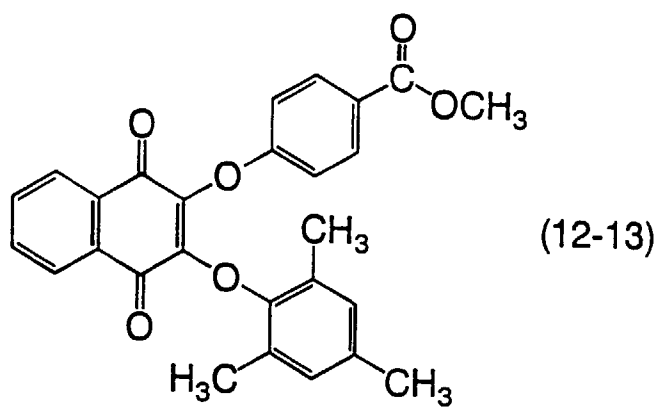
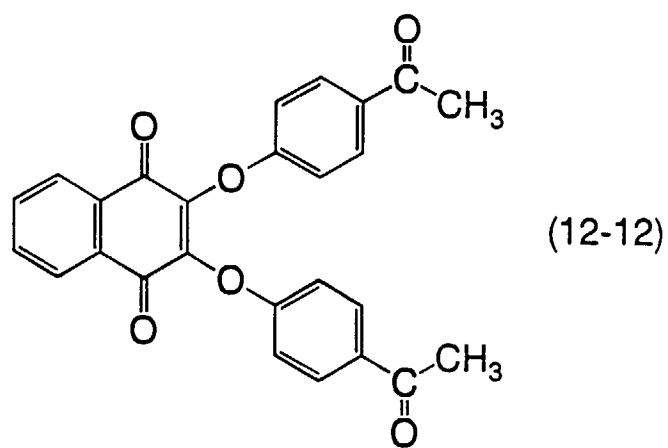
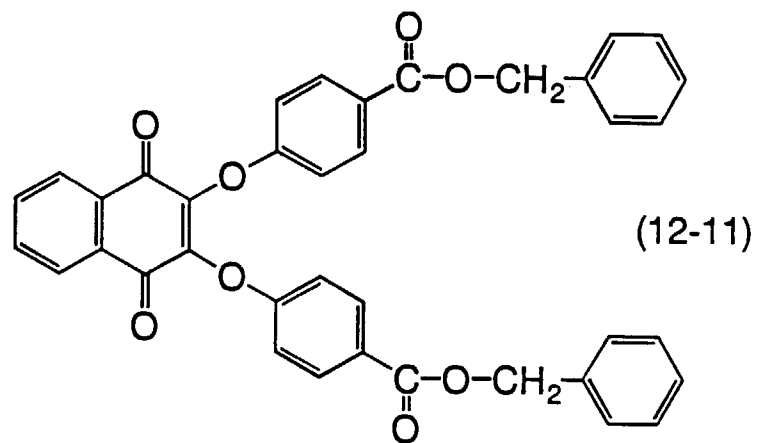
(12-8)

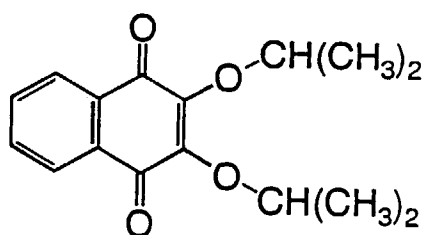


(12-9)

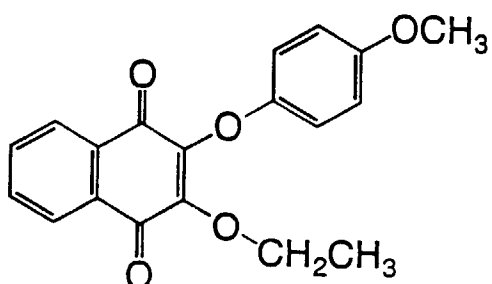


(12-10)





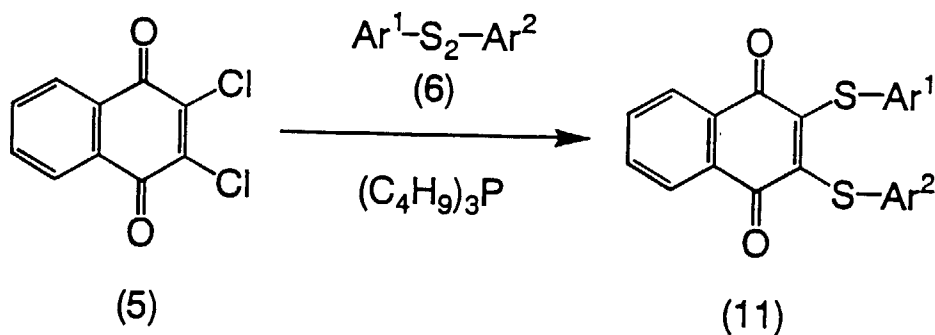
(12-14)



(12-15)

One embodiment of the method for synthesis of the naphthoquinone derivative represented by the general formula (11) is shown in the reaction scheme (I).

Reaction scheme (I)



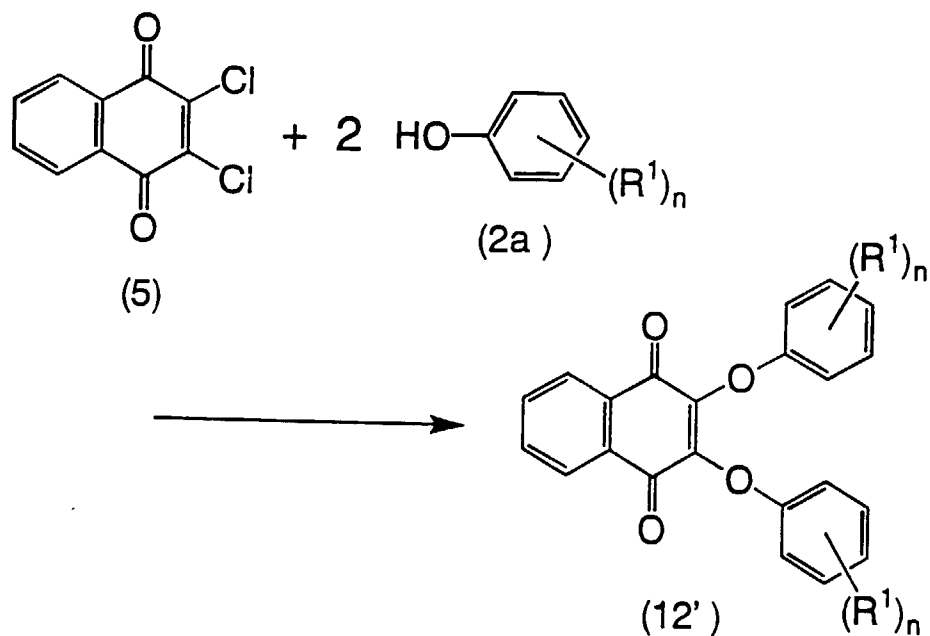
wherein Ar^1 and Ar^2 are as defined above.

That is, the naphthoquinone derivative (11) is synthesized by adding a disulfide derivative (6) in a solvent such as

tetrahydrofuran (THF), dimethylformamide (DMF), etc., stirring the solution in the presence of a phosphine (e.g. tri-n-butylphosphine, etc.) and an alkali (e.g. sodium hydroxide, etc.) and adding 2,3-dichloro-1,4-naphthoquinone (5), followed by stirring at the temperature of about room temperature for about 3 to 6 hours.

On the other hand, as one embodiment of the method for synthesis of the naphthoquinone derivative represented by the general formula (12), a method for synthesis of the naphthoquinone derivative represented by the general formula (12') is shown in the reaction scheme (II).

Reaction scheme (II)



wherein R^1 and n are as defined above.

That is, the naphthoquinone derivative (12') is synthesized by adding a compound represented by the general formula (2a) and potassium carbonate, sodium hydroxide, sodium hydride, etc. in a solvent such as DMF, THF, etc., stirring the solution at 40 to 50°C and adding 2,3-dichloro-1,4-naphthoquinone (5), followed by stirring at the temperature of about room temperature for about 1 to 2 hours.

In case of synthesizing the naphthoquinone derivative represented by the general formula (12), a compound represented by the formula (2b) or (2c):



wherein Ar¹ and Ar² are as defined above, may be used in place of the above compound (2a).

The electrophotosensitive material of the present invention will be described hereinafter.

The electrophotosensitive material of the present invention is that obtained by providing a photosensitive layer containing the naphthoquinone derivative represented by the above general formula (1) as an electron transferring material on a conductive substrate.

The electrophotosensitive material of the present invention can be applied to both single-layer type and multilayer type, but the effect of use of the naphthoquinone derivative (1) of the present invention is remarkably apparent in the single-layer type.

The single-layer type electrophotosensitive material may be obtained by providing a single photosensitive layer containing at least a naphthoquinone derivative (1) as an electron transferring material, an electric charge generating material and a binding resin, on a conductive substrate. This single-layer type photosensitive material can be applied to both positive charging type and negative charging type in its single layer construction, but is preferably used as the positive charging type which requires no negative polarity corona discharge. This single-layer type photosensitive material has the following advantages. The productivity is excellent because the layer construction is simple and film defects of the photosensitive layer can be prevented and, furthermore, the optical characteristics can be improved because of small interface between layers.

Since the single-layer type photosensitive material using the above naphthoquinone derivative (1) as the electron transferring material in combination with the hole transferring material having excellent hole transferring properties does not cause an interaction between the naphthoquinone derivative (1) and hole transferring material, the transferring of electrons and holes can be efficiently performed even if both transferring materials are contained in the same photosensitive layer in high concentration. Consequently, the photosensitive material having high sensitivity can be obtained.

On the other hand, the multi-layer type electrophotosensitive material may be obtained by laminating an electric charge generating layer containing an electric charge generating material and an electric charge transferring layer containing an electric charge transferring material on a conductive substrate in this sequence, or in the reverse sequence. Incidentally, the film thickness of the electric charge generating layer is preferably smaller than that of the electric charge transferring material. Therefore, in order to protect the electric charge generating layer, it is preferred that the electric charge generating layer is formed on the conductive substrate and then the electric charge transferring layer is formed thereon.

The charging type (negative or positive type) of the multi-layer type photosensitive material is selected by the sequence of formation of the above electric charge generating layer and electric charge transferring layer and by the kind of electron transferring material used in the electric charge transferring material. For example, when an electron transferring material such as naphthoquinone derivative (1) is used as the electric charge transferring material in the electric charge transferring layer, in the layer construction where the electric charge generating layer is formed on the conductive substrate and the electric charge transferring layer is formed thereon, a positive charging type photosensitive material is obtained. In this case, a hole transferring material may be contained in the electric charge generating layer. In the above layer construction, when the hole transferring material is used as the electric charge transferring material in the electric charge transferring layer, a negative charging type photosensitive material is obtained. In this case, an electron transferring material may be contained in the electric charge generating layer.

In the photosensitive material of the present invention, the other electron transferring material may be contained in the photosensitive layer, together with the naphthoquinone derivative (electron transferring material) represented by the above general formula (1).

When the redox potential of the above other electron transferring material is from -0.8 to -1.4 V, it may have the effect that the residual potential is largely lowered and the sensitivity of the photosensitive material is more improved.

Regarding the other electron transferring material whose redox potential is within the above range, since the energy level of the LUMO (Lowest Unoccupied Molecular Orbital) is lower than that of the electric charge generating material, electrons are efficiently drawn from the electric charge generating material when an ion couple of electrons (-) and holes (+) is formed using the electric charge generating material by light irradiation (that is, it acts as an electron acceptive material). Therefore, the probability of disappearance of the ion couple due to recombination of electrons and holes is reduced and the charge generation efficiency is improved. The above other electron transferring material also has a function of efficiently transferring electrons drawn from the electric charge generating material to the naphthoquinone derivative (1) as main electron transferring material. Therefore, in the system using the naphthoquinone derivative (1) in combination with the above other electron transferring material, the injection and transferring of electrons from the electric charge generating material are smoothly performed and the sensitivity of the photosensitive material is further improved.

When the redox potential of the other electron transferring material is greater than -0.8 V, there is a possibility that carrier trapping is caused by falling electrons transferring with repeating trapping-detraping into the level where de-trapping can not be effected. This carrier trapping prevents transferring of electrons and can cause a decrease in

sensitivity of the photosensitive material. On the contrary, when the redox potential of the electron transferring material is smaller than -1.4 V, the energy level of LUMO becomes higher than that of the electric charge generating material, and electrons are not transferred to the other electron transferring material when the above ion couple is formed. As a result, there is fear that the charge generation efficiency is not improved. Considering the sensitivity of the photosensitive material, the redox potential of the other electron transferring material is preferably within the above range, more preferably from -0.85 to -1.00 V.

As shown in Fig. 1, E_1 and E_2 shown in the same figure were determined from a relation between a tractive voltage (V) and a current (μA), and then the redox potential was calculated by using the following calculation formula:

$$\text{Redox potential (V)} = (E_1 + E_2)/2$$

The above tractive voltage (V) and current (μA) were measured by means of a three-electrode system cyclic voltammetry using a measuring solution prepared from the following materials.

Electrode: work electrode (glassy carbon electrode), counter electrode (platinum electrode)
Reference electrode: silver nitrate electrode (0.1 mol/l AgNO_3 -acetonitrile solution)

Measuring solution:

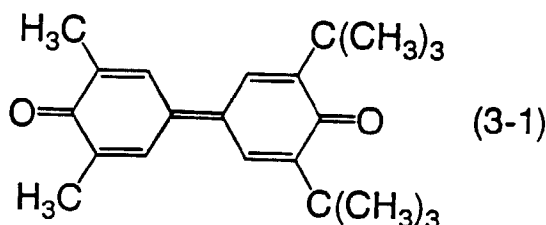
Electrolyte: tetra-n-butylammonium perchlorate (0.1 mols)
Measuring substance: electron transferring material (0.001 mols)
Solvent: CH_2Cl_2 (1 liter)

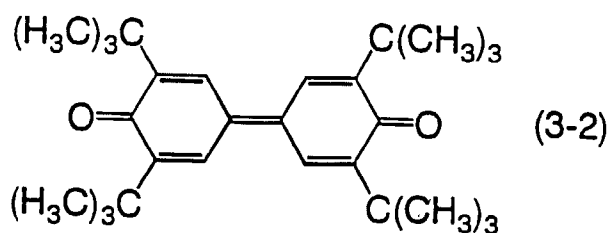
Such an other electron transferring material may be any compound whose redox potential is within the range from -0.8 to -1.4 V, and is not specifically limited. Examples thereof include compounds having electron acceptance properties, such as diphenoquinone derivative represented by the above general formula (3), benzoquinone derivative represented by the above general formula (4), anthraquinone derivative, malononitrile derivative, thiopyran derivative, trinitrothioxanthone derivative, fluorenone derivative (e.g. 3,4,5,7-tetranitro-9-fluorenone, etc.), dinitroanthracene derivative, dinitroacridine derivative, nitroanthraquinone derivative, dinitroanthraquinone derivative and the like.

Considering the combination with the naphthoquinone derivative (1) of the present invention, among the above exemplified other electron transferring materials, the diphenoquinone compound represented by the general formula (3) and benzoquinone compound represented by the general formula (4) are preferably used.

Examples of the alkyl group, aryl group and aralkyl group corresponding to the groups R^{A} to R^{H} in the above general formulas (3) and (4) include the same groups as those described above. Examples of the cycloalkyl group include groups having 3 to 8 carbon atoms, such as cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl and the like. Examples of the amino group which may have a substituent include monomethylamino, dimethylamino, monoethylamino, diethylamino, etc., in addition to amino. Among the groups R^{A} to R^{D} in the general formula (3) and groups R^{E} to R^{H} in the general formula (4), two or more of them are preferably the same groups, but are not limited thereto.

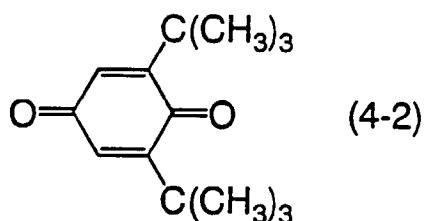
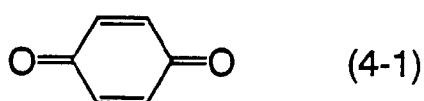
Specific examples of the diphenoquinone derivative (3) include 3,5-dimethyl-3',5'-di(t-butyl)-4,4'-diphenoquinone (redox potential: -0.86 V) represented by the following formula (3-1), 3,3',5,5'-tetrakis(t-butyl)-4,4'-diphenoquinone (redox potential: -0.94 V) represented by the following formula (3-2), 3,3'-dimethyl-5,5'-di(t-butyl)-4,4'-diphenoquinone, 3,5'-dimethyl-3',5'-di(t-butyl)-4,4'-diphenoquinone and the like.





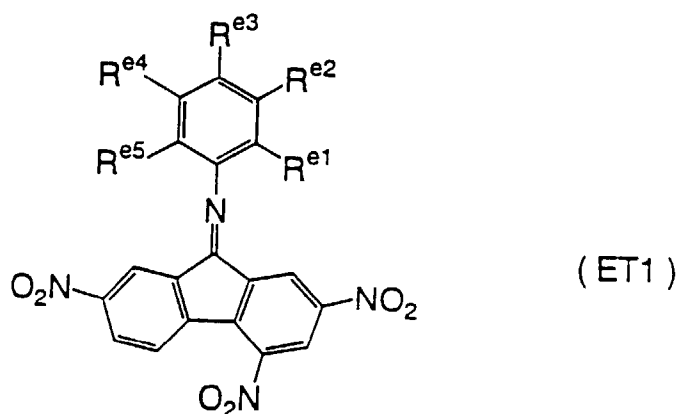
Specific examples of the benzoquinone derivative (4) include p-benzoquinone (redox potential: -0.81 V) represented by the formula (4-1), 2,6-di(t-butyl)-p-benzoquinone (redox potential: -1.31 V) represented by the formula (4-2) and the like.

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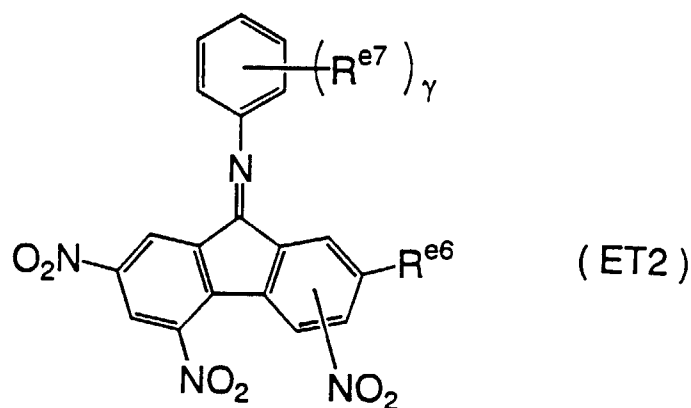
In the present invention, other electron transferring materials, which have hitherto been known, may be contained in the photosensitive layer, in addition to the above electron transferring material. Examples thereof include compounds represented by the following general formulas (ET1) to (ET16):

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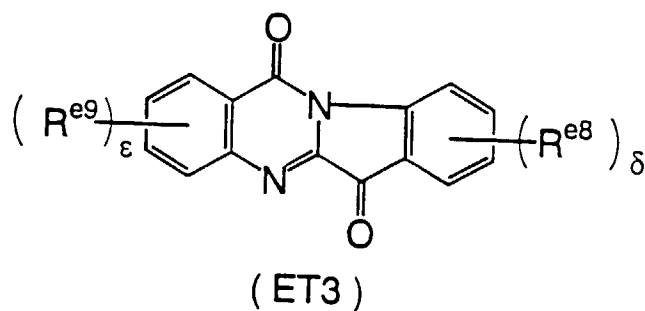
wherein R^{e1} , R^{e2} , R^{e3} , R^{e4} and R^{e5} are the same or different and represent a hydrogen atom, an alkyl group which may have a substituent, an alkoxy group which may have a substituent, an aryl group which may have a substituent, an aralkyl group which may have a substituent, a phenoxy group which may have a substituent, or a halogen atom;

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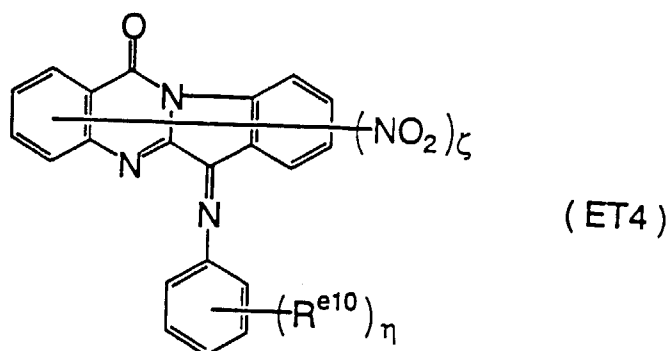
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wherein R^{e6} represents an alkyl group; R^{e7} represents an alkyl group which may have a substituent, an alkoxy group which may have a substituent, an aryl group which may have a substituent, an aralkyl group which may have a substituent, a halogen atom or a halogenated alkyl group; and γ represents any one of integers 0 to 5; provided that each R^{e7} may be different when γ is 2 or more;



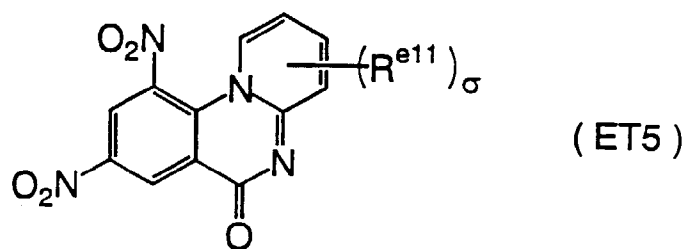
35

wherein R^{e8} and R^{e9} may be the same or different and represent an alkyl group; δ represents an integer of 1 to 4; and ϵ represents an integer of 0 to 4; provided that each R^{e8} and R^{e9} may be different when δ and ϵ are 2 or more;

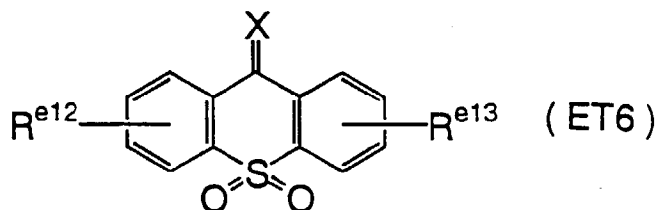


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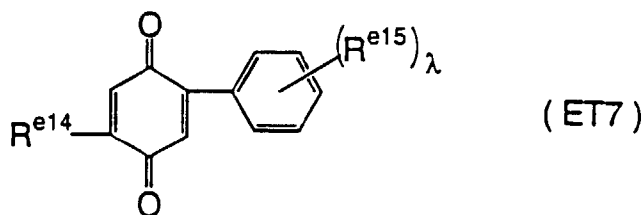
wherein R^{e10} represents an alkyl group, an aryl group, an aralkyl group, an alkoxy group, a halogenated alkyl group or a halogen atom; ζ represents any one of integers 0 to 4; and η represents any one of integers 0 to 5; provided that each R^{e10} may be different when η is 2 or more;



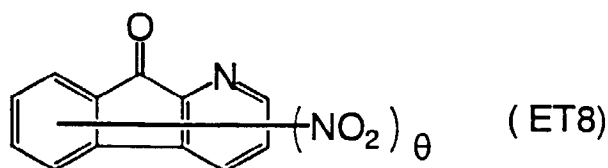
10 wherein R^{e11} represents an alkyl group; and σ represents any one of integers 1 to 4; provided that each R^{e11} may be different when σ is 2 or more;



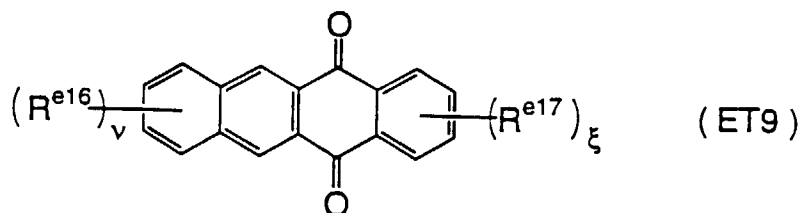
25 wherein R^{e12} and R^{e13} are the same or different and represent a hydrogen atom, a halogen atom, an alkyl group, an aryl group, an aralkyloxycarbonyl group, an alkoxy group, a hydroxyl group, a nitro group or a cyano group; and X represents an oxygen atom, a =N-CN group or a =C(CN)₂ group;



35 wherein R^{e14} represents a hydrogen atom, a halogen atom, an alkyl group, or a phenyl group which may have a substituent; R^{e15} represents a halogen atom, an alkyl group which may have a substituent, a phenyl group which may have a substituent, an alkoxy carbonyl group, a N-alkyl carbamoyl group, a cyano group or a nitro group; and λ represents any one of integers 0 to 3; provided that each R^{e15} may be different when λ is 2 or more;

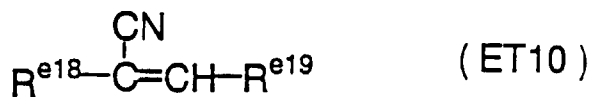


wherein θ represents an integer of 1 to 2;

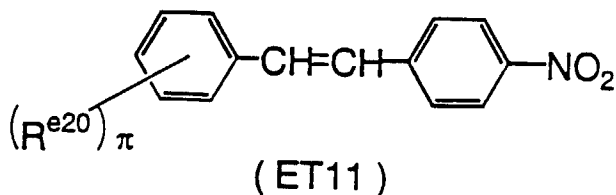


wherein R^{e16} and R^{e17} are the same or different and represent a halogen atom, an alkyl group which may have a substituent, a cyano group, a nitro group or an alkoxy carbonyl group; and v and ξ respectively represent any one of

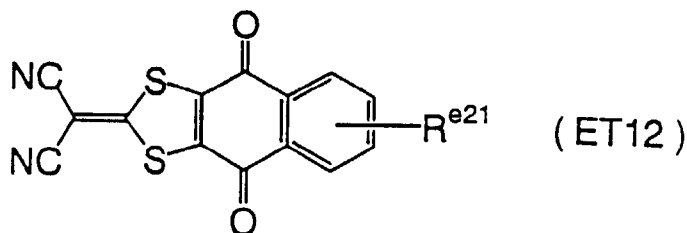
integers 0 to 3; provided each R^{e16} and R^{e17} may be different when either of v or ξ is 2 or more;



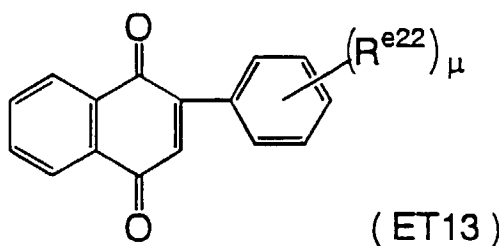
wherein R^{e18} and R^{e19} are the same or different and represent a phenyl group, a polycyclic aromatic group or a heterocyclic group, and these groups may respectively have a substituent;



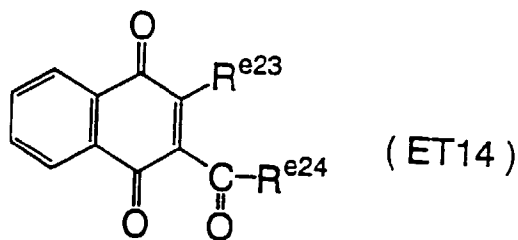
wherein R^{e20} represents an amino group, a dialkylamino group, an alkoxy group, an alkyl group or a phenyl group; and π represents an integer of 1 or 2; provided that each R^{e2} may be different when π is 2;



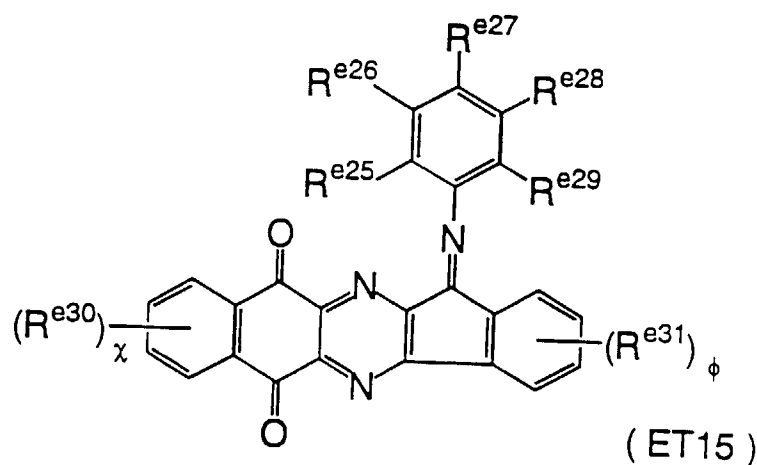
wherein R^{e21} represents a hydrogen atom, an alkyl group, an aryl group, an alkoxy group or an aralkyl group;



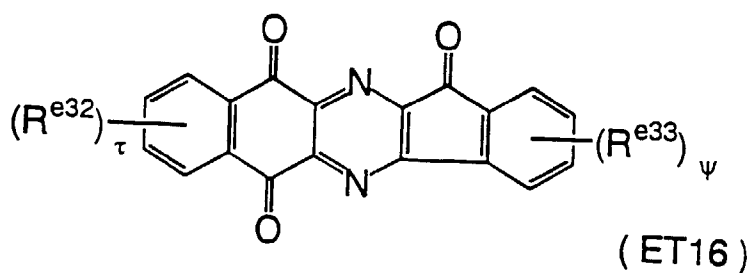
wherein R^{e22} represents a halogen atom, an alkyl group which may have a substituent, a phenyl group which may have a substituent, an alkoxy carbonyl group, a N-alkyl carbamoyl group, a cyano group or a nitro group; and μ represents any one of integers 0 to 3; provided that each R^{e22} may be different when μ is 2 or more;



wherein R^{e23} represents an alkyl group which may have a substituent, or an aryl group which may have a substituent; and R^{e24} represents an alkyl group which may have a substituent, an aryl group which may have a substituent, or a group: $-O-R^{e24a}$ (R^{e24a} represents an alkyl group which may have a substituent, or an aryl group which may have a substituent);



wherein R^{e25} , R^{e26} , R^{e27} , R^{e28} , R^{e29} , R^{e30} and R^{e31} are the same or different and represent an alkyl group, aryl group, aralkyl group, alkoxy group, a halogen atom or a halogenated alkyl group; and χ and ϕ are the same or different and represent any one of integer 0 to 4; and



wherein R^{e32} and R^{e33} are the same or different and represent an alkyl group, an aryl group, an alkoxy group, a halogen atom or a halogenated alkyl group; τ and ϕ are the same or different and represent any one of integers 0 to 4.

In the above electron transferring materials, examples of the alkyl group, alkoxy group, aryl group, aralkyl group, halogen atom, halogenated alkyl group, cycloalkyl group, alkoxy carbonyl group and aralkyloxycarbonyl group include the same groups as those described above.

Examples of the heterocyclic group include thienyl, furyl, pyrrolyl, pyrrolidinyl, oxazolyl, isooxazolyl, thiazolyl, isothiazolyl, imidazolyl, 2H-imidazolyl, pyrazolyl, triazolyl, tetrazolyl, pyranlyl, pyridyl, piperidyl, piperidino, 3-morpholinyl, morpholino, thiazolyl and the like. In addition, it may be a heterocyclic group condensed with an aromatic ring.

Examples of the polycyclic aromatic group include naphthyl, penanthryl and anthryl and the like.

Examples of the N-alkylcarbamoyl group include those of which alkyl portions are various alkyl groups described above.

Examples of the dialkylamino group include those of which alkyl portions are various alkyl groups described above. Two alkyl groups substituted on the amino may be the same or different.

Examples of the substituent, which may be substituted on alkyl group and alkoxy group described above, include halogen atom, amino group, hydroxyl group, optionally esterified carboxyl group, cyano group, alkoxy group having 1 to 6 carbon atoms, alkenyl having 2 to 6 carbon atoms which may have an aryl group, and the like. The substitution position of the substituent is not specifically limited.

Examples of the substituent, which may be substituted on aryl group, aralkyl group and phenyl group described above, include halogen atom, amino group, hydroxyl group, optionally esterified carboxyl group, cyano group, alkyl group having 1 to 6 carbon atoms, alkoxy group having 1 to 6 carbon atoms, alkenyl having 2 to 6 carbon atoms which may have an aryl group, and the like. The substitution position of the substituent is not specifically limited.

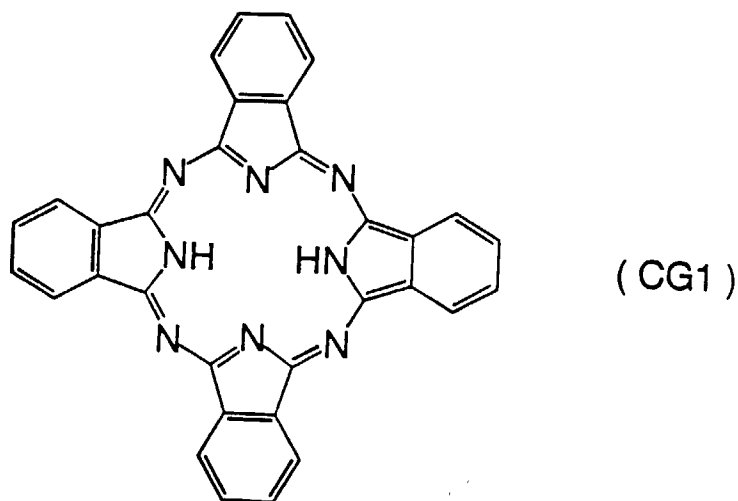
Furthermore, there can be used electron transferring materials, with the above-described electron transferring materials (ET1) to (ET16), or in place of them, which have hitherto been known, such as benzoquinone compound, malononitrile, thiopyran compound, tetracyanoethylene, 2,4,8-trinitrothioxanthone, dinitrobenzene, dinitroanthracene, dinitroacridine, nitroanthraquinone, dinitroanthraquinone, succinic anhydride, maleic anhydride, dibromomaleic anhydride, etc., in addition to those described above.

Examples of the electric charge generating material, hole transferring material and binding resin, that may be used in the electrophotosensitive material of the present invention, are as follows.

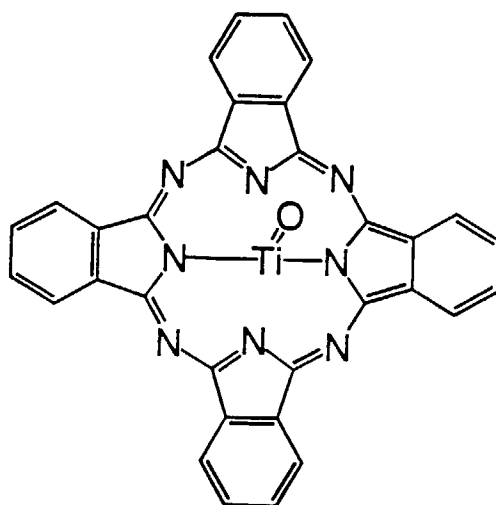
Electric charge generating material

Examples of the electric charge generating material include compounds represented by the following general formulas (CG1) to (CG12):

(CG1) Metal-free phthalocyanine

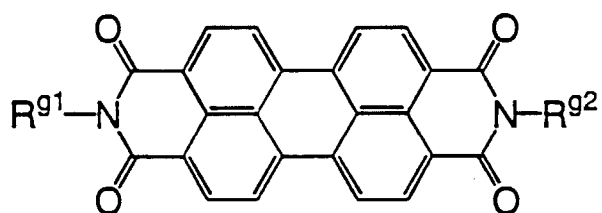


(CG2) Oxotitanyl phthalocyanine



(CG2)

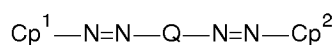
(CG3) Perylene pigment



(CG3)

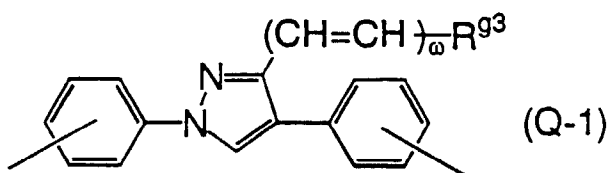
wherein R^{g1} and R^{g2} are the same or different and represent a substituted or non-substituted alkyl group having 18 or less carbon atoms, a cycloalkyl group, an aryl group, an alkanoyl group or an aralkyl group;

(CG4) Bisazo pigment



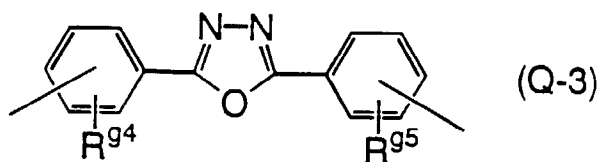
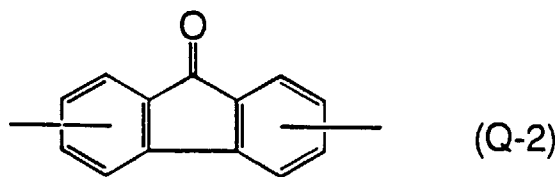
(CG4)

wherein Cp^1 and Cp^2 are the same or different and represent a coupler residue; and Q represents a group represented by the following formulas (Q-1) to (Q-8):

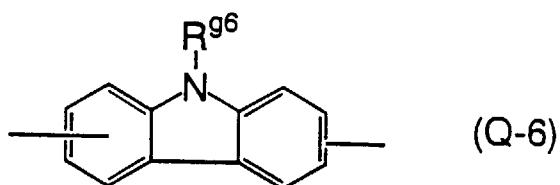
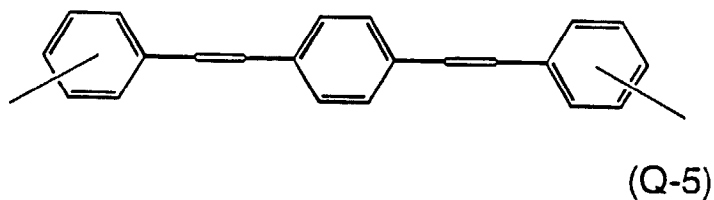
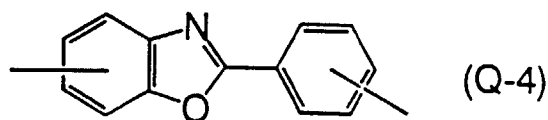


(Q-1)

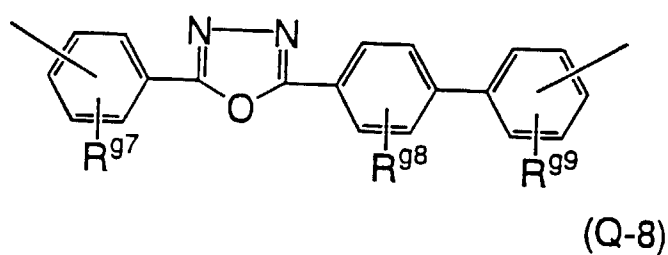
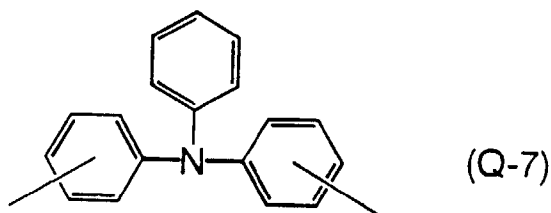
(wherein R^{g3} represents a hydrogen atom, an alkyl group, an aryl group or a heterocyclic group, and the alkyl group, aryl group or heterocyclic group may have a substituent; and ω represents 0 or 1);



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20 (wherein R⁹⁴ and R⁹⁵ are the same or different and represents a hydrogen atom, an alkyl group having 1 to 5 carbon atoms, a halogen atom, an alkoxy group, an aryl group or an aralkyl group);

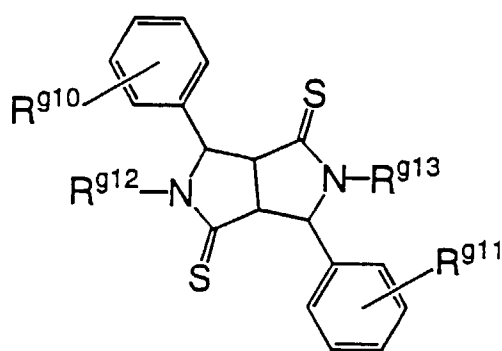


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55 (wherein R⁹⁶ represents a hydrogen atom, an ethyl group, a chloroethyl group or a hydroxyethyl group);



(wherein R^{97} , R^{98} and R^{99} are the same or different and represent a hydrogen atom, an alkyl group having 1 to 5 carbon atoms, a halogen atom, an alkoxy group, an aryl group or an aralkyl group);

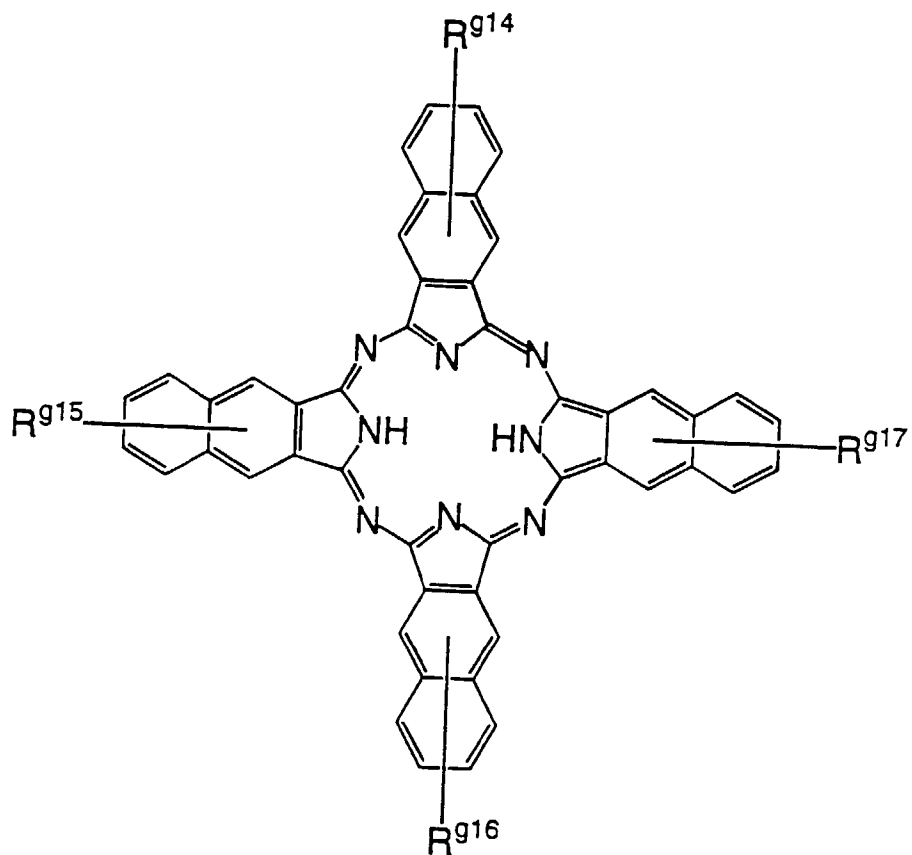
(CG5) Dithioketopyrrolopyrrole pigment



(CG5)

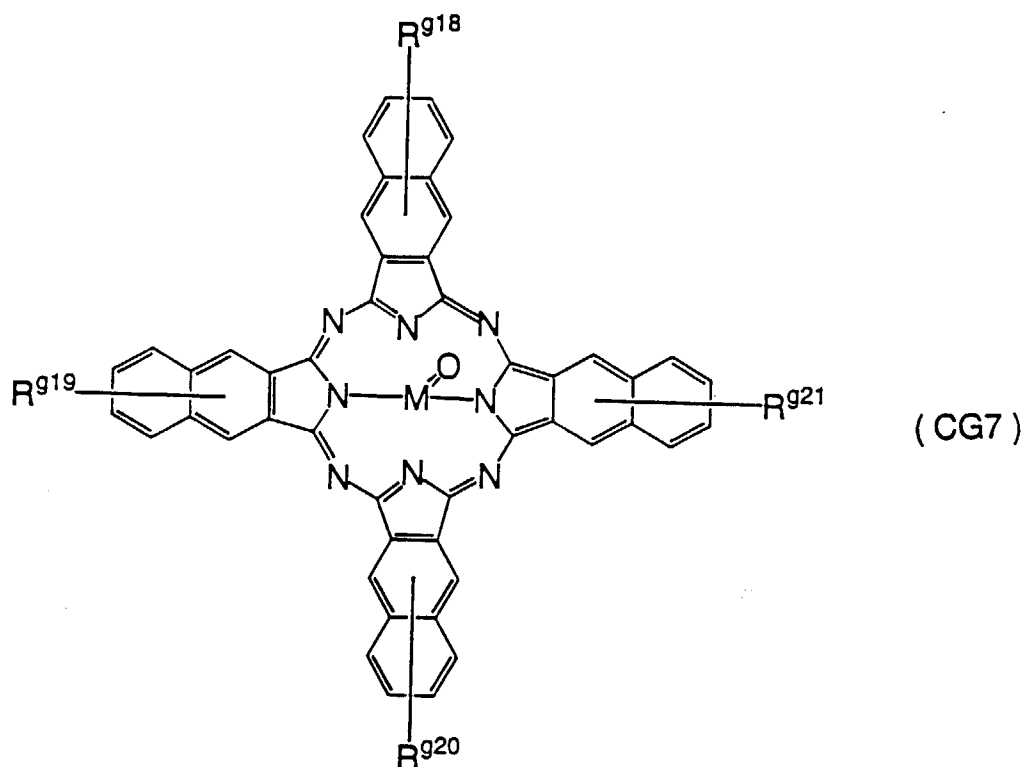
wherein R^{910} and R^{911} are the same or different and represent a hydrogen atom, an alkyl group, an alkoxy group or a halogen atom; and R^{912} and R^{913} are the same or different and represent a hydrogen atom, an alkyl group or an aryl group;

(CG6) Metal-free naphthalocyanine pigment

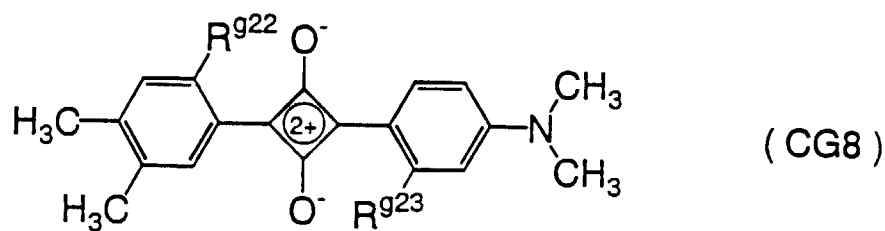


(CG6)

(wherein R⁹¹⁴, R⁹¹⁵, R⁹¹⁶ and R⁹¹⁷ are the same or different and represent a hydrogen atom, an alkoxy group or a halogen atom;

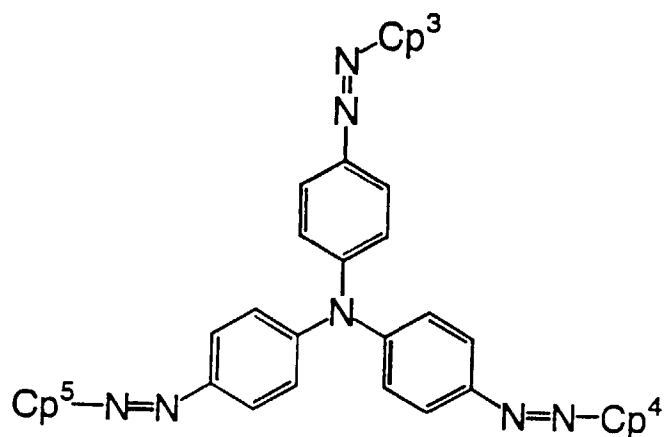
(CG7) Metal phthalocyanine pigment

30 (wherein R^{g18} , R^{g19} , R^{g20} and R^{g21} are the same or different and represent a hydrogen atom, an alkyl group, an alkoxy group or a halogen atom; and M represents Ti or V;

(CG8) Squaline pigment

wherein R^{g22} and R^{g23} are the same or different and represent a hydrogen atom, an alkyl group, an alkoxy group or a halogen atom;

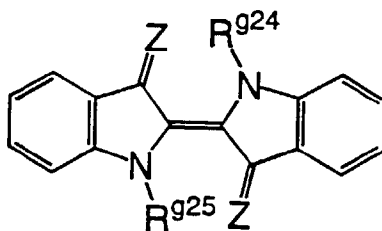
(CG9) Trisazo pigment



(CG9)

wherein Cp³, Cp⁴ and Cp⁵ are the same or different and represent a coupler residue;

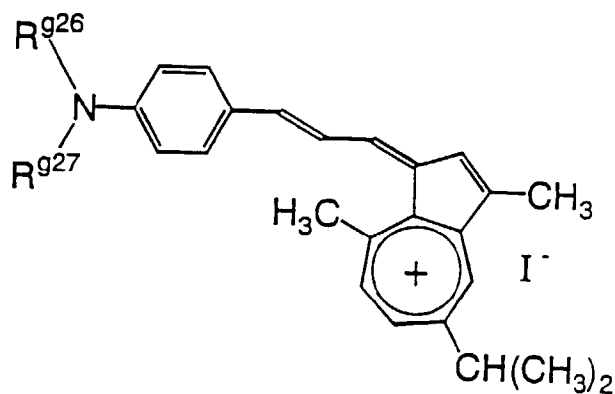
(CG10) Indigo pigment



(CG10)

wherein R⁹²⁴ and R⁹²⁵ are the same or different and represent a hydrogen atom, an alkyl group or an aryl group; and Z is an oxygen atom or a sulfur atom;

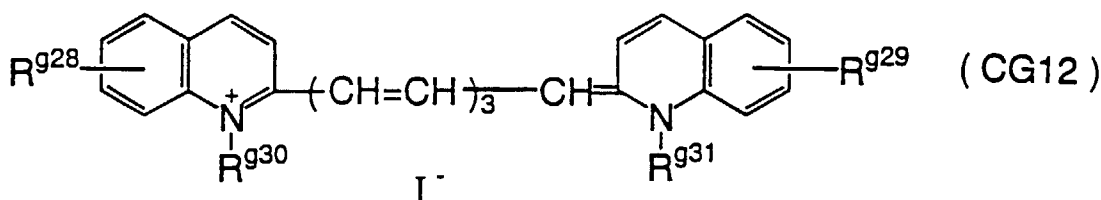
(CG11) Azulenium pigment



(CG11)

wherein R^{926} and R^{927} are the same or different and represent a hydrogen atom, an alkyl group or an aryl group; and

(CG12) Cyanine pigment



wherein R^{928} and R^{929} are the same or different and represent a hydrogen atom, an alkyl group, an alkoxy group or a halogen atom; and R^{930} and R^{931} are the same or different and represent a hydrogen atom, an alkyl group or an aryl group.

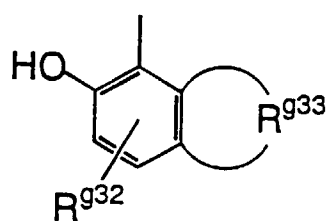
In the above electron charge generating material, examples of the alkyl group, alkoxy group, aryl group, aralkyl group, alkanoyl group, cycloalkyl and heterocyclic group include the same groups as those described above.

Examples of the alkyl group include substituted or non-substituted alkyl groups having 18 or less carbon atoms, such as octyl, nonyl, decyl, dodecyl, tridecyl, pentadecyl, octadecyl, etc., in addition to the above alkyl groups having 1 to 6 carbon atoms.

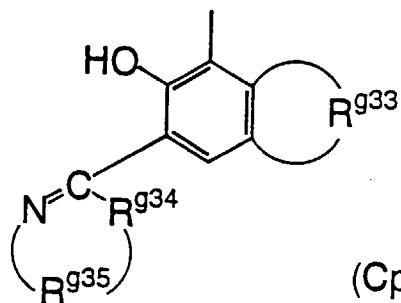
Examples of the substituent which may be substituted on the alkyl groups include halogen atom, amino group, hydroxyl group, optionally esterified carboxyl group, cyano group, alkoxy group having 1 to 6 carbon atoms, alkenyl group having 2 to 6 carbon atoms which may have an aryl group, etc.

Examples of the substituent which may be substituted on the aryl group include halogen atom, amino group, hydroxyl group, optionally esterified carboxyl group, cyano group, alkyl group having 1 to 6 carbon atoms, alkoxy group having 1 to 6 carbon atoms, alkenyl group having 2 to 6 carbon atoms which may have an aryl group, etc.

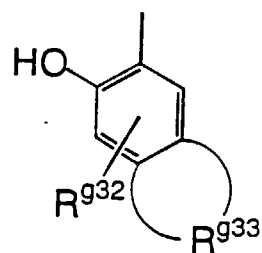
Examples of the coupler residue represented by Cp^1 , Cp^2 , Cp^3 , Cp^4 and Cp^5 include the groups shown in the following formulas ($Cp-1$) to ($Cp-11$).



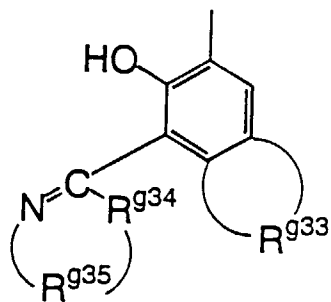
(Cp-1)



(Cp-2)



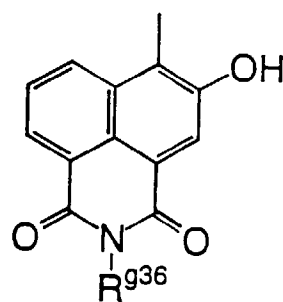
(Cp-3)



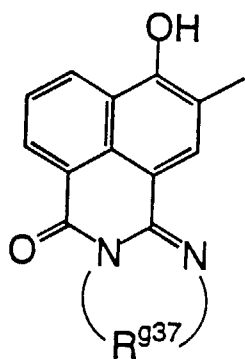
(Cp-4)



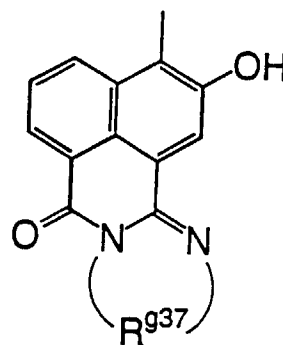
(Cp-5)



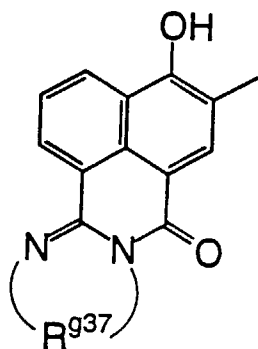
(Cp-6)



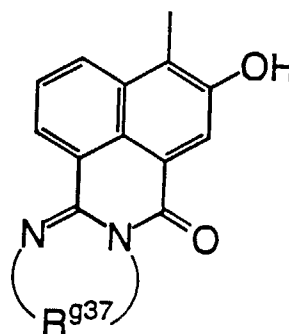
(Cp-7)



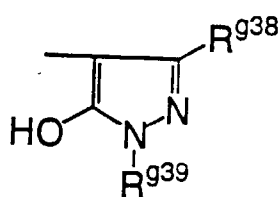
(Cp-8)



(Cp-9)



(Cp-10)



(Cp-11)

In the respective formulas, R^{932} is a carbamoyl group, a sulfamoyl group, an allophanoyl group, oxamoyl group, anthranoyl group, carbazoyl group, glycol group, hydantoyl group, phthalamoyl group or a succinamoyl group. These groups may have substituents such as halogen atom, phenyl group which may have a substituent, naphthyl group which may have a substituent, nitro group, cyano group, alkyl group, alkenyl group, carbonyl group, carboxyl group and the like.

R^{933} is an atomic group which is required to form an aromatic ring, a polycyclic hydrocarbon or a heterocycle by condensing with a benzene ring, and these rings may have the same substituents as that described above.

R^{934} is an oxygen atom, a sulfur atom or an imino group.

R^{935} is a divalent chain hydrocarbon or aromatic hydrocarbon group, and these groups may have the same substituents as that described above.

R^{936} is an alkyl group, an aralkyl group, an aryl group or a heterocyclic group, and these groups may have the same substituents as that described above.

R^{937} is an atomic group which is required to form a heterocycle, together with a divalent chain hydrocarbon or aromatic hydrocarbon group, or two nitrogen atoms in the above formulas (Cp-1) to (Cp-2), and these rings may have the same substituents as that described above.

R^{938} is a hydrogen atom, an alkyl group, an amino group, a carbamoyl group, a sulfamoyl group, an allophanoyl group, a carboxyl group, an alkoxy carbonyl group, an aryl group or a cyano group, and the groups other than a hydrogen atom may have the same substituents as that described above.

R^{939} is an alkyl group or an aryl group, and these groups may have the same substituents as that described above.

Examples of the alkenyl group include alkenyl groups having 2 to 6 carbon atoms, such as vinyl, allyl, 2-butenyl, 3-butenyl, 1-methylallyl, 2-pentenyl, 2-hexenyl and the like.

In the above R^{933} , examples of the atomic group which is required to form an aromatic ring by condensing with a benzene ring include alkylene groups having 1 to 4 carbon atoms, such as methylene, ethylene, trimethylene, tetramethylene and the like.

Examples of the aromatic ring to be formed by condensing the above R^{933} with a benzene ring include naphthalene ring, anthracene ring, phenanthrene ring, pyrene ring, chrysene ring, naphthacene ring and the like.

In the above R^{933} , examples of the atomic group which is required to form a polycyclic hydrocarbon by condensing with a benzene ring include the above alkylene groups having 1 to 4 carbon atoms, or carbazole ring, benzocarbazole ring, dibenzofuran ring and the like.

In the above R^{933} , examples of the atomic group which is required to form a heterocycle by condensing with a benzene ring include benzofuranyl, benzothiophenyl, indolyl, 1H-indolyl, benzoxazolyl, benzothiazolyl, 1H-indazolyl,

benzimidazolyl, chromenyl, chromanyl, isochromanyl, quinoliny, isoquinoliny, cinnoliny, phthalaziny, quinazoliny, quinoxaliny, dibenzofrany, carbazolyl, xanthenyl, acridiny, phenanthridiny, phenaziny, phenoxaziny, thianthrenyl and the like.

Examples of the aromatic heterocyclic group to be formed by condensing the above R^{933} and the benzene ring include thienyl, furyl, pyrrolyl, oxazolyl, isoxazolyl, thiazolyl, isothiazolyl, imidazolyl, pyrazolyl, triazolyl, tetrazolyl, pyridyl, thiazolyl and the like. In addition, it may also be a heterocyclic group condensed with other aromatic rings (e.g. benzofuranyl, benzimidazolyl, benzoxazolyl, benzothiazolyl, quinolyl, etc.).

In the above R^{935} and R^{937} , examples of the divalent chain hydrocarbon include ethylene, trimethylene, tetramethylene and the like. Examples of the divalent aromatic hydrocarbon include phenylene, naphthylene, phenanthrylene and the like.

In the above R^{936} , examples of the heterocyclic group include pyridyl, pyrazyl, thienyl, pyranly, indolyl and the like.

In the above R^{937} , examples of the atomic group which is required to form a heterocycle, together with two nitrogen atoms, include phenylene, naphthylene, ethylene, trimethylene, tetramethylene and the like.

Examples of the aromatic heterocyclic group to be formed by the above R^{937} and two nitrogen atoms include benzimidazole, benzo[f]benzimidazole, dibenzo[e,g]benzimidazole, benzopyrimidine and the like. These groups may respectively have the same group as that described above.

In the above R^{938} , examples of the alkoxycarbonyl group include methoxycarbonyl, ethoxycarbonyl, propoxycarbonyl, butoxycarbonyl and the like.

In the present invention, there can be used powders of inorganic photoconductive materials such as selenium, selenium-tellurium, selenium-arsenic, cadmium sulfide, amorphous silicon, etc. and electric charge generating materials, which have hitherto been known, such as pyrilium salt, anthanthrone pigments, triphenylmethane pigments, threne pigments, toluidine pigments, pyrazoline pigments, quinacridone pigments, etc., in addition to the above electric charge generating materials.

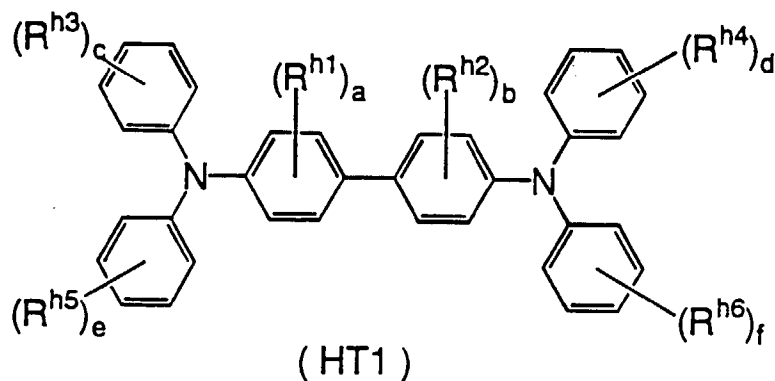
The above electric charge generating materials can be used alone or in combination to present an absorption wavelength within a desired range.

Among the above electric charge generating materials, a photosensitive material having sensitivity at the wavelength range of 700 nm or more is required in digital-optical image forming apparatuses such as laser beam printers, facsimile machines which use a light source of a semiconductor laser, etc. Therefore, phthalocyanine pigments such as metal-free phthalocyanine represented by the above general formula (CG1), oxotitanyl phthalocyanine represented by the general formula (CG2), etc. are preferably used. The crystal form of the above phthalocyanine pigments is not specifically limited, and various phthalocyanine pigments having different crystal form can be used.

In analogue-optical image forming apparatuses such as electrostatic copying machine using a white light source such as halogen lamp, etc., a photosensitive material having sensitivity at the visible range is required. Therefore, for example, the perylene pigment represented by the above general formula (CG3) and bisazo pigment represented by the general formula (CG4) are suitably used.

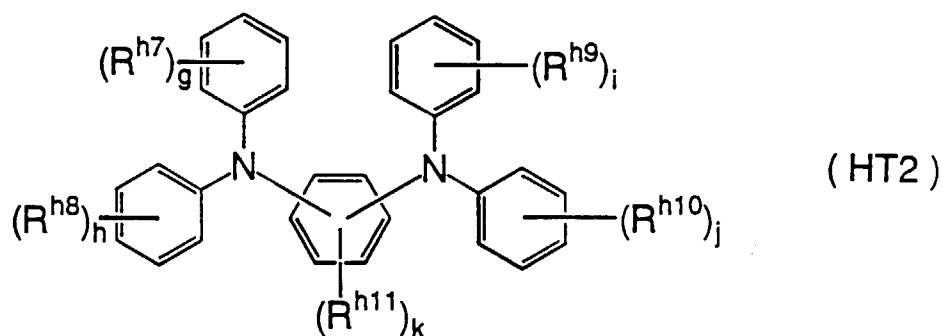
Hole transferring material

Examples of the hole transferring material include compounds represented by the following general formulas (HT1) to (HT13):

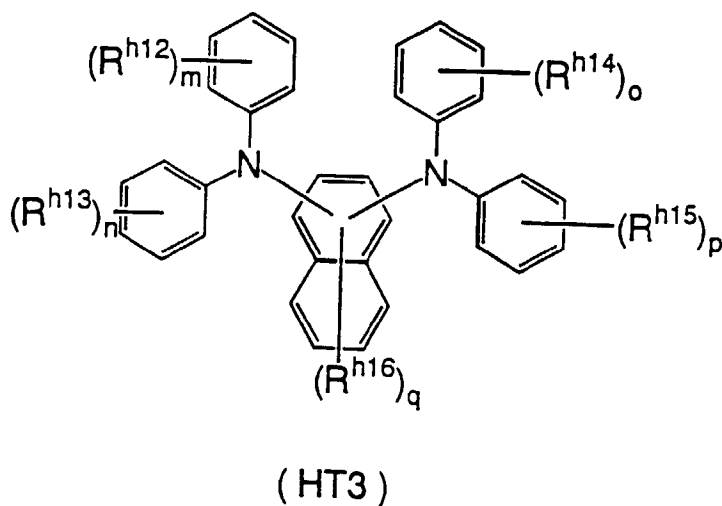


wherein R^{h1} , R^{h2} , R^{h3} , R^{h4} , R^{h5} and R^{h6} are the same or different and represent a halogen atom, an alkyl group which may have a substituent, an alkoxy group which may have a substituent, or an aryl group which may have a substituent;

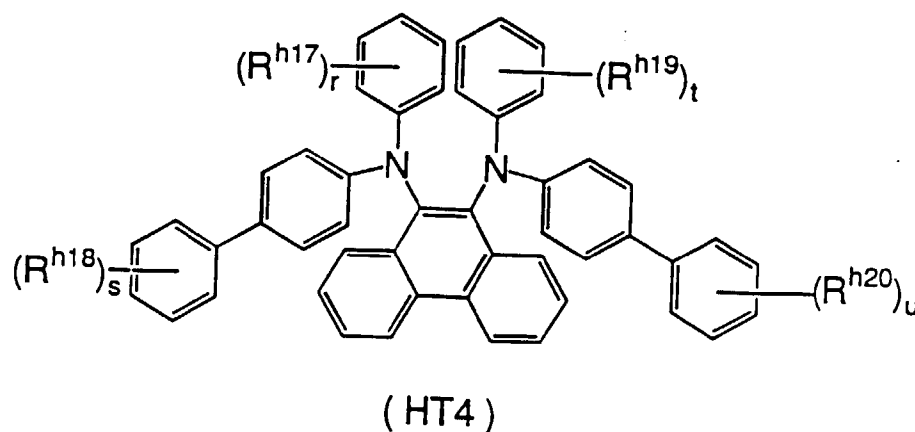
a and b are the same or different and represent any one of integers 0 to 4; and c, d, e and f are the same or different and represent any one of integers 0 to 5; provided that each R^{h1} , R^{h2} , R^{h3} , R^{h4} , R^{h5} and R^{h6} may be different when a, b, c, d, e or f is 2 or more;



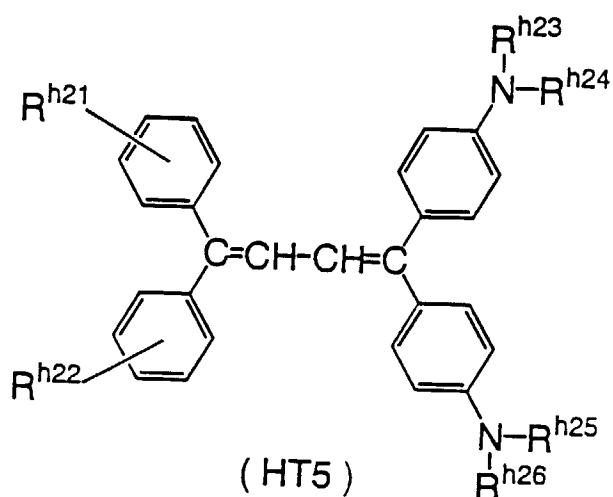
wherein R^{h7} , R^{h8} , R^{h9} , R^{h10} and R^{h11} are the same or different and represent a halogen atom, an alkyl group which may have a substituent, an alkoxy group which may have a substituent, or an aryl group which may have a substituent; g, h, i and j are the same or different and represent any one of integers 0 to 5; and k is any one of integers 0 to 4; provided that each R^{h7} , R^{h8} , R^{h9} , R^{h10} and R^{h11} may be different when g, h, i, j or k is 2 or more;



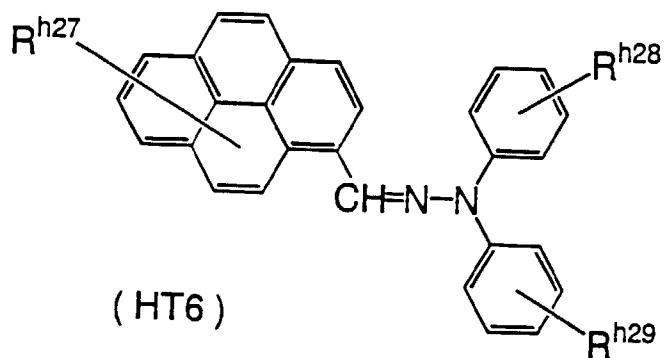
wherein R^{h12} , R^{h13} , R^{h14} and R^{h15} are the same or different and represent a halogen atom, an alkyl group which may have a substituent, an alkoxy group which may have a substituent, or an aryl group which may have a substituent; R^{h16} is a halogen atom, a cyano group, a nitro group, an alkyl group which may have a substituent, an alkoxy group which may have a substituent, or an aryl group which may have a substituent; m, n, o and p are the same or different and represent any one of integers 0 to 5; and q is any one of integers 1 to 6; provided that each R^{h12} , R^{h13} , R^{h14} , R^{h15} and R^{h16} may be different when m, n, o, p or q is 2 or more;



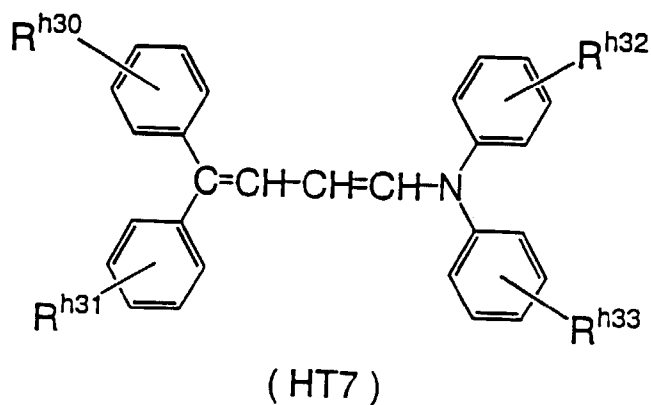
20 wherein R^{h17} , R^{h18} , R^{h19} and R^{h20} are the same or different and represent a halogen atom, an alkyl group which may have a substituent, an alkoxy group which may have a substituent, or an aryl group which may have a substituent; r , s , t and u are the same or different and represent any one of integers 0 to 5; provided that each R^{h17} , R^{h18} , R^{h19} and R^{h20} may be different when r , s , t or u is 2 or more;



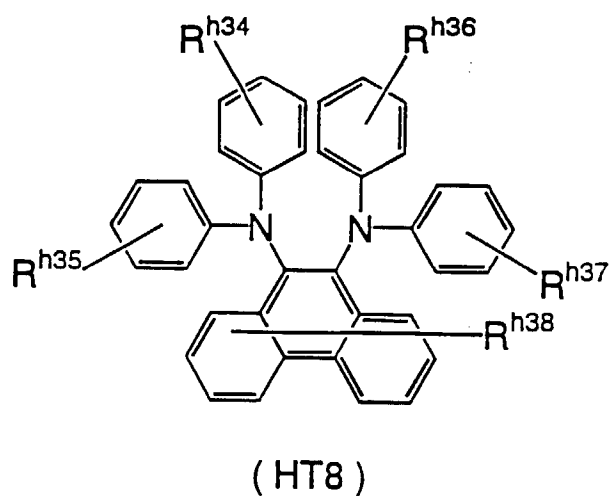
45 wherein R^{h21} and R^{h22} are the same or different and represent a hydrogen atom, a halogen atom, an alkyl group or an alkoxy group; and R^{h23} , R^{h24} , R^{h25} and R^{h26} may be same or different and represent a hydrogen atom, an alkyl group or an aryl group;



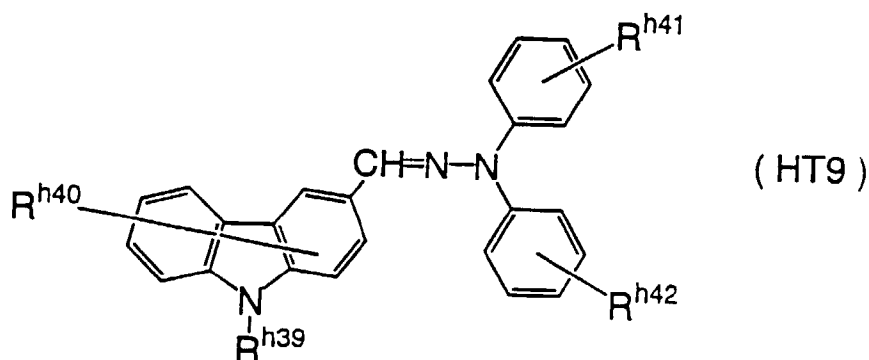
15 wherein R^{h27} , R^{h28} and R^{h29} are the same or different and represent a hydrogen atom, a halogen atom, an alkyl group or an alkoxy group;



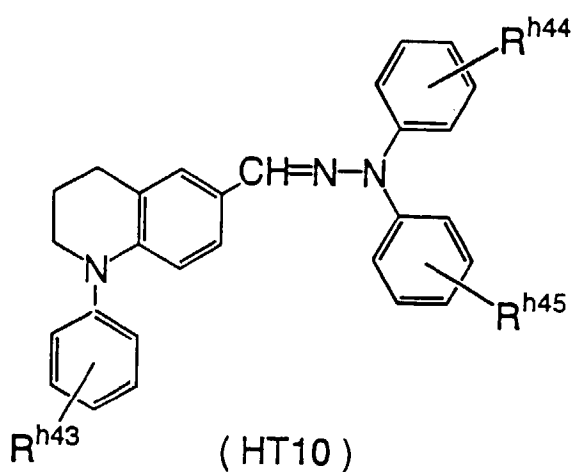
35 wherein R^{h30} , R^{h31} , R^{h32} and R^{h33} may be the same or different and represent a hydrogen atom, a halogen atom, an alkyl group or an alkoxy group;



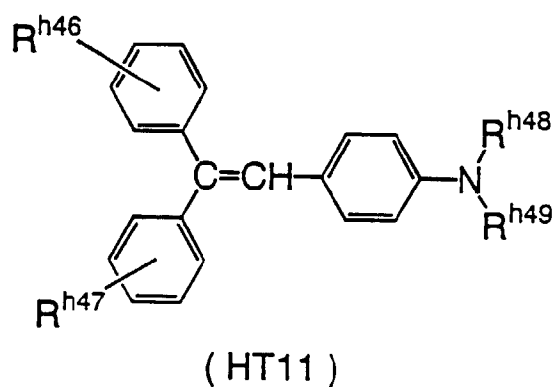
55 wherein R^{h34} , R^{h35} , R^{h36} , R^{h37} and R^{h38} may be the same or different and represent a hydrogen atom, a halogen atom, an alkyl group or an alkoxy group;



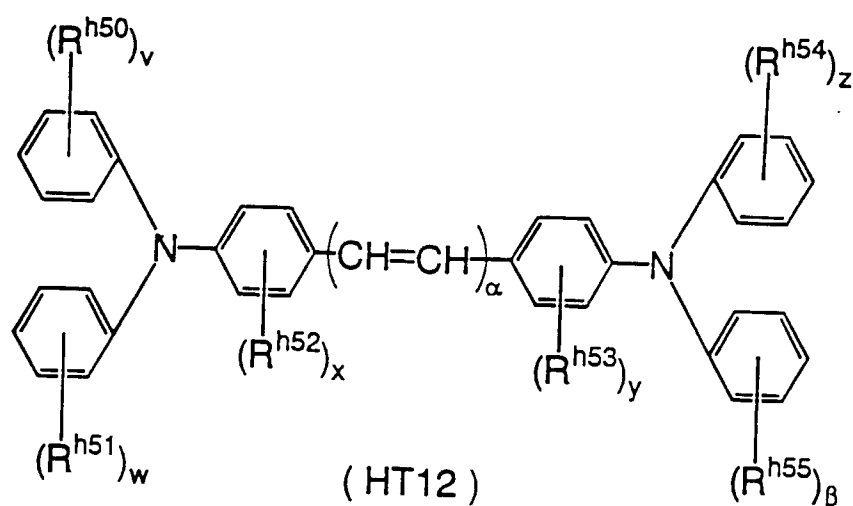
15 wherein R^{h39} represents a hydrogen atom or an alkyl group; and R^{h40} , R^{h41} and R^{h42} may be the same or different and represent a hydrogen atom, a halogen atom, an alkyl group or an alkoxy group;



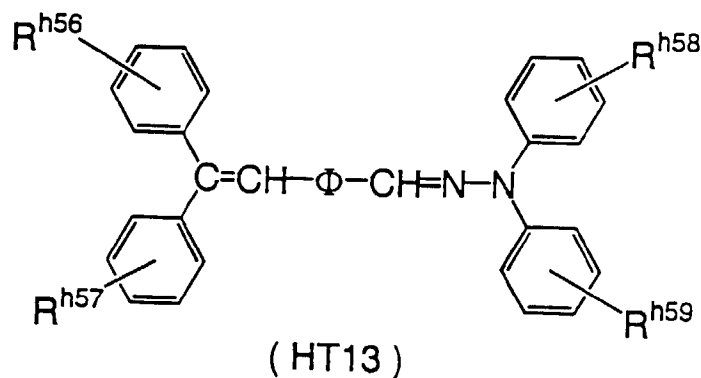
35 wherein R^{h43} , R^{h44} and R^{h45} may be the same or different and represent a hydrogen atom, a halogen atom, an alkyl group or an alkoxy group;



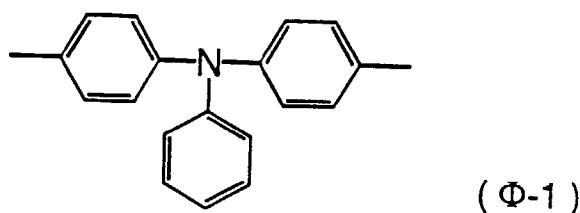
55 wherein R^{h46} and R^{h47} are the same or different and represent a hydrogen atom, a halogen atom, an alkyl group which may have a substituent, or an alkoxy group which may have a substituent; and R^{h48} and R^{h49} are the same or different and represent a hydrogen atom, an alkyl group which may have a substituent, or an aryl group which may have a substituent;

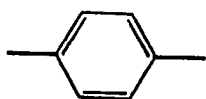


wherein R^{h50} , R^{h51} , R^{h52} , R^{h53} , R^{h54} and R^{h55} are the same or different and represent an alkyl group which may have a substituent, an alkoxy group which may have a substituent, or an aryl group which may have a substituent; α represents any one of integers 1 to 10; v , w , x , y , z and β are the same or different and represent any one of integers of 0 to 2; provided that each R^{h50} , R^{h51} , R^{h52} , R^{h53} , R^{h54} and R^{h55} may be different when either of v , w , x , y , z or β is 2; and

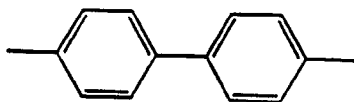


wherein R^{h56} , R^{h57} , R^{h58} and R^{h59} may be the same or different and represent a hydrogen atom, a halogen atom, an alkyl group or an alkoxy group; and Φ represent any one of groups (Φ -1), (Φ -2) or (Φ -3) respectively represented by the formulas.





(Φ-2)



(Φ-3)

In the hole transferring material as described above, examples of the alkyl group, alkoxy group, aryl group, aralkyl group and halogen atoms include the same groups as those described above.

Examples of the substituents which may be substituted on the alkyl group and alkoxy group include halogen atom, amino group, hydroxyl group, optionally esterified carboxyl group, cyano group, alkoxy group having 1 to 6 carbon atoms, alkenyl group having 2 to 6 carbon atoms which may have an aryl group, etc. In addition, the substitution position of the substituent are not specifically limited.

Examples of the substituents which may be substituted on the aryl groups include halogen atom, amino group, hydroxyl group, optionally esterified carboxyl group, cyano group, alkyl group having 1 to 6 carbon atoms, alkoxy group having 1 to 6 carbon atoms, alkenyl group having 2 to 6 carbon atoms which may have an aryl group, etc. In addition, the substitution position of the substituent are not specifically limited.

Furthermore, there can be used hole transferring materials, with the above-described electron transferring materials (HT1) to (HT13), or in place of them, which have hitherto been known, that is, nitrogen-containing cyclic compounds and condensed polycyclic compounds, e.g. oxadiazole compounds such as 2,5-di(4-methylaminophenyl)-1,3,4-oxadiazole, etc.; styryl compounds such as 9-(4-diethylaminostyryl)anthracene, etc.; carbazole compounds such as polyvinyl carbazole, etc.; organopolysilane compounds; pyrazoline compounds such as 1-phenyl-3-(pdimethylaminophenyl)pyrazoline, etc.; hydrazone compounds; triphenylamine compounds; indole compounds; oxazole compounds; isoxazole compounds; thiazole compounds; thiadiazole compounds; imidazole compounds; pyrazole compounds; and triazole compounds.

In the present invention, these hole transferring materials may be used alone or in combination. When using the hole transferring material having film forming properties, such as poly(vinylcarbazole), etc., a binding resin is not required necessarily.

Binding resin

As the binding resin for dispersing the above respective components, there can be used various resins which have hitherto been used in the photosensitive layer, and examples thereof include thermoplastic resins such as styrene-butadiene copolymer, styrene-acrylonitrile copolymer, styrenemaleic acid copolymer, acrylic copolymer, styrene-acrylic acid copolymer, polyethylene, ethylene-vinyl acetate copolymer, chlorinated polyethylene, polyvinyl chloride, polypropylene, ionomer, vinyl chloride-vinyl acetate copolymer, polyester, alkyd resin, polyamide, polyurethane, polycarbonate, polyarylate, polysulfon, diaryl phthalate resin, ketone resin, polyvinyl butyral resin, polyether resin, polyester resin, etc.; crosslinking thermosetting resins such as silicone resin, epoxy resin, phenol resin, urea resin, melamine resin, etc.; and photosetting resins such as epoxy acrylate, urethane acrylate, etc.

In addition, various additives which have hitherto been known, such as deterioration inhibitors (e.g. antioxidants, radical scavengers, singlet quenchers, ultraviolet absorbers, etc.), softeners, plasticizers, surface modifiers, bulking agents, thickening agents, dispersion stabilizers, wax, acceptors, donors, etc. can be formulated in the photosensitive layer without injury to the electrophotographic characteristics. In order to improve the sensitivity of the photosensitive layer, known sensitizers such as terphenyl, halonaphthoquinones, acenaphthylene, etc. may be used in combination with the electric charge generating material.

A method of producing the electrophotosensitive material of the present invention will be described hereinafter.

A single-layer type electrophotosensitive material, an electric charge generating material, a hole transferring material, a binding resin and an electron transferring material may be dissolved or dispersed in a suitable solvent, and the resulting coating solution may be applied to a conductive substrate using means such as application, followed by

drying.

In the single-layer type photosensitive material, the electric charge generating material may be formulated in the amount of 0.1 to 50 parts by weight, preferably 0.5 to 30 parts by weight, based on 100 parts by weight of the binding resin. The electron transferring material may be formulated in the amount of 5 to 100 parts by weight, preferably 10 to 80 parts by weight, based on 100 parts by weight of the binding resin. In addition, the hole transferring material may be formulated in the amount of 5 to 500 parts by weight, preferably 25 to 200 parts by weight, based on 100 parts by weight of the binding resin. In a case that the electron transferring material is used with the hole transferring material, it is suitable that the total amount of the hole transferring material and electron transferring material is 10 to 500 parts by weight, preferably 30 to 200 parts by weight, based on 100 parts by weight of the binding resin. When the other electron transferring material which has a predetermined redox potential is used, the amount of the other electron transferring material may be 0.1 to 40 parts by weight, preferably 0.5 to 20 parts by weight, based on 100 parts by weight of the binding resin.

The thickness of the single-layer type photosensitive material may be 5 to 100 μm , preferably 10 to 50 μm .

For multi-layer type electrophotosensitive material, an electric charge generating layer containing an electric charge generating material may be formed on a conductive substrate using means such as deposition, application, etc., and then a coating solution containing an electron transferring material and a binding resin may be applied to the electric charge generating layer using means such as application, followed by drying, to form an electric charge transferring layer.

In the multi-layer photosensitive material, the electric charge generating material and binding resin which constitute the electric charge generating layer may be used in various proportions. It is suitable that the electric charge generating material is formulated in the amount of 5 to 1,000 parts by weight, preferably 30 to 500 parts by weight, based on 100 parts by weight of the binding resin. When a hole transferring material is contained in the electric charge generating layer, it is suitable that the hole transferring material is formulated in the amount of 10 to 500 parts by weight, preferably 50 to 200 parts by weight, based on 100 parts by weight of the binding resin.

The electron transferring material and binding resin, which constitute the electric charge transferring layer, may be used in various proportions within such a range as not to prevent the transfer of electrons and to prevent crystallization. It is suitable that the electron transferring material is used in the amount of 10 to 500 parts by weight, preferably 25 to 100 parts by weight, based on 100 parts by weight of the binding resin, so as to easily transfer electrons generated by light irradiation in the electric charge generating layer. When the other electron transferring material which has a predetermined redox potential is used, the amount of the other electron transferring material may be 0.1 to 40 parts by weight, preferably 0.5 to 20 parts by weight of the binding resin.

Regarding the thickness of the multi-layer type photosensitive layer, the thickness of the electric charge generating layer may be about 0.01 to 5 μm , preferably about 0.1 to 3 μm , and that of the electric charge transferring layer may be 2 to 100 μm , preferably about 5 to 50 μm .

A barrier layer may be formed, in such a range as not to injure the characteristics of the photosensitive material, between the conductive substrate and photosensitive layer in the single-layer type photosensitive material, or between the conductive substrate and electric charge generating layer or between the conductive substrate layer and electric charge transferring layer in the multi-layer type photosensitive material. Further, a protective layer may be formed on the surface of the photosensitive layer.

As the conductive substrate to be used in the electrophotosensitive material of the present invention, various materials having conductivity can be used, and examples thereof include single metals such as iron, aluminum, copper, tin, platinum, silver, vanadium, molybdenum, chromium, cadmium, titanium, nickel, palladium, indium, stainless steel, brass, etc.; plastic materials which are vapor-deposited or laminated with the above metals; glass materials coated with aluminum iodide, tin oxide, indium oxide, etc.

The conductive substrate may be made in the form of a sheet or a drum for the construction of image forming apparatuses. The substrate itself may have conductivity or only the surface of the substrate may have conductivity. It is preferred that the conductive substrate has sufficient mechanical strength when used.

The photosensitive layer may be produced by applying a dispersing (coating) solution, obtainable by dissolving or dispersing a resin composition containing the above respective components in a suitable solvent, on a conductive substrate, followed by drying.

That is, the above electric charge generating material, electric charge transferring material and binding resin may be dispersed and mixed with a suitable solvent by a known method, for example, using a roll mill, a ball mill, an attriter, a paint shaker, a supersonic dispenser, etc. to prepare a dispersion, which may be applied by a known means and then allowed to dry.

As the solvent for preparing the dispersing solution, there can be used various organic solvents, and examples thereof include alcohols such as methanol, ethanol, isopropanol, butanol, etc.; aliphatic hydrocarbons such as n-hexane, octane, cyclohexane, etc.; aromatic hydrocarbons such as benzene, toluene, xylene, etc.; halogenated hydrocarbons such as dichloromethane, dichloroethane, chloroform, carbon tetrachloride, chlorobenzene, etc.; ethers such as dime-

thyl ether, diethyl ether, tetrahydrofuran, ethylene glycol dimethyl ether, diethylene glycol dimethyl ether, etc.; ketones such as acetone, methyl ethyl ketone, cyclohexanone, etc.; esters such as ethyl acetate, methyl acetate, etc.; dimethylformaldehyde, dimethylformamide, dimethyl sulfoxide, etc. These solvents may be used alone or in combination.

In order to improve the dispersibility of the electric charge transferring material and electric charge generating material, as well as the smoothness of the surface of the photosensitive layer, there may be used surfactants, leveling agents, etc.

EXAMPLES

The following Synthesis Examples, Examples and Comparative Examples further illustrate the present invention in detail.

Synthesis of naphthoquinone derivative

Synthesis Example 1

(Synthesis of naphthoquinone derivative (11-1))

After the atmosphere in a flask was replaced by argon, THF 60 ml, diethyl disulfide 14.6 g (0.06 mol) and tributylphosphine 12.0 g (0.06 mol) were charged and the mixture was stirred at room temperature for 5 minutes. Furthermore, an aqueous 10% sodium hydroxide solution 40 ml was added, followed by stirring at room temperature for 15 minutes to obtain a white suspension. Then, 2,3-dichloro-1,4-naphthoquinone 6.81 g (0.03 mol) was dissolved in 90 ml of THF and the solution was added dropwise in the above white suspension, followed by stirring at room temperature for 4 hours. The reaction solution thus obtained was added to an aqueous sodium hypochlorite. The reaction product was extracted with chloroform, washed with water and then purified by silica gel chromatography (developing solvent: mixed solvent of chloroform:hexane = 1:1) and recrystallization to obtain 6.5 g (yield 77.9%) of a naphthoquinone derivative represented by the above formula (11-1).

Melting point: 119-123°C

The ¹H-NMR spectrum of the naphthoquinone derivative (11-1) is shown in Fig. 2.

Synthesis Example 2

(Synthesis of naphthoquinone derivative (11-2))

According to the same manner as that described in Synthesis Example 1 except for using diphenyl disulfide 11.2 g (0.06 mol) in place of diethyl disulfide, the reaction was performed to obtain 9.37 g (yield 83.5%) of a naphthoquinone derivative represented by the above formula (11-2).

Melting point: 152-155°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (11-2) is shown in Fig. 3.

Synthesis Example 3

(Synthesis of naphthoquinone derivative (11-3))

According to the same manner as that described in Synthesis Example 1 except for using dimethyl disulfide 5.64 g (0.06 mol) in place of diethyl disulfide, the reaction was performed to obtain 5.93 g (yield 79.1%) of a naphthoquinone derivative represented by the above formula (11-3).

Melting point: 125-127°C.

The infrared absorption (IR) spectrum of the naphthoquinone derivative (11-3) is shown in Fig. 4.

Synthesis Example 4

(Synthesis of naphthoquinone derivative (11-4))

According to the same manner as that described in Synthesis Example 1 except for using di(p-tolyl) disulfide 14.6 g (0.06 mol) in place of diethyl disulfide, the reaction was performed to obtain 12.0 g (yield 99.5%) of a naphthoquinone derivative represented by the above formula (11-4).

Melting point: 147-149°C.

The infrared absorption (IR)spectrum of the naphthoquinone derivative (11-4) is shown in Fig. 5.

Synthesis Example 5

(Synthesis of naphthoquinone derivative (12-1))

4-isopropylphenol 7.5 g (0.55 mol), DMF 70 ml and potassium carbonate 7.6 g (0.055 mol) were charged in a flask and the mixture was stirred with heating at 40 to 50°C. Then, a solution prepared by dissolving 2,3-dichloro-1,4-naphthoquinone 5 g (0.022 mol) in 30 ml of DMF was added, followed by stirring at room temperature for 2 hours. The reaction solution thus obtained was added to water and a crude product was obtained by suction filtration. Furthermore, the crude product was purified by silica gel column chromatography (developing solvent: mixed solvent of chloroform:hexane=1:1) to obtain 6.2 g (yield 64%) of a naphthoquinone derivative represented by the above formulas (12-1).

Melting point: 139-140°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-1) is shown in Fig. 6.

Synthesis Example 6

(Synthesis of naphthoquinone derivative (12-2))

According to the same manner as that described in Synthesis Example 5 except for using phenol 5.2 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 4.2 g (yield 56%) of a naphthoquinone derivative represented by the above formula (12-2).

Melting point: 204-205°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-2) is shown in Fig. 7.

Synthesis Example 7

(Synthesis of naphthoquinone derivative (12-3))

According to the same manner as that described in Synthesis Example 5 except for using 4-benzylphenol 10.1 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 9.1 g (yield 79%) of a naphthoquinone derivative represented by the above formula (12-3).

Melting point: 154-156°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-3) is shown in Fig. 8.

Synthesis Example 8

(Synthesis of naphthoquinone derivative (12-4))

According to the same manner as that described in Synthesis Example 5 except for using 4-phenoxyphenol 10.2 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 7.7 g (yield 66%) of a naphthoquinone

derivative represented by the above formula (12-4).

Melting point: 167-169°C.

5 The ¹H-NMR spectrum of the naphthoquinone derivative (12-4) is shown in Fig. 9.

Synthesis Example 9

(Synthesis of naphthoquinone derivative (12-5))

10

According to the same manner as that described in Synthesis Example 5 except for using 4-trifluoromethylphenol 8.9 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 7.2 g (yield 69%) of a naphthoquinone derivative represented by the above formula (12-5).

15 Melting point: 199-201°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-5) is shown in Fig. 10.

Synthesis Example 10

20

(Synthesis of naphthoquinone derivative (12-6))

According to the same manner as that described in Synthesis Example 5 except for using 3-isopropylphenol 7.5 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 8.6 g (yield 92%) of a naphthoquinone derivative represented by the above formula (12-6).

25

Melting point: 99-100°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-6) is shown in Fig. 11.

30

Synthesis Example 11

(Synthesis of naphthoquinone derivative (12-7))

35 According to the same manner as that described in Synthesis Example 5 except for using 2-isopropylphenol 7.5 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 7.1 g (yield 76%) of a naphthoquinone derivative represented by the above formula (12-7).

Melting point: 100-102°C.

40

The ¹H-NMR spectrum of the naphthoquinone derivative (12-7) is shown in Fig. 12.

Synthesis Example 12

(Synthesis of naphthoquinone derivative (12-8))

45 According to the same manner as that described in Synthesis Example 5 except for using 2-trifluoromethylphenol 8.9 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 5.7 g (yield 54%) of a naphthoquinone derivative represented by the above formula (12-8).

50

Melting point: 192-194°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-8) is shown in Fig. 13.

55

Synthesis Example 13

(Synthesis of naphthoquinone derivative (12-9))

According to the same manner as that described in Synthesis Example 5 except for using 3,4-dimethylphenol 6.7 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 7.5 g (yield 86%) of a naphthoquinone derivative represented by the above formula (12-9).

Melting point: 149-151°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-9) is shown in Fig. 14.

Synthesis Example 14

(Synthesis of naphthoquinone derivative (12-10))

According to the same manner as that described in Synthesis Example 5 except for using 3,5-dimethylphenol 6.7 g (0.055 mol) in place of 4-isopropylphenol, the reaction was performed to obtain 8.0 g (yield 91%) of a naphthoquinone derivative represented by the above formula (12-10).

Melting point: 176-178°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-10) is shown in Fig. 15.

Synthesis Example 15

(Synthesis of naphthoquinone derivative (12-11))

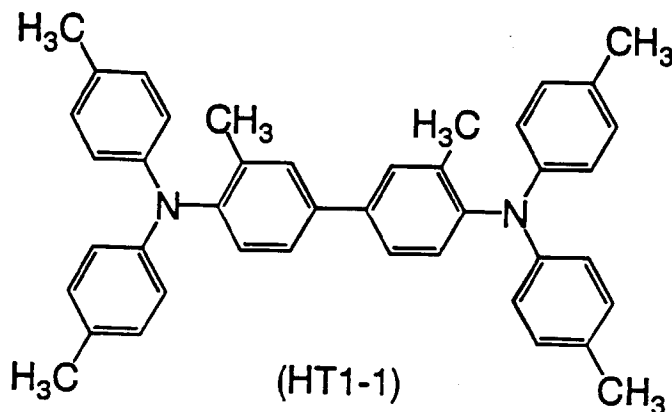
According to the same manner as that described in Synthesis Example 5 except for using 4(benzyloxycarbonyl) phenol 12.6 g (0.055 mol) in place of 4isopropylphenol, the reaction was performed to obtain 9.9 g (yield 74%) of a naphthoquinone derivative represented by the above formula (12-11).

Melting point: 149-151°C.

The ¹H-NMR spectrum of the naphthoquinone derivative (12-11) is shown in Fig. 16.

Production of electrophotosensitive materialExample 1

A metal-free phthalocyanine pigment (CG1) was used as the electric charge generating material, a benzidine derivative represented by the formula (HT1-1):



was used as the hole transferring material, and a naphthoquinone derivative represented by the above formula (11-1) was used as the electron transferring material, respectively.

5 Parts by weight of the above electric charge generating material, 50 parts by weight of the above hole transferring material, 30 parts by weight of the above electron transferring material, 100 parts by weight of a binding resin (polycarbonate) and 800 parts by weight of a solvent (tetrahydrofuran) were mixed and dispersed in a ball mill for 50 hours to prepare a coating solution for single-layer type photosensitive layer. Then, this coating solution was applied on a conductive substrate (aluminum tube) by a dip coating method, followed by hot-air drying at 100 °C for 60 minutes to obtain a single-layer type electrophotosensitive material (for digital light source) having a photosensitive layer of 15 to 20 μm in film thickness.

Example 2

According to the same manner as that described in Example 1 except for using a titanyl phthalocyanine pigment (CG2) as the electric charge generating material, a single-layer type photosensitive material (for digital light source) was produced.

Example 3

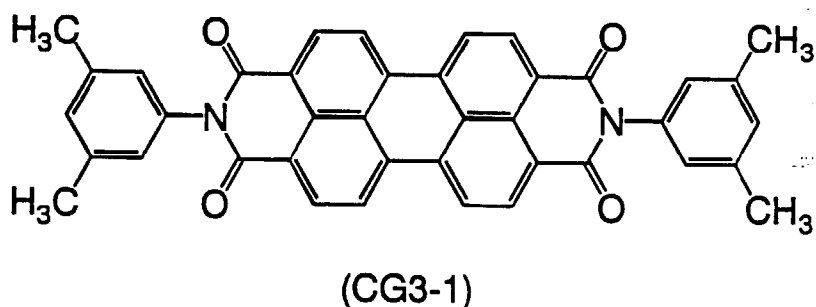
A metal-free phthalocyanine pigment (CG1) was used as the electric charge generating material and a naphthoquinone derivative represented by the above formula (11-1) was used as the electron transferring material, respectively.

100 Parts by weight of the above electric charge generating material, 100 parts by weight of a binding resin (polyvinyl butyral) and 2,000 parts by weight of a solvent (tetrahydrofuran) were mixed and dispersed in a ball mill for 50 hours to prepare a coating solution for electric charge generating layer. Then, this coating solution was applied on a conductive substrate (aluminum tube) by a dip coating method, followed by hot-air drying at 100 °C for 60 minutes to form an electric charge generating layer of 1 μm in film thickness.

Then, 100 parts by weight of the above electron transferring material, 100 parts by weight of a binding resin (polycarbonate) and 800 parts by weight of a solvent (toluene) were mixed and dispersed in a ball mill for 50 hours to prepare a coating solution for electric charge transferring layer. Then, this coating solution was applied on the above electric charge generating layer by a dip coating method, followed by hot-air drying at 100 °C for 60 minutes to form an electric charge transferring layer of 20 μm in film thickness, thereby producing a multi-layer type electrophotosensitive material (for digital light source).

Example 4

According to the same manner as that described in Example 1 except for using a perylene pigment represented by the formula (CG3-1):



15 as the electric charge generating material, a single-layer type electrophotosensitive material (for analog light source) was produced.

Example 5

20 According to the same manner as that described in Example 3 except for using a perylene pigment represented by the above formula (CG3-1) as the electric charge generating material, a multi-layer type electrophotosensitive material (for analog light source) was produced.

Examples 6 to 9

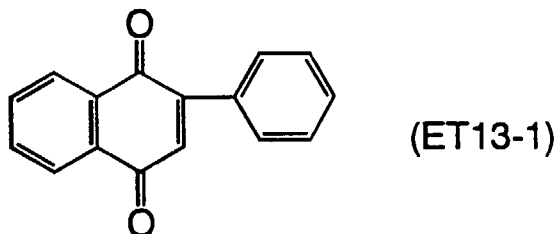
25 A metal-free phthalocyanine pigment (CG1) was used as the electric charge generating material, a benzidine derivative represented by the above formula (HT1-1) was used as the hole transferring material, and a naphthoquinone derivative represented by the above formula (11-1) was used as the electron transferring material, respectively.

30 As the other electron transferring material having a predetermined redox potential, a benzoquinone derivative (Example 6) represented by the above formula (4-1), a benzoquinone derivative (Example 7) represented by the above formula (4-2), a diphenoquinone derivative (Example 8) represented by the above formula (3-1) and a diphenoquinone derivative (Example 9) represented by the above formula (3-2) were used, respectively.

35 5 Parts by weight of the above electric charge generating material, 50 parts by weight of the above hole transferring material, 30 parts by weight of the above electron transferring material, 10 parts by weight of the above other electron transferring material, 100 parts by weight of a binding resin (polycarbonate) and 800 parts by weight of a solvent (tetrahydrofuran) were mixed and dispersed in a ball mill for 50 hours to prepare a coating solution for single-layer type photosensitive layer. Then, this coating solution was applied on a conductive substrate (aluminum tube) by a dip coating method, followed by hot-air drying at 100 °C for 60 minutes to obtain a single-layer type electrophotosensitive material (for digital light source) having a photosensitive layer of 15 to 20 μm in film thickness, respectively.

Comparative Examples 1 and 10

45 According to the same manner as that described in Example 1 except for using a naphthoquinone derivative (Comparative Example 1) represented by the formula (ET13-1):



55 or a diphenoquinone derivative (Comparative Example 10) represented by the above formula (3-1) as the electron transferring material, a single-layer type electrophotosensitive material (for digital light source) was produced, respectively.

Comparative Examples 2 and 11

According to the same manner as that described in Example 2 except for using a naphthoquinone derivative (Comparative Example 2) represented by the above formula (ET13-1) or a diphenoquinone derivative (Comparative Example 11) represented by the above formula (3-1) as the electron transferring material, a single-layer type electrophotosensitive material (for digital light source) was produced, respectively.

Comparative Examples 3 and 13

According to the same manner as that described in Example 3 except for using a naphthoquinone derivative (Comparative Example 3) represented by the above formula (ET13-1) or a diphenoquinone derivative (Comparative Example 13) represented by the above formula (3-1) as the electron transferring material, a multi-layer type electrophotosensitive material (for digital light source) was produced, respectively.

Comparative Examples 4 and 14

According to the same manner as that described in Example 4 except for using a naphthoquinone derivative (Comparative Example 4) represented by the above formula (ET13-1) or a diphenoquinone derivative (Comparative Example 14) represented by the above formula (3-1) as the electron transferring material, a single-layer type electrophotosensitive material (for analog light source) was produced, respectively.

Comparative Examples 5 and 16

According to the same manner as that described in Example 5 except for using a naphthoquinone derivative (Comparative Example 5) represented by the above formula (ET13-1) or a diphenoquinone derivative (Comparative Example 16) represented by the above formula (3-1) as the electron transferring material, a multi-layer type electrophotosensitive material (for analog light source) was produced, respectively.

Comparative Examples 6 to 9

According to the same manner as that described in Examples 6 to 9 except for using a naphthoquinone derivative represented by the above formula (ET13-1) as the electron transferring material, a single-layer type electrophotosensitive material (for digital light source) was produced, respectively.

As the other electron transferring material having a predetermined redox potential, a benzoquinone derivative (Comparative Example 6) represented by the above formula (4-1), a benzoquinone derivative (Comparative Example 7) represented by the above formula (4-2), a diphenoquinone derivative (Comparative Example 8) represented by the above formula (3-1) and a diphenoquinone derivative (Comparative Example 9) represented by the above formula (3-2) were used, respectively.

Comparative Example 12

According to the same manner as that described in Example 1 except for using no electron transferring material, a single-layer type electrophotosensitive material (for digital light source) was produced.

Comparative Example 15

According to the same manner as that described in Example 4 except for using no electron transferring material, a single-layer type electrophotosensitive material (for analog light source) was produced.

Among the photosensitive materials obtained in the above Examples and Comparative Examples, the photosensitive materials for digital light source were subjected to the following electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the following electric characteristics test (B), and their electric characteristics were evaluated.

Electric characteristics test (A)

By using a drum sensitivity tester manufactured by GENTEC Co., a voltage was applied on the surface of the photosensitive material to charge the surface at +700 V. Then, the above photosensitive material was exposed by irradiating monochromatic light (irradiation time: 80 msec.) having a wavelength of 780 nm (half-width: 20 nm, light in-

tensity: $16 \mu\text{W}/\text{cm}^2$) from white light of a halogen lamp through a band-pass filter to measure, as a residual potential V_r (unit: V), a surface potential at the time at which 330 msec. has passed since the beginning of exposure.

Electric characteristics test (B)

According to the same manner as that described in the above electric characteristics test (A) except that white light (light intensity: $147 \mu\text{W}/\text{cm}^2$) of a halogen lamp was used as an exposure light source and the irradiation time was set to 50 msec., a residual potential V_r (V) was measured.

The smaller a value of the residual potential V_r , the better the sensitivity.

The kind of the electric charge generating materials, hole transferring materials, electron transferring materials and other electron transferring materials having a predetermined redox potential used in the above Examples 1 to 9 and Comparative Examples 1 to 16 are shown in Tables 1 to 2, together with the results of the electric characteristics test. The kind of the electric charge generating material, hole transferring material and electron transferring material was represented by the number put to each compound.

Table 1

	photosensitive layer	CGM	HTM	ETM	residual potential V_r (V)
Example 1	single	CG 1	HT 1-1	11-1	183
Example 2	single	CG 2	HT 1-1	11-1	194
Example 3	multi	CG 1	-	11-1	269
Example 4	single	CG 3-1	HT 1-1	11-1	231
Example 5	multi	CG 3-1	-	11-1	218
Example 6	single	CG 1	HT 1-1	11-1, 4-1	139
Example 7	single	CG 1	HT 1-1	11-1, 4-2	139
Example 8	single	CG 1	HT 1-1	11-1, 3-1	130
Example 9	single	CG 1	HT 1-1	11-1, 3-2	124

Table 2

	photosensitive layer	CGM	HTM	ETM	residual potential V_r (V)
Comp. Ex. 1	single	CG 1	HT 1-1	ET13-1	305
Comp. Ex. 2	single	CG 2	HT 1-1	ET13-1	330
Comp. Ex. 3	multi	CG 1	-	ET13-1	409
Comp. Ex. 4	single	CG 3-1	HT 1-1	ET13-1	375
Comp. Ex. 5	multi	CG 3-1	-	ET13-1	455
Comp. Ex. 6	single	CG 1	HT 1-1	ET13-1, 4-1	295
Comp. Ex. 7	single	CG 1	HT 1-1	ET13-1, 4-2	290
Comp. Ex. 8	single	CG 1	HT 1-1	ET13-1, 3-1	290
Comp. Ex. 9	single	CG 1	HT 1-1	ET13-1, 3-2	288
Comp. Ex. 10	single	CG 1	HT 1-1	3-1	220
Comp. Ex. 11	single	CG 2	HT 1-1	3-1	242
Comp. Ex. 12	single	CG 1	HT 1-1	-	478
Comp. Ex. 13	multi	CG 1	-	3-1	346
Comp. Ex. 14	single	CG 3-1	HT 1-1	3-1	294
Comp. Ex. 15	single	CG 3-1	HT 1-1	-	521
Comp. Ex. 16	multi	CG 3-1	-	3-1	386

Examples 10 to 18

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (11-2) as the electron transferring material, an electrophotosensitive material was produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 10 to 18 are shown in Table 3, together with the results of the electric characteristics test.

Table 3

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 10	single	CG 1	HT 1-1	11-2	171
Example 11	single	CG 2	HT 1-1	11-2	189
Example 12	multi	CG 1	-	11-2	265
Example 13	single	CG 3-1	HT 1-1	11-2	223
Example 14	multi	CG 3-1	-	11-2	210
Example 15	single	CG 1	HT 1-1	11-2, 4-1	132
Example 16	single	CG 1	HT 1-1	11-2, 4-2	130
Example 17	single	CG 1	HT 1-1	11-2, 3-1	127
Example 18	single	CG 1	HT 1-1	11-2, 3-2	120

Examples 19 to 27

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (11-3) as the electron transferring material, an electrophotosensitive material was produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 19 to 27 are shown in Table 4, together with the results of the electric characteristics test.

Table 4

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 19	single	CG 1	HT 1-1	11-3	185
Example 20	single	CG 2	HT 1-1	11-3	197
Example 21	multi	CG 1	-	11-3	273
Example 22	single	CG 3-1	HT 1-1	11-3	235
Example 23	multi	CG 3-1	-	11-3	221
Example 24	single	CG 1	HT 1-1	11-3, 4-1	140
Example 25	single	CG 1	HT 1-1	11-3, 4-2	139
Example 26	single	CG 1	HT 1-1	11-3, 3-1	130
Example 27	single	CG 1	HT 1-1	11-3, 3-2	127

Examples 28 to 36

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (11-4) as the electron transferring material, an electrophotosensitive material was

produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 28 to 36 are shown in Table 5, together with the results of the electric characteristics test.

Table 5

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 28	single	CG 1	HT 1-1	11-4	170
Example 29	single	CG 2	HT 1-1	11-4	189
Example 30	multi	CG 1	-	11-4	267
Example 31	single	CG 3-1	HT 1-1	11-4	222
Example 32	multi	CG 3-1	-	11-4	220
Example 33	single	CG 1	HT 1-1	11-4, 4-1	130
Example 34	single	CG 1	HT 1-1	11-4, 4-2	128
Example 35	single	CG 1	HT 1-1	11-4, 3-1	127
Example 36	single	CG 1	HT 1-1	11-4, 3-2	120

Examples 37 to 45

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (12-1) as the electron transferring material, an electrophotosensitive material was produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 37 to 45 are shown in Table 6, together with the results of the electric characteristics test.

Table 6

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 37	single	CG 1	HT 1-1	12-1	174
Example 38	single	CG 2	HT 1-1	12-1	189
Example 39	multi	CG 1	-	12-1	265
Example 40	single	CG 3-1	HT 1-1	12-1	209
Example 41	multi	CG 3-1	-	12-1	192
Example 42	single	CG 1	HT 1-1	12-1, 4-1	131
Example 43	single	CG 1	HT 1-1	12-1, 4-2	130
Example 44	single	CG 1	HT 1-1	12-1, 3-1	127
Example 45	single	CG 1	HT 1-1	12-1, 3-2	121

Examples 46 to 54

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (12-3) as the electron transferring material, an electrophotosensitive material was produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 46 to 54 are shown in Table 7, together with the results of the electric characteristics test.

Table 7

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 46	single	CG 1	HT 1-1	12-3	178
Example 47	single	CG 2	HT 1-1	12-3	191
Example 48	multi	CG 1	-	12-3	268
Example 49	single	CG 3-1	HT 1-1	12-3	210
Example 50	multi	CG 3-1	-	12-3	194
Example 51	single	CG 1	HT 1-1	12-3, 4-1	135
Example 52	single	CG 1	HT 1-1	12-3, 4-2	134
Example 53	single	CG 1	HT 1-1	12-3, 3-1	130
Example 54	single	CG 1	HT 1-1	12-3, 3-2	125

Examples 55 to 63

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (12-5) as the electron transferring material, an electrophotosensitive material was produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 55 to 63 are shown in Table 8, together with the results of the electric characteristics test.

Table 8

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 55	single	CG 1	HT 1-1	12-5	179
Example 56	single	CG 2	HT 1-1	12-5	191
Example 57	multi	CG 1	-	12-5	269
Example 58	single	CG 3-1	HT 1-1	12-5	211
Example 59	multi	CG 3-1	-	12-5	196
Example 60	single	CG 1	HT 1-1	12-5, 4-1	137
Example 61	single	CG 1	HT 1-1	12-5, 4-2	135
Example 62	single	CG 1	HT 1-1	12-5, 3-1	133
Example 63	single	CG 1	HT 1-1	12-5, 3-2	128

Examples 64 to 72

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (12-6) as the electron transferring material, an electrophotosensitive material was produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 64 to 72 are shown in Table 9, together with the results of the electric characteristics test.

Table 9

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 64	single	CG 1	HT 1-1	12-6	171
Example 65	single	CG 2	HT 1-1	12-6	188
Example 66	multi	CG 1	-	12-6	264
Example 67	single	CG 3-1	HT 1-1	12-6	208
Example 68	multi	CG 3-1	-	12-6	191
Example 69	single	CG 1	HT 1-1	12-6, 4-1	130
Example 70	single	CG 1	HT 1-1	12-6, 4-2	129
Example 71	single	CG 1	HT 1-1	12-6, 3-1	125
Example 72	single	CG 1	HT 1-1	12-6, 3-2	120

Examples 73 to 81

According to the same manner as that described in Examples 1 to 9 except for using a naphthoquinone derivative represented by the above formula (12-9) as the electron transferring material, an electrophotosensitive material was produced, respectively.

Then, the photosensitive materials for digital light source were subjected to the above electric characteristics test (A) and the photosensitive materials for analog light source were subjected to the above electric characteristics test (B), and their electric characteristics were evaluated.

The kind of the electric charge generating materials, hole transferring materials, and electron transferring materials used in the above Examples 73 to 81 are shown in Table 10, together with the results of the electric characteristics test.

Table 10

	photosensitive layer	CGM	HTM	ETM	residual potential Vr (V)
Example 73	single	CG 1	HT 1-1	12-9	172
Example 74	single	CG 2	HT 1-1	12-9	188
Example 75	multi	CG 1	-	12-9	266
Example 76	single	CG 3-1	HT 1-1	12-9	208
Example 77	multi	CG 3-1	-	12-9	190
Example 78	single	CG 1	HT 1-1	12-9, 4-1	129
Example 79	single	CG 1	HT 1-1	12-9, 4-2	127
Example 80	single	CG 1	HT 1-1	12-9, 3-1	126
Example 81	single	CG 1	HT 1-1	12-9, 3-2	122

As is apparent from Tables 1 to 10, all of the photosensitive materials using a naphthoquinone derivative represented by the general formula (1) as the electron transferring material of Examples 1 to 81 have a residual potential V_r smaller than that of corresponding photosensitive materials of Comparative Examples 1 to 16, and are superior in sensitivity.

The photosensitive material using the naphthoquinone derivative (1) in combination with the other electron transferring material having a predetermined redox potential has smaller residual potential V_r , and its sensitivity is more excellent.

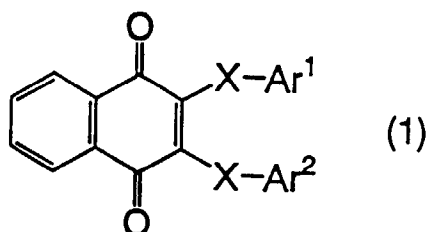
As described above, the naphthoquinone derivative (1) of the present invention can be suitably used as the electric charge transferring material (electron transferring material) in the electrophotosensitive material, solar battery, electroluminescence, etc. because of high electric charge transferring capability (electron transferring capability) and excellent compatibility with a binding resin.

Furthermore, the electrophotosensitive material of the present invention has high sensitivity because a photosensitive layer containing the naphthoquinone derivative represented by the general formula (1) is provided. Accordingly, the electrophotosensitive material of the present invention has advantages, such as contribution of realization of high

speed, high performance, etc. for various image forming apparatuses such as electrostatic copying machines, laser beam printers and the like.

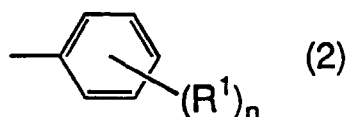
Claims

1. A naphthoquinone derivative represented by the general formula (1):



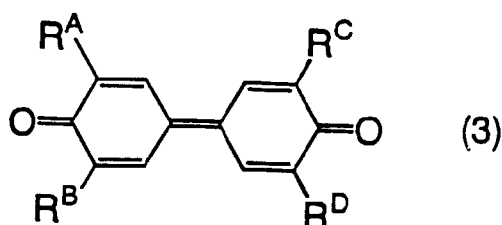
wherein X represents a sulfur atom or an oxygen atom; and Ar¹ and Ar² are the same or different and represent an alkyl group, or a substituted or unsubstituted phenyl group.

2. The naphthoquinone derivative according to claim 1, wherein the substituted or unsubstituted phenyl group is represented by a group (2):

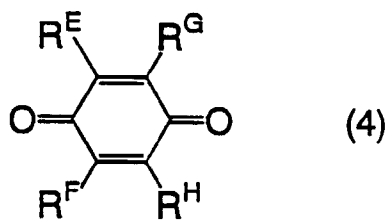


wherein R¹ represents an alkyl group, a halogenated alkyl group, an aryl group, an aralkyl group, an alkoxy group, an aryloxy group, an aralkyloxy group, an acyl group, an alkoxycarbonyl group, an aryloxycarbonyl group, an aralkyloxycarbonyl group or a nitro group; and n represents an integer of 0 to 3.

3. An electrophotosensitive material comprising a conductive substrate and a photosensitive layer provided on the conductive substrate, the photosensitive layer comprising the naphthoquinone derivative claimed in claim 1 or claim 2.
4. The electrophotosensitive material according to claim 3, wherein the photosensitive layer comprises an electron transferring material having a redox potential of -0.8 to -1.4 V.
5. The electrophotosensitive material according to claim 4, wherein the electron transferring material is a diphenoquinone derivative represented by the general formula (3):

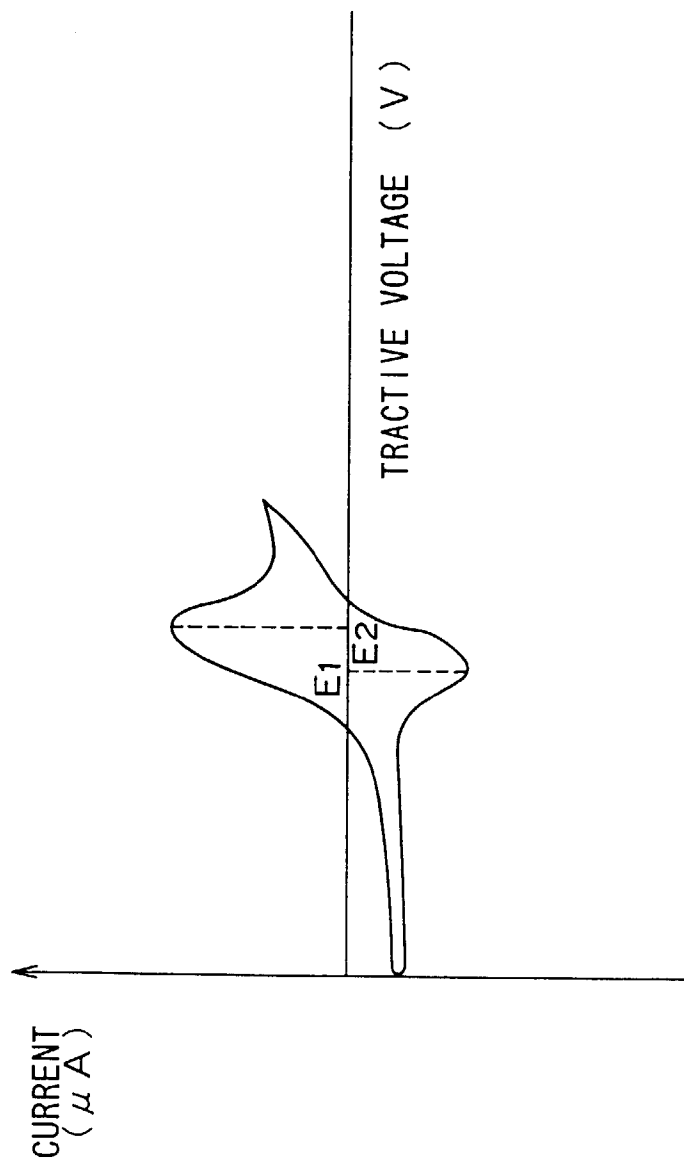


wherein R^A, R^B, R^C and R^D are the same or different and represent a hydrogen atom, an alkyl group, an aryl group, an aralkyl group, a cycloalkyl group, an alkoxy group, or a substituted or unsubstituted amino group, or a benzoquinone derivative represented by the general formula (4):



10 wherein R^E , R^F , R^G and R^H are the same or different and represent a hydrogen atom, an alkyl group, an aryl group, an aralkyl group, a cycloalkyl group, an alkoxy group, or a substituted 20 or unsubstituted amino group.

FIG. 1



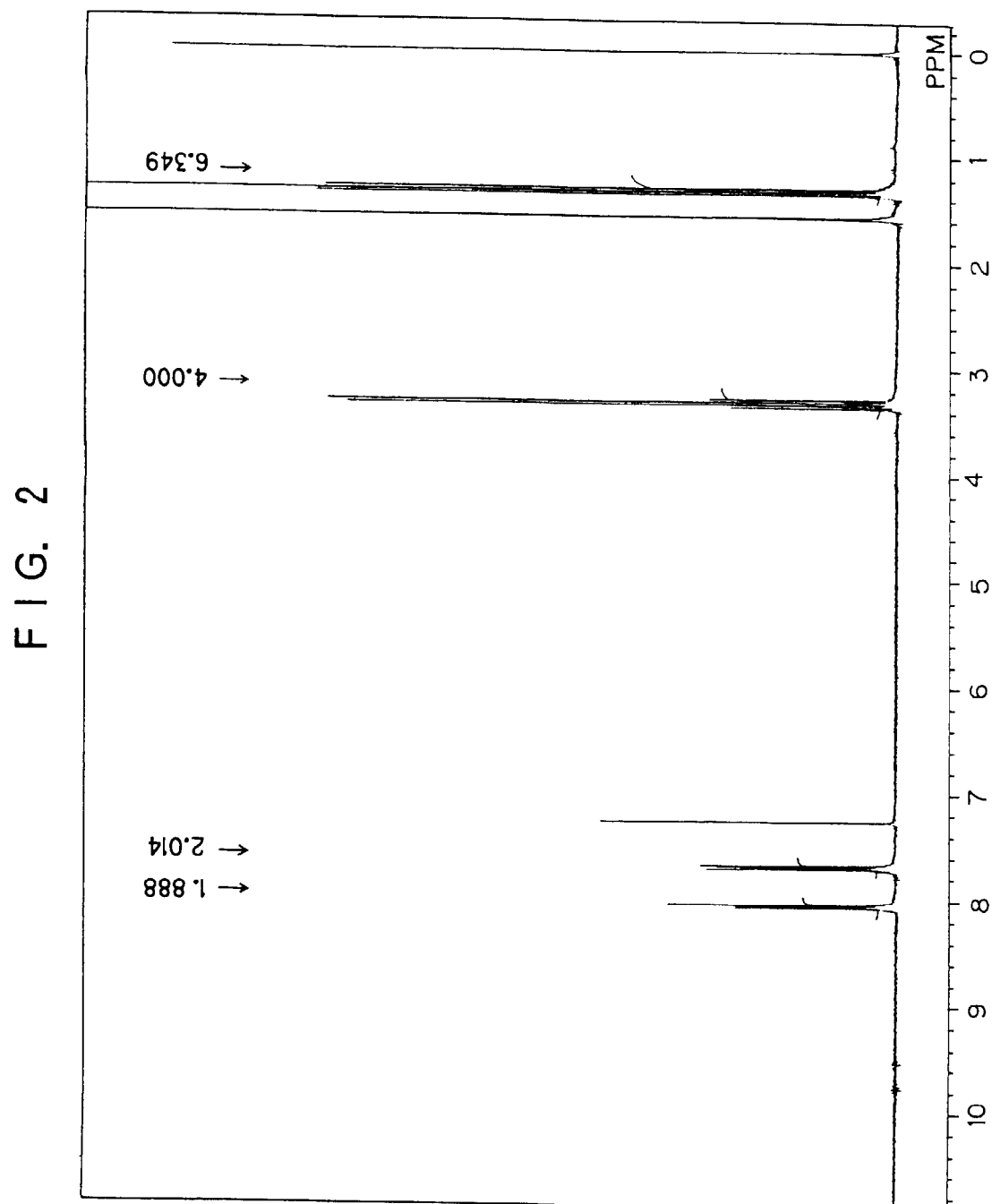


FIG. 3

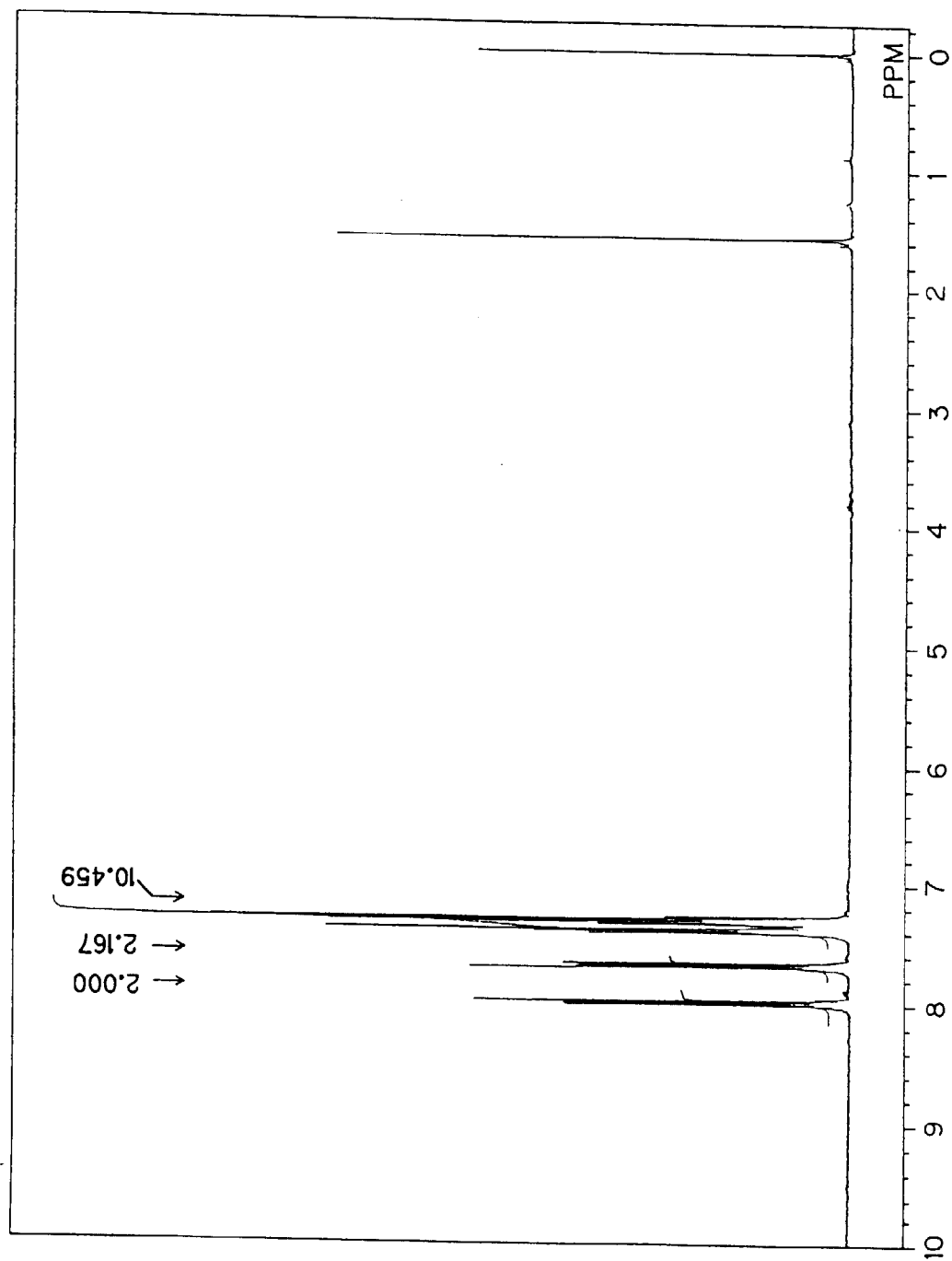


FIG. 4

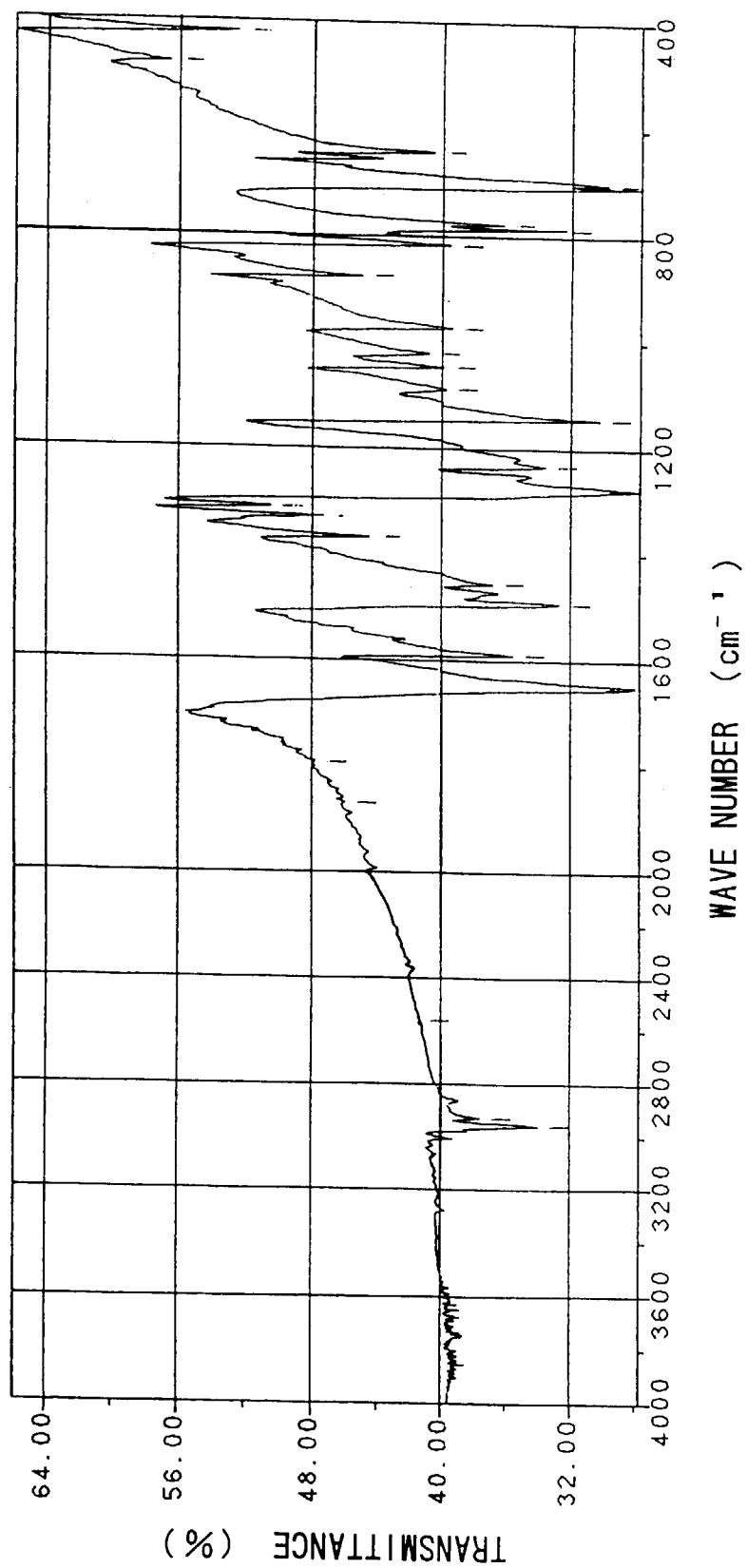


FIG. 5

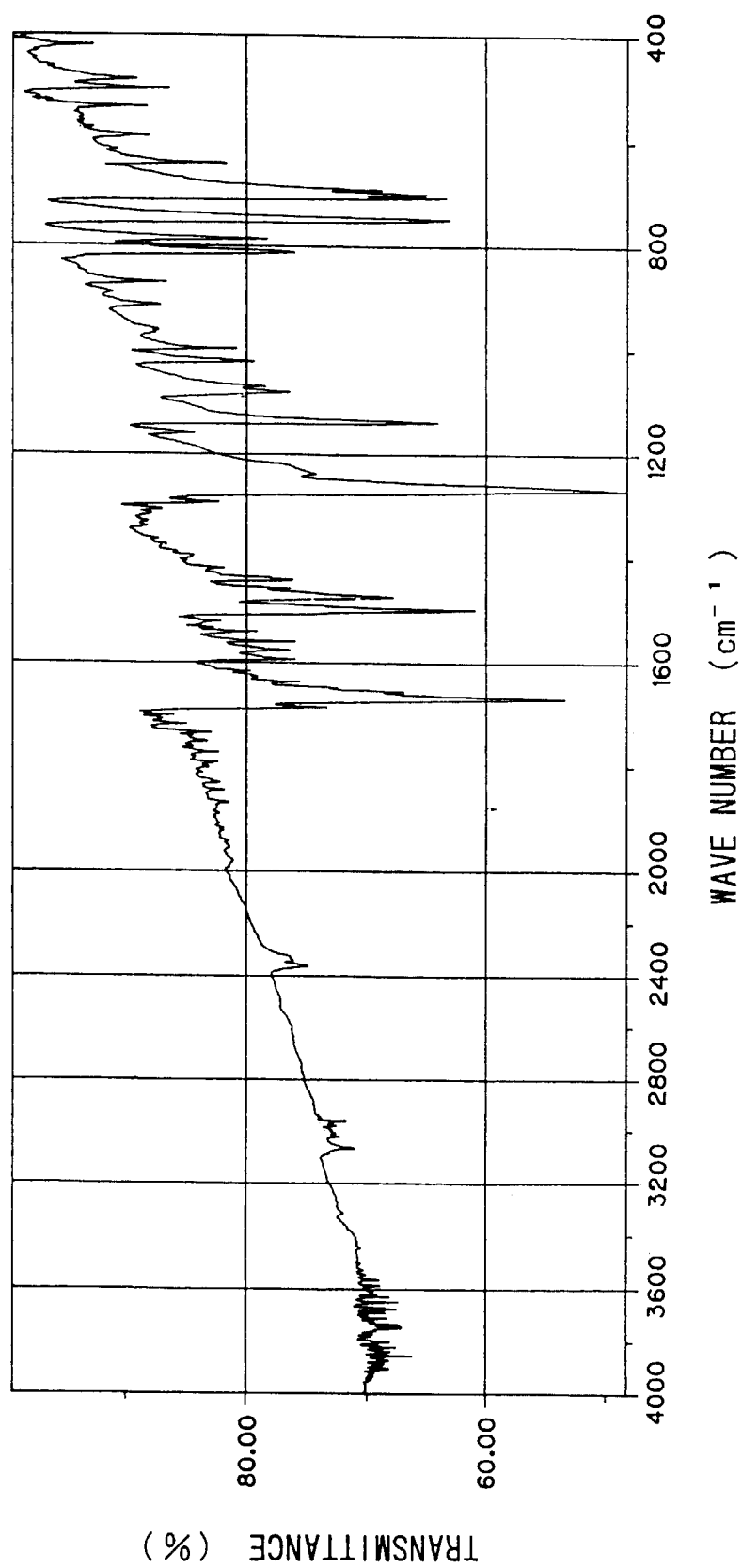


FIG. 6

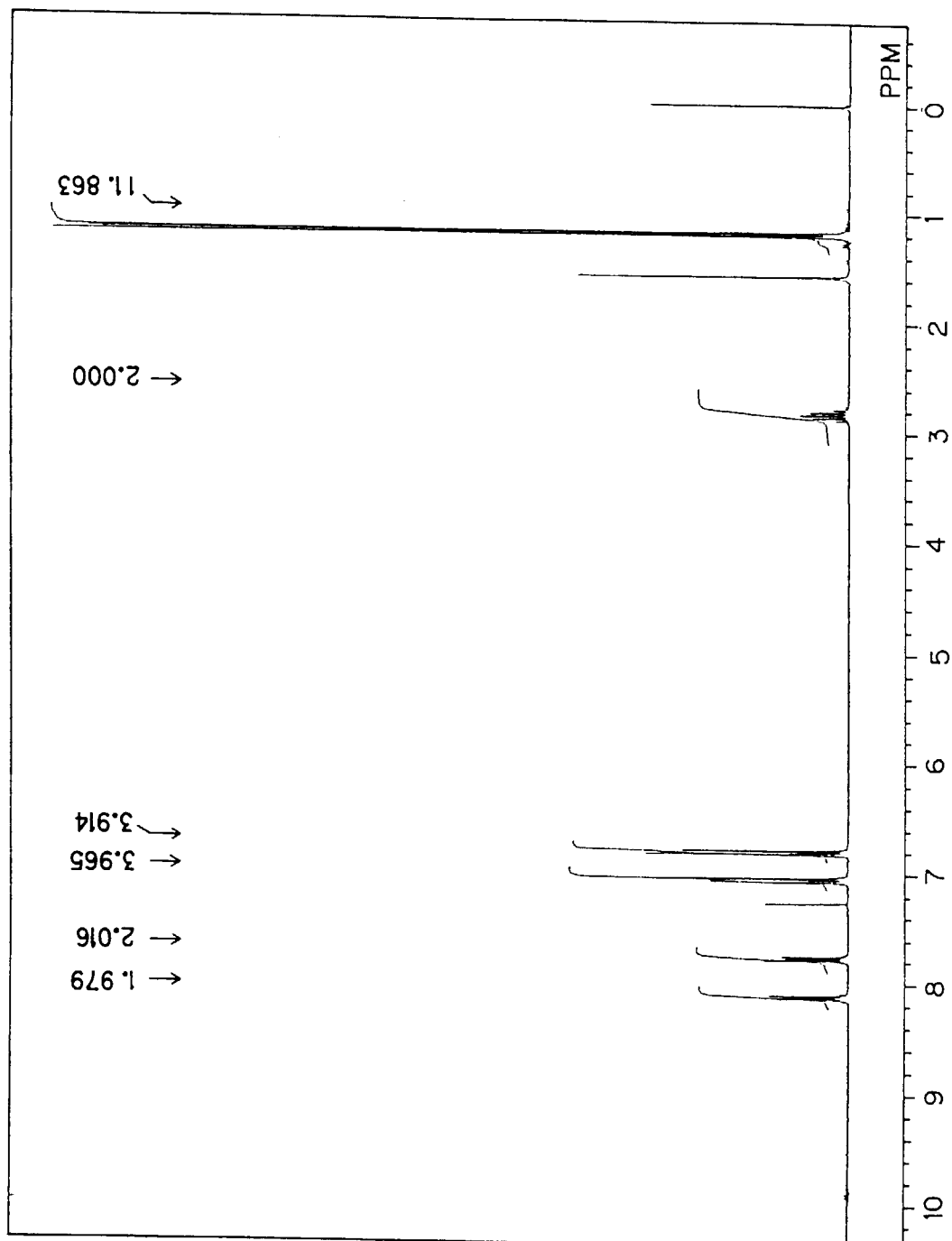


FIG. 7

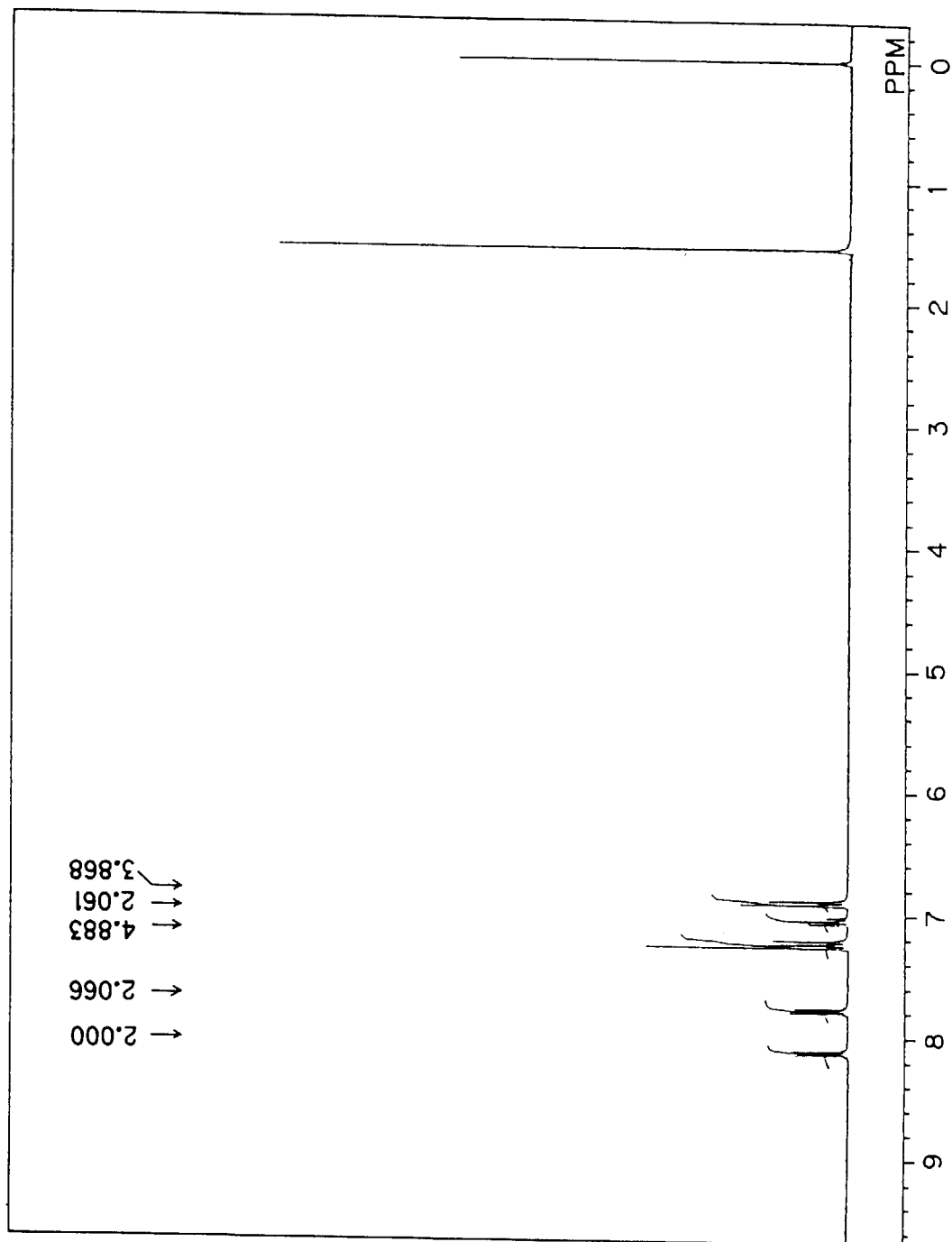


FIG. 8

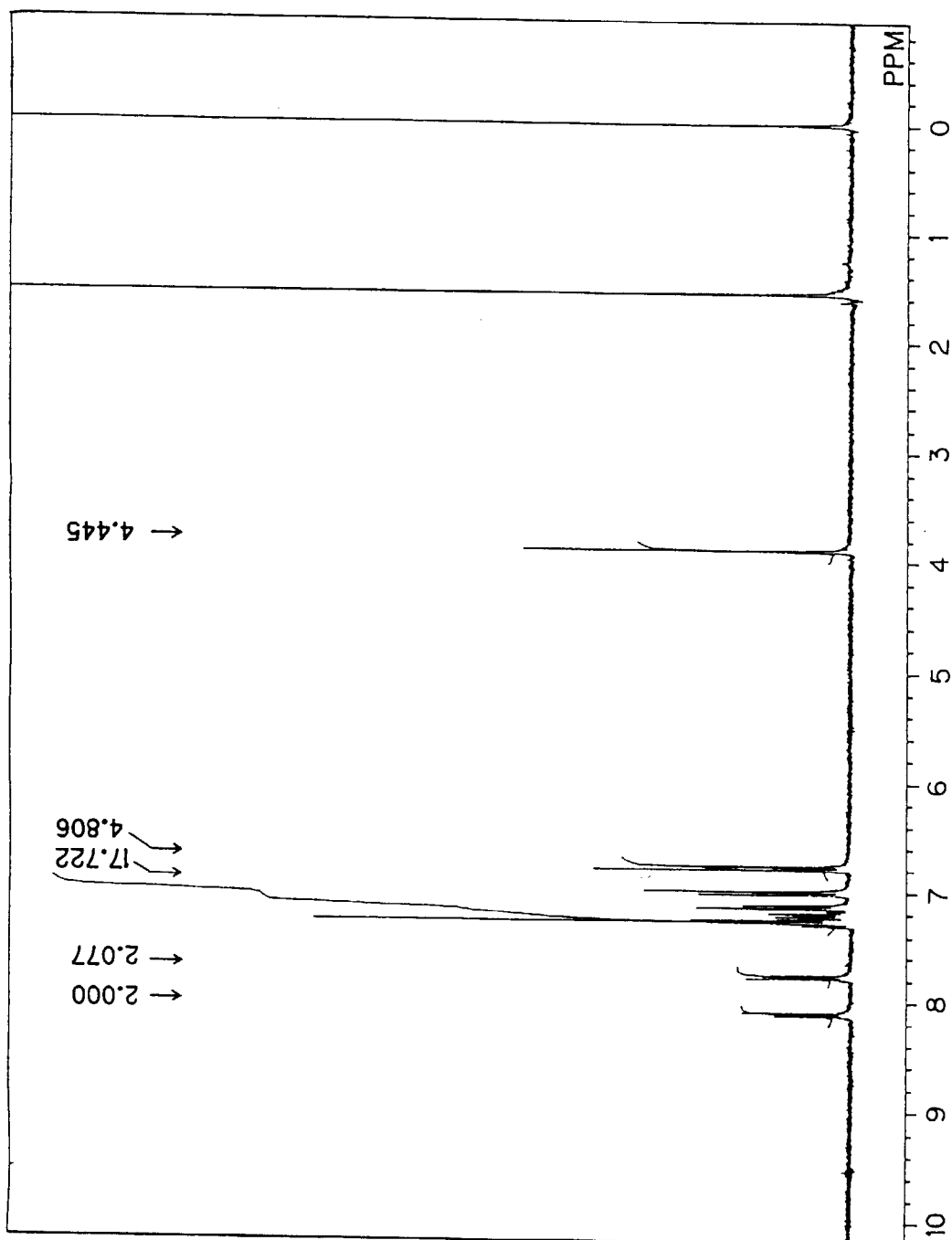


FIG. 9

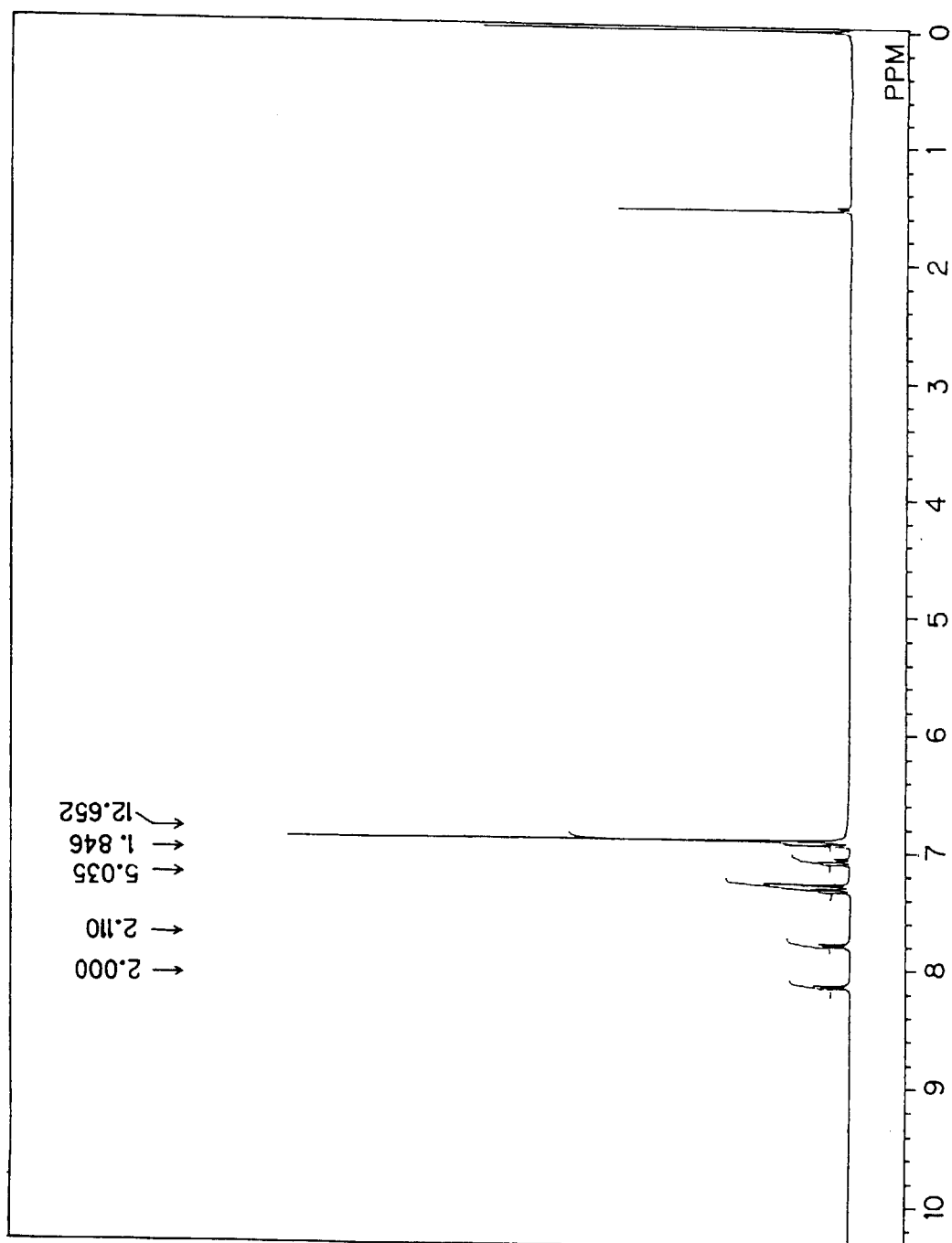


FIG. 10

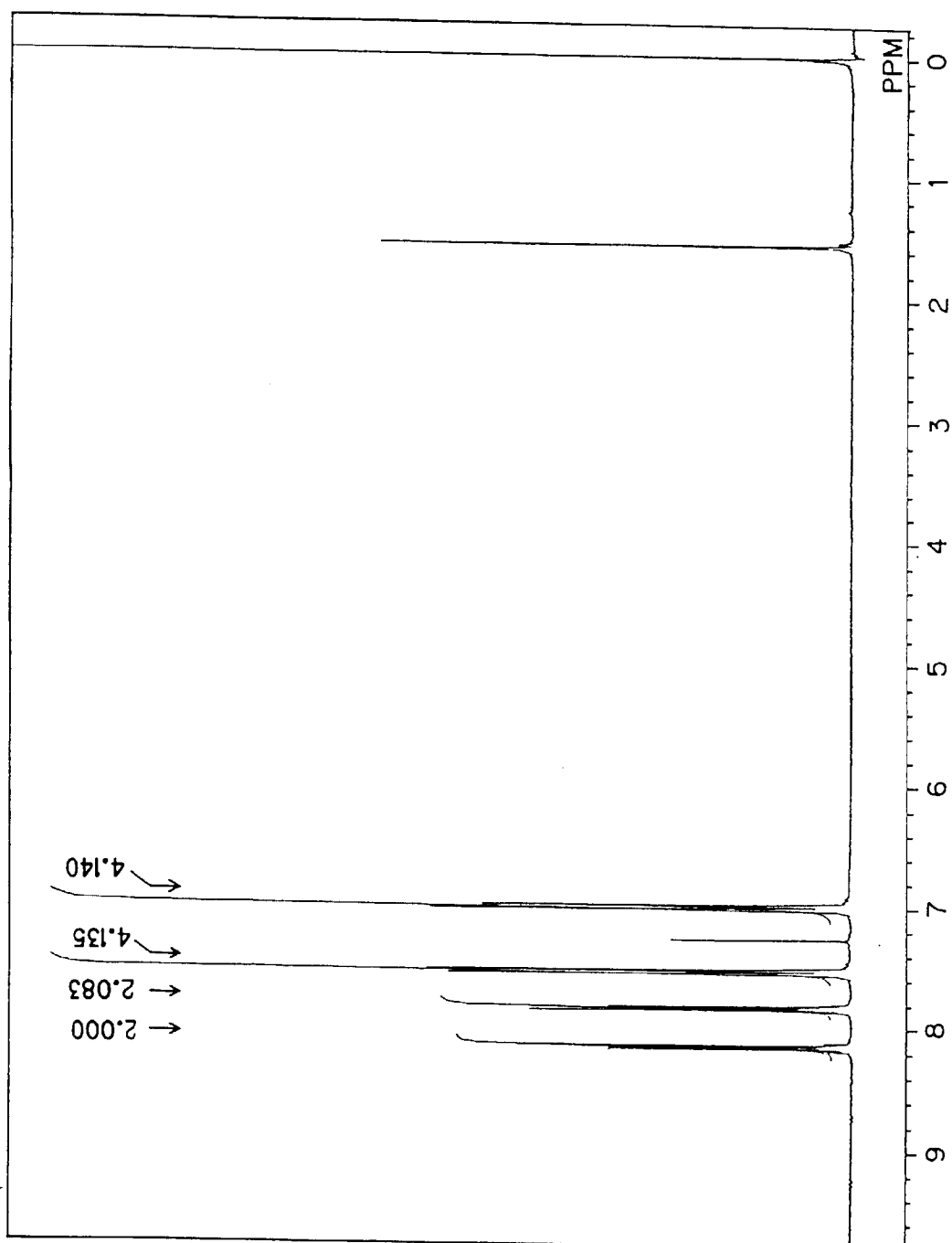


FIG. 11

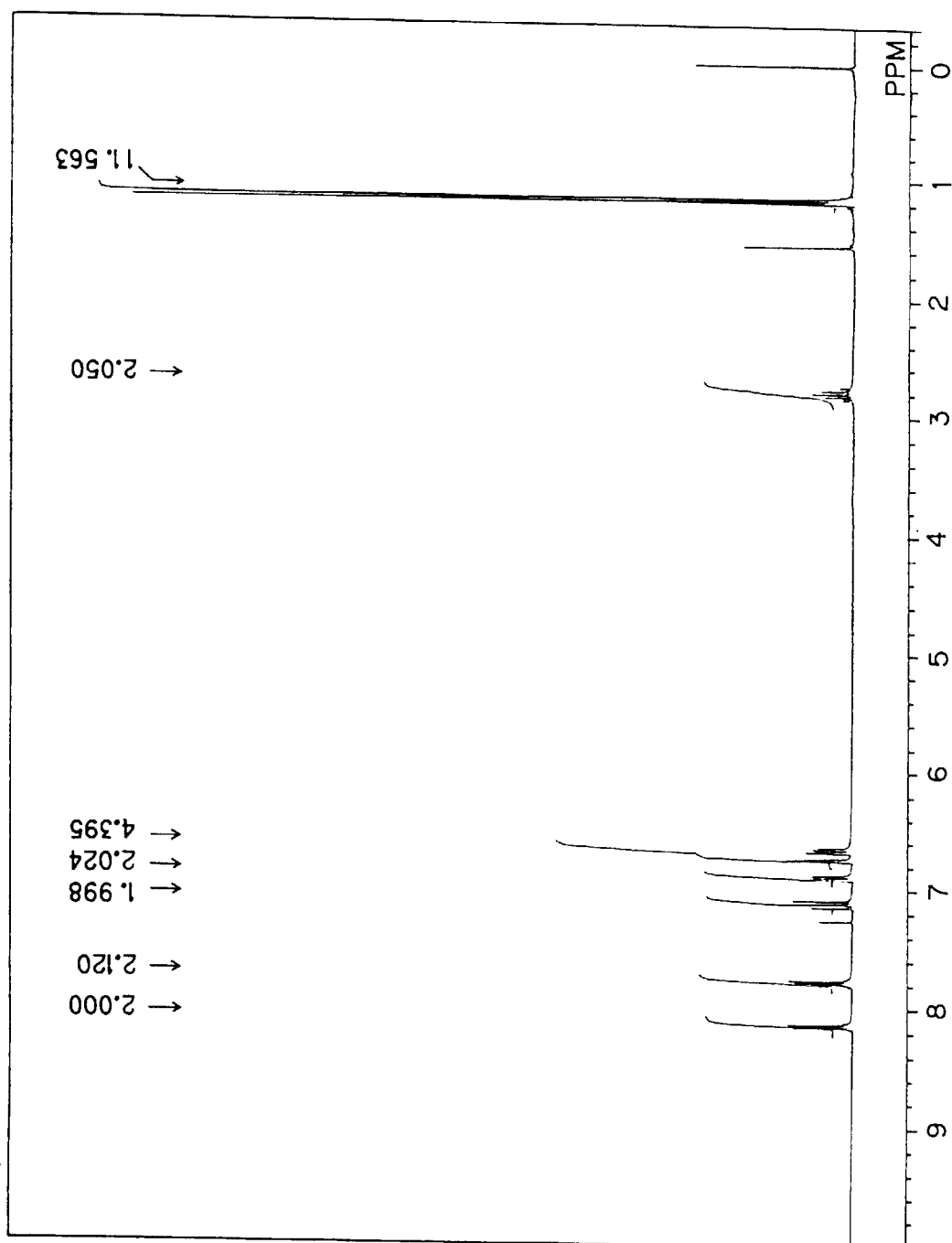


FIG. 12

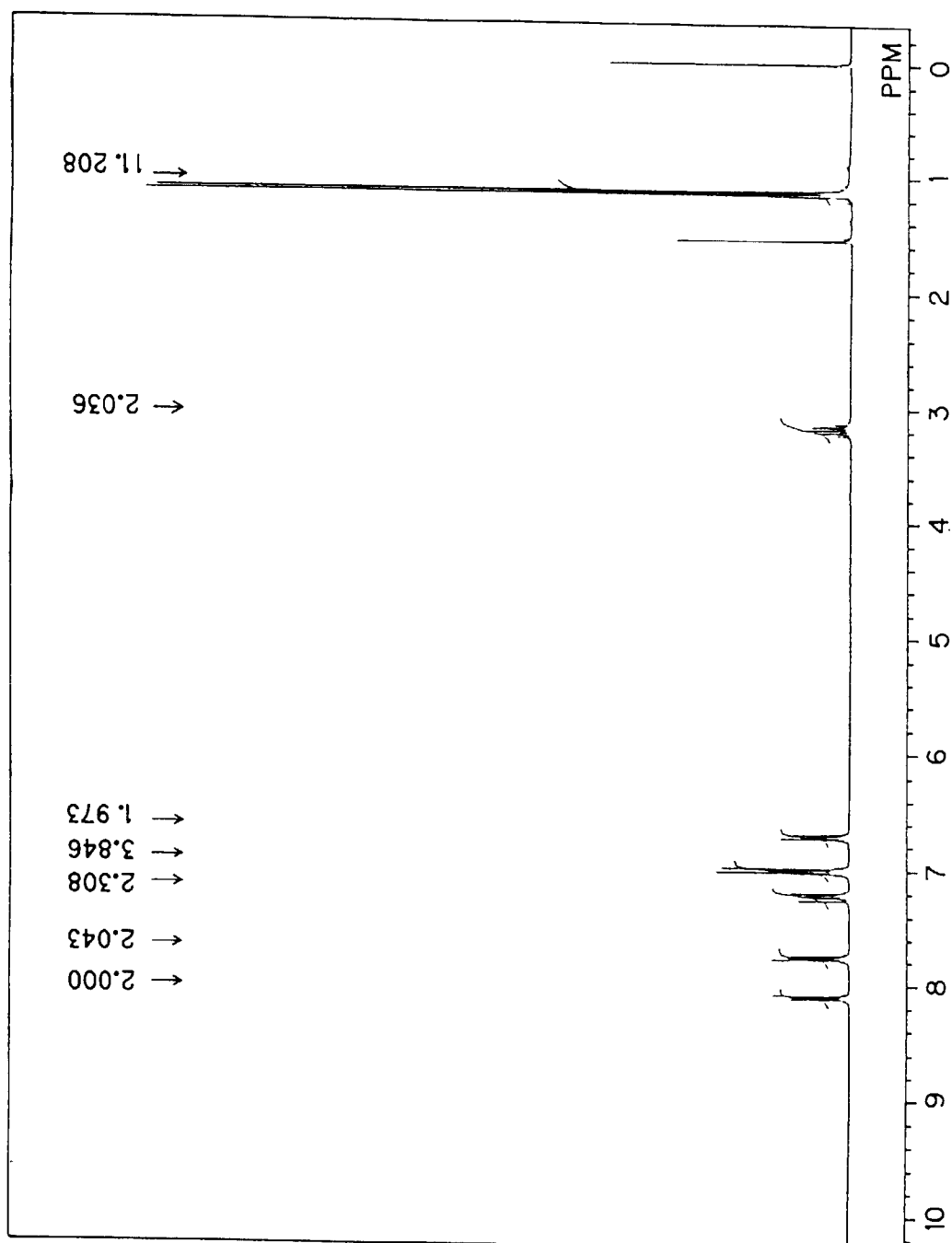


FIG. 13

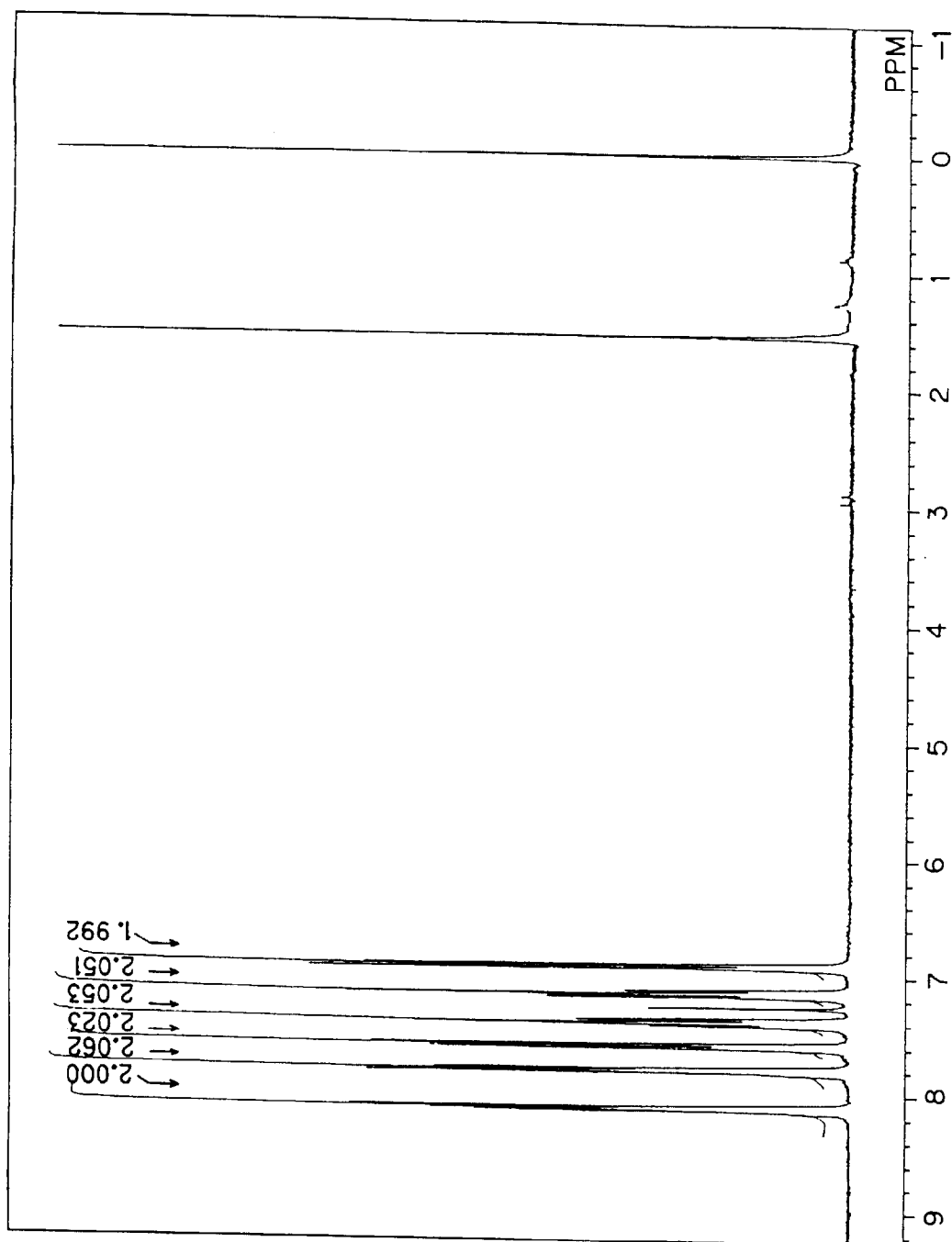


FIG. 14

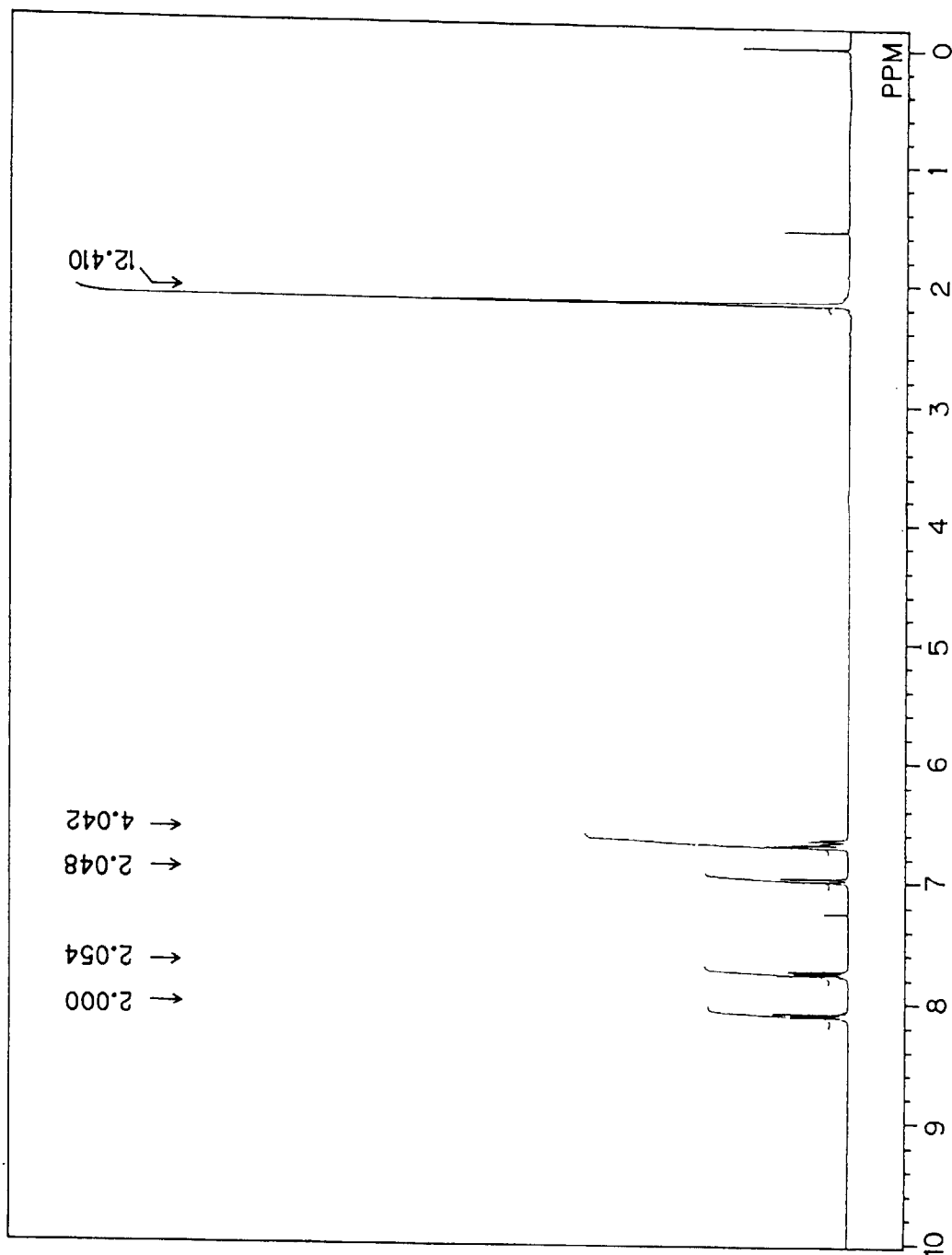


FIG. 15

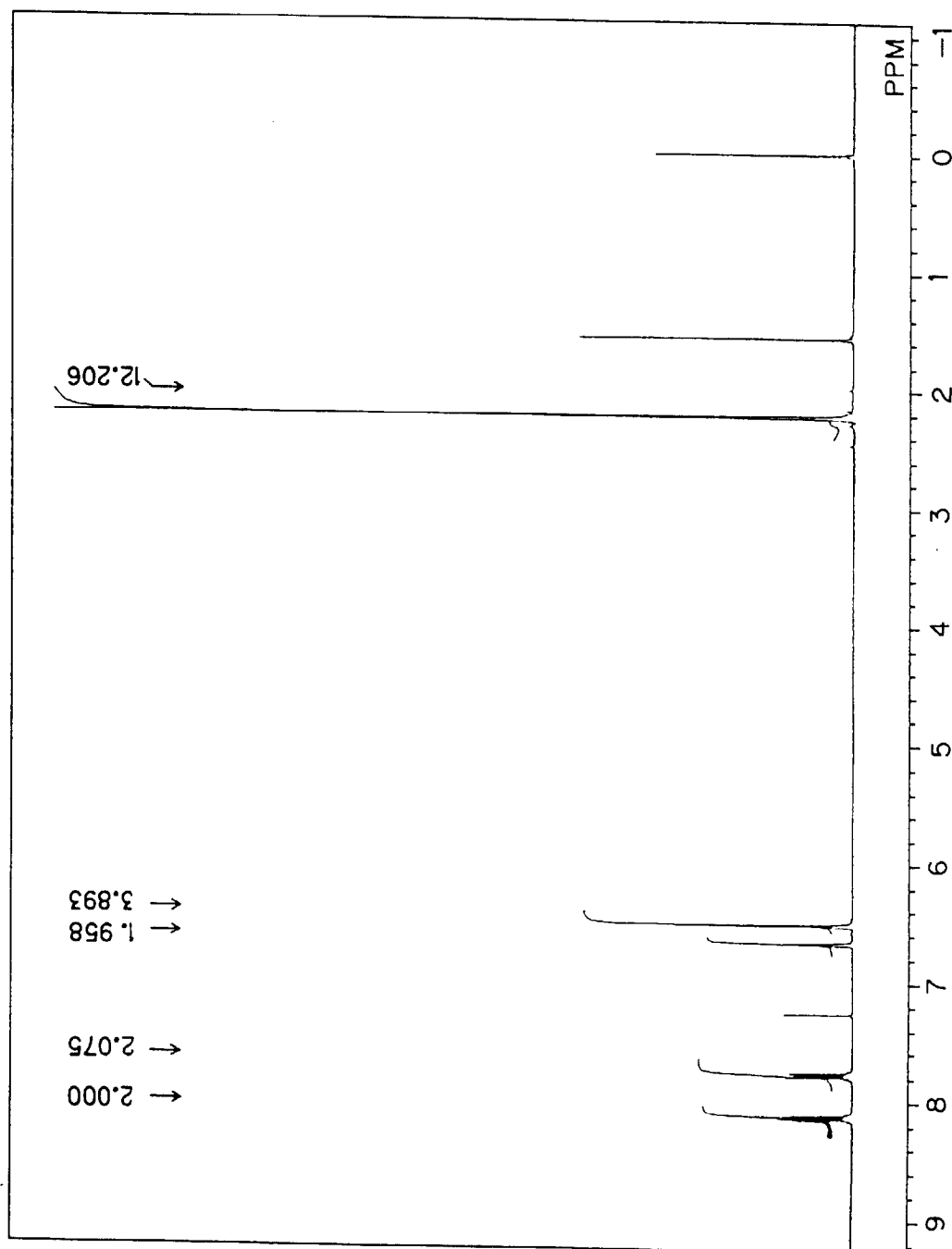


FIG. 16

