



(11)

EP 4 826 122 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
C23C 22/07 ^(2006.01) **C23C 22/74** ^(2006.01)
C23C 22/82 ^(2006.01)

(21) Application number: **24903100.6**

(52) Cooperative Patent Classification (CPC):
C23C 22/07; C23C 22/74; C23C 22/82

(22) Date of filing: **30.12.2024**

(86) International application number:
PCT/IB2024/063275

(87) International publication number:
WO 2025/126168 (19.06.2025 Gazette 2025/25)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

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(30) Priority: **15.12.2023 KR 20230183911**

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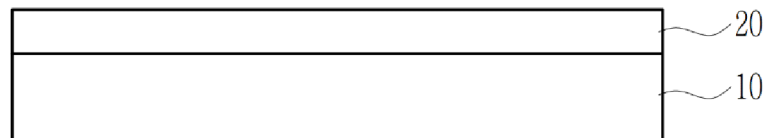
(54) **INSULATION COATING COMPOSITION FOR ELECTRICAL STEEL SHEET, ELECTRICAL STEEL SHEET, AND METHOD FOR MANUFACTURING SAME**

(57) An insulation coating composition for an electrical steel sheet according to an embodiment of the present invention comprises 100 parts by weight of a

metal phosphate, 30 to 170 parts by weight of silica, 20 to 102 parts by weight of a nitrate, and 20 to 102 parts by weight of a Zr compound.

FIG. 1

100



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Description**[Technical Field]**

5 **[0001]** An embodiment of the present invention relates to an insulation coating composition for an electrical steel sheet, an electrical steel sheet, and a manufacturing method thereof. Specifically, it relates to an insulation coating composition for an electrical steel sheet, an electrical steel sheet, and a manufacturing method thereof, which enable the coating to remain intact without separation even in a high temperature and high humidity environment by appropriately combining the components of the insulation coating composition, and which provide an excellent tension providing effect.

[Background Art]

15 **[0002]** An electrical steel sheet is a product used as a material for a transformer, a motor, or an electrical appliance. Unlike general carbon steel, which emphasizes workability such as mechanical properties, the electrical steel sheet is a functional product that emphasizes electrical properties. Required electrical properties include low iron loss, and high magnetic flux density, magnetic permeability, and space factor.

20 **[0003]** Electrical steel sheets are further classified into grain-oriented electrical steel sheets and non-oriented electrical steel sheets. A grain-oriented electrical steel sheet is an electrical steel sheet that exhibits excellent magnetic properties in a rolling direction by forming a Goss texture ($\{110\}<001>$ texture) throughout the steel sheet using an abnormal grain growth phenomenon known as secondary recrystallization. A non-oriented electrical steel sheet is an electrical steel sheet having uniform magnetic properties in all directions of the rolled sheet.

25 **[0004]** Meanwhile, the formation of an insulation coating is a process corresponding to a final manufacturing process of a product. In addition to electrical properties that suppress the generation of eddy current, requirements for this process include: continuous punching workability, which suppresses mold wear when forming an iron core by stacking a plurality of sheets after punching into a predetermined shape; and sticking resistance and surface adhesion, which prevent sticking between iron core steel sheets after an SRA process that recovers magnetic properties by removing processing stress from the steel sheet. In addition to these basic properties, excellent coating workability of the coating solution and solution stability that allows for long term use after mixing are also required. Coating solutions used for this purpose include a chromium-based coating using chromic acid and a phosphate based coating using phosphate.

30 **[0005]** These coatings have excellent corrosion resistance. However, they have disadvantages of being weak in weather resistance and being sticky. If the weather resistance is weak and the coating is sticky, a problem occurs in that the coatings adhere to each other when unwinding a wound coil. In addition, a mottled pattern may be generated on the surface due to defects in various steel sheets.

[Disclosure]**[Technical Problem]**

40 **[0006]** An embodiment of the present invention aims to provide an insulation coating composition for an electrical steel sheet, an electrical steel sheet, and a manufacturing method thereof. Specifically, an embodiment of the present invention aims to provide an insulation coating composition for an electrical steel sheet, an electrical steel sheet, and a manufacturing method thereof, which prevents the coating from delaminating even in a high-temperature and high-humidity environment, and also provides an excellent tension providing effect by appropriately combining the components of the insulation coating composition.

[Technical Solution]

50 **[0007]** An insulation coating composition for an electrical steel sheet according to an embodiment of the present invention comprises 100 parts by weight of a metal phosphate, 30 to 170 parts by weight of silica, 20 to 102 parts by weight of a nitrate, and 20 to 102 parts by weight of a Zr compound.

[0008] The metal phosphate may include at least one of Mg, Ca, Ba, Sr, Zn, and Al.

55 **[0009]** The nitrate may include at least one of aluminum nitrate ($\text{Al}(\text{NO}_3)_3$), cobalt nitrate ($\text{Co}(\text{NO}_3)_2$), calcium nitrate ($\text{Ca}(\text{NO}_3)_2$), strontium nitrate ($\text{Sr}(\text{NO}_3)_2$), zinc nitrate ($\text{Zn}(\text{NO}_3)_2$), manganese nitrate ($\text{Mn}(\text{NO}_3)_2$), magnesium nitrate ($\text{Mg}(\text{NO}_3)_2$), and silver nitrate (AgNO_3).

[0010] The nitrate may include at least two of aluminum nitrate ($\text{Al}(\text{NO}_3)_3$), cobalt nitrate ($\text{Co}(\text{NO}_3)_2$), calcium nitrate ($\text{Ca}(\text{NO}_3)_2$), strontium nitrate ($\text{Sr}(\text{NO}_3)_2$), zinc nitrate ($\text{Zn}(\text{NO}_3)_2$), manganese nitrate ($\text{Mn}(\text{NO}_3)_2$), magnesium nitrate ($\text{Mg}(\text{NO}_3)_2$), and silver nitrate (AgNO_3).

[0011] The Zr compound may include at least one of alkoxy zirconium and zirconyl oxynitrate.

[0012] The silica may have a pH of 8 to 12.

[0013] An electrical steel sheet according to an embodiment of the present invention comprises an electrical steel sheet substrate and an insulation coating located on a surface of the electrical steel sheet substrate, wherein the insulation coating comprises 100 parts by weight of a metal phosphate, 30 to 170 parts by weight of silica, 20 to 102 parts by weight of a nitrate, and 20 to 102 parts by weight of a Zr compound.

[0014] A manufacturing method of an electrical steel sheet according to an embodiment of the present invention comprises: the steps of: preparing an electrical steel sheet substrate; applying an insulation coating composition onto a surface of the electrical steel sheet substrate; and a heat treating the electrical steel sheet substrate, wherein the insulation coating composition comprises 100 parts by weight of metal phosphate, 30 to 170 parts by weight of silica, 20 to 102 parts by weight of nitrate, and 20 to 102 parts by weight of a Zr compound.

[0015] The heat treating step may be performed at a temperature of 700 to 1000°C for 10 to 300 seconds.

[Advantageous Effects]

[0016] According to an embodiment of the present invention, the material exhibits excellent durability in a high temperature and high humidity environment, possesses extreme corrosion resistance, and maintains excellent heat resistance at temperatures high enough to require workability treatments such as stress relief annealing (SRA).

[0017] According to an embodiment of the present invention, the apparatus exhibits an excellent shielding and tensioning effect in a high-frequency magnetic field environment.

[Brief Description of the Drawings]

[0018] Fig. 1 is a schematic view of a cross section of an electrical steel sheet according to an embodiment of the present invention.

[Mode for Invention]

[0019] Terms such as first, second and third are used to describe various parts, components, regions, layers and/or sections, but are not limited thereto. These terms are only used to distinguish any part, component, region, layer or section from another part, component, region, layer or section. Accordingly, a first part, component, region, layer or section described below may be referred to as a second part, component, region, layer or section without departing from the scope of the present invention.

[0020] When an element is referred to as being "on" or "above" another element, it may be directly on or above the other element, or there may be intervening elements therebetween. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements.

[0021] When an element is referred to as being "on" or "above" another element, it may be directly on or above the other element, or there may be intervening elements therebetween. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements.

[0022] Although not defined otherwise, all terms including technical terms and scientific terms used herein have the same meanings as commonly understood by a person skilled in the art to which the present invention belongs. Terms defined in a commonly used dictionary are further interpreted as having meanings consistent with the related technical documents and the currently disclosed content, and are not interpreted as having ideal or very formal meanings unless defined.

[0023] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings so that a person skilled in the art to which the present invention pertains may easily implement the invention. However, the present invention may be implemented in many different forms and is not limited to the embodiments described herein.

[0024] An insulation coating composition for an electrical steel sheet according to an embodiment of the present invention comprises 100 parts by weight of a metal phosphate, 30 to 170 parts by weight of silica, 20 to 102 parts by weight of a nitrate, and 20 to 102 parts by weight of a Zr compound.

[0025] Hereinafter, each component will be described in detail. In an embodiment of the present invention, the term 'parts by weight' refers to a relative weight ratio based on 100 parts by weight of the metal phosphate, and is based on the solid content of each component. The term 'solid content' refers to the weight of each component when dried to a state free of volatile components such as a solvent. Specifically, it refers to the weight remaining after a heat treatment process, assuming such a process is performed during the formation of an insulation coating.

[0026] The metal phosphate acts as a binder in the insulation coating composition. If a proper amount of the metal phosphate is not included, the adhesion of the insulation coating may be deteriorated or sufficient tension may not be

obtained. The metal phosphate may be manufactured by a manufacturing process of adding a metal oxide to pure phosphoric acid (H_3PO_4) and reacting them. In order to improve the adhesion of the metal phosphate, boric acid may be further added during the reaction process and maintained for 3 hours or more to induce a condensation reaction between the metal phosphate and boric acid, and it is also possible to use this condensation reactant instead of the metal phosphate. In an embodiment of the present invention, the metal phosphate includes not only the metal phosphate itself but also a condensation reactant of the metal phosphate and boric acid. The manufactured metal phosphate is strongly acidic.

[0027] The metal phosphate may be added to the composition using a solution having a solid content of 50 to 70% by weight. At this time, if the solid content in the solution is too small, free phosphoric acid in the metal phosphate increases, so that surface moisture absorption may occur after manufacturing the metal phosphate, and if the solid content is too large, a reaction failure and precipitation may occur due to an excess of solid content compared to pure phosphoric acid.

[0028] The metal phosphate and the metal oxide may include various metals without limitation. Specifically, the metal of the metal phosphate and the metal oxide may include at least one of Mg, Ca, Ba, Sr, Zn, and Al. More specifically, the metal phosphate may include at least one of monobasic magnesium phosphate ($\text{Mg}(\text{H}_2\text{PO}_4)_2$) and monobasic aluminum phosphate ($\text{Al}(\text{H}_2\text{PO}_4)_3$). In this case, the metal phosphate may comprise, based on the solid content, 10 to 90 parts by weight of monobasic aluminum phosphate and 10 to 90 parts by weight of monobasic magnesium phosphate with respect to 100 parts by weight of the total. If too little monobasic aluminum phosphate is included, the effect of improving tension by adding monobasic aluminum phosphate may not be sufficient. If too much monobasic aluminum phosphate is added, the Al component increases the crystallization of silica, which may cause cracks in the insulation coating. Specifically, the metal phosphate may comprise, based on the solid content, 20 to 80 parts by weight of monobasic aluminum phosphate and 20 to 80 parts by weight of monobasic magnesium phosphate with respect to 100 parts by weight of the total, and more specifically, 30 to 70 parts by weight of monobasic aluminum phosphate and 30 to 70 parts by weight of monobasic magnesium phosphate.

[0029] An insulation coating composition for an electrical steel sheet according to an embodiment of the present invention comprises 30 to 170 parts by weight of silica based on 100 parts by weight of metal phosphate.

[0030] Silica is a component necessary for reducing iron loss by imparting tension to the steel sheet. If the content of silica is too low, it is difficult to sufficiently obtain a tension imparting effect on the steel sheet. If the content of silica is too high, problems may occur in terms of sticking resistance or solution stability. More specifically, the composition comprises 35 to 160 parts by weight of silica with respect to 100 parts by weight of metal phosphate. Still more specifically, the composition comprises 39 to 100 parts by weight of silica with respect to 100 parts by weight of metal phosphate.

[0031] The silica may be basic or acidic, and more specifically, it may be basic. When basic silica is included, it is advantageous in terms of the stability of the insulation coating composition, and the storage property of the solution may be improved. The basic silica may have a pH of 8 to 12. The pH of the silica may be measured in a sol form.

[0032] The silica may have an average particle diameter in a range of 5 to 20 nm. If the average particle diameter of the silica is too small, the condensation reaction rate becomes fast, resulting in an agglomeration phenomenon and causing a color variation defect on the surface. If the average particle diameter is too large, the surface area per unit mass becomes small, so that the condensation reaction rate becomes slow, and defects may occur accordingly. More specifically, the silica may have an average particle diameter in a range of 10 to 15 nm. In an embodiment of the present invention, the particle size may be measured by a particle size analyzer (Zeta Potential), and the average particle diameter is an arithmetic average.

[0033] The silica may be composed of at least one type of silica nanoparticle having a different average particle diameter. Specifically, in order to form an insulation coating having excellent coating properties, the silica may be used by mixing at least two types of silica nanoparticles having different average particle diameters.

[0034] An insulation coating composition for an electrical steel sheet according to an embodiment of the present invention comprises 20 to 102 parts by weight of a nitrate with respect to 100 parts by weight of a metal phosphate. The nitrate contributes to improving corrosion resistance and weather resistance. In addition, it also serves as a dispersant for stably dispersing a Zr compound, which will be described later, in the insulation coating composition. In particular, when used as an insulation coating for a grain-oriented electrical steel sheet, it is difficult to use an organic dispersant, and the nitrate serves as a dispersant. When the nitrate is included in an excessively small amount, it may be difficult to sufficiently achieve the above-mentioned roles. When the nitrate is included in an excessively large amount, there is a risk of fire. More specifically, the composition comprises 15 to 100 parts by weight of the nitrate with respect to 100 parts by weight of the metal phosphate.

[0035] The nitrate may include at least one of aluminum nitrate ($\text{Al}(\text{NO}_3)_3$), cobalt nitrate ($\text{Co}(\text{NO}_3)_2$), calcium nitrate ($\text{Ca}(\text{NO}_3)_2$), strontium nitrate ($\text{Sr}(\text{NO}_3)_2$), zinc nitrate ($\text{Zn}(\text{NO}_3)_2$), manganese nitrate ($\text{Mn}(\text{NO}_3)_2$), magnesium nitrate ($\text{Mg}(\text{NO}_3)_2$), and silver nitrate (AgNO_3).

[0036] The nitrate may include at least two of aluminum nitrate ($\text{Al}(\text{NO}_3)_3$), cobalt nitrate ($\text{Co}(\text{NO}_3)_2$), calcium nitrate

($\text{Ca}(\text{NO}_3)_2$), strontium nitrate ($\text{Sr}(\text{NO}_3)_2$), zinc nitrate ($\text{Zn}(\text{NO}_3)_2$), manganese nitrate ($\text{Mn}(\text{NO}_3)_2$), magnesium nitrate ($\text{Mg}(\text{NO}_3)_2$), and silver nitrate (AgNO_3). When two or more types of nitrate are included, it is advantageous in terms of improving weather resistance and corrosion resistance. More specifically, the nitrate may comprise aluminum nitrate ($\text{Al}(\text{NO}_3)_3$) and magnesium nitrate ($\text{Mg}(\text{NO}_3)_2$). In this case, 10 to 100 parts by weight of each may be included. More specifically, 13 to 50 parts by weight of each may be included.

[0037] An insulation coating composition for an electrical steel sheet according to an embodiment of the present invention comprises 20 to 102 parts by weight of a Zr compound with respect to 100 parts by weight of a metal phosphate. The Zr compound may improve the corrosion resistance and weather resistance of the insulation coating. When too little of the Zr compound is included, it is difficult to sufficiently achieve the above-mentioned role. When too much of the Zr compound is included, a problem may occur in terms of solution stability. More specifically, 25 to 100 parts by weight of the Zr compound may be included with respect to 100 parts by weight of the metal phosphate.

[0038] The Zr compound may include at least one of alkoxy zirconium and zirconyl oxynitrate.

[0039] Alkoxy zirconium is represented by $\text{Zr}(\text{OR})_4$ (where R is an alkyl group), and may include butoxy zirconium $\text{Zr}(\text{OBu})_4$. In butoxy zirconium $\text{Zr}(\text{OBu})_4$, the butoxy group may be at least one of an n-butoxy group, an iso-butoxy group, a tert-butoxy group, or a sec-butoxy group. More specifically, it may be a tert-butoxy group.

[0040] Zirconyl oxynitrate is represented by $\text{ZrO}(\text{NO}_3)_2$.

[0041] More specifically, it may comprise alkoxy zirconium and zirconyl oxynitrate. In this case, 10 to 100 parts by weight of each may be included. More specifically, 13 to 50 parts by weight of each may be included. When two types of Zr compounds are included, the weather resistance and corrosion resistance may be further improved.

[0042] In addition to the components described above, the composition for forming an insulation coating may further include a solvent. The solvent serves to facilitate the application of the composition and uniformly disperse the components. The amount of the solvent is not particularly limited, but 100 parts by weight to 1000 parts by weight of the solvent may be included with respect to 100 parts by weight of the metal phosphate.

[0043] Fig. 1 shows a schematic view of a cross-section of an electrical steel sheet 100 according to an embodiment of the present invention. As shown in Fig. 1, the electrical steel sheet 100 according to an embodiment of the present invention includes an electrical steel sheet substrate 10 and an insulation coating 20 located on the electrical steel sheet substrate 10.

[0044] As the electrical steel sheet substrate 10, a general non-oriented or grain-oriented electrical steel sheet may be used without limitation. In an embodiment of the present invention, since forming an insulation coating 20 of specific components on the electrical steel sheet substrate 10 is a main configuration, a detailed description of the electrical steel sheet substrate 10 will be omitted.

[0045] Supplementally, the components of the grain-oriented electrical steel sheet substrate are described as follows.

[0046] The grain-oriented electrical steel sheet substrate comprises 2.0 to 7.0 wt% of silicon (Si), 0.020 to 0.040 wt% of aluminum (Al), 0.01 to 0.20 wt% of manganese (Mn), 0.01 to 0.15 wt% of phosphorus (P), 0.01 wt% or less of carbon (C) (excluding 0%), 0.005 to 0.05 wt% of N, and 0.01 to 0.15 wt% of antimony (Sb), tin (Sn), or a combination thereof, and the balance comprises Fe and other inevitable impurities. Since the description of each component of the grain-oriented electrical steel sheet substrate (10) is the same as generally known content, a detailed description thereof will be omitted.

[0047] A metal oxide layer (base coating layer, primary coating), which is formed by reacting with an annealing separator and an oxide layer of the steel sheet during a secondary recrystallization process, may exist between the grain-oriented electrical steel sheet substrate and the insulation coating. An example of the metal oxide layer may be a forsterite layer. In the manufacturing process of the grain-oriented electrical steel sheet, the grain-oriented electrical steel sheet substrate and the insulation coating may contact each other by suppressing the formation of the metal oxide layer or by removing the metal oxide layer.

[0048] The thickness of the insulation coating 20 may be 0.5 to 10 μm . If the thickness of the insulation coating 20 is too thin, it is difficult to secure appropriate insulation. If the thickness of the insulation coating 20 is too thick, the space factor may decrease. In an embodiment of the present invention, appropriate insulation may be secured even if a thin insulation coating 20 is formed. More specifically, the thickness of the insulation coating 20 may be 1 to 5 μm .

[0049] The insulation coating 20 comprises 100 parts by weight of metal phosphate, 30 to 170 parts by weight of silica, 20 to 105 parts by weight of nitrate, and 20 to 105 parts by weight of a Zr compound. The insulation coating may be substantially identical to the solid content of the above-described insulation coating composition.

[0050] A manufacturing method of an electrical steel sheet according to an embodiment of the present invention comprises the steps of: preparing an electrical steel sheet substrate; applying an insulation coating composition onto a surface of the electrical steel sheet substrate; and heat treating the electrical steel sheet substrate.

[0051] Since the detailed content of the electrical steel sheet substrate and the insulation coating composition has been described above, duplicate descriptions will be omitted.

[0052] As an example, the substrate of the electrical steel sheet may be manufactured as follows.

[0053] A steel slab is prepared. In the next step, the steel slab is heated. At this time, the slab may be heated at 1,200°C or lower using a low-temperature slab method. Next, the heated steel slab is hot-rolled to manufacture a hot-rolled sheet. Thereafter, the manufactured hot-rolled sheet may be subjected to hot-rolled sheet annealing. Next, the hot-rolled sheet is cold-rolled to manufacture a cold-rolled sheet. Cold rolling may be performed once, or cold rolling may be performed two or more times including intermediate annealing. Next, the cold-rolled sheet is subjected to primary recrystallization annealing. At this time, the step of performing primary recrystallization annealing on the cold-rolled sheet may include a step of simultaneously performing decarburization annealing and nitriding annealing on the cold-rolled sheet, or may include a step of performing nitriding annealing after decarburization annealing. Next, an annealing separator is applied to the surface of the primary recrystallization annealed steel sheet. The application amount of the annealing separator may be 1 to 5 g/m². If the application amount of the annealing separator is too small, coating formation may not be smoothly achieved. If the application amount of the annealing separator is too large, secondary recrystallization may be affected. Therefore, the application amount of the annealing separator may be adjusted to the above-mentioned range. Next, the steel sheet on which the annealing separator is applied is subjected to secondary recrystallization annealing. In the secondary recrystallization annealing, a primary soaking temperature may be 650 to 750°C, and a second soaking temperature may be 1100 to 1250°C. In the temperature range of the heating section, the temperature may be controlled at a rate of 15°C/hr. In addition, the gas atmosphere may be maintained in an atmosphere containing 20 to 30% by volume of nitrogen and 70 to 80% by volume of hydrogen until the primary soaking step, and in the second soaking step, the sheet may be maintained in a 100% hydrogen atmosphere for 15 hours and then furnace cooled.

[0054] In the heat treating step, the heat treatment temperature may be 700 to 1000°C. If the temperature is too low, the time taken for insulation coating formation is too long, so that continuous processing workability may deteriorate. If the temperature is too high, heat resistance and blueing resistance due to cracking may decrease. More specifically, the heat treatment temperature may be 750 to 950°C. The heat treatment time may be 10 to 300 seconds. More specifically, it may be 30 to 180 seconds.

[0055] The atmosphere during heat treatment may be a nitrogen atmosphere.

[0056] Hereinafter, preferred Examples of the present invention, Comparative Examples contrasted therewith, and evaluation examples thereof will be described. However, the following Examples are only preferred Examples of the present invention, and the present invention is not limited to the following Examples.

Example

[0057] A grain-oriented electrical steel sheet (300*60 mm) having a sheet thickness of 0.23 mm and containing 3.1% Si by weight, provided with a finish annealed primary coating, was prepared as a test material.

[0058] An insulation coating composition was prepared by mixing components in the ratios summarized in Table 1 below. First, basic colloidal silica (average particle diameter of 15 nm) was added to a phosphate solution comprising 50 parts by weight of aluminum phosphate and 50 parts by weight of magnesium phosphate, and the resulting mixture was mixed. Thereafter, a nitrate solution comprising aluminum nitrate and magnesium nitrate was added, and then a Zr compound was added to finally prepare the insulation coating composition.

[0059] The prepared solution was applied to both sides of the electrical steel sheet at 3.1 g/m², and heat treated at 850°C for 45 seconds to form an insulation coating having a thickness of 1 μm.

[0060] Weather resistance, corrosion resistance, solution stability, coating property, and heat-resistant adhesion were evaluated by the following methods and summarized in Table 2.

Weather resistance evaluation

[0061] Weather resistance was evaluated under conditions of 98% humidity, 60°C, and 72 hours, and was indicated as "OK" for good results and "NG" for poor results.

Corrosion resistance evaluation

[0062] A salt spray test was performed under conditions of 5% NaCl, 100% RH, 65°C, and 8 hours. The test results were indicated as "OK" for a good result and "NG" for a poor result.

Solution stability evaluation

[0063] 100 ml of 10% NaOH is used to dissolve a coating plate having a size of 2x2 cm, and the resulting mixture is filtered. A material that remains as an undissolved powder is PO₄. After measuring the weight of the powder remaining on the filter, if the powder exists, it may be determined that HPO₄ was removed by an oxidant.

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[0064] Cl tracking method: After dissolving a 2x2 cm coating in 100 mL of 10% NaOH, if a Cl component is present in the solution, it may be considered that Cl has been added.

Coating property evaluation

[0065] A visual evaluation was performed; the result was indicated as "OK" when no stains were present and as "NG" when stains were present.

Heat resistant adhesion evaluation

[0066] For the heat resistant adhesion evaluation, the sample was heated for 2 hours at 560°C in an atmosphere of 20% hydrogen and 80% nitrogen. Thereafter, it was confirmed that the adhesion was 5B or higher through a cross-hatch cut test.

[0067] If the test result was 5B or higher, it was indicated as "OK"; if the test result was less than 5B, it was indicated as "NG".

[Table 1]

Category (parts by weight)	Phosphate	Silica	Magnesium nitrate	Aluminum nitrate	Butoxy zirconium (Zr(OBu) ₄)	Zirconyl oxynitrate (ZrO(NO ₃))
1	100	39	13	13	13	13
2	100	39	0	26	13	13
3	100	39	26	0	13	13
4	100	39	3	3	13	13
5	100	39	0	0	13	13
6	100	39(acidic)	13	13	13	13
7	100	39	7	7	13	13
8	100	39	13	13	13	13
9	100	39	13	13	0	26
10	100	39	13	13	26	0
11	100	39	13	13	3	3
12	100	39	13	13	7	7
13	100	80	50	50	13	13
14	100	195	61	61	13	13
15	100	39	105	0	13	13
16	100	39	0	105	13	13
17	100	39	13	13	50	50
18	100	39	13	13	61	61
19	100	39	13	13	105	0
20	100	39	13	13	0	105
21	100	80	13	13	13	13
22	100	195	13	13	13	13

[Table 2]

Category	Weather resistance	Corrosion resistance	Solution stability	Coating property	Heat resistant adhesion	Category
1	OK	OK	OK	OK	OK	Example
2	OK	OK	OK	OK	OK	Example
3	OK	OK	OK	OK	OK	Example
4	NG	NG	NG	NG	OK	Comparative Example
5	NG	NG	NG	NG	OK	Comparative Example
6	OK	NG	OK	OK	OK	Comparative Example
7	NG	NG	OK	OK	OK	Comparative Example
8	OK	OK	OK	OK	OK	Example
9	OK	OK	OK	OK	OK	Example
10	OK	OK	OK	OK	OK	Example
11	NG	NG	OK	OK	OK	Comparative Example
12	NG	NG	OK	OK	OK	Comparative Example
13	OK	OK	OK	OK	OK	Example
14	OK	OK	NG	OK	OK	Comparative Example
15	OK	OK	NG	OK	OK	Comparative Example
16	OK	OK	NG	OK	OK	Comparative Example
17	OK	OK	OK	OK	OK	Example
18	OK	OK	NG	OK	OK	Comparative Example
19	OK	OK	NG	OK	NG	Comparative Example
20	OK	OK	NG	OK	NG	Comparative Example
21	OK	OK	OK	OK	OK	Example
22	OK	OK	NG	OK	OK	Comparative Example

[0068] As shown in Table 1 and Table 2, when the components of the insulation coating composition are contained in an appropriate amount, it may be confirmed that weather resistance, corrosion resistance, solution stability, coating properties, and heat resistant adhesion are simultaneously excellent. On the other hand, when the components of the insulation coating composition are not appropriately included, it may be confirmed that some properties are inferior.

[0069] The present invention is not limited to the Examples described above but may be manufactured in various other forms, and it will be understood by a person skilled in the art to which the present invention pertains that the present invention may be embodied in other specific forms without changing the technical spirit or essential features of the present invention. Therefore, it should be understood that the Examples described above are illustrative in all respects and are not restrictive.

[Description of symbols]

100: electrical steel sheet 10: electrical steel sheet substrate
20: insulation coating

Claims

1. An insulation coating composition for an electrical steel sheet comprising:

100 parts by weight of a metal phosphate,

30 to 170 parts by weight of silica,
20 to 102 parts by weight of a nitrate, and
20 to 102 parts by weight of a Zr compound.

- 5 **2.** The insulation coating composition of claim 1,
 wherein the metal phosphate comprises at least one of Mg, Ca, Ba, Sr, Zn, and Al.
- 3.** The insulation coating composition of claim 1,
 wherein the nitrate includes at least one of aluminum nitrate, cobalt nitrate, calcium nitrate, strontium nitrate, zinc
10 nitrate, manganese nitrate, magnesium nitrate, and silver nitrate.
- 4.** The insulation coating composition of claim 1,
 wherein the nitrate includes at least two of aluminum nitrate, cobalt nitrate, calcium nitrate, strontium nitrate, zinc
15 nitrate, manganese nitrate, magnesium nitrate, and silver nitrate.
- 5.** The insulation coating composition of claim 1,
 wherein the Zr compound may include at least one of alkoxy zirconium and zirconyl oxynitrate.
- 6.** The insulation coating composition of claim 1,
20 wherein the silica has a pH of 8 to 12.
- 7.** An electrical steel sheet comprising an electrical steel sheet substrate and an insulation coating located on a
 surface of the electrical steel sheet substrate,
 wherein the insulation coating comprises 100 parts by weight of a metal phosphate, 30 to 170 parts by weight of
25 silica, 20 to 102 parts by weight of a nitrate, and 20 to 102 parts by weight of a Zr compound.
- 8.** A method for manufacturing an electrical steel sheet comprising the steps of:

 preparing an electrical steel sheet substrate;
30 applying an insulation coating composition to a surface of the electrical steel sheet substrate; and
 heat treating the electrical steel sheet substrate,
 wherein the insulation coating composition comprises 100 parts by weight of metal phosphate, 30 to 170 parts
 by weight of silica, 20 to 102 parts by weight of nitrate, and 20 to 102 parts by weight of a Zr compound.
- 35 **9.** The method for manufacturing an electrical steel sheet of claim 8,
 wherein the heat treating step is performed at a temperature of 700 to 1000°C for 10 seconds to 300 seconds.

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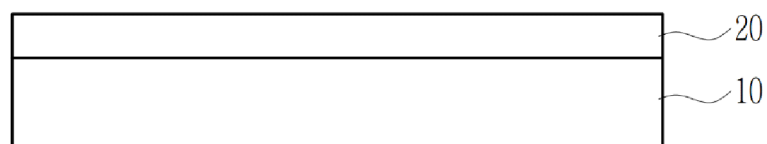
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FIG. 1

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2024/063275

A. CLASSIFICATION OF SUBJECT MATTER

C23C 22/07(2006.01)i; C23C 22/74(2006.01)i; C23C 22/82(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C23C 22/07(2006.01); B05D 3/02(2006.01); C01B 33/40(2006.01); C09D 5/08(2006.01); C21D 9/46(2006.01);
C22C 38/02(2006.01); C22C 38/04(2006.01); C23C 22/00(2006.01); C23C 22/12(2006.01); C23C 22/24(2006.01)

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

Korean utility models and applications for utility models: IPC as above

Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & keywords: 전기강판(electrical steel sheet), 절연코팅(insulation coating), 조성물(composit
ion), 금속 인산염(metal phosphate), Zr화합물(Zr compounds), 실리카(silica), 질산염(nitrate)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 3358041 B1 (NIPPON STEEL CORPORATION) 24 March 2021 (2021-03-24) See claims 1 and 6.	1-9
A	JP 2010-013692 A (NIPPON STEEL CORPORATION) 21 January 2010 (2010-01-21) See claims 1-3.	1-9
A	KR 10-2016-0134781 A (JFE STEEL CORPORATION) 23 November 2016 (2016-11-23) See claim 1.	1-9
A	US 2016-0068687 A1 (NIHON PARKERIZING CO., LTD.) 10 March 2016 (2016-03-10) See claims 1-10.	1-9
A	JP 09-053185 A (NIPPON PARKERIZING CO., LTD.) 25 February 1997 (1997-02-25) See claims 1-9.	1-9

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

* Special categories of cited documents:

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

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“E” earlier application or patent but published on or after the international filing date

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

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

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

“&” document member of the same patent family

Date of the actual completion of the international search

15 April 2025

Date of mailing of the international search report

15 April 2025

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/IB2024/063275

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