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ELECTROPHOTOGRAPHIC COMPOSITIONS AND ELEMENTS

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ABSTRACT OF THE DISCLOSURE

Novel photoconductive compositions and elements are described containing substituted anthracene photoconductors. These compositions and elements are especially useful in xerographic processes.

This invention relates to electrophotography, and in particular to organic photoconductor-containing compositions and elements having enhanced photosensitivity when electrically charged.

The process of xerography, as disclosed by Carlson in U.S. 2,297,691, employs an electrophotographic element comprising a support material bearing a coating of a normally insulating material whose electrical resistance varies with the amount of incident actinic radiation it receives during an imagewise exposure. The element, commonly termed a photoconductive element, is first given a uniform surface charge, generally in the dark after a suitable period of dark adaptation. It is then exposed to a pattern of actinic radiation which has the effect of differentially reducing the potential of the surface charge in accordance with the relative energy contained in various parts of the radiation pattern. The differential surface charge or electrostatic latent image remaining on the electrophotographic element is then made visible by contacting the surface with a suitable electroscopic marking material. Such marking material or toner, whether contained in an insulating liquid or on a dry carrier may be selected to be deposited on the exposed surface in accordance with either the charge pattern or the absence of charge pattern as desired. The deposited marking material may then be either permanently fixed to the surface of the sensitive element by known means such as heat, pressure, solvent vapor, or the like, or transferred to a second element to which it may similarly be fixed. Likewise, the electrostatic latent image may be transferred to a second element and developed there.

Various photoconductive insulating materials have been employed in the manufacture of electrophotographic elements. For example, selenium and selenium alloys vapor deposited on a suitable support and particles of photoconductive zinc oxide held in a resinous, film-forming binder have found wide application in present-day document copying applications.

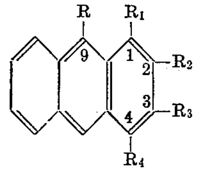
Since the introduction of electrophotography, a great many organic compounds have also been screened for their photoconductive properties. As a result a very large number of organic compounds are known to possess some degree of photoconductivity. Many organic compounds have revealed a useful level photoconduction and have been incorporated into photoconductive compositions. Optically clear organic photoconductor-containing elements having desirable electrophotographic properties can be especially useful in electrophotography. Such electrophotographic elements may be exposed through a transparent base if desired thereby providing unusual flexibility in equipment design. Such compositions, when coated as a film or layer, on a suitable support also yield an element which is reusable; that is it can be used to form subsequent images after residual toner from prior images has been removed by transfer and/or cleaning. Thus far, the selection of organic compounds for incorporation into photoconductor compositions to form electrophotographic layers has proceeded on a compound-by-compound basis. Nothing has yet been discovered from the large number of different photoconductive substances tested which permits effective prediction and therefore selection of particular compounds exhibiting the desired electrophotographic properties.

It is an object of this invention to provide novel photoconductive elements containing at least one organic photoconductor in an amount sufficient to be useful in electrophotographic applications.

It is another object of this invention to provide particularly effective novel photoconductive compositions containing certain substituted anthracene compounds.

It is likewise an object of this invention to provide new photoconductive elements containing an organic photoconductor that can be effectively sensitized with pyrylium and thiapyrylium sensitizers.

These and further objects and advantages of this invention have been achieved by discovery of the advantageous photoconductive properties of certain substituted anthracenes. In particular, substituted anthracene photoconductors having substituted in their 2, 3, and 9 positions a group selected from the class consisting of a hydrogen atom, an alkyl radical containing from 1 to 4 carbon atoms and aryl radicals; and having substituted in their 1 and 4 positions a group selected from the class consisting of a hydrogen atom, an alkyl radical containing from 1 to 4 carbon atoms, an aryl radical, and taken together, the necessary atoms to form an alkylene chain containing 10 to 15 carbon atoms; and where at least 1 of the pairs of substitutions in the 1 and 4 positions and the 2 and 3 positions is other than a hydrogen atom. Typical compounds of this type correspond to the general formula:



where R_1, R_2, R_3, R_4 and R are the 1, 2, 3, 4, and 9 position substituents described above. For example, highly useful photoconductive compositions are obtained when formulated of compounds selected from the hereinbefore described group where R_1 and R_4 are the same aryl radicals when R_2 and R_3 are hydrogen substituted and also where R_2 and R_3 are the same aryl radicals when R_1 and R_4 are selected from the group consisting of hydrogen atoms and alkyl radicals. Similarly, preferred compounds include 9-arylanthracene derivatives where R_2 and R_3 are the same aryl radicals and R_1 and R_4 are selected from the group consisting of hydrogen atoms and alkyl radicals and where R_2 and R_3 are selected from the group consisting of hydrogen atoms and alkyl radicals when R_1 and R_4 are aryl radicals. Included in the foregoing specific class of compounds are compounds such as

1,4,9-triphenylanthracene;
2,3,9-triphenylanthracene;
2,3-dimethyl-9-phenylanthracene;
1,4-diethyl-2,3,9-triphenylanthracene;
1,4-dimethyl-9-phenylanthracene;
1,4-dimethyl-2,3,9-triphenylanthracene;
2,3-dipropyl-9-phenylanthracene;
1,4-dibutyl-2,3,9-triphenylanthracene;
1,4-dipropyl-2,3,9-triphenylanthracene;
2,3-dipropyl-9-triphenylanthracene;
1,4-diphenylanthracene;

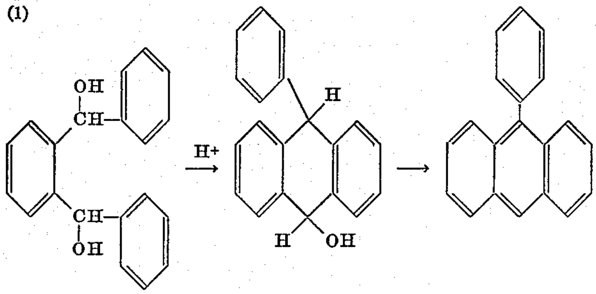
1,4-decano-2,3-diphenylanthracene;
1,4-dodecano-2,3-diphenylanthracene;
1,4-hexadecano-2,3-diphenylanthracene;
1,4-dipropyl-2,3-diphenylanthracene

and the like. All of the foregoing compounds have shown superior electrophotographic properties when used in photoconductive composition.

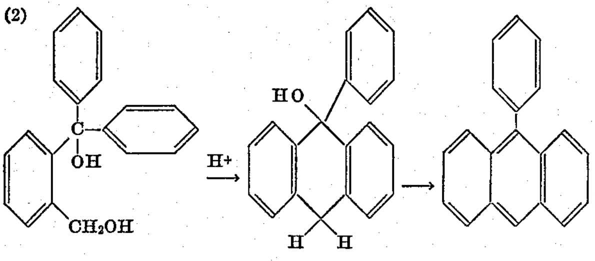
Compounds included in the hereinbefore described general formula are generally known and obtainable, or they can readily be synthesized. For example, the procedures described in Elderfield, Heterocyclic Compounds 2, pp. 70, 89 and Elsevier's Encyclopedia 13, 222 may be used in the preparation of many of the 9-arylanthracenes of this invention.

In particular the desired compounds of this invention can be prepared using as an appropriate starting material a compound which yields a hydroxy carbonium ion upon treatment with an acid. Compounds satisfying this requirement include epoxides, glycols, and phthalans. The resulting intermediate can then subsequently be made to undergo an internal alkylation of an aromatic ring and a dehydration or an aromatic trans-annular cyclodehydration to form the desired anthracene derivative. Any of the following reaction schematics may readily be utilized by one skilled in the art in preparing compounds useful as photoconductors in the present invention.

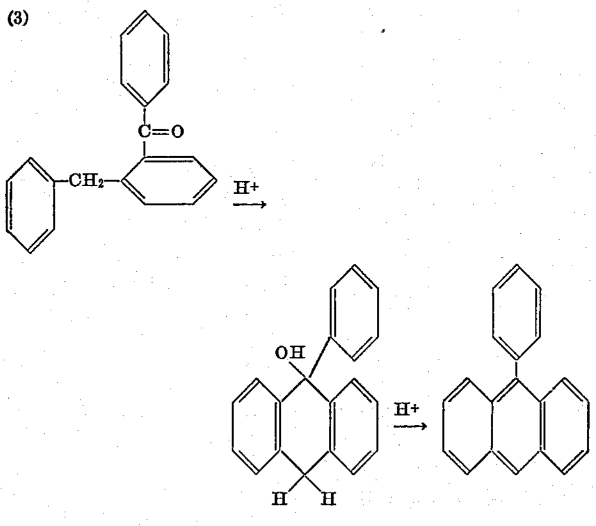
(1)



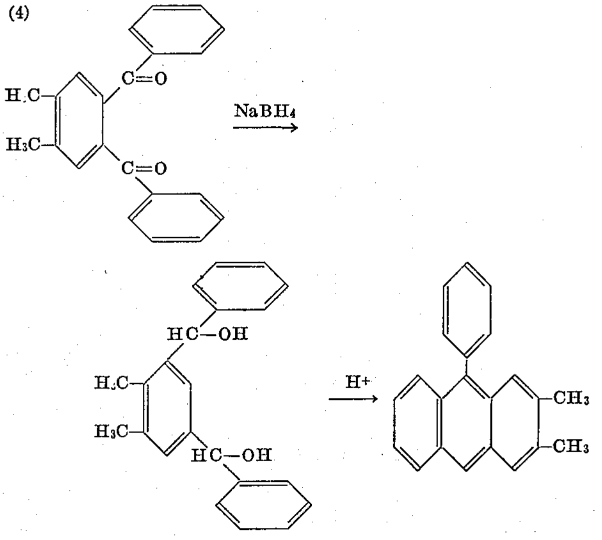
(2)



(3)



(4)



A large number of anthracene compounds, as well as many complex organic compounds, have shown some degree of photoconduction when they are incorporated into a suitable layer-like structure which is examined for its electrophotographic usefulness. In particular, 9-phenylanthracene; 9,10-diphenylanthracene; 9-cyanoanthracene; 9,10-dicyanoanthracene; and 9,10-anthracenedicarboxyaldehyde dioxime have been incorporated into photoconductive compositions. Unfortunately, these compounds, as well as most previously employed anthracenederivatives, are limited in their usefulness due to their inability to form non-sticky, tough, clear, noncrystalline coatings. This fact forms an important obstacle to the preparation of clear stable mechanically sound electrophotographic layers.

For example, 9-phenylanthracene can be successfully incorporated into photoconductive compositions. However, when one more phenyl radical is added, as in 9,10-diphenylanthracene, that compound is not well suited for forming a clear, homogeneous electrophotographic element. It was therefore quite unexpected that a triphenylanthracene or other specifically substituted anthracenes should exhibit solubility characteristics vastly superior to the diphenylanthracenes. On the contrary, it would normally be expected that particularly the triaryl substituted anthracene should be less soluble than the diphenylanthracene since the 9,10-diphenyl derivative is less soluble, and therefore less satisfactory than the monophenylanthracene. The specific derivatives of anthracene disclosed herein have unexpectedly been discovered to possess very outstanding electrophotographic properties. It should be noted that the use of the 1,4 and 2,3 positions promotes the advantageous properties which characterize the compounds of this invention. The theoretical importance of the substitution at these positions is not at present fully understood. It is, however, clear from the examples and table contained herein that substitution at these particular positions uniquely produces the unexpected properties which are important in electrophotography and the preparation of photoconductor-containing compositions. The compounds of this invention have particularly attractive film-forming properties. In general they form noncrystalline appearing films from conventional solvents.

Surprisingly, the electrophotographic response as well as the solubility and coatability of the anthracene based photoconductive compositions is greatly enhanced when one of the pair of position 1,4 and 2,3 are substituted by alkyl radicals or aryl radicals. Particularly, unexpected is the observation of the improved electrophotographic performance when the 1,4 and 2,3 positions are aryl substituted. It was, therefore, not to be anticipated that the specific position substitution of the compounds of this invention should provide enhanced electrophotographic effectiveness over other kinds of substituted anthracenes. Contrary to what normally might be expected, the specific compounds of this invention exhibit highly useful photoconductive response and outstanding film-forming characteristics.

In preparing electrophotographic elements utilizing the photoconductor compounds of this invention, the photoconductive composition compounds may be formulated and coated with or without a binder. When a binder is employed, the compound is dissolved in a solution of binder and solvent and then after thorough mixing, the composition is coated on an electrically conducting support in a well-known manner, such as swirling, spraying, doctor-blade coating, and the like.

Preferred binders for use in preparing the photoconductive layers comprise polymers having fairly high dielectric strength and which are good electrically insulating film-forming vehicles. Materials of this type comprise styrenebutadiene copolymers; silicone resins; styrene-alkyd resins; silicone-alkyd resins; soya-alkyd resins; poly(vinyl chloride); poly(vinylidene chloride); vinylidene chloride; acrylonitrile copolymers; poly(vinyl acetate); vinyl acetate; vinyl chloride copolymers; poly(vinyl acetals), such as poly(vinyl butyral); polyacrylic and methacrylic esters, such as poly(methylmethacrylate), poly(n-butylmethacrylate), poly(isobutyl methacrylate), etc.; polystyrene; nitrated polystyrene polymethylstyrene; isobutylene polymers; polyesters, such as poly(ethylenealkaryloxyalkylene terephthalate); phenol-formaldehyde resins; ketone resins; polyamide; polycarbonates; etc. Methods of making resins of this type have been described in the prior art, for example, styrene-alkyd resins can be prepared according to the method described in U.S. Pats. 2,361,019 and 2,258,423. Suitable resins of the type contemplated for use in the photoconductive layers of the invention are sold under such names as Vitel PE–101 resin, Cymac resin, Piccopale 100 resin, and Saran F–220 resin. Other types of binders which can be used in the photoconductive layers of the invention include such materials as paraffin, mineral waxes, etc.

Solvents of choice for preparing coating compositions of the present invention can include a number of solvents such as benzene, toluene, acetone, 2-butanone, chlorinated hydrocarbons, e.g., methylene chloride, ethylene chloride, etc., ethers, e.g., tetrahydrofuran, or mixtures of these solvents, etc.

In preparing the coating composition useful results were obtained where the photoconductor substance was present in an amount equal to at least about 1 weight percent of the coating composition. The upper limit in the amount of photoconductor substance present can be widely varied in accordance with usual practice. In those cases where a binder is employed, it is normally required that the photoconductor substance be present in an amount from about 1 weight percent of the coating composition to about 99 weight percent of the coating composition. A preferred weight range for the photoconductor substance in the coating composition is from about 10 weight percent to about 60 weight percent.

Coating thicknesses of the photoconductive composition on a support can vary widely in accordance with usual practice. Normally, a coating in the range of about 0.001 inch to about 0.01 inch before drying was useful for the invention. The preferred range of coating thickness was found to be in the range from about 0.002 inch to about 0.006 inch before drying.

Suitable supporting materials for coating the photoconductive layers of the present invention can include any of a wide variety of conventional supports. Likewise the support should preferably be suitably conductive. For example, a support such as paper (at a relative humidity above 20 percent) or aluminum-paper laminates or metal foils such as aluminum foil, zinc foil, etc.; metal plates, such as aluminum, copper, zinc, brass, and galvanized plates. Flexible film supports, such as regenerated cellulose and cellulose derivatives; certain polyesters, especially polyesters having a conductive layer coated thereon, which may be overcoated with an insulating layer, if desired to prevent charge injection into the photoconductive layer, are suitable for use with this invention. Conducting layers useful in the present invention include those described in U.S. Pat. Nos. 3,112,192 and 3,245,833.

The elements of the present invention can be employed in any of the well-known electrophotographic processes which require photoconductive layers. One such process is the xerographic process. In a process of this type, the electrophotographic element is given a blanket electrostatic charge by placing the same under a corona discharge which serves to give a uniform charge to the surface of the photoconductive layer. This charge is retained by the layer owing to the substantial insulating property of the layer, i.e., the low conductivity of the layer in the dark. The electrostatic charge formed on the surface of the photoconducting layer is then selectively dissipated from the surface of the layer by imagewise exposure to light by conventional exposure operations such as, for example, by contact-printing technique, or by lens projection, etc., to form a latent electrostatic image in the photoconducting layer. By exposure of the surface, in this manner, a charged pattern is created by virtue of the fact that light causes the charge to be conducted away in proportion to the intensity of the illumination in a particular area. The charge pattern remaining after exposure is then developed, i.e., rendered visible, by treatment with a medium comprising electrostatically attractable particles having optical density. The developing electrostatically attractable particles can be in the form of a dust, e.g., powder, a pigment in a resinous carrier, i.e., toner, or a liquid developer may be used in which the developing particles are carried in an electrically insulating liquid carrier. Methods of development of this type are widely known and have been described in the patent literature in such patents, for example, as U.S. Pat. 2,297,691, and in Australian Pat. 212,315. In processes of electrophotographic reproduction such as in xerography, by selecting a developing particle which has as one of its components, a low-melting resin, it is possible to treat the developed photoconductive material with heat and cause the powder to adhere permanently to the surface of the photoconductive layer. In other cases, a transfer of the image formed on the photoconductive layer can be made to a second support, which would then become the final print. Techniques of the type indicated are well known in the art and have been described in a number of U.S. and foreign patents, such as U.S. Pats. 2,297,691 and 2,551,582, and in "RCA Review," vol. 15 (1954), pages 469–484.

The photoconductive compositions of the invention can also be sensitized to highly improved speed. Sensitizing compounds for use with the present photoconductive derivatives can include a wide variety of substances such as pyrylium and thiapyrylium salts of U.S. application Ser. No. 146,743, filed Oct. 23, 1961; fluorenes, such as 7,12-dioxo - 13 - dibenzo(a,b)fluorene, 5,10-dioxo-4a,11-diazabenzo(b)fluorene, 3,13 - dioxo - 7 - oxadibenzo(b,g) fluorene, and the like; aromatic nitro compounds of U.S. Pat. 2,610,120; anthrones of U.S. Pat. 2,670,285; quinones of U.S. Pat. 2,670,286; benzophenones of U.S. Pat. 2,670,287; thiazoles of U.S. Pat. 2,732,301; mineral acids; carboxylic acids, such as maleic acid, dichloroacetic acid, and salicylic acid; sulfonic and phosphoric acids; and various dyes such as triphenylmethane, diarylmethane, thiazine, azine, oxazine, xanthene, phthalein, acridine, azo, and anthraquinone dyes. The preferred sensitizers of the invention, however, are pyrylium and thiapyrylium salts, fluorenes, carboxylic acids and the triphenylmethane dyes.

Where a sensitizing compound of the invention is to be used with a photoconductive layer of the invention, it is the usual practice to mix a suitable amount of the sensitizing compounds with the coating composition so that, after thorough mixing, the sensitizing compound is uniformly distributed in the coated element. In preparing the photoconducting layers, no sensitizing compound is required to give photoconductivity in the layers which contain the photoconducting substances of the invention, so of course, the lower limit of sensitizer required in a particular photoconductive layer is zero. However, since relatively minor amounts of sensitizing compound give substantial improvement in speed in such layers, the sensitizer is preferred. The amount of sensitizer that can be added to a photoconductor-incorporating layer to give effective increases in speed can vary widely. The optimum concentration in any given case will vary with the specific photoconductor and sensitizing compound used. In general, substantial speed gains can be obtained where an appropriate sensitizer is added in a concentration range from about 0.0001 to about 30 percent by weight based on the weight of the film-forming hydrophobic coating composition.

The invention is further illustrated by the following examples of preferred embodiment thereof.

EXAMPLE 1

For the preparation of 2,3-dimethyl-9-phenylanthracene (according to Equation 4) approximately 9.4 mg. or 0.03 mole of 1,2-dibenzoyl-4,5-dimethylbenzene was reduced with approximately 0.02 mole of sodium borohydride by heating while stirring, a mixture of the two compounds in 500 ml. of diglyme, (bis(2-methoxyethyl)ether). After the reactants and diglyme have been brought to a boil, the mixture was then cooled to room temperature and diluted with approximately three liters of water. The resultant solid was crystallized from a methanol-water mixture and then heated on a steam bath together with 25 ml. of acetic acid and 25 ml. of 30% hydrogen bromide in acetic acid. This reaction produced a solid which was cooled to room temperature by the addition of water, the solid product was then separated by filtration and then washed with water. The reaction yielded 89.5% of dry, 2,3-dimethyl-9-phenylanthracene (M.P. 171° C.–173° C.). A photoconductive layer of 2,3-dimethyl-9-phenylanthracene was made for coating on a support material by mixing 0.15 part of the photoconductor with 0.002 part of 2,6-(4-ethylphenyl)-4 - (4-n-amyloxyphenyl) thiapyrylium perchlorate and dissolving these together with 0.5 part by weight of a resinous polyester binder with suitable stirring in methylene chloride. The resultant mixture was then hand-coated on an aluminum-laminated paper support. The polyester binder used in this example was a copolymer of terephthalic acid and a glycol mixture comprising a 9:1 wt. ratio of 2,2-bis[4-(β-hydroxyethoxy)phenyl]propane and ethylene glycol. The wet coating thickness on the support was 0.004 inch thickness. After drying, the electrophotographic element was tested using conventional electrophotographic techniques. The element was given an electrostatic surface charge by placing the element in an electrostatic corona. After charging the element was then given an imagewise exposure to light through an image-bearing transparency. The exposure was accomplished by a 3000° K. tungsten light source at an intensity of 20 foot/candle/seconds. The resulting charge image or electrostatic latent image on the element was rendered visible by dusting its exposed surface with an electrostatically attractable powder having optical density according to the method and materials described in U.S. Pat. 2,297,691 and tested by the following procedure: The element was charged under positive corona source until the surface potential, as measured by an electrometer probe, reached a maximum value, usually about 600 volts. It was then exposed to a light source in the manner described herein replacing the image-bearing transparency with a stepped density gray scale. The exposure caused reduction of the surface potential of the element under each step of the gray scale from its initial potential, V*o*, to some lower potential, V, whose exact value depended on the actual amount of exposure received by the area. The results of these measurements were then plotted on a graph of surface potential V vs. log exposure for each step. The actual positive speed of the element may then be expressed in terms of the reciprocal of the exposure required to reduce the surface potential to any arbitrarily selected value. In this example and the ones that follow the actual positive speed is the numerical expression of 10^4 divided by the exposure in meter-candle seconds required to reduce a positive surface potential to a value 100 volts below the maximum charged surface potential. In the case of the 2,3-dimethyl-9-phenylanthracene containing photoconductive element prepared herein the actual positive electrical H and D speed determined was 320.

EXAMPLE 2

A quantity of 1,4-diethyl-2,3,9-triphenylanthracene was prepared in a manner similar to the method of preparation of Example 1. An electrophotographic element using 0.15 part of 1,4-diethyl-2,3,9-triphenylanthracene in the photoconductor composition was prepared, exposed and developed, as in Example 1, producing a useful image.

EXAMPLE 3

To prepare 1,4,9-triphenylanthracene a mixture of 1.3 grams of 1,3,4,7-tetraphenylphthalan, 10 ml. of acetic anhydride and a drop of concentrated sulfuric acid was boiled until the mixture was homogeneous. The mixture was cooled and diluted as in Example 1 and the resultant solid product was separated by filtration. Recrystallization from acetic acid produced 1,4,9-triphenylanthracene (M.P. 171.5° C.–174° C.). The procedure of Example 1 was followed in preparing an electrophotographic element using 0.15 part of 1,4,9-triphenylanthracene as the photoconductor in the coating composition. Exposure of the element and development, as in Example 1, produced a useful image.

EXAMPLE 4

A quantity of 2,3,9-triphenylanthracene was prepared in a manner similar to the method of preparation of Example 3. An electrophotographic element using 0.15 part of 2,3,9-triphenylanthracene in the photoconductor composition was prepared, exposed and developed, as in Example 1, producing a useful image.

EXAMPLE 5

A quantity of 1,4-diphenylanthracene was prepared in a manner similar to the method of preparation of Example 3. An electrophotographic element using 0.15 part of 1,4-diphenylanthracene in the photoconductor composition was prepared, exposed and developed, as in Example 1, producing a useful image.

EXAMPLE 6

A quantity of the compound 1,4-dipropyl-2,3-diphenylanthracene was prepared by first using the procedure of L. F. Fieser and M. J. Haddadin, Can. J. Chem., 43, 1599 (1965) for the preparation of 1,2,3,4-tetraphenylanthracene using about 0.02 mole of 3,4-diphenyl-2,5-dipropylcyclopentadienone. The crude product obtained was a pasty red solid. A benzene solution of the solid product was chromatographed on alumina with benzene as the developer. The resulting colorless effluent was then stripped to yield an oil which crystallized when triturated with methanol. The crystalline product was recovered by filtration and recrystallized from acetic acid to yield a compound having a melting point of 161.5° C.–163° C. An electrophotographic element using 0.15 part of 1,4-dipropyl-2,3-diphenylanthracene in the photoconductive composition was prepared, exposed and developed, as in Example 1, producing a useful image.

EXAMPLE 7

The compound 1,4-dibutyl-9-phenylanthracene was prepared according to the method of Example 1 starting with 1,4-dibutyl-2,3-benzoyl benzene. The product was incorporated into a photoconductive composition using 0.15 part. An electrophotographic element using this composition was then prepared, exposed and developed according to the procedure in Example 1, to produce a useful image.

EXAMPLE 8

A quantity of the compound 1,4-dodecano-2,3-diphenylanthracene was prepared by adding to a refluxing solution of 15.9 g. (0.04 mole) of 2,5-dodecano-3,4-diphenyl cyclopentadienone in 100 ml. of 1,2-dimethoxyethane, a solution of 7.48 g. (0.04 mole) of 3-amino - 2 - naphthoic acid in 80 ml. of 1,2-dimethoxyethane and 12 ml. of isomyl nitrite in 80 ml. of the same solvent. This mixture was refluxed for 2 hrs., cooled, and made basic with 5% sodium hydroxide solution. The resulting scarlet solid was stirred in benzene and filtered to remove insoluble residue. After drying the benzene solution was chromatographed on alumina. The effluent was stripped to yield an orange solid. Washing with methanol gave 6.83 g. of yellow solid, M.P. 244–249°. Two recrystallizations from acetic acid produced a yellow solid having, M.P. 251.5° C.–253.5° C. An electrophotographic element using 0.15 part of 1,4-dodecano-2,3-diphenylanthracene in the photoconductor composition was prepared, exposed and developed, as in Example 1, producing a useful image.

EXAMPLE 9

The procedure of Examples 1 through 8 was followed in preparing an electrophotographic element wherein, in each case the photosensitizer employed was substituted with the compound 2,4-di(4-ethoxyphenyl)-6-(4-n-amyloxystyryl)pyrylium fluoroborate. Final exposure of the element according to Example 1 produced a useful image in each case.

The following table records the actual electrical H and D speeds (obtained as described in Example 1) of coatings containing the listed compounds determined as described hereinbefore in Examples 1–8. All of the compounds listed were incorporated into identical coating compositions which conformed in composition to the coating prepared in Examples 1–8.

Substituted anthracene:	+Electrical H and D Speed
1,4-diphenylanthracene	630
1,4,9-triphenylanthracene	500
2,3,9-triphenylanthracene	500
1,4-dipropyl-2,3-diphenylanthracene	500
1,4-diethyl-2,3,9-triphenylanthracene	500
2,3-dimethyl-9-phenylanthracene	320
1,4-dibutyl-9-phenylanthracene	320
1,4 - bis - (dodecamethylene) - 2,3 - diphenyl anthracene	320
9-phenylanthracene	320
1,4-dimethylanthracene	250
9,10-diphenylanthracene	250
syn-9-anthraldehyde oxime	20
9-cyanoanthracene	15
9,10-dicyanoanthracene	4
9,10-anthracenedicarboxaldehyde dioxime	0
9,10-anthracenedicarboxaldehydedioxime	0

It is readily apparent from the foregoing table that the particular substituted anthracenes of this invention show enhanced electrophotographic activity over the other substituted anthracenes. It is also important to note that the comparison compounds 9,10 - diphenylanthracene; 9,10-dicyanoanthracene; and 9,10-anthracenedicarboxaldehydedioxime, do not form clear, smooth, homogeneous, noncrystalline coatings and are not well suited as photoconductors in layer-type electrophotographic elements. The positive speed numbers in the above table for these compounds, where comparable with some of the positive speed numbers of the compounds of this invention, do not therefore adequately represent the overall unsuitability of these compounds for use in electrophotographic elements.

It will be apparent from the foregoing description that the photoconductive layers of the present invention may be used in electrophotographic elements having many structural variations. For example, the photoconductive composition may be coated in the form of single layers or multiple layers on a suitable opaque or transparent conducting support. Likewise, the layers may be contiguous or spaced having layers of insulating material or other photoconducting material between layers or overcoated or interposed between the layer and the conducting layer. It is also possible to adjust the position of the support and the conducting layer placing a photoconductor layer over a support and coating the exposed face of the support or the exposed or overcoated face of the photoconductor with a conducting layer. Configurations differing from those contained in the examples may be useful or even preferred for the same or different applications for the electrophotographic element.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

I claim:

1. A photoconductive composition for use in electrophotographic image-forming processes comprising a polymeric film-forming binder and a substituted anthracene photoconductor having substituted in its 2, 3 and 9 positions a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and a phenyl radical.

2. The photoconductor composition of claim **1** wherein the photoconductor comprises at least one percent by weight of 2,3-dimethyl-9-phenylanthracene.

3. The photoconductor composition of claim **1** wherein the photoconductor comprises at least one percent by weight of 2,3,9-triphenylanthracene.

4. The photoconductive composition as described in claim **1** wherein the photoconductor comprises a 2,3-dialkyl-9-phenylanthracene.

5. A photoconductive composition for use in electrophotographic image-forming processes comprising a polymeric film-forming binder and a substituted anthracene photoconductor having substituted in its 1, 4 and 9 positions a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and a phenyl radical.

6. The photoconductor composition of claim **5** wherein the photoconductor comprises at least one percent by weight of 1,4,9-triphenylanthracene.

7. The photoconductor composition of claim **5** wherein the photoconductor comprises at least one percent by weight of 1,4-dibutyl-9-phenylanthracene.

8. An electrophotographic element comprising a support having coated thereon a photoconductive composition comprising an electrically insulating film-forming polymeric binder and an anthracene photoconductor having substituted in its 2, 3 and 9 positions a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and a phenyl radical.

9. An electrophotographic element comprising a support having coated thereon a photoconductive composition comprising an electrically insulating film-forming polymeric binder and an anthracene photoconductor having substituted in its 1, 4 and 9 positions a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and a phenyl radical.

10. An electrophotographic element comprising a support having coated thereon a photoconductive composition comprising an electrically insulating film-forming polymeric binder and an anthracene photoconductor having substituted in its 1, 2, 3, and 4 positions a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and an phenyl radical.

11. The electrophotographic element of claim **10** wherein the 9 position of said anthracene photoconductor contains a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and a phenyl radical.

12. The photoconductor composition of claim **11** wherein the photoconductor comprises at least one percent by weight of 1,4-diethyl-2,3,9-triphenylanthracene.

13. A photoconductive composition for use in electrophotographic image-forming processes comprising a polymeric film-forming binder and a substituted anthracene photoconductor having substituted in its 1, 2, 3, and 4 positions a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and a phenyl radical.

14. The photoconductive composition of claim **13** wherein the **9** position of said substituted anthracene photoconductor contains a group selected from the class consisting of an alkyl radical having 1 to 4 carbon atoms and a phenyl radical.

15. The photoconductor composition of claim **13** wherein the photoconductor comprises at least one percent by weight of 1,4-dipropyl-2,3-diphenylanthracene.

16. The photoconductor composition of claim **13** wherein the photoconductor comprises at least one percent by weight of 1,4-dodecano-2,3-diphenylanthracene.

17. The photoconductive composition as described in claim **14** wherein the photoconductor comprises a 1,4-dialkyl-2,3,9-triphenylanthracene.

18. The photoconductive composition as described in claim **13** wherein the photoconductor comprises a 1,4-alkano-2,3-diphenylanthracene.

19. The photoconductive composition as described in claim **13** wherein the photoconductor comprises a 1,4-dialkyl-2,3-diphenylanthracene.

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