

Recording Medium and Recording Method
Utilizing the Same

The present invention relates to a recording medium best suited for recording with inks and
5 excellent in ink-receiving properties and in the distinctness and other quality of recorded full-color images and to a recording method utilizing the recording medium.

The ink-jet recording process comprises
10 ejecting droplets of recording liquid by various techniques (e.g. the electrostatic attraction technique, the technique of providing mechanical vibration or displacement to the recording liquid by using piezoelectric elements, and the technique of
15 heating the recording liquid to produce a foam and utilizing the foaming pressure), and causing parts or all of the droplets to deposit on a recording medium such as paper. This process draws attention
20 as a recording method capable of high speed printing and multicolor printing, with less noise generation.

Aqueous inks are chiefly used as recording liquids for ink-jet recording from the standpoint of

1 safety and recording characteristics, and a poly-
hydric alcohol or the like is often added to these
inks in order to prevent the nozzle clogging and to
improve the discharge stability.

5 Recording media hitherto used for ink-jet
recording are ordinary paper and sheets called ink-jet
recording papers which are made by forming porous
ink-receiving layers on base paper. However, various
sophisticated characteristics are increasingly
10 demanded also for recording media with the improvement
of ink-jet recorders in functions, such as the speed-
up of recording and the development of multicolor
recording, and with the spreading use of ink-jet
recorders. That is, recording medium for ink-jet
15 recording need to satisfy the following fundamental
requirements in order to record good quality images
with high resolution.

(1) The recording media should absorb ink
as rapidly as possible.

20 (2) When ink dots overlap each other, the
recording media should function so that the later
applied ink will not diffuse into the previously
marked ink dot.

(3) Ink diffusion on the recording media
25 should not be so great as to enlarge the diameter of
ink dots more than necessary.

1 (4) Ink dots on the recording media should have good circularity and the circumferences of the dots should be smooth.

5 (5) Ink dots on the recording media should exhibit high O.D. (optical density) and the outline of each dot should not be blurred.

 In addition, the following requirements need to be satisfied in order to attain such image quality of high resolution by multicolor ink-jet recording as to be comparable to that of color
10 photographs.

 (6) The coloring components of ink should be able to develop excellent colors on a recording medium.

15 (7) The ink-fixing ability of the recording media should be superior since ink droplets as many as the number of ink colors may overlap one another.

 No recording medium satisfying all of these requirements has not been known yet.

20 Most of the conventional recording media for surface image observation purposes are provided with a porous ink-receiving surface layer, the cells of which serve to receive recording liquids and fix the recording agents thereof. Since the recording agents
25 penetrate deep into the ink-receiving layer, the recorded images are low in distinctness.

 When the surface of the ink-receiving layer

1 is non-porous, on the contrary, nonvolatile components
of ink remain such as polyhydric alcohols on the
surface of the layer for many hours after recording
thus long times being required for drying and fixing
5 the ink. Therefore, clothes, if brought into
contact with the recorded image, will be stained and
the image may be impaired.

In one aspect, the invention aims to provide a
recording medium superior particularly in ink-
10 receiving properties and in distinctness of recorded
images as well as a recording method utilizing the
recording medium.

In another aspect, the invention aims to provide
a recording medium on which ink dots uniform in
15 diameter and in optical density and superior in
contrast can be obtained, and a recording method
utilizing the recording medium.

In another aspect, the invention aims to
provide a recording medium on which an image giving
20 perspective feeling and high-quality sensation can
be recorded, and a recording method utilizing the
recording medium.

1 According to one aspect of the invention,
there is provided a recording medium comprising a
substrate and an ink-receiving layer formed thereon,
wherein a recording surface of the ink-receiving
5 layer has a 60° specular gloss of at least 30% as
measured in accordance with JIS Z8741 and a Munsell
lightness of at least 7.5 as measured in accordance
with JIS Z8721, and an opacity no higher than that
of the substrate, and the substrate has a Bekk
10 smoothness of at least 50 sec. as measured in
accordance with JIS P8119.

 According to further aspect of the invention,
there is provided a recording method comprising
forming droplets of at least one recording liquid
15 and causing the droplets to deposit onto the recording
medium of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

 An essential prerequisite for the recording
medium of the invention is that the recording surface

1 thereof should have a 60° specular gloss of at least
30% as measured in accordance with JIS Z8741.

When records such as prints, photographs,
and written records are illuminated directly or
5 indirectly with diffused light, the recorded images
on the records reflect parts of the light and absorb
other parts, thereby diffused light corresponding to
the images being radiated.

For instance, when illuminated, a completely
10 glossless record reflects light to produce diffused
light flux in a complete spherical form
relative to the recorded surface
regardless of the incident angle distribution of
illuminating light.

15 Moreover, even if a record absorbing 100%
of the incident light is made on a recording medium,
about 5% of the light will cause diffuse reflection
according to Frenel's formula before arriving at
absorption sites.

20 Accordingly, a record which absorbs actually
95% of the incident light will exhibit an apparent
optical density (O.D.) as low as about 1.0 even if
the real O.D. of the record is 1.3.

On the recording medium of the invention,
25 however, having a specular gloss of at least 30%,
the apparent O.D. will be about 1.2, the lowering
of the apparent O.D. being little. On the other hand,

1 on the glossy surface of the medium, a distinct image
of high quality can be recorded, since such a surface
is smooth and gives an improved degree of resolution.

Another prerequisite for the recording medium
5 of the invention is that the Munsell lightness should
be at least 7.5 as measured in accordance with JIS
Z8721. A low lightness is not desirable since it
makes the entire image dark and results in a small
difference of the reflectivity between a recorded
10 portion and non-recorded portion even with a highest
O.D. value, thus resulting an image of low contrast
and low mellowness.

In consequence, the recording medium of the
invention has a lightness of at least 7.5, preferably
15 at least 8.0, particularly preferably at least 8.5.

When a recording medium in the invention is
made of a substrate and an ink-receiving layer, the
surface smoothness of the substrate is important to
provide a sufficient gloss to the recording surface
20 and attain uniform diameters of ink dots.

Thus, the Bekk smoothness of the substrate,
as measured in accordance with JIS P8119, is desirably
at least 50 sec., preferably at least 60 sec., for
the purpose of attaining uniform diameters of ink
25 dots.

When a recording medium made by coating a
substrate having a Bekk smoothness of less than

1 50 sec. with an ink-receiving layer is used for
ink-jet recording, the diamters of ink dots will be
nonuniform and no adequate dot O.D. will be attain-
able. This is because the ink-receiving layer formed
5 on the substrate having a smoothness of less than
50 sec. exhibits a great nonuniformity of thickness
on account of the great roughness of the substrate
surface.

On the contrary, when ink-jet recording is
10 conducted on the recording medium of the invention
comprising a substrate having Bekk smoothness of
at least 50 sec., uniform dot diameters and dot O.D.
will be attainable because of the small variation in
the thickness of the ink-receiving layer. Accordingly,
15 images superior in dot resolution, distinctness, and
contrast will be obtained. Additionally, the smooth
surface of the substrate will make it possible to
control the thickness of the ink receiving layer and
the diameters of the dots. Moreover, a small amount
20 of coating material is sufficient to form the ink-
receiving layer, because the layer can be made
uniform and thin. Further the recording medium
comprising a substrate having a Bekk smoothness of
at least 50 sec. exhibits a high gloss and an image
25 of high quality and giving perspective sensation can
be recorded on the medium.

For the smoothing treatment of substrates

1 having low surface smoothness, well-known means,
may be employed such as a machine calendering,
supercalendering and gloss calendering.

5 In order to secure the circularity and gloss
of ink dots and the uniformity of the layer thickness,
the roughness of the substrate surface to be in
contact with the ink-receiving layer should not
exceed 20 μm , expressed in terms of the maximum
height per a base length of 2.5 mm, as measured in
10 accordance with JIS B0601. The recording medium
constituted of a substrate overlaid with an ink-
receiving layer having the construction described
later satisfies the foregoing various property
requirements for ink-jet recording media. Moreover,
15 when ink dots are marked on such a recording medium
with droplets of the same ink in the same amounts
under the same recording conditions, dots generally
uniform in diameter and in O.D. and more distinct
images with good contrast can invariably be obtained.

20 In other words, images exhibiting good
distinctness and good contrast are hardly obtainable
on the recording medium formed by laminating an
ink-receiving layer having the construction described
later, on a substrate surface having such a roughness.
25 that the maximum height per a base length of 2.5 mm
exceeds 20 μm as measured in accordance with JIS B0601.
Reasons for this are as follows:

1 (1) The surface of the ink-receiving layer,
formed on the substrate surface having such a
roughness as mentioned above, has a rough state
nearly corresponding to the roughness of the substrate
5 surface. When ink-jet recording is performed on such
a rough surface of the ink-receiving layer, the
circumferences of the resulting ink dots will be
often deformed or jagged, that is, ink dots having
tood circularity and smooth circumferences will be
10 hardly obtained.

(2) Uniform thickness of the laminated
ink-receiving layer is difficult to obtain, the
absorbability and diffusion state of an ink vary
from site to site on the surface of the ink-receiving
15 layer, and hence the dot diameter and O.D., each of
which should be definite when droplets of the same
ink are applied in the same amounts, vary from dot
to dot.

In contrast to this, the recording medium of
20 the invention gives good shapes of ink dots as stated
above; since the used substrate has such a smooth
surface that nearly equal diameters and densities of
ink dots will be obtained when droplets of the same
ink are applied in the same amounts under the same
25 recording conditions, the above-mentioned problems
are solved and superior quality images with high
resolution can be obtained by ink-jet recording.

1 Moreover, a smoother and glossier recording
surface can be formed, and an image of higher quality
with more perspective sensation can be recorded on
the recording surface, by using a substrate which
5 has such a smooth surface that the maximum height
per a base length of 2.5 mm is up to 6 μ m, even when
an ink-receiving layer of the same construction as
above is laminated on the substrate.

 When a recording medium is made by using a
10 substrate having a rougher surface than the substrate
to be used in the invention, voids are liable to
develop between the ink-receiving layer and the
substrate as the result of the shrinkage of the
resins in the drying and/or cooling step following
15 lamination of the ink-receiving layer. These voids
tend to cause the scaling or flaking of the ink-
receiving layer from the substrate. If such a defect
is present, an recorded image will be markedly
impaired.

20 On the contrary, the recording medium of the
invention has the structure in which an ink-receiving
layer is accurately formed on a substrate surface and
adheres intimately thereto, since the substrate
surface has such smoothness as mentioned above.
25 Therefore, the recording medium of the invention
scarcely suffers from such a defect as the scaling
or flaking of the ink-receiving layer from the

1 substrate, thus solving the above problem.

When an opaque substrate is used in the invention, its opacity needs to be at least 70%, preferably at least 90% as measured in accordance
5 with JIS P8138. If the opacity is less than 70%, the recorded image will be dark and obscure, since transmittance of the incident light through the recording medium is high and a small proportion of the light is therefore reflected from the record.

10 On the other hand, the ink-receiving layer needs to have an opacity not higher than that of the substrate. In general, dyes in ink droplets applied to the surface of an ink-receiving layer penetrate and diffuse thereinto and held in dispersed
15 form therein. Accordingly, if the ink-receiving layer has a high opacity, a large proportion of the incident light will be reflected by the ink-receiving layer, and consequently, a small proportion of the light will be reflected after arriving at the dyes
20 dispersed in the ink-receiving layer. As the result, the recorded image will look whitish and dull without distinctness.

For these reasons, it is desirable for obtaining a highly distinct image that the ink-
25 receiving layer be more transparent while the substrate exhibits a higher reflectivity to incident light. That is, the ink-receiving layer needs to have

1 an opacity not higher than that of the substrate,
and it is desirable in the invention that the
difference in opacity therebetween be large.

The substrate used in the invention may be
5 formed of any suitable material hitherto known.
Suitable transparent substrates include, e.g. films
or plates of polyester resins, diacetate resins,
triacetate resins, acrylic resins, polycarbonate
resins, polyvinyl chloride resins, polyimide resins,
10 Cellophane (trademark) and Celluloid (trademark),
and glass plates. Suitable opaque substrates
include, e.g. ordinary paper, clothes, wood plates,
metal plates, opaque films, synthetic papers, and
further products of treating the transparent substrates
15 to make them opaque.

The ink-receiving layer used in the invention
may be formed of one or more materials, as desired,
having affinity for water and polyhydric alcohols,
which are liquid components of inks. Such materials
20 include natural resins, e.g. polyvinyl alcohol
albumin, gelatin, casein, starch, cationic starch,
gum arabic, and sodium alginate and synthetic resins,
e.g. polyamide, polyvinylpyrrolidone and quaternary
salts thereof, polyethyleneimine, polyvinylpyridinium
25 halide, melamine resin, polyurethane, carboxymethyl-
cellulose, polyester, SBR latex, NBR latex, polyvinyl
formal, polyvinyl methacrylate, polyvinylbutyral,

1 polyacrylonitrile, polyvinyl chloride, polyvinyl
acetate, phenolic resin, and alkyd resin.

For the purpose of further improving the
ink receptivity of the ink-receiving layer or
5 opacifying the layer, a filler can be dispersed
therein such as silica, clay, talc, diatomaceous
earth, calcium carbonate, calcium sulfate, barium
sulfate, aluminum silicate, synthetic zeolite,
alumina, zinc oxide, lithopone, and satin white.

10 Suitable mixing ratios of the filler to the
resin are 1.5 to 0. The mixing ratio of more than
1.5 is undesirable since it lowers the gloss of the
recording surface, the distinctness of the image,
and the contrast.

15 The ink-receiving layer can be formed in the
following ways: Preferably, the resin and, if
necessary, the filler mentioned above, are dissolved
or dispersed in a suitable solvent to prepare a
coating liquid, which is then applied on the above-
20 mentioned transparent type of substrate by a conven-
tional coating method, e.g. the roll coating, rod
bar coating, spray coating, or air-knife coating
method, and then the coating product is dried quickly.
Alternatively, a mixture of the resin and the filler
25 is applied by hot melt coating, or a sheet for use
as the ink-receiving layer is formed separately from
the above materials and laminated with the above

1 substrate.

Besides the above coating methods, the cast coating method may be applied as occasion demands.

5 The thickness of the ink-receiving layer is generally about 0.1 to 200 μm , preferably about 5 to 100 μm .

The present invention has been described above with reference to typical embodiments of the recording medium of the invention. However, it is
10 a matter of course that the recording medium is not limited to these embodiments. In any of the embodiments, the ink-receiving layer and/or a protective layer formed thereon may contain various known additives such as a dispersant, a fluorescent dye,
15 a pH adjusting agent, an antifforming agent, a lubricant, a preservative, and a surfactant.

The present invention is illustrated in more detail with reference to the following examples.

In these examples, parts are all based on weight.

Example 1

20 On a paper substrate, having a Bekk smoothness of 610 sec. (supplied by Sanyo Kokusaku Pulp Co., Ltd.; tradename: Kintai Coat), the following composition was applied by means of a bar coater so as to give a coating of 2 μm dry thickness. The resulting sheet
25 was dried at 80°C for 10 min., thus preparing a recording medium (f) of the invention.

1 Composition:

Hydroxyethylcellulose 5 parts
(supplied by Fuji Chemicals Co., Ltd.;
tardename:HEC AG-15)

5 Calcium carbonate 5 parts
(supplied by Sankyo Seifun Co., Ltd.;
tradename:Eskaron #2000)

Water	90 parts
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Example 2.

On a paper substrate having a Bekk smoothness of 186 sec. supplied by Kanzaki Paper Mfg. Co., Ltd.; tradename: LOSTON Color), the following composition was applied by means of a bar coater so as to give a coating of 5 μ m dry thickness. The resulting sheet was dried at 100°C for 10 min., thus preparing a recording medium (g) of the invention.

15 **Composition:**

Polyvinylpyrrolidone	5 parts
(supplied by GAF Corp.;	
tradename:PVP K-90)	

Polyvinyl alcohol 5 parts
(supplied by Kuraray Co., Ltd.;
tradename: PVA 217)

20	Water	90 parts
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Example 3

On a paper substrate having a Bekk smoothness of 68 sec. (supplied by Kanzaki Paper Mfg. Co., Ltd.; tradename: New Age), the following composition was applied by means of a bar coater so as to give a coating of 10 μ m dry thickness. The resulting sheet was dried at 60°C for 10 min., thus preparing a

1 recording medium (h) of the invention.

Composition:

	Polyvinyl alcohol	8 parts
	(supplied by Kuraray Co., Ltd.;	
	tradename: PVA-420H)	
5	Silica gel	5 parts
	(supplied by Fuji-Davison Chemical,	
	Ltd.; tradename SYLOID 74)("SYLOID" is a	
	registered trade mark)	
	Water	87 parts

Comparative Example 1

10 A recording medium (i) was prepared in the same manner as in Example 1 except for using paper (supplied by Sanyo Kokusaku Pulp Co., Ltd.; tradename Ginrin) having a Bekk smoothness of 28 sec., as the substrate.

Comparative Example 2

15 A recording medium (j) was prepared in the same manner as in Example 2 except for using paper (supplied by Sanyo Kokusaku Pulp Co., Ltd.; tradename Ginzan) having a Bekk smoothness of 34 sec., as the substrate.

1 On the recording media prepared in the above
examples and comparative examples, ink-jet recording
was performed by using a recorder provided with an
on-demand type of head from which inks can be
5 ejected by means of piezo-electric oscillators
(orifice diameter 60 μ m, piezo oscillator driving
voltage 70 V, frequency 2 KHz) and the following four
different inks:

Yellow ink (composition)

10	C.I. Direct Yellow 86	2 parts
	Diethylene glycol	20 parts
	Polyethylene glycol #200	10 parts
	Water	70 parts

Red ink (composition)

15	C.I. Acid Red 35	2 parts
	Diethylene glycol	20 parts
	Polyethylene glycol #200	10 parts
	Water	70 parts

Blue ink (composition)

20	C.I. Direct Blue 86	2 parts
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1	Diethylene glycol	20 parts
	Polyethylene glycol #200	10 parts
	Water	70 parts

Black ink (composition)

5	C.I. Food Black 2	2 parts
	Diethylene glycol	20 parts
	Polyethylene glycol #200	10 parts
	Water	70 parts

Results of evaluating the recording media
10 prepared in Examples 1 - 3 and Comparative Examples
1 and 2 above are shown in Table 1. The evaluation
items shown in Table 1 were determined in the
following ways:

(1) Ink fixing time: This is the time
15 elapsing from attaching ink droplets on the recording
medium to the moment the ink was dried to such an
extent that no ink stuck to the finger touching the
recorded image.

(2) Optical density of ink dot: The optical
20 density of black ink dots was determined with a micro-
densitometer (model Sakura PDM-5, supplied by
Konishiroku Photo Industry Co., Ltd.) by applying the
method of JIS K7505 to printed micro-dots.

(3) Gloss: The 60° specular gloss was
25 measured in accordance with JIS Z8741 by using a
digital varying angle glossmeter (model UGV-5,
supplied by Suga Shikenki Co., Ltd.).

1 (4) Munsell lightness: This was determined
in accordance with JIS Z8721 from the value of
spectroscopic reflectivity measured by using a color
analyzer (model CA-35, supplied by Murakami Color
5 Laboratory, Ltd.).

(5) Ink dot diameter: This was determined by
using an industrial microscope (supplied by Union
Kogaku Co., Ltd.).

10 (6) Bekk smoothness of substrate: This was
determined by using an Oken's air resistance type of
smoothness tester (supplied by Asahi Seiko Co., Ltd.).

15 (7) Panel test: This was conducted for
Comprehensive image evaluation. An illustration
(10 x 20 cm) recorded on the recording medium was
shown to 50 panelists (28 men and 22 women), who were
asked whether the illustration showed a high contrast
and distinctness. The result of the evaluation is
represented by the number of the panelists who
answered with "Yes" to this question.

20 In the table, a mark * in the table means the
ratio of the found-value variance to the average of
the found value.

1

Table 1

Evaluation item	Recording medium				
	f	g	h	i	j
5 Ink fixing time	≤1 min	≤1 min	≤1 min	≤1 min	≤1 min
* O.D. of ink dot	0.018	0.015	0.018	0.087	0.092
* Ink dot diameter	0.022	0.019	0.020	0.072	0.089
10 Bekk smoothness of substrate	610 sec.	186 sec.	68 sec.	28 sec.	34 sec.
Gloss	68	51	62	12	28
Munsell lightness	9.0	8.6	9.2	8.9	9.0
15 Panel test	38	42	40	5	8

1 As demonstrated above, ink-jet recording on
the recording medium having a 60° specular gloss of
at least 30% as measured in accordance with JIS Z8741
and a Munsell lightness of at least 7.5 as measured
5 in accordance with JIS Z8721 provides images high in
O.D. and in contrast, superior in distinctness, and
giving mellowness and high-quality sensation.

 Secondly, ink dots uniform in diameter and
in O.D. are obtainable by ink-jet recording on the
10 recording medium of the present invention wherein the
substrate has a Bekk smoothness of at least 50 sec.
as measured in accordance with JIS P8119. Accordingly,
it is possible to record full-color images high in
contrast, superior in distinctness, and having a high
15 quality.

 Thirdly, images giving perspective feeling
and high-quality sensation can be recorded on this
recording medium since the recording surface thereof
has a high gloss.

1 Fourthly, the recording medium of the
invention has structural advantages in that the
ink-receiving layer can be formed to adhere intimately
to the substrate without developing any appreciable
5 void and hence the void-attributable scaling or
flaking of the ink-receiving layer scarcely from the
substrate scarcely takes place.

 The recording medium of the invention,
although described hereinbefore referring to the
10 application to ink-jet recording, is not particularly
limited to this but is free to use for any recording
method employing inks, for example, thermography.



CLAIMS

1. A recording medium comprising a substrate and an ink-receiving layer formed thereon the recording surface of the ink-receiving layer having a 60° specular gloss of at least 30% as measured in accordance with JIS Z8741, a Munsell lightness of at least 7.5 as measured in accordance with JIS Z8721, and an opacity no higher than that of the substrate, and the substrate having a Bekk smoothness of at least 50 sec. as measured in accordance with JIS P8119.
2. A recording medium according to claim 1, wherein the roughness of the substrate surface in contact with the ink-receiving layer, expressed in terms of the maximum height per a base length of 2.5 mm, is not more than 20 um as measured in accordance with JIS B0601.
3. A recording medium according to claim 1 or 2, wherein the opacity of the substrate is at least 70% as measured in accordance with JIS P8138.



- 25 -

4. A recording medium substantially as described herein with reference to the examples (excluding comparative examples).

5 5. A recording method comprising the steps of forming droplets of at least one recording liquid and causing the deposition of the droplets onto a recording medium according to any preceding claim.

10 6. A recording method according to claim 5, wherein the recording liquid is an ink.
