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(54) **PRINTING METHOD AND PRINTING APPARATUS**

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(52) **U.S. Cl.**
CPC ***B41J 11/0015*** (2013.01); ***B41J 11/002*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0270351 A1 12/2005 Mouri et al.
2009/0153613 A1 6/2009 Yamanobe
2010/0079524 A1* 4/2010 Saita H04N 1/6033 347/14
2013/0201252 A1* 8/2013 Namba C09D 5/00 347/21
2015/0224787 A1 8/2015 Ohtsuka

FOREIGN PATENT DOCUMENTS

JP 2005-343049 12/2005
JP 2012-106350 6/2012
JP 05-103154 10/2012
JP 2014-083789 5/2014

OTHER PUBLICATIONS

Ohtsuka S., Printing Method Used for Printing Character . . . and Dye Ink on To-Be-Printed Product, May 1, 2014, Japan.*

* cited by examiner

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(57) **ABSTRACT**

A printing method uses a reaction liquid containing an aggregating agent capable of causing the aggregation of a color material. This printing method includes: applying a first reaction liquid to a recording medium; applying a background color ink that contains a color material for a background color to a region of the recording medium which is coated with the first reaction liquid; drying the recording medium coated with the background color ink by heating the recording medium; applying a second reaction liquid to a region of the dried recording medium which is coated with the background color ink; and applying an image forming ink that contains a color material having a color different from that of the background color ink to a region of the recording medium which is coated with the second reaction liquid.

3 Claims, 5 Drawing Sheets

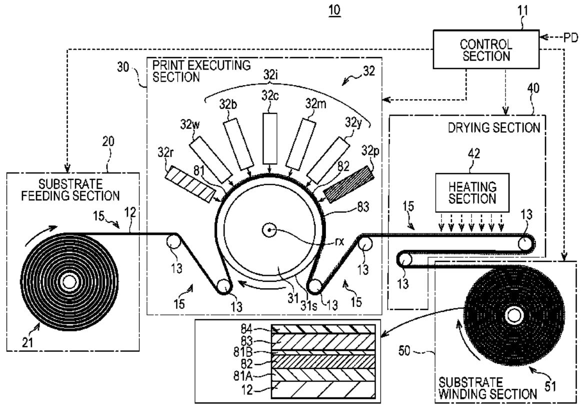
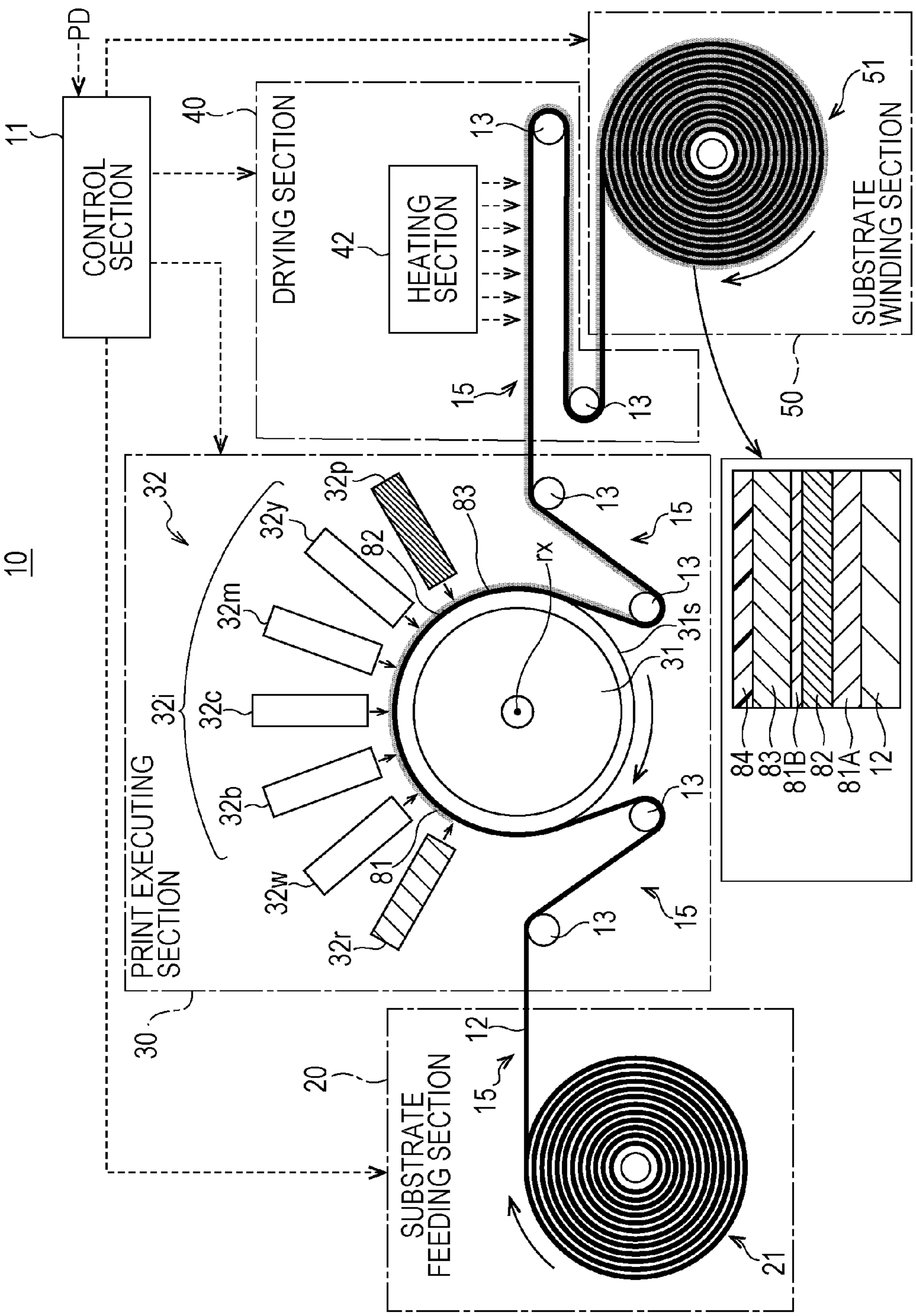


FIG. 1



10
PD
11
CONTROL SECTION
40
DRYING SECTION
42
HEATING SECTION
13
15
51
SUBSTRATE WINDING SECTION
50
30
PRINT EXECUTING SECTION
32
32p
32y
32m
32c
32i
32b
32w
32r
81
82
83
rx
31
31s
84
81B
81A
12
20
SUBSTRATE FEEDING SECTION
21

FIG. 2

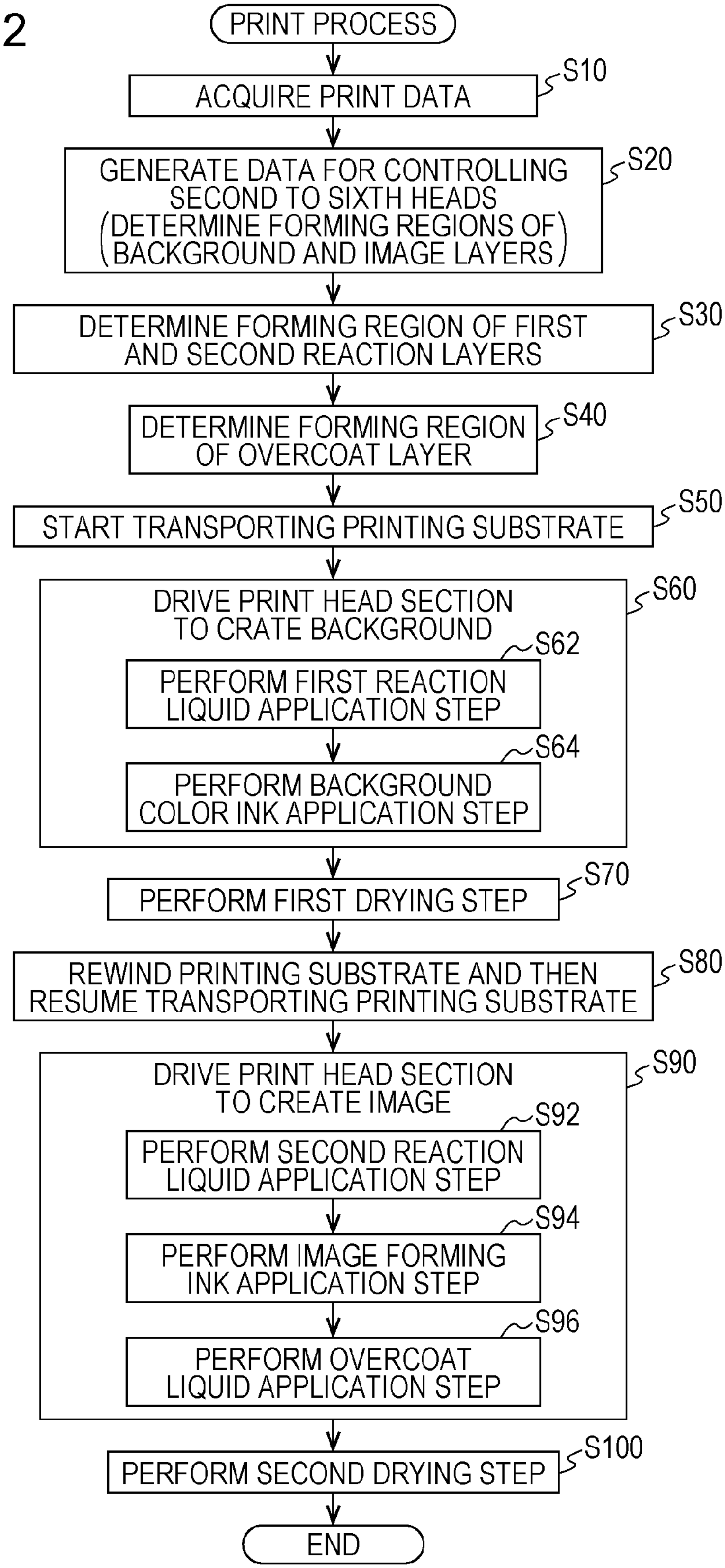

PRINT PROCESS
ACQUIRE PRINT DATA
S10
GENERATE DATA FOR CONTROLLING SECOND TO SIXTH HEADS (DETERMINE FORMING REGIONS OF BACKGROUND AND IMAGE LAYERS)
S20
DETERMINE FORMING REGION OF FIRST AND SECOND REACTION LAYERS
S30
DETERMINE FORMING REGION OF OVERCOAT LAYER
S40
START TRANSPORTING PRINTING SUBSTRATE
S50
DRIVE PRINT HEAD SECTION TO CRATE BACKGROUND
S60
PERFORM FIRST REACTION LIQUID APPLICATION STEP
S62
PERFORM BACKGROUND COLOR INK APPLICATION STEP
S64
PERFORM FIRST DRYING STEP
S70
REWIND PRINTING SUBSTRATE AND THEN RESUME TRANSPORTING PRINTING SUBSTRATE
S80
DRIVE PRINT HEAD SECTION TO CREATE IMAGE
S90
PERFORM SECOND REACTION LIQUID APPLICATION STEP
S92
PERFORM IMAGE FORMING INK APPLICATION STEP
S94
PERFORM OVERCOAT LIQUID APPLICATION STEP
S96
PERFORM SECOND DRYING STEP
S100
END

FIG. 3

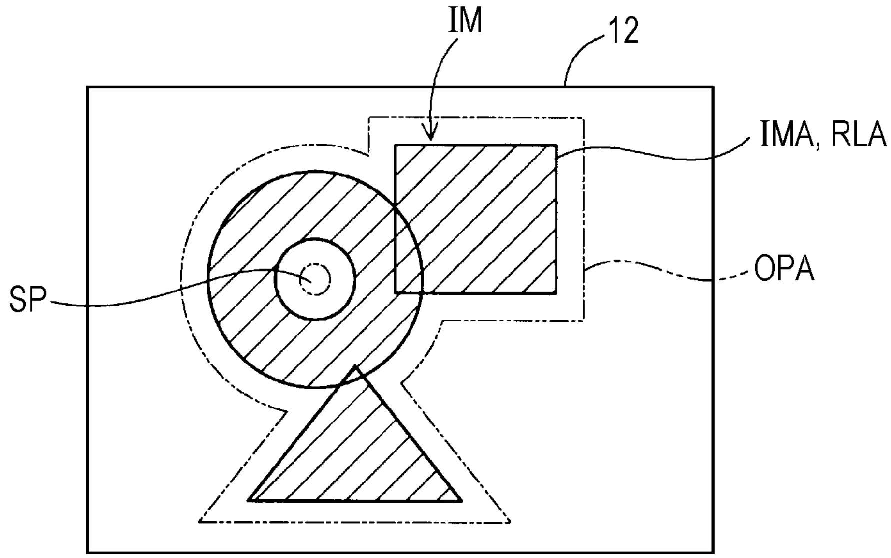


FIG. 4

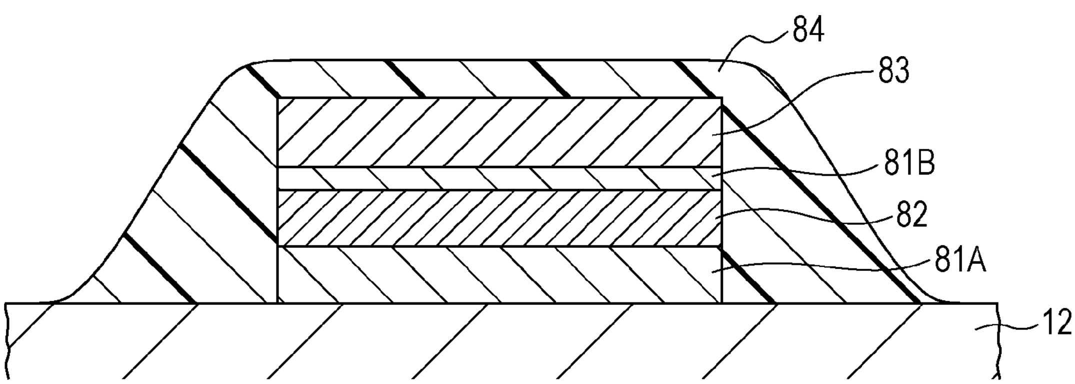


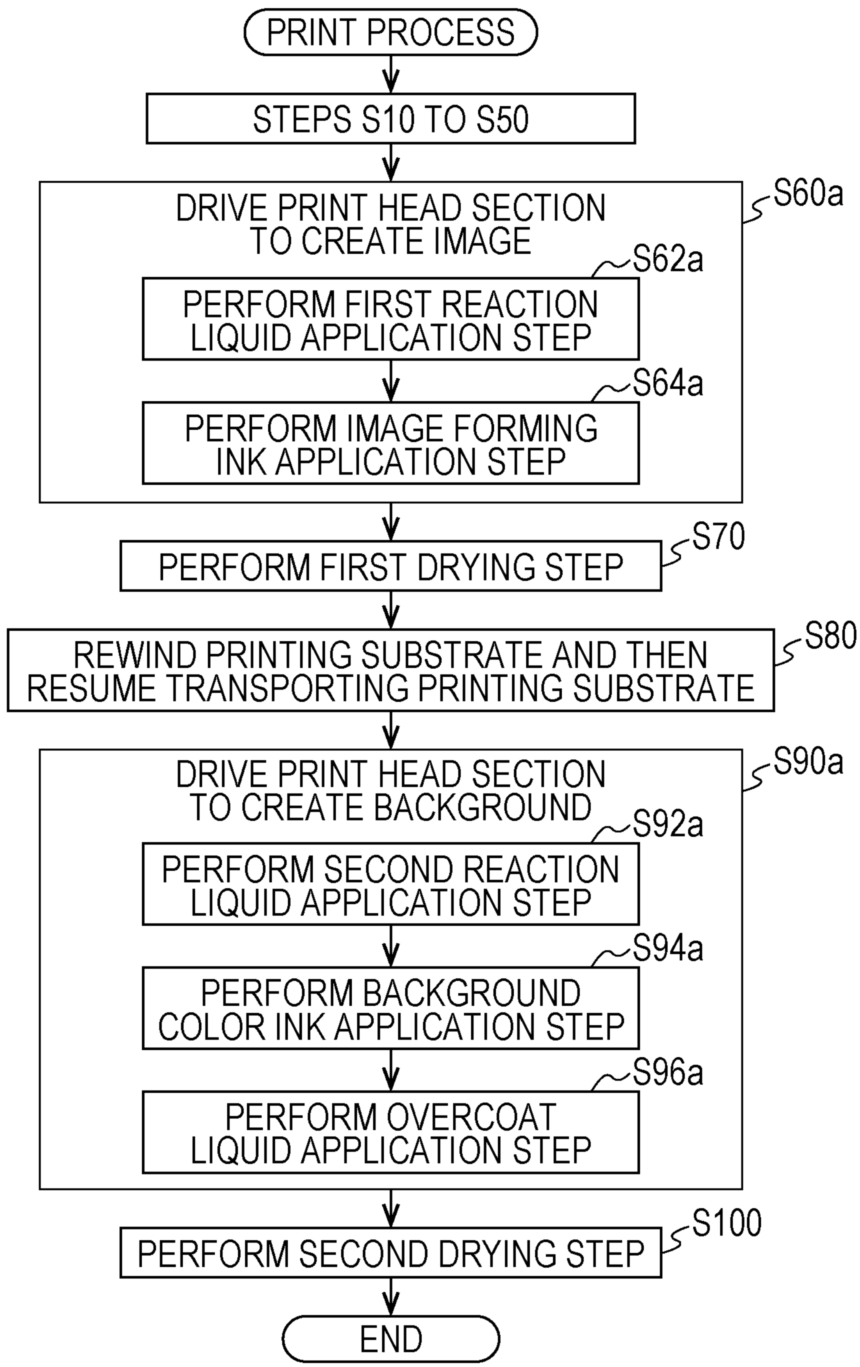
FIG. 5

STEP	NECESSARY QUANTITY (mg/in^2)
S62	1.3
S64	13.5
S92	0.2
S94	7.2
S96	3.6
S100	–
TOTAL LIQUID QUANTITY	25.8

FIG. 6

STEP	NECESSARY QUANTITY (mg/in^2)
S62	1.3
S64	13.5
S70	–
S92	0.43
S94	7.2
S96	1.33
S100	–
TOTAL LIQUID QUANTITY	23.76

FIG. 7


PRINT PROCESS
STEPS S10 TO S50
DRIVE PRINT HEAD SECTION TO CREATE IMAGE
S60a
S62a
PERFORM FIRST REACTION LIQUID APPLICATION STEP
S64a
PERFORM IMAGE FORMING INK APPLICATION STEP
PERFORM FIRST DRYING STEP
S70
REWIND PRINTING SUBSTRATE AND THEN RESUME TRANSPORTING PRINTING SUBSTRATE
S80
DRIVE PRINT HEAD SECTION TO CREATE BACKGROUND
S90a
S92a
PERFORM SECOND REACTION LIQUID APPLICATION STEP
S94a
PERFORM BACKGROUND COLOR INK APPLICATION STEP
S96a
PERFORM OVERCOAT LIQUID APPLICATION STEP
PERFORM SECOND DRYING STEP
S100
END

PRINTING METHOD AND PRINTING APPARATUS

BACKGROUND

1. Technical Field

The present invention relates to a printing method and a printing apparatus for use in printing images on recording media.

2. Related Art

In one known printing technology, a reaction liquid is applied to a recording medium and then color-material-containing inks are applied to the reaction liquid. The reaction liquid causes the aggregation of the color materials, helping the fixing of these color materials to the recording medium. In another known printing technology, called a "background color precoat printing method," a white ink for use in creating a background is applied to a recording medium and then color inks or other image forming inks are applied to areas of the recording medium which are coated with the white ink. If these technologies are combined, a reaction liquid is applied to a recording medium, then a white ink to the reaction liquid, and image forming inks to the white ink. In this case, a large quantity of white ink is applied to the entire surface of the recording medium in order to create the background of the image. Also, a large quantity of reaction liquid is applied in order to aggregate the white ink. Therefore, just before the image forming inks are applied, large quantities of liquids are present over the recording medium. If the image forming inks are applied to this recording medium, the image forming inks may bleed.

For example JP-A-2014-83789 describes a printing technology in which a reaction liquid is applied separately to a recording medium before a white ink is applied and before image forming inks are applied.

The technology described in JP-A-2014-83789 can decrease the quantity of the reaction liquid applied before the application of the image forming inks. However, a large quantity of reaction liquid is still needed, because the white ink is applied to the entire surface of the recording medium, in which case the image forming inks may also bleed.

The disadvantage described above commonly lies in printing technologies that use a background color ink containing a color material for a background, image forming inks for an image, and a reaction liquid. For example even if a printing method called a "background color postcoat printing method," in which image forming inks are applied to a recording medium and then a background color ink is applied to areas of the recording medium which are coated with the image forming inks is employed, a similar disadvantage may also arise. More specifically, when almost an entire surface of the recording medium is coated with image forming inks or when image forming inks that involve using a large quantity of reaction liquid for aggregation is used, for example, the background color ink may bleed.

SUMMARY

An advantage of some aspects of the invention is that a printing method and a printing apparatus capable of addressing at least a part of the above disadvantages are provided. The printing method and the printing apparatus can be embodied by aspects that will be described below.

A first aspect of the invention provides a printing method that uses a reaction liquid containing an aggregating agent capable of causing aggregation of a color material. This printing method includes: applying a first reaction liquid to a recording medium; applying a background color ink to a region of the recording medium which is coated with the first reaction liquid, the background color ink containing a color material for a background color; drying the recording medium coated with the background color ink by heating the recording medium; applying a second reaction liquid to a region of the dried recording medium which is coated with the background color ink; and applying an image forming ink to a region of the recording medium which is coated with the second reaction liquid, the image forming ink containing a color material having a color different from that of the background color ink.

According to the printing method of the first aspect, the background color ink is applied to the recording medium, and then the recording medium is dried. The image forming ink is thereby applied to the recording medium after extra moisture in the background color ink has been evaporated. This can reduce bleeding of the image forming ink.

The printing method of the first aspect may further include applying an overcoat liquid to a region of the recording medium which is coated with the first and second reaction liquids after the applying of the image forming ink.

According to the printing method described above, applying the overcoat liquid can reduce the risk that the first or second reaction liquid contacts air, especially moisture contained in air. Therefore, if a printed material is produced by this printing method, the printed material is less likely to cause disadvantages that could be attributed to the first or second reaction liquid, such as giving off a rank odor or exhibiting an adhesion property due to deliquescence of the first or second reaction liquid. In addition, this printing method allows for printing with a small total quantity of liquids.

In the printing method of the above aspect, the overcoat liquid may be applied so as to cover the region of the recording medium which is coated with the first and second reaction liquids.

According to the printing method described above, applying the overcoat liquid in the above manner can further reduce the risk that the first or second reaction liquid contacts air.

A second aspect of the invention provides a printing method that uses a reaction liquid containing an aggregating agent capable of causing aggregation of a color material. This printing method includes: applying a first reaction liquid to a recording medium; applying an image forming ink to a region of the recording medium which is coated with the first reaction liquid, the image forming ink containing a color material for use in creating an image; drying the recording medium coated with the image forming ink by heating the recording medium; applying a second reaction liquid to a region of the dried recording medium which is coated with the image forming ink; and applying a background color ink to a region of the recording medium which is coated with the second reaction liquid, the background color ink containing a color material for a background color which has a color different from the color material of the image forming ink.

According to the printing method of the second aspect, the image forming ink is applied to the recording medium, and then the recording medium is dried. The background color ink is thereby applied to the recording medium after extra moisture in the image forming ink has been evaporated. This can reduce bleeding of the background color ink.

A third aspect of the invention provides a printing apparatus that includes a reaction liquid application section that applies a reaction liquid to a recording medium, the reaction liquid containing an aggregating agent capable of causing aggregation of a color material. A background color ink application section applies a background color ink to the recording medium, the background color ink containing a color material for a background color. An image forming ink application section applies an image forming ink to the recording medium, the image forming ink containing a color material having a color different from that of the background color ink. A drying section dries the recording medium by heating the recording medium. Further, the reaction liquid application section applies a first reaction liquid to the recording medium. The background color ink application section applies the background color ink to a region of the recording medium which is coated with the first reaction liquid. After the applying of the background color ink, the drying section dries the recording medium by heating the recording medium. The reaction liquid application section applies a second reaction liquid to a region of the dried recording medium which is coated with the background color ink. The image forming ink application section applies the image forming ink to a region of the recording medium which is coated with the second reaction liquid.

According to the printing apparatus of the third aspect, the background color ink is applied to the recording medium, and then the recording medium is dried by the drying section. The reaction liquid as the second reaction liquid and the image forming ink are thereby applied to the recording medium after extra moisture in the background color ink has been evaporated. This can reduce bleeding of the image forming ink.

The printing apparatus of the third aspect may further include a transport section that can transport the recording medium in a first direction and a second direction, the first and second directions being opposite to each other. The recording medium may be coated with both the first reaction liquid and the background color ink and dried by the drying section while being transported in the first direction by the transport section. Then, the recording medium may be transported in the second direction by the transport section. The recording medium may subsequently be coated with the second reaction liquid and the image forming ink while being transported in the first direction by the transport section.

According to the printing apparatus of the third aspect, the recording medium is coated with the first reaction liquid and the background color ink, dried, and coated with the second reaction liquid and the image forming ink while being transported in the first direction by the transport section.

The printing apparatus of the third aspect may further include an overcoat liquid application section that applies an overcoat liquid to a region of the recording medium which is coated with the first and second reaction liquids.

According to the printing apparatus described above, applying the overcoat liquid can reduce the risk that the first or second reaction liquid contacts air, especially moisture contained in air. Therefore, if this printing apparatus produces a printed material, the printed material is less likely to cause disadvantages that could be attributed to the first or second reaction liquid, such as giving off a rank odor or exhibiting an adhesion property due to deliquescence of the first or second reaction liquid.

The invention can be implemented in various forms, including a printing method and a printing apparatus. For example the invention can be implemented using a print system including the printing apparatus, a method of controlling the printing apparatus or the printing system, a computer program for use in performing the control method, a nonvolatile recording medium that stores the computer program, or a printed material produced by the printing apparatus or the printing method.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

FIG. **1** schematically illustrates a configuration of a printing apparatus in a first embodiment of the invention.

FIG. **2** is a flowchart of a print process performed by the control section.

FIG. **3** schematically illustrates the forming regions of the individual layers.

FIG. **4** illustrates a layered structure of the printing substrate that has been subjected to Step S**100**.

FIG. **5** is a table of a reference example to be used to explain an effect of the first embodiment.

FIG. **6** is a table of an example in the first embodiment to be used to explain the effect of the first embodiment.

FIG. **7** is a flowchart of a print process in a second embodiment of the invention.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

First Embodiment

FIG. **1** schematically illustrates a configuration of a printing apparatus **10** in a first embodiment of the invention. In FIG. **1**, the three arrows indicate a forward rotational direction of a substrate roller **21**, a rotating drum **31**, and a winding roller **51**. The printing apparatus **10** in the first embodiment is an ink jet line printer that creates images by ejecting ink droplets onto a printing substrate **12** as a recording medium. Specifically, the printing apparatus **10** sequentially prints images on the printing substrate **12** transported in a longitudinal direction of the printing apparatus **10**. The printing substrate **12** in the first embodiment may be a transparent film. The printing apparatus **10** performs a print process for creating a background image that is to be a background and a normal image, such as a color image, over the printing substrate **12**. More specifically, the printing apparatus **10** stacks a first reaction layer **81**A, a background layer **82**, a second reaction layer **81**B, an image layer **83** and an overcoat layer **84** over the printing substrate **12** in this order. In short, this printing apparatus **10** performs a background color precoat printing method in which the background layer **82** and the image layer **83** are formed in this order.

The printing substrate **12** will be used as wrapping films for goods. The print surface of the printing substrate **12** exhibits low ink absorption. To help the fixing of ink droplets to the printing substrate **12**, the printing apparatus **10** applies a reaction liquid containing an aggregating agent to the surface of the printing substrate **12** before ejecting ink droplets thereto. However, this printing method is not limiting, and the printing apparatus **10** may conform to another printing method. Examples of the printing substrate **12** include glossy paper, coated paper, OHP films, and other substrates. Alternatively, the printing substrate **12** may be an arbitrary substrate having high liquid absorption, such as plain paper, Japanese paper, or ink jet printing paper.

The printing apparatus **10** includes a control section **11**, a plurality of transport rollers **13**, a substrate feeding section **20**, a print executing section **30**, a drying section **40**, and a substrate winding section **50**. The control section **11** implemented using a microcomputer including a CPU and a main memory can control individual sections in the printing apparatus **10**. The control section **11** acquires print data PD from an external computer or device to which the printing apparatus **10** is connected and performs the print process based on the print data PD in response to a user's instruction. The print data PD as image data may be document data on text and figures laid out, raster data on picture images, or image data created by various application programs, for example.

The plurality of transport rollers **13** constitute a transport route **15** through which the printing apparatus **10** transports the printing substrate **12** along its long side. These transport rollers **13** are placed within the printing apparatus **10** at appropriate positions such that the substrate feeding section **20**, the print executing section **30**, the drying section **40**, and the substrate winding section **50** are arranged along the transport route **15**. In this case, the substrate feeding section **20** is positioned on the "upstream side" of the transport route **15**; the substrate winding section **50** is positioned on the "downstream side" of the transport route **15**. Each transport roller **13** supports the printing substrate **12** along width direction of the printing substrate **12**. Herein, the transport route **15** corresponds to a "transport section."

The substrate feeding section **20** is provided with the substrate roller **21** around which the printing substrate **12** is wound in roll form. The substrate roller **21** is rotated at a predetermined rotational speed by a motor (not illustrated) that the control section **11** controls, feeding the printing substrate **12** to the print executing section **30**. In addition, the substrate feeding section **20** has a function of winding the printing substrate **12** that has been fed by the substrate winding section **50** and passed through the rotating drum **31**. In short, in response to an instruction from the control section **11**, the substrate roller **21** can rotate in the forward direction, transporting the printing substrate **12** from the upstream side to the downstream side, and can rotate in the reverse direction, transporting the printing substrate **12** from the downstream side to the upstream side. The print executing section **30** is provided with the rotating drum **31** and a print head section **32** and creates print images over the print surface of the printing substrate **12**.

The rotating drum **31** is rotated at a predetermined rotational speed by a motor (not illustrated) that the control section **11** controls. The rotating drum **31** has a circumferential surface **31***s* with which the surface of the printing substrate **12** opposite the print surface makes surface contact, and transports the printing substrate **12** while supporting the printing substrate **12** with the circumferential surface **31***s*. Thus, the rotating drum **31** forms a part of the transport route **15**. The transport rollers **13** are disposed both upstream and downstream of the rotating drum **31** so that a tension is applied to the printing substrate **12** on the circumferential surface **31***s* of the rotating drum **31**. In response to an instruction from the control section **11**, the rotating drum **31** can rotate in the forward direction, transporting the printing substrate **12** from the upstream side to the downstream side, and can rotate in the reverse direction, transporting the printing substrate **12** from the downstream side to the upstream side.

The print head section **32** has first to seventh liquid ejecting heads **32***r*, **32***w*, **32***b*, **32***c*, **32***m*, **32***y*, and **32***p*. Each of the first to seventh liquid ejecting heads **32***r* to **32***p* is a line head that ejects predetermined sized liquid droplets at predetermined timing; the size and ejection timing of the liquid droplets are determined in accordance with an instruction from the control section **11**. When the printing substrate **12** passes through the print head section **32**, the first to seventh liquid ejecting heads **32***r* to **32***p* eject liquid droplets onto the printing substrate **12**, forming the first reaction layer **81**A, the background layer **82**, the second reaction layer **81**B, the image layer **83**, and the overcoat layer **84** over the surface of the printing substrate **12**. Functions of the first to seventh liquid ejecting heads **32***r* to **32***p* and details of the first reaction layer **81**A, the background layer **82**, the second reaction layer **81**B, the image layer **83**, and the overcoat layer **84** will be described later.

The drying section **40** has a heating section **42** that heats and dries the printing substrate **12**. This drying section **40** receives the printing substrate **12** from the print executing section **30**, and then the heating section **42** heats and dries the printing substrate **12**. The heating section **42** dries the printing substrate **12** by blowing air heated to a preset temperature to the printing substrate **12**. The temperature of the air blown may be set by the control section **11**; the temperature may depend on the type, property or quantity of a liquid applied to the printing substrate **12** or may be maintained at a heatproof temperature of the printing substrate **12**, such as 30 to 90° C., or below. To reliably dry the printing substrate **12**, the transport route **15** in the drying section **40** has a winding part of a predetermined length, causing the printing substrate **12** to reciprocate laterally multiple times.

The substrate winding section **50** is provided with the winding roller **51**, which is driven to rotate at a predetermined rotational speed in response to an instruction from the control section **11**. This winding roller **51** winds the printing substrate **12** fed from the drying section **40**. Also, the substrate winding section **50** has a function of feeding the printing substrate **12** wound around the substrate winding section **50** itself in roll form to the drying section **40**. In response to an instruction from the control section **11**, the winding roller **51** can rotate in the forward direction, transporting the printing substrate **12** from the upstream side to the downstream side, and can rotate in the reverse direction, transporting the printing substrate **12** from the downstream side to the upstream side. The printing apparatus **10** configured above sequentially prints images on the printing substrate **12**.

The first to seventh liquid ejecting heads **32***r* to **32***p* in the print head section **32** each have: a liquid passage including a space in which a liquid to be ejected is stored; and an element, such as a piezo element or a heater element, that can generate a driving force by which the liquid is ejected. Furthermore, the first to seventh liquid ejecting heads **32***r* to **32***p* each have a plurality of ejection holes, or nozzles, formed along the width of the printing substrate **12**; the ejection holes are arranged at regular spacings according to the print resolution of the printing apparatus **10**.

The first to seventh liquid ejecting heads **32***r* to **32***p* are arrayed radially with respect to the rotation axis rx of the rotating drum **31** with their nozzles facing the circumferential surface **31***s*. These first to seventh liquid ejecting heads **32***r* to **32***p* can thereby eject liquid droplets onto the print region of the printing substrate **12**. Thus, in the printing apparatus **10** in the first embodiment, the rotating drum **31** functions as a so-called platen. Hereinafter, it is assumed that the first to seventh liquid ejecting heads **32***r* to **32***p* are arrayed in this order along the transport route **15** from the upstream side to the downstream side.

The first liquid ejecting head **32***r* applies droplets of a reaction liquid to the print surface of the printing substrate **12**. The first reaction layer **81**A or the second reaction layer **81**B is thereby formed on the print surface of the printing substrate **12**. The reaction liquid contains an aggregating agent that can cause the aggregation of color materials. Examples of the aggregating agent in the first embodiment include multivalent metal salts, such as calcium acetate and calcium nitrate, that can cause the aggregation of color materials, or pigment particles. The reaction liquid in the first embodiment contains approximately 1 mol/l of aggregating agent. In addition to the aggregating agent, the reaction liquid may contain water as a solvent and a surface active agent. The aggregating agent may be a multivalent metal salt other than calcium acetate and calcium nitrate. Hereinafter, the first liquid ejecting head **32***r* is also referred to as a "reaction liquid application section **32***r*."

The second liquid ejecting head **32***w* applies a background color ink to the print surface of the printing substrate **12**. The background layer **82** is thereby formed on the print surface of the printing substrate **12**. The background color ink contains pigment particles as a color material for the background. The background color ink in the first embodiment may be a white-based ink. Examples of white color materials (white pigments) include metal oxides, barium sulfate, and calcium carbonate; examples of metal oxides include titanium dioxide, zinc oxide, silica, alumina, and magnesium oxide. The word "white-based" does not necessarily mean pure white. The background color ink is not limited to a white-based ink and may be any ink that can form the background of the image layer **83** to be formed with image forming inks. The background color ink may be, for example, a glittering or metallic ink. The glittering ink may contain, for example, silver or aluminum particles as a color material. Thereinafter, the second liquid ejecting head **32***w* is also referred to as a "background color ink application section **32***w*."

The third to sixth liquid ejecting heads **32***b*, **32***c*, **32***m*, and **32***y*, which act as an image forming ink application section, apply image forming inks to the print surface of the printing substrate **12**; each image forming ink contains a color material (pigment particles) having a color different from that of the color material contained in the background color ink. The image layer **83** is thereby formed on the print surface of the printing substrate **12**. The third to sixth liquid ejecting heads **32***b*, **32***c*, **32***m*, and **32***y* eject a black-based ink, a cyan-based ink, a magenta-based ink, and a yellow-based ink, respectively. Each of the background color ink and the image forming inks may be a water-based ink and may contain water as a main solvent accordingly. The combination of the third to sixth liquid ejecting heads **32***b*, **32***c*, **32***m*, and **32***y* in the first embodiment is referred to as an image forming ink application section **32***i*.

The seventh liquid ejecting head **32***p* applies an overcoat liquid or an overprint liquid to at least a region on the print surface of the printing substrate **12** which is coated with the reaction liquid. The overcoat layer **84** is thereby formed on the print surface of the printing substrate **12**. Hereinafter, the seventh liquid ejecting head **32***p* is referred to as an "overcoat liquid application section **32***p*." The word "overcoat" herein refers to a translucent resin film formed by depositing and drying an ink material over a print image. The word "overcoat liquid" refers to an ink material used for the overcoat; the word "overcoat layer" refers to a liquid layer made of this ink material or a film layer formed by drying this liquid layer.

The overcoat liquid in the first embodiment may be a solution in which at least one of resins described below is dispersed in an inorganic or organic solvent. By using at least one of the resins described below, a substantially transparent film can be formed as the overcoat layer, although there is no limitation on the resin material used for the overcoat liquid. Examples of the resin contained in the overcoat liquid include a styrene-acrylonitrile-based resin, a polyethylene-based resin, a urethane-based resin, a polyester-based resin, an acrylic-based resin, and a fluorine-based resin.

In the printing apparatus **10** in the first embodiment, the reaction liquid application section **32***r* and the overcoat liquid application section **32***p* each have a lower nozzle resolution than the background color ink application section **32***w* and the image forming ink application section **32***i*. The word "nozzle resolution" refers to the number of nozzles per unit length. Assuming that the image forming ink application section **32***i* and the background color ink application section **32***w* each have a nozzle resolution of 1200 dpi, the reaction liquid application section **32***r* and the overcoat liquid application section **32***p* may each have a nozzle resolution of approximately 600 dpi.

The reaction liquid and the overcoat liquid tend to spread out more widely over the surface of the printing substrate **12** than the image forming inks. Therefore, the reaction liquid application section **32***r* and the overcoat liquid application section **32***p* that have a lower nozzle resolution can eject the reaction liquid and the overcoat liquid, respectively, such that adjacent droplets are connected to one another. It is thus possible to form the first reaction layer **81**A, the second reaction layer **81**B, and the overcoat layer **84** so as to seamlessly cover the same area as the background layer **82** and the image layer **83**. Moreover, decreasing the nozzle resolution of the reaction liquid application section **32***r* and the overcoat liquid application section **32***p* can reduce excessive use of the reaction liquid and the overcoat liquid and can decrease the number of components therein, thus lowering fabricating costs of the printing apparatus **10**.

When the printing apparatus **10** performs the print process, the control section **11** controls the first to seventh liquid ejecting heads **32***r* to **32***p* to eject liquid droplets onto the printing substrate **12**, on the basis of the print data PD. A description will be given below of the print process performed by the control section **11** and a manner in which the control section **11** controls the first to seventh liquid ejecting heads **32***r* to **32***p* in the print process.

FIG. **2** is a flowchart of the print process performed by the control section **11**. FIG. **3** schematically illustrates the forming regions of the individual layers. In FIG. **3**, an exemplary print image IM is formed over the printing substrate **12**, a forming region IMA of the background layer **82** and the image layer **83** is hatched, and a forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B coincides with the forming region IMA. A forming region OPA of the overcoat layer **84** is indicated by an alternate long and two short dashes line.

At Step S**10** (FIG. **2**), the control section **11** acquires the print data PD described above. At Step S**20**, the control section **11** generates data for use in controlling the second to sixth liquid ejecting heads **32***w*, **32***b*, **32***c*, **32***m*, and **32***y* to eject the inks, on the basis of the print data PD. More specifically, the control section **11** analyzes colors of an image expressed by the print data PD and subjects each color to a half-tone process. Then, the control section **11** generates control data that indicates the timing at which the second to fifth liquid ejecting heads eject ink droplets through the nozzles. It should be noted that regions in which the background layer **82** and the image layer **83** are to be formed is determined at Step S**20**. The regions in which the background layer **82** and the image layer **83** are to be formed may be substantially coincide with each other. The print data PD may be composed of a single piece of data or two pieces of data for a background and an image. Continuing, at Steps S**30** and S**40**, the control section **11** determines both the forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B and the forming region OPA of the overcoat layer **84**, on the basis of the forming region IMA of the background layer **82** and the image layer **83** which has been determined at Step S**20**. Then, the control section **11** generates control data for use in controlling the reaction liquid application section **32***r* and the overcoat liquid application section **32***p* to eject liquid droplets through the nozzles, on the basis of the determined forming regions RLA and OPA.

As illustrated in FIG. **3**, the forming region IMA of the background layer **82** and the image layer **83** corresponds to an area of the print image IM which is colored with at least one of the five color inks. The first reaction layer **81**A and the second reaction layer **81**B in the first embodiment are formed within an area that extends at the periphery of the background layer **82** and the image layer **83** so as to contain the forming region IMA of the background layer **82** and the image layer **83**. In the first embodiment, the outer edge of the forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B substantially conforms to that of the forming region IMA of the background layer **82** and the image layer **83**. Alternatively, the outer edge of the forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B may be formed outside that of the forming region IMA of the background layer **82** and the image layer **83**.

The overcoat layer **84** is formed over the forming region RLA on the print surface of the printing substrate **12** which is coated with the reaction liquid. The overcoat layer **84** in the first embodiment is formed so as to cover both the forming region IMA and the forming region RLA. Thus, the outer edge of the forming region OPA of the overcoat layer **84** is formed along and outside the outer edge of the forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B. In this case, for example the outer edge of the forming region OPA of the overcoat layer **84** may be several millimeters away from the outer edge of the forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B. However, both outer edges do not necessarily have to be a constant distance away from each other. Moreover, if the first reaction layer **81**A and the second reaction layer **81**B contain a blank region SP, the forming region OPA of the overcoat layer **84** has an inner edge inside this blank region SP. Alternatively, the overcoat layer **84** may be formed within the entire blank region SP. The forming region of the background layer **82**, the forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B, and the forming region OPA of the overcoat layer **84** may be formed over an entire possible area on the print surface of the printing substrate **12**.

At Step S**50** (see FIG. **2**), the control section **11** drives the substrate roller **21**, the rotating drum **31**, and the winding roller **51** to rotate in the forward direction, thereby starting to transport the printing substrate **12** along the transport route **15** from the substrate feeding section **20** to the substrate winding section **50**. Simultaneously, the control section **11** may start to operate the heating section **42**.

At Step S**60**, the control section **11** drives the print head section **32** to create the background. More specifically, the control section **11** drives both the reaction liquid application section **32***r* and the background color ink application section **32***w* in the print head section **32**, on the basis of the pieces of control data generated at Steps S**20** and S**30**. In the printing apparatus **10** in the first embodiment, the reaction liquid application section **32***r* and the background color ink application section **32***w* are arrayed in this order from the upstream side to the downstream side. At Step S**62**, the control section **11** performs a first reaction liquid application step at which the reaction liquid application section **32***r* applies the reaction liquid as a first reaction liquid to the printing substrate **12** while transporting the printing substrate **12** from the upstream side to the downstream side. At Step S**64**, the control section **11** performs a background color ink application step at which the background color ink application section **32***w* applies the background color ink to the forming region RLA (see FIG. **3**) that has been coated with the reaction liquid (first reaction liquid) at Step S**62**. In this way, the first reaction layer **81**A and the background layer **82** (FIG. **1**) are formed.

At Step S**70**, the control section **11** performs a first drying step as a drying step. At this first drying step, the heating section **42** in the drying section **40** dries the printing substrate **12** coated with the reaction liquid and the background color ink. In this case, the heating section **42** blows hot air to the printing substrate **12**. The temperature of this hot air is determined by the control section **11**, in accordance with the quantities of the reaction liquid and background color ink applied to the printing substrate **12**. For example the temperature of the hot air may be set such that the reaction liquid and the background color ink that have been applied to the printing substrate **12** at Step S**60** are fixed thereto, that is, such that the solvents in the reaction liquid and the background color ink are sufficiently evaporated. More specifically, as larger quantities of reaction liquid and background color ink have been applied to the printing substrate **12** at Step S**60**, the hot air is set to a higher temperature. The setting in this manner can reduce bleeding of the reaction liquid and the background color ink over the printing substrate **12** and can prevent liquid to be applied to the printing substrate **12** at a following step from transferring from the printing substrate **12** to another. In the printing apparatus **10** in the first embodiment, the heating section **42** may directly blow the hot air to the printing substrate **12** over a fixed period of time. It should be noted that there is no limitation on a manner in which the control section **11** controls the heating section **42**. Alternatively, the hot air may be set to a fixed temperature, such as 70° C., independently of the quantities of the reaction liquid and the background color ink applied to the printing substrate **12**. The printing substrate **12** that has been subjected to Step S**70** is wound around the winding roller **51** in the substrate winding section **50**.

At Step S**80**, the control section **11** rewinds the printing substrate **12**, and then resumes transporting the printing substrate **12** from the substrate feeding section **20** to the substrate winding section **50**. More specifically, the control section **11** starts to drive the substrate roller **21**, the rotating drum **31**, the winding roller **51** to rotate in the reverse direction, transporting the printing substrate **12** along the transport route **15** from the substrate winding section **50** to the substrate feeding section **20**. In this way, the printing substrate **12** is rewound around the substrate roller **21**. Then, the control section **11** resumes transporting the rewound printing substrate **12** along the transport route **15** from the substrate feeding section **20** to the substrate winding section **50**. When the printing substrate **12** is rewound, the control section **11** may or may not stop the operation of the heating section **42**. If the heating section **42** stops its operation when the printing substrate **12** is rewound, the heating section **42** preferably resumes its operation until Step S**100** that will be described later has started.

The control section **11** drives the print head section **32** to create the image (Step S**90**). More specifically, the control section **11** drives the reaction liquid application section **32***r*, the image forming ink application section **32***i*, and the overcoat liquid application section **32***p* in the print head section **32**, on the basis of the pieces of control data generated at Steps S**20** to S**40**. In the printing apparatus **10** in the first embodiment, the reaction liquid application section **32***r*, the image forming ink application section **32***i*, and the overcoat liquid application section **32***p* are arrayed in this order from the upstream side to the downstream side. At Step S**92**, the control section **11** performs a second reaction liquid application step at which the reaction liquid application section **32***r* applies the reaction liquid as a second reaction liquid to the printing substrate **12** while transporting the printing substrate **12** from the upstream side to the downstream side. Then, at Step S**94**, the control section **11** performs an image forming ink application step at which the image forming ink application section **32***i* applies the image forming inks to the region RLA that has been coated with the reaction liquid, or the second reaction liquid, at Step S**92**. Subsequent to Step S**94**, at Step S**96**, the control section **11** performs an overcoat liquid application step at which the overcoat liquid application section **32***p* applies the overcoat liquid to both the forming region RLA of the first reaction layer **81**A and the second reaction layer **81**B and the forming region IMA of the background layer **82** and the image layer **83** so as to cover the forming regions RLA and IMA. In this way, the second reaction layer **81**B, the image layer **83**, and the overcoat layer **84** are formed at Step S**90**.

At Step S**100**, the control section **11** performs a second drying step. At this second drying step, the heating section **42** dries the printing substrate **12** coated with the reaction liquid as the second reaction liquid, the image forming ink, and the overcoat liquid, similar to the first drying step. The temperature of the hot air that the heating section **42** blows to the printing substrate **12** is determined by the control section **11**, in accordance with the quantities of the liquids, or the reaction liquid, the image forming inks, and the overcoat liquid, that have been applied to the printing substrate **12** at Step S**90**, although there is no limitation on a manner in which the control section **11** controls the heating section **42**. Alternatively, the hot air may be set to a fixed temperature, such as 70° C., independently of the quantities of the reaction liquid, the image forming ink, and the overcoat liquid applied to the printing substrate **12**. The printing substrate **12** that has been subjected to Step S**100** is wound around the winding roller **51** in the substrate winding section **50**.

FIG. **4** illustrates a layered structure of the printing substrate **12** that has been subjected to Step S**100**. As illustrated in FIG. **4**, the first reaction layer **81**A made of the first reaction liquid, the background layer **82** made of the background color ink, the second reaction layer **81**B made of the second reaction liquid, and the image layer **83** made of the image forming inks are stacked, in this order, over the printing substrate **12** that has been subjected to Step S**100**. Furthermore, the overcoat layer **84** made of the overcoat liquid is formed over the printing substrate **12** so as to cover the first reaction layer **81**A, the background layer **82**, the second reaction layer **81**B, and the image layer **83**. If a person views the printing substrate **12** from the surface over which the first reaction layer **81**A to the overcoat layer **84** are formed, the person can visually identify the image created with the image layer **83**. The printing substrate **12** that has been subjected to Step S**100** will be cut into some pieces of a predetermined length, and they will be used as labels, for example.

According to the first embodiment described above, at first, a printing apparatus **10** performs a background color ink application step, and then performs a first drying step at which extra moisture in a reaction liquid and a background color ink applied to the printing substrate **12** is evaporated. After that, the printing apparatus **10** applies image forming inks to the printing substrate **12**. The printing apparatus **10** thereby reduces bleeding of the image forming inks, making it possible to create a high-quality image on the printing substrate **12**. Second, the printing apparatus **10** performs an overcoat liquid application step at which an overcoat liquid is applied to the printing substrate **12** so as to cover both a forming region RLA (see FIG. **3**) coated with the reaction liquid and a forming region IMA (see FIG. **3**) coated with the background color ink and the image forming inks. Applying the overcoat liquid in this manner can reduce the risk that the reaction liquid contacts air, especially moisture contained in air. Therefore, if the printing apparatus **10** produces a printed material, this printed material is less likely to cause disadvantages that could be attributed to the reaction liquid, such as giving off a rank odor or exhibiting an adhesion property due to deliquescence of the reaction liquid. Third, the printing apparatus **10** sequentially performs a first reaction liquid application step (Step S**60**), the background color ink application step (Step S**64**), and a first drying step (Step S**70**) while transporting the printing substrate **12** along a transport route **15** in a first direction, or in the direction from the upstream side to the downstream side. After that, the printing apparatus **10** rewinds the printing substrate **12** in a second direction, or in the direction from the downstream side to the upstream side (Step S**80**). Subsequent to Step S**80**, the printing apparatus **10** performs a second reaction liquid application step (Step S**92**) and an image forming ink application step (Step S**94**) while re-transporting the printing substrate **12** along the transport route **15** in the first direction. In this way, Steps S**62**, S**64**, S**70**, S**92**, and S**94** are performed while the printing substrate **12** is being transported in the first direction. This enables the printing apparatus **10** to perform the print process by using a single print executing section **30**. Consequently, the printing apparatus **10** can be fabricated at a low cost.

FIG. **5** is a table of a reference example to be used to explain an effect of the first embodiment. FIG. **6** is a table of an example in the first embodiment to be used to explain the effect of the first embodiment. The data in FIG. **5** was obtained through the print process in the first embodiment from which the first drying step (Step S**70**) was removed. FIGS. **5** and **6** show liquid quantities (mg/in^2) per square inch at each step when images were created on printing substrates **12** on the basis of the same print data PD. According to FIG. **5**, for example, 1.3 mg/in^2 of liquid was used at Step S**62**, or at the first reaction liquid application step. The total liquid quantity in each of FIGS. **5** and **6** corresponds to the total quantity of liquids used at all the steps. The quantity of overcoat liquid at Step S**100** in each of FIGS. **5** and **6** which needs to eliminate an odor of the reaction liquid from the printing substrate **12** is determined with a sensory inspection (an inspection using a smelling sense). FIGS. **5** and **6** reveal that the print process in the first embodiment can reduce an odor of a reaction liquid, which is its harmful effect, with a smaller quantity of overcoat liquid. A possible reason for this is that drying a reaction liquid that has been applied at Step S**60** at a first drying step

(Step **S70** in FIG. **2**) decreases the quantity of unreacted reaction liquid that could be the odor source. In addition, the decrease in the quantity of overcoat liquid lightens a load that would be placed on a drying section **40** at a second drying step (Step **S100**). It is thus possible to lower a temperature of hot air blown by a heating section **42** at a second drying step and to decrease the total quantity of liquids used to perform the print process.

Second Embodiment

FIG. **7** is a flowchart of a print process in a second embodiment of the invention. The steps in the flowchart shown in FIG. **7** are performed by a control section **11** (see FIG. **1**) in a printing apparatus **10** in the first embodiment. The second embodiment differs from the first embodiment in the order in which the first reaction layer **81**A, the background layer **82**, the second reaction layer **81**B, the image layer **83**, and the overcoat layer **84** are stacked over the printing substrate **12**. More specifically, in the print process in the second embodiment, first the image layer **83** is formed and then the background layer **82** is formed. In other words, the print process employs the background color postcoat printing method. Steps in the second embodiment which are identical to those in the first embodiment are given the same reference numbers and will not be described.

After Step **S50**, the control section **11** drives the print head section **32** to create an image at Step **S60***a*. Specifically, a first reaction liquid application step performed at Step **S62***a* in Step **S60***a* is identical to the second reaction liquid application step at Step **S92** in FIG. **2**; an image forming ink application step performed at Step **S64***a* in Step **S60***a* is identical to that at Step **S94** in FIG. **2**. Subsequently, the control section **11** performs Steps **S70** and **S80** and then drives the print head section **32** to create the background at Step **S90***a*. Specifically, a second reaction liquid application step at Step **S92***a* in Step **S90***a* is identical to the first reaction liquid application step at Step **S62** in FIG. **2**; a background color ink application step at Step **S94***a* of Step **S90***a* is identical to that at Step **S64** in FIG. **2**. In this case, the temperature of hot air that a heating section **42** blows to a printing substrate **12** at Step **S70** is determined by the control section **11**, for example in accordance with the quantities of the liquids that have been applied to the printing substrate **12** at Step **S60***a*. Likewise, the temperature of hot air that the heating section **42** blows to the printing substrate **12** at Step **S100** is determined by the control section **11**, for example in accordance with the quantities of the liquids that have been applied to the printing substrate **12** at Step **S90***a*. Alternatively, the heating section **42** may blow hot air of a fixed temperature in the range of 30 to 90° C., for example, to the printing substrate **12** at Steps **S60***a* and **S100**. Then, the printing substrate **12** that has been subjected to Step **S100** is wound around the winding roller **51** in the substrate winding section **50**. If a person views the printing substrate **12** that has been subjected to the print process in the second embodiment from the surface opposite to that over which the first reaction layer **81**A to the overcoat layer **84** are formed, the person can visually identify the image created from the image layer **83**.

The same steps as in the first embodiment are performed in the second embodiment described above, and thus the second embodiment produces the same effects as the first embodiment. To give an example, a printing apparatus **10** performs an image forming ink application step, and then performs a first drying step at which extra moisture in a reaction liquid and image forming inks applied to the printing substrate **12** is evaporated. After that, the printing apparatus **10** applies a background color ink to the printing substrate **12**. The printing apparatus **10** thereby reduces bleeding of the background color ink, making it possible to create a high-quality image on the printing substrate **12**. To give another example, the printing apparatus **10** performs an overcoat liquid application step, which can reduce the risk that the reaction liquid contacts air, especially moisture contained in air. Therefore, if the printing apparatus **10** produces a printed material, this printed material is less likely to cause disadvantages that could be attributed to the reaction liquid, such as giving off a rank odor or exhibiting an adhesion property due to deliquescence of the reaction liquid. In addition, the printing apparatus **10** can perform a print process with a smaller total quantity of liquids.

Modification

The invention is not limited to the first and second embodiments described above, and these embodiments can be modified in various ways without departing from the spirit of the invention. Exemplary modifications will be described below.

First Modification

Instead of a drying section **40** having a heating section **42** that blows hot air, another configuration that dries a printing substrate **12** may be used. For example a transport belt or some other structure that supports the printing substrate **12** may be installed as a part of a transport route, and a heater may be provided in this structure as a heating section **42**.

Second Modification

In the first and second embodiments described above, a printing apparatus **10** drives a substrate roller **21**, a rotating drum **31**, and a winding roller **51** to rotate in a reverse direction, rewinding a printing substrate **12** from a substrate winding section **50** to a substrate feeding section **20** (Step **S80** in FIGS. **2** and **7**). In addition, the printing apparatus **10** performs a second drying step (Step **S100** in FIGS. **2** and **7**). However, the printing apparatus **10** does not necessarily have to perform the rewinding and second drying steps. Alternatively, the printing apparatus **10** may sequentially perform all steps in a print process other than Step **S100** while transporting a printing substrate **12** from a substrate feeding section **20** to a substrate winding section **50**. In this case, the printing apparatus **10** may be modified so as to be able to sequentially perform all the steps in a print process other than Step **S100** while transporting a printing substrate **12**. If the printing apparatus **10** in the first embodiment performs a print process, an additional print executing section **30** may be installed along a transport route **15** between the drying section **40** and the substrate winding section **50**. If the printing apparatus **10** sequentially performs the steps while transporting the printing substrate **12**, the print executing section **30** (see FIG. **1**) installed between the substrate feeding section **20** and the drying section **40** does not have to be provided with an image forming ink application section **32***i* and an overcoat liquid application section **32***p*. Likewise, the additional print executing section **30** does not have to be provided with a background color ink application section **32***w*.

Third Modification

An overcoat liquid in the first and second embodiments is applied so as to cover a forming region RLA (see FIG. **3**) coated with a first reaction liquid and a second reaction liquid; however, there is no limitation on a method of applying the overcoat liquid. Alternatively, the overcoat liquid may be applied so as to at least partially cover the forming region RLA. This can also reduce an odor of the reaction liquid.

Fourth Modification

In the first and second embodiments, the same reaction liquid is used to cause the aggregation of a background color ink and image forming inks; however, different reaction liquids may be used separately. For example a first reaction liquid and a second reaction liquid may be selected depending on properties of a background color ink and image forming inks, respectively. In this case, the first reaction liquid readily causes the aggregation of a background color ink, and a second reaction liquid readily causes the aggregation of image forming inks.

The entire disclosure of Japanese Patent Application No. 2014-228071, filed Nov. 10, 2014 is expressly incorporated by reference herein.

What is claimed is:

1. A printing method that uses a reaction liquid containing an aggregating agent capable of causing aggregation of a color material, the printing method comprising:

applying a first reaction liquid to a recording medium;

applying a background color ink to a region of the recording medium which is coated with the first reaction liquid, the background color ink containing a color material for a background color;

drying the recording medium coated with both the first reaction liquid and the background color ink by heating the recording medium;

following drying the recording medium, applying a second reaction liquid to a region of the dried recording medium which is coated with the background color ink; and

applying an image forming ink to a region of the recording medium which is coated with the second reaction liquid, the image forming ink containing a color material having a color different from that of the background color ink.

2. The printing method according to claim **1**, further comprising applying an overcoat liquid to a region of the recording medium which is coated with the first and second reaction liquids after the applying of the image forming ink.

3. The printing method according to claim **2**, wherein

the overcoat liquid is applied so as to cover the region of the recording medium which is coated with the first and second reaction liquids.

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