

COVERED ELECTRODE

Technical Field

[0001]

5 The present invention relates to a covered electrode.

Background Art

[0002]

10 Shielded metal arc welding is a method in which a covered electrode (simply referred to as an "electrode" or "welding rod " and the like) in which a metal rod (core wire) is provided with a flux or protective material, called a covering, is used as an electrode, an arc is generated between the electrode and a base metal, and welding is performed by melting the electrode and the base metal by arc heat. The shielded metal arc welding does not require shielding gas and can be performed even outdoors with strong
15 wind, and is widely used in various manufacturing factories, buildings, ships, vehicles, or the like.

[0003]

 The covered electrode is required to stably maintain the arc, to form a continuous weld bead, and to be free from defects such as blow holes in the weld bead. From these
20 viewpoints, the inventions described in Patent Literatures 1 to 3, for example, have been proposed for a covered electrode. In addition, it is said that the arc stability is good when the arc can be stably maintained, and the arc stability is poor when the arc cannot be maintained stably.

[0004]

25 Patent Literature 1 describes a low hydrogen type covered electrode in which the average grain size and content of silica sand in the covering are limited within a predetermined range and the contents of rutile, carbonate lime, fluorite, wollastonite, ferromanganese, ferrosilicon are respectively within predetermined ranges.

 Patent Literature 2 describes a covered electrode in which the contents of C, Mn,
30 and O are respectively set within predetermined ranges, and the contents of Si, P, S, Cu, and N are respectively equal to or less than predetermined values.

 Patent Literature 3 describes a covered electrode in which the crystal strain rate of a scale crystal attached to a core base is within a predetermined range.

Citation List

Patent Literature

[0005]

- 5 Patent Literature 1: JP-A-H05-169296
 Patent Literature 2: JP-A-S58-209498
 Patent Literature 3: JP-A-S62-179895

Summary of Invention

10 Technical Problem

[0006]

 In the inventions described in Patent Literatures 1 to 3, although the arc stability is improved by the contents proposed respectively, there is room for improvement concerning the improvement of the arc stability. The present invention has been made in
15 view of the above circumstances, and an object thereof is to provide a covered electrode excellent in arc stability.

[0007]

 The covered electrode which solves the above object is a covered electrode comprising a core wire containing Fe and a covering with which a part of the core wire is
20 covered, wherein: a grip portion of the core wire held by a welding holder is covered with a coating layer containing a Ca compound; an area ratio of the coating layer to the grip portion is 20% or more; the coating layer has a thickness of 0.5 μm to 15 μm ; and the coating layer has a surface roughness Ra of 1.0 μm or less.

25 Solution to Problem

[0008]

 Since a grip portion of a conventional core wire is not covered with a covering such as a flux, the surface oxidizes after manufacturing and before being used in welding, and an oxide film containing FeO, Fe₂O₃, or the like is formed. When an oxide film is
30 formed on the grip portion of the core wire, the arc is unstable.

 However, since the grip portion of the core wire in the covered electrode in the present invention is covered with a coating layer containing a Ca compound, oxidation of Fe contained in the core wire can be prevented. Therefore, an oxide film is hardly formed

on the grip portion of the core wire in the covered electrode in the present invention, and the arc stability is improved.

In the covered electrode in the present invention, since the area ratio of the coating layer containing the Ca compound is equal to or more than the specific value, the arc stability is more reliably improved. In addition, in the covered electrode in the present invention, the thickness of the coating layer is set within the specific range and the surface roughness Ra of the coating layer is equal to or less than the specific value. Therefore, in the covered electrode in the present invention, despite the difficulty in peeling of the coating layer containing the Ca compound until the covered electrode is used in the welding, the coating layer can be easily peeled merely by holding with a welding holder during welding and applying pressure, and a stable arc can be generated.

[0009]

In the covered electrode in the present invention, it is preferable that: a content of Ca in the coating layer, as measured by energy dispersive X-ray spectroscopy, is 15 mass% to 40 mass%; a content of C in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 5 mass% to 25 mass%; a content of O in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 30 mass% to 70 mass%; and a content of K in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 1 mass% to 8 mass%.

With such a configuration, the covered electrode in the present invention has good fixability and peelability of the coating layer containing Ca, and has an effect of preventing the formation of an oxide film in the grip portion of the core wire, so that the arc stability is further improved.

Advantageous Effects of Invention

[0010]

Since the grip portion of the core wire in the covered electrode in the present invention is covered with the coating layer containing the Ca compound, and the area ratio, thickness, and surface roughness Ra of the coating layer are specified, respectively, the arc stability is excellent.

Brief Description of Drawings

[0011]

[FIG.1] FIG.1 is a schematic view of a covered electrode in the present embodiment for explaining one use mode thereof.

[FIG. 2] FIG. 2 is an enlarged sectional view of a part of FIG. 1.

[FIG. 3] FIG. 3 is a graph illustrating an example of a voltage waveform when
5 welding is performed using the covered electrode in the present embodiment.

[FIG. 4] FIG. 4 is an SEM image (magnification is 400 times) of a surface of the covered electrode in the present embodiment. In the image, the scale bar in the lower right shows 10 μm . In addition, in the image, the white portion represents the coating layer containing a Ca compound and the black portion represents a surface of the core
10 wire.

Description of Embodiments

[0012]

An embodiment of the covered electrode in the present invention (hereinafter
15 referred to simply as "electrode") is described in detail with reference to the drawings as appropriate. In the present specification, numerical values before and after indicated by "to" shall be included in the range represented thereby. Numeric values attached with words such as "less than", "smaller than", "exceeded", "greater than" shall not be included in the range represented thereby. In addition, numerical values attached with words such
20 as "or more", "or less" and the like shall be included in the range represented thereby. Further, "mass%" and "weight%" are synonymous.

[0013]

(Electrode)

As shown in FIG. 1, in an electrode 1 in the present embodiment, a part of a core
25 wire (steel core wire) 2 containing Fe (specifically, a prescribed portion in a length direction used as a filler metal) is covered with a covering 3. The partially cut view of the electrode 1 is shown in FIG. 1 for illustrating the internal structure thereof.

Any covering 3 can be used as long as the covering can be used as a so-called flux in the shielded metal arc welding. Examples of such a covering 3 include TiO_2 ,
30 SiO_2 , Al_2O_3 , CaCO_3 , MgCO_3 , BaCO_3 and the like. As the covering 3, one kind of the above-mentioned components can be selected and used alone, or two or more kinds can be selected and used in combination.

[0014]

The core wire 2 may be, for example, a rod-like member having a circular cross section perpendicular to a longitudinal direction, but it is not limited thereto, and any shape may be used as long as the shape can be adopted as an electrode.

[0015]

Specifically, as specified in JIS Z3200: 2005, the electrode 1 in which the core wire 2 is covered with the covering 3 may have a diameter of 1.6 mm ϕ , 2.0 mm ϕ , 2.5 mm ϕ , 2.6 mm ϕ (including the tolerance of ± 0.06 mm ϕ in diameter), and the length in these cases may be set to 200 mm to 350 mm (including the tolerance of ± 5 mm in length). In addition, the diameter of the electrode 1 may be 3.2 mm ϕ , 4.0 mm ϕ , 4.5 mm ϕ , 5.0 mm ϕ , 5.5 mm ϕ , 6.0 mm ϕ , 6.4 mm ϕ , 7.0 mm ϕ (including the tolerance of ± 0.10 mm ϕ in diameter) and 8.0 mm ϕ (including the tolerance of diameter ± 0.1 mm ϕ), and the length in these cases may be set to 275 mm to 450 mm (including the tolerance of ± 5 mm in length).

[0016]

In the electrode 1 in the present embodiment, as shown in FIG. 2, a grip portion 5 of the core wire 2 held by a welding holder 4 is covered with a coating layer 6 containing a Ca compound. The grip portion 5 is a portion to be held by the welding holder 4 during welding.

In addition, as shown in FIG. 1 and FIG. 2, in the electrode 1 in the present embodiment, the grip portion 5 is not covered with the covering 3, and the core wire 2 covered with the coating layer 6 is exposed in the grip portion 5. When welding is performed, the grip portion 5 is held by the welding holder 4, pressure is applied thereto or the grip portion 5 is rubbed to peel off the coating layer 6 covering the grip portion 5 before use. Examples of the Ca compound contained in the coating layer 6 include calcium hydroxide, calcium oxide, and the like.

[0017]

Here, the welding holder 4 is connected to a welding power source 8 with a cable 7. In addition, the welding power source 8 is connected to a base metal (metal to be welded) 10 to be welded, with a cable 9. Any power source can be used as the welding power source 8 as long as the arc can be stably maintained. The current generated by the welding power source 8 may be direct current or alternating current. When welding is performed with direct current, the electrode 1 side may be positive or negative. The voltage value and current value applied to the electrode 1 may be appropriately set in

consideration of the thickness of the base metal 10 and the like. Commercially available welding holders 4, cables 7, 9, welding power source 8, and the like can be used.

[0018]

(Area ratio, thickness, surface roughness of coating layer)

5 In the electrode 1 in the present embodiment, the area ratio of the coating layer 6 to the grip portion 5 is 20% or more, the thickness of the coating layer 6 is 0.5 μm to 15 μm , and the surface roughness Ra of the coating layer 6 is 1.0 μm or less.

[0019]

10 Generally, the arc stability of an electrode is influenced by the chemical composition of the core wire. As a result of the examination by the present inventor, it was found that there is a difference in arc stability even for electrodes manufactured by using core wires having the same chemical composition. Further, as a result of the researches using various core wires by the present inventor, it was found that the properties of the coating layer covering the surface of the core wire influence the arc stability.

15 According to the examination by the present inventor, it was found that the arc stability can be greatly improved especially when the grip portion 5 of the core wire 2 is covered with the coating layer 6 containing a Ca compound. It is difficult to peel off the coating layer without external pressure since the coating layer 6 containing the Ca compound is fixed to the surface of the core wire 2 with a proper fixing force, but when it is held by the welding holder 4 during welding, the coating layer 6 in the portion in contact with the welding holder 4 is peeled off by the pressure, so that the conductivity can be ensured. In addition, it is also considered that the coating layer 6 containing the Ca compound plays a role of preventing the formation of an oxide film on the grip portion 5 of the core wire 2. For this reason, it can be said that the coating layer 6 is suitable for
20 protecting the grip portion 5 of the core wire 2.

[0020]

In the electrode 1 in the present embodiment, when the area ratio of the coating layer 6, that is, the ratio of the area of the coating layer 6 formed to the unit area of the grip portion 5 is 20% or more, good arc stability is reliably obtained.

30 On the other hand, when the area ratio of the coating layer 6 is less than 20%, it is impossible to prevent the formation of an oxide film on the grip portion 5 of the core wire 2, so that the arc stability deteriorates. From the viewpoint of further improving the arc stability, the area ratio of the coating layer 6 is preferably 40% or more, more preferably

50% or more, and even more preferably 70% or more. In addition, it is also possible to set the area ratio of the coating layer 6 to 100%, that is, to completely cover the entire grip portion 5 with the coating layer 6.

[0021]

5 The area ratio of the coating layer 6 can be measured in the following manner. That is, the grip portion 5 of the core wire 2 is analyzed by using a WD/ED combine electron probe micro analyzer (EPMA) JXA-8200 manufactured by JEOL Ltd., with an acceleration voltage of 15 kV and an irradiation current of 5×10^{-10} A (magnification is 400 times, fields of view is three).

10 Further, for one field of view, 1280×950 pixels (1,216,000 pixels) are binarized using image analysis software JTrim to calculate the ratio between black and white. Regarding binarization, it is advisable to set the boundary threshold to 128 (default setting). By performing binarization for three fields of view and calculating the average value of the ratio of white from the measurement result, the area ratio of the coating layer 6
15 can be obtained.

[0022]

 Further, the difficulty level of peeling varies depending on the thickness of the coating layer 6. In the case of the present embodiment, the thickness of the coating layer 6 is preferably 0.5 μm to 15 μm . In this way, the coating layer 6 is hardly peeled off until
20 the welding, and when welding is performed, the grip portion 5 is held by the welding holder 4 and pressure is applied thereto, and then, the coating layer is peeled off. On the other hand, when the thickness of the coating layer 6 exceeds 15 μm , peeling during welding becomes difficult. From the viewpoint of further improving the arc stability, the thickness of the coating layer 6 is more preferably 12 μm or less. In addition, when the
25 thickness of the coating layer 6 is less than 0.5 μm , the coating layer is easily peeled off, so that the coating layer 6 may be peeled off from the grip portion 5 due to shock or the like during transportation. Further, when the thickness of the coating layer 6 is less than 0.5 μm , the effect of preventing the formation of an oxide film on the grip portion 5 of the core wire 2 is insufficient. From the viewpoint of obtaining the effect more sufficiently, the
30 thickness of the coating layer 6 is more preferably 0.7 μm or more, further preferably 1 μm or more.

[0023]

The thickness of the coating layer 6 can be measured as follows: the coating layer 6 is embedded in the resin such that the cross section perpendicular to the longitudinal direction of the core wire 2 serves as the observation surface and the cross section of the core wire 2 is observed by a scanning electron microscope (SEM) (magnification: 1,000 times, and backscattered electron (BSE) image); and the thickness of the coating layer 6 is measured at three places and the average thickness thereof is calculated.

[0024]

Further, the difficulty level of peeling varies depending on the surface roughness of the coating layer 6. When the surface roughness (arithmetic mean roughness) Ra of the coating layer 6 is 1.0 μm or less, when welding is performed, the grip portion 5 is held by the welding holder 4 and pressure is applied thereto, so that the coating layer 6 can be easily peeled off. On the other hand, when the surface roughness Ra of the coating layer 6 exceeds 1.0 μm , peeling during welding becomes difficult. The lower the surface roughness Ra of the coating layer 6 is preferable, and the lower limit thereof is not specified, but the practical lower limit is about 0.05 μm . The surface roughness Ra of the coating layer 6 can be measured by using an apparatus conforming to JIS B 0601: 2001.

[0025]

(Preferred Embodiment of Electrode)

As a preferred embodiment of the electrode 1 in the present embodiment, the content of Ca in the coating layer, as measured by energy dispersive X-ray spectroscopy, is 15 mass% to 40 mass%, the content of C in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 5 mass% to 25 mass%, the content of O in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 30 mass% to 70 mass%, and the content of K in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 1 mass% to 8 mass%. When the coating layer 6 contains Ca, C, O and K within the respective ranges as described above, the fixability and peelability of the coating layer 6 are good, and an effect of preventing the formation of an oxide film on the grip portion of the core wire is improved, so that the arc stability is further improved.

[0026]

Analysis by the energy dispersive X-ray spectroscopy can be carried out as follows. For example, using a WD/ED combine EPMA JXA-8200 manufactured by JEOL Ltd., in the field of magnification of 400, three rectangular places of 10 μm $\times$ 10 μm in the grip portion 5 are selected, and EDX measurement is performed. Quantitative

analysis of EDX can be done by the pure standard method. The concentration (content) of each element is calculated from the intensity ratio between the standard sample and the actual sample. By performing the measurement on the above three places and calculating the average value thereof, the contents of Ca, C, O and K in the coating layer 6 can be
5 determined by EDX.

[0027]

(Manufacturing method)

The electrode 1 in the present embodiment can be manufactured with general equipment under general conditions for manufacturing an electrode. The electrode 1 in
10 the present embodiment can be manufactured, for example, as follows.

Firstly, wire bars or billets containing Fe are manufactured with general equipment under general conditions. Subsequently, they are extruded and drawn to manufacture the core wire 2.

As one embodiment of the manufacturing method, examples thereof include the
15 case of using a lubricant containing calcium hydroxide as the main component (70 mass% or more) during drawing. The coating amount of the lubricant can be 0.5 mg/cm² to 1.0 mg/cm². The drawing rate can be 300 m/min to 770 m/min. The temperature of the core wire 2 during drawing can be 100 °C to 120 °C. These drawing conditions are merely described as one example, and the present embodiment is not limited to these
20 conditions.

After the grip portion 5 of the core wire 2 is covered with the coating layer 6 in this way, the area ratio, thickness and surface roughness Ra of the coating layer 6 are adjusted within the respective ranges described above. These adjustments can be made, for example, by using a mechanical descaler to remove the scale.

25 Thereafter, by covering a portion to be a filler metal with the covering 3, the electrode 1 in the present embodiment can be manufactured.

Examples

[0028]

30 Next, the present invention is described in detail with reference to examples which produce the effects of the present invention, and Comparative Examples which do not produce the effects.

A wire bar having the components shown in Table 1 was manufactured with general equipment under general conditions. Subsequently, the wire bar was drawn using a lubricant having the components shown in Table 2 to manufacture a core wire having a diameter of 3.2 mmφ and a length of 350 mm. Then, using a mechanical descender, the coating layer containing the Ca compound was treated by changing the conditions variously, and a covered electrode including a coating layer with an area ratio (%), a thickness (μm), and a surface roughness Ra (μm) shown in No. 1 to No. 20 in Table 3 later was manufactured. The area ratio, thickness and surface roughness of the coating layer containing the Ca compound were measured in the following manner, respectively.

[0029]

Table 1

	Chemical components of core wire (mass%)							
	C	Si	Mn	P	S	Ni	O	N
Core wire	0.06	0.01	0.4	0.006	0.005	0.01	0.003	0.0046

[0030]

Table 2

	Components of lubricant (mass%)					
	CaO	MgO	SiO ₂	Ca(OH) ₂	NaOH	H ₂ O
Lubricant	54	3	6	13	0.5	23.5

[0031]

(1) Area ratio of coating layer

The area ratio of the coating layer containing the Ca compound to the grip portion was measured by using a WD/ED combine EPMA JXA-8200 manufactured by JEOL Ltd. with an accelerating voltage of 15 kV and an irradiation current of 5×10^{-10} A to analyze the grip portion of the core wire (magnification was 400 times, and fields of view was three). Further, for one field of view, $1,280 \times 950$ pixels (1,216,000 pixels) were binarized using the image analysis software JTrim to calculate the ratio between black and white.

Regarding the binarization, the boundary threshold was set to 128. By performing binarization for three fields of view and calculating the average value of the ratio of white from the measurement result, the area ratio of the coating layer containing the Ca compound was obtained.

[0032]

(2) Thickness of coating layer

The thickness of the coating layer containing the Ca compound was measured as follows: the coating layer was embedded in the resin such that the cross section perpendicular to the longitudinal direction of the core wire was the observation surface and the cross section of the core wire was observed by SEM (magnification: 1,000 times and BSE image); and the thickness of the coating layer was measured at three places and the average thickness was calculated.

[0033]

(3) Surface roughness of coating layer

The surface roughness Ra of the coating layer containing the Ca compound was measured by using an apparatus conforming to JIS B 0601: 2001.

[0034]

(4) Arc Stability

Shielded gas arc welding was performed using the manufactured electrodes in No. 1 to No. 20 under the following welding conditions, and the arc stability was evaluated.

[0035]

<Welding Conditions>

·Welding position: Downward bead on plate

·Covered electrode diameter: 4.0 mmφ

·Current value: 160 Amp. (target)

·Voltage: 25 V (target)

·Thickness of base metal: 12 mm

[0036]

[Evaluation of Arc Stability]

The arc stability was evaluated by observing the voltage waveform and counting the number of rapid voltage drops occurring per 30 seconds. The rapid voltage drop means that the voltage drop by 5 V or more with respect to the average voltage. In FIG. 3, a thick solid line indicated by “⊙” is a voltage waveform in which a rapid voltage drop does not occur, and a thin solid line indicated by “×” is an example of a voltage waveform in which a rapid voltage drop occurs. As shown in FIG. 3, in the example of a thin solid line indicated by “×”, it can be seen that a rapid voltage drop occurs at a position of about 14 seconds and a position of about 22 seconds. The measurement of voltage data was

performed using NR 2000 and NR 2010 manufactured by Keyence Corporation. WAVE SHOT! 2000 (version 1.08, default setting) was used as data collection software.

[0037]

The arc stability was evaluated as follows.

5 A: The number of rapid voltage drops occurring per 30 seconds exceeds 0.5 time, and is 1 time or less

AA: The number of rapid voltage drops occurring per 30 seconds exceeds 0, and is 0.5 time or less

10 AAA: The number of rapid voltage drops occurring per 30 seconds is 0 (the number of rapid voltage drops is 0 three times in all three welding)

B: The number of rapid voltage drops occurring per 30 seconds exceeds 1 time

The number of voltage drops was calculated by averaging the results of welding three times for each sample. The evaluation results of the arc stability are shown in Table 3.

15 [0038]

(5) Analysis of elements in coating layer

In addition, the elements in the coating layer were analyzed as follows.

Using a WD/ED combine EPMA JXA-8200 manufactured by JEOL Ltd., in the field of magnification of 400, three rectangular region of $10\ \mu\text{m} \times 10\ \mu\text{m}$ in the grip portion 5 were selected, and EDX measurement was performed. Quantitative analysis of EDX was performed by a pure standard method. The content of each element was calculated from the intensity ratio between the standard sample and the actual sample. By performing the measurement on the above three places and calculating the average value thereof, the contents (mass%) of Ca, C, O and K in the coating layer were determined by EDX. In Table 3, those in which the content of Ca was 15 mass% to 40 mass%, the content of C was 5 mass% to 25 mass%, the content of O was 30 mass% to 70 mass% and the content of K was 1 mass% to 8 mass% were indicated as "○", and those not included in the above ranges are indicated by "×".

[0039]

Table 3

No.	Area ratio of coating layer (%)	Thickness of coating layer (μm)	Surface roughness (μm)	Elements in coating layer				Arc stability
				Ca	C	O	K	
				EDX Measurement Value				
1	55	1.3	0.25	○	○	○	○	AAA
2	80	12	0.23	○	○	○	○	AAA
3	60	3	0.2	○	○	○	○	AAA
4	62	1.5	0.1	○	○	○	○	AAA
5	70	1.5	0.2	○	○	○	○	AAA
6	42	1.6	0.15	○	○	○	○	AA
7	22	1.7	0.18	○	○	○	○	A
8	68	0.8	0.2	○	○	○	○	AA
9	57	0.5	0.2	○	○	○	○	A
10	59	1.9	0.7	○	○	○	○	AA
11	60	1.9	1	○	○	○	○	A
12	57	1.2	0.26	○	○	×	×	A
13	48	0.9	0.28	○	×	○	×	A
14	53	0.7	0.54	○	×	×	○	A
15	44	0.6	0.86	○	○	○	×	A
16	53	0.9	0.93	○	○	×	○	A
17	38	0.3	0.95	○	○	○	○	B
18	18	0.6	0.92	○	○	○	○	B
19	35	0.9	1.15	○	○	○	○	B
20	55	16	0.2	○	○	○	○	B

[0040]

As shown in Table 3, it is confirmed that the electrodes in No. 1 to No. 16 in the embodiment of the present invention had excellent arc stability. Particularly, when the electrodes in No. 1 to No. 11 in which the contents of Ca, C, O and K satisfy the specific requirements tended to have better arc stability. FIG. 4 shows an SEM image (magnification: 400 times) of a surface of the covered electrode in No. 1.

[0041]

The evaluation results of the electrodes in No. 17 to No. 20 as Comparative Examples are shown in Table 3.

Specifically, the electrode in No. 17 was inferior in arc stability since the coating layer containing the Ca compound was too thin.

The electrode in No. 18 was inferior in arc stability since the area ratio of the coating layer containing the Ca compound was too small.

The electrode in No. 19 was inferior in arc stability since the surface roughness of the coating layer containing the Ca compound was too large.

The electrode in No. 20 was inferior in arc stability since the thickness of the coating layer containing the Ca compound was too large.

[0042]

While the present invention has been described in detail and with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof. This application is based on Japanese Patent Application No. 2016-148388 filed on July 28, 2016, the entire subject matters of which are incorporated herein by reference.

Description of Reference Numerals

[0043]

- 1: Electrode (Covered electrode)
- 2: Core wire
- 3: Covering
- 4: Welding holder
- 5: Grip portion
- 6: Coating layer

CLAIMS

1. A covered electrode comprising a core wire containing Fe and a covering with which a part of the core wire is covered, wherein:

5 a grip portion of the core wire held by a welding holder is covered with a coating layer containing a Ca compound;

an area ratio of the coating layer to the grip portion is 20% or more;

the coating layer has a thickness of 0.5 μm to 15 μm ; and

the coating layer has a surface roughness Ra of 1.0 μm or less.

10

2. The covered electrode according to claim 1, wherein:

a content of Ca in the coating layer, as measured by energy dispersive X-ray spectroscopy, is 15 mass% to 40 mass%;

15 a content of C in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 5 mass% to 25 mass%;

a content of O in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 30 mass% to 70 mass%; and

20 a content of K in the coating layer, as measured by the energy dispersive X-ray spectroscopy, is 1 mass% to 8 mass%.