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54 **Ink-jet recording medium and method.**

57 An ink-jet recording method of the present invention, in which a recording is made by jetting ink onto a recording medium, is characterized in that the recording medium is formed by applying an ink acceptor on a base paper having a basis weight of 50 to 90 g/m² and a sizing degree of 5 to 100 seconds, and that the water content and/or liquid physical properties of the ink is set in suitable ranges.

Ink-Jet Recording Medium and Method

The present invention relates to an ink-jet recording medium and to an ink-jet recording method employing an improved recording medium and inks suited for this recording medium to provide good quality records.

Along with recent progress of recording systems such as printers, plotters and facsimile devices, ink-jet recording methods are greatly noticed because of advantages thereof such that high-speed and low-noise recording is possible and color recording is easy. However, as recording speed is increased and multicolor recording is advanced, the use of common paper as a recording medium can not afford good recording characteristics and therefore particular types of paper, i.e. so-called ink-jet recording papers become to be used. Such ink-jet recording papers include so-called non-sized paper, which is a common paper untreated with size, and a coated paper having a porous ink-absorbing layer on the surface thereof.

Of the above-mentioned ink-jet recording papers, a non-coated paper has drawbacks in that inks on adhering thereto diffuse along fibers thereof and shapes of ink

1 dots are hence disordered, and that recording agents
(dyes) penetrate inside the paper, thus the optical
density of recorded images being lowered. On the
other hand, a coated paper has drawbacks in that it is
5 deficient in the feel of common paper since it is a
special processed paper, and that, when ink droplets
are applied thereon, microscopically ink dots are good
in shape and high in optical density, but macroscopically
the ink dot diameter varies from part to part of the
10 paper, unevenness of optical density is observed, and
the recorded image looks roughened.

In the manufacture of a conventional ink-jet
recording paper, these drawbacks of existing ink-jet
recording papers are partly attributable to unevenness
15 of the coating thickness or to unevenness of the coating
surface. In recording performances, the recording
paper, if having such unevenness, will cause irregular
spread of the applied ink droplets, forming no image
faithful to input information, and the surface unevenness
20 will cause disordered dot shapes, thus giving images
which have not only unevenness of optical density but
also coarse feel (the state resulting from the
contamination of input information with noises) and
lowered sharpness of images.

25 These various drawbacks of the existing ink-jet
recording paper can be offset to some extents by
various treatments of the paper. However, only with

the correction of these drawbacks of the existing ink-jet recording papers, it is not always possible to obtain satisfactory recording images.

An object of the invention is to correct the above-noted drawbacks of existing ink-jet recording papers and additionally provide an ink-jet recording method which gives good quality image records.

According to a first aspect of the invention there is provided use in ink-jet recording of recording medium comprising a base paper and an ink acceptor coated on the base paper, characterised in that the base paper has a basis weight of 50 to 90 g/m² and a sizing degree of 5 to 100 seconds.

According to another aspect of the invention, there is provided an ink-jet recording method in which a recording is made by jetting ink onto a recording medium, characterised in that the recording medium comprises a base paper and an ink acceptor coated on the base paper, the base paper having a basis weight of 50 to 90 g/m² and a sizing degree of 5 to 100 seconds, and that the water content of the ink is in the range of 10 to 90 % by weight.

According to another aspect of the invention, there is provided an ink-jet recording method in which a recording is made by jetting ink onto a recording medium, characterised in that the recording medium comprises a

base paper and an ink acceptor coated on the base paper, the base paper having a basis weight of 50 to 90 g/m² and a sizing degree of 5 to 100 seconds, and that the surface tension of the ink is in the range of 20 to 60 dyn/cm at 20°C.

According to a further aspect of the invention, there is provided an ink-jet recording method in which a recording is made by jetting ink onto a recording medium, characterised in that the recording medium comprises a base paper and an ink acceptor coated on the base paper, the base paper having a basis weight of 50 to 90 g/m² and a sizing degree of 5 to 100 seconds, and that the viscosity of the ink is 25 cp or less at 25°C.

The main feature of the present invention consists in the recording medium having specific structure. Important preferred features lie in the use of inks appropriate to said recording medium.

The preferred recording medium featuring first the present invention is described below in detail. The recording medium can be obtained by providing an ink acceptor on a base paper, in the other words, applying an aqueous coating composition comprising a known filler such as an extender pigment or inorganic pigment, a water-soluble binder such as polyvinyl alcohol, cellulose derivative, polyacrylamide, or starch, and/or an aqueous emulsion (if necessary, a fluorescent whitening agent, dispersant, defoaming

1 agent, surfactant and the like are added) on the base
paper of specific properties. For the purpose of
securing a good feeling of the resulting recording
medium, it is generally desirable to use a common
5 paper as the base paper. In particular, a neutral
paper sized in a neutral state is favorably used.
That is, according to detailed studies made by the
present inventors, ink-jet recording on recording media
produced by using prior art papers as base materials
10 of the media raises occasionally various problems such
as defective coloration of inks or discoloration or
fading of images after recording; further studies made
by the present inventors, for the purpose of solving
these problems have revealed that almost all the papers
15 hitherto widely used as the base materials have been
sheeted under acidic conditions, these acidic papers
contain large amounts of acidic components, particularly
aluminum sulfate, this aluminum sulfate and other
components migrate into ink-receiving layers formed on
20 the papers or adversely affect the ink-receiving layers,
changing the layers in quality, and the aluminum sulfate
causes defective coloration of dyes contained in inks
and discoloration or fading of the dyes after recording.

Accordingly, in the case of the recording
25 medium produced by using the prior art paper as the
base material, a considerable amount of a cationic
substance is incorporated into the ink-receiving layer

to improve the water resistance and thereby reduce the adverse effect of the aluminum sulfate. However, it has been found that the light resistance of dyes is markedly lowered by such an excess cationic substance.

5 We have found that the above drawbacks of the prior art can be removed by using a neutral paper as the base material of the recording medium.

 The neutral paper preferably used in the present invention is a paper produced by sheeting in a neutral
10 state using not aluminum sulfate, which is used in the prior art, but such a paper-making auxiliary as an alkylketene dimer, and is noticed in that, even after preservation over a long period (several decades to several hundred years), strength of the papers does not vary
15 differing from the acidic paper hitherto generally used.

 When such a neutral paper is used as the base material of the recording medium, an ink-receiving layer, when formed thereon, is under no detrimental influence thereof, and such drawbacks of the prior art as noted
20 above in ink-jet recording can be overcome.

 In the production of ink-jet recording media according to the prior art, such undesirable matters have been often experienced that drying of an aqueous coating material applied on base paper results in unevenness on
25 the recording surface and curling of the

1 recording medium, and moreover that the aqueous coating
material is not uniformly applied on the base paper,
forming coatings having minute thickness irregularity.
From a great number of investigation data, the present
5 inventors found that the above undesirable matters can
be solved almost completely by proper control of
characteristics of the base paper. That is, it was
revealed that the basis weight and sizing degree of
the base paper are specially important factors, and a
10 useful recording medium has been obtained by limiting
each of these factors within a specific
range.

The base paper used for the recording
medium in the invention has a basis weight of 50 to
15 90 g/m^2 . When the basis weight of the paper is less
than 50 g/m^2 , a large portion of the aqueous coating
material applied will penetrate the paper and this
will tend to develop uneven coating thickness after
drying. When the basis weight is heavier than 90 g/m^2 ,
20 the paper may be too thick, inferior in feel and
undesirable with respect to the recording workability
of the resulting recording medium. Measurement of
the basis weight of paper is possible in accordance
with JIS P 8110 and P 8111, and also in the present
25 invention, was made in accordance therewith.

In addition, the base paper used in the
invention needs to have a sizing degree of 5 to 100

1 seconds. The sizing degree is a value indicating the
resistance of paper to wetting with a liquid. Based
on this value, it is possible to know the degree of the
permeation of an aqueous coating material to the paper
5 . When the sizing degree is less than 5 seconds even
the binder contained in the applied coating material
will diffuse into the paper and the paper will swell,
resulting in waviness, i.e. minute projections and
depressions, on the recording surface. On the contrary,
10 when the sizing degree exceeds 100 seconds, the applied
coating material will scarcely permeate the paper and
be repelled by the paper surface, failing in perfect
covering of the paper or causing curling of the
recording medium on drying. The above sizing degree
15 was measured in accordance with JIS P 8122.

As described above, the present inventors have
found that papers of basis weights ranging from 50 to
90 g/m² and of sizing degrees ranging from 5 to 100
seconds are appropriate as supports for the recording
20 media used in the present invention. In addition to
the above requirements, the thickness of the base paper
is desired to be in the range of 60 to 100 μ m. When
the paper thickness is less than 60 μ m, the paper will
result in inconvenient handling because of limpness of
25 itself. When the thickness exceeds 100 μ m, the recording
medium will be felt to be bulky, that is, the preferable
feel thereof as a recording medium will be impaired.

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The recording medium favourably used in the present invention is obtained by using such a specific base paper as described above and coating the base paper with a known aqueous coating material by a known method.

5 The ink preferably used in the method of the present invention is composed basically of a recording agent, i.e. a colourant such as a dye, and a liquid medium. Suitable liquid media for the ink include mixtures of water with various organic solvents. The water content
10 of the ink used is preferably adjusted to be from 10 to 90 %, more preferably 30 to 70 %, by weight. When the water content of the ink exceeds 90 % by weight, the affinity of the ink to the surface of the recording medium may prove insufficient even for the recording
15 surface of the above described recording medium, in which case the absorbability of the ink will be low, the ink fixing time will be prolonged, the recording speed will be restricted, and additionally with ink droplets overlap at the recording surface, inks dissimilar in colour will
20 mix together and unnecessary spread of ink dots or disorder thereof will occur. Moreover such an ink tends to involve problems in

1 discharge stability and solution stability of the
recording agent. When the water content of the ink
is less than 10 % by weight, the coloration, spread,
and shape of ink dots may prove insufficient even on
5 the recording surface of the above described recording
medium.

When an ink is used for recording, it is
generally important to match liquid physical properties
(viscosity, surface tension, etc.) of the ink to the
10 recording medium. For instance, the rate of ink
absorption decreases nearly in inverse proportion to
the ink viscosity and thereby the ink dot diameter tends
to become smaller. Such degrees of changes in recording
characteristics vary with the structure and quality
15 of the recording medium. Hence liquid physical
properties of the ink need to be matched to the
recording medium.

Liquid medium components of the inks used in
the method of the present invention may include not only
20 water alone but preferably mixtures of water
with various water-miscible organic solvents. The
viscosity of the resulting ink preferably exceeds 25 cp, more preferably
15 cp, particularly preferably 12 cp. When the ink
viscosity at 25 °C exceeds 25 cp, the ink absorbability
25 of even the above described specific recording medium
will be low and therefore the ink fixing time will be
prolonged and the recording speed will be restricted,

and additionally when ink droplets overlap each other at the recording surface, inks dissimilar in colour will tend to mix together and unnecessary spread of ink dots or disorder thereof may occur, which is undesirable.

5 Further it is very desirable in the present invention to choose inks high in ability to wet the recording medium. In other words, since the surface tension of the preferred recording medium is from 40 to 50 dyn/cm, it is desirable to use inks having surface
10 tensions near to the range. Consequently, the ink used in the method of the present invention preferably has a surface tension from 20 to 60 dyn/cm, more preferably 35 to 55 dyn/cm, particularly preferably 40 to 50 dyn/cm, at 20°C. When an ink having a surface tension lower than 20
15 dyn/cm is used for recording even on the above described desirable recording medium, the spread of ink dots may be too large though the wettability of the recording medium will be high. On the contrary, when an ink having a surface tension higher than 60 dyn/cm, the wettability of
20 the recording medium will be reduced and as a result the absorbability of the ink and the optical density of ink dots will be reduced.

 Liquid medium components of the ink used in the method of the present invention may include not only
25 water alone but preferably mixtures of water with various water-miscible organic solvents.

Water-miscible organic solvents suitable for use in the preparation of such inks as stated above include; C₁-C₄ alkyl alcohols, e.g. methanol, ethanol, n-propanol, isopropanol, n-butanol, sec-butanol, tert-butanol and isobutanol; amides, e.g. dimethylformamide and dimethylacetamide; ketones or ketone alcohols, e.g. acetone and diacetone alcohol; ethers, e.g. tetrahydrofuran and dioxane; nitrogen-containing heterocyclic ketones, e.g. N-methyl-2-pyrrolidone and 1,3-dimethyl-2-imidazolidinone; polyalkylene glycols, e.g. polyethylene glycol and polypropylene glycol; alkylene glycols, e.g. having 2 to 6 carbon atoms in the alkylene group, e.g. ethylene glycol, propylene glycol, butylene glycol, triethylene glycol, 1,2,6-hexanetriol, thiodiglycol, hexylene glycol, and diethylene glycol; glycerol; lower alkyl ethers of polyhydric alcohols, e.g. ethylene glycol methyl ether, diethylene glycol methyl (or ethyl) ether, and triethylene glycol monomethyl (or monoethyl) ether.

Of these many water-miscible organic solvents, particularly preferred are diethylene glycol, which is a polyhydric alcohol, and triethylene glycol monomethyl (or monoethyl) ether, which is a lower alkyl ether of

1 polyhydric alcohol. Polyhydric alcohols are particularly
favorable because of the great effect thereof as
wetting agents for preventing the clogging of the
nozzle with the recording agent precipitated on
5 evaporation of water from the ink.

A solubilization agent may be added to the
ink. Typical examples of the solubilization agents
are nitrogen-containing heterocyclic ketones and the
expected action thereof it to improve markedly the
10 solubility of the recording agent in the solvent.
For example, N-methyl-2-pyrrolidone and 1,3-dimethyl-
2-imidazolidinone are favorably used.

Inks per se prepared from such components as
described above are superior in recording characteristics
15 (signal responsiveness, stability for producing droplets,
discharge stability, continuous recording workability
for many hours, and discharge stability after a long
rest), storage stability, and also in such
characteristics on the above specified recording medium
20 as dot density, dot shape, degree of spread, clearness
of color, ink absorbability, and ink fixability.
Additionally, various additives may be incorporated
into the inks for the purpose of further improving these
characteristics. These additives include; viscosity
25 modifiers, e.g. polyvinyl alcohol, cellulosic resins,
and other water-soluble resins; various surfactants of
cationic, anionic, and nonionic types; surface tension

1 modifiers, e.g. diethanolamine and triethanolamine;
and pH conditioners such as buffers.

For the preparation of the ink to be used in
the recording system based on the electrification of
5 the ink, an inorganic salt such as lithium chloride,
ammonium chloride, or sodium chloride is used as a
resistivity modifier. Urea or thiourea is favorably
used for improving the water-holding ability of the
ink at a head of a discharge orifice. In the case of
10 the recording system wherein the ink is discharged
by the action of thermal energy, thermal properties
(e.g. specific heat, coefficient of thermal expansion,
and heat conductivity) of the ink may be conditioned.

The ink-jet recording method of the present
15 invention employing the above specified ink and
recording medium may be applied on the basis of any
technique that is capable of discharging the ink
effectively through nozzles and making it adhere to
the above specified recording medium that is the
20 target. Representatives of such techniques
are detailed, for example, in IEEE Transactions on
Industry Applications, Vol, IA-13, No. 1 (Feb. and
Mar. 1977), "Nikkei Electronics" issued April 19, 1976,
January 29, 1973 and May 6, 1974.

25 Some of these techniques are briefly described
below. The first is the electrostatic attraction
technique, which comprises (1) applying a strong

1 electric field between a nozzle and an accelerating
electrode placed apart from several milli meters in
front of the nozzle to withdraw ink particles
successively through the nozzle and applying information
5 signals to deflecting electrodes when the ink particles
fly between these electrodes or (2) jetting ink
particles in response to information signals without
deflecting the path of each particle, thereby recording
information.

10 The second is the supersonic vibration
technique, which comprises applying high pressure with
a small pump to the ink vibrating the nozzle
mechanically by means of e.g. a quartz oscillator to
jet fine ink particles forcibly, giving electric
15 charge at the same time to jetted ink particles in
response to information signals, and deflecting the
path of each ink particles passing between deflecting
electrode plates, in response to amount of the charge
given to the particles.

20 Another type of the supersonic vibration
technique is the micro-dot ink-jet technique, which
comprises discharging two groups of ink droplets
different in size through a nozzle by keeping the ink
pressure and vibration conditions within respective
25 proper ranges, and utilizing the smaller ink droplets
alone for recording. This technique is characterized
in that fine ink droplets can be produced even by using

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a usual large diameter nozzle.

The third is the piezoelectric device technique, which, unlike the other techniques, utilises not any mechanical means such as a pump but a piezoelectric device. This technique comprises jetting ink droplets through a nozzle by applying electric signal to the piezoelectric device to cause mechanical displacement to pressurize the ink. Any of the above various ink-jet recording techniques can be used in the present invention.

It is possible by using the recording medium above described preferably in conjunction with inks as described to obtain good recording results, as will be shown in the following examples, such that the optical density of ink dots is uniform throughout the recording surface, shapes of almost all the ink dots are circles of similar sizes without distortion, and the spread of ink dots is appropriate. Accordingly, the invention permits very distinct, high quality images to be obtained, free of unevenness throughout the recording surface. In addition, the recording medium shows no curling after recording as well and has a good feel.

The invention is illustrated in more detail with reference to the following examples. In the examples parts are all by weight.

1 Example 1a

A coating composition was prepared by using precipitated calcium carbonate (average particle size 1 μm) as a filler and poly (vinyl alcohol) and an

5 SBR latex as binders according to the following recipe:

Precipitated calcium carbonate	100 parts
Polyvinyl alcohol	25 "
SBR latex	5 "
Water	500 "

10 This coating composition was applied on a wood-free paper, as a base paper of 52 g/m^2 in basis weight, 12 seconds in sizing degree, and 65 μm in thickenss by means of a blade coater to give a coating thickenss of 2 μm , and was dried in the ordinary way.

15 The thus obtained recording medium was free of the unevenness of coating thickness and the curling.

Ink-jet recording on this recording medium was performed by using the following six kinds of inks and a recorder provided with an on-demand type of ink-jet

20 recording head (discharge orifice diameter 65 μm , piezoelectric oscillator driving voltage 70 V, its frequency 3 KHz) for discharging ink droplets therefrom by means of the piezoelectric oscillator, and recording characteristics of the recording medium were evaluated.

25 Thus, extremely distinct images free of recording irregularity were obtained. The recording medium did not curl after recording and was good in feel as a paper.

1	Ink No. Aa (composition)		
	Glycerol	8 parts	
	Water	90 parts	
	C.I. Direct Blue 86	2 parts	
5	Ink No. Ba (composition)		
	Glycerol	28 parts	
	Water	70 parts	
	C.I. Direct Blue 86	2 parts	
	Ink No. Ca (composition)		
10	Ethylene glycol	48 parts	
	Water	50 parts	
	C.I. Direct Blue 86	2 parts	
	Ink No. Da (composition)		
	Diethylene glycol	20 parts	
15	N-Methyl-2-pyrrolidone	20 parts	
	Ethyl cellosolve	28 parts	
	Water	30 parts	
	C.I. Direct Blue 86	2 parts	
	Ink No. Ea (composition)		
20	Diethylene glycol	10 parts	
	N-Methyl-2-pyrrolidone	30 parts	
	Ethyl cellosolve	38 parts	
	Water	20 parts	
	C.I. Direct Blue 86	2 parts	
25	Ink No. Fa (composition)		
	Diethylene glycol	10 parts	
	N-Methyl-2-pyrrolidone	40 parts	

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1	Ethyl Cellosolve	38 parts
	Water	10 parts
	C.I. Direct Blue 86	2 parts

Results of the above evaluation of recording
5 characteristics are shown in Table 1a. Measurements
of the evaluation items shown in Table 1a were made
according to the following methods:

(1) Optical density of ink dot: This was
measured by using a Sakura Micro densito meter PDM-5
10 (supplied by Konishiroku Photo Industry Co., Ltd.).

(2) Shape of ink dot: Ink dots were observed
with a stereomicroscope, and rated as follows:

○ ... nearly complete circles
△ ... slightly distorted circles
15 X ... irregular shapes

(3) Degree of ink dot spread: The diameter
of ink dot was measured with a stereomicroscope and
the above degree was expressed by the ratio of the
found diameter to the diameter of ink droplets.

20 (4) Clearness of color: Colors of images
ink-jet recorded were compared with one another by
visual observation and ranked into groups ◎, ○, △
and X in the order of reducing clearness.

(5) Ink absorbability: Three ink droplets
25 were shot to superpose their dots one upon another
and the state of the dots after one second was rated
as follows:

{

1 ○ ... No effusion of the ink on the recording
 surface was observed and the image was
 distinct

 X ... The state other than the above

5 (6) Irregularity in dot diameter: Diameters
of ink dots were measured with a stereomicroscope, and
the irregularity was expressed by ((Standard deviation
of dot diameters)/(Average value of dot diameters))x
100

10 Example 2a

 Various grades of base papers, as shown in Table
2a, different in sizing degree and definite in basis
weight (55 g/m^2) and in thickness ($70 \mu\text{m}$) were coated
similarly to Example 1a with the same coating
15 composition as used therein, thus preparing recording
media.

 In this case, waviness was observed throughout
the recording surface of sample No. 2a-1 and many
coat-lacking sites were observed on the recording
20 surfaces of samples No. 2a-8 and No. 2a-9.

 Using each sample medium shown in Table 2a, the
recording procedure of Example 1a was followed (ink
No. Ba was used). After recording, the irregularity in
dot diameters was determined on each sample. Results
25 thereof are shown in Table 2a.

Example 3a .

 A coating composition was prepared by using a

1 silica powder (tradename: Nipsil E 220 A, supplied by
Nippon Silica Kogyo Co., Ltd., average particle size
1.0 μm) as a filler according to the following recipe:

	Silica	100 parts
5	Starch	30 parts
	SBR latex	10 parts
	Water	300 parts

A portion of this coating composition was
applied on a wood-free paper of 60 g/m^2 in basis
10 weight, 20 seconds in sizing degree, and 73 μm in
thickness by means of a blade coater to give a coating
thickness of 2 μm , and was dried in the ordinary way,
giving a recording medium. On this recording medium,
the unevenness of coating thickness or the coat-lacking
15 site was not observed at all and the curling did not
result. Recording on this recording medium was
conducted in the same manner as in Example 1a, giving
extremely distinct images free of recording irregularity.
This recording medium did not curl on recording and
20 was good in feel as paper. Results of evaluating
recording characteristics are shown in Table 3a.

Example 4a

Various grades of base papers, as shown in
Table 4a, different in basis weight and definite in
25 sizing degree (12 seconds) and in thickness (70 μm and
85 μm) were coated similarly to Example 3a with a
portion of the coating composition prepared therein,

1 thus preparing recording media.

Many coating irregularities were observed on samples No. 4a-1 and No. 4a-2 of these recording media, and sample No. 4a-9 was not good in feel, too.

5 Ink-jet recording on these recording media (all the samples of this example) was made in the same manner as in Example 1a (using ink No. Ca). Then the irregularity in dot diameters was measured on each sample. Results thereof are shown in Table 4a.

10 Example 1b

A coating composition was prepared by using precipitated calcium carbonate (average particle size 1 μm) as a filler and polyvinyl alcohol and an SBR latex as binders according to the following recipe:

15	Precipitated calcium carbonate	100 parts
	Polyvinyl alcohol	25 parts
	SBR latex	5 parts
	Water	500 parts

This coating composition was applied on a
20 wood-free base paper of 52 g/m^2 in basis weight, 12 seconds in sizing degree and 65 μm in thickness by means of a blade coater to give a coating thickness of 2 μm , and was dried in the ordinary way. The thus obtained recording medium was free of the unevenness of
25 coating thickness and the curling.

Ink-jet recording on this recording medium was performed by using the following 6 kinds of inks and a

1 recorder provided with an on-demand type of ink-jet recording head (discharge orifice diameter 65 μ m, piezoelectric oscillator driving voltage 70 V, its frequency 3 KHz) for discharging ink droplets therefrom ; by means of the piezoelectric oscillator, and recording characteristics of this recording medium were evaluated. Thus, extremely distinct images free of recording unevenness were obtained. The recording medium did not curl on recording and was good in feel as paper.

) Ink No. Ab (composition)(viscosity of about 25 cp)

Glycerol	70 parts
Water	30 parts
Acetynol EH (a surfactant supplied by Kawaken Fine chemicals Co., Ltd.)	0.1 part
C.I. Direct Blue 86	2 parts

Ink No. Bb (composition)(viscosity of about 20 cp)

Glycerol	65 parts
Water	35 parts
Acetynol EH	0.1 part
C.I. Direct Blue 86	2 parts

Ink No. Cb (composition)(viscosity of about 15 cp)

Diethylene glycol	80 parts
Water	20 parts
Acetynol EH	0.1 part
C.I. Direct Blue 86	2 parts

1	Ink No. Db (composition)(viscosity of about 10 cp)	
	Diethylene glycol	70 parts
	Water	30 parts
	Acetynol EH	0.1 part
5	C.I. Direct Blue 86	2 parts
	Ink No. Eb (composition)(viscosity of about 5 cp)	
	Triethylene glycol monomethyl	
	ether	50 parts
	Water	50 parts
10	Acetynol EH	0.1 part
	C.I. Direct Blue 86	2 parts
	Ink No. Fb (composition)(viscosity about 3 cp)	
	Ethylene glycol	45 parts
	Water	55 parts
15	Acetynol EH	0.1 part
	C.I. Direct Blue 86	2 parts
	Ink No. Gb (composition)(viscosity of about 1.5 cp)	
	Ethylene glycol	70 parts
	Water	30 parts
20	Acetynol EH	0.1 part
	C.I. Direct Blue 86	2 parts

Results of the above evaluation of recording characteristics are shown in Table 1b. Measurements of the evaluation items shown in Table 1b were made according to the methods described in Example 1a.

Example 2b .

Various grades of base papers, as shown in

1 Table 2b, different in sizing degree and definite in
basis weight (55 g/m^2) and in thickness ($70 \text{ }\mu\text{m}$) were
coated similarly to Example 1b with the same coating
composition as used therein, thus preparing recording
5 media.

In this case, waviness developed throughout
the recording surface of sample No. 2b-1 and many
coat-lacking sites were observed on samples No. 2b-8
and No. 2b-9.

10 Using each sample medium shown in Table 2b,
the recording procedure of Example 1b was repeated
(ink No. Cb was used). After recording, the irregularity
in dot diameters was determined on each sample.
Results thereof are shown in Table 2b.

15 Example 3b

A coating composition was prepared by using
a silica powder (tradename: Nipsil E 220 A, supplied
by Nippon Silica Kogyo Co., Ltd., average particle
size $1.0 \text{ }\mu\text{m}$) as a filler according to the following

20 recipe:

Silica	100 parts
Starch	30 parts
SBR latex	10 parts
Water	300 parts

25 A portion of this coating composition was
applied on a wood-free base paper of 60 g/m^2 in basis
weight, 20 seconds in sizing degree, and $73 \text{ }\mu\text{m}$ in

1 thickness by means of a blade coater to give a
coating thickness of 2 μm , and was dried in the
ordinary way, giving a recording medium. On this
recording medium, the unevenness of coating thickness
5 or the coat-lacking site was not observed at all and
the curling did not result. Recording on this
recording medium in a similar way as in Example 1b
gave extremely distinct images free of record
irregularity. This recording medium did not curl on
10 recording and was good in feel as paper. Results of
evaluating recording characteristics are shown in
Table 3b.

Example 4b

Various grades of base papers, as shown in
15 Table 4, different in basis weight and definite in
sizing degree (12 seconds) and in thickness (70 μm and
85 μm) were coated similarly to Example 3b with a
portion of the coating composition prepared in Example
3b, thus preparing recording media.

20 Many coating irregularities were observed on
samples No. 4b-1 and No. 4b-2 of these recording media,
and sample No. 4b-9 was not good in feel, too.

Ink-jet recording on these recording media
(all the samples of this example) was made in the
25 same manner as in Example 1b (using ink No. Cb). Then
the irregularity in dot diameters was measured on
each sample. Results thereof are shown in Table 4b.

1 Example 1c

A coating composition was prepared by using precipitated calcium carbonate (average particle size 1 μm) as a filler and poly (vinyl alcohol) and an SBR latex as binders according to the following recipe:

Precipitated calcium carbonate	100 parts
Poly (vinyl alcohol)	25 parts
SBR latex	5 parts
Water	500 parts

10 This coating composition was applied on a wood-free base paper of 52 g/m^2 in basis weight, 12 seconds in sizing degree, and 65 μm in thickness by means of a blade coater to give a coating thickness of 2 μm , and was dried in the ordinary way. The thus
15 obtained recording medium was free of the unevenness of coating thickness and the curling.

Ink-jet recording on this recording medium was performed by using the following 6 kinds of inks and a recorder provided with an on-demand type of ink-jet recording head (discharge orifice diameter 65 μm ,
20 piezoelectric oscillator driving voltage 70 V, its frequency 3 KHz) for discharging ink droplets therefrom by means of the piezoelectric oscillator, and recording characteristics of this recording
25 medium were evaluated. Thus, extremely distinct images free of recording unevenness were obtained. The recording medium did not curl after recording and was

1 good in feel as paper.

Ink No. Ac (composition)(surface tension of about
60 dyn/cm)

	Ethylene glycol	30 parts
5	Water	70 parts
	C.I. Direct Blue 86	2 parts

Ink No. Bc (composition)(surface tension of about
55 dyn/cm)

	Ethylene glycol	30 parts
10	Water	70 parts
	Acetynol EH (10 % aq.)(surfactant, supplied by Kawaken Fine Chemicals Co., Ltd.)	0.05 part
	C.I. Direct Blue 86	2 parts

15 Ink No. Cc (composition)(surface tension of about
50 dyn/cm)

	Ethylene glycol	30 parts
	Water	70 parts
	Acetynol EH(10 % aq.)	0.07 part
20	C.I. Direct Blue 86	2 parts

Ink No. Dc (composition)(surface tension of about
45 dyn/cm)

	Ethylene glycol	30 parts
	Water	70 parts
25	Acetynol EH (10 % aq.)	0.5 part
	C.I. Direct Blue 86	2 parts

}

1 Ink No. Ec (composition)(surface tension of about
40 dyn/cm)

	Diethylene glycol	30 parts
	Water	70 parts
5	Acetynol EH (10 % aq.)	1.1 parts
	C.I. Direct Blue 86	2 parts

Ink No. Fc (composition)(surface tension of about
35 dyn/cm)

	Propylene glycol monomethyl ether	30 parts
10	Water	70 parts
	Acetynol EH (10 % aq.)	1.0 part
	C.I. Direct Blue 86	2 parts

Ink No. Gc (composition)(surface tension of about
30 dyn/cm)

15	Propylene glycol monomethyl ether	50 parts
	Water	50 parts
	Acetynol EH (10 % aq.)	0.1 part
	C.I. Direct Blue 86	2 parts

Results of the above evaluation of recording
20 characteristics are shown in Table 1c. Measurements
of the evaluation items shown in Table 1c were made
according to the methods described in Example 1a.

1 Example 2c

Various grades of base papers, as shown in Table 2, different in sizing degree and definite in basis weight (55g/m^2) and in thickness ($70\mu\text{m}$) were
5 coated similarly to Example 1c with the same coating composition as used therein, thus preparing recording media.

In this case, waviness developed throughout the recording surface of sample No.2c-1 and many coat-
10 laking sites were observed on samples No.2c-8 and No. 2c-9.

Using each sample medium shown in Table 2c, the recording procedure of Example 1c was followed (ink No.Cc was used). After recording, the irregularity
15 in dot diameters was determined on each sample. Results thereof are shown in Table 2c.

Example 3c

A coating composition was prepared by using a silica powder (tradename: Nipsil E220A, supplied by
20 Nippon Silica Kogyo Co., Ltd., average particle size $1.0\mu\text{m}$) as a filler according to the following recipe:

	Silica	100 Parts
	Starch	30 parts
	SBR latex	10 parts
25	Water	300 parts

A portion of this coating composition was applied on a wood-free base paper of 60g/m^2 in basis

1 weight, 20 seocnds in sizing degree, and 73 μ m in thick-
ness by means of a blade coater to give a coating thick-
ness of 2 μ m, and was dried in the ordinary way, giving
recording medium. On this recording medium, the un-
5 evenness of coating thickness or the coat-lacking site
was not observed at all and the curling did not result.
Recording on this recording medium in a similar way as
in Example 1c gave extremely distinct images free of
recording irregularity. This recording medium did not
10 curl on recording and was good in feel as paper.
Results of evaluating recording characteristics are
shown in Table 3c.

Example 4c

Various grades of base paper, as shown in
15 Table 4c, different in basis weight and definite in
sizing degree (12 seconds) and in thickness (70 μ m and
85 μ m) were coated similarly to Example 3c with a portion
of the coating composition prepared in Example 3c, thus
preparing recording media.

20 Many coating irregularities were observed on
samples No.4c-1 and No.4c-2 of these recording media,
and sample No.4c-9 was not good in feel, too.

Then, ink-jet recording on these recording media
(all the samples of this examples) was performed in
25 the same manner as in Example 1c (using ink No.Dc).
Thereafter, the irregularity in dot diameters was
measured on each sample. Results thereof are shown in

1 Table 4c.

Example 1d

The ink-jet recording and the evaluation of the ink recording characteristics of the recording medium were repeated similarly to Examples 1a to 4a except for using a neutral paper of 90 g/m^2 in basis weight and 0 seconds in sizing degree being prepared as base paper by mixing a hard wood bleached kraft pulp and a soft wood bleached kraft pulp, as raw material pulps, in a weight ratio of 1 : 1, and beating the mixture in a refiner to a freeness of 100 ml, followed by sheeting, in place of the papers used in Examples 1a to 4a. Similar results to Examples 1a to 4a were obtained.

Example 2d

15 The ink-jet recording and the evaluation of the ink recording characteristics of the recording medium were repeated similarly to Examples 1b to 4b except for using a neutral paper of 50 g/m^2 in basis weight and 30 seconds in sizing degree being prepared as base paper in the same manner as in Example 1d but using an alkylketene dimer (Size Pine K-902, supplied by Arakawa Chemical Co., Ltd.) in the sheeting process as an auxiliary for preparing neutral paper. Similar results to Examples 1b to 4b were obtained.

25 Example 3d

The ink-jet recording and the evaluation of the ink recording characteristics of the recording medium

1 were repeated similarly to Examples 1c to 4c except
 for using the same neutral paper as in Example 3d.
 Similar results to Examples 1c to 4c were obtained.

Table 1a

5	Ink No.	Aa	Ba	Ca	Da	Ea	Fa
	Water content of ink (%)	90	70	50	30	20	10
	Optical density of ink dot	0.64	0.64	0.63	0.63	0.63	0.62
	Shape of ink dot	○	○	○	○	○	○
10	Degree of ink dot spread	4.4	4.5	4.5	4.7	4.9	5.0
	Clearness of color	○	○	○	○	○	○
	Ink absorbability	○	○	○	○	○	○
15	Irregularity in dot diameters	2.8	2.9	3.0	3.2	3.4	3.6

Table 2a

	Sample No.	Sizing degree (sec.) of base paper	Irregularity in dot diameters
	2a-1	2	21.5
20	2a-2	5	9.1
	2a-3	9	7.0
	2a-4	15	2.4
	2a-5	32	3.2
	2a-6	85	4.8
25	2a-7	100	8.3
	2a-8	110	32.6
	2a-9	118	43.5

1

Table 3a

Ink No.	Aa	Ba	Ca	Da	Ea	Fa
Water content of ink (%)	90	70	50	30	20	10
5 Optical density of ink dot	0.79	0.77	0.77	0.76	0.75	0.75
Shape of ink dot	○	○	○	○	○	○
Degree of ink dot spread	3.3	3.3	3.3	3.4	3.6	3.8
Clearness of color	◎	◎	◎	◎	◎	○
10 Ink absorbability	○	○	○	○	○	○
Irregularity in dot diameter	2.6	2.6	2.7	2.9	3.2	3.5

Table 4a

Sample No.	Basis weight of base ₂ paper (g/m ²)	Thickness of paper (μm)	Irregularity in dot diameters
15 4a-1	42	70	32.5
4a-2	48	70	24.7
4a-3	52	70	11.8
20 4a-4	55	70	2.0
4a-5	63	70	3.2
4a-6	70	85	8.4
4a-7	75	85	4.7
4a-8	84	85	3.1
25 4a-9	93	85	2.6

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Table 1b

Ink	Ab	Bb	Cb	Db	Eb	Fb	Gb
Viscosity of ink (cp)	25	20	15	10	5	3	1.5
5 Optical density of ink dot	0.65	0.63	0.62	0.62	0.61	0.61	0.60
Shape of ink dot	△	○	○	○	○	○	○
Degree of ink dot spread	4.8	4.6	4.5	4.4	4.4	4.4	4.4
Clearness of color	○	○	○	○	○	○	○
10 Ink absorbability	○	○	○	○	○	○	○
Irregularity in dot diameters	3.6	3.4	3.3	3.2	3.2	3.0	2.9

Table 2b

Sample No.	Sizing degree of base paper	Irregularity in dot diameters
2b-1	2	24.9
2b-2	5	12.1
2b-3	9	6.5
2b-4	15	3.0
20 2b-5	32	4.2
2b-6	85	5.3
2b-7	100	11.7
2b-8	110	29.4
25 2b-9	118	38.6

1

Table 3b

Ink	Ab	Bb	Cb	Db	Eb	Fb	Gb
Viscosity of ink (cp)	25	20	15	10	5	3	1.5
5 Optical density of ink dot	0.76	0.75	0.75	0.74	0.72	0.72	0.71
Shape of ink dot	△	△	○	○	○	○	○
Degree of ink dot spread	3.0	3.0	2.8	2.8	2.7	2.7	2.6
10 Clearness of color	◎	◎	◎	◎	◎	◎	◎
Ink absorbability	○	○	○	○	○	○	○
Irregularity in dot diameters	3.2	3.2	3.0	2.9	2.7	2.6	2.3

Table 4b

Sample No.	Basis weight of base paper (g/m ²)	Thickness of paper (μm)	Irregularity in dot diameters
4b-1	42	70	38.9
4b-2	48	70	26.0
4b-3	52	70	10.5
20 4b-4	55	70	1.8
4b-5	63	70	2.3
4b-6	70	85	8.8
4b-7	75	85	4.7
4b-8	84	85	3.2
25 4b-9	93	85	1.9

1	Table 1c							
	Ink	Ac	Bc	Cc	Dc	Ec	Fc	Gc
	Surface tension	60	55	50	45	40	35	30
5	optical density of ink dot	0.62	0.63	0.63	0.63	0.64	0.64	0.64
	Shape of ink dot	○	○	○	○	○	○	△
	Degree of ink dot spread	4.3	4.4	4.5	4.5	4.5	4.8	5.0
	Clearness of color	○	○	○	○	○	○	○
10	Ink absorbability	○	○	○	○	○	○	○
	Irregularity in dot diameters	2.3	2.4	2.6	2.6	2.7	3.0	3.4

15	Table 2c		
	Sample No.	sizing degree of base paper (sec)	Irregularity in dot diameters
	2c-1	2	20.4
	2c-2	5	9.2
	2c-3	9	4.6
20	2c-4	15	2.6
	2c-5	32	1.8
	2c-6	85	3.8
	2c-7	100	6.7
	2c-8	110	23.6
25	2c-9	118	32.1

1

Table 3c

Ink	Ac	Bc	Cc	Dc	Ec	Fc	Gc
Surface tension	60	55	50	45	40	35	30
5 Optical density of ink dot	0.75	0.77	0.77	0.77	0.78	0.78	0.78
Shape of ink dot	○	○	○	○	○	○	△
Degree of ink dot spread	3.1	3.2	3.3	3.3	3.3	3.6	3.8
Clearness of color	◎	◎	◎	◎	◎	◎	◎
10 Ink absorbability	○	○	○	○	○	○	○
Irregularity in dot diameters	2.1	2.3	2.4	2.5	2.6	2.9	3.3

Table 4c

Sample No.	Basis weight of base paper (g/m ²)	Thickness of paper (μm)	Irregularity in dot diameters
4c-1	42	70	38.2
4c-2	48	70	20.0
4c-3	52	70	8.2
20 4c-4	55	70	1.9
4c-5	63	70	2.8
4c-6	70	85	9.8
4c-7	75	85	4.2
4c-8	84	85	2.3
25 4c-9	93	85	1.9

CLAIMS:

1. Use in ink-jet recording of recording medium comprising a base paper and an ink acceptor coated on the base paper, characterised in that the
5 base paper has a basis weight of 50 to 90 g/m² and a sizing degree of 5 to 100 seconds.
2. Use according to claim 1, wherein the thickness of the base paper is from 60 to 100 µm.
3. Use according to claim 1 or claim 2
10 wherein the base paper is a neutral paper that is made in a neutral state.
4. Use according to any preceding claim wherein the ink acceptor comprises a filler and binder resin.
- 15 5. An ink-jet recording method utilising a recording medium in accordance with any preceding claim characterised in that the water content of the ink is in the range of 10 to 90 % by weight.

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6. An ink-jet recording method utilising a recording medium in accordance with any of claims 1 to 4 characterised in that the viscosity of the ink is 25 cp or less at 25°C.

5 7. An ink-jet recording method utilising a recording medium in accordance with any of claims 1 to 4 characterised in that the surface tension of the ink is from 20 to 60 dyn/cm at 20°C.

8. A method according to any of claims 5 to 7
10 wherein the ink comprises a dye, water-miscible organic solvent, and water.

9. A method according to any of claims 5 to 8 wherein the water content of the ink is from 30 to 70 % by weight.

15 10. A method according to any of claims 5 to 9 wherein the viscosity of the ink is 15 cp or less at 25°C.

11. A method according to claim 10 wherein the viscosity of the ink is 12 cp or less at 25°C.

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12. A method according to any of claims 5 to 11 wherein the surface tension of the ink is from 35 to 55 dyn/cm at 20°C.

13. A method according to claim 12 wherein the surface tension of the ink is from 40 to 50 dyn/cm at 20°C.