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(54) Title: INK SET HAVING MIX COLOR GLOSS UNIFORMITY

(57) Abstract: The present disclosure provides ink sets and related methods mix color gloss uniformity. The ink set can include a black ink with a black pigment having a particle size of about 14 nm to about 16 nm, a DBP absorption of about 80 ml/100g to about 350 ml/100g, and a BET surface area of about 160 m²/g to about 1600 m²/g. The ink set can also include pigmented magenta ink, pigmented cyan ink, and pigmented yellow ink. As a whole, the ink set can have a mix color gloss uniformity of at least 7.



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INK SET HAVING MIX COLOR GLOSS UNIFORMITY**BACKGROUND**

There are several reasons that ink jet printing has become a popular way
10 of recording images on various media surfaces, particularly paper and photo
media substrates. Some of these reasons include low printer noise, capability of
high-speed recording, and capability of multi-color recording. Additionally, these
advantages can be obtained at a relatively low price to consumers. With respect
to ink jet ink chemistry, the majority of commercial ink jet inks are water-based.
15 Thus, their constituents are generally water-soluble, as in the case with many
dyes, or water dispersible, as in the case with pigments. Furthermore, ink jet inks
have low viscosity to accommodate high frequency jetting and firing chamber
refill processes common to thermal ink jet architecture.

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DETAILED DESCRIPTION

Before the present disclosure is described, it is to be understood that this
disclosure is not limited to the particular process steps and materials disclosed
herein because such process steps and materials may vary somewhat. It is also
25 to be understood that the terminology used herein is used for the purpose of
describing particular examples only. The terms are not intended to be limiting
because the scope of the present disclosure is intended to be limited only by the
appended claims and equivalents thereof.

It is be noted that, as used in this specification and the appended claims,
30 the singular forms "a," "an," and "the" include plural referents unless the context
clearly dictates otherwise.

As used herein, "alkyl" refers to a branched, unbranched, or cyclic
saturated hydrocarbon group, which typically, although not necessarily, contains

from 1 to about 50 carbon atoms, or 1 to about 40 carbon atoms, or 1 to about 30 carbon atoms for example. Alkyls include, but are not limited to, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, t-butyl, octyl, and decyl, for example, as well as cycloalkyl groups such as cyclopentyl, and cyclohexyl, for example. The term
5 "lower alkyl" refers to an alkyl group having from 1 to 6 carbon atoms. The term "higher alkyl" refers to an alkyl group having more than 6 carbon atoms, for example, 7 to about 50 carbon atoms, or 7 to about 40 carbon atoms, or 7 to about 30 carbon atoms or more. As used herein, "substituted alkyl" refers to an alkyl substituted with at least one substituent group. The term "heteroalkyl" refers
10 to an alkyl in which at least one carbon atom is replaced with a heteroatom. If not otherwise indicated, the term "alkyl" includes unsubstituted alkyl, substituted alkyl, lower alkyl, and heteroalkyl.

As used herein, "substituted" means that a hydrogen atom of a compound or moiety is replaced by another atom such as a carbon atom or a heteroatom,
15 which is part of a group referred to as a substituent. Substituents include, for example, alkyl, alkoxy, aryl, aryloxy, alkenyl, alkenoxy, alkynyl, alkynoxy, thioalkyl, thioalkenyl, thioalkynyl, and thioaryl.

As used herein, "aryl" refers to a group containing a single aromatic ring or multiple aromatic rings that are fused together, directly linked, or indirectly linked
20 (such that the different aromatic rings are bound to a common group such as a methylene or ethylene moiety). Aryl groups described herein may contain, but are not limited to, from 5 to about 50 carbon atoms, or 5 to about 40 carbon atoms, or 5 to 30 carbon atoms or more. Aryl groups include, for example, phenyl, naphthyl, anthryl, phenanthryl, biphenyl, diphenylether, diphenylamine,
25 and benzophenone. The term "substituted aryl" refers to an aryl group comprising at least one substituent group. The term "heteroaryl" refers to an aryl group in which at least one carbon atom is replaced with a heteroatom. If not otherwise indicated, the term "aryl" includes unsubstituted aryl, substituted aryl, and heteroaryl.

30 As used herein, "photo paper" refers to a paper with photographic quality in feel and gloss appearance. Photo paper includes a photobase and one or more ink-absorbing layers on top of one size of the photobase. Photobase is typically a highly sized base paper with polyethylene or polypropylene extruded

on each size. In one embodiment, the photo paper can be HP Advanced Glossy Photo Paper.

As used herein, "mix color gloss uniformity" is determined by printing images from a magenta ink mixed with a black ink, a cyan ink mixed with the black ink, and a yellow ink mixed with the black ink, each at a 1:1 weight ratio on photo paper and measured for 20° gloss. Each gloss measurement is then averaged, thereby providing an average gloss uniformity. The average gloss uniformity is then divided by the standard deviation to produce a mix color gloss uniformity value.

As used herein, "gloss" refers generally to the amount of light reflected by an object's surface, such as, e.g., an ink jet media surface. Gloss can be quantified and measured relative to specific specular angles from an object surface. The specular angle is the angle equal to but opposite the angle of incidence. This specular light is responsible for the highlights visible on shiny materials. When quantifying gloss, it can be measured at angles of 20 degrees, 60 degrees, and 85 degrees off of the normal. Gloss measurements are indicated by gloss units in relation to the angle used for measurement.

As used herein, "20° gloss" is the gloss of an image measured by using "BYK-Gardner micro-TRI-gloss" meter with incident angle set at 20°.

As used herein, "standard deviation" is the calculated standard deviation of the measurements of the average gloss.

As used herein, "haze" generally refers to a cloudy or smoky appearance to an image resulting from light scattering off of the surface of the print. For the purposes of the present disclosure, haze is measured by "BYK-Gardner micro haze plus" meter.

As used herein, "DBP absorption" is determined by the amount of dibutyl phthalate (DBP) a given mass of a pigment can absorb before reaching a specified viscous paste according to ASTM D-2414. In one example, the pigment measured can be a carbon black pigment.

As used herein, "BET surface area" refers to the surface area of a pigment as measured by the BET (Brunauer, Emmet, and Teller) nitrogen absorption method according to ASTM D-6556.

As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual
5 member of such list should be construed as a *de facto* equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary.

It has been recognized that it would be advantageous to develop an ink set that provides good mix color gloss uniformity suitable over a wide variety of
10 applications. In accordance with this, compositions and methods described herein can include an ink set comprising a black ink, a magenta ink, a cyan ink, and a yellow ink that can provide good mix color gloss uniformity when printed on recording media. It is noted that when discussing the present compositions and methods, each of these discussions can be considered applicable to each of
15 these embodiments, whether or not they are explicitly discussed in the context of that embodiment. Thus, for example, in discussing a black ink used in an ink set, such a black ink can also be used in a method for manufacturing an ink set or a method of improving a mix color gloss uniformity of an ink set, and vice versa.

In light of the above, an ink jet ink set having mix color gloss uniformity can
20 comprise a black ink including a black pigment, a magenta ink including a magenta pigment, a cyan ink including a cyan pigment, and a yellow ink including a yellow pigment. The black pigment can have a particle size of about 14 nm to about 16 nm, a DBP absorption of about 80 ml/100g to about 350 ml/100g, and a BET surface area of about 160 m²/g to about 1600 m²/g. The ink set can also
25 have a mix color gloss uniformity of at least 7, as defined herein.

Additionally, a method of manufacturing an ink set can comprise formulating a magenta ink by admixing a first ink vehicle with a magenta pigment; formulating a cyan ink by admixing a second ink vehicle with a cyan pigment; formulating a yellow ink by admixing a third ink vehicle with a yellow pigment; and
30 formulating a black ink by admixing a fourth ink vehicle with a black pigment. The black pigment can have a particle size of about 14 nm to about 16 nm, a DBP absorption of about 80 ml/100g to about 350 ml/100g, and a BET surface area of

about 160 m²/g to about 1600 m²/g. The ink set can be formulated to have a mix color gloss uniformity of at least 7.

In another embodiment, a method of generating an image with mix color gloss uniformity can comprise matching a black ink with a magenta ink, a cyan ink, and a yellow ink to form the ink set with a mix color gloss uniformity of at least 7, and ink jet printing a color image by mixing the black ink with each of the magenta ink, the cyan ink, and the yellow ink.

The compositions and methods described herein can provide good mix color gloss uniformity measured as images printed separately from each of a magenta ink with a black ink, a cyan ink with the black ink, and a yellow ink with the black ink in a 1:1 ratio by weight on photo paper. In one embodiment, the compositions and methods described herein can provide superior mix color gloss uniformity measured as a mix color gloss uniformity of at least 9. In another embodiment, the compositions and methods described herein can provide excellent mix color gloss uniformity measured as a mix color gloss uniformity of at least 11.

Other inks may also be used in addition to the black ink, the magenta ink, the cyan ink, and the yellow ink. In one example, a light or pale magenta can be used as the magenta ink or in addition to the magenta ink. In another example, a light or pale cyan ink can be used as the cyan ink or in addition to the cyan ink. In yet another example, a light or pale magenta ink can be used as the magenta ink and a light or pale cyan ink can be used as the cyan ink. Other inks that can be used include without limitation blue inks, red inks, orange inks, violet inks, green inks, gray inks, light gray inks, etc. Such inks can include a pigment with an ink vehicle as described herein.

Generally, the black ink includes a black pigment in an ink vehicle, although other colorants may also be present in the black ink, e.g., to improve neutrality of the black ink in some examples. In one example, the black pigment can be carbon black. While the black ink can include various black pigments, in one example, the black pigment can have a primary particle size of about 10 nm to 20 nm. In a more detailed aspect, the particle size can be from about 14 nm to about 16 nm. Additionally, the black pigment can have a DBP absorption of about 80 ml/100g to about 350 ml/100g. In one particular aspect, the DBP

absorption can be from about 80 ml/100g to about 130 ml/100g. Further, the black pigment can have a BET surface area of about 160 m²/g to about 1600 m²/g. In one specific aspect, the BET surface area can be from about 160 m²/g to about 350 m²/g. Exemplary pigments that can be used include certain BLACK
5 PEARLS® 2000 from Cabot, having a DBP absorption of about 330 ml/100g and a BET surface area of about 1500 m²/g.

The present inks sets can also provide acceptable levels of haze. In one embodiment, the haze can be less than 450 as measured using a BYK-Gardner micro haze plus" meter as described herein. In another embodiment, the haze
10 can be less than 415.

The ink vehicles of the various inks in the ink set can be the same or different. In one embodiment, the black ink can have a unique ink vehicle compared to the other inks in the ink set, and in another embodiment, it can have a common ink vehicle with one or more of the other inks in the ink set.

15 In one specific embodiment, the present inks can also include a pigment dispersed by an acrylic dispersant. The acrylic dispersant can include acrylic polymers having hydrophilic monomers including acid monomers, and hydrophobic monomers. Hydrophobic monomers that can be polymerized in the acrylic dispersant include, without limitation, styrene, p-methyl styrene, methyl
20 methacrylate, hexyl acrylate, hexyl methacrylate, butyl acrylate, butyl methacrylate, ethyl acrylate, ethyl methacrylate, propyl acrylate, propyl methacrylate, octadecyl acrylate, octadecyl methacrylate, stearyl methacrylate, vinylbenzyl chloride, isobornyl acrylate, tetrahydrofurfuryl acrylate, 2-
25 phenoxyethyl methacrylate, ethoxylated nonyl phenol methacrylate, isobornyl methacrylate, cyclohexyl methacrylate, t-butyl methacrylate, n-octyl methacrylate, lauryl methacrylate, tridecyl methacrylate, alkoxyated tetrahydrofurfuryl acrylate, isodecyl acrylate, isobornylmethacrylate, combinations thereof, derivatives thereof, and mixtures thereof.

Acidic monomers can be present in the acrylic dispersant at from about
30 0.1 wt% to about 30 wt%. Acidic monomers that can be used in the acrylic dispersant include, without limitation, acrylic acid, methacrylic acid, ethacrylic acid, dimethylacrylic acid, maleic anhydride, maleic acid, vinylsulfonate, cyanoacrylic acid, vinylacetic acid, allylacetic acid, ethylideneacetic acid,

propylidineacetic acid, crotonic acid, fumaric acid, itaconic acid, sorbic acid, angelic acid, cinnamic acid, styrylacrylic acid, citraconic acid, glutaconic acid, aconitic acid, phenylacrylic acid, acryloxypropionic acid, aconitic acid, phenylacrylic acid, acryloxypropionic acid, vinylbenzoic acid, N-vinylsuccinamic acid, mesaconic acid, methacryloylalanine, acryloylhydroxyglycine, sulfoethyl methacrylic acid, sulfopropyl acrylic acid, styrene sulfonic acid, sulfoethylacrylic acid, 2-methacryloyloxymethane-1-sulfonic acid, 3-methacryloyloxypropane-1-sulfonic acid, 3-(vinylloxy)propane-1-sulfonic acid, ethylenesulfonic acid, vinyl sulfuric acid, 4-vinylphenyl sulfuric acid, ethylene phosphonic acid, vinyl phosphoric acid, vinyl benzoic acid, 2-acrylamido-2-methyl-1-propanesulfonic acid, combinations thereof, derivatives thereof, and mixtures thereof.

Additionally, the acrylic dispersants can include reactive surfactants such as functionalized ethylene glycol acrylates, including the SIPOMER® series of surfactants from Rhodia. Other non-limiting examples of reactive surfactants include HITENOL™ (polyoxyethylene alkylphenyl ether ammonium sulfate) and NOIGEN™ (polyoxyethylene alkylphenyl ether) reactive surfactants commercially available from Dai-Ichi Kogyo Seiyaku Co., Ltd. of Japan; TREM® (sulfosuccinates) commercially available from Henkel; and the MAXEMUL® (anionic phosphate ester) reactive surfactants commercially available from Uniqema of the Netherlands. Suitable grades of some of the materials listed above may include HITENOL BC-20, NOIGEN RN-30, TREM LT-40, and MAXEMUL 6106 and 6112.

The ink jet ink compositions of the present disclosure can also be suitable for use on many types of substrates of recording media, including but not limited to vinyl media, cellulose-based paper media, various cloth materials, polymeric materials (non-limitative examples of which include polyester white film or polyester transparent film), photopaper (non-limiting examples of which include polyethylene or polypropylene extruded on one or both sides of paper), metals, and/or mixtures or composites thereof. A non-limiting example of a suitable metal material is a metal in foil form made from, for example, at least one of aluminum, silver, tin, copper, alloys thereof, and/or mixtures thereof.

Typical ink vehicle formulations described herein can include water, and can further include co-solvents present in total at from 0.1 wt% to 30 wt%,

depending on the jetting architecture, though amounts outside of this range can also be used. Further, non-ionic, cationic, and/or anionic surfactants can be present, ranging from 0.01 wt% to 10 wt%. In addition to the colorant, the balance of the formulation can be purified water, or other vehicle components known in the art, such as biocides, viscosity modifiers, materials for pH adjustment, sequestering agents, preservatives, and the like. In one embodiment, the ink vehicle can be predominantly water and can be referred to as an aqueous liquid vehicle.

The present inks can also include a binder, such as for example, a polyurethane binder. The polyurethane binder can comprise polymerized monomers including a polyether polyol, a diisocyanate, and an acid polyol. Additionally, the polyurethane binder can have a M_w from about 30K to 100K and an acid number from 30 to 60. In one embodiment, the M_w can be from about 40K to about 45K and the acid number can be from about 53 to about 57.

Classes of co-solvents that can be used can include organic co-solvents including aliphatic alcohols, aromatic alcohols, diols, glycol ethers, polyglycol ethers, caprolactams, formamides, acetamides, and long chain alcohols. Examples of such compounds include primary aliphatic alcohols, secondary aliphatic alcohols, 1,2-alcohols, 1,3-alcohols, 1,5-alcohols, ethylene glycol alkyl ethers, propylene glycol alkyl ethers, higher homologs (C_6 - C_{12}) of polyethylene glycol alkyl ethers, N-alkyl caprolactams, unsubstituted caprolactams, both substituted and unsubstituted formamides, both substituted and unsubstituted acetamides, and the like.

Consistent with the formulation of this disclosure, various other additives may be employed to enhance the properties of the ink composition for specific applications. Examples of these additives are those added to inhibit the growth of harmful microorganisms. These additives may be biocides, fungicides, and other microbial agents, which are routinely used in ink formulations. Examples of suitable microbial agents include, but are not limited to, NUOSEPT® (Nudex, Inc.), UCARCIDE™ (Union carbide Corp.), VANCIDE® (R.T. Vanderbilt Co.), PROXEL® (ICI America), and combinations thereof.

Sequestering agents, such as EDTA (ethylene diamine tetra acetic acid), may be included to eliminate the deleterious effects of heavy metal impurities,

and buffer solutions may be used to control the pH of the ink. From 0 wt% to 2 wt%, for example, can be used. Viscosity modifiers and buffers may also be present, as well as other additives known to those skilled in the art to modify properties of the ink as desired. Such additives can be present at from 0 wt% to 20 wt%.

EXAMPLES

The following examples illustrate some embodiments of the present ink compositions and methods that are presently known. However, it is to be understood that the following are only exemplary or illustrative of the application of the principles of the present compositions, devices, and methods. Numerous modifications and alternative compositions, methods, and devices may be devised by those skilled in the art without departing from the spirit and scope of the present compositions and methods. The appended claims are intended to cover such modifications and arrangements. Thus, while the present ink compositions and methods have been described above with particularity, the following examples provide further detail in connection with what are presently deemed to be the acceptable embodiments.

Example 1 –Black Ink Preparations

Three black inks were prepared with pigments set forth in Table 1. Specifically, a first black ink having a pigment primary particle size of 14 nm, a BET surface area of 300 m²/g, and a DBP absorption of 95 ml/100g, was prepared by dispersing a carbon black pigment in an aqueous liquid vehicle having the components of which are outlined in Table 2. The second and third black inks were prepared in the same fashion with the same vehicle components as listed in Table 2, except that the second and third black inks used different pigments.

Table 1

Ink	Ink 1	Ink 2	Ink 3
Black Pigment	Pigment 1 (PRINTEX® 90 from Evonik)	Pigment 2 (NIPEX® 180 IQ from Evonik)	Pigment 3
Primary Particle Size (nm)	14	15	16
BET Surface Area (m ² /g)	300	260	250
DBP Absorption (ml/100g)	95	100	105

Table 2

Vehicle Component	Amounts (wt%)
Heterocyclic solvent	3-11
Buffer	0.5-1
Anionic surfactant	0.1-0.5
Non-ionic surfactant	0.1-0.5
Fluoro surfactant	0.01-0.2
Biocide	0.01-0.2
Polyurethane resin	0.1-2.5
Styrene acrylic resin	0.5-2.5
Glycol	1-5
Total pigment	0.5-5
Water	balance

5 Example 2 –Color Ink Preparations

Four color inks were prepared by dispersing a color pigment in an aqueous liquid vehicle, the components of which are outlined in Table 3.

Table 3

Vehicle Component	Magenta	Light Magenta	Yellow	Light Cyan
Heterocyclic solvent	3-11	3-11	3-11	3-11
Buffer	0.5-1	0.5-1	0.5-1	0.5-1
Anionic surfactant	0.1-0.5	0.1-0.5	0.1-0.5	0.1-0.5
Non-ionic surfactant	0.1-0.5	0.1-0.5	0.1-0.5	0.1-0.5
Fluoro surfactant	0.01-0.2	0.01-0.2	0.01- 0.2	0.01- 0.2
Biocide	0.01-0.2	0.01-0.2	0.01- 0.2	0.01- 0.2
Polyurethane resin	0.1-2.5	0.1-2.5	0.1-2.5	0.1-2.5
Styrene acrylic resin	0.5-2.5	0.5-2.5	0.5-2.5	0.5-2.5
Glycol	1-5	1-5	1-5	1-5
Pigment – Yellow pigment dispersion	0	0	2-5	0
Pigment – Cyan pigment dispersion	0	0	0	0.5-2
Pigment – Magenta pigment dispersion Violet pigment 19	2-5	0.5-2	0	0
Water	balance	balance	balance	balance

Example 3 – Comparative Black Inks

Five comparative black inks were prepared with the ink vehicle as outlined in Table 2 and as discussed in Example 1, except that 5 comparative black pigments were used as outlined in Table 4.

5

Table 4

Ink	Comparative Ink 1	Comparative Ink 2	Comparative Ink 3	Comparative Ink 4	Comparative Ink 5
Black Pigment	Pigment 4	Pigment 5 (PRINTEX® 85 from Evonik)	Pigment 6 (PRINTEX® 75 from Evonik)	Pigment 7 (Black Pigment 3)	Pigment 8 (BP880 from Cabot)
Primary Particle Size (nm)	15	16	17	20	16
BET Surface Area (m ² /g)	320	200	150	140	220
DBP Absorption (ml/100g)	64	48	49	131	105

Example 4 – Mix Color Gloss Uniformity Measurements

The black inks from Example 1 and the comparative black inks from Example 3 were printed using a HP DesignJet Z3200 photo printer with each of the color inks from Example 2 in a 1:1 ratio by weight on HP Advanced Glossy Photo Paper. Data for three types of ink sets were as follows: Ink set 1 (pK, Y, M, Lc), Ink set 2 (pK, Y, Lm, Lc), and Ink set 3 (pK, M, Y, Lc, Lm) is presented in Table 5 below. The difference between each of the ink sets is the type of black pigment used.

Table 5

	Comparative Black Inks of Example 3					Black Inks of Example 1		
Black Ink	1	2	3	4	5	1st	2nd	3rd
Gloss 20° pK-M	69.24	76.79	70.79	28.58	61.75	61.09	50.43	55.38
Gloss 20° pK-Y	51.27	43.32	37.15	37.28	53.18	56.26	60.99	55.32
Gloss 20° pK-Im	64.28	60.54	61.58	24.53	75.25	64.69	56.61	60.5
Gloss 20° pK-Ic	58.24	48.7	46.38	20.39	53.01	54.96	48.34	46.01
AVG Gloss for INK SET 1 (pK-M, pK-Y, pK- Ic)	59.58	56.27	51.44	28.75	55.98	57.44	53.25	52.24
Standard Deviation Ink Set 1	9.06	17.97	17.38	8.45	5.00	3.23	6.78	5.39
Mix Color Gloss Uniformity Ink Set 1	6.58	3.13	2.96	3.40	11.20	17.78	7.85	9.69
AVG Gloss for INK SET 2 (pK-Im, pK-Y, pK- Ic)	57.93	50.85	48.37	27.40	60.48	58.64	55.31	53.94
Standard Deviation Ink Set 2	6.51	8.81	12.34	8.80	12.79	5.28	6.42	7.34
Mix Color Gloss Uniformity Ink Set 2	8.90	5.77	3.92	3.11	4.73	11.10	8.61	7.35
AVG Gloss for INK SET 3	60.76	57.34	53.98	27.70	60.80	59.25	54.09	54.30

(pK-M, pK-Y, pK-lc, pK-lm)								
Standard Deviation Ink Set 3	7.76	14.83	15.07	7.21	10.46	4.48	5.79	6.04
Mix Color Gloss Uniformity Ink Set 3	7.83	3.87	3.58	3.84	5.81	13.21	9.35	8.99

pK – black ink, M – magenta ink, Y – yellow ink, lm – light magenta ink, and lc – light cyan ink

As can be seen in Table 5, the inks sets of the present disclosure (Inks 1-3) provided consistent mix color gloss uniformity of 7 or more, while the comparative inks did not. Additionally, some of the ink sets were able to provide superior (≥ 9) and excellent (≥ 11) mix color gloss uniformity.

While the disclosure has been described with reference to certain embodiments, those skilled in the art will appreciate that various modifications, changes, omissions, and substitutions can be made without departing from the spirit of the disclosure. It is intended, therefore, that the present disclosure be limited only by the scope of the following claims.

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CLAIMS

What Is Claimed Is:

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1. An ink set having mix color gloss uniformity, comprising:

a black ink including a black pigment, the black pigment having a particle size of about 14 nm to about 16 nm, a DBP absorption of about 80 ml/100g to about 350 ml/100g, and a BET surface area of about 160 m²/g to about 1600 m²/g;

10

a magenta ink including a magenta pigment;

a cyan ink including a cyan pigment; and

a yellow ink including a yellow pigment,

wherein the ink set has a mix color gloss uniformity of at least 7.

15

2. The ink set of claim 1, wherein the black pigment has a DBP absorption of about 80 ml/100g to about 130 ml/100g.

20

3. The ink set of claim 1, wherein the black pigment has a BET surface area of about 160 m²/g to about 350 m²/g.

4. The ink set of claim 1, wherein the ink set provides an image having a haze of less than 450.

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5. The ink set of claim 1, wherein the black pigment is a carbon black pigment.

30

6. The ink set of claim 1, wherein the magenta ink is a light magenta ink, the cyan ink is a light cyan ink, or both the magenta ink is a light magenta ink and the cyan ink is a light cyan ink.

7. The ink set of claim 1, wherein the mix color gloss uniformity is at least 9.

8. The ink set of claim 1, wherein the mix color gloss uniformity is at least 11.

5 9. The ink set of claim 1, wherein the black ink includes an ink vehicle that is the same as an ink vehicle from one of the cyan ink, the magenta ink, and the yellow ink.

10 10. The ink set of claim 1, wherein the black ink includes an ink vehicle that is different than ink vehicles from the cyan ink, the magenta ink, and the yellow ink.

15 11. A method of manufacturing an ink set, comprising:
 formulating a magenta ink by admixing a first ink vehicle with a magenta pigment;
 formulating a cyan ink by admixing a second ink vehicle with a cyan pigment; and
 formulating a yellow ink by admixing a third ink vehicle with a yellow pigment;
20 formulating a black ink by admixing a fourth ink vehicle with a black pigment, the black pigment having a particle size of about 14 nm to about 16 nm, a DBP absorption of about 80 ml/100g to about 350 ml/100g, and a BET surface area of about 160 m²/g to about 1600 m²/g,
 wherein the ink set is formulated to have a mix color gloss uniformity of at
25 least 7.

 12. The method of claim 11, wherein the black pigment has a DBP absorption of about 80 ml/100g to about 130 ml/100g, a BET surface area of about 160 m²/g to about 350 m²/g, and the ink set provides an image having a
30 haze of less than 450.

 13. The method of claim 11, wherein the mix color gloss uniformity is at least 9.

14. A method of generating an image with mix color gloss uniformity, comprising:

5 matching a black ink with a magenta ink, a cyan ink, and a yellow ink to form the ink set with a mix color gloss uniformity of at least 7; and ink jet printing a color image by mixing the black ink with each of the magenta ink, the cyan ink, and the yellow ink.

10 15. The method of claim 14, wherein the black ink includes a black pigment having a particle size of about 14 nm to about 16 nm, a DBP absorption of about 80 ml/100g to about 350 ml/100g, and a BET surface area of about 160 m²/g to about 1600 m²/g.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/053722**A. CLASSIFICATION OF SUBJECT MATTER*****B41J 2/175(2006.01)i, B41J 2/21(2006.01)i, C09D 11/02(2006.01)i***

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B41J 2/175; C09D 5/00; H01B 1/24; C08K 3/04; C08L 51/08; C03C 17/00; G01D 11/00; B05D 5/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: inkjet, ink, pigment, uniform, gloss, DBP, BET, particle, magenta, cyan, absorption, surface, color, black, yellow, carbon.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0034972 A1 (MUKAE FUMIHIKO et al.) 11 February 2010 See paragraphs [0072], [0098], [0123]	1-15
A	US 2004-0030001 A1 (ZEYING MA et al.) 12 February 2004 See paragraphs [0011], [0020], [0031] and claims 12, 13	1-15
A	US 05837766A A (METRO; JAMES N. et al.) 17 November 1998 See abstract and claim 1	1-15
A	US 2003-0189626 A1 (SHUICHI KATAOKA et al.) 09 October 2003 See paragraphs [0169]-[0173], [0188] and table 3	1-15

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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