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(54) **Electrophotographic photoreceptor.**

(57) An electrophotographic photoreceptor has a light-sensitive layer on an electroconductive base. The lights-sensitive layer contains at least one carrier transport material represented by the following general formula (I):

$$\begin{matrix} Ar_1 \\ Ar_2 \end{matrix}\!\!>\! N-Ar_3-CH=CH-Ar_4-N\!<\!\!\begin{matrix} R_1 \\ R_2 \end{matrix} \qquad (I)$$

where Ar_1 and Ar_2 each represents an aryl group; Ar_3 represents an arylene group; Ar_4 represents a p-phenylene or naphthylene group; R_1 and R_2 each represents an alkyl or aralkyl group; and each of these groups may optionally have a substituent.

EP 0 337 307 A2

ELECTROPHOTOGRAPHIC PHOTORECEPTOR

BACKGROUND OF THE INVENTION

The present invention relates to an electrophotographic photoreceptor. More particularly, the present invention relates to a novel electrophotographic photoreceptor having a light-sensitive layer that contains an organic photoconductive compound as a main component.

Inorganic photoreceptors that have a light-sensitive layer based on inorganic photoconductive compounds such as selenium, zinc oxide and cadmium sulfide have been used extensively in electrophotography. However, the performance of inorganic photoreceptors has not been completely satisfactory in such aspects as sensitivity, heat stability, moisture resistance and durability. Photoreceptors using selenium are difficult to manufacture since selenium will crystallize for various causes such as heat and finger prints to deteriorate the performance of the photoreceptor. Cadmium sulfide or zinc oxide based photoreceptors have problems in terms of moisture resistance and durability.

With a view to eliminating the defects of inorganic photoreceptors, active R&D efforts have been undertaken to commercialize organic photoreceptors that have a light-sensitive layer containing a variety of organic photoconductive compounds as chief components. Japanese Patent Publication No. 50-10496 describes an organic photoreceptor that has a light-sensitive layer containing poly-N-vinylcarbazole and 2,4,7-trinitro-9-fluorenone. However, this photoreceptor did not prove to be completely satisfacoty in terms of sensitivity and durability.

In an effort to solve this problem, a high-performance organic photoreceptor has been proposed that employs different materials responsible for carrier generation and carrier transport. Such a "functionally separated" type of electrophotographic photoreceptor has been the subject of many studies because it has the advantage of providing a greater latitude in the selection of materials to ensure that electrophotographic photoreceptors having desired features can be manufactured with comparative ease. As a result of intensive studies made in this field, a variety of azo compounds have been developed and put to practical use as carrier generating materials. As for carrier transporting materials, many various compounds have been proposed as shown in U.S. Patent Nos. 4,030,923, 4,265,990 and 4,338,388.

Electrophotographic photoreceptors using these carrier transport materials exhibit fairly good performance in electrophotography but they are still incapable of fully satisfying the requirements of practical use because their resistance to light, ozone or electrical load is so poor that their performance is unstable to experience deterioration and other problems in cyclic use. Therefore, it has been desired to devlop a carrier transport material that has an even better capability of carrier transport and which exhibits consistent performance in extended use.

The demand for using organic photoreceptors with a faster operating electrophotographic copying machine is growing year by year and a need has arisen for the development of a more sensitive and more durable photoreceptor. Carrier transport materials in a carrier transport layer are commonly employed in amounts ranging from 60 to 100 parts by weights per 100 parts by weight of a binder. This is because the intermolecular distance of a carrier transport material is important for the transport of carriers. If the concentration of a carrier transport material is less than 60 parts by weight per 100 parts by weight of a binder, the intermolecular distance of the carrier transport material is so much increased as to cause difficulty in carrier transport, which leads to significant decrease in sensitivity.

From a durability viewpoint, a lower concentration of the carrier transport material in a carrier transport layer is effective for increasing the film strength of the transport layer and making it highly durable not only because it is scratch-proof but also because it can be used for an extended period without experiencing substantial surface wear by the action of a cleaning blade or a magnetic brush. Therefore, it has been desired to develop a carrier transport material that can be incorporated at a reduced concentration without causing a substantial decrease in sensitivity.

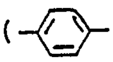
SUMMARY OF THE INVENTION

An object, therefore, of the present invention is to provide an electrophotographic photoreceptor that contains a carrier transport material at a reduced concentration and which yet ensures a very high sensitivity and durability in a carrier transport layer.

This object of the present invention can be attained by an electrophotographic photoreceptor having a light-sensitive layer formed on an electroconductive base, said light-sensitive layer containing at least one carrier transport material represented by the following general formula (I):

$$\begin{matrix} Ar_1 \\ Ar_2 \end{matrix} \Big> N - Ar_3 - CH = CH - Ar_4 - N \Big< \begin{matrix} R_1 \\ R_2 \end{matrix} \qquad (I)$$

where Ar_1 and Ar_2 each represents an aryl group, preferably a phenyl or naphthyl group; Ar_3 represents an arylene group, preferably a phenylene or naphthylene group; Ar_4 represents a p-phenylene group

()

or a naphthylene group; R_1 and R_2 each represents an alkyl or aralkyl group, preferably a C_{1-8} alkyl group, a benzyl group or a phenethyl group; the groups listed above may have substituents, preferred examples of which include an alkyl group, an aralkyl group, an alkoxy group, a halogen atom, an aryl group, an aryloxy group, a cyano group, and a substituted amino group.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 - 6 are schematic cross sections of various layer arrangements that can be adopted in the photoreceptor of the present invention; and

Fig. 7 is a graph showing the sensitivity vs carrier transport material content of a photoreceptor.

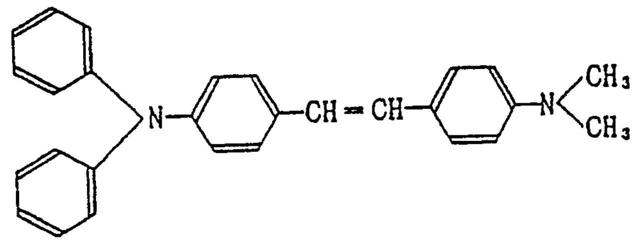
DETAILED DESCRIPTION OF THE INVENTION

In the present invention, the compound of the general formula (I) is used as a carrier transport material in a so-called "functionally separated" electrophotographic photoreceptor which employs different materials for carrier generation and transport thereof. The photoreceptor so fabricated offers the following advantages: it has good physical properties as a film; even if the carrier transport material is incorporated at a low concentration, the photoreceptor exhibits good electrophotographic characteristics in such aspects as change retention, sensitivity and residual potential; it will experience reduced fatigue deterioration during cyclic use; and it ensures consistent characteristics even if it is exposed to heat, ozone or light.

The carrier transport material to be used in the present invention may be composed of either one or more compounds selected from those represented by the general formula (I). If desired, this carrier transport material may be combined with other carrier transport materials known in the art.

Specific examples of the carrier transport material of formula (I) which may be used with advantage in the present invention include but are not limited to those having the structural formulas noted below:

Illustrative Compounds



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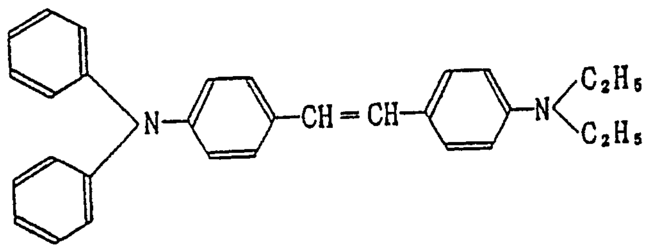

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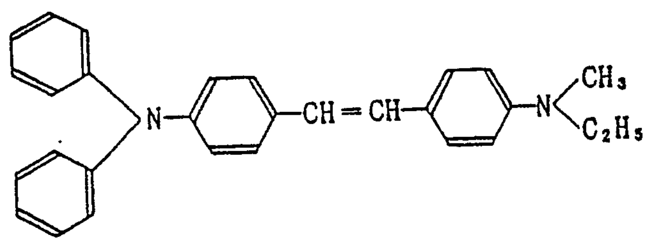

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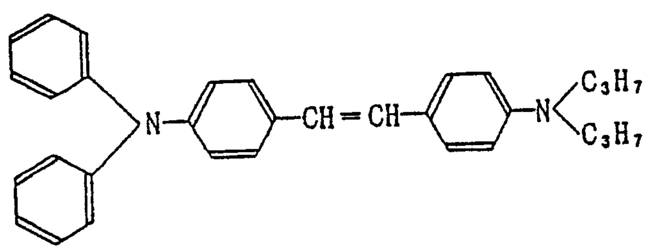

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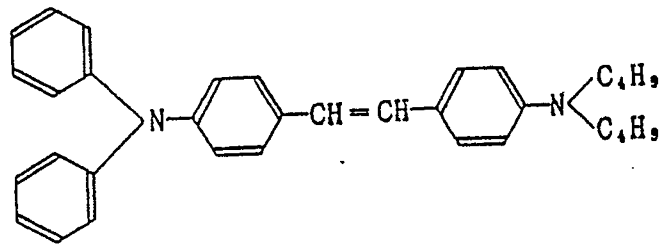

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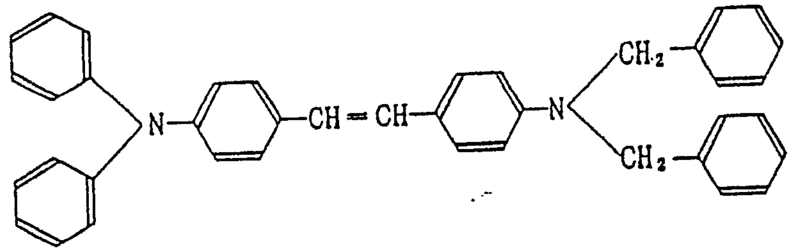

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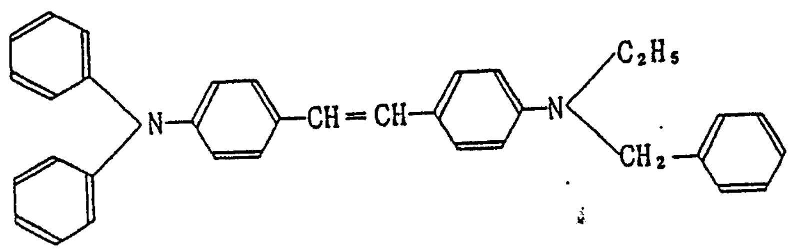

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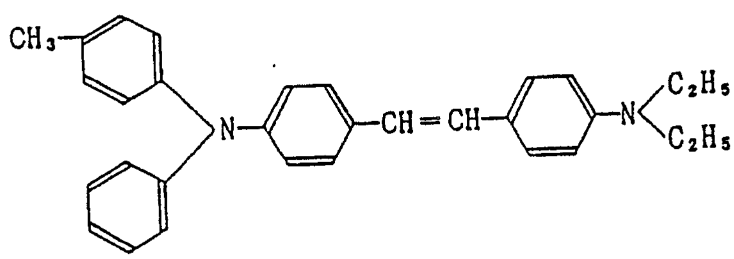

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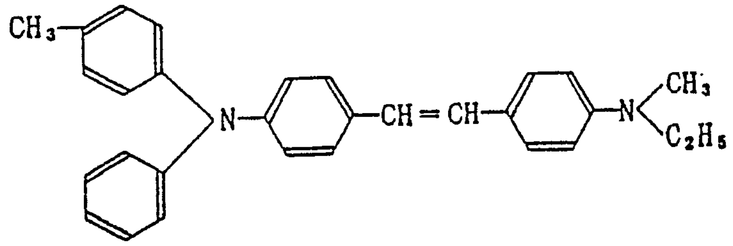
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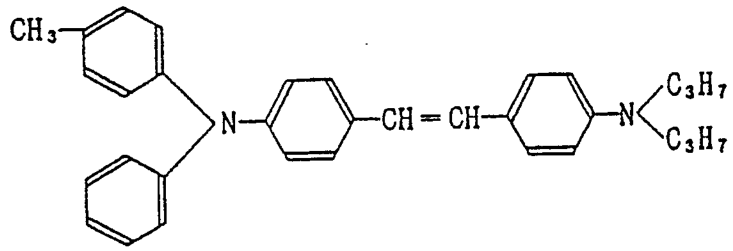
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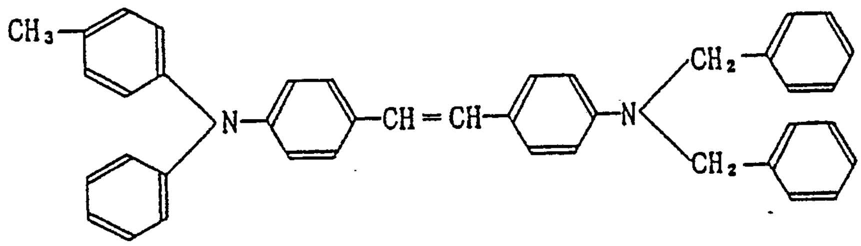
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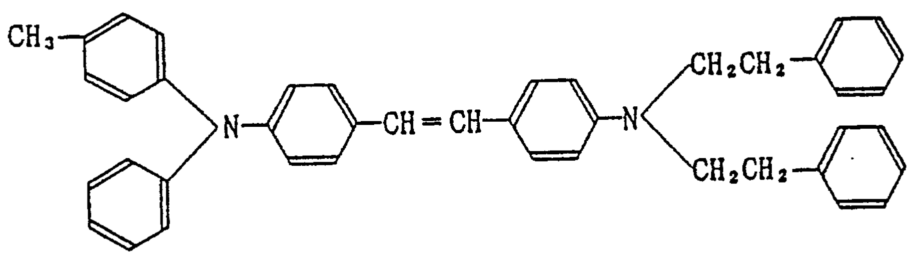
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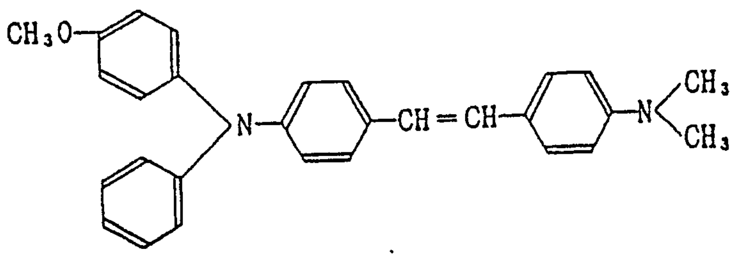

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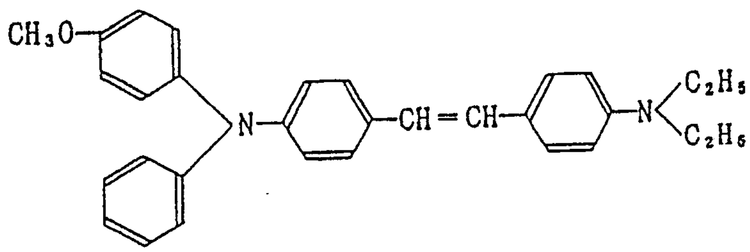

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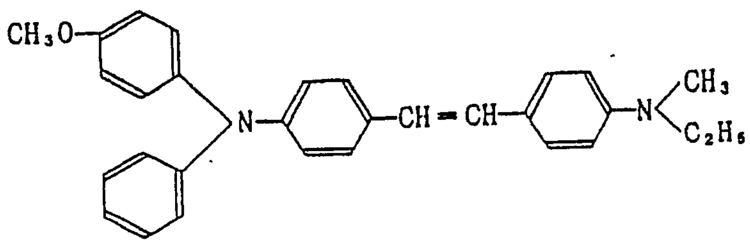

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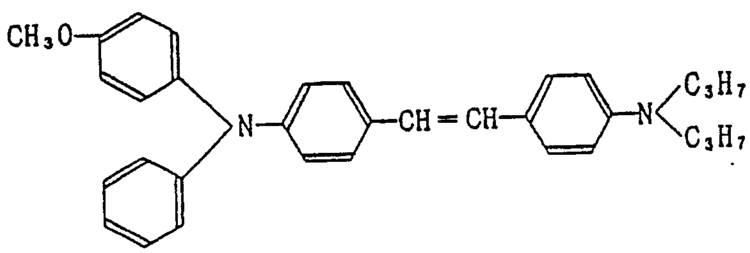

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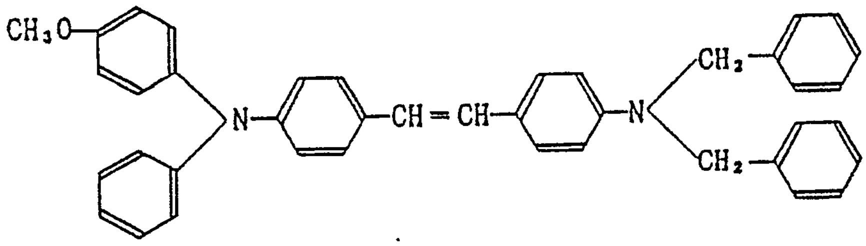

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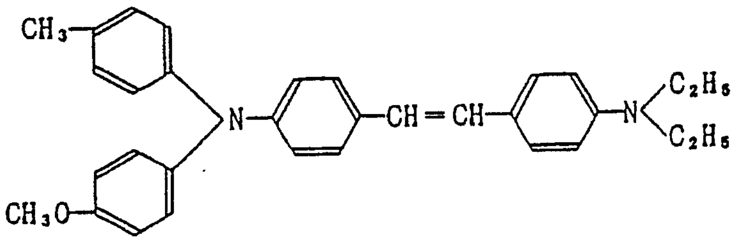

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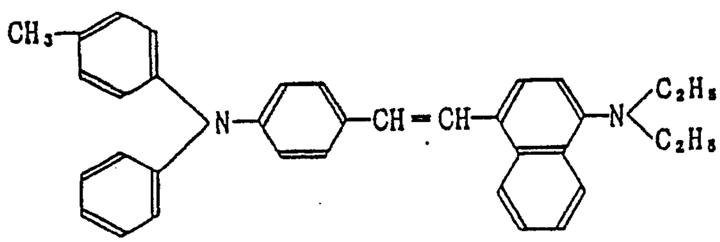

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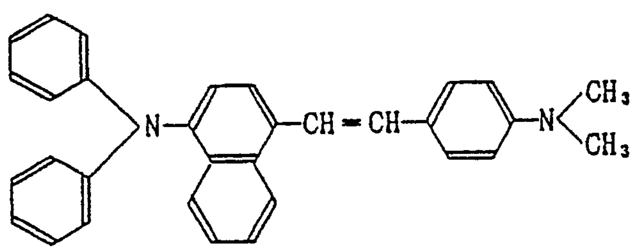

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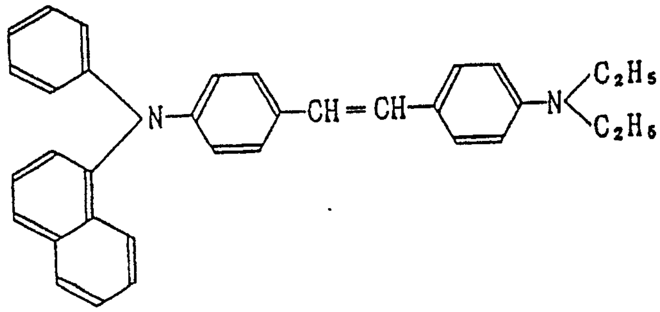

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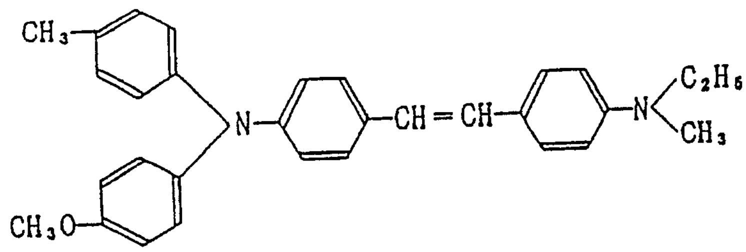

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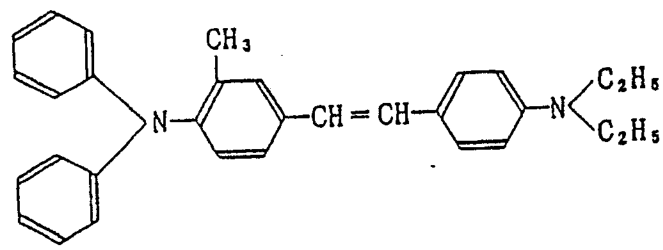

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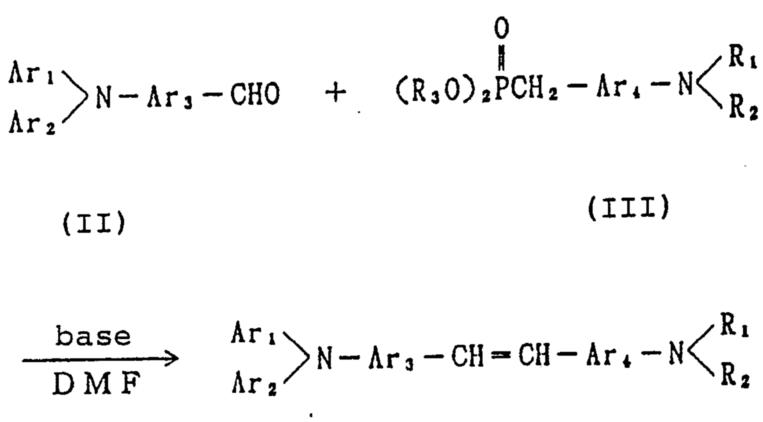
The stilbene derivatives listed above can be readily synthesized by known methods, one of which is described in Organic Reactions, Vol. 25, p. 73, John & Willey & Sons, Inc. According to this method, a desired stilbene derivative can easily be obtained by condensing an aromatic aldehyde of the general formula (II) shown below with a dialkyl ester of phosphonic acid of the general formula (III) shown below in a solvent such as N,N-dimethylformamide in the presence of a base such as a sodium alkoxide:



where Ar_1, Ar_2, Ar_3, Ar_4, R_1 and R_2 have the same meanings as defined in the general formula (I); and R_3 represents an alkyl or aryl group.

A typical method of synthesizing a stilbene derivative that is suitable for use in the present invention is described below in detail.

Synthesis of Illustrative Compound (2):

N,N-Diphenylaminobenzaldehyde (5.5 g, or 0.02 moles) and diethyl p-diethylaminobenzylphosphonate (6.0 g, or 0.02 moles) were dissolved in N,N-dimethylformamide (70 ml). To the solution, sodium hydride (1 g, or 0.04 moles) was slowly added, with the temperature in the reactor being held at 5 °C or below. Thereafter, the reaction mixture was stirred for 1 h under cooling with ice, then for 5 h at room temperature. Upon addition of ice water (50 ml), the resulting crystal was recovered by filtration and recrystallized twice with a mixed solvent of toluene-isopropyl alcohol (1:2).
Yield, 4.5 g (53.8%); m.p. 108 - 109 °C.

When an FD-mass spectrum was taken, a molecular ion peak was detected at m/e of 418 and this confirmed that the crystal obtained was identical to the end compound.

Azo pigments are preferred for use as carrier generation materials in the present invention but both inorganic and organic pigments can generally be used as long as they generate free carriers by absorbing light in the visible to infrared region. Illustrative inorganic pigments that may be used as charge generation materials include amorphous selenium, trigonal selenium, Se-As alloys, Se-Te alloys, and cadmium sulfide. Also usable are the organic pigments that may be illustrated by the following typical examples:

(1) azo pigments such as monoazo pigments, bisazo pigments, trisazo pigments, and metal complex salt azo pigments;
(2) perylene pigments such as perylenic acid anhydride and perylenic acid imide;
(3) polycyclic quinone pigments such as anthraquinone derivatives, anthanthrone derivatives, dibenzpyrenequinone derivatives, pyranthrone derivatives, bioranthrone derivatives and isobioranthrone derivatives;
(4) indigoid pigments such as indigo derivatives and thioindigo derivatives;
(5) phthalocyanine pigments such as metallic phthalocyanine and nonmetallic phthalocyanine;
(6) carbonium pigments such as diphenylmethane pigments, triphenylmethane pigments, xanthene pigments, and acridine pigments;
(7) quinoneimine pigments such as azine pigments, oxazine pigments and thiazine pigments;
(8) methine pigments such as cyanine pigments and azomethine pigments;
(9) quinoline pigments;
(10) benzoquinone and naphthoquinone pigments;
(11) naphthalimide pigments; and
(12) perinone pigments such as bisbenzimidazole derivatives.

The carrier transport materials used in the present invention are incapable of forming films by themselves, so they are combined with a variety of binders to form a light-sensitive layer. Any binders may be used in carrier generation and transport layers but preferred binders are hydrophobic, electrically insulating film-forming high-molecular weight polymers. Such high-molecular weight polymers include but are not limited to the following:

(1) polycarbonates;
(2) polyesters;
(3) methacrylic resins;
(4) acrylic resins;
(5) polyvinyl chloride;
(6) polyvinylidene chloride;
(7) polystyrene;
(8) polyvinyl acetate;
(9) styrene copolymer resins (e.g. styrene-butadiene copolymer and styrene-methyl methacrylate copolymer);
(10) acrylonitrile copolymer resins (e.g. vinylidene chloride-acrylonitrile copolymer);
(11) vinyl chloride-vinyl acetate copolymer;
(12) vinyl chloride-vinyl acetate-maleic anhydride copolymer;
(13) silicone resins;
(14) silicone-alkyd resins;
(15) phenolic resins (e.g. phenol-formaldehyde resin and cresol-formaldehyde resin);
(16) styrene-alkyd resins;
(17) poly-N-vinylcarbazole;

(18) polyvinylbutyral;
(19) polyvinylformal; and
(20) polyhydroxystyrene.

These binders may be used either on their own or as admixtures.

Two basic examples of the photoreceptor of the present invention are shown schematically in Figs. 1 and 2. The photoreceptor shown in Fig. 1 comprises an electroconductive base 1 which has formed thereon a light-sensitive layer 4 comprising a carrier generation layer 2 that contains a carrier generation material as a chief component and which is overlaid with a carrier transport layer 3 that contains a carrier transport material beased on the stilbene derivative represented by the general formula (I) specified herein. The order of superposition of the carrier generation layer 2 and the carrier transport layer 3 may be reversed as shown in Fig. 2. As shown in Figs. 3 and 4, an intermediate layer 5 may be disposed between the light-sensitive layer 4 and the conductive base 1. By adopting such a dual structure in the light-sensitive layer 4, a photoreceptor having most desirable electrophotographic characteristics can be obtained. Other modifications of the photoreceptor of the present invention are shown in Figs. 5 and 6; in the case shown in Fig. 5, a light-sensitive layer 4 having the fine particles of a carrier generation material 7 dispersed in a layer 6 that is based on the carrier transport material described herein is formed directly on the conductive base; or as in the case shown in Fig. 6, such a light-sensitive layer may be formed on the conductive base 1, with an intermediate layer 5 being interposed. And such a light-sensitive layer may be formed on a carrier transport layer.

In either of the embodiments described above, a protective layer 8 may optionally be formed on the light-sensitive layer 4 as shown in Fig. 4.

In adopting a dual structure in the light-sensitive layer 4, which of the two layers, carrier generation layer 2 and carrier transport layer 3, should be disposed on top of the other depends on the polarity of charging of the light-sensitive layer. If the light-sensitive layer is to be charged negatively, the carrier transport layer 3 is advantageously placed on top of the carrier generation layer 2 because the carrier transport material in the layer 3 has a high capability for hole transport.

The carrier generation layer 2 which is the other element of the dual light-sensitive layer 4 may be formed by one of the following methods either directly on the conductive base 1 or carrier transport layer 3 or with an intermediate layer such as an adhesive layer or a barrier layer interposed:

(1) vacuum evaporation;
(2) coating a solution having a carrier generation material dissolved in a suitable solvent; and
(3) coating a dispersion having a carrier generation material dispersed as fine particles in a dispersion medium by means of a suitable device such as a ball mill or a sand grinder (if desired, a binder may also be incorporated as a dispersion aid).

The so formed carrier generation layer 2 preferably has a thickness of 0.01 - 5 µm, with the range of 0.05 - 3 µm being more preferred.

The thickness of the carrier transport layer 3 may be adjusted to a suitable value depending on the need but is preferably within the range of 5 - 30 µm. A binder is preferably used in the carrier transport layer 3 in an amount of 0.8 - 10 parts by weight per part by weight of the carrier transport material specified herein. In order to form a light-sensitive layer 4 having the fine particles of a carrier generation material in the layer based on the carrier transport material specified herein, a binder is preferably used in an amount not exceeding 5 parts by weight per part by weight of the carrier generation material.

In the case of a light-sensitive layer of single layer constitution which contains a carrier transport material as the main component and which has the fine particles of a carrier generation material dispersed therein, a binder is preferably used in an amount within the range of 0.5 to 10 parts by weight per part by weight of said carrier generation material and in an amount within the range of 0.5 to 10 parts by weight per part by weight of said carrier transport material, respectively.

As described above, the light-sensitive layer in the photoreceptor of the present invention may be double- or single-layered. In either case, one or more electron-accepting materials may be incorporated in the surface layer (i.e., carrier transport layer, carrier generation layer, single-layered light-sensitive layer, or protective layer) either alone or together with underlying layers for attaining various purposes such as improved sensitivity and reduced residual potential or fatigue due to cyclic use.

The intermediate layer described above serves as an adhesive or barrier layer and may employ polyvinyl alcohol, ethyl cellulose, carboxymethyl cellulose, casein, etc. in addition to the binder resins listed above.

Examples of the conductive base 1 used in the electrophotographic photoreceptor of the present invention include but are not limited to the following:

(1) a metal plate such as an aluminum or stainless steel plate, which may be shaped into drum form;

(2) a base such as a paper or plastic film, which is provided with an aluminum, palladium, gold or other metal foil by lamination or evaporation; or

(3) a base such as a paper or plastic film, which is provided with a layer of a conductive compound such as a conductive polymer, indium oxide or tin oxide by coating or evaporation.

The carrier transport layer, carrier generation layer and other constituent layers of the photoreceptor of the present invention may be formed by any method selected from among vapor-phase deposition techniques such as vacuum evaporation, sputtering and CVD, and from coating techniques such as dip coating, spray coating, blade coating and roll coating.

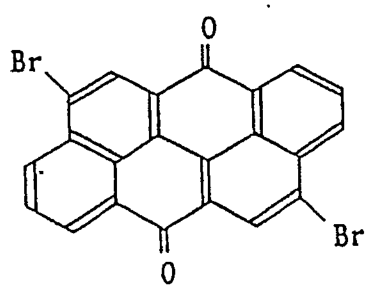
Being prepared in the way described above, the electrophotographic photoreceptor of the present invention shows good chargeability, sensitivity and image forming characteristics as will be demonstrated in the examples that follow. A particularly notable advantage of this photoreceptor is its very high durability and it will experience minimum fatigue deterioration even if it is used in electrophotography by a cyclic transfer process.

The following examples are provided for the purpose of further illustrating the present invention but are in no way to be taken as limiting.

EXAMPLE 1

An electroconductive base in the form of a polyester film having an evaporated aluminum coating was overlaid with an intermediate layer 0.1 µm thick that was composed of a vinyl chloride = vinyl acetate-maleic anhydride copolymer ("ES-lec MF-10" of Sekisui Chemical Co., Ltd.).

One part by weight of dibromoanthanthrone having the structural formula shown below ("Monolight Red 2Y" of Imperical Chemical Industries Limited) was mixed with 0.5 parts by weight of a polycarbonate resin ("Panlite L-1250" of TEIJIN LTD.) in 100 parts by weight of 1,2-dichloroethane and dispersed in a ball mill for 24 h. The resulting dispersion was coated on the intermediate layer to form a carrier generation layer in a dry thickness of 1 µm:

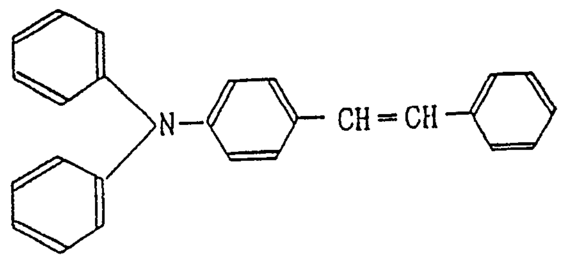


Four parts by weight of a carrier transport material [Illustrative compound (1)] and 10 parts by weight of a polycarbonate resin ("Panlite L-1250") were dissolved in 80 parts by weight of 1,2-dichloroethane. The solution was coated on the carrier generation layer to form a carrier transport layer in a dry thickness of 16 µm. In this way, a sample of the electrophotographic photoreceptor of the present invention was fabricated.

The electrophotographic characteristics of this sample were measured dynamically with a paper analyzer Model EPA-8100 of Kawaguchi Electric Works Co., Ltd. First, the surface of the light-sensitive layer was charged with a negative voltage of 6 kV for 5 seconds to a surface potential V_A; then, the surface of the same light-sensitive layer was exposed to light from a tungsten lamp to attain an illuminance of 3.5 lux and the amount of exposure (sensitivity) E_{100}^{600} necessary for the surface potential to be attenuated from -600 volts to -100 volts was determined; the surface potential (residual potential) V_R that was left after exposure of 30 lux•sec was also determined. The same measurements were repeated 100 times and the results are shown in Table 1.

COMPARATIVE EXAMPLE 1

A comparative sample (No. 1) of photoreceptor was prepared as in Example 1 except that a stilbene derivative represented by the structural formula shown below was used as a carrier transport material. This comparative sample was subjected to the same measurements as those performed in Example 1.



The results are shown in Tab1e 1.

TABLE 1

Characteristics \ No. of cycles \ Sample	Example 1		Comparative Example 1	
	1	100	1	100
V_A(v)	-1125	-1105	-1065	-995
E^{600}_{100} (ℓux.sec)	3.6	3.7	6.2	6.5
V_R(v)	0	0	0	-10

As is clear from the above data, the photoreceptor sample of the present invention prepared in Example 1 was by far superior to the comparative sample No. 1 in terms of sensitivity, residual potential and stability in cyclic use.

EXAMPLES 2 - 10

Additional samples of the photoreceptor of the present invention were prepared as in Example 1 except that Illustrative compound Nos. 2, 4, 6, 8, 10, 12, 14, 16 and 18 were used as carrier transport materials. These samples were subjected to the same measurements as those performed in Example 1. The result are shown in Table 2 below.

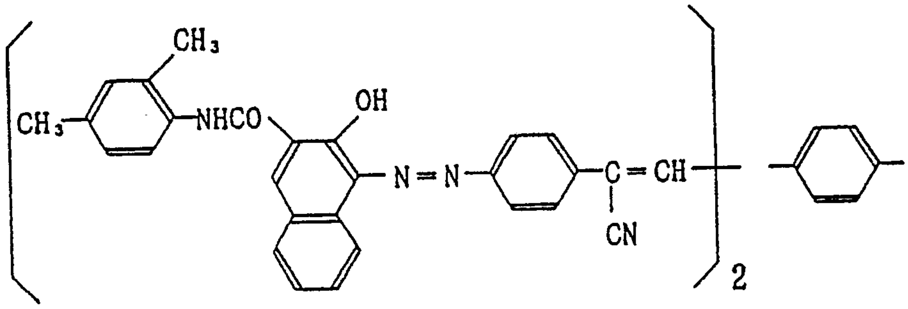
TABLE 2

Example	Illustrative compound	No. of cycles	V_A (v)	E_{100}^{600} (lux•sec)	V_R (v)
2	(2)	1	-1145	3.7	0
		100	-1125	3.7	0
3	(4)	1	-1165	3.7	0
		100	-1140	3.8	0
4	(6)	1	-1035	3.8	0
		100	-1000	3.9	0
5	(8)	1	-1065	3.6	0
		100	-1050	3.7	0
6	(10)	1	-1150	3.6	0
		100	-1120	3.7	0
7	(12)	1	-1030	3.6	0
		100	-985	3.6	0
8	(14)	1	-1010	3.7	0
		100	-970	3.8	0
9	(16)	1	-1040	3.7	0
		100	-1005	3.7	0
10	(18)	1	-1076	3.6	0
		100	-1035	3.6	0

EXAMPLE 11

A conductive support was prepared by laminating a polyester film with an aluminum foil.

One part by weight of a carrier generation material (bisazo pigment represented by the stuructural formula shown below) and 0.5 parts by weight of a polymethyl methacrylate resin ("Dianal BR-80" of Mitsubishi Rayon Co., Ltd.) were added to 100 parts by weight of 1,2-dichloroethane and dispersed in a sand grinder for 4 h. The dispersion was coated on the conductive base to form a carrier generation layer in a dry thickness of 0.4 µm.



Four parts by weight of a carrier transport material [Illustrative compound (8)] and 10 parts by weight of a polycarbonate resin ("Panlite K-1300" of TEIJIN LTD.) were dissolved in 100 parts by weight of 1,2-dichloroethane. The solution was coated in a dry thickness of 15 µm on the carrier generation layer to form a carrier transport layer. In this way, a sample of the electrophotographic photoreceptor of the present invention was fabricated.

When this photoreceptor was subjected to the same measurements as those performed in Example 1, the results shown in Table 3 were obtained.

COMPARATIVE EXAMPLE 2

A comparative sample (No. 2) of photoreceptor was prepared as in Example 11 except that a stilbene derivative represented by the structural formula shown below was used as a carrier transport material. This comparative sample was subjected to the same measurements as those performed in Example 1. The results are shown in Table 3.

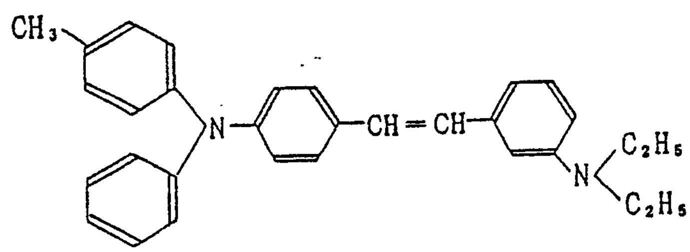


TABLE 3

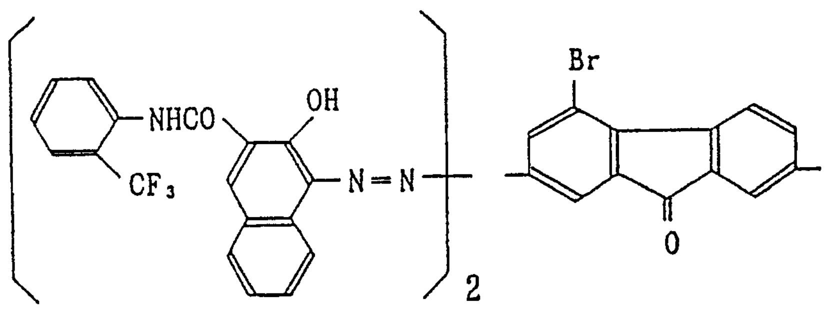
Characteristics \ No. of cycles \ Sample	Example 11		Comparative Example 2	
	1	100	1	100
V_A (v)	-1230	-1195	-1150	-1075
E^{600}_{100} (ℓux·sec)	2.7	2.7	4.6	5.2
V_A (v)	0	0	0	-5

As is clear from the above data, the photoreceptor sample of the present invention prepared in Example 11 was by far superior to the comparative sample in terms of sensitivity, residual potential and stability in cyclic use.

EXAMPLE 12

An electroconductive base in the form of a polyester film having an evaporated aluminum coating was overlaid with an intermediate layer 0.1 µm thick that was composed of a vinyl chloride = vinyl acetate-maleic anhydride copolymer ("ES-lec MF-10").

One part by weight of a carrier generation material (bisazo pigment represented by the structural formula shown below) and 0.5 parts by weight of a polycarbonate resin ("Panlite K-1300") were added to 100 parts by weight of tetrahydrofuran and dispersed in a ball mill for 24 h. The dispersion was coated in a dry thickness of 0.4 µm on the intermediate layer to form a carrier generation layer.

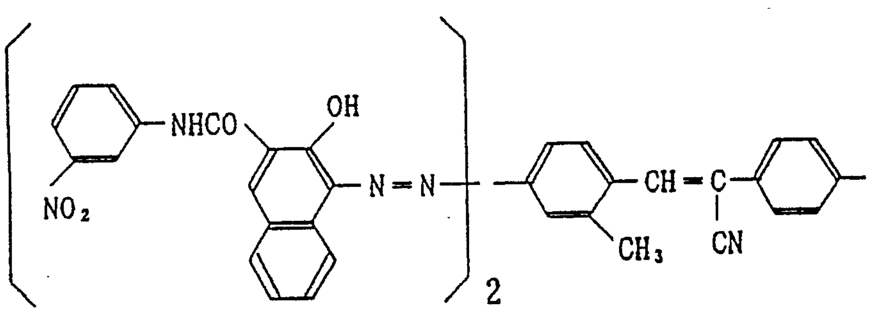


A carrier transport material [3.5 parts by weight of Illustrative compound (5)] and 10 parts by weight of a polycarbonate resin ("Panlite K-1300") were dissolved in 100 parts by weight of tetrahydrofuran. The solution was coated on the carrier generation layer to form a carrier transport layer in a dry thickness of 17 µm. In this way, a sample of the electrophotographic photoreceptor of the present invention was fabricated.

This photoreceptor was subjected to the same measurements as those performed in Example 1 and the results are shown in Table 4.

EXAMPLE 13

Another sample of the photoreceptor of the present invention was prepared as in Example 12 except that a bisazo pigment represented by the structural formula shown below was used as a carrier generation material.



This sample was subjected to the same measurements as those performed in Example 1 and the results are shown in Table 4.

TABLE 4

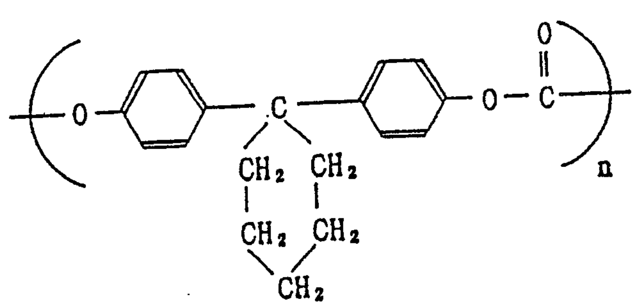
Characteristics \ No. of cycles \ Sample	Example 12		Example 13	
	1	100	1	100
V_A (v)	-1155	-1120	-1250	-1215
E^{600}_{100} (ℓux·sec)	1.6	1.6	2.0	2.1
V_R (v)	0	0	0	0

EXAMPLE 14

An intermediate layer 0.1 µm thick that was composed of a vinyl chloride-vinyl acetate-maleic anhydride copolymer ("ES-lec MF-10") was dip-coated on a cylindrical aluminum drum having a diameter of 80 mm.

One part by weight of dibromoanthanthrone ("Monolight Red 2Y") and one part by weight of a polycarbonate resin ("Panlite L-1250") were added to 100 parts by weight of 1,2-dichloroethane and dispersed in a ball mill for 24 h. The dispersion was dip-coated on the intermediate layer to form a carrier generation layer in a thickness of 1 µm.

Four parts by weight of a carrier transport material [Illustrative compound (2)] and 10 parts by weight of a polycarbonate resin having the structural formula shown below ("Z-200" of MITSUBISHI GAS CHEMICAL CO., INC.) were dissolved in 80 parts by weight of 1,2-dichloroethane:



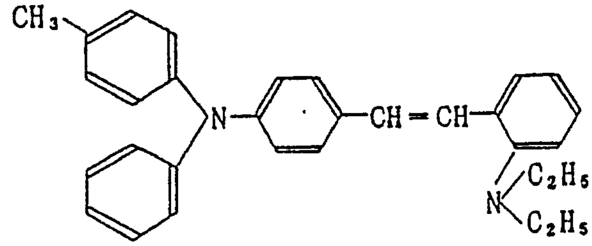
The solution was dip-coated on the carrier generation layer to form a carrier transport layer in a thickness of 17 µm. In this way, a sample of the electrophotographic photoreceptor of the present invention was fabricated.

This photoreceptor was set in an electrophotographic copier "U- Bix 1550MR" for duplication of image. A faithful, high-contrast and good-gradation copy was obtained. The results were the same even after 5 x

10^4 copies were taken.

COMPARATIVE EXAMPLE 3

A comparative sample (No. 3) of photoreceptor was prepared as in Example 14 except that a stilbene derivative having the structural formula shown below was used as a carrier transport material:



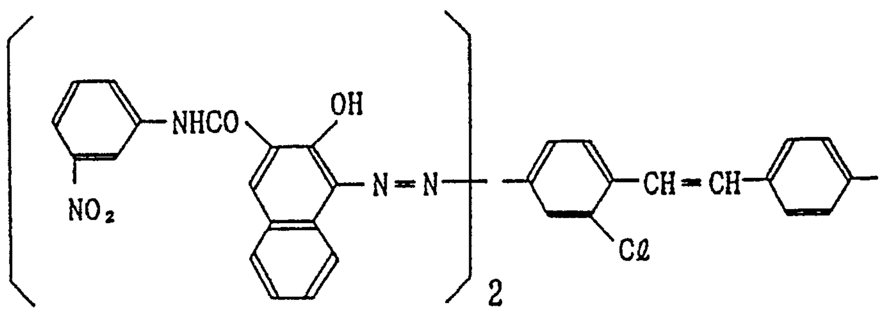
This comparative sample was subjected to a copying test as in Example 14. In the initial stage, good copies were obtained but when 2 x 10^4 or more copies were taken, the fog problem became pronounced. Only a foggy and low-contrast image was obtained after copying 3 x 10^4 copies.

EXAMPLE 15

An intermediate layer 0.1 µm thick that was composed of a vinyl chloride=vinyl acetate-maleic anhydride copolymer ("ES-lec MF-10") was formed on a conductive base that was prepared by laminating a polyester film with an aluminum foil.

Four parts by weight of a carrier transport material [Illustrative compound (10)] and 10 parts by weight of a polycarbonate resin ("Panlite L-1250") were dissolved in 80 parts by weight of 1,2-dichloroethane. The solution was coated on the intermediate layer to form a carrier transport layer in a dry thickness of 15 µm.

One part by weight of a carrier generation material having the structural formula shown below, 1.5 parts by weight of a carrier transport material [Illustrative compound (10)] and 2 parts by weight of a polycarbonate resin ("Panlite L-1250") were added to 100 parts by weight of 1,2-dichloroethane and dispersed in a ball mill for 24 h:

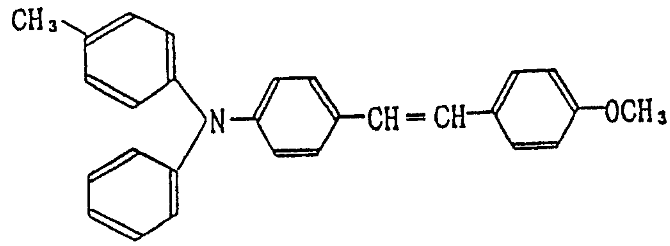


The dispersion was coated on the carrier transport layer to form a layer having the fine particles of a carrier generation material dispersed in a layer that is based on the carrier transport material, in a dry thickness of 3 µm. In this way, a sample of the electrophotographic photoreceptor of the present invention was fabricated.

This sample was subjected to the same measurements as those performed in Example 1 except that it was charged with a positive voltage of 6 kV. The results are shown in Table 5.

COMPARATIVE EXAMPLE 4

A comparative sample (No. 4) of photorecept was prepared as in Example 15 except that a stilbene derivative represented by the structural formula shown below was used as a carrier transport material



This comparative sample was subjected to the same measurements as those performed in Example 15. The results are shown in Table 5.

TABLE 5

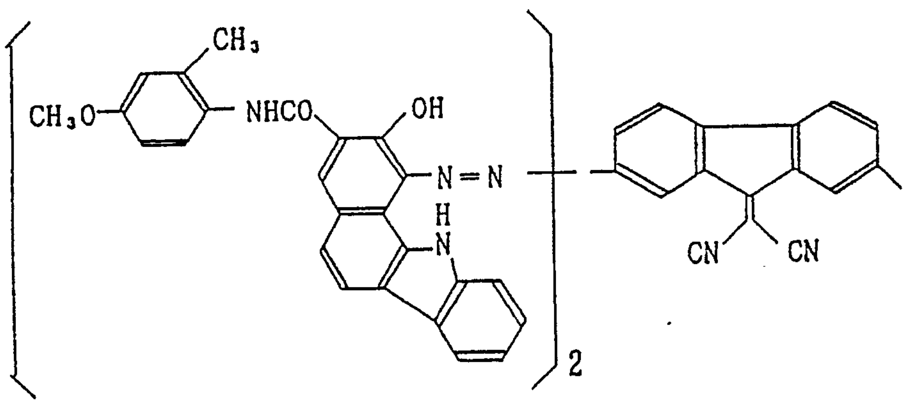
Characteristics \ No. of cycles \ Sample	Example 15		Comparative Example 4	
	1	100	1	100
V_A. (v)	+1290	+1265	+1330	+1395
E^{600}_{100} (ℓux·sec)	2.8	2.8	5.2	5.5
V_R (v)	0	0	0	+5

As is clear from the above data, the photoreceptor sample of the present invention exhibited far better characteristics than the comparative sample in terms of sensitivity and stability in cyclic use.

EXAMPLE 16

An intermediate layer 0.1 µm thick that was composed of a vinyl chloride-vinyl acetate-maleic anhydride copolymer ("ES-lec MF-10") was formed on an aluminum-evaporated polyester film.

One part by weight of a carrier generation layer (bisazo pigment represented by the structural formula shown below) and 0.5 parts by weight of a polycarbonate resin ("Panlite L-1250") were added to 100 parts by weight of 1,2-dichloroethane and dispersed in a ball mill for 24 h:



The dispersion was coated on the intermediate layer to form a carrier generation layer in a dry thickness of 0.3 µm.

Four parts by weight of a carrier transport material [Illustrative compound (9)] and 10 parts by weight of a polycarbonate resin ("Panlite K-1300") were dissolved in 100 parts by weight of 1,2-dichloroethane and the solution was coated on the carrier generation layer to form a carrier transport layer in a dry thickness of 16 µm. In this way, a sample of the electrophotographic photoreceptor of the present invention was fabricated.

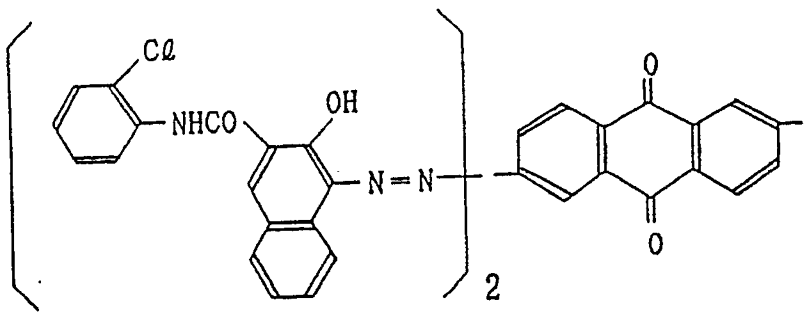
This sample was subjected to the same measurements as those performed in Example 1 and the results are shown in Table 6:

TABLE 6

Characteristics \ No. of cycles	1	100
V_A (v)	-1220	-1195
E^{600}_{100} (ℓux·sec)	2.0	2.0
V_R (v)	0	0

EXAMPLE 17

One part by weight of a carrier generation material having the structural formula shown below and 0.5 parts by weight of a polyester resin ("Vylon 200" of TOYOBO CO., LTD.) were added to 100 parts by weight of 1,2-dichloroethane and dispersed in a ball mill for 24 h. The dispersion was coated on an aluminum-evaporated polyester film to form a carrier generation layer in a thickness of 0.5 µm.

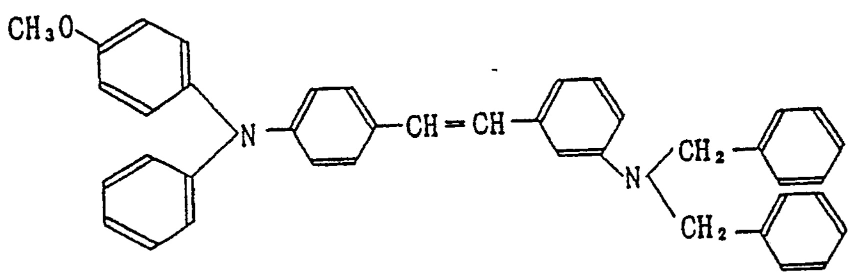


Four parts by weight of a carrier transport material [Illustrative compound (17)] and 10 parts by weight of a polycarbonate resin ("Panlite K-1300") were dissolved in 100 parts by weight of 1,2-dichloroethane. The solution was coated on the carrier generation layer to form a carrier transport layer in a thickness of 15 µm. In this way, a sample of the electrophotographic photoreceptor of the present invention was fabricated.

This sample was subjected to the same measurements as those performed in Example 1 and the results are shown in Table 7.

COMPARATIVE EXAMPLE 5

A comparative sample (No. 5) of photoreceptor was prepared as in Example 17 except that 4.0 parts by weight of a stilbene derivative having the structural formula shown below was used as a carrier transport material:



This comparative sample was subjected to the same measurements as those performed in Example 1 and the results are shown in Table 7.

TABLE 7

Characteristics \ No. of cycles \ Sample	Example 17		Comparative Example 5	
	1	100	1	100
V_A (v)	-1180	-1145	-1270	-1190
E^{600}_{100} (ℓux·sec)	2.6	2.6	4.4	5.2
V_R (v)	0	0	0	-20

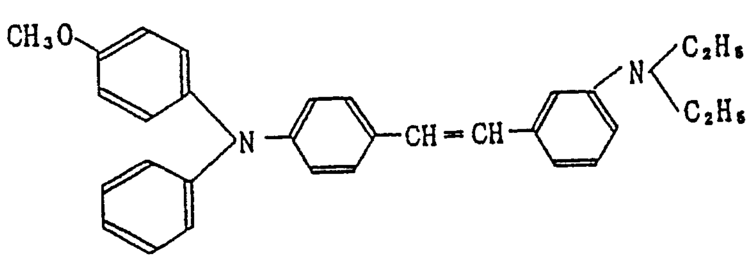
EXAMPLE 18

A carrier generation layer was formed as in Example 11 except that nonmetallic τ-phthalocyanine (TOYO INK MFG. CO., LTD.) was used as a carrier generation material.

To 10 parts by weight of a polycarbonate resin ("Z-200" of Mitsubishi Gas Chemical Co., Ltd.), a carrier transport material [Illustrative compound (14)] was added in different amounts (7.5, 6.0, 5.0, 4.0 and 3.0 parts by weight) and the mixtures were processed as in Example 11 and coated on the carrier generation layer to form carrier transport layers in a thickness of 20 µm. The so fabricated samples of the electrophotographic photoreceptor of the present invention were subjected to measurements of sensitivity (E^{600}_{100}) as in Example 1. The results are shown in Fig. 7.

COMPARATIVE EXAMPLE 6

Comparative samples of photoreceptor were prepared as in Example 18 except that a stilbene derivative having the structural formula shown below was used as a carrier transport material:



These comparative samples were subjected to the same measurements as those performed in Example 18 and the results are also shown in Fig. 7.

As will be understood from the foregoing description, the electrophotographic photoreceptor of the present invention is far superior to the comparative samples in terms of sensitivity and stability in cyclic use. The advantage of the present invention is particularly notable in the low concentration range of a carrier transport material where it experiences a much smaller decrease in sensitivity than the comparative samples.

Claims

1. An electrophotographic photoreceptor having a light-sensitive layer formed on an electroconductive base, said light-sensitive layer containing at least one carrier transport material represented by the following general formula (I):

$$\begin{matrix} Ar_1 \\ Ar_2 \end{matrix}\!\!>N-Ar_3-CH=CH-Ar_4-N\!\!<\!\!\begin{matrix} R_1 \\ R_2 \end{matrix} \qquad (I)$$

where Ar_1 and Ar_2 each represents an aryl group; Ar_3 represents an arylene group; Ar_4 represents a p-phenylene or naphthylene group; R_1 and R_2 each represents an alkyl or aralkyl group; and each of these groups may optionally have a substituent.

2. An electrophotographic photoreceptor according to claim 1, wherein Ar_1 and Ar_2 in said general formula (I) each represents a phenyl or naphthyl group.

3. An electrophotographic photoreceptor according to claim 1 or 2, wherein Ar_3 in said general formula (I) represents a phenylene or naphthylene group.

4. An electrophotographic photoreceptor according to claim 1, 2 or 3, wherein R_1 and R_2 in said general formula (I) each represents a C_{1-8} alkyl group, a benzyl group or a phenethyl group.

5. An electrophotographic photoreceptor according to claims 1, or 2 to 4, wherein said light-sensitive layer contains azo pigments as carrier generation materials.

6. An electrophotographic photoreceptor according to claims 1, or 2 to 5, wherein said light-sensitive layer at least comprises a carrier transport layer and a carrier generation layer.

7. An electrophotographic photoreceptor according to claim 6, wherein the thickness of said carrier generation layer is 0.01 to 5 μm.

8. An electrophotographic photoreceptor according to claim 7, wherein the thickness of said carrier generation layer is 0.05 to 3 μm.

9. An electrophotographic photoreceptor according to claim 6, wherein the thickness of said carrier transport layer is 5 to 30 μm.

10. An electrophotographic photoreceptor according to claims 6, or 7 to 9, wherein said carrier transport layer contains a binder in an amount of 0.8 to 10 parts by weight per part by weight of the compound represented by said general formula (I).

11. An electrophotographic photoreceptor according to claims 6, or 7 to 10, wherein said carrier generation layer contains a binder in an amount not exceeding 5 parts by weight per part by weight of the carrier generation material.

12. An electrophotographic photoreceptor according to claims 1, or 2 to 11, wherein said light-sensitive layer which contains the compound represented by said general formula (I) as the main component has the fine particles of a carrier generation material dispersed therein.

13. An electrophotographic photoreceptor according to claim 12, wherein said light-sensitive layer contains a binder in an amount of 0.5 to 10 parts by weight per part by weight of said carrier generation material.

14. An electrophotographic photoreceptor according to claim 12, wherein said light-sensitive layer contains a binder in an amount of 0.5 to 10 parts by weight per part by weight of the compound represented by said general formula (I).

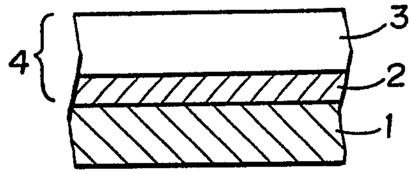


Fig. 1

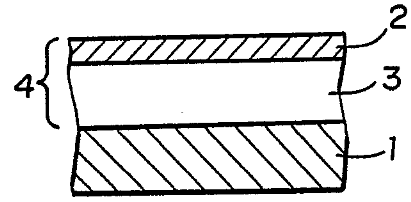


Fig. 2

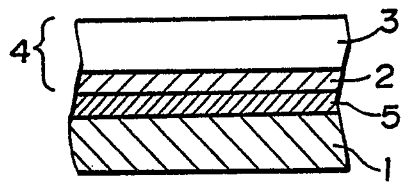


Fig. 3

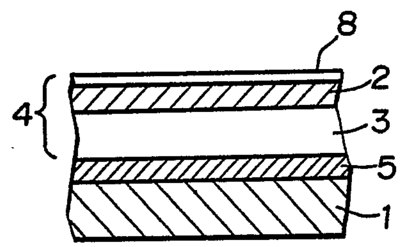


Fig. 4

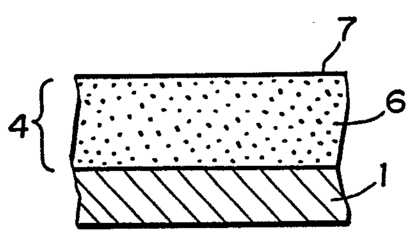


Fig. 5

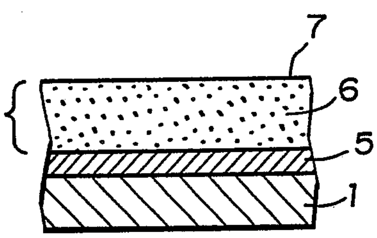


Fig. 6

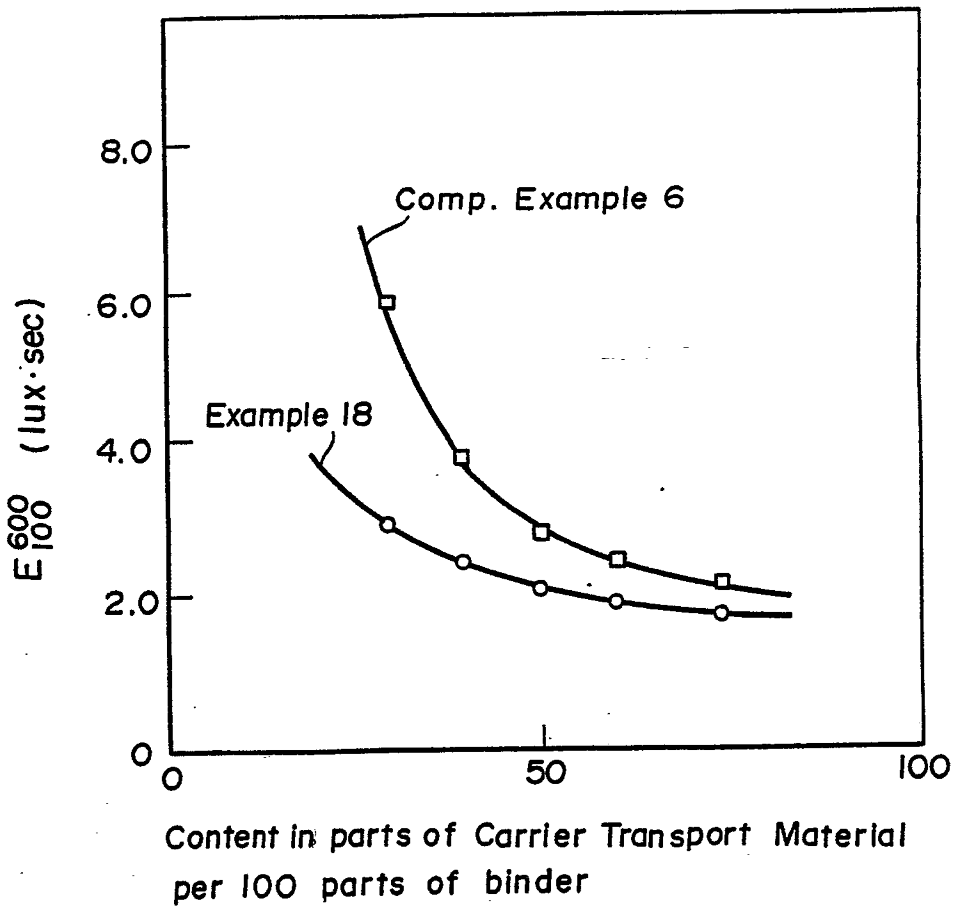

8.0
6.0
4.0
2.0
0
E^{600}_{100} (lux·sec)
Comp. Example 6
Example 18
0
50
100
Content in parts of Carrier Transport Material
per 100 parts of binder

Fig. 7