

## **【DESCRIPTION】**

### **【Invention Title】**

#### **INTERMEDIATE TRANSFER BELT AND METHOD OF MANUFACTURING THE SAME**

### **5      【Technical Field】**

The present invention relates to an intermediate transfer belt for use in a laser printer, a fax machine, or a copier, and a method of manufacturing the same.

### **【Background Art】**

10            Generally, an intermediate transfer belt for a laser printer, a fax machine, or a copier should have excellent properties of heat dissipation, water repellency, oil repellency, contamination resistance, heat resistance, modulus, releasability from paper, antistatic properties,  
15            and durability.

             Accordingly, in order to realize such an intermediate transfer belt, thorough research into the use of a polyimide compound, which has many advantages, including high heat stability and superior mechanical and electrical  
20            properties, is being conducted. However, this compound is very sensitive to moisture, undesirably reducing the reliability of electrical insulating properties thereof over time, and also, the compound is very difficult to

process due to a high glass transition temperature, and easily becomes electrically charged.

Further, the intermediate transfer belt is required to have volume resistivity suitable for transferring toner.

5 If the transfer belt has volume resistivity lower or higher than required, properties thereof, including antistatic properties, transfer properties, imaging properties, releasability, and contamination resistance, are deteriorated, whereby critical defects, such as poor

10 images, may occur.

When the intermediate transfer belt has a large difference in surface resistivity between the inner surface and the outer surface thereof, it is difficult to control the resistivity of an intended region thereof, and

15 furthermore, volume resistivity varies depending on the portion that is measured, thus making it problematic to operate the intermediate transfer belt at the time of realizing an image. Hence, a conventional process for decreasing the difference in the surface resistivity

20 includes antistatic coating or polishing the inner surface or outer surface of the intermediate transfer belt such that the surface resistivity is adjusted, but is disadvantageous because it is complicated.

Specifically, additional antistatic coating

25 complicates the manufacturing process and increases the manufacturing cost, and as well, causes layer separation

between the antistatic coating layer and the belt or scratching of the coating layer, adversely affecting the quality of an image to be realized.

5 The intermediate transfer belt for a laser printer, a fax machine, or a copier functions to transfer the toner, and thus should be manufactured to be seamless.

Accordingly, with the goal of manufacturing an intermediate transfer belt that is seamless, there is a method of applying a polyamic acid solution on the inner  
10 surface or outer surface of a mold using a dispenser. However, this method suffers because the solution is difficult to uniformly apply on all surfaces of the mold, and should have high viscosity. Further, when the polyamic acid solution is applied on the outer surface of the mold  
15 using a dispenser and external heat is applied thereto, the evaporation of the solvent is impossible, leading to high defect rates.

In addition, with the goal of manufacturing an intermediate transfer belt that is seamless, there is a  
20 wash tub method employing fast rotation to conduct centrifugal molding. However, this method is usable only when the viscosity of the solution is low. Moreover, when the rotational axis of the tub is inclined, it is impossible to manufacture an intermediate transfer belt  
25 having a predetermined thickness. Meanwhile, when the rotational axis of the tub is vertically positioned, there

is a limitation in fast rotation, undesirably resulting in some thickness variation.

### **【Disclosure】**

### **【Technical Problem】**

5           Accordingly, the present invention provides an intermediate transfer belt, which is manufactured from a polyimide compound and has a low difference in surface resistivity between the inner surface and the outer surface thereof, thus exhibiting improved operating properties, and  
10           a method of manufacturing the same.

          In addition, the present invention provides an intermediate transfer belt, which is seamless and has a uniform thickness, and a method of manufacturing the same.

### **【Technical Solution】**

15           According to a first embodiment of the present invention, there is provided a polyimide-based intermediate transfer belt, which is not subjected to additional surface treatment and has a surface resistivity ratio of outer surface resistivity to inner surface resistivity in a range  
20           of  $10^{-2} \sim 10^2$ .

          The intermediate transfer belt according to the first embodiment may have thickness variation of 7% or less, volume resistivity of  $10^5 \sim 10^{12} \Omega\text{cm}$ , and a modulus of 3.0~7.0 GPa.

According to a second embodiment of the present invention, there is provided a method of manufacturing a polyimide-based intermediate transfer belt, comprising applying a polyamic acid solution on the outer surface of a mold using rollers; and subjecting the applied polyamic acid solution to heat treatment for imidization.

In the second embodiment, a number of the rollers may be two or more.

In the second embodiment, the polyamic acid solution may contain 0.5~20 wt% of an electrically conductive filler based on the total amount of a solute.

In the second embodiment, the heat treatment for imidization may be conducted at 60~450°C.

### **【Advantageous Effects】**

As described hereinbefore, the present invention may provide an intermediate transfer belt, which is manufactured from a polyimide compound and has decreased difference in surface resistivity between the inner surface and the outer surface thereof, even without the application of additional treatment, such as antistatic coating, thus realizing improved operating properties, and also provides a method of manufacturing the same.

In addition, the present invention may provide an intermediate transfer belt, which is seamless and has a uniform thickness thanks to the minimization of thickness

variation, and also provides a method of manufacturing the same.

### **[Description of Drawing]**

FIG. 1 is a schematic perspective view illustrating a process of manufacturing an intermediate transfer belt according to the present invention.

\* Description of the Reference Numerals in the Drawing \*

1: 1<sup>st</sup> roller

2: 2<sup>nd</sup> roller

3: mold

4: polyamic acid solution

### **10      [Best Mode]**

Hereinafter, a detailed description will be given of the present invention.

Useful for an intermediate transfer belt of the present invention, polyimide resin is obtained by dissolving dianhydride, diamine, and an electrically  
15      conductive filler in a solvent, thus preparing a polyamic acid solution, which is then applied on the outer surface of a mold using a roller, followed by heat treatment for imidization.

20      When the outer surface resistivity and the inner surface resistivity of the intermediate transfer belt, which is molded but is not subjected to subsequent surface treatment, such as antistatic coating, are measured, the surface resistivity ratio thereof is preferably in the

range of  $10^{-2} \sim 10^2$ . The surface resistivity ratio may be calculated by Equation 1 below:

Equation 1

$$\text{Surface resistivity ratio} = \left| \frac{\text{outer surface resistivity}}{\text{inner surface resistivity}} \right|.$$

When the surface resistivity ratio exceeds  $10^2$ , it is difficult to control the resistivity of an intended region of the intermediate transfer belt, and volume resistivity varies, and thus the belt is difficult to operate at the time of realizing an image. On the other hand, when the surface resistivity ratio is less than  $10^{-2}$ , the outer surface of the belt has low resistivity to applied voltage, and developing fillers, such as toner, are not well fused thereon.

In the intermediate transfer belt satisfying the surface resistivity ratio in the aforementioned range, not only monomers for polyimide resin constituting the intermediate transfer belt, but also the electrically conductive filler, greatly affecting electrical conductivity, are uniformly dispersed. Thus, when applied to a printer or a copier, an intermediate transfer belt may realize good development performance.

Useful for the preparation of the polyimide resin able to provide the intermediate transfer belt having the aforementioned surface resistivity ratio, the diamine is

not particularly limited, as long as it is typically used to prepare polyimide resin, and examples thereof include 4,4'-oxydianiline (ODA), para-phenylene diamine (pPDA), meta-phenylene diamine (mPDA), para-methylene diamine (pMDA), and meta-methylene diamine (mMDA).

The dianhydride is not particularly limited as long as it is typically used to prepare a polyimide resin, and examples thereof include 1,2,4,5-benzene tetracarboxylic dianhydride (pyromellitic acid dianhydride, PMDA), 3,3,4,4-benzophenone tetracarboxylic dianhydride (BTDA), 3,3,4,4-biphenyl tetracarboxylic dianhydride (BPDA), and 4,4-oxydiphthalic dianhydride.

When the polyimide resin is prepared, the diamine and the dianhydride may be used in equivalent molar amounts.

The solvent may be selected from among highly polar aprotic solvents, such as N,N-dimethylformamide (DMF), dimethylacetamide (DMAc), and N-methylpyrrolidinone (NMP).

Further, the electrically conductive filler, which functions to control the volume resistivity of the intermediate transfer belt, is added when the polyamic acid solution is prepared. As the electrically conductive filler, one or a mixture of two or more selected from among Ketjen black, acetylene black, furnace black, or conductive or semi-conductive powder, including metal such as aluminum or nickel, metal oxide such as tin oxide, or potassium titanate, or conductive polymers, such as polyaniline or

polyacetylene, may be used in an amount of 0.5~35 wt% based on the total amount of a solute, in order to attain desired electrical conductivity. As such, a metal filler may be additionally contained in an amount of 0.1~5 wt% based on  
5 the total amount of a solute.

The method of dispersing the electrically conductive filler is not particularly limited, and the use of an ultrasonic homogenizer, enabling efficient dispersion, is preferable.

10 Used in the present invention, a dispersion stabilizer is a polymer dispersant, examples thereof including poly-N-vinyl formamide, poly-N-vinyl acetamide, poly-N-vinyl pyrrolidone, and poly-N-vinyl caprolactam. The dispersant may be variously used depending on the type of  
15 dispersion solution.

The reaction for the preparation of the polyamic acid solution to obtain the polyimide resin is conducted at 0~60°C for 0.5~12 hours.

The polyamic acid solution thus prepared is applied  
20 on the outer surface of a mold using rollers, and is then subjected to heat treatment for imidization, thereby obtaining a polyimide-based intermediate transfer belt.

In the present invention, two or more rollers are used to manufacture the intermediate transfer belt having  
25 the aforementioned surface resistivity ratio. In this regard, a description is given in greater detail with

reference to the appended drawing.

FIG. 1 is a schematic perspective view illustrating the process of manufacturing the intermediate transfer belt according to the present invention.

5           In the present invention, a polyamic acid solution 4 is applied on the outer surface of a mold 3 using rollers 1, 2, and is then subjected to heat treatment for imidization, thereby manufacturing an intermediate transfer belt.

10           The rollers 1, 2 are located parallel to the mold 3, and two rollers 1, 2 and the mold 3 are rotated in a state in which they are engaged with each other.

          Specifically, when the first roller 1 is rotated in a clockwise direction, the second roller 2 is rotated in a counterclockwise direction and the mold 3 is rotated in a clockwise direction. At this time, the first roller 1 is brought into contact with the polyamic acid solution 4. So, while the first roller 1 is rotated, the polyamic acid solution 4 is applied on the first roller 1, and the applied solution 4 is sequentially applied on the second roller 2, which is rotated in a state of being brought into contact with the first roller 1. Subsequently, the solution 4 is applied on the outer surface of the mold 3, which is rotated in a state of being brought into contact with the second roller 2. In this way, the polyamic acid solution 4 is applied on the mold 3 through a plurality of rollers 1,

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2, thereby adjusting the amount and thickness of the polyamic acid solution that is applied. The polyamic acid solution 4 is applied such that an intermediate transfer belt formed on the mold 3 through heat treatment is 40~200  
5  $\mu\text{m}$  thick. The thickness variation is preferably 7% or less. In the case where the thickness variation exceeds 7%, the polyamic acid solution 4 is imidized, and then the thickness variation of the film is increased, undesirably deteriorating the development performance of the  
10 intermediate transfer belt.

If the rollers 1, 2 and the mold 3 are not parallel to each other, the solution 4 is intensively applied toward the wider sides of the gaps between the first roller 1 and the second roller 2 and between the second roller 2 and the  
15 mold 3, resulting in considerably non-uniform application thickness, and also, it is difficult to efficiently rotate the rollers and the mold with each other. Thus, it is very important for the rollers and the mold to be located parallel to each other.

20 In the case where the rotation speed and the rotation time of the rollers 1, 2 and the mold 3 are not adjusted, the polyamic acid solution 4 is intensively applied between the first roller 1 and the second roller 2, and thus may not be applied on the mold 3, and also, the thickness  
25 variation may be increased. So, it should be noted that the rotation speed and the rotation time can be adjusted. In

consideration thereof, the rotation speed of the rollers 1, 2 and the mold 3 is set to 50~200 rpm, and the rotation time is set to 1~4 hours.

5 The mold 3 may be formed of alumina, stainless steel, or Teflon, and the size thereof is not particularly limited, but has a length of 200~300 mm and an inner diameter of 100~150 mm.

10 The polyamic acid solution 4, which is applied on the mold 3, is subjected to stepwise heat treatment and is then separated from the mold 3, thus manufacturing the polyimide-based intermediate transfer belt. The stepwise heat treatment may be conducted using an IR heater, an electrical furnace, or a hot air oven, and includes pre-baking at 50~100°C to primarily remove the solvent and  
15 moisture from the surface of the belt and then final post-curing at 350~400°C at a heating rate of 2~10°C per minute to completely remove the solvent and moisture from the surface and the inside of the belt such that imidization progresses, thereby completing a solidified film.  
20 Alternatively, after the pre-baking is conducted, the belt may be separated from the mold, turned inside out, fitted on a mold having a smaller size, and post-cured, as necessary.

25 In the case where the intermediate transfer belt is manufactured through the above method, the rotation of the mold 3 for adjusting the thickness of the intermediate

transfer belt is minimized, thereby decreasing the thickness variation and reducing the difference in surface resistivity between the outer surface and the inner surface of the intermediate transfer belt.

5           In a state in which the polyamic acid solution 4 applied on the mold 3 is molded and subsequent surface treatment, such as antistatic coating, is not conducted, the surface resistivity ratio of the outer surface resistivity to the inner surface resistivity is in the  
10   range of  $10^{-2} \sim 10^2$ , and also, the thickness variation is 7% or less, thus realizing an intermediate transfer belt exhibiting superior insulating properties and development performance.

          Although the preferred embodiments of the present  
15   invention have been disclosed for illustrative purposes in conjunction with the drawing, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the spirit of the invention.

20           The intermediate transfer belt thus obtained has volume resistivity of  $10^5 \sim 10^{12} \Omega\text{cm}$ , which is classified as a medium intrinsic resistivity value, resulting in an intermediate transfer belt for use in a laser printer, a fax machine, or a copier, which has improved antistatic  
25   properties and printability and is semi-conductive.

          The transfer belt of the present invention has a

modulus of 3.0~7.0 GPa, and preferably 3.2~5.0 GPa. When the modulus is low, the intermediate transfer belt may be mechanically deformed upon extended use. On the other hand, when the modulus is high, the intermediate transfer belt is stiff and difficult to mold.

### **【Mode for Invention】**

A better understanding of the present invention may be obtained through the following examples, which are set forth to illustrate, but are not to be construed as the limit of the present invention.

#### **<Example 1>**

While nitrogen was introduced into a four-neck flask equipped with a mechanical stirrer, a reflux condenser, and a nitrogen inlet, 3.36 g of Ketjen black was added to 1007 g of DMF and dispersed using an ultrasonic homogenizer, after which 118 g of BPDA and 80 g of ODA were added thereto and dispersed using an ultrasonic homogenizer. The dispersion solution was reacted at room temperature, thus preparing a polyamic acid solution containing electrically conductive filler. The viscosity of the solution was 1950 poise at 23°C.

Thereafter, the polyamic acid solution was applied on the outer surface of a cylindrical mold as shown in FIG. 1, pre-baked at 80°C to primarily remove the solvent and moisture from the surface of the belt, and finally post-

cured at 350°C at a heating rate of 5°C per minute to completely remove the solvent and moisture from the surface and the inside of the belt, thus manufacturing a polyimide-based intermediate transfer belt which is seamless and contains electrically conductive filler. The thickness of the belt thus manufactured was 65 μm.

#### <Example 2>

A polyamic acid solution was prepared, applied on the mold, and then pre-baked, in the same manner as in Example 1, after the resultant belt was separated from the mold, turned inside out, fitted on a mold having an inner diameter 4% smaller than that of the mold used in Example 1, and post-cured, thus manufacturing a polyimide-based intermediate transfer belt. The thickness of the belt thus manufactured was 63 μm.

#### <Comparative Example 1>

While nitrogen was introduced into a four-neck flask equipped with a mechanical stirrer, a reflux condenser, and a nitrogen inlet, 3.36 g of Ketjen black was added to 1007 g of DMF and dispersed using an ultrasonic homogenizer, after which 118 g of BPDA and 80 g of ODA were added thereto and dispersed using an ultrasonic homogenizer. The dispersion solution was reacted at room temperature, thus preparing a polyamic acid solution containing electrically

conductive filler. The viscosity of the solution was 1840 poise at 24°C.

Thereafter, the polyamic acid solution was applied on the inner surface of a cylinder having an inner diameter of 120 mm and a length of 250 mm, rotated at 1200 rpm for 20 min, treated under the same conditions as Example 1 to remove the solvent, and post-cured, thus manufacturing a polyimide-based intermediate transfer belt. The thickness of the belt thus manufactured was 71 µm.

#### <Comparative Example 2>

A polyamic acid solution was prepared as in Comparative Example 1, loaded into a cylindrical Teflon mold having a double structure comprising an outer cylinder and an inner cylinder, and pre-baked at 80°C to primarily remove the solvent and moisture from the surface of the belt, after which the inner cylinder was removed from the outer cylinder.

Thereafter, final post-curing was conducted at 350°C at a heating rate of 5°C per minute, thus manufacturing a polyimide-based intermediate transfer belt. The thickness of the belt thus manufactured was 68 µm.

The properties of the intermediate transfer belts manufactured in the examples and comparative examples were evaluated through the following methods. The results are

shown in Table 1 below.

#### (1) Surface Resistivity Ratio

Voltage was continuously applied to the sample and measurement was conducted using a resistivity meter (HIRESTA UP), available from Mitsubishi Chemical. The voltage applied to the sample was 100 V. The surface resistivity was measured in a manner such that the sample was placed on a substrate formed of a fluorinated polymer having high insulating properties, and the inner surface resistivity and the outer surface resistivity of the sample were separately measured at intervals of 10 sec. As such, a ring probe was used. The size of the sample used for measuring the surface resistivity was 20 cm × 20 cm, and 10 measurements were conducted on the corresponding surface and averaged. The obtained values were substituted into Equation 1 below, thus calculating the surface resistivity ratio.

Equation 1

$$\text{Surface resistivity ratio} = \left| \frac{\text{outer surface resistivity}}{\text{inner surface resistivity}} \right|$$

#### (2) Volume Resistivity

Voltage was continuously applied to the sample and measurement was conducted using a resistivity meter (HIRESTA UP), available from Mitsubishi Chemical. As such, the voltage applied to the sample was 100 V. The volume resistivity was measured in a manner such that the sample

was placed on a metal substrate, and the volume resistivity thereof was measured at intervals of 10 sec using a ring probe. The size of the sample used for measuring the volume resistivity was 20 cm × 20 cm, and 10 measurements were conducted and averaged.

### (3) Modulus

The modulus of the intermediate transfer belt was measured according to ASTM D882 using a universal testing machine, Model 1000, available from Instron.

### (4) Thickness and Thickness Variation

The sample was dried at 100°C for 1 hour, and the thickness thereof was measured using a micrometer (Anritus, Electronic micrometer). The thickness of the sample was determined by conducting 50 measurements and averaging the measured values other than the maximum and the minimum. The thickness variation was determined according to a general thickness variation equation, and was represented by %.

### (5) Development performance

Each of the intermediate transfer belts manufactured in the examples and comparative examples was applied to a transfer unit and then connected to a color laser printer, after which the same image was repeatedly transferred. The state of the developed paper image was determined by checking the number of defects. Upon 1000 developments, the case where the number of defects was 10 or less was indicated as "very good", the case where the number of

defects exceeded 10 but was 30 or less was indicated as “good”, the case where the number of defects exceeded 30 but was 50 or less was indicated as “fair”, the case where the number of defects exceeded 50 but was 100 or less was indicated as “poor”, and the case where the number of defects exceeded 100 was indicated as “very poor”.

TABLE 1

|        | Surface Resistivity Ratio | Volume Resistivity ( $\Omega\text{cm}$ ) | Modulus (GPa) | Thick. ( $\mu\text{m}$ ) | Thick. Variation (%) | Development Performance |
|--------|---------------------------|------------------------------------------|---------------|--------------------------|----------------------|-------------------------|
| Ex.1   | 4.23                      | $1.75 \times 10^9$                       | 3.65          | 65                       | 3.5                  | Very Good               |
| Ex.2   | 2.17                      | $1.62 \times 10^9$                       | 3.7           | 63                       | 3.5                  | Very Good               |
| C.Ex.1 | 253.3                     | $2.73 \times 10^9$                       | 3.5           | 71                       | 7.9                  | Good                    |
| C.Ex.2 | 1527.3                    | $2.55 \times 10^9$                       | 3.41          | 68                       | 9.2                  | Fair                    |

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As is apparent from the results of measurement of the properties, the intermediate transfer belts of the examples manufactured through the manufacturing method of the present invention had a surface resistivity ratio of 4.23 and 2.17, and thus, the difference in the surface resistivity between the inner surface and the outer surface thereof was very low, from which the filler could be confirmed to be uniformly dispersed. Further, because the thickness variation was 7% or less, the intermediate transfer belt of the present invention had a relatively uniform thickness and thus exhibited good development performance.

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However, the intermediate transfer belts of the

comparative examples had a surface resistivity ratio of  $10^2$  or more, and thus, the difference in the surface resistivity between the inner surface and the outer surface thereof was large, and the thickness variation exceeded 7%,  
5 resulting in deteriorated development performance.

## **【CLAIMS】**

### **【Claim 1】**

A polyimide-based intermediate transfer belt, which is not subjected to additional surface treatment, comprises  
5 electrically conductive filler and has a surface resistivity ratio of outer surface resistivity to inner surface resistivity in a range of  $10^{-2} \sim 10^2$ , according to Equation 1 below:

Equation 1

10            Surface resistivity ratio =  $\left| \frac{\text{outer surface resistivity}}{\text{inner surface resistivity}} \right|$ .

### **【Claim 2】**

The intermediate transfer belt according to claim 1, which has thickness variation of 7% or less.

### **【Claim 3】**

15            The intermediate transfer belt according to claim 1, which has volume resistivity of  $10^5 \sim 10^{12} \Omega\text{cm}$ .

### **【Claim 4】**

20            The intermediate transfer belt according to claim 1, which has a modulus of 3.0~7.0 GPa.

### **【Claim 5】**

A method of manufacturing a polyimide-based intermediate transfer belt, comprising:

applying a polyamic acid solution on an outer surface of a mold using rollers; and

subjecting the applied polyamic acid solution to heat treatment for imidization.

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**【Claim 6】**

The method according to claim 5, wherein a number of the rollers is two or more.

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**【Claim 7】**

The method according to claim 5, wherein the polyamic acid solution contains 0.5~35 wt% of an electrically conductive filler based on a total amount of a solute.

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**【Claim 8】**

The method according to claim 5, wherein the heat treatment for imidization is conducted at 50~400°C.