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(54) **IONIC LIQUID FOR PICKLING STAINLESS STEEL AND METHOD FOR PICKLING STAINLESS STEEL BY USING SAME**

(57) Disclosed are an ionic liquid for pickling a stainless steel capable of rapidly removing oxide scale from the stainless steel at room temperature without using nitric acid or hydrofluoric acid and a method for pickling a stainless steel by using the same.

The method for pickling a stainless steel according to an embodiment includes performing electrolytic pickling treatment by immersing a stainless steel in a pickling solution including an ionic liquid, wherein the ionic liquid

comprises at least one of an imidazolium cation, a betainium cation, a sulfonium cation, a piperidinium cation, a phosphonium cation, an ammonium cation, a pyridium cation, a pyrrolidinium cation, and a morpholinium cation, as a cationic functional group, and at least one of a halide anion, a sulfonate anion, an alkylsulfate anion, a phosphinate anion, a salicylate anion, a nitrate anion, a tetrafluoroborate anion, a hexafluorophosphate anion, and a bistriflimide anion, as an anionic functional group.

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Description

[Technical Field]

5 **[0001]** The present disclosure relates to an ionic liquid for pickling a stainless steel and a method for pickling a stainless steel by using the same, and more particularly, to an ionic liquid for pickling a stainless steel capable of rapidly removing oxide scale from the stainless steel at room temperature without using nitric acid or hydrofluoric acid and a method for pickling a stainless steel by using the same.

10 [Background Art]

15 **[0002]** Cold-rolled stainless steel sheets undergo a heat treatment process at a temperature of 800 to 1150°C to obtain mechanical properties after cold rolling. In this case, oxide scale (SiO_2 , $(\text{Cr,Fe})_3\text{O}_4$) having a thickness of 100 to 300 nm, or the like is generally formed by reaction between high-temperature oxygen in a furnace and the surface of the cold-rolled steel sheet, and thus surface quality deteriorates and corrosion resistance decreases.

20 **[0003]** Therefore, a pickling process to remove such oxide scale is conducted in order to obtain a cold-rolled stainless steel sheet having high surface quality and excellent corrosion resistance. In general, the pickling process is performed by using various methods, alone or in combination, such as physical descaling (brushing and shot ball blasting), electrolytic descaling (sodium sulfate, sulfuric acid, or nitric acid electrolyte), and chemical descaling (salt bath and mixed acid bath).

25 **[0004]** A conventional pickling process is generally performed in two steps. A primary pickling step to remove oxide scale is conducted by immersing a stainless steel in a solution containing sodium sulfate electrolyte and applying a current thereto or by immersing the stainless steel in a salt bath containing sodium hydroxide and sodium nitrate at a high temperature of 400°C or higher, and then a secondary pickling step is performed by using nitric acid or a mixed acid containing nitric acid and hydrofluoric acid at a high temperature of 80°C or higher to obtain high surface quality and corrosion resistance by uniformly forming a passivated layer. In this regard, nitric acid has effects on increasing the activity of hydrofluoric acid by lowering a pH in a pickling bath and maintaining an oxidation-reduction potential suitable for pickling by oxidizing ferrous cation (Fe^{2+}) dissolved on the surface of the steel sheet to ferric cation (Fe^{3+}).

30 **[0005]** However, nitric acid causes various environmental problems. The use of a salt containing nitric acid and nitric acid generates NO_x that is a substance whose emission into the atmosphere is regulated and nitrate nitrogen ($\text{NO}_3\text{-N}$) is contained in waste acid and wash water. In addition, there may be a problem that production costs are considerably increased due to additional installation of facilities to prevent environmental pollution in a pickling process and operation costs thereof because a total nitrogen contained in discharged effluent water is limited and a NO_x concentration of a facility discharging to atmosphere is limited in accordance with domestic and foreign strengthened environmental regulations.

35 **[0006]** As a prior art to solve these problems, developed is a nitric acid-free pickling method in which nitric acid is replaced with hydrochloric acid, sulfuric acid, or the like and insufficient oxidizing power is replaced by hydrogen peroxide, potassium permanganate, ferric ion (Fe^{3+}), and air injection during a pickling process.

40 **[0007]** Starting with Patent Document 1 in which an oxidation-reduction potential of a pickling solution is maintained at 300 mV or more by using sulfuric acid, hydrofluoric acid, or iron sulfate as a pickling solution and adding hydrogen peroxide, Patent Documents 2 and 3 in which ranges of hydrofluoric acid, iron ions, air, hydrogen peroxide, and oxidation-reduction potential (ORP) of a solution are appropriately modified, and other patent applications have been continuously filed since the 1990s. However, most of those methods are limitedly applicable to products that do not strictly require high quality such as wire rods, bar steels, thick plates.

45 **[0008]** Patent Document 4 discloses a pickling method by using a pickling solution containing sulfuric acid, hydrofluoric acid, and ferric salt, periodically adding hydrogen peroxide, and adjusting a composition of a wetting agent, a polishing agent, and a corrosion inhibitor, wherein the pickling solution is automatically controlled based on Fe(III) and ORP thereby. Accordingly, CLEANOX352, as a pickling solution, has been commercialized and the most widely used worldwide. Although this method has been practically used for wire rods and hot-rolled products, manufacturing costs for products are higher than those of conventional products by 20% or more and the composition of the pickling solution and the control method are complex. Particularly, due to a relatively low pickling rate of about 1.5 to 3 $\text{g/m}^2\text{-min}$, this method is not suitable for a high-speed pickling ($\text{TV}=130$ or more). In addition, Patent Document 5, as a patent disclosing improved properties, discloses a method of increasing a pickling rate by adding copper and chlorine ions to a pickling composition. However, when an open circuit potential (OCP) of the surface of a ferritic stainless steel sheet is less than an oxidation-reduction potential (0.1 V) of copper, copper particles may be precipitated on the surface of the steel sheet during a pickling process, thereby causing discoloration of the steel sheet. In addition, when a pickling solution includes chlorine ions at a certain level or more, there is a risk of occurrence of pitting corrosion.

55 **[0009]** As described above, extensive research on the composition of a nitric acid-free pickling solution has been conducted so far. However, according to the conventional pickling processes, a high concentration pickling solution

should be used, pickling should be performed by immersing a stainless steel in a high-temperature pickling solution, and pickling takes a long time.

(Patent Document 0001) DE Publication No. DE 3937438

(Patent Document 0002) US Patent No. US 5154774

(Patent Document 0003) EP Publication No. EP 0236354

(Patent Document 0004) US Patent No. US 5908511

(Patent Document 0005) US Patent No. US 6554908

[Disclosure]

[Technical Problem]

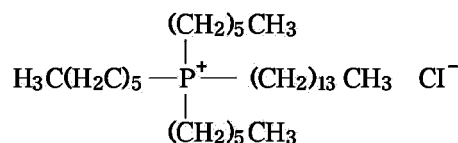
[0010] The present disclosure has been proposed to solve the above-described problems, and provided is an ionic liquid for pickling stainless steel capable of rapidly removing oxide scale of stainless steel at room temperature without using nitric acid or hydrofluoric acid and method for pickling stainless steel by using the same.

[Technical Solution]

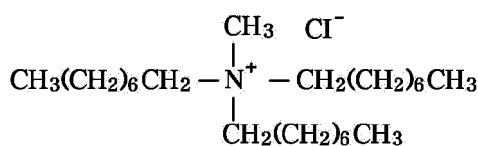
[0011] In accordance with an aspect of the present disclosure to achieve the above-described objects, an ionic liquid for pickling a stainless steel may include at least one of an imidazolium cation, a betainium cation, a sulfonium cation, a piperidinium cation, a phosphonium cation, an ammonium cation, a pyridium cation, a pyrrolidinium cation, and a morpholinium cation, as a cationic functional group, and at least one of a halide anion, a sulfonate anion, an alkylsulfate anion, a phosphinate anion, a salicylate anion, a nitrate anion, a tetrafluoroborate anion, a hexafluorophosphate anion, and a bistriflimide anion, as an anionic functional group.

[0012] The ionic liquid for pickling a stainless steel according to an embodiment of the present disclosure may be represented by one of the compounds (a) to (c) below.

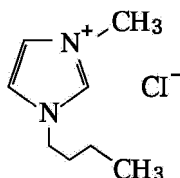
(a) [00019]



(b)



(c)

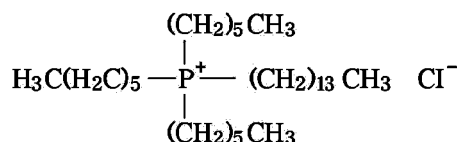


[0013] Also, in accordance with another aspect of the present disclosure to achieve the above-described objects, a method for pickling a stainless steel includes performing electrolytic pickling treatment by immersing a stainless steel in a pickling solution including an ionic liquid, wherein the ionic liquid includes at least one of an imidazolium cation, a betainium cation, a sulfonium cation, a piperidinium cation, a phosphonium cation, an ammonium cation, a pyridium cation, a pyrrolidinium cation, and a morpholinium cation, as a cationic functional group, and at least one of a halide

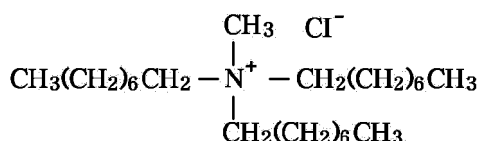
anion, a sulfonate anion, an alkylsulfate anion, a phosphinate anion, a salicylate anion, a nitrate anion, a tetrafluoroborate anion, a hexafluorophosphate anion, and a bistriflimide anion, as an anionic functional group.

[0014] In the method for pickling the stainless steel according to an embodiment of the present disclosure, the ionic liquid may be represented by one of the compounds (a) to (c) below.

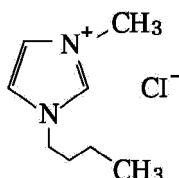
(a)



(b)



(c)



[0015] In the method for pickling the stainless steel according to an embodiment of the present disclosure, the ionic liquid may be contained in the pickling solution in a concentration of 2 M or less.

[0016] In the method for pickling the stainless steel according to an embodiment of the present disclosure, the pickling solution may be a solution prepared by adding an ionic liquid to a hydrochloric acid solution having a concentration of 1 M or less or a neutral solution including at least one of sodium chloride, potassium chloride, magnesium chloride, sodium sulfate, and potassium sulfate.

[0017] In the method for pickling the stainless steel according to an embodiment of the present disclosure, a temperature of the pickling solution may be from 15 to 25°C.

[0018] In the method for pickling the stainless steel according to an embodiment of the present disclosure, the electrolytic pickling treatment may be performed by applying a current density of 0.5 to 1.3 A/cm² while maintaining a surface potential of the stainless steel in the range of -1.5 to 1.5 V using an Ag/AgCl electrode as a reference electrode.

[0019] In the method for pickling the stainless steel according to an embodiment of the present disclosure, a time taken to completely remove the oxide scale may be 1 minute or less.

[Advantageous Effects]

[0020] According to embodiments of the present disclosure, oxide scale of a stainless steel may be removed in an eco-friendly manner by adding an ionic liquid to a pickling solution without using nitric acid or hydrofluoric acid.

[0021] In addition, according to an embodiment of the present disclosure, the number of times of repeatedly applying a potential until the oxide scale of the stainless steel is completely removed in a state where the stainless steel is immersed in the pickling solution at a temperature of 15 to 25°C, rather than a high temperature of 80°C or higher, may be 5 times or less and a time taken therefor may be 1 minute or less.

[0022] In addition, according to the present disclosure, oxide scale may be removed using a low concentration of an acidic solution or neutral solution, rather than a high concentration, in a pickling solution.

[0023] In addition, according to the present disclosure, economic feasibility may be improved by simplifying a pickling process conventionally performed in two steps into an electrolytic pickling process performed in a single step.

[Best Mode]

[0024] An ionic liquid for pickling a stainless steel according to an embodiment of the present disclosure may include at least one of an imidazolium cation, a betainium cation, a sulfonium cation, a piperidinium cation, a phosphonium cation, an ammonium cation, a pyridium cation, a pyrrolidinium cation, and a morpholinium cation, as a cationic functional group, and at least one of a halide anion, a sulfonate anion, an alkylsulfate anion, a phosphinate anion, a salicylate anion, a nitrate anion, a tetrafluoroborate anion, a hexafluorophosphate anion, and a bistriflimide anion, as an anionic functional group.

[Modes of the Invention]

[0025] Hereinafter, preferred embodiments of the present disclosure will now be described. However, the present disclosure may be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art.

[0026] The terms used herein are merely used to describe particular embodiments. Thus, an expression used in the singular encompasses the expression of the plural, unless it has a clearly different meaning in the context. In addition, it is to be understood that the terms such as "including" or "having" are intended to indicate the existence of features, steps, functions, components, or combinations thereof disclosed in the specification, and are not intended to preclude the possibility that one or more other features, steps, functions, components, or combinations thereof may exist or may be added.

[0027] Meanwhile, unless otherwise defined, all terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. Thus, these terms should not be interpreted in an idealized or overly formal sense unless expressly so defined herein. As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0028] In addition, the terms "about", "substantially", etc. used throughout the specification mean that when a natural manufacturing and substance allowable error are suggested, such an allowable error corresponds a value or is similar to the value, and such values are intended for the sake of clear understanding of the present invention or to prevent an unconscious infringer from illegally using the disclosure of the present invention.

[0029] Also, as used herein, the term "stainless steel" refers to a cold-rolled stainless steel sheet manufactured by cold rolling and annealing according to a process commonly used to manufacture cold-rolled stainless steel sheets. However, the embodiment is not interpreted as being limited thereto, and the stainless steel means any stainless steel having oxide scale formed on the surface thereof within a range that may be clearly recognized by those of ordinary skill in the art.

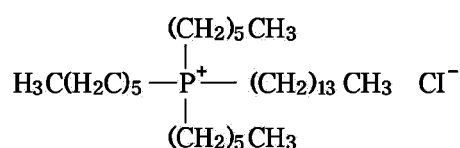
[0030] In addition, as used herein, the term "ionic liquid" refers to a salt compound including a metal cation and a non-metal anion and present as a liquid at a temperature of 100°C or below.

[0031] The present disclosure provides a method for removing oxide scale formed on the surface of the stainless steel by immersing the stainless steel in a pickling solution and performing an electrolytic pickling treatment. The pickling solution of the present disclosure refers to an acidic solution or neutral solution containing an ionic liquid.

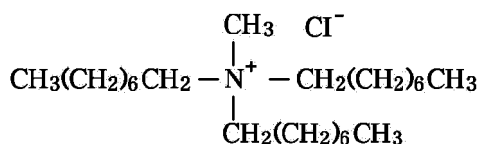
[0032] The present inventors have found that efficiency of pickling a stainless steel may be increased by adding an ionic liquid to a pickling solution. The ionic liquid according to the present disclosure may include at least one of an imidazolium cation, a betainium cation, a sulfonium cation, a piperidinium cation, a phosphonium cation, an ammonium cation, a pyridium cation, a pyrrolidinium cation, and a morpholinium cation, as a cationic functional group, and at least one of a halide anion, a sulfonate anion, an alkylsulfate anion, a phosphinate anion, a salicylate anion, a nitrate anion, a tetrafluoroborate anion, a hexafluorophosphate anion, and a bistriflimide anion, as an anionic functional group.

[0033] In addition, according to an embodiment, the ionic liquid of the present disclosure may be represented by one of the compounds (a) to (c) below.

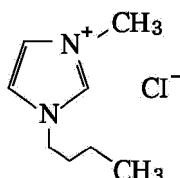
(a)



(b)



(c)



[0034] The compounds (a) to (c) are sequentially trihexyl(tetradecyl)phosphonium chloride, methyltrioctylammonium chloride, and 1-butyl-3-methylimidazolium chloride.

[0035] When the ionic liquid of the present disclosure is added to a pickling solution, the ionic liquid performs a function to dissolve a metal of a metal oxide. Therefore, according to the present disclosure, oxide scale of a stainless steel may be removed in an eco-friendly manner by adding an ionic liquid to a pickling solution without using nitric acid or hydrofluoric acid. Also, the oxide scale of the stainless steel may be rapidly removed by immersing the pickling solution at room temperature rather than a high temperature of 80°C or higher, and the oxide scale may be sufficiently removed by using a low concentration, rather than a high concentration, of the acidic solution or neutral solution in the pickling solution. In addition, economic feasibility may be improved by simplifying a pickling process conventionally performed in two steps into an electrolytic pickling process performed in a single step.

[0036] According to the present disclosure, the ionic liquid is added to the pickling solution. According to an embodiment, the ionic liquid may be contained in the pickling solution in a concentration of 2 M or less. However, in the case where the ionic liquid is added to an acidic solution, the pickling efficiency may be sufficiently increased in a low concentration of 0.2 M or less. In this regard, molarity of the ionic liquid corresponds to a value calculated relative to a total volume of the pickling solution.

[0037] According to the present disclosure, oxide scale may be sufficiently removed in the case of using a low concentration of the acidic solution, rather than a high concentration, by adding the ionic liquid to the pickling solution. According to an embodiment, the acidic solution may be a hydrochloric acid solution having a concentration of 1 M or less. In this regard, the molarity of the hydrochloric acid solution corresponds to a value calculated relative to a total volume of the pickling solution.

[0038] The neutral solution according to the present disclosure is not particularly limited, as long as the neutral solution is suitable for immersing the stainless steel and the electrolytic pickling treatment and contains a water-soluble electrolyte commonly used in the electrochemical field. Examples of the electrolyte may include sodium chloride (NaCl), potassium chloride (KCl), magnesium chloride (MgCl₂), sodium sulfate (Na₂SO₄), and potassium sulfate (K₂SO₄). In addition, the concentration of the neutral solution is not particularly limited, as long as the electrolytic pickling treatment is performed using the neutral solution. The neutral solution according to an embodiment may be a 1 M to 2 M sodium chloride solution.

[0039] According to the present disclosure, oxide scale may be rapidly removed by immersing the stainless steel in the pickling solution at a temperature of 15 to 25°C, rather than a high temperature of 80°C or higher. According to an embodiment of the present disclosure, the number of times of repeatedly applying a potential until the oxide scale of the stainless steel is completely removed may be 5 times or less and a time taken therefor may be 1 minute or less.

[0040] The electrolytic pickling treatment according to the present disclosure is a process of removing oxide scale formed on the surface of the stainless steel by performing electrolytic pickling treatment after immersing the stainless steel in a pickling solution prepared by adding an ionic liquid to an acidic solution or neutral solution. According to an embodiment, the electrolytic pickling treatment may be performed by applying a current density of 0.5 to 1.3 A/cm² while maintaining a surface potential of the stainless steel at -1.5 to 1.5 V using an Ag/AgCl electrode as a reference electrode. The electrolytic pickling treatment may be performed by AC electrolysis or DC electrolysis in which a current is applied, or by a constant voltage method in which a voltage is applied.

[0041] Hereinafter, the present disclosure will be described in more detail through examples. However, it is necessary to note that the following examples are only intended to illustrate the present disclosure in more detail and are not intended to limit the scope of the present disclosure. This is because the scope of the present disclosure is determined by matters described in the claims and able to be reasonably inferred therefrom.

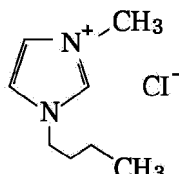
Examples

[0042] STS 304 type steel containing 18 wt% of Cr and 8 wt% of Ni was cold-rolled and annealed using a process commonly used to manufacture cold-rolled stainless steel sheets. Although the STS 304 type steel was used in the examples of the present disclosure, any other stainless steel having a different compositions and including oxide scale formed on the surface thereof may also be pickled according to the pickling method of the present disclosure.

[0043] To remove oxide scale formed by annealing heat treatment, the stainless steel was immersed in the pickling solution shown in Table 1 below at a temperature of 15 to 25°C, and then electrolytic pickling treatment was performed. The electrolytic pickling treatment was performed by repeatedly applying a potential several times at a scan speed of 0.5 V/s until the oxide scale is completely removed in a state where the surface potential of the stainless steel was maintained in the range of -1.5 to 1.5 V using an Ag/AgCl electrode as a reference electrode. The removal of the oxide scale was observed by using an optical microscope and an electron microscope.

[0044] In Table 1 below, the compositions (acidic solution or neutral solution, ionic liquid) of the pickling solution are listed in the order of molarity (M) and compounds of compositions. In this regard, the molarity is a value calculated relative to a total volume of the pickling solution. The current density (A/cm²) of Table 1 means a current density applied to the stainless steel, and the number of repetition means the number of repeatedly applying a potential until the oxide scale is completely removed. The time (sec) of Table 1 means a time taken until the oxide scale is completely removed.

Table 1

	Pickling solution				Current density (A/cm ²)	No. of repetition (time s)	Time (sec)
	Acidic solution or neutral solution		Ionic liquid				
	Molarity	Compound	Molarity	Compound			
Inventive Example 1	1M	HCl	0.17 M	$\begin{array}{c} \text{(CH}_2\text{)}_5\text{CH}_3 \\ \\ \text{H}_3\text{C}(\text{CH}_2\text{C)}_3-\text{P}^+-\text{(CH}_2\text{)}_{13}\text{CH}_3 \quad \text{Cl}^- \\ \\ \text{(CH}_2\text{)}_5\text{CH}_3 \end{array}$	1.01	4	24
Inventive Example 2	1M	NaCl	0.17 M	$\begin{array}{c} \text{(CH}_2\text{)}_5\text{CH}_3 \\ \\ \text{H}_3\text{C}(\text{CH}_2\text{C)}_3-\text{P}^+-\text{(CH}_2\text{)}_{13}\text{CH}_3 \quad \text{Cl}^- \\ \\ \text{(CH}_2\text{)}_5\text{CH}_3 \end{array}$	0.492	5	30
Inventive Example 3	1M	NaCl	0.17 M	$\begin{array}{c} \text{CH}_3 \quad \text{Cl}^- \\ \quad \\ \text{CH}_3(\text{CH}_2)_6\text{CH}_2-\text{N}^+-\text{CH}_2(\text{CH}_2)_6\text{CH}_3 \\ \\ \text{CH}_2(\text{CH}_2)_6\text{CH}_3 \end{array}$	0.643	5	30
Inventive Example 4	1M	NaCl	0.17 M		0.669	5	30

[0045] Referring to the results of Table 1, it was confirmed that oxide scale of the stainless steel may be removed in an eco-friendly manner by adding the ionic liquid to the pickling solution without using nitric acid or hydrofluoric acid according to the present disclosure. Also, it was confirmed that the oxide scale of the stainless steel may be completely removed at a high speed within 1 minute by repeatedly applying a potential 5 times or less by immersing the stainless steel in the pickling solution at room temperature, rather than at a high temperature of 80°C or higher according to the present disclosure. Also, it was confirmed that oxide scale may be removed by using a low concentration of the acidic solution or neutral solution, rather than a high concentration, in the pickling solution according to the present disclosure. Also, it was confirmed that economic feasibility may be improved by simplifying a pickling process conventionally performed in two steps into the electrolytic pickling process performed in a single step according to the present disclosure. While the present disclosure has been particularly described with reference to exemplary embodiments, it should be understood by those of skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the present disclosure.

[Industrial Applicability]

[0046] Because the oxide scale of the stainless steel may be rapidly removed at room temperature in an eco-friendly manner without using nitric acid or hydrofluoric acid according to the present disclosure, an ionic liquid for pickling a stainless steel and a method for pickling the stainless steel using the same may be provided with improved economic feasibility.

Claims

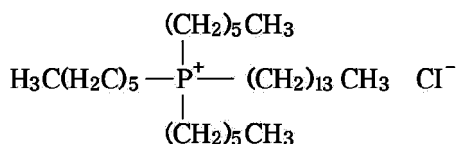
1. An ionic liquid for pickling a stainless steel comprising:

at least one of an imidazolium cation, a betainium cation, a sulfonium cation, a piperidinium cation, a phosphonium cation, an ammonium cation, a pyridium cation, a pyrrolidinium cation, and a morpholinium cation, as a cationic functional group, and

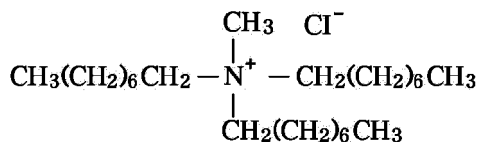
at least one of a halide anion, a sulfonate anion, an alkylsulfate anion, a phosphinate anion, a salicylate anion, a nitrate anion, a tetrafluoroborate anion, a hexafluorophosphate anion, and a bistriflimide anion, as an anionic functional group.

2. The ionic liquid according to claim 1, wherein the ionic liquid is represented by one of the compounds (a) to (c) below:

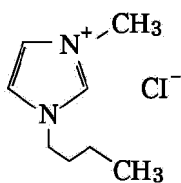
(a)



(b)



(c)



3. A method for pickling a stainless steel, the method comprising:

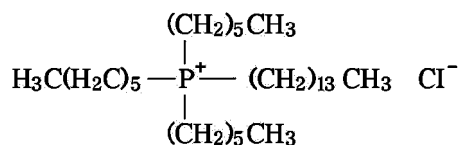
performing electrolytic pickling treatment by immersing a stainless steel in a pickling solution including an ionic liquid,

wherein the ionic liquid comprises at least one of an imidazolium cation, a betainium cation, a sulfonium cation, a piperidinium cation, a phosphonium cation, an ammonium cation, a pyridium cation, a pyrrolidinium cation, and a morpholinium cation, as a cationic functional group, and

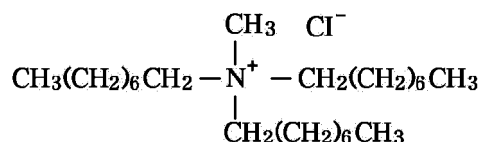
at least one of a halide anion, a sulfonate anion, an alkylsulfate anion, a phosphinate anion, a salicylate anion, a nitrate anion, a tetrafluoroborate anion, a hexafluorophosphate anion, and a bistriflimide anion, as an anionic functional group.

4. The method according to claim 3, wherein the ionic liquid is represented by one of the compounds (a) to (c) below:

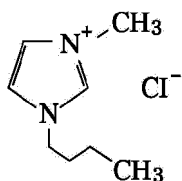
(a)



(b)



(c)



5. The method according to claim 3, wherein the ionic liquid is contained in the pickling solution in a concentration of 2 M or less.
6. The method according to claim 3, wherein the pickling solution is a solution prepared by adding an ionic liquid to a hydrochloric acid solution having a concentration of 1 M or less or a neutral solution including at least one of sodium chloride, potassium chloride, magnesium chloride, sodium sulfate, and potassium sulfate.
7. The method according to claim 3, wherein a temperature of the pickling solution is from 15 to 25°C.
8. The method according to claim 3, wherein the electrolytic pickling treatment is performed by applying a current density of 0.5 to 1.3 A/cm² while maintaining a surface potential of the stainless steel in the range of -1.5 to 1.5 V using an Ag/AgCl electrode as a reference electrode.
9. The method according to claim 3, wherein a time taken to completely remove the oxide scale is 1 minute or less.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2020/014199

A. CLASSIFICATION OF SUBJECT MATTER C25F 1/14(2006.01)i; C23G 1/32(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) C25F 1/14(2006.01); C23C 18/18(2006.01); C25D 11/02(2006.01); C25D 11/04(2006.01); C25D 21/12(2006.01); C25D 5/56(2006.01); C25D 7/12(2006.01); C25F 1/06(2006.01); C25F 7/00(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: 스테인리스강(stainless steel), 산세(pickling), 이온성 액체(ionic liquid), 양이온(cation), 음이온(anion), 스케일(scale), 제거(removal)																					
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>KR 10-2017-0053748 A (BASF SE) 16 May 2017 (2017-05-16) See claims 1 and 4; and paragraphs [0034], [0081] and [0083]-[0086].</td> <td>1-4</td> </tr> <tr> <td>Y</td> <td></td> <td>5-9</td> </tr> <tr> <td>Y</td> <td>KR 10-2013-0047078 A (LEE, Byungro) 08 May 2013 (2013-05-08) See abstract; and claim 2.</td> <td>5-9</td> </tr> <tr> <td>A</td> <td>KR 10-1592147 B1 (LEE, Dae Seok) 04 February 2016 (2016-02-04) See abstract; and claim 1.</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>JP 07-216600 A (DAISO CO., LTD. et al.) 15 August 1995 (1995-08-15) See abstract; and claims 1 and 2.</td> <td>1-9</td> </tr> <tr> <td>A</td> <td>EP 1538237 B1 (NIPPON MINING & METALS CO., LTD.) 30 September 2009 (2009-09-30) See entire document.</td> <td>1-9</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	KR 10-2017-0053748 A (BASF SE) 16 May 2017 (2017-05-16) See claims 1 and 4; and paragraphs [0034], [0081] and [0083]-[0086].	1-4	Y		5-9	Y	KR 10-2013-0047078 A (LEE, Byungro) 08 May 2013 (2013-05-08) See abstract; and claim 2.	5-9	A	KR 10-1592147 B1 (LEE, Dae Seok) 04 February 2016 (2016-02-04) See abstract; and claim 1.	1-9	A	JP 07-216600 A (DAISO CO., LTD. et al.) 15 August 1995 (1995-08-15) See abstract; and claims 1 and 2.	1-9	A	EP 1538237 B1 (NIPPON MINING & METALS CO., LTD.) 30 September 2009 (2009-09-30) See entire document.	1-9
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex. <table border="0"> <tr> <td style="vertical-align: top;"> * Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </td> <td style="vertical-align: top;"> "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 </td> </tr> </table>	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "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																			
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Date of the actual completion of the international search 16 March 2021	Date of mailing of the international search report 16 March 2021																				
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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