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(54) **Organic photoconductor**

Organischer Photoleiter

Photoconducteur organique

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method of reducing stress related cracking in a photoconductor when the photoconductor is subjected to mechanical stress and used in a liquid toner imaging machine as defined in claim 1 and to an inorganic photoconductor obtainable by this method as defined in claim 10 organic photoconductors.

BACKGROUND OF THE INVENTION

[0002] Various types of organic photoconductors are known. Most organic photoconductors are susceptible to attack by organic solvents of the type used in liquid toner electrophotography and are therefore unsuitable for such applications. These photoconductors include those which dissolve in the solvents and others which are caused to crack as the result of exposure thereto when they are under stress, especially when under tension.

[0003] It is known in the art to provide protective coatings for organic photoconductors. Examples of these coatings are given in U.S. Patents 4,891,290 and 4,894,304.

SUMMARY OF THE INVENTION

[0004] The present invention seeks to provide an improved organic photoconductor which is resistant to cracking in a stressed environment wherein organic solvents of the type used in liquid toner electrophotography are present.

[0005] There is thus in accordance with the present invention a method of reducing stress related cracking in a photoconductor when the photoconductor is subjected to mechanical stress and used in a liquid toner imaging machine as defined in claim 1 and to an inorganic photoconductor obtainable by this method as defined in claim 10. It also provides an organic photoconductor including a base layer formed of a first material and a photoconductive layer formed of a second material comprising a charge generating layer and a charge transport layer, the organic photoconductor being characterized in that when it is maintained in a curved orientation with the photoconductive layer facing outward, the photoconductive layer is subjected to less stress than the base layer. In accordance with a preferred embodiment of the invention the first material is relatively more flexible than the second material. In accordance with an alternative preferred embodiment of the invention the first material is relatively flexible less flexible and stretchable material, which has been chemically treated to increase its stretchability and flexibility.

[0006] There is further provided in accordance with the present invention an organic photoconductor including a base layer formed on a first material and a photoconduc-

tive layer formed of a second material, the second material being chemically treated to relieve stress therein. In the invention, the chemical treatment causes the charge transport layer to become more flexible and stretchable. Preferably the charge transport layer becomes more elastic or plastic.

[0007] Additionally in accordance with the present invention there is provided a method of reducing stress related cracking in an organic photoconductor as defined in claim 1.

[0008] Additionally in accordance with the above embodiment of the invention, the base layer of the organic photoconductor has greater flexibility and stretchability than the photoconductor layer.

[0009] Further in accordance with the above embodiment of the invention, the base layer has a stress relief temperature higher than that of the photoconductive layer.

[0010] In accordance with the invention, the step of treating includes the step of chemically treating the photoconductive layer to soften and render it more elastic or plastic that it previously was.

[0011] Additionally in accordance with the invention there is provided a liquid toner electrophotographic apparatus as claimed in claim 11.

[0012] In accordance with a preferred embodiment of the invention, the photoconductor sheet is constructed and operative in accordance with any of the embodiments described above, alone or in suitable combination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified sectional illustration of liquid toner electrophotographic apparatus constructed and operative in accordance with the present invention; and

Fig. 2 is a simplified illustration of an organic photoconductor sheet used in the apparatus of Fig. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0014] Reference is now made to Fig. 1 which illustrates liquid toner electrophotographic imaging apparatus constructed and operative in accordance with the present invention. The invention is described for liquid developer systems with negatively charged toner particles, and negatively charged photoconductors, i.e., systems operating in the reversal mode. For other combinations of toner particle and photoconductor polarity, the values and polarities of the voltages are changed, in accordance with the principle of the invention.

[0015] The invention can be practiced using a variety of liquid developer types but is especially useful for liquid

developers comprising carrier liquid and pigmented polymeric toner particles. In a preferred embodiment of the invention the carrier liquid is a solvent such as Isopar (Exxon). Examples of such developers are given in U. S. Patent 4,794,651, the disclosure of which is included herein by reference.

[0016] As in conventional electrophotographic systems, the apparatus of Fig. 1 typically comprises a drum 10 arranged for rotation about an axle 12 in a direction generally indicated by arrow 14. An organic photoconductor 100 is mounted on the drum and is stretched tight by stretchers 99.

[0017] A corona discharge device 18 is operative to generally uniformly charge organic photoconductor 100 with a negative charge. Continued rotation of drum 10 brings charged organic photoconductor 100 into image receiving relationship with an exposure unit including a lens 20, which focuses an image onto charged organic photoconductor 100, selectively discharging the photoconductor, thus producing an electrostatic latent image thereon. The latent image comprises image areas at a given range of potentials and background areas at a different potential. The image may be laser generated as in printing from a computer or it may be the image of an original as in a copier.

[0018] Continued rotation of drum 10 brings charged photoconductor 100, bearing the electrostatic latent image, into a development unit 22 including charged developer plates 24. Development unit 22 is operative to apply liquid developer, comprising a solids portion including pigmented toner particles and a liquid portion including carrier liquid preferably an organic liquid, to develop the electrostatic latent image. The developed image includes image areas having pigmented toner particles thereon and background areas.

[0019] While development unit 22 is shown as a single color developer of a conventional type, it may be replaced by a plurality of single color developers for the production of full color images as is known in the art. Alternatively, full color images may be produced by changing the liquid toner in the development unit when the color to be printed is changed. Alternatively, highlight color development may be employed, as is known in the art.

[0020] In accordance with a preferred embodiment of the invention, following application of toner thereto, photoconductor 100 passes a typically charged rotating roller 26, preferably rotating in a direction indicated by an arrow 28. Typically the spatial separation of roller 26 from photoconductor 100 is about 50 microns. Roller 26 thus acts as a metering roller as is known in the art, reducing the amount of carrier liquid on the background areas and reducing the amount of liquid overlaying the image.

[0021] Preferably the potential on roller 26 is intermediate that of the latent image areas and of the background areas on the photoconductor. Typical approximate voltages are: roller 26: -200 V to -800 V, background area: -1000 V and latent image areas: -150 V.

[0022] The liquid toner image which passes roller 26

should be relatively free of pigmented particles except in the region of the latent image.

[0023] Downstream of roller 26 there is preferably provided a rigidizing roller 30. Rigidizing roller 30 is preferably formed of resilient polymeric material, such as polyurethane which may have only its natural conductivity or which may be filled with carbon black to increase its conductivity.

[0024] According to one embodiment of the invention, roller 30 is urged against photoconductor 100 as by a spring mounting (not shown). The surface of roller 30 typically moves in the same direction and with the same velocity as the photoconductor surface to remove liquid from the image.

[0025] Preferably, the biased squeegee described in U. S. Patent 4,286,039, the disclosure of which is incorporated herein by reference, is used as the roller 30. Roller 30 is biased to a potential of at least several hundred and up to several thousand Volts with respect to the potential of the developed image on photoconductor 100, so that it repels the charged pigmented particles and causes them to more closely approach the image areas of photoconductor 100, thus compacting and rigidizing the image.

[0026] In a preferred embodiment of the invention, rigidizing roller 30 comprises an aluminum core having a 20 mm diameter, coated with a 4 mm thick carbon-filled polyurethane coating having a Shore A hardness of about 30-35, and a volume resistivity of about 10^8 ohm-cm. Preferably roller 30 is urged against photoconductor 100 with a pressure of about 40-70 grams per linear cm of contact, which extends along the length of the drum. The core of rigidizing roller 30 is energized to between about -1800 and -2800 volts, to provide a voltage difference of preferably between about 1600 and 2700 volts between the core and the photoconductor surface in the image areas.

[0027] Under these conditions and for the preferred toner, the solids percentage in the image portion is believed to be as high as 35% or more. It is preferable to have an image with at least 25-30% solids, after rigidizing.

[0028] Downstream of rigidizing roller 30 there is provided apparatus for direct transfer of the image from organic photoconductor 100 to a substrate 130 such as paper. The direct transfer is effected by the provision of guide rollers 132, 134 and 136, which guide a continuous web of substrate 130, and a drive roller 138, which cooperates with a support web 140. A suitable charging device, such as corona discharge device 142, charges the substrate at a transfer location, for effecting electrophoretic transfer of the image from photoconductor 100 to substrate 130.

[0029] Following transfer of the toner image to substrate 130, photoconductor 100 is engaged by a cleaning roller 50, which typically rotates in a direction indicated by an arrow 52, such that its surface moves in a direction opposite to the movement of adjacent surface of photo-

conductor 100 which it operatively engages. Cleaning roller 50 is operative to scrub and clean photoconductor 100. A cleaning material, such as toner or another cleaning solvent, may be supplied to the cleaning roller 50, via a conduit 54. A wiper blade 56 completes the cleaning of the photoconductor surface. Any residual charge left on photoconductor 100 is removed by flooding the photoconductor surface with light from a lamp 58.

[0030] In a multi-color system, subsequent to completion of the cycle for one color the cycle is sequentially repeated for other colors which are sequentially transferred from photoconductor 100 to substrate 130.

[0031] Alternatively the direct transfer apparatus may be replaced by an intermediate transfer member which receives the images from photoconductor 100 and transfers them to the final substrate.

[0032] Fig. 2 illustrates an organic photoconductor sheet 100, used in the apparatus of Fig. 1. The sheet comprises a base layer 102, typically formed of Aluminized Polyethylene Telephthalate, which is commercially available under the trademark Mylar. The base layer is preferably about 80 μm (microns) in thickness and has a melting point of 250°C.

[0033] Disposed above the base layer 102 is a sublayer 104, typically formed of Polyester, Toluenesulfonamide-formaldehyde resin and a Polyamide and having a thickness of about 0.2 μm (microns). Disposed above the sublayer 104 is a charge generation layer 106, typically formed of Hydroxysquarylium Dye and Toluenesulfonamide-resin and having a thickness of about 0.3 μm (microns).

[0034] Disposed above layer 106 is a charge transport layer 108, typically formed of Polyester, Polycarbonate, Yellow Dye, 4-[N,N-diethylamino] benzaldehydiphenylhydrazone and Polysiloxane in a minor proportion, having a thickness of about 18 μm (microns). Charge transport layer 108 and charge generation layer 106 together define the photoconductive layer referred to above.

[0035] The organic photoconductor described so far is commercially available from IBM Corporation under the trade name Emerald.

[0036] In accordance with the present invention, organic photoconductor 100 is treated chemically to reduce stress cracking in a liquid toner environment. The charge transport layer is treated with a solvent or other reagent to soften charge transport layer 108 end to render it more stretchable, i.e., more plastic or elastic than it was previously.

[0037] The chemical treatment is selected so as to leave the electrical and optical characteristics of the photoconductor essentially unchanged. When such a chemically treated photoconductor sheet is stretched around drum 10, stress does not develop in charge transport layer 108. Accordingly, when stretched photoconductor 100 is exposed to organic solvents it does not tend to crack.

[0038] A specific chemical treatment which has been found to be effective is dipping of photoconductor 100 in

cyclohexanone diluted by isopropyl alcohol in the ratio 1:5 for 2 minutes. This treatment does not significantly change the electrical and optical characteristics of the photoconductor but eliminates cracking as described above.

[0039] An alternative chemical treatment employs cyclohexanone alone or vinyl modified epoxy 1A24, commercially available from HumiSeal Division of Columbia Chase Corporation of Woodside, NY, diluted 1:20 with cyclohexanone. These materials can be applied by a wire-rod technique on the top surface of photoconductor 100. In such a case, an RK Print-Coat Instrument Ltd. of Litlington, Royston, Merts., UK, Model KCC 303 coater, using bar #2 (rod diameter 13 mm, wire diameter 0.15 mm) may be operated with bar linear speed of 70 mm/sec.

[0040] If pure cyclohexanone is used, then the results are similar to those for dipping, and the solvent evaporates within about 20-30 seconds.

[0041] If the mixture of cyclohexanone and epoxy is used, then in addition to the above described effects of the cyclohexanone, the residual vinyl modified epoxy forms a mechanically protective overcoating which is substantially abhesive to toner particles after the evaporation of the solvent.

[0042] It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the appended claims.

Claims

1. A method of reducing stress related cracking in an organic photoconductor, when the photoconductor is subjected to mechanical stress and used in a liquid toner imaging machine, including the steps of:
 - providing an organic photoconductor (100) having a base layer (102) and a photoconductive layer formed of a charge generating layer (106) and a charge transport layer (108); and
 - chemically treating the charge transport layer (108) in the provided organic photoconductor by contacting it with a solvent or other reagent to soften the charge transport layer and make it more stretchable to reduce stress related cracking in the charge transport layer, without substantially changing the optical and electrical characteristics of the photoconductor.
2. A method according to claim 1 wherein the base layer of the provided organic photoconductor has greater flexibility and stretchability than the charge transport layer
3. A method according to claim 1 or claim 2 wherein

the step of chemically treating includes rendering the charge transport layer more elastic than it previously was.

4. A method according to any of the preceding claims wherein the step of treating includes rendering the charge transport layer more plastic than it previously was. 5
5. A method according to claim 3 or claim 4 wherein the step of chemically treating also includes forming a mechanically protective layer on the charge transport layer. 10
6. A method according to claim 5 wherein said protective material is an vinyl modified epoxy. 15
7. A method according to any of the preceding claims, wherein said step of chemically treating comprises the step of applying an organic solvent to the charge transport layer. 20
8. A method according to any of claims 1-6 wherein said step of chemically treating comprises the steps of: 25

applying of a protective material in an organic solvent to the charge transport layer whereby said solvent causes said charge transport layer to soften and become more-stretchable; and 30

allowing the solvent to evaporate to leave a protective coating on the charge transport layer.
9. A method according to claim 7 or claim 8 wherein said solvent is cyclohexanone. 35
10. An organic photoconductor (100) having a base layer (102) and a photoconductive layer formed of a charge generating layer (106) and a charge transport layer (108) and being obtainable according to the method of any one of the preceding claims. 40
11. A liquid toner electrophotographic apparatus comprising: 45

a drum (10);

an organic photoconductor according to claim 10 disposed on the surface of the drum; means for forming a latent image on the charge transport surface; 50

means for liquid toner development of the latent image on the charge transport surface and

means for transferring the image after development thereof to a final substrate. 55

Patentansprüche

1. Ein Verfahren zum Verringern einer mit Spannungen zusammenhängenden Rissbildung in einem organischen Photoleiter, wenn der Photoleiter einer mechanischen Spannung unterworfen ist und in einer Flüssigtoner-Bilderzeugungsmaschine verwendet wird, wobei das Verfahren folgende Schritte umfasst:

Bereitstellen eines organischen Photoleiters (100), der eine Basisschicht (102) und eine aus einer Ladungserzeugungsschicht (106) und einer Ladungstransportschicht (108) gebildete photoleitende Schicht aufweist; und chemisches Behandeln der Ladungstransportschicht (108) in dem bereitgestellten organischen Photoleiter durch ein Inberührungbringen derselben mit einem Lösungsmittel oder einem anderen Reagens, um die Ladungstransportschicht weich zu machen und sie dehnbarer zu machen, um eine mit Spannungen zusammenhängende Rissbildung in der Ladungstransportschicht zu verringern, ohne die optischen und elektrischen Charakteristika des Photoleiters wesentlich zu verändern.
2. Ein Verfahren gemäß Anspruch 1, bei dem die Basisschicht des bereitgestellten organischen Photoleiters eine größere Flexibilität und Dehnbarkeit aufweist als die Ladungstransportschicht.
3. Ein Verfahren gemäß Anspruch 1 oder 2, bei dem der Schritt des chemischen Behandeln beinhaltet, dass die Ladungstransportschicht elastischer gemacht wird als sie zuvor war.
4. Ein Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem der Schritt des Behandeln umfasst, dass die Ladungstransportschicht plastischer gemacht wird als sie zuvor war.
5. Ein Verfahren gemäß Anspruch 3 oder 4, bei dem der Schritt des chemischen Behandeln ferner ein Bilden einer mechanisch schützenden Schicht auf der Ladungstransportschicht umfasst.
6. Ein Verfahren gemäß Anspruch 5, bei dem das schützende Material ein vinylmodifiziertes Epoxid ist.
7. Ein Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem der Schritt des chemischen Behandeln den Schritt des Aufbringens eines organischen Lösungsmittels auf die Ladungstransportschicht umfasst.
8. Ein Verfahren gemäß einem der Ansprüche 1 bis 6,

bei dem der Schritt des chemischen Behandelns folgende Schritte umfasst:

- Aufbringen eines schützenden Materials in einem organischen Lösungsmittel auf die Ladungstransportschicht, wodurch das Lösungsmittel bewirkt, dass die Ladungstransportschicht weicher und dehnbarer wird; und Ermöglichen, dass das Lösungsmittel verdampft, um eine schützende Beschichtung auf der Ladungstransportschicht zu hinterlassen.
9. Ein Verfahren gemäß Anspruch 7 oder Anspruch 8, bei dem das Lösungsmittel Cyclohexanon ist.
10. Ein organischer Photoleiter (100), der eine Basischicht (102) und eine aus einer Ladungserzeugungsschicht (106) und einer Ladungstransportschicht (108) gebildete photoleitende Schicht aufweist und gemäß dem Verfahren gemäß einem der vorhergehenden Ansprüche erhältlich ist.
11. Eine elektrophotographische Flüssigtonervorrichtung, die folgende Merkmale aufweist:
- eine Trommel (10);
einen organischen Photoleiter gemäß Anspruch 10, der auf der Oberfläche der Trommel angeordnet ist;
eine Einrichtung zum Erzeugen eines latenten Bildes auf der Ladungstransportoberfläche;
eine Einrichtung zur Flüssigtonerentwicklung des latenten Bildes auf der Ladungstransportoberfläche; und
eine Einrichtung zum Transferieren des Bildes an ein Endsubstrat nach einer Entwicklung des Bildes.

Revendications

1. Procédé de réduction de craquelure liée aux contraintes dans un photoconducteur organique, lorsque le photoconducteur est soumis à une contrainte mécanique et utilisé dans une machine de formation d'image en toner liquide, comprenant les étapes consistant à :
- produire un photoconducteur organique (100) ayant une couche de base (102) et une couche photoconductrice formée d'une couche de génération de charge (106) et une couche de transport de charge (108) ; et
traiter chimiquement la couche de transport de charge (108) dans le photoconducteur organique produit en la mettant en contact avec un solvant ou un autre réactif afin d'assouplir la couche de transport de charge et de la rendre plus

étirable pour réduire la craquelure liée aux contraintes dans la couche de transport de charge, sans modifier de manière significative les caractéristiques optique et électrique du photoconducteur.

2. Procédé selon la revendication 1 dans lequel la couche de base du photoconducteur organique produit a une plus grande flexibilité et une meilleure aptitude à l'étirage que la couche de transport de charge.
3. Procédé selon la revendication 1 ou la revendication 2 dans lequel l'étape consistant à traiter chimiquement comprend le fait de rendre la couche de transport de charge plus élastique qu'elle ne l'était précédemment.
4. Procédé selon l'une quelconque des revendications précédentes dans lequel l'étape de traitement comprend le fait de rendre la couche de transport de charge plus plastique qu'elle ne l'était précédemment.
5. Procédé selon la revendication 3 ou la revendication 4 dans lequel l'étape de traitement chimique comprend également la formation d'une couche de protection mécanique sur la couche de transport de charge.
6. Procédé selon la revendication 5 dans lequel ledit matériau de protection est un époxy modifié au vinyle.
7. Procédé selon l'une quelconque des revendications précédentes dans lequel ladite étape de traitement chimique comprend l'étape consistant à appliquer un solvant organique sur la couche de transport de charge.
8. Procédé selon l'une quelconque des revendications 1-6 dans lequel ladite étape de traitement chimique comprend les étapes consistant à :
- appliquer un matériau de protection dans un solvant organique sur la couche de transport de charge ce qui entraîne que ledit solvant amène ladite couche de transport de charge à s'assouplir et à devenir plus étirable ; et
permettre au solvant de s'évaporer pour laisser un revêtement de protection sur la couche de transport de charge.
9. Procédé selon la revendication 7 ou la revendication 8 dans lequel ledit solvant est le cyclohexanone.
10. Photoconducteur organique (100) ayant une couche de base (102) et une couche photoconductrice formée d'une couche de génération de charge (106) et

une couche de transport de charge (108) et pouvant être obtenu selon le procédé de l'une quelconque des revendications précédentes.

11. Appareil électrophotographique à toner liquide 5
comprenant :

un tambour (10) ;
un photoconducteur organique selon la revendication 10, disposé sur la surface du tambour ; 10
des moyens destinés à former une image latente sur la surface de transport de charge ;
des moyens destinés au développement par toner liquide de l'image latente sur la surface de transport de charge ; et 15
des moyens destinés à transférer l'image après le développement de celle-ci vers un substrat final.

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FIG. 1



