

DESCRIPTION

Title of Invention

COATED METAL PLATE

5 Technical Field

[0001] The present invention relates to a coated metal sheet.

Background Art

[0002] Stainless steel sheets with designability enhanced by etching, coloring, surface
10 treatment, or the like are used, for example, for conventional door materials, control panels,
and so forth for elevators. Such stainless steel sheets are required to have a less tendency
to be stained with fingerprints and the like, high stain resistance, high scratch resistance,
and so forth. Accordingly, a coating film consisting of resin, wax, oil, or the like is
commonly formed on such a stainless steel sheet.

15 [0003] If a coating film consisting of resin is formed on the surface of a stainless steel
sheet, however, the coating film undergoes cracking, whitening, or the like through
temporal change, frequently leading to deterioration of the designability. Moreover,
re-coating is needed on regular basis for wax and oil.

[0004] Consideration has thus been made on forming a coating film consisting of an
20 inorganic material on the surface of a stainless steel sheet (for example, PTL 1). Coating
films consisting of an inorganic material have advantages of less temporal change and high
hardness.

[0005] On the other hand, more and more stainless steel sheets are provided with
sophisticated design in recent years, and it is required, for example, to provide more
25 elaborate patterns on the surface of a stainless steel sheet. For example, a technique to
enhance designability through reduction of polishing depth for stainless steel sheets has

been adopted.

Citation List

Patent Literature

5 [0006]

PTL 1

Japanese Patent Application Laid-Open No. 2009-1685

Summary of Invention

10 Technical Problem

[0007] If a coating film consisting of an inorganic material is formed on the surface of a metal sheet such as a stainless steel sheet, light reflected on the surface of the metal sheet and light reflected on the surface of the coating film tend to interfere with each other, and hence color unevenness, coloring, or the like (hereinafter, also referred to as "interference
15 patterns") is likely to occur. Moreover, interference patterns are particularly likely to be generated in a metal sheet with high surface smoothness, for example, because of the large amount of light specularly reflected on the surface and the tendency that the surface of the coating film and the surface of the metal sheet lie in parallel.

[0008] Forming a thick coating film on the surface of a metal sheet is contemplated as an
20 approach to prevent generation of such interference patterns. In this case, however, the texture derived from the metal sheet (such as metallic feeling) is likely to be lost, thus disadvantageously leading to deterioration of the designability. Although inclusion of an aggregate in a coating film is contemplated to prevent generation of interference patterns, however, such inclusion is likely to lower the transparency of the coating film, thus and to
25 lead to deterioration of the designability, similarly.

[0009] The present invention has been made in view of such circumstances.

Specifically, an object of the present invention is to provide a coated metal sheet which is superior in stain resistance, does not cause interference patterns, and is superior in designability.

5 Solution to Problem

[0010] The present invention provides the following coated metal sheet.

[1] A coated metal sheet, comprising:

a metal sheet having an average surface roughness, $Ra_{(\text{metal sheet})}$, of $0.40\ \mu\text{m}$ or smaller; and

10 a coating film formed on at least one surface of the metal sheet, substantially consisting of a composition represented by a compositional formula $K_2O \cdot xSiO_2$, where x satisfies $3.5 \leq x < 6.8$, and having an average thickness, t , of $0.2\ \mu\text{m}$ or larger and $3.0\ \mu\text{m}$ or smaller, wherein

the average thickness, t , of the coating film and an average surface roughness, $Ra_{(\text{coating film})}$, of the coating film satisfy expression (1):

$$Ra_{(\text{coating film})} \geq 0.03 / t + 0.15 \quad (1).$$

[0011]

[2] The coated metal sheet according to [1], wherein the average thickness, t , of the coating film and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film further

20 satisfy expression (2):

$$Ra_{(\text{coating film})} \geq 0.08 / t + 0.12 \quad (2).$$

Advantageous Effects of Invention

[0012] The present invention can provide a coated metal sheet which is superior in stain

25 resistance, does not cause interference patterns, and is superior in designability.

Description of Embodiments

[0013] The present invention relates to a coated metal sheet including: a metal sheet having a relatively smooth surface, specifically, a metal sheet having an average surface roughness, $Ra_{(\text{metal sheet})}$, of 0.40 μm or smaller; and a coating film formed on the metal sheet and consisting of an inorganic material. The coated metal sheet can be applied, for example, to door materials and control panels for elevators, outer panels for home appliances, furniture and furnishings, and building materials.

[0014] As described above, consideration has been made on forming a coating film consisting of an inorganic material on the surface of a metal sheet for the purpose of enhancing the stain resistance or the like of a metal sheet. If a coating film consisting of an inorganic material is formed on the surface of a metal sheet having high surface smoothness, however, light reflected on the surface of the metal sheet and light reflected on the surface of the coating film tend to interfere with each other, and hence interference patterns are likely to be generated. Forming a thick coating film to prevent generation of interference patterns is, on the other hand, likely to deteriorate the texture derived from the metal sheet, and thus to lower the designability.

[0015] The present inventors found, in contrast, that if the average thickness, t , of a coating film to be formed on the surface of a metal sheet and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film satisfy a specific relation, interference patterns are less likely to be generated, and a coated metal sheet superior in designability is provided, even when the coating film is thin. Specifically, interference patterns are less likely to be generated if the average thickness, t , of the coating film and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film satisfy expression (1):

$$Ra_{(\text{coating film})} \geq 0.03 / t + 0.15 \quad (1)$$

where the average thickness, t , of the coating film is 0.2 μm or larger and 3.0 μm or smaller.

[0016] The reason why interference patterns are less likely to be generated if the average thickness, t , of the coating film and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film satisfy expression (1) is as follows. As the thickness, t , of the coating film formed on the metal sheet is smaller, light reflected on the surface of the metal sheet and light reflected on the surface of the coating film tend to interfere with each other to a higher degree, and thus interference patterns are more likely to be generated. In view of this, in the coated metal sheet according to the present invention, a coating film is formed so that the surface roughness, $Ra_{(\text{coating film})}$, of the coating film becomes larger as the thickness, t , of the coating film is smaller. Appropriate unevenness in the surface of the coating film tends to cause variation in the direction of light reflected on the surface of the coating film and the direction of light reflected on the surface of the metal sheet and exiting from the surface of the coating film. As a result, the interference between light reflected on the surface of the coating film and light reflected on the surface of the metal sheet becomes difficult to occur, and hence interference patterns are less likely to be generated.

[0017] Here, it is preferable that the average thickness, t , of the coating film and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film further satisfy expression (2). If the average thickness, t , of the coating film and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film satisfy expression (2), interference patterns are further less likely to be generated.

$$Ra_{(\text{coating film})} \geq 0.08 / t + 0.12 \quad (2)$$

[0018] If the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film is excessively large, however, the gloss or the like of the coated metal sheet may be lost to lower the designability. For this reason, the upper limit of the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film is preferably $0.8 \mu\text{m}$, and more preferably $0.4 \mu\text{m}$.

[0019] The average thickness, t , of the coating film is required to be $0.2 \mu\text{m}$ or larger and $3.0 \mu\text{m}$ or smaller; however, the average thickness is more preferably 0.2 to $1.0 \mu\text{m}$. If

the average thickness, t , of the coating film is excessively large, the texture derived from the metal sheet in the coated metal sheet is likely to be deteriorated. If the average thickness, t , of the coating film is $3.0\ \mu\text{m}$ or smaller, in contrast, the light transmission of the coating film is good, and a coated metal sheet having high designability is reliably
5 obtained. If the coating film has the aforementioned average surface roughness, $Ra_{(\text{coating film})}$, and the average thickness, t , of the coating film is $0.2\ \mu\text{m}$ or larger, the coating film formed on the surface of the metal sheet tends to have no gap, thus providing the coated metal sheet with good corrosion resistance.

[0020] The average surface roughness, $Ra_{(\text{metal sheet})}$, of the metal sheet and the average
10 surface roughness, $Ra_{(\text{coating film})}$, of the surface of the coating film are each a value measured in accordance with JIS B0601: 2001, and can be measured by using a known surface roughness meter or the like. The average thickness, t , of the coating film is measured through observation of a cross-section arbitrarily cut out of the coated metal sheet. Specifically, a test piece cut out of the coated metal sheet is embedded in resin,
15 from which an appropriate cross-section is then produced by polishing or the like. Ion milling or the like is further performed for the cross-section to produce a cross-section for precise observation. Ten arbitrary positions are then observed through SEM or TEM, and the average of thicknesses at the 10 positions is used as the average thickness, t .

[0021] In the coated metal sheet according to the present invention, the coating film may
20 be formed only on one surface or on both surfaces of the metal sheet. The coating film may be formed only in some regions of the metal sheet, or in the entire region of one surface or both surfaces of the metal sheet.

[0022] The average value of coating rates per mm^2 at 10 arbitrary positions having the coating film in the coated metal sheet (hereinafter, also referred to as "average coating
25 rate") is preferably 95% or higher, and it is particularly preferable that the coating film formed on the metal sheet have no gap. The shape of each of the regions ($1\ \text{mm}^2$) to

determine coating rates is not limited, and may be any shape, for example, a rectangle such as a square and an oblong square, or a circle; however, the shape is typically a rectangle. The average coating rate is determined in the following manner.

[0023] Ten arbitrary positions (regions of 1 mm²) in regions with the coating film formed therein are subjected to SEM (scanning electron microscopy)/EDS (energy dispersive X-ray spectrometry) to determine Si element distribution. Subsequently, the Si distribution images acquired are binarized by using image processing software. In the binarization, regions with any increase in Si from a reference Si detection value in a part without the coating film formed therein (metal sheet) are assumed as regions with the coating film for processing. From each of the resulting binarized images, the number of pixels in regions with increase in Si (regions with the coating film) is obtained, which is divided by the total number of pixels to calculate the coating rate. The average value of the coating rates is used as the average coating rate.

[0024] Here, the average surface roughness, Ra_(metal sheet), of the metal sheet is required to be 0.40 μm or lower, and is more preferably 0.05 to 0.35 μm. For such a metal sheet, for example, austenitic stainless steel such as SUS304 and SUS316 or ferritic stainless steel such as SUS430 can be used. For applications requiring mechanical strength, it is preferred to use a material made of austenitic or ferritic stainless steel hardened through cold rolling, a sheet of martensitic stainless steel such as SUS410 and SUS420, or a sheet of precipitation-hardened stainless steel such as SUS631. In addition to stainless steel sheets, copper, carbon steel, iron-nickel alloy, various plated steel sheets, and aluminum sheets may be used.

[0025] These metal sheets may have been subjected to surface processing according to a conventional method, for example, smooth surface finish such as BA finish and mirror finish, polishing to give linear patterns such as HL finish for designability and functionality, polishing to give curved patterns such as vibration polishing, embossing to give dots, or

coloring with various techniques such as oxidation coloring and coloring by sputtering.

[0026] The coating film substantially consists of a composition represented by the compositional formula $K_2O \cdot xSiO_2$ ($3.5 \leq x < 6.8$), and can be a film obtained by applying a mixed solution of potassium silicate ($K_2O \cdot nSiO_2$ ($2 \leq n \leq 4$)) and colloidal silica (SiO_2) and drying the mixed solution. The compositional formula $K_2O \cdot xSiO_2$ represents not the state of the elements in the coating film but the ratio of the constituent elements. In the coating film, SiO_2 is typically forming siloxane bonds. On the other hand, potassium is present as potassium ions, electrically attracting and attracted by silicate ions not forming a siloxane bond.

[0027] The ratio of silicon oxide (SiO_2) to potassium oxide (K_2O), which is represented by x in the above compositional formula, is required to be 3.5 or higher and lower than 6.8; however, the ratio is preferably 3.8 or higher and 5.2 or lower. If the value represented by x is lower than 3.5, potassium ions are excessively dissolved out on the surface of the coating film, and the potassium ions dissolved out tend to react with carbon dioxide in the atmosphere to precipitate as carbonate, which is the phenomenon of efflorescence. If the value represented by x is 6.8 or higher, on the other hand, it is required to mix a large amount of colloidal silica in forming the coating film. As a result, the film-forming capability is lowered, and insufficient strength for films may be provided. The composition of the coating film can be adjusted, for example, through the mixing ratio between potassium silicate and colloidal silica. The composition of the coating film can be confirmed by EDS, XRF, EPMA, or the like, and the state of chemical bonding of Si can be confirmed by XPS, IR, or the like.

[0028] The coated metal sheet according to the present invention has high stain resistance due to the coating film consisting of a composition represented by the compositional formula $K_2O \cdot xSiO_2$ ($3.5 \leq x < 6.8$). The reason is inferred as follows. In the coating film consisting of the composition, a trace amount of potassium is dissolved out on the

surface. Potassium ions then attract moisture in the atmosphere through hydration therewith. As a result, the whole surface of the coated metal sheet is covered with a thin water film. Therefore, even when an oil stain of sebum, oil-based ink, or the like attaches to the surface of the coated metal sheet, the stain floats on the water film and can be easily removed by wiping or the like.

[0029] In most cases, it becomes difficult with time to remove a stain attaching to the surface of a coated metal sheet because some of the components of the stain are impregnated into the coating film or the metal sheet. In the coated metal sheet according to the present invention, in contrast, a water film with a sufficient thickness is present on the surface, which makes the permeation of the stain components into the coated metal sheet difficult. In addition, the high hydrophilicity of the coating film facilitates the permeation of water into a space between the surface of the coated metal sheet and the stain. Therefore, stains attaching to the surface of the coated metal sheet can be peeled off, for example, by wiping with a damped cloth. The hydrophilicity of the coating film is inferred to develop by virtue of the high hydration ability of a trace amount of potassium ions dissolved out on the surface of the coating film and the hydrophilicity of silanol groups.

[0030] To obtain the coating film, a mixed solution of potassium silicate and colloidal silica is applied onto a metal sheet in a manner described later, and dried. The potassium silicate and colloidal silica to form the coating film may be each a common reagent or an industrial chemical. Examples of commercially available products of potassium silicate include "Potassium Silicate A" and "Potassium Silicate 2K" produced by Nippon Chemical Industrial CO., LTD.; "Potassium Silicate No. 2" produced by Fuji Kagaku CORP.; and "SNOWTEX K2" produced by Nissan Chemical Corporation. Examples of commercially available products of colloidal silica include "ADELITE AT" produced by ADEKA CORPORATION, "SNOWTEX" produced by Nissan Chemical Corporation, and

"SILICADOL" produced by Nippon Chemical Industrial CO., LTD. To the mixed solution to form the coating film, a solvent, a leveling agent, a defoamer, and so forth may be added, as necessary, together with potassium silicate and colloidal silica.

[0031] To apply the mixed solution to form the coating film, any method may be used which is capable of forming the coating film so that the average thickness, t , of the coating film and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film satisfy expression (1). However, it is difficult to obtain a coating film such that the average thickness, t , and the average surface roughness, $Ra_{(\text{coating film})}$, satisfy expression (1) only by applying the mixed solution onto the metal sheet with a common application method (such as a roll coating method, a curtain flow coating method, bar coating method, and a spraying method), because the mixed solution is easily leveled.

[0032] An example of techniques to obtain a coating film satisfying expression (1) is a method in which the mixed solution is applied and dried in a plurality cycles by adopting an atomization spray method. The atomization spray method can control the particle size of the mixed solution released from a spray discharge nozzle to be smaller (atomize) than that with use of conventional spraying methods, and leveling can be prevented when the mixed solution hits (is applied onto) a steel sheet. In addition, thickness control (thinning) is easier because the amount of application per coating can be reduced, and the number of cycles of applying and drying can be increased. Repeating a cycle of applying and drying a small amount of the mixed solution gradually increases the average surface roughness, $Ra_{(\text{coating film})}$, and thus a coating film satisfying expression (1) is formed.

[0033] Another example is a method in which a cycle of applying the mixed solution onto a metal sheet and drying the mixed solution is repeated, with the nonvolatile components (potassium silicate and colloidal silica) therein reduced. If the amount of the nonvolatile components in the mixed solution is small, the amount of components to substantially form a coating film per application can be reduced. This facilitates thickness

control (thinning), and thus the number of cycles of applying and drying can be increased. Repeating a cycle of applying and drying a small amount of such a mixed solution gradually increases the average surface roughness, $Ra_{(\text{coating film})}$, and thus a coating film satisfying expression (1) is formed. In this case, the amount of the nonvolatile components in the mixed solution is appropriately selected in accordance with a desired thickness, t , or average surface roughness, $Ra_{(\text{coating film})}$, of the coating film, and can be, for example, less than 4mass% to the total amount of the mixed solution.

[0034] The drying time and drying temperature for the mixed solution are appropriately selected in accordance with the amount and type of the solvent contained in the mixed solution.

[0035] In using the atomization spray method, the number of cycles of coating is appropriately selected in accordance with adjustment of the amount of application (spraying duration) per coating, and a targeted average thickness, t , or average surface roughness, $Ra_{(\text{coating film})}$, of the coating film, and is in typical cases preferably about 2 to 20, and more preferably about 4 to 12.

[0036] An example of methods of forming the coating film by using the atomization spray method is a method in which a metal sheet is conveyed very slowly with a conveyer or the like while an atomization spray gun is reciprocated in the direction perpendicular to the traveling direction of the metal sheet. By using this method, the coating film can be continuously formed in an efficient manner.

[0037] Alternatively, a method can be adopted in which the mixed solution is applied by using a roll coating method, and the resultant is further over-coated with the mixed solution by using the atomization spray method. While it is difficult to achieve an average surface roughness, $Ra_{(\text{coating film})}$, satisfying expression (1) with a desired thickness, t , of the coating film by using roll coating singly as conventional techniques, over-coating by the atomization spray method can impart surface roughness. By using the described method,

the coating film can be formed without any gap on the surface of a metal sheet by virtue of the capability of uniformly applying, a feature of roll coating. Accordingly, the method reliably provides a coated metal sheet having high corrosion resistance.

5 Examples

[0038] Hereinafter, the present invention will be described in detail with reference to Examples; however, the present invention is not limited to Examples.

[0039] Coated metal sheets were produced by using the following methods, and surface stain resistance and the presence or absence of interference patterns were determined for each of the coated metal sheets. The metal sheets used were metal sheets A to F listed in Table 1.

[0040]

[Table 1]

Metal sheet	Steel species	Surface finish
A	SUS316	vibration polishing
B	SUS304	hairline polishing
C	SUS430	shot blasting
D	SUS316	vibration polishing + coloring by sputtering
E	SUS304	hairline polishing + oxidation coloration
F	SUS304	dull finish (rolled only)

15 [0041]

[Preparation of mixed solution]

Potassium silicate (product name: Potassium Silicate No. 2, $K_2O \cdot nSiO_2$ ($n = 3.61$), produced by Fuji Kagaku CORP.) and colloidal silica (product name: SILICADOL, produced by Nippon Chemical Industrial CO., LTD.) were mixed together with a mass ratio of 100:13.3 in terms of solid contents to afford a mixed solution. Here, the

concentration of the nonvolatile components (potassium silicate and colloidal silica) was set to 3mass%.

[0042]

[Application of mixed solution]

5 The mixed solution was applied onto each of metal sheets A to F by using a method shown in Table 2 (a roll coating method, spray coating method, and/or atomization spray method). The number of cycles of applying the mixed solution with each method is also shown in Table 2.

10 The average thicknesses, t , of the coating films obtained were determined as follows. First, a test piece was cut out of a coated metal sheet, and the test piece cut out was embedded in resin, from which a cross-section was then produced by polishing. Further, ion milling or the like was performed for the cross-section to produce a cross-section for precise observation, and 10 arbitrary positions therein were observed through SEM. Thickness was measured for the 10 positions, and the average of the
15 thicknesses was used as the average thickness, t . The average surface roughness, $Ra_{(\text{coating film})}$, of each of the coating films obtained was measured by using the surface roughness meter SURFCOM 130A produced by TOKYO SEIMITSU CO., LTD. in accordance with JIS B0601: 2001. The measurements are shown in Table 2. Each of the coating films was evaluated on whether or not the average thickness, t , of the coating film and the
20 average surface roughness $Ra_{(\text{coating film})}$, of the coating film satisfied expression (1) or (2). In evaluation in Table 2, cases of satisfying expression (1) or (2) were rated as "pass", otherwise as "fail".

$$Ra_{(\text{coating film})} \geq 0.03 / t + 0.15 \quad (1)$$

$$Ra_{(\text{coating film})} \geq 0.08 / t + 0.12 \quad (2)$$

25 [0043]

[Evaluation]

An oil-based ink removal test (stain resistance) and determination of the presence or absence of interference patterns were performed for each of the coated metal sheets obtained in Examples and Comparative Examples. The results are shown in Table 2.

[0044] (1) Checking interference patterns

5 The presence or absence of interference patterns was visually evaluated under a standard light source. The standard light source apparatus used was one with product name: Macbeth Judge II, produced by X-Rite Inc. TL84 was used as reference light. Evaluation of interference patterns was based on the following criteria.

A: without any interference pattern (influence on design: none)

10 B: with a few interference patterns (influence on design: mild)

C: with significantly many interference patterns (influence on design: significant)

[0045] (2) Oil-based ink removal test (stain resistance)

On each of the coated metal sheets obtained in Examples and Comparative Examples, an image was drawn with a permanent marker (product name: magic INK (R) No. 700 black, produced by Teranishi Chemical Industry Co., Ltd.). The oil-based ink on
15 the drawing portion was wiped with a cloth (product name: BEMCOT M3-II, produced by Asahi Kasei Corporation) impregnated with water 1 minute and 1 hour after the drawing, and the state of a trace of the oil-based ink after wiping with a damped cloth was evaluated. Evaluation of a trace of the oil-based ink was based on the following criteria.

20 A: without any trace (100% of removal)

B: with a very slight trace (90% or higher and lower than 100% of removal)

C: with a trace (5% or higher and lower than 90% of removal)

D: with almost no removal (lower than 5% of removal)

[0046]

25 [Table 2]

No.	Metal sheet		Coating film				Expression (1)		Expression (2)		Evaluation			Others	
	Metal sheet	Surface roughness, Ra _(metal sheet)	x ^{*1} (mol)	Average thickness, t (μm)	Average surface roughness, Ra _(coating film)	Coating method (number of cycles of applying)	(0.03/t +0.15)	Evaluation	(0.08/t +0.12)	Evaluation	Interference patterns	Oil-based ink removal test			
												After 1 minute	After 1 hour		
1	A	0.21	-	0	-	-	-	-	-	-	A	D	D		Comparative Example
2	A	0.21	4.3	0.5	0.19	roll coating (1)	0.21	fail	0.28	fail	C	A	A		Comparative Example
3	A	0.21	4.3	0.5	0.18	spraying (1)	0.21	fail	0.28	fail	C	A	A		Comparative Example
4	A	0.21	4.3	0.5	0.22	atomization spray (4)	0.21	pass	0.28	fail	B	A	A		Example
5	A	0.21	4.3	0.5	0.25	roll coating (1) + atomization spray (6)	0.21	pass	0.28	fail	B	A	A		Example
6	A	0.21	4.3	0.5	0.27	roll coating (1) + atomization spray (8)	0.21	pass	0.28	fail	B	A	A		Example
7	A	0.21	4.3	0.5	0.29	roll coating (1) + atomization spray (10)	0.21	pass	0.28	pass	A	A	A		Example
8	B	0.25	4.3	0.5	0.31	roll coating (1) + atomization spray (8)	0.21	pass	0.28	pass	A	A	A		Example
9	C	0.34	4.3	0.5	0.34	roll coating (1) + atomization spray (8)	0.21	pass	0.28	pass	A	A	A		Example
10	D	0.19	4.3	0.5	0.28	roll coating (1) + atomization spray (8)	0.21	pass	0.28	pass	A	A	A		Example
11	E	0.22	4.3	0.5	0.30	roll coating (1) + atomization spray (8)	0.21	pass	0.28	pass	A	A	A		Example
12	F	0.48	4.3	0.5	0.36	roll coating (1) + atomization spray (2)	0.21	pass	0.28	pass	A	A	A		Reference Example
13	F	0.48	4.3	0.5	0.20	roll coating (1)	0.21	fail	0.28	fail	A	A	A	without interference pattern	Reference Example
14	A	0.21	3.7	0.5	0.29	roll coating (1) + atomization spray (8)	0.21	pass	0.28	pass	A	A	A		Example
15	A	0.21	6.6	0.5	0.29	roll coating (1) + atomization spray (8)	0.21	pass	0.28	pass	A	A	A		Example
16	A	0.21	3.2	0.5	0.29	roll coating (1) + atomization spray (8)	0.21	pass	0.28	pass	A	A	A	with efflorescence	Comparative Example
17	A	0.21	6.9	-	-	roll coating (1) + atomization spray (8)	-	-	-	-	-	-	-	failure in film formation	Comparative Example
18	A	0.21	4.3	0.2	0.28	roll coating (1) + atomization spray (8)	0.30	fail	0.52	fail	C	A	A		Comparative Example
19	A	0.21	4.3	0.2	0.30	roll coating (1) + atomization spray (12)	0.30	pass	0.52	fail	B	A	A		Example
20	A	0.21	4.3	1.0	0.18	atomization spray (4)	0.18	pass	0.20	fail	B	A	A		Example
21	A	0.21	4.3	1.0	0.20	atomization spray (8)	0.18	pass	0.20	pass	A	A	A		Example
22	A	0.21	4.3	1.5	0.18	atomization spray (4)	0.17	pass	0.17	pass	A	A	A		Example
23	A	0.21	4.3	2.8	0.18	atomization spray (4)	0.16	pass	0.15	pass	A	A	A		Example
24	A	0.21	4.3	2.8	0.14	spraying (1)	0.16	fail	0.15	fail	C	A	A		Comparative Example
25	A	0.21	4.3	0.1	0.19	atomization spray (1)	0.45	fail	0.92	fail	C	A	A	poor coating rate	Comparative Example
26	A	0.21	4.3	3.2	0.18	atomization spray (4)	0.16	pass	0.15	pass	A	A	A	poor designability	Comparative Example

*1 value of x in K₂O·xSiO₂

[0047] As demonstrated in Table 2, while interference patterns were generated when the average thickness, t , and average surface roughness, $Ra_{(\text{coating film})}$, of a coating film did not satisfy expression (1) (rated as "fail") (Nos. 2, 3, 18, 24, and 25), fewer interference patterns were generated when expression (1) was satisfied (rated as "pass") (Nos. 4 to 12, 14 to 16, 19 to 23, and 26). It is inferred that sufficient unevenness formed in the surface of such a coating film made the interference between light reflected on the surface of the metal sheet and light reflected on the surface of the coating film difficult to occur. In particular, no interference pattern was generated when the average thickness, t , and average surface roughness, $Ra_{(\text{coating film})}$, of a coating film satisfied expression (2) (rated as "good") (Nos. 7 to 12, 14 to 16, 21 to 23, and 26). When the average thickness, t , of a coating film exceeded $3.0\ \mu\text{m}$, however, the texture derived from the metal sheet was lost (No. 26). When the surface roughness, $Ra_{(\text{metal sheet})}$, of a metal sheet exceeded $4.0\ \mu\text{m}$, no interference pattern was generated similarly even when the surface roughness after coating did not satisfy expression (1) (No. 13).

[0048] When a coating film was not formed, a trace of oil-based ink could not be removed in the oil-based ink removal test (No. 1). With forming a coating film, in contrast, oil-based ink was successfully removed in any case (Nos. 2 to 16, and 18 to 26). When x in the compositional formula $\text{K}_2\text{O} \cdot x\text{SiO}_2$ was lower than 3.5 for the composition constituting a coating film, efflorescence occurred and the designability of the coated metal sheet was deteriorated (No. 16). When x was 6.8 or higher, on the other hand, film formation failed (No. 17). Further, when the average thickness of a coating film was smaller than $0.2\ \mu\text{m}$, the coating rate was as low as 92%, and the corrosion resistance was lower (No. 25).

[0049] The present application claims priority to Japanese Patent Application No. 2016-181359 filed on September 16, 2016. The contents of the specification of the application are totally incorporated herein by reference.

Industrial Applicability

[0050] The coated metal sheet according to the present invention is superior in stain resistance, does not cause interference patterns, and is superior in designability.

- 5 Accordingly, the coated metal sheet can be applied, for example, to door materials and control panels for elevators, outer panels for home appliances, furniture and furnishings, and various interior building materials.

CLAIMS

Claim 1 A coated metal sheet, comprising:

a metal sheet having an average surface roughness, $Ra_{(\text{metal sheet})}$, of 0.40 μm or
5 smaller; and

a coating film formed on at least one surface of the metal sheet, substantially
consisting of a composition represented by a compositional formula $K_2O \cdot xSiO_2$, where x
satisfies $3.5 \leq x < 6.8$, and having an average thickness, t , of 0.2 μm or larger and 3.0 μm
or smaller, wherein

10 the average thickness, t , of the coating film and an average surface roughness,
 $Ra_{(\text{coating film})}$, of the coating film satisfy expression (1):

$$Ra_{(\text{coating film})} \geq 0.03 / t + 0.15 \quad (1).$$

Claim 2 The coated metal sheet according to claim 1, wherein the average thickness, t ,
15 of the coating film and the average surface roughness, $Ra_{(\text{coating film})}$, of the coating film
further satisfy expression (2):

$$Ra_{(\text{coating film})} \geq 0.08 / t + 0.12 \quad (2).$$