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(54) **SUBSTRATE WITH WATER REPELLENT OIL REPELLENT LAYER, VAPOR DEPOSITION MATERIAL, AND METHOD FOR PRODUCING SUBSTRATE WITH WATER REPELLENT OIL REPELLENT LAYER**

SUBSTRAT MIT WASSERABWEISENDER ÖLABWEISENDER SCHICHT, AUFDAMPFMATERIAL UND VERFAHREN ZUR HERSTELLUNG EINES SUBSTRATS MIT WASSERABWEISENDER ÖLABWEISENDER SCHICHT

SUBSTRAT À COUCHE HYDROFUGE-OLÉOFUGE, MATÉRIAU DE DÉPÔT EN PHASE VAPEUR, ET PROCÉDÉ DE PRODUCTION D'UN SUBSTRAT À COUCHE HYDROFUGE-OLÉOFUGE

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a water/oil repellent layer-provided substrate and a method for producing a water/oil repellent layer-provided substrate.

BACKGROUND ART

10 **[0002]** In order to impart to the surface of a substrate water/oil repellency, fingerprint stain removability, lubricity (smoothness when touched with a finger), etc., it has been known to form a water/oil repellent layer comprising a hydrolyzed condensate of a fluorinated compound on the surface of the substrate by surface treatment using a fluorinated compound having a poly(oxyperfluoroalkylene) chain and a hydrolysable silyl group.

15 **[0003]** Further, since the water/oil repellent layer is required to have abrasion resistance, in order to improve adhesion between the substrate and the water/oil repellent layer, an undercoat layer is formed between them. For example, Patent Documents 1 and 2 disclose to form a silicon oxide layer by deposition between the substrate and the water/oil repellent layer.

PRIOR ART DOCUMENTS

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PATENT DOCUMENTS

[0004]

25 Patent Document 1: JP-A-2014-218639
Patent Document 2: JP-A-2012-72272

[0005] Further, JP 2013 155399 A describes a substrate with an antifouling film and a method for producing the same; and

30 **[0006]** WO 2016/011041 A1 discloses thin-film sol-gel coatings and, in particular, coatings on substrates such as glass or solar panels.

DISCLOSURE OF INVENTION

35 TECHNICAL PROBLEM

[0007] In recent years, performance required for the water/oil repellent layer becomes higher and for example, a water/oil repellent layer more excellent in abrasion resistance has been required.

40 **[0008]** The present inventors have evaluated a water/oil repellent layer-provided substrate having the undercoat layer (silicon oxide layer) as disclosed in Patent Documents 1 and 2 and as a result, found that the abrasion resistance of the water/oil repellent layer can further be improved.

[0009] Under these circumstances, the object of the present invention is to provide a water/oil repellent layer-provided substrate having a water/oil repellent layer excellent in abrasion resistance and a method for producing a water/oil repellent layer-provided substrate.

45

SOLUTION TO PROBLEM

50 **[0010]** The present inventors have conducted extensive studies on the above object and as a result, have found that a water/oil repellent layer-provided substrate having a water/oil repellent layer excellent in abrasion resistance can be obtained by using an undercoat layer containing an oxide containing silicon and at least one element of boron and phosphorus, the ratio of the total molar concentration of boron and phosphorus in the undercoat layer to the molar concentration of silicon in the undercoat layer being within the predetermined range, and have accomplished the present invention.

55 **[0011]** That is, the present inventors have found that the above object can be achieved by the subject matter as defined in the appended set of claims.

ADVANTAGEOUS EFFECTS OF INVENTION

[0012] According to the present invention, it is possible to provide a water/oil repellent layer-provided substrate having a water/oil repellent layer excellent in abrasion resistance and a method for producing a water/oil repellent layer-provided substrate.

BRIEF DESCRIPTION OF DRAWING

[0013] Fig. 1 is a cross sectional view schematically illustrating an example of a water/oil repellent layer-provided substrate of the present invention.

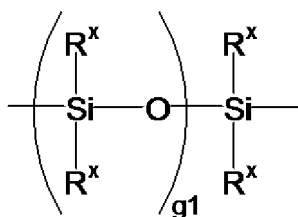
DESCRIPTION OF EMBODIMENTS

[0014] In this specification, the units represented by the formula (1) will be referred to as "units (1)". The same applies to units represented by other formulae. The group represented by the formula (2) will be referred to as "group (2)". The same applies to groups represented by other formulae. The compound represented by the formula (3) will be referred to as "compound (3)". The same applies to compounds represented by other formulae.

[0015] In this specification, the wording "the alkylene group may have a group A" means that the alkylene group may have the group A between carbon-carbon atoms of the alkylene group, or may have the group A at the terminal, i.e. the alkylene group-group A-.

[0016] Meanings of the following terms in this specification are as follows.

[0017] A "bivalent organopolysiloxane residue" is a group represented by the following formula. R^x in the following formula is an alkyl group (preferably C_{1-10}) or a phenyl group. g_1 is an integer of at least 1, preferably an integer of from 1 to 9, particularly preferably from 1 to 4.



[0018] A "silphenylene skeleton group" is a group represented by $-\text{Si}(R^y)_2\text{PhSi}(R^y)_2-$ (wherein Ph is a phenylene group, and R^y is a monovalent organic group). R^y is preferably an alkyl group (preferably C_{1-10}).

[0019] A "dialkylsilylene group" is a group represented by $-\text{Si}(R^z)_2-$ (wherein R^z is an alkyl group (preferably C_{1-10})).

[0020] The "number average molecular weight" of a compound is calculated by obtaining the number (average value) of oxyfluoroalkylene groups on the basis of the terminal group, by $^1\text{H-NMR}$ and $^{19}\text{F-NMR}$.

[0021] The content of each element in the undercoat layer is a value measured by X-ray photoelectron spectroscopy (XPS) depth profiling by ion sputtering, unless otherwise specified. The content of each element obtained by XPS analysis is represented by molar concentration (mol%). Specifically, from the depth profile of the molar concentration (mol%) in the vertical axis obtained by ion sputtering in XPS analysis, the average molar concentration (mol%) of each element in the undercoat layer is obtained, which is taken as the molar concentration (mol%) of each element.

[0022] The content of each element in the deposition material is a value measured by wet analysis unless otherwise specified. The content of each element obtained by wet analysis is represented by mass percent concentration (mass%). Atomic absorption spectrometry is employed for measurement of alkali metal elements (Li, Na and K), and inductively coupled plasma (ICP) atomic emission spectrometry or ICP mass spectrometry is employed for measurement of the other elements, and quantitative determination is conducted by analytical curve (matrix matching) method. From mass% of each element obtained by wet analysis and the atomic weight (g/mol) of each element, the ratio of the molar concentrations of the respective elements can be obtained. The atomic weights used for calculation are as follows.

Atomic weight of Si (g/mol): 28.09

Atomic weight of B (g/mol): 10.81

Atomic weight of P (g/mol): 30.97

Atomic weight of Al (g/mol): 26.98

Atomic weight of Li (g/mol): 6.941

Atomic weight of Na (g/mol): 22.99

Atomic weight of K (g/mol): 39.10

Atomic weight of Ni (g/mol): 58.69
 Atomic weight of Fe (g/mol): 55.85
 Atomic weight of Ti (g/mol): 47.88
 Atomic weight of Zr (g/mol): 91.22
 Atomic weight of Mo (g/mol): 95.94
 Atomic weight of W (g/mol): 183.8

[0023] The dimensional ratio in Fig. 1 is different from actual one for explanatory convenience.

[Water/oil repellent layer-provided substrate]

[0024] The water/oil repellent layer-provided substrate of the present invention is a water/oil repellent layer-provided substrate comprising a substrate, an undercoat layer and a water/oil repellent layer in this order, wherein the water/oil repellent layer comprises a condensate of a fluorinated compound having a reactive silyl group.

[0025] Further, the undercoat layer contains an oxide containing silicon and at least one element of boron and phosphorus, and the ratio of the total molar concentration of boron and phosphorus in the undercoat layer to the molar concentration of silicon in the undercoat layer is from 0.003 to 9.

[0026] Of the water/oil repellent layer-provided substrate of the present invention, the water/oil repellent layer is excellent in abrasion resistance. The details of the reason have not yet been clearly understood but are estimated as follows.

[0027] Since boron has an empty p orbital, boron is considered to be likely to receive lone-pair electrons of e.g. oxygen which the reactive silyl group of the fluorinated compound used for formation of the water/oil repellent layer may have. Thus, hydrolysis and dehydration condensation reaction of the reactive silyl group of the fluorinated compound are promoted, whereby the obtainable water/oil repellent layer has improved abrasion resistance.

[0028] Further, since phosphorus has lone-pair electrons, phosphorus is considered to be likely to react with silicon and carbon which the reactive silyl group of the fluorinated compound has. Thus, hydrolysis and dehydration condensation reaction of the reactive silyl group of the fluorinated compound are promoted, whereby the obtainable water/oil repellent layer has improved abrasion resistance.

[0029] Fig. 1 is a cross sectional view schematically illustrating an example of a water/oil repellent layer-provided substrate of the present invention. The water/oil repellent layer-provided substrate 10 comprises a substrate 12, an undercoat layer 14 formed on one surface of the substrate 12 and a water/oil repellent layer 16 formed on the surface of the undercoat layer 14.

[0030] In the example shown in Fig. 1, the substrate 12 and the undercoat layer 14 are in contact with each other, but the structure is not limited thereto, and the water/oil repellent layer-provided substrate may have other layer which is not shown between the substrate 12 and the undercoat layer 14. Further, in the example shown in Fig. 1, the undercoat layer 14 and the water/oil repellent layer 16 are in contact with each other, but the structure is not limited thereto, and the water/oil repellent layer-provided substrate may have other layer which is not shown between the undercoat layer 14 and the water/oil repellent layer 16.

[0031] In the example shown in Fig. 1, the undercoat layer 14 is formed entirely on one surface of the substrate 12, but the structure is not limited thereto, and the undercoat layer 14 may be formed only on a part of the substrate 12. Further, in the example shown in Fig. 1, the water/oil repellent layer 16 is formed entirely on the undercoat layer 14, but the structure is not limited thereto, and the water/oil repellent layer 16 may be formed only on a part of the undercoat layer 14.

[0032] In the example shown in Fig. 1, the undercoat layer 14 and the water/oil repellent layer 16 are formed only on one surface of the substrate 12, but the structure is not limited thereto, and the undercoat layer 14 and the water/oil repellent layer 16 may be formed on both surfaces of the substrate 12.

(Substrate)

[0033] The substrate is, since the water/oil repellency can be imparted, particularly preferably a substrate which is required to have water/oil repellency imparted. As specific examples of a material of the substrate, a metal, a resin, glass, sapphire, a ceramic, a stone, and a composite material thereof may be mentioned. Glass may be chemically tempered.

[0034] As the substrate, a substrate for a touch panel or a substrate for a display is preferred, and a substrate for a touch panel is particularly preferred. The substrate for a touch panel preferably has translucency. "Having translucency" means that the normal incidence visible light transmittance in accordance with JIS R3106: 1998 (ISO9050: 1990) is at least 25%. As a material of the substrate for a touch panel, glass or a transparent resin is preferred.

[0035] Further, as the substrate, the following examples may be mentioned. A building material, a decorative building material, an interior article, a transport equipment (such as an automobile), an advertising display/sign-board, tableware,

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an aquarium, a decorative device (such as a frame or a box), laboratory ware, furniture, glass or a resin to be used for art/sports/game, or glass or a resin to be used for an exterior portion (excluding the display portion) of a device such as a mobile phone (such as a smartphone), a personal digital assistant, a gaming machine or a remote controller, are also preferred. The shape of the substrate may be a plate form or a film form.

[0036] The substrate may be a substrate having either one of or both surfaces subjected to surface treatment such as corona discharge treatment, plasma treatment or plasma graft polymerization treatment. The surface-treated surface achieves more excellent adhesion of the substrate and the undercoat layer and as a result, the water/oil repellent layer will be more excellent in abrasion resistance. Thus, it is preferred to apply surface treatment to the surface of the substrate on the side to be in contact with the undercoat layer.

(Undercoat layer)

[0037] The undercoat layer is a layer containing an oxide containing silicon and at least one element of boron and phosphorus.

[0038] The oxide may contain both of boron and phosphorus, or may contain only one of them. The oxide preferably contains one of boron and phosphorus, and in a case where it contains both of them, the proportion of boron to the total amount of them is preferably from 20 to 80 mol%.

[0039] The oxide contained in the undercoat layer may be a mixture of oxides each containing only one of the above elements (silicon, boron and phosphorus) (for example, a mixture of silicon oxide and at least one of boron oxide and phosphorus oxide), may be a composite oxide containing two or more of the above elements, or may be a mixture of the oxide containing one of the above elements and the composite oxide.

[0040] The content of the oxide in the undercoat layer is, to the total mass of the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at least 80 mass%, more preferably at least 95 mass%, particularly preferably 100 mass% (the undercoat layer is entirely formed of the oxide).

[0041] The content of oxygen in the undercoat layer is, as the molar concentration (mol%) of oxygen atoms to all the elements in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 40 to 70 mol%, more preferably from 50 to 70 mol%, particularly preferably from 60 to 70 mol%. The content of oxygen in the undercoat layer is measured by depth profiling by XPS by ion sputtering.

[0042] The ratio of the total molar concentration of boron and phosphorus in the undercoat layer to the molar concentration of silicon in the undercoat layer is from 0.003 to 9, and in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 0.003 to 2, particularly preferably from 0.003 to 0.5.

[0043] The content of silicon in the undercoat layer is, as the molar concentration (mol%) of silicon to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 10.6 to 99.8 mol%, more preferably from 33 to 99.8 mol%, particularly preferably from 66 to 99.7 mol%.

[0044] The content of silicon in the undercoat layer is, as the mass percent concentration (mass%) of silicon to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 23.6 to 99.9 mass%, more preferably from 56.5 to 99.9 mass%, particularly preferably from 83 to 99.8 mass%.

[0045] The total content of boron and phosphorus in the undercoat layer is, as the total molar concentration (mol%) of boron and phosphorus to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 0.003 to 89.4 mol%, more preferably from 0.003 to 66.7 mol%, particularly preferably from 0.003 to 34 mol%.

[0046] The total content of boron and phosphorus in the undercoat layer is, as the total mass percent concentration (mass%) of boron and phosphorus to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 0.001 to 76.4 mass%, more preferably from 0.001 to 43.5 mass%, particularly preferably from 0.001 to 16.5 mass%.

[0047] The total content of boron and phosphorus means, when one type of element of boron and phosphorus is contained, the content of the one element, and when two types of elements are contained, the total content of the two elements.

[0048] The oxide contained in the undercoat layer may further contain aluminum, whereby the water/oil repellent layer will be more excellent in abrasion resistance.

[0049] Aluminum may be present in the form of an oxide of aluminum by itself, or may be present in the form of a composite oxide of aluminum and the above element (silicon, boron or phosphorus).

[0050] In a case where the oxide contained in the undercoat layer contains aluminum, the ratio of the molar concentration of aluminum in the undercoat layer to the molar concentration of silicon in the undercoat layer is, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 0.5, particularly preferably from 0.001 to 0.1.

[0051] In a case where the oxide contained in the undercoat layer contains aluminum, the content of aluminum in the

undercoat layer is, as the molar concentration (mol%) of aluminum to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 20 mol%, more preferably at most 10 mol%, particularly preferably from 0.1 to 5 mol%.

[0052] In a case where the oxide contained in the undercoat layer contains aluminum, the content of aluminum in the undercoat layer is, as the mass percent concentration (mass%) of aluminum to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 40 mass%, more preferably at most 30 mass%, particularly preferably from 0.1 to 10 mass%.

[0053] The oxide contained in the undercoat layer may further contain an alkali metal element, in that the water/oil repellent layer will be more excellent in abrasion resistance.

[0054] The alkali metal element may, for example, be specifically lithium, sodium, potassium, rubidium or cesium, and in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably sodium, lithium or potassium, particularly preferably sodium. As the alkali metal element, two or more types may be contained.

[0055] The alkali metal element may be present in the form of an oxide of one type of alkali metal element, or may be present in the form of a composite oxide of one or more types of alkali metal element and the above element (silicon, boron or phosphorus).

[0056] In a case where the oxide contained in the undercoat layer contains the alkali metal element, the ratio of the total molar concentration of the alkali metal element in the undercoat layer to the molar concentration of silicon in the undercoat layer is, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 1.0, particularly preferably from 0.001 to 0.5.

[0057] In a case where the oxide contained in the undercoat layer contains the alkali metal element, the content of the alkali metal element in the undercoat layer is, as the total molar concentration (mol%) of the alkali metal element to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 30 mol%, more preferably at most 20 mol%, particularly preferably from 0.1 to 15 mol%.

[0058] In a case where the oxide contained in the undercoat layer contains the alkali metal element, the content of the alkali metal element in the undercoat layer is, as the mass percent concentration (mass%) of the alkali metal element to all the elements excluding oxygen in the undercoat layer, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 40 mass%, more preferably at most 30 mass%, particularly preferably from 0.1 to 20 mass%.

[0059] The content of the alkali metal element means, when one type of alkali metal element is contained, the content of the one element, and when two or more types of alkali metal elements are contained, the total content of the respective elements.

[0060] The undercoat layer may be a layer in which components contained are uniformly distributed (hereinafter sometimes referred to as "homogeneous layer") or may be a layer in which components contained are non-uniformly distributed (hereinafter sometimes referred to as "inhomogeneous layer"). The inhomogeneous layer may, for example, be specifically a layer in which there is a concentration gradient (horizontally or vertically to a plane of the layer) of the components (gradation structure) or a layer in which in a continuous component, other components are discontinuously present (sea-island structure). Specifically, a case where the concentration of the boron compound or the like (the material may, for example, be boron oxide, boric acid, boron simple substance, boron carbide, boron nitride or borax) increases towards the surface (surface on the opposite side from the substrate) relative to silicon oxide (silica), a case where portions at which the concentration of the boron compound or the like is high are dotted in the silica matrix, or a case where silica and the boron compound or the like form a checkered pattern, may, for example, be mentioned.

[0061] The undercoat layer may be a monolayer or may be a multilayer, and from the viewpoint of the process, preferably a monolayer.

[0062] The undercoat layer may have irregularities on its surface.

[0063] The thickness of the undercoat layer is preferably from 1 to 100 nm, more preferably from 1 to 50 nm, particularly preferably from 2 to 20 nm. When the thickness of the undercoat layer is at least the above lower limit value, the adhesion of the water/oil repellent layer by the undercoat layer will more improve, and the water/oil repellent layer will be more excellent in abrasion resistance. When the thickness of the undercoat layer is at most the above upper limit value, the undercoat layer itself will be excellent in abrasion resistance.

[0064] The thickness of the undercoat layer is measured by observation of the cross section of the undercoat layer with a transmission electron microscope (TEM).

(Water/oil repellent layer)

[0065] The water/oil repellent layer comprises a condensate of a fluorinated compound having a reactive silyl group.

[0066] The reactive silyl group means a hydrolysable silyl group and a silanol group (Si-OH). As a specific example of the hydrolysable silyl group, a group represented by the after-described formula (2) wherein L is a hydrolysable group

may be mentioned.

[0067] The hydrolysable silyl group becomes a silanol group represented by Si-OH by being hydrolyzed. The silanol groups further undergo dehydration condensation reaction to form a Si-O-Si bond. The silanol group undergoes dehydration condensation reaction with a silanol group derived from the oxide contained in the undercoat layer to form a Si-O-Si bond. That is, in a case where at least part of the reactive silyl groups are hydrolysable silyl groups, the water/oil repellent layer contains a condensate having the reactive silyl groups of the fluorinated compound being hydrolyzed and subjected to dehydration condensation reaction. In a case where all the reactive silyl groups are silanol groups, the water/oil repellent layer contains a condensate having silanol groups of the fluorinated compound subjected to dehydration condensation reaction. The reactive silyl groups of the fluorinated compound are preferably such that at least a part thereof are hydrolysable silyl groups.

[0068] The thickness of the water/oil repellent layer is preferably from 1 to 100 nm, particularly preferably from 1 to 50 nm. When the thickness of the water/oil repellent layer is at least the lower limit value, effects by the water/oil repellent layer will be sufficiently obtained. When the thickness of the water/oil repellent layer is at most the above upper limit value, high utilization efficiency will be obtained.

[0069] The thickness of the water/oil repellent layer is calculated from the oscillation period of an interference pattern of reflected X-rays obtained by X-ray reflectometry (XRR) using an X-ray diffractometer for thin film analysis.

<Fluorinated compound having reactive silyl group>

[0070] The fluorinated compound having a reactive silyl group is, in that the water/oil repellent layer will be excellent in water/oil repellency, preferably a fluorinated ether compound having a poly(oxyfluoroalkylene) chain and a reactive silyl group.

[0071] The poly(oxyfluoroalkylene) chain contains a plurality of units represented by the formula (1):



[0072] X is a fluoroalkylene group having at least one fluorine atom.

[0073] The number of carbon atoms in the fluoroalkylene group is preferably from 1 to 6, particularly preferably from 2 to 4, in that the film will be more excellent in weather resistance and corrosion resistance.

[0074] The fluoroalkylene group may be linear or branched, and in that more excellent effects of the present invention will be obtained, preferably linear.

[0075] The number of fluorine atoms in the fluoroalkylene group is, in that the film will be more excellent in corrosion resistance, preferably from 1 to 2 times the number of carbon atoms, particularly preferably from 1.7 to 2 times.

[0076] The fluoroalkylene group may be a group having all the hydrogen atoms in the fluoroalkylene group substituted by fluorine atoms (perfluoroalkylene group).

[0077] As specific examples of the units (1), -OCHF-, -OCF₂CHF-, -OCHF₂CF₂-, -OCF₂CH₂-, -OCH₂CF₂-, -OCF₂CF₂CHF-, -OCHF₂CF₂CF₂-, -OCF₂CF₂CH₂-, -OCH₂CF₂CF₂-, -OCF₂CF₂CF₂CH₂-, -OCH₂CF₂CF₂CF₂-, -OCF₂CF₂CF₂CF₂CH₂-, -OCH₂CF₂CF₂CF₂CF₂-, -OCF₂CF₂CF₂CF₂CF₂CH₂-, -OCH₂CF₂CF₂CF₂CF₂CF₂-, -OCF₂CF₂-, -OCF₂CF₂CF₂-, -OCF(CF₃)CF₂-, -OCF₂CF₂CF₂CF₂-, -OCF(CF₃)CF₂CF₂-, -OCF₂CF₂CF₂CF₂CF₂-, -OCF₂CF₂CF₂CF₂CF₂CF₂- may be mentioned.

[0078] The number m of repetition of the units (1) contained in the poly(oxyfluoroalkylene) chain is at least 2, preferably an integer of from 2 to 200, more preferably an integer of from 5 to 150, particularly preferably an integer of from 5 to 100, most preferably an integer of from 10 to 50.

[0079] The poly(oxyfluoroalkylene) chain may contain two or more types of the units (1). The two or more types of the units (1) may, for example, be two or more types of the units (1) differing in the number of carbon atoms, two or more types of the units (1) having the same number of carbon atoms but differing in whether the units have a side chain or not or in the type of the side chain, or two or more types of the units (1) having the same number of carbon atoms but differing in the number of fluorine atoms.

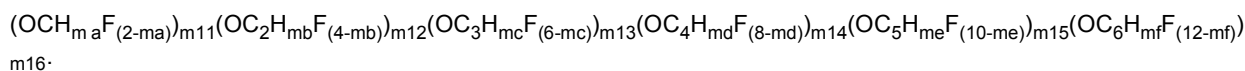
[0080] The bonding order of the two or more types of (OX) is not limited, and they may be arranged randomly, alternately or in blocks.

[0081] The poly(oxyfluoroalkylene) chain is preferably a poly(oxyfluoroalkylene) chain composed mainly of the units (1) as the oxyperfluoroalkylene group, in order to obtain a film excellent in fingerprint stain removability. In the poly(oxyfluoroalkylene) chain represented by (OX)_m, the proportion of the number of the units (1) as the oxyperfluoroalkylene group to the total number m of the units (1) is preferably from 50 to 100%, more preferably from 80 to 100 %, particularly preferably from 90 to 100%.

[0082] The poly(oxyfluoroalkylene) chain is more preferably a poly(oxyperfluoroalkylene) chain or a poly(oxyperfluoroalkylene) chain having one or two oxyfluoroalkylene units having a hydrogen atom on one terminal or on both terminals.

[0083] (OX)_m which the poly(oxyfluoroalkylene) chain has is preferably

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[0084] m_a is 0 or 1, m_b is an integer of from 0 to 3, m_c is an integer of from 0 to 5, m_d is an integer of from 0 to 7, m_e is an integer of from 0 to 9, and m_f is an integer of from 0 to 11.

[0085] m_{11} , m_{12} , m_{13} , m_{14} , m_{15} and m_{16} are each independently an integer of at least 0, and preferably at most 100.

[0086] $m_{11}+m_{12}+m_{13}+m_{14}+m_{15}+m_{16}$ is an integer of at least 2, preferably an integer of from 2 to 200, more preferably an integer of from 5 to 150, further preferably an integer of from 5 to 100, particularly preferably an integer of from 10 to 50.

[0087] Particularly, m_{12} is preferably an integer of at least 2, particularly preferably an integer of from 2 to 200.

[0088] Further, $\text{C}_3\text{H}_{m_c}\text{F}_{(6-m_c)}$, $\text{C}_4\text{H}_{m_d}\text{F}_{(8-m_d)}$, $\text{C}_5\text{H}_{m_e}\text{F}_{(10-m_e)}$ and $\text{C}_6\text{H}_{m_f}\text{F}_{(12-m_f)}$ may be linear or branched, and in that the film will be more excellent in abrasion resistance, preferably linear.

[0089] The above formula represents the type and number of units, and does not represent arrangement of the units. That is, m_{11} to m_{16} represent the number of units, and for example, $(\text{OCH}_{m_a}\text{F}_{(2-m_a)})_{m_{11}}$ does not necessarily represent a block of continuous m_{11} $(\text{OCH}_{m_a}\text{F}_{(2-m_a)})$ units. Likewise, the order of description of $(\text{OCH}_{m_a}\text{F}_{(2-m_a)})$ to $(\text{OC}_6\text{H}_{m_f}\text{F}_{(12-m_f)})$ does not represent arrangement of them in the order of description.

[0090] In the above formula, in a case where two or more of m_{11} to m_{16} are not 0 (that is, $(\text{OX})_m$ consists of two or more types of units), the arrangement of different units may be random, alternate, in blocks, or a combination thereof.

[0091] Further, in a case where two or more of each of the above units are contained, they may be different. For example, in a case where m_{11} is 2 or more, the plurality of $(\text{OCH}_{m_a}\text{F}_{(2-m_a)})$ may be the same or different.

[0092] The reactive silyl group is preferably a group represented by the formula (2):



[0093] The number of the group (2) in the fluorinated ether compound is one or more, and in that the film will be more excellent in abrasion resistance, preferably two or more, more preferably from 2 to 10, further preferably from 2 to 5, particularly preferably 2 or 3.

[0094] In a case where there are two or more groups (2) in one molecule, the two or more groups (2) may be the same or different. In view of availability of materials and production efficiency of the fluorinated ether compound, the two or more groups (2) are preferably the same.

[0095] R is a monovalent hydrocarbon group, preferably a saturated monovalent hydrocarbon group. The number of carbon atoms in R is preferably from 1 to 6, more preferably from 1 to 3, particularly preferably from 1 to 2.

[0096] L is a hydrolysable group or a hydroxy group.

[0097] The hydrolysable group is a group which becomes a hydroxy group by being hydrolyzed. That is, a hydrolysable silyl group represented by Si-L becomes a silanol group represented by Si-OH by being hydrolyzed. The silanol groups further react with each other to form a Si-O-Si bond. Further, the silanol group undergoes dehydration condensation reaction with a silanol group derived from the oxide contained in the undercoat layer to form a Si-O-Si bond.

[0098] The hydrolysable group may, for example, be specifically an alkoxy group, an aryloxy group, a halogen atom, an acyl group, an acyloxy group or an isocyanate group (-NCO). The alkoxy group is preferably a C_{1-4} alkoxy group. The aryloxy group is preferably a C_{3-10} aryloxy group. The aryl group in the aryloxy group includes a heteroaryl group. The halogen atom is preferably a chlorine atom. The acyl group is preferably a C_{1-6} acyl group. The acyloxy group is preferably a C_{1-6} acyloxy group.

[0099] L is, in view of more easy production of the fluorinated ether compound, preferably a C_{1-4} alkoxy group or a halogen atom. L is, in that outgassing at the time of coating is small and the fluorinated ether compound will be more excellent in storage stability, preferably a C_{1-4} alkoxy group, and in a case where the fluorinated ether compound is required to have long-term storage stability, particularly preferably an ethoxy group, and in a case where the reaction time after coating is to be short, particularly preferably a methoxy group.

[0100] In the present invention, as compared with a case where the undercoat layer is formed only of silica, the hydrolysis and the condensation reaction of the reactive silyl group in the fluorinated ether compound are promoted. Accordingly, even when the fluorinated ether compound having a reactive silyl group is used which hardly undergoes reaction if the undercoat layer is formed only of silica, the water/oil repellent layer will be excellent in abrasion resistance.

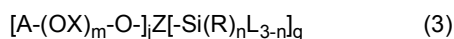
[0101] n is an integer of from 0 to 2.

[0102] n is preferably 0 or 1, particularly preferably 0. By the presence of a plurality of L, adhesion of the film to the substrate will be stronger.

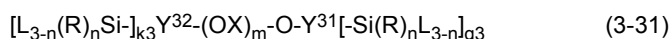
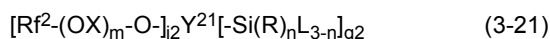
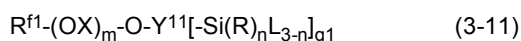
[0103] When n is 1 or less, the plurality of L present in one molecule may be the same or different. In view of availability of materials and production efficiency of the fluorinated ether compound, they are preferably the same. When n is 2, the plurality of R present in one molecule may be the same or different. In view of availability of materials and production efficiency of the fluorinated ether compound, they are preferably the same.

[0104] The fluorinated ether compound is, in that the film will be more excellent in water/oil repellency and abrasion

resistance, preferably a compound represented by the formula (3):



- 5 **[0105]** A is a perfluoroalkyl group or $-Q[-Si(R)_nL_{3-n}]_k$
[0106] The number of carbon atoms in the perfluoroalkyl group is, in that the film will be more excellent in abrasion resistance, preferably from 1 to 20, more preferably from 1 to 10, further preferably from 1 to 6, particularly preferably from 1 to 3.
[0107] The perfluoroalkyl group may be linear or branched.
10 **[0108]** When A is $-Q[-Si(R)_nL_{3-n}]_k$, j is 1.
[0109] The perfluoroalkyl group may, for example, be CF_3- , CF_3CF_2- , $CF_3CF_2CF_2-$, $CF_3CF_2CF_2CF_2-$, $CF_3CF_2CF_2CF_2CF_2-$, $CF_3CF_2CF_2CF_2CF_2CF_2-$, or $CF_3CF(CF_3)-$.
[0110] The perfluoroalkyl group is, in that the film will be more excellent in water/oil repellency, preferably CF_3- , CF_3CF_2- , or $CF_3CF_2CF_2-$.
15 **[0111]** Q is a (k+1) valent linking group. As described hereinafter, k is an integer of from 1 to 10. Accordingly, Q is a bivalent to undecavalent linking group.
[0112] Q may be any group which does not impair the effects of the present invention, and may, for example, be an alkylene group which may have an etheric oxygen atom or a bivalent organopolysiloxane residue, a carbon atom, a nitrogen atom, a silicon atom, a bivalent to octavalent organopolysiloxane residue, or the after described groups (g2-1) to (g2-9) and groups (g3-1) to (g3-9).
20 **[0113]** R, L, n, X and m are as defined above.
[0114] Z is a (j+g) valent linking group.
[0115] Z may be any group which does not impair the effects of the present invention and may, for example, be an alkylene group which may have an etheric oxygen atom or a bivalent organopolysiloxane residue, a carbon atom, a nitrogen atom, a silicon atom, a bivalent to octavalent organopolysiloxane residue, or the after described groups (g2-1) to (g2-9) and groups (g3-1) to (g3-9).
25 **[0116]** j is an integer of at least 1, and in that the film will be more excellent in water/oil repellency, preferably an integer of from 1 to 5, and in that the compound (3) will readily be produced, particularly preferably 1.
[0117] g is an integer of at least 1, and in that the film will be more excellent in abrasion resistance, preferably an integer of from 2 to 4, more preferably 2 or 3, particularly preferably 3.
30 **[0118]** The compound (3) is, in that the water/oil repellent layer will be more excellent in initial water contact angle and abrasion resistance, preferably compound (3-11), (3-21) or (3-31). Among them, with the compounds (3-11) and (3-21), the water/oil repellent layer will be particularly excellent in initial water contact angle, and with the compound (3-31), the water/oil repellent layer will be particularly excellent in abrasion resistance.



- 35 **[0119]** In the formula (3-11), X, m, R, n and L are respectively the same as X, m, R, n and L in the formula (3).
[0120] R^{f1} is a perfluoroalkyl group, and the preferred embodiments and specific examples of the perfluoroalkyl group are as described above.
45 **[0121]** Y^{11} is a (g1+1) valent linking group, and its specific examples are the same as Z in the formula (3).
[0122] g_1 is an integer of at least 2, and in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably an integer of from 2 to 15, more preferably an integer of from 2 to 4, further preferably 2 or 3, particularly preferably 3.
[0123] In the formula (3-21), X, m, R, n and L are respectively the same as X, m, R, n and L in the formula (3).
50 **[0124]** R^{f2} is a perfluoroalkyl group, and the preferred embodiments and specific examples of the perfluoroalkyl group are as described above.
[0125] j_2 is an integer of at least 2, preferably an integer of from 2 to 6, more preferably an integer of from 2 to 4.
[0126] Y^{21} is a (j2+g2) valent linking group, and its specific examples are the same as Z in the formula (3).
[0127] g_2 is an integer of at least 2, and in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably an integer of from 2 to 15, more preferably from 2 to 6, further preferably from 2 to 4, particularly preferably 4.
55 **[0128]** In the formula (3-31), X, m, R, n and L are respectively the same as X, m, R, n and L in the formula (3).
[0129] k_3 is an integer of at least 1, preferably an integer of from 1 to 4, more preferably 2 or 3, particularly preferably 3.
[0130] Y^{32} is a (k3+1) valent linking group, and its specific examples are the same as Q in the formula (3).

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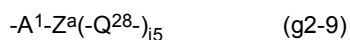
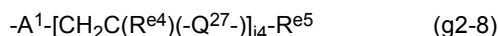
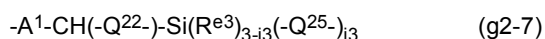
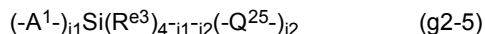
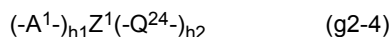
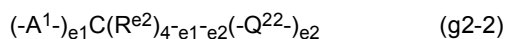
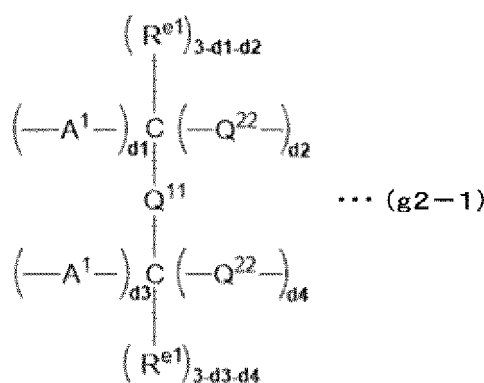
[0131] Y³¹ is a (g₃+1) valent linking group, and its specific examples are the same as Z in the formula (3).

[0132] g₃ is an integer of at least 1, preferably an integer of from 1 to 4, more preferably 2 or 3, particularly preferably 3.

[0133] Y¹¹ in the formula (3-11) may be group (g₂-1) (provided that d₁+d₃=1 (that is, d₁ or d₃ is 0), g₁=d₂+d₄, d₂+d₄≥2), group (g₂-2) (provided that e₁=1, g₁=e₂, e₂≥2), group (g₂-3) (provided that g₁=2), group (g₂-4) (provided that h₁=1, g₁=h₂, h₂≥2), group (g₂-5) (provided that i₁=1, g₁=i₂, i₂≥2), group (g₂-7) (provided that g₁=i₃+1), group (g₂-8) (provided that g₁=i₄, i₄≥2), or group (g₂-9) (provided that g₁=i₅, i₅≥2).

[0134] Y²¹ in the formula (3-21) may be group (g₂-1) (provided that j₂=d₁+d₃, d₁+d₃≥2, g₂=d₂+d₄, d₂+d₄≥2), group (g₂-2) (provided that j₂=e₁, e₁=2, g₂=e₂, e₂=2), group (g₂-4) (provided that j₂=h₁, h₁≥2, g₂=h₂, h₂≥2) or group (g₂-5) (provided that j₂=i₁, i₁=2, g₂=i₂, i₂=2).

[0135] Further, Y³¹ and Y³² in the formula (3-31) may be independently group (g₂-1) (provided that g₃=d₂+d₄, k₃=d₂+d₄), group (g₂-2) (provided that g₃=e₂, k₃=e₂), group (g₂-3) (provided that g₃=2, k₃=2), group (g₂-4) (provided that g₃=h₂, k₃=h₂), group (g₂-5) (provided that g₃=i₂, k₃=i₂), group (g₂-6) (provided that g₃=1, k₃=1), group (g₂-7) (provided that g₃=i₃+1, k₃=i₃+1), group (g₂-8) (provided that g₃=i₄, k₃=i₄), or group (g₂-9) (provided that g₃=i₅, k₃=i₅).



[0136] In the formulae (g₂-1) to (g₂-9), the A¹ side is connected to (OX)_m, and Q²², Q²³, Q²⁴, Q²⁵, Q²⁸, Q²⁷ or Q²⁸ side is connected to [-Si(R)_nL_{3-n}].

[0137] A¹ is a single bond, an alkylene group or an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms -C(O)NR⁶-, -C(O)-, -OC(O)O-, -NHC(O)O-, -NHC(O)NR⁶-, -O- or -SO₂NR⁶-, and in each formula, when two or more A¹ are present, the two or more A¹ may be the same or different. The hydrogen atom in the alkylene group may be substituted by a fluorine atom.

[0138] Q²² is an alkylene group, an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms -C(O)NR⁶-, -C(O)-, -NR⁶- or -O-, an alkylene group having -C(O)NR⁶-, -C(O)-, -NR⁶- or -O- at the terminal on the side not connected to Si, or an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms -C(O)NR⁶-, -C(O)-, -NR⁶- or -O- and having -C(O)NR⁶-, -C(O)-, -NR⁶- or -O- at the terminal on the side not connected to Si, and in each formula, when two or more Q²² are present, the two or more Q²² may be the same or different.

[0139] Q²³ is an alkylene group, or an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms -C(O)NR⁶-, -C(O)-, -NR⁶- or -O-, and the two Q²³ may be the same or different.

[0140] Q²⁴ is Q²² when the atom in Z¹ to which Q²⁴ is bonded is a carbon atom, Q²³ when the atom in Z¹ to which

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Q²⁴ is bonded is a nitrogen atom, and in each formula, when two or more Q²⁴ are present, the two or more Q²⁴ may be the same or different.

[0141] Q²⁵ is an alkylene group, or an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms -C(O)NR⁶-, -C(O)-, -NR⁶- or -O-, and in each formula, when two or more Q²⁵ are present, the two or more Q²⁵ may be the same or different.

[0142] Q²⁶ is an alkylene group, or an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms -C(O)NR⁶-, -C(O)-, -NR⁶- or -O-.

[0143] R⁶ is a hydrogen atom, a C₁₋₆ alkyl group or a phenyl group.

[0144] Q²⁷ is a single bond or an alkylene group.

[0145] Q²⁸ is an alkylene group, or an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms an etheric oxygen atom or a bivalent organopolysiloxane residue.

[0146] Z¹ is a group having a h¹+h² valent cyclic structure having a carbon atom or a nitrogen atom to which A' is directly bonded and having a carbon atom or a nitrogen atom to which Q²⁴ is directly bonded.

[0147] R^{e1} is a hydrogen atom or an alkyl group, and in each formula, when two or more R^{e1} are present, the two or more R^{e1} may be the same or different.

[0148] R^{e2} is a hydrogen atom, a hydroxy group, an alkyl group or an acyloxy group.

[0149] R^{e3} is an alkyl group.

[0150] R^{e4} is a hydrogen atom or an alkyl group and in view of easy production of the compound, preferably a hydrogen atom. In each formula, when two or more R^{e4} are present, the two or more R^{e4} may be the same or different.

[0151] R^{e5} is a hydrogen atom or a halogen atom, and in view of easy production of the compound, preferably a hydrogen atom.

[0152] d₁ is an integer of from 0 to 3, preferably 1 or 2. d₂ is an integer of from 0 to 3, preferably 1 or 2. d₁+d₂ is an integer of from 1 to 3.

[0153] d₃ is an integer of from 0 to 3, and is preferably 0 or 1. d₄ is an integer of from 0 to 3, preferably 2 or 3. d₃+d₄ is an integer of from 1 to 3.

[0154] d₁+d₃ is, in Y¹¹ and Y²¹, an integer of from 1 to 5, preferably 1 or 2, and in Y¹¹, Y³¹ and Y³², 1.

[0155] d₂+d₄ is, in Y¹¹ and Y²¹, an integer of from 2 to 5, preferably 4 or 5, and in Y³¹ and Y³², an integer of from 3 to 5, preferably 4 or 5.

[0156] e₁+e₂ is 3 or 4. e₁ is 1 in Y¹¹, an integer of from 2 to 3 in Y²¹, and 1 in Y³¹ and Y³². e₂ is 2 or 3 in Y¹¹ and Y²¹, and 2 or 3 in Y³¹ and Y³².

[0157] h₁ is 1 in Y¹¹, an integer of at least 2 (preferably 2) in Y²¹, and 1 in Y³¹ and Y³². h₂ is an integer of at least 2 (preferably 2 or 3) in Y¹¹ and Y²¹, and an integer of at least 1 (preferably 2 or 3) in Y³¹ and Y³².

[0158] i₁+i₂ is 3 or 4 in Y¹¹, 4 in Y¹², and 3 or 4 in Y³¹ and Y³². i₁ is 1 in Y¹¹, 2 in Y²¹, and 1 in Y³¹ and Y³². i₂ is 2 or 3 in Y¹¹, 2 in Y¹², and 2 or 3 in Y³¹ and Y³².

[0159] i₃ is 2 or 3.

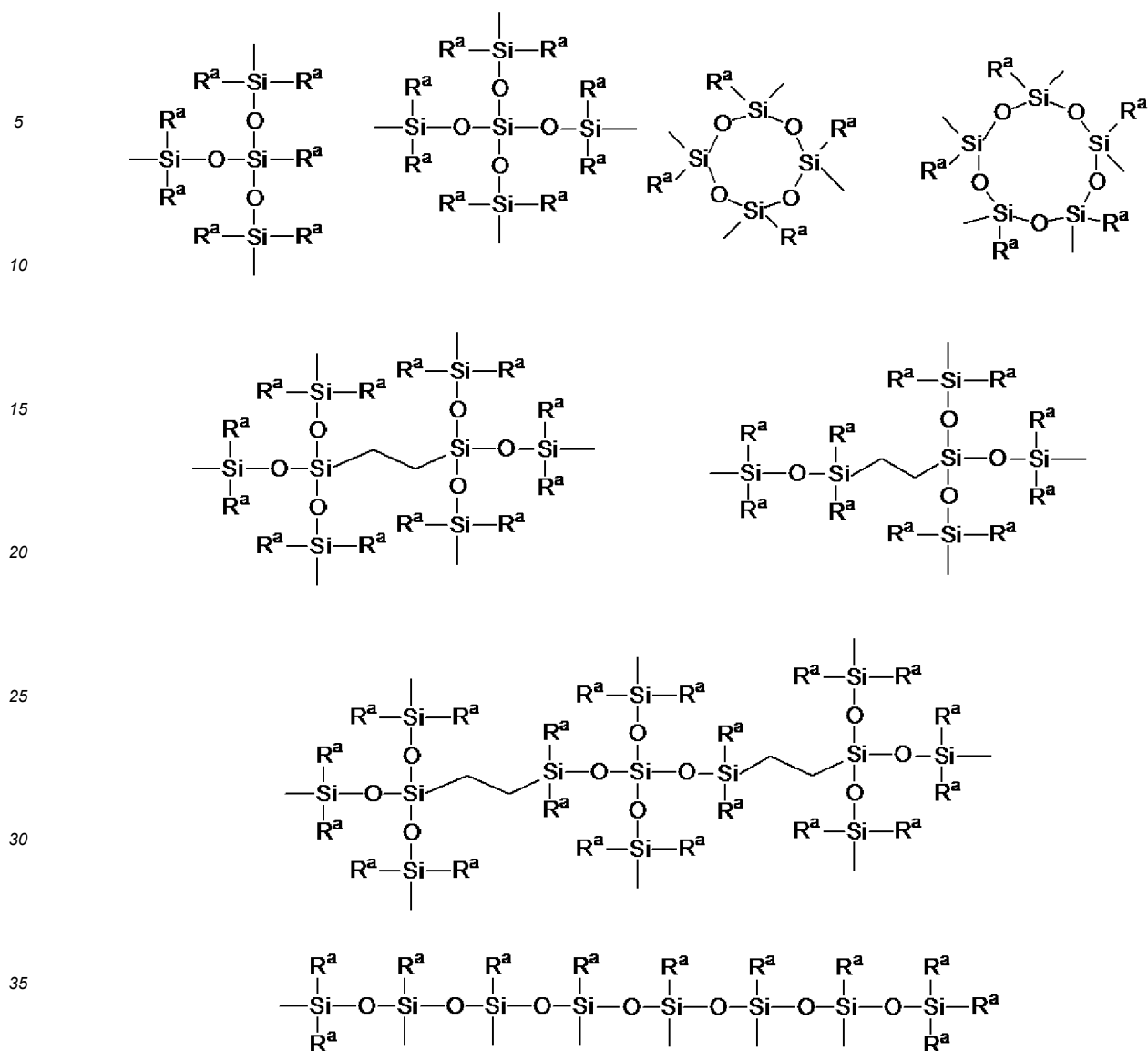
[0160] i₄ is at least 2 (preferably an integer of from 2 to 10, particularly preferably an integer of from 2 to 6) in Y¹¹, and at least 1 (preferably an integer of from 1 to 10, particularly preferably an integer of from 1 to 6) in Y³¹ and Y³².

[0161] i₅ is at least 2, preferably an integer of from 2 to 7.

[0162] The number of carbon atoms in the alkylene group in Q²², Q²³, Q²⁴, Q²⁵, Q²⁶, Q²⁷ and Q²⁸ is, in that the compounds (3-11), (3-21) and (3-31) are readily produced and in that the water/oil repellent layer will be more excellent in abrasion resistance, light resistance and chemical resistance, preferably from 1 to 10, more preferably from 1 to 6, particularly preferably from 1 to 4. When the alkylene group has a specific bond between carbon-carbon atoms, the lower limit of the number of carbon atoms in such an alkylene group is 2.

[0163] As the cyclic structure in Z¹, the above-described cyclic structures may be mentioned, and the preferred embodiments are also the same. Since A¹ and Q²⁴ are directly bonded to the cyclic structure in Z¹, A' and Q²⁴ will not be connected to, for example, an alkylene group connected to the cyclic structure.

[0164] Z^a is a (i₅+1) valent organopolysiloxane residue, and the following groups are preferred. In the following formulae, R^a is an alkyl group (preferably C₁₋₁₀) or a phenyl group.



40 **[0165]** The number of carbon atoms in the alkyl group as R^{e1} , R^{e2} , R^{e3} and R^{e4} is, in that the compounds (3-11), (3-21) and (3-31) are readily produced, preferably from 1 to 10, more preferably from 1 to 6, further preferably from 1 to 3, particularly preferably from 1 to 2.

[0166] The number of carbon atoms in the alkyl group moiety in the acyloxy group as R^{e2} is, in that the compounds (3-11), (3-21) and (3-31) are readily produced, preferably from 1 to 10, more preferably from 1 to 6, further preferably from 1 to 3, particularly preferably from 1 to 2.

45 **[0167]** h_1 is, in that the compounds (3-11), (3-21) and (3-31) are readily produced, and in that the water/oil repellent layer will be more excellent in abrasion resistance and fingerprint stain removability, preferably from 1 to 6, more preferably from 1 to 4, further preferably 1 or 2, particularly preferably 1.

[0168] h_2 is, in that the compounds (3-11), (3-21) and (3-31) are readily produced, and in that the water/oil repellent layer will be more excellent in abrasion resistance and fingerprint stain removability, preferably from 2 to 6, more preferably from 2 to 4, particularly preferably 2 or 3.

[0169] As other embodiment of Y^{11} , group (g3-1) (provided that $d_1+d_3=1$ (that is, d_1 or d_3 is 0), $g_1=d_2 \times r_1+d_4 \times r_1$), group (g3-2) (provided that $e_1=1$, $g_1=e_2 \times r_1$), group (g3-3) (provided that $g_1=2 \times r_1$), group (g3-4) (provided that $h_1=1$, $g_1=h_2 \times r_1$), group (g3-5) (provided that $i_1=1$, $g_1=i_2 \times r_1$), group (g3-6) (provided that $g_1=r_1$), group (g3-7) (provided that $g_1=r_1 \times (i_3+1)$), group (g3-8) (provided that $g_1=r_1 \times i_4$), or group (g3-9) (provided that $g_1=r_1 \times i_5$) may be mentioned.

55 **[0170]** As other embodiment of Y^{21} , group (g3-1) (provided that $j_2=d_1+d_3$, $d_1+d_3 \geq 2$, $g_2=d_2 \times r_1+d_4 \times r_1$), group (g3-2) (provided that $j_2=e_1$, $e_1=2$, $g_2=e_2 \times r_1$, $e_2=2$), group (g3-4) (provided that $j_2=h_1$, $h_1 \geq 2$, $g_2=h_2 \times r_1$), or group (g3-5) (provided that $j_2=i_1$, i_1 is 2 or 3, $g_2=i_2 \times r_1$, i_1+i_2 is 3 or 4) may be mentioned.

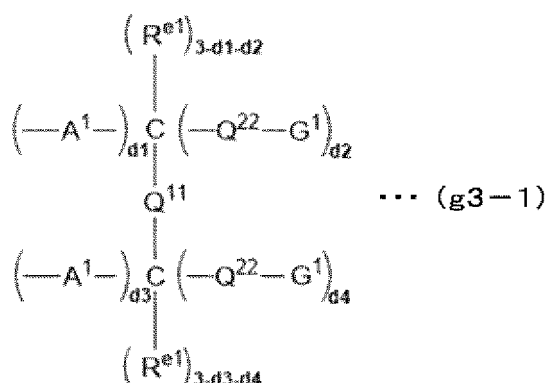
[0171] As other embodiment of Y^{31} and Y^{32} , group (g3-1) (provided that $g_3=d_2 \times r_1+d_4 \times r_1$, $k_3=d_2 \times r_1+d_4 \times r_1$), group

(g3-2) (provided that $g_3=e_2 \times r_1$, $k_3=e_2 \times r_1$), group (g3-3) (provided that $g_3=2 \times r_1$, $k_3=2 \times r_1$), group (g3-4) (provided that $g_3=h_2 \times r_1$, $k_3=h_2 \times r_1$), group (g3-5) (provided that $g_3=i_2 \times r_1$, $k_3=i_2 \times r_1$), group (g3-6) (provided that $g_3=r_1$, $k_3=r_1$), group (g3-7) (provided that $g_3=r_1 \times (i_3+1)$, $k_3=r_1 \times (i_3+1)$), group (g3-8) (provided that $g_3=r_1 \times i_4$, $k_3=r_1 \times i_4$), or group (g3-9) (provided that $g_3=r_1 \times i_5$, $k_3=r_1 \times i_5$) may be mentioned.

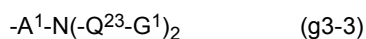
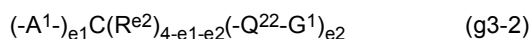
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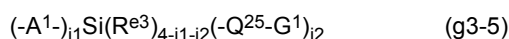
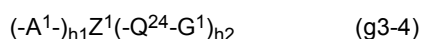
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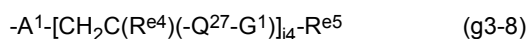
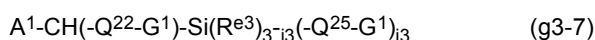
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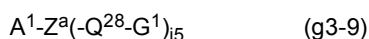
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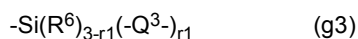
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[0172] In the formulae (g3-1) to (g3-9), the A^1 side is connected to $(OX)_m$, and the G^1 side is connected to $[-Si(R)_n L_{3-n}]$.

[0173] G^1 is group (g3), and in each formula, when two or more G^1 are present, the two or more G^1 may be the same or different. Symbols other than G^1 are the same as symbols in the formulae (g2-1) to (g2-9).

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[0174] In the formula (g3), the Si side is connected to Q^{22} , Q^{23} , Q^{24} , Q^{25} , Q^{26} , Q^{27} or Q^{28} , and the Q^3 side is connected to $[-Si(R)_n L_{3-n}]$. R^8 is an alkyl group. Q^3 is an alkylene group, or an alkylene group having at least 2 carbon atoms and having between carbon-carbon atoms $-C(O)NR^6-$, $-C(O)-$, $-NR^6-$ or $-O-$, or $-(OSi(R^9)_2)_p-O-$, and two or more Q^3 may be the same or different. r_1 is 2 or 3. R^6 is a hydrogen atom, or a C_{1-6} alkyl group, or a phenyl group. R^9 is an alkyl group, a phenyl group or an alkoxy group, and two R^9 may be the same or different. p is an integer of from 0 to 5, and when p is at least 2, the two or more $(OSi(R^9)_2)$ may be the same or different.

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[0175] The number of carbon atoms in the alkylene group as Q^3 is, in that the compounds (3-11), (3-21) and (3-31) are readily produced and in that the water/oil repellent layer will be more excellent in abrasion resistance, light resistance and chemical resistance, preferably from 1 to 10, more preferably from 1 to 6, particularly preferably from 1 to 4. When the alkylene group has a specific bond between carbon-carbon atoms, the lower limit of the number of carbon atoms in such an alkylene group is 2.

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[0176] The number of carbon atoms in the alkyl group as R^8 is, in that the compounds (3-11), (3-21) and (3-31) are readily produced, preferably from 1 to 10, more preferably from 1 to 6, further preferably from 1 to 3, particularly preferably from 1 to 2.

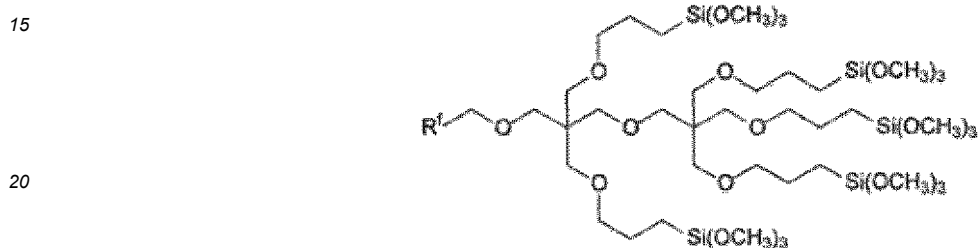
[0177] The number of carbon atoms in the alkyl group as R^9 is, in that the compounds (3-11), (3-21) and (3-31) are readily produced, preferably from 1 to 10, more preferably from 1 to 6, further preferably from 1 to 3, particularly preferably from 1 to 2.

[0178] The number of carbon atoms in the alkoxy group as R⁹ is, in that the compounds (3-11), (3-21) and (3-31) are excellent in storage stability, preferably from 1 to 10, more preferably from 1 to 6, further preferably from 1 to 3, particularly preferably from 1 to 2.

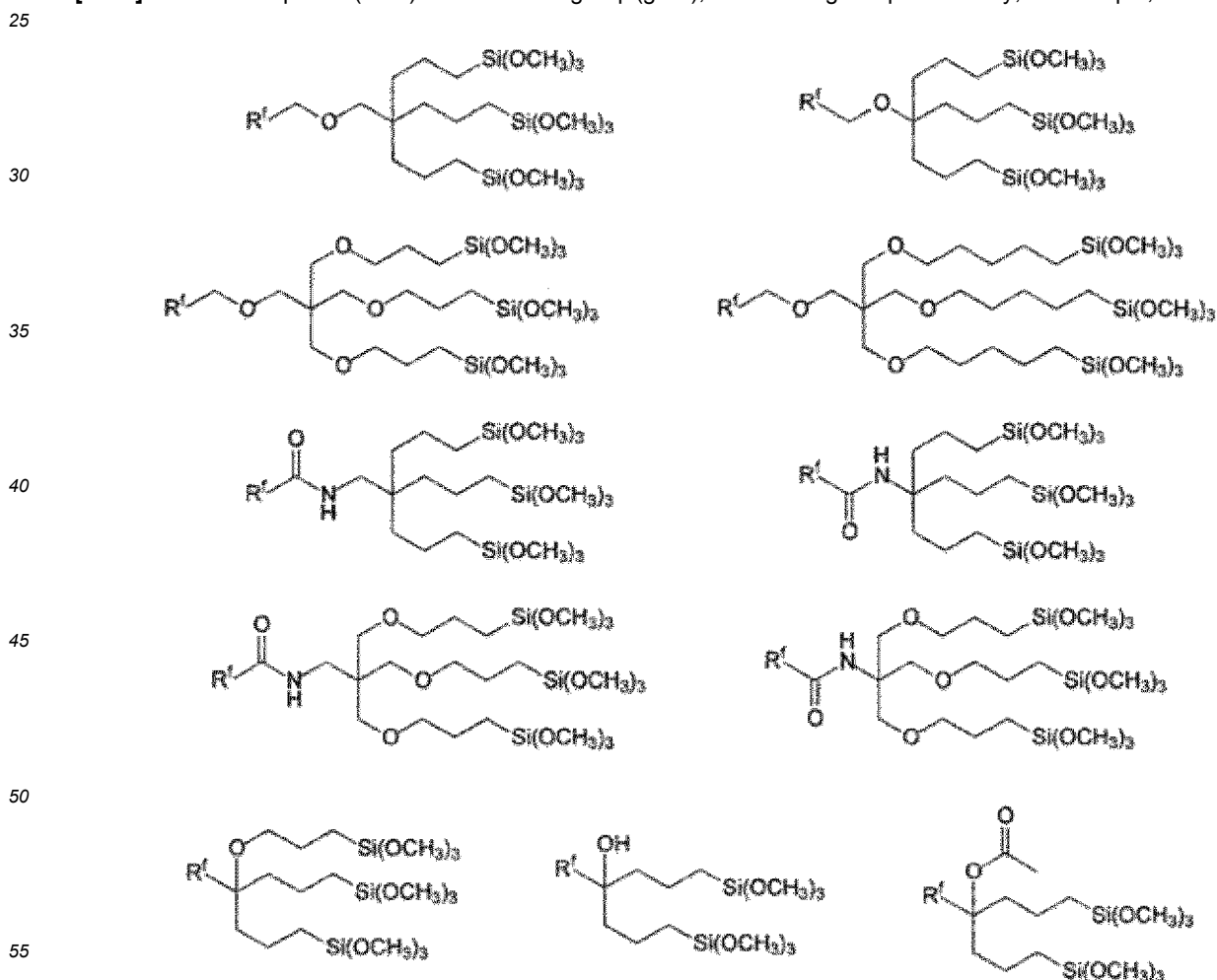
[0179] p is preferably 0 or 1.

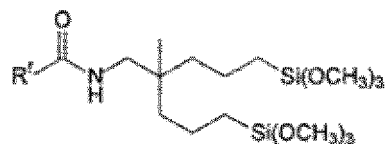
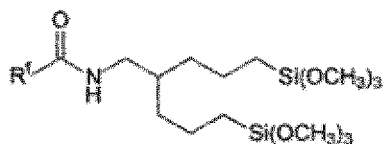
5 [0180] As the compounds (3-11), (3-21) and (3-31), for example, the following compounds may be mentioned. The following compounds are industrially readily produced, are easily handled, and provide a water/oil repellent layer excellent in water/oil repellency, abrasion resistance, fingerprint stain removability, lubricity, chemical resistance, light resistance and chemical resistance, particularly light resistance. In the following compounds, R^f is the same as that in R^{f1}-(OX)_m-O- in the formula (3-11) or R^{f2}-(OX)_m-O- in the formula (3-21), and the preferred embodiments are also the same. In the
10 following compounds, Q^f is the same as that in -(OX)_m-O- in the formula (3-31), and the preferred embodiments are also the same.

[0181] As the compound (3-11) wherein Y¹¹ is group (g2-1), the following compound may, for example, be mentioned.

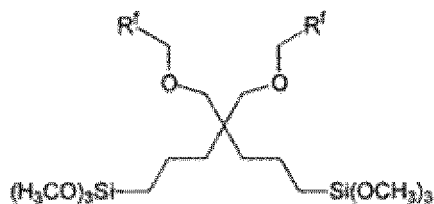
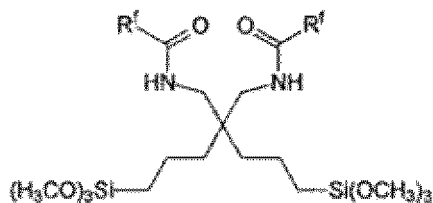
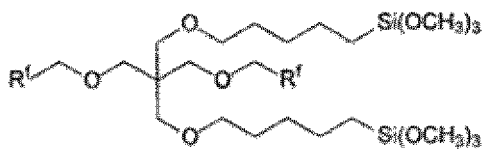


[0182] As the compound (3-11) wherein Y¹¹ is group (g2-2), the following compounds may, for example, be mentioned.

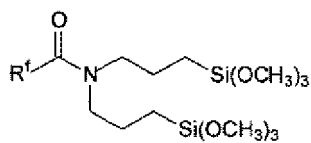
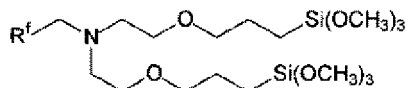
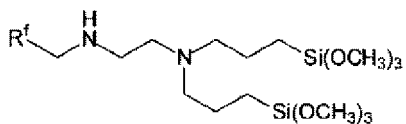
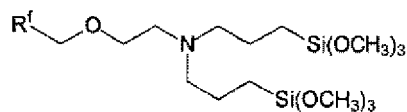
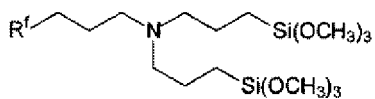
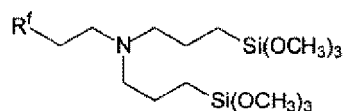
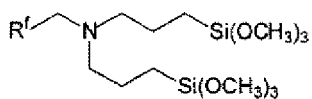




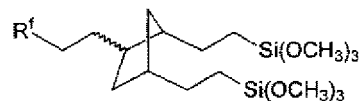
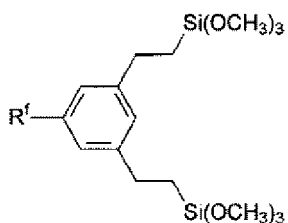
[0183] As the compound (3-21) wherein Y²¹ is group (g2-2), the following compounds may, for example, be mentioned.



[0184] As the compound (3-11) wherein Y¹¹ is group (g2-3), the following compounds may, for example, be mentioned.

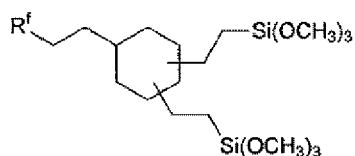
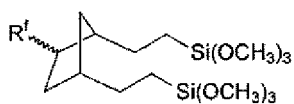


[0185] As the compound (3-11) wherein Y¹¹ is group (g2-4), the following compounds may, for example, be mentioned.

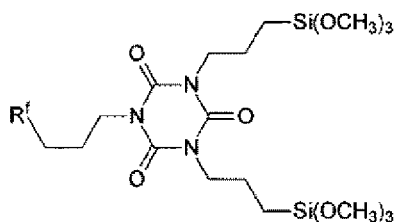
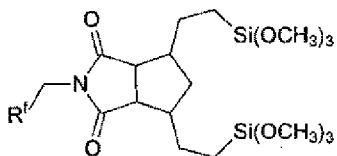


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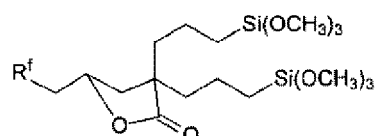
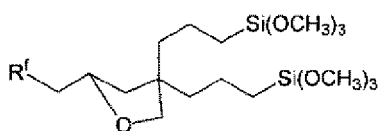
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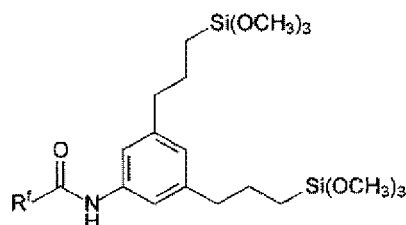
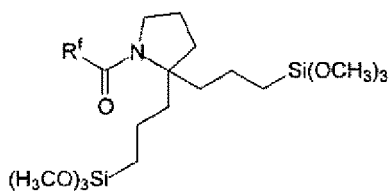
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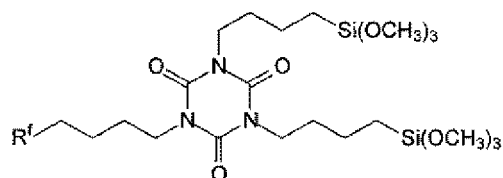
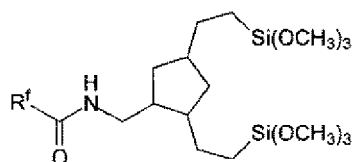


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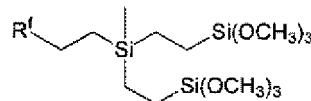
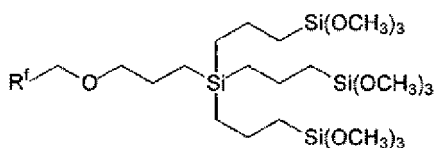
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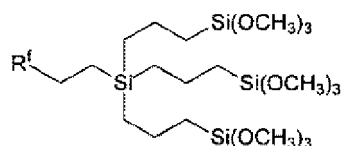
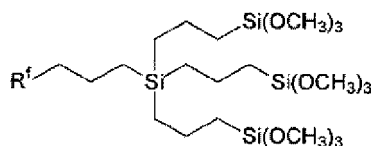
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[0186] As the compound (3-11) wherein Y¹¹ is group (g2-5), the following compounds may, for example, be mentioned.

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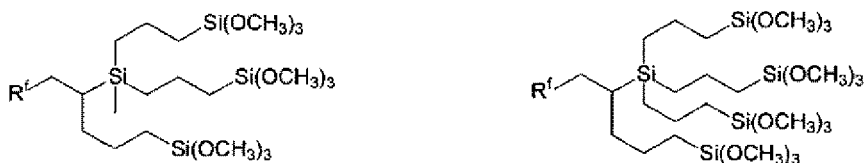


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[0187] As the compound (3-11) wherein Y¹¹ is group (g2-7), the following compounds may, for example, be mentioned.

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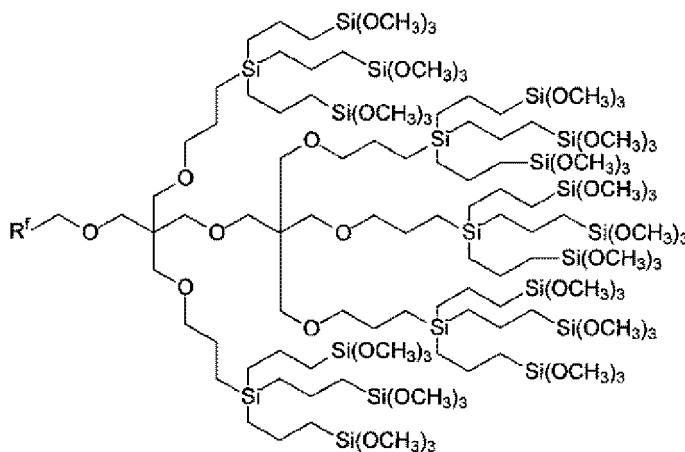
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[0188] As the compound (3-11) wherein Y¹¹ is group (g3-1), the following compounds may, for example, be mentioned.

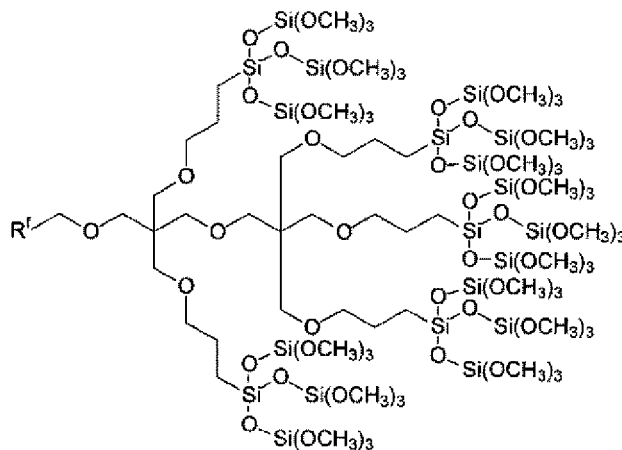
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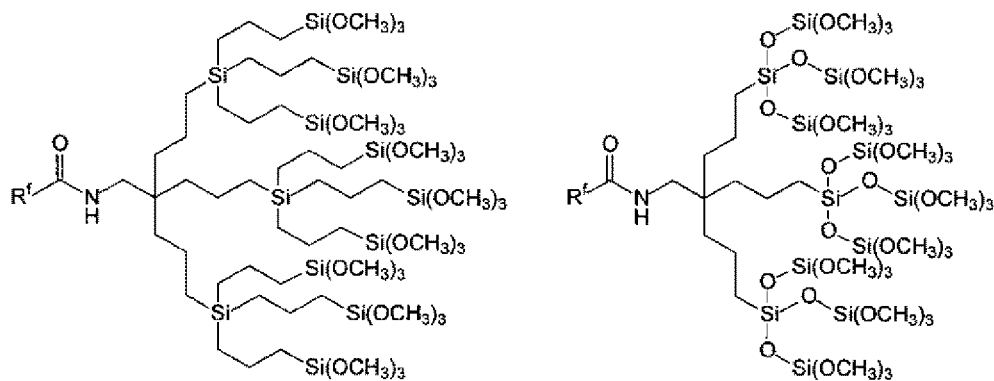


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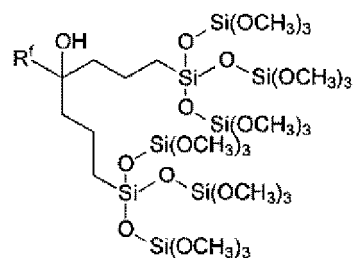
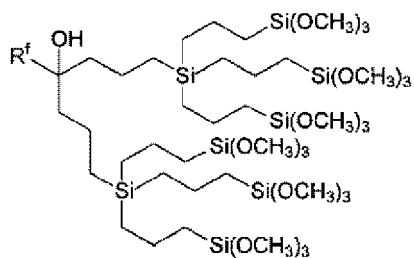
[0189] As the compound (3-11) wherein Y¹¹ is group (g3-2), the following compounds may, for example, be mentioned.

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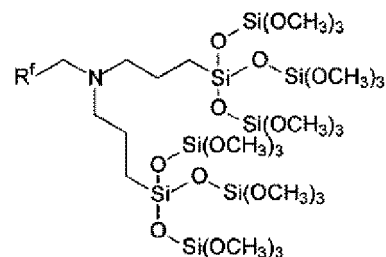
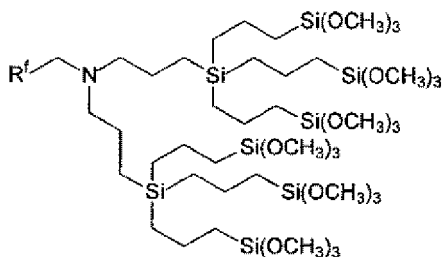


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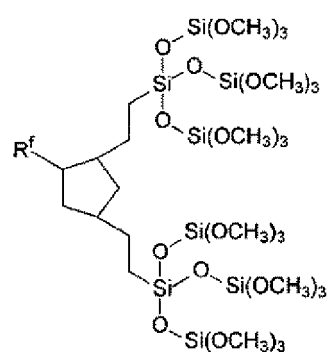
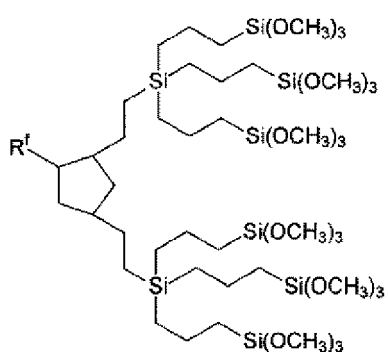
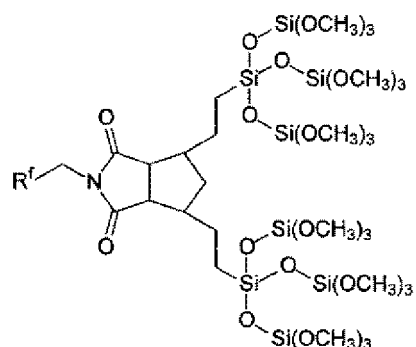
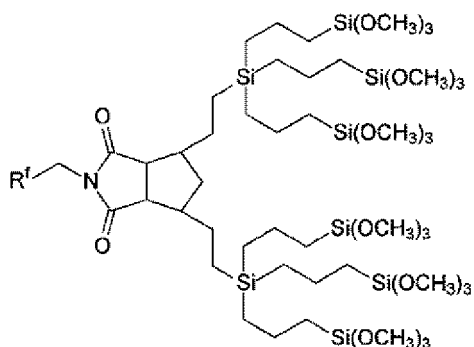
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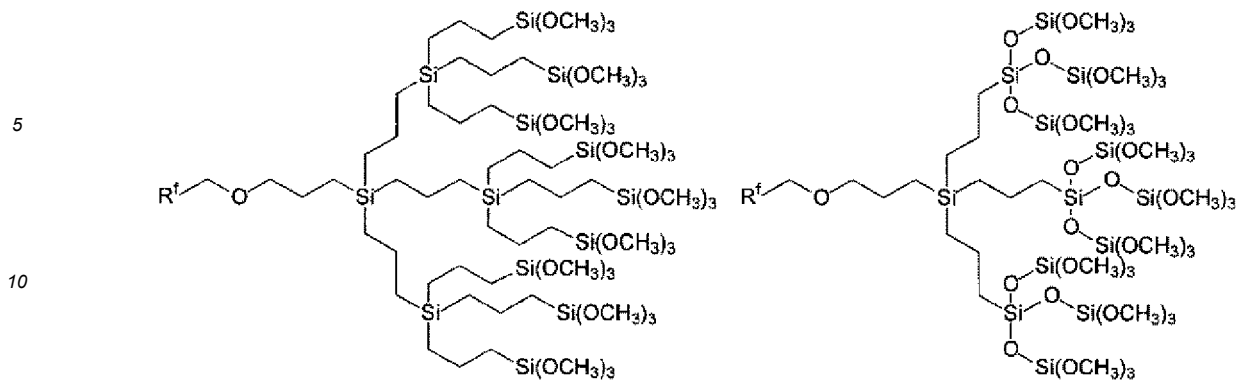
[0190] As the compound (3-11) wherein Y¹¹ is group (g3-3), the following compounds may, for example, be mentioned.



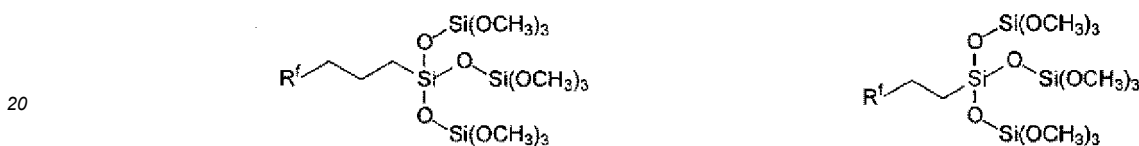
[0191] As the compound (3-11) wherein Y¹¹ is group (g3-4), the following compounds may, for example, be mentioned.



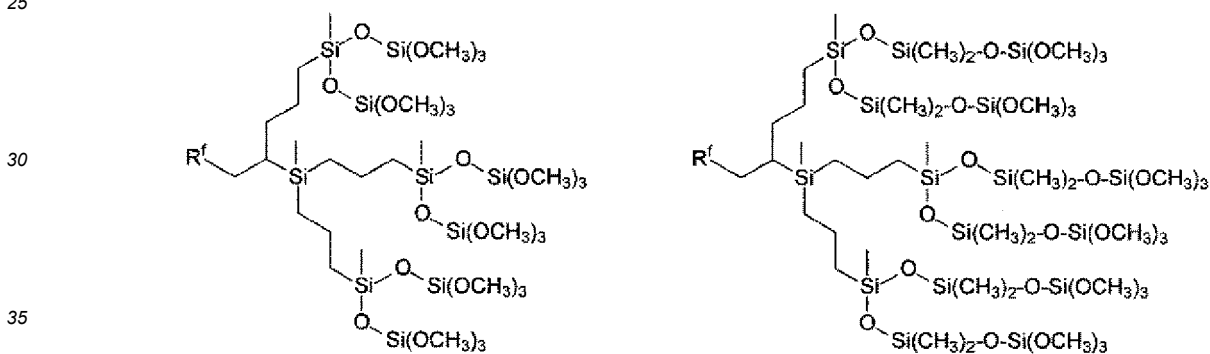
[0192] As the compound (3-11) wherein Y¹¹ is group (g3-5), the following compounds may, for example, be mentioned.



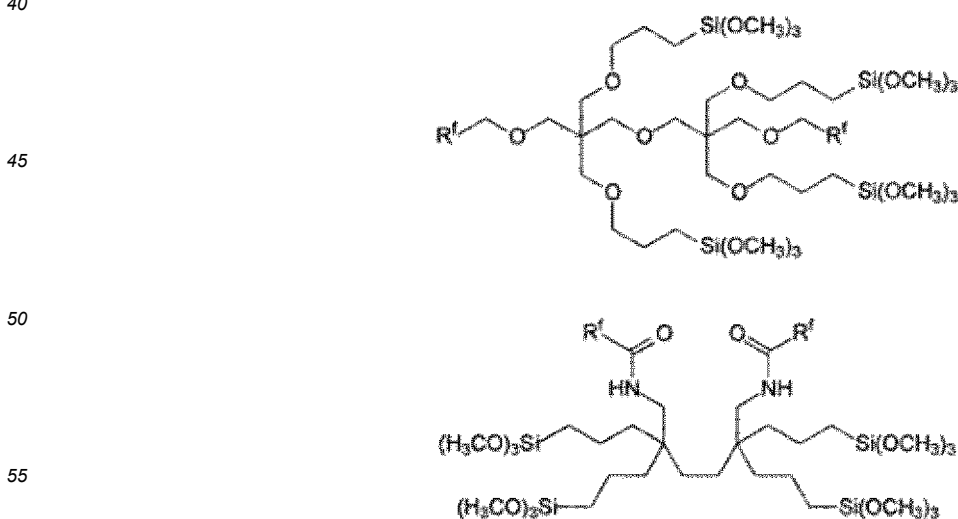
15 **[0193]** As the compound (3-11) wherein Y¹¹ is group (g3-6), the following compounds may, for example, be mentioned.



25 **[0194]** As the compound (3-11) wherein Y¹¹ is group (g3-7), the following compounds may, for example, be mentioned.

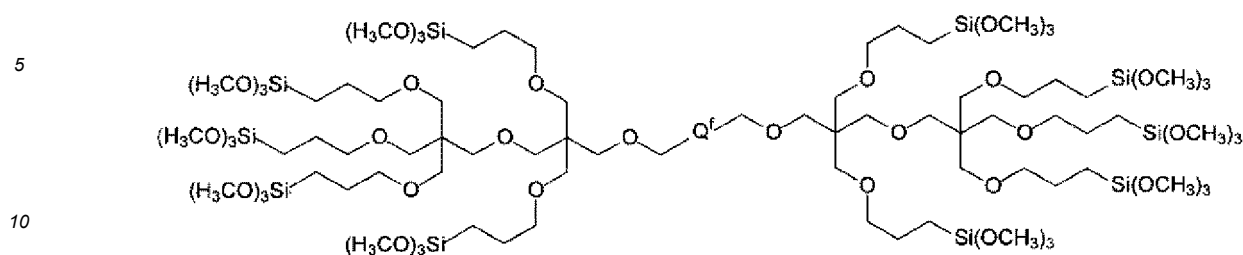


40 **[0195]** As the compound (3-21) wherein Y²¹ is group (g2-1), the following compounds may, for example, be mentioned.

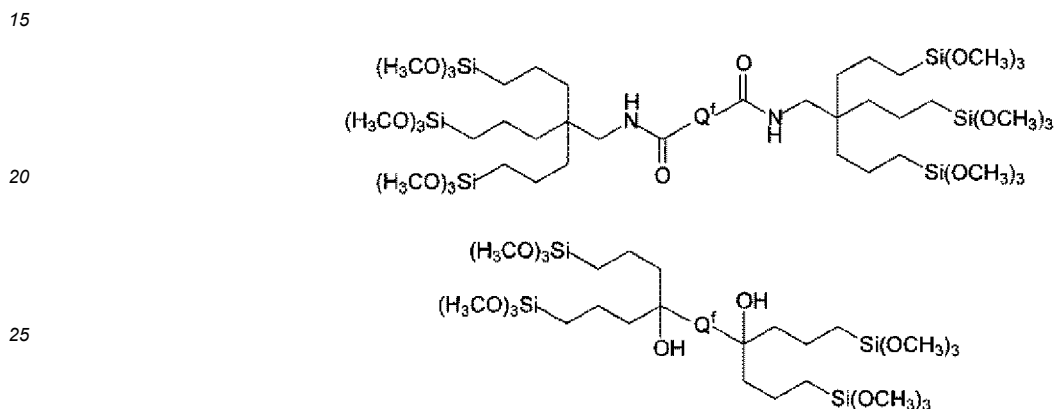


[0196] As the compound (3-31) wherein Y³¹ and Y³² are group (g2-1), the following compound may, for example, be

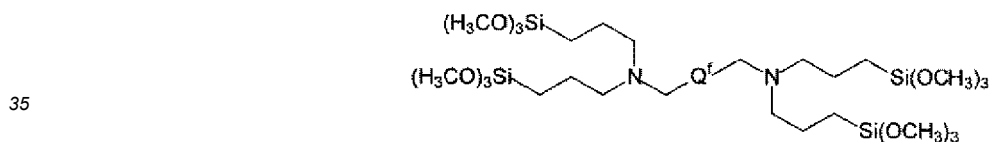
mentioned.



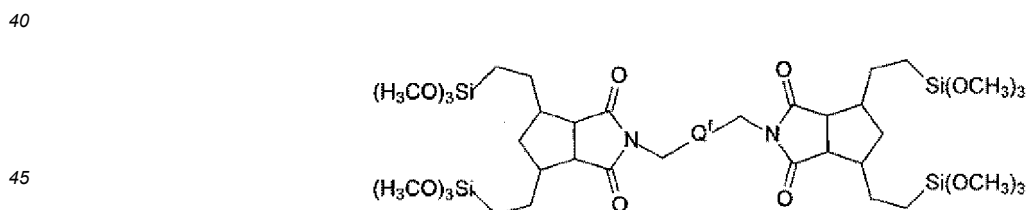
[0197] As the compound (3-31) wherein Y³¹ and Y³² are group (g2-2), the following compounds may, for example, be mentioned.



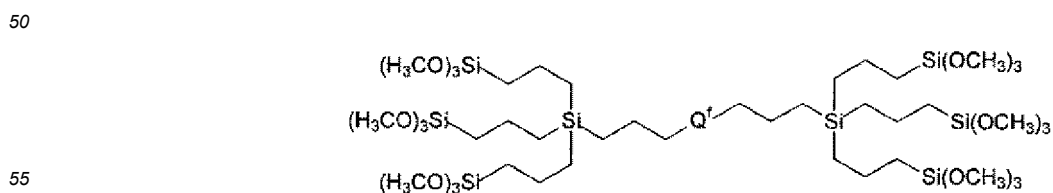
[0198] As the compound (3-31) wherein Y³¹ and Y³² are group (g2-3), the following compound may, for example, be mentioned.



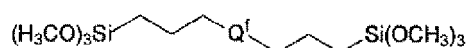
[0199] As the compound (3-31) wherein Y³¹ and Y³² are group (g2-4), the following compound may, for example, be mentioned.



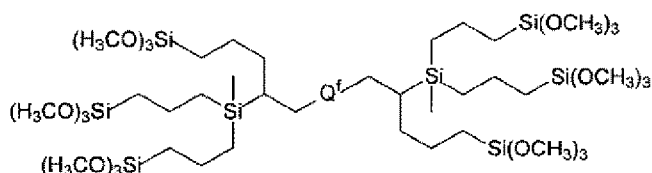
[0200] As the compound (3-31) wherein Y³¹ and Y³² are group (g2-5), the following compound may, for example, be mentioned.



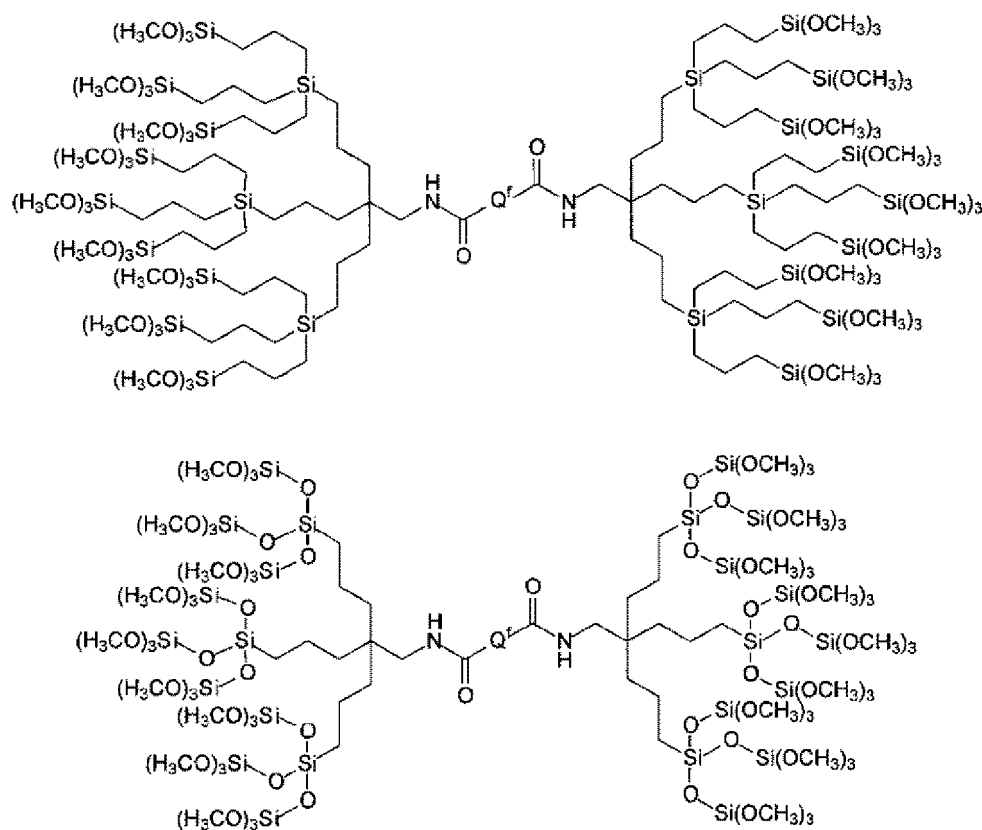
[0201] As the compound (3-31) wherein Y³¹ and Y³² are group (g2-6), the following compound may, for example, be mentioned.



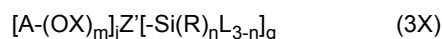
[0202] As the compound (3-31) wherein Y³¹ and Y³² are group (g2-7), the following compound may, for example, be mentioned.



[0203] As the compound (3-31) wherein Y³¹ and Y³² are group (g3-2), the following compounds may, for example, be mentioned.



[0204] As the fluorinated ether compound, in that the film will be more excellent in water/oil repellency and abrasion resistance, compound represented by the formula (3X) is also preferred.



[0205] The compound (3X) is, in that the film will be more excellent in water/oil repellency, preferably a compound represented by the formula (3-1).



[0206] In the formula (3-1), A, X and m are as defined for the respective groups in the formula (3).

[0207] Z' is a (j+g) valent linking group.

[0208] Z' is any group which does not impair the effects of the present invention and may, for example, be an alkylene group which may have an etheric oxygen atom or a bivalent organopolysiloxane residue, an oxygen atom, a carbon

atom, a nitrogen atom, a silicon atom, a bivalent to octavalent organopolysiloxane residue, or a group having $\text{Si}(\text{R})_n\text{L}_{3-n}$ removed from the formulae (3-1A), (3-1B) and (3-1A-1) to (3-1A-6).

Z^{31} is group (3-1A) or group (3-1B).

$-\text{Q}^a-\text{X}^{31}(-\text{Q}^b-\text{Si}(\text{R})_n\text{L}_{3-n})_h(-\text{R}^{31})_i$ (3-1A)

$-\text{Q}^c-[\text{CH}_2\text{C}(\text{R}^{32})(-\text{Q}^d-\text{Si}(\text{R})_n\text{L}_{3-n})]_y-\text{R}^{33}$ (3-1B)

10 **[0209]** Q^a is a single bond or a bivalent linking group.

[0210] The bivalent linking group may, for example, be a bivalent hydrocarbon group, a bivalent heterocyclic group, $-\text{O}-$, $-\text{S}-$, $-\text{SO}_2-$, $-\text{N}(\text{R}^d)-$, $-\text{C}(\text{O})-$, $-\text{Si}(\text{R}^a)_2-$ or a group having two or more of them combined. R^a is an alkyl group (preferably C_{1-10}) or a phenyl group. R^d is a hydrogen atom or an alkyl group (preferably C_{1-10}).

15 **[0211]** The bivalent hydrocarbon group may be a bivalent saturated hydrocarbon group, a bivalent aromatic hydrocarbon group, an alkenylene group or an alkynylene group. The bivalent saturated hydrocarbon group may be linear, branched or cyclic, and may, for example, be an alkylene group. The number of carbon atoms in the bivalent saturated hydrocarbon group is preferably from 1 to 20. Further, the bivalent aromatic hydrocarbon group preferably has from 5 to 20 carbon atoms and may, for example, be a phenylene group. The alkenylene group is preferably a C_{2-20} alkenylene group, and the alkynylene group is preferably a C_{2-20} alkynylene group.

20 **[0212]** The group having two or more of them combined may, for example, be $-\text{OC}(\text{O})-$, $-\text{C}(\text{O})\text{N}(\text{R}^d)-$, an alkylene group having an etheric oxygen atom, an alkylene group having $-\text{OC}(\text{O})-$, or alkylene group- $\text{Si}(\text{R}^a)_2$ -phenylene group- $\text{Si}(\text{R}^a)_2$.

[0213] X^{31} is a single bond, an alkylene group, a carbon atom, a nitrogen atom, a silicon atom or a bivalent to octavalent organopolysiloxane residue.

25 **[0214]** The alkylene group may have $-\text{O}-$, a silphenylene skeleton group, a bivalent organopolysiloxane residue or a dialkylsilylene group. The alkylene group may have a plurality of groups selected from the group consisting of $-\text{O}-$, a silphenylene skeleton group, a bivalent organopolysiloxane residue and a dialkylsilylene group.

[0215] The number of carbon atoms in the alkylene group represented by X^{31} is preferably from 1 to 20, particularly preferably from 1 to 10.

30 **[0216]** The bivalent to octavalent organopolysiloxane residue may be a bivalent organopolysiloxane residue or the after described $(w+1)$ valent organopolysiloxane residue.

[0217] Q^b is a single bond or a bivalent linking group.

[0218] The bivalent linking group is as defined for the above Q^a .

[0219] R^{31} is a hydroxy group or an alkyl group.

35 **[0220]** The number of carbon atoms in the alkyl group is preferably from 1 to 5, more preferably from 1 to 3, particularly preferably 1.

[0221] When X^{31} is a single bond or an alkylene group, h is 1, and i is 0,

[0222] when X^{31} is a nitrogen atom, h is an integer of from 1 to 2, i is an integer of from 0 to 1, and $h+i=2$ is satisfied,

40 **[0223]** when X^{31} is a carbon atom or a silicon atom, h is an integer of from 1 to 3, i is an integer of from 0 to 2, and $h+i=3$ is satisfied, and

[0224] when X^{31} is a bivalent to octavalent organopolysiloxane residue, h is an integer of from 1 to 7, i is an integer of from 0 to 6, and $h+i=1$ to 7 is satisfied.

[0225] When there are two or more $(-\text{Q}^b-\text{Si}(\text{R})_n\text{L}_{3-n})$, the two or more $(-\text{Q}^b-\text{Si}(\text{R})_n\text{L}_{3-n})$ may be the same or different. When there are two or more R^{31} , the two or more $(-\text{R}^{31})$ may be the same or different.

45 **[0226]** Q^c is a single bond, or an alkylene group which may have an etheric oxygen atom, and in view of easy production of the compound, preferably a single bond.

[0227] The number of carbon atoms in the alkylene group which may have an etheric oxygen atom is preferably from 1 to 10, particularly preferably from 2 to 6.

50 **[0228]** R^{32} is a hydrogen atom or a C_{1-10} alkyl group, and in view of easy production of the compound, preferably a hydrogen atom.

[0229] The alkyl group is preferably a methyl group.

[0230] Q^d is a single bond or an alkylene group. The number of carbon atoms in the alkylene group is preferably from 1 to 10, particularly preferably from 1 to 6. In view of easy production of the compound, Q^d is preferably a single bond or $-\text{CH}_2-$.

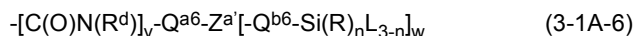
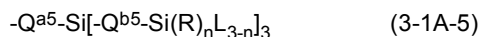
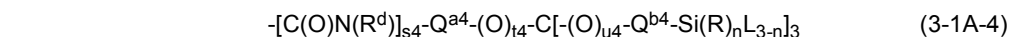
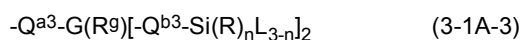
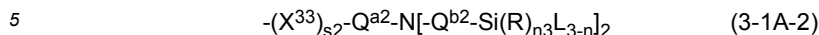
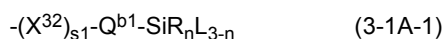
55 **[0231]** R^{33} is a hydrogen atom or a halogen atom, and in view of easy production of the compound, preferably a hydrogen atom.

[0232] y is an integer of from 1 to 10, preferably an integer of from 1 to 6.

[0233] The two or more $[\text{CH}_2\text{C}(\text{R}^{32})(-\text{Q}^d-\text{Si}(\text{R})_n\text{L}_{3-n})]$ may be the same or different.

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[0234] As the group (3-1A), groups (3-1A-1) to (3-1A-6) are preferred.



15 [0235] In the formulae (3-1A-1) to (3-1A-6), R, L, and n are as defined above.

[0236] X^{32} is -O- or -C(O)N(R^d)- (provided that N in the formula is bonded to Q^{b1}).

[0237] R^d is as defined above.

[0238] s₁ is 0 or 1.

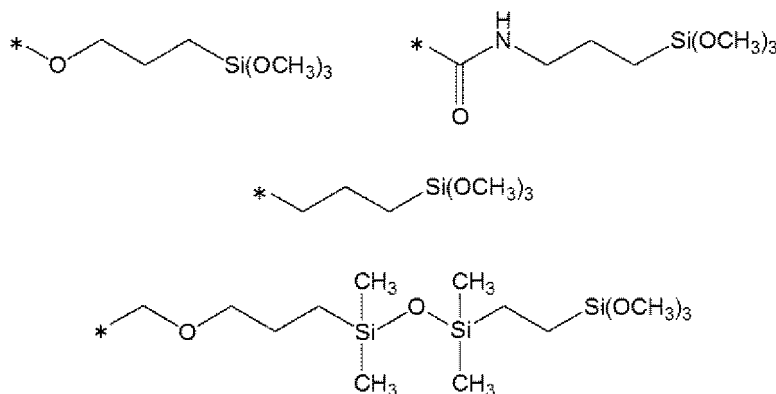
20 [0239] Q^{b1} is an alkylene group. The alkylene group may have -O-, a silphenylene skeleton group, a bivalent organopolysiloxane residue or a dialkylsilylene group. The alkylene group may have a plurality of groups selected from the group consisting of -O-, a silphenylene skeleton group, a bivalent organopolysiloxane residue and a dialkylsilylene group.

[0240] When the alkylene group has -O-, a silphenylene skeleton group, a bivalent organopolysiloxane residue or a dialkylsilylene group, the alkylene group preferably has such a group between carbon atom-carbon atom.

25 [0241] The number of carbon atoms in the alkylene group represented by Q^{b1} is preferably from 1 to 10, particularly preferably from 2 to 6.

[0242] Q^{b1} is, when s₁ is 0, preferably -CH₂OCH₂CH₂CH₂-, -CH₂OCH₂CH₂OCH₂CH₂CH₂-, -CH₂CH₂-, -CH₂CH₂CH₂ or -CH₂OCH₂CH₂CH₂Si(CH₃)₂OSi(CH₃)₂CH₂CH₂-. When (X³²)_{s1} is -O-, it is preferably -CH₂CH₂CH₂-, or -CH₂CH₂OCH₂CH₂CH₂-. When (X³²)_{s1} is -C(O)N(R^d)-, it is preferably a C₂₋₆ alkylene group (provided that N in the formula is bonded to Q^{b1}). When Q^{b1} is such a group, the compound will readily be produced.

30 [0243] As specific examples of the group (3-1A-1), the following groups may be mentioned. In the following formulae, * represents the position of bonding to (OX)_m.



[0244] X^{33} is -O-, -NH- or -C(O)N(R^d)-.

[0245] R^d is as defined above.

50 [0246] Q^{a2} is a single bond, an alkylene group, -C(O)- or an alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom, -C(O)-, -C(O)O-, -OC(O)- or -NH-.

[0247] The number of carbon atoms in the alkylene group represented by Q^{a2} is preferably from 1 to 10, particularly preferably from 1 to 6.

55 [0248] The number of carbon atoms in the alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom, -C(O)-, -C(O)O-, -OC(O)- or -NH-, represented by Q^{a2}, is preferably from 2 to 10, particularly preferably from 2 to 6.

[0249] Q^{a2} is, in that the compound will readily be produced, preferably -CH₂-, -CH₂CH₂-, -CH₂CH₂CH₂-, -CH₂OCH₂CH₂-, -CH₂NHCH₂CH₂-, -CH₂CH₂OC(O)CH₂CH₂-, or -C(O)- (provided that the right side is bonded to N).

[0250] s₂ is 0 or 1 (provided that when Q^{a2} is a single bond, it is 0). It is preferably 0 in that the compound will readily

be produced.

[0251] Q^{b2} is an alkylene group or an alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom a bivalent organopolysiloxane residue, an etheric oxygen atom or -NH-.

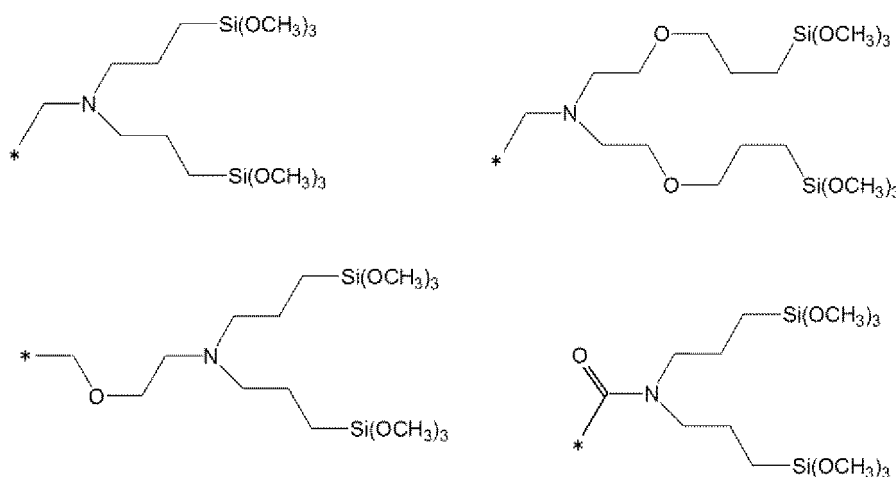
[0252] The number of carbon atoms in the alkylene group represented by Q^{b2} is preferably from 1 to 10, particularly preferably from 2 to 6.

[0253] The number of carbon atoms in the alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom a bivalent organopolysiloxane residue, an etheric oxygen atom or -NH-, represented by Q^{b2} , is preferably from 2 to 10, particularly preferably from 2 to 6.

[0254] Q^{b2} is, in that the compound will readily be produced, preferably -CH₂CH₂CH₂-, or -CH₂CH₂OCH₂CH₂CH₂- (provided that the right side is bonded to Si).

[0255] The two [- Q^{b2} -Si(R)_nL_{3-n}] may be the same or different.

[0256] As specific examples of the group (3-1A-2), the following groups may be mentioned. In the following formulae, * represents the position of bonding to (OX)_m.



[0257] Q^{a3} is a single bond or an alkylene group which may have an etheric oxygen atom, and in that the compound will readily be produced, preferably a single bond.

[0258] The number of carbon atoms in the alkylene group which may have an etheric oxygen atom is preferably from 1 to 10, particularly preferably from 2 to 6.

[0259] G is a carbon atom or a silicon atom.

[0260] R^g is a hydroxy group or an alkyl group. The number of carbon atoms in the alkyl group represented by R^g is preferably from 1 to 4.

[0261] $G(R^g)$ is, in that the compound will readily be produced, preferably C(OH) or Si(R^{ga}) (provided that R^{ga} is an alkyl group, preferably having from 1 to 10 carbon atoms, and is particularly preferably a methyl group).

[0262] Q^{b3} is an alkylene group or an alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom or a bivalent organopolysiloxane residue.

[0263] The number of carbon atoms in the alkylene group represented by Q^{b3} is preferably from 1 to 10, particularly preferably from 2 to 6.

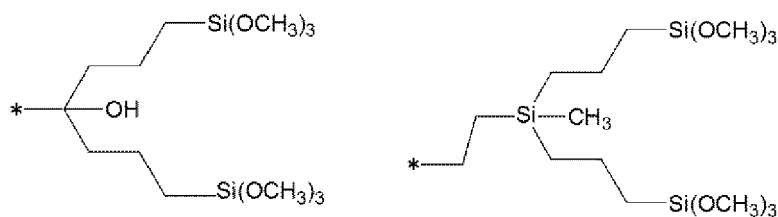
[0264] The number of carbon atoms in the alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom or a bivalent organopolysiloxane residue, represented by Q^{b3} , is preferably from 2 to 10, particularly preferably from 2 to 6.

[0265] Q^{b3} is, in that the compound will readily be produced, preferably -CH₂CH₂-, -CH₂CH₂CH₂-, or -CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂CH₂-.

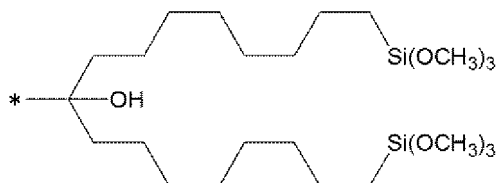
[0266] The two [- Q^{b3} -Si(R)_nL_{3-n}] may be the same or different.

[0267] As specific examples of the group (3-1A-3), the following groups may be mentioned. In the following formulae, * represents the position of bonding to (OX)_m.

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[0268] R^d in the formula (3-1A-4) is as defined above.

[0269] s₄ is 0 or 1.

[0270] Q^{a4} is a single bond or an alkylene group which may have an etheric oxygen atom.

20

[0271] The number of carbon atoms in the alkylene group which may have an etheric oxygen atom is preferably from 1 to 10, particularly preferably from 2 to 6.

[0272] t₄ is 0 or 1 (provided that when Q^{a4} is a single bond, it is 0) .

[0273] -Q^{a4}-(O)_{t4}- is, in that the compound will readily be produced, when s₄ is 0, preferably a single bond, -CH₂O-, -CH₂OCH₂-, -CH₂OCH₂CH₂O-, -CH₂OCH₂CH₂OCH₂-, or -CH₂OCH₂CH₂CH₂CH₂OCH₂- (provided that the left side is bonded to (OX)_m), and when s₄ is 1, it is preferably a single bond, -CH₂-, or -CH₂CH₂-.

25

[0274] Q^{b4} is an alkylene group, and the alkylene group may have -O-, -C(O)N(R^d)- (R^d is as defined above), a silphenylene skeleton group, a bivalent organopolysiloxane residue or a dialkylsilylene group.

[0275] In a case where the alkylene group has -O- or a silphenylene skeleton group, the alkylene group preferably has -O- or a silphenylene skeleton group between carbon atom-carbon atom. Further, in a case where the alkylene group has -C(O)N(R^d)-, a dialkylsilylene group or a bivalent organopolysiloxane residue, the alkylene group preferably has such a group between carbon atom-carbon atom or at the terminal on the side bonded to (O)_{u4}.

30

[0276] The number of carbon atoms in the alkylene group represented by Q^{b4} is preferably from 1 to 10, particularly preferably from 2 to 6.

[0277] u₄ is 0 or 1.

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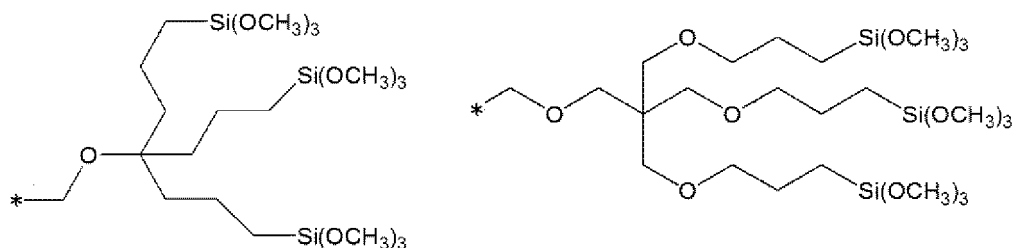
[0278] -(O)_{u4}-Q^{b4}- is, in that the compound will readily be produced, preferably -CH₂CH₂-, -CH₂CH₂CH₂-, -CH₂OCH₂CH₂CH₂-, -CH₂OCH₂CH₂CH₂CH₂CH₂-, -OCH₂CH₂CH₂-, -OSi(CH₃)₂CH₂CH₂CH₂-, -OSi(CH₃)₂OSi(CH₃)₂CH₂CH₂CH₂-, or -CH₂CH₂CH₂Si(CH₃)₂PhSi(CH₃)₂CH₂CH₂- (provided that the right side is bonded to Si).

[0279] The three [- (O)_{u4}-Q^{b4}-Si(R)_nL_{3-n}] may be the same or different.

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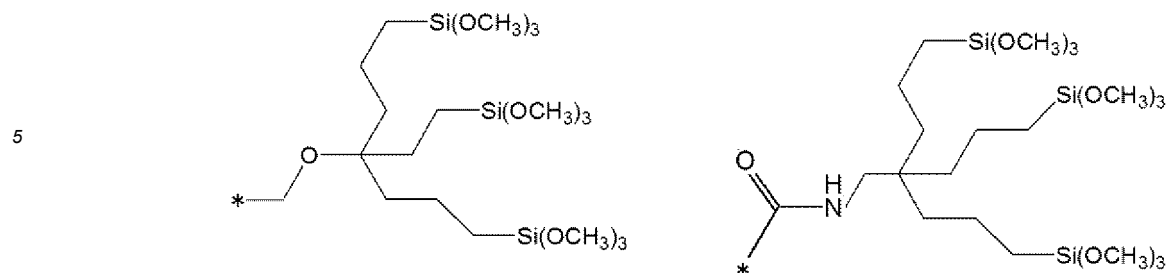
[0280] As specific examples of the group (3-1A-4), the following groups may be mentioned. In the following formulae, * represents the position of bonding to (OX)_m.

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[0281] Q^{a5} is an alkylene group which may have an etheric oxygen atom.

[0282] The number of carbon atoms in the alkylene group which may have an etheric oxygen atom is preferably from 1 to 10, particularly preferably from 2 to 6.

[0283] Q^{a5} is, in that the compound will readily be produced, preferably -CH₂OCH₂CH₂CH₂-, -CH₂OCH₂CH₂OCH₂CH₂CH₂-, -CH₂CH₂-, or -CH₂CH₂CH₂- (provided that the right side is bonded to Si).

[0284] Q^{b5} is an alkylene group or an alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom or a bivalent organopolysiloxane residue.

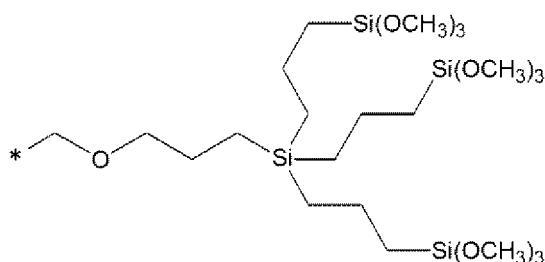
[0285] The number of carbon atoms in the alkylene group represented by Q^{b5} is preferably from 1 to 10, particularly preferably from 2 to 6.

[0286] The number of carbon atoms in the alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom or a bivalent organopolysiloxane residue, represented by Q^{b5} , is preferably from 2 to 10, particularly preferably from 2 to 6.

[0287] Q^{b5} is, in that the compound will readily be produced, preferably -CH₂CH₂CH₂-, or -CH₂CH₂OCH₂CH₂CH₂- (provided that the right side is bonded to Si(R)_nL_{3-n}).

[0288] The three [- Q^{b5} -Si(R)_nL_{3-n}] may be the same or different.

[0289] As specific examples of the group (3-1A-5), the following group may be mentioned. In the following formula, * represents the position of bonding to (OX)_m.



[0290] R^d in the formula (3-1A-6) is as defined above.

[0291] v is 0 or 1.

[0292] Q^{a6} is an alkylene group which may have an etheric oxygen atom.

[0293] The number of carbon atoms in the alkylene group which may have an etheric oxygen atom is preferably from 1 to 10, particularly preferably from 2 to 6.

[0294] Q^{a6} is, in that the compound will readily be produced, preferably -CH₂OCH₂CH₂CH₂-, -CH₂OCH₂CH₂OCH₂CH₂CH₂-, -CH₂CH₂-, or -CH₂CH₂CH₂- (provided that the right side is bonded to Z^a).

[0295] Z^a is a (w+1) valent organopolysiloxane residue.

[0296] w is at least 2, preferably an integer of from 2 to 7.

[0297] As the (w+1) valent organopolysiloxane residue, the same group as the (i5+1) valent organopolysiloxane residue may be mentioned.

[0298] Q^{b6} is an alkylene group or an alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom or a bivalent organopolysiloxane residue.

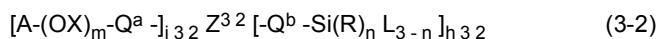
[0299] The number of carbon atoms in the alkylene group represented by Q^{b6} is preferably from 1 to 10, particularly preferably from 2 to 6.

[0300] The number of carbon atoms in the alkylene group having at least 2 carbon atoms and having between carbon atom-carbon atom an etheric oxygen atom or a bivalent organopolysiloxane residue, represented by Q^{b6} , is preferably from 2 to 10, particularly preferably from 2 to 6.

[0301] Q^{b6} is, in that the compound will readily be produced, preferably -CH₂CH₂-, or -CH₂CH₂CH₂-.

[0302] w [- Q^{b6} -Si(R)_nL_{3-n}] may be the same or different.

[0303] As the compound (3X), in that the film will be more excellent in water/oil repellency, compound represented by the formula (3-2) is also preferred.

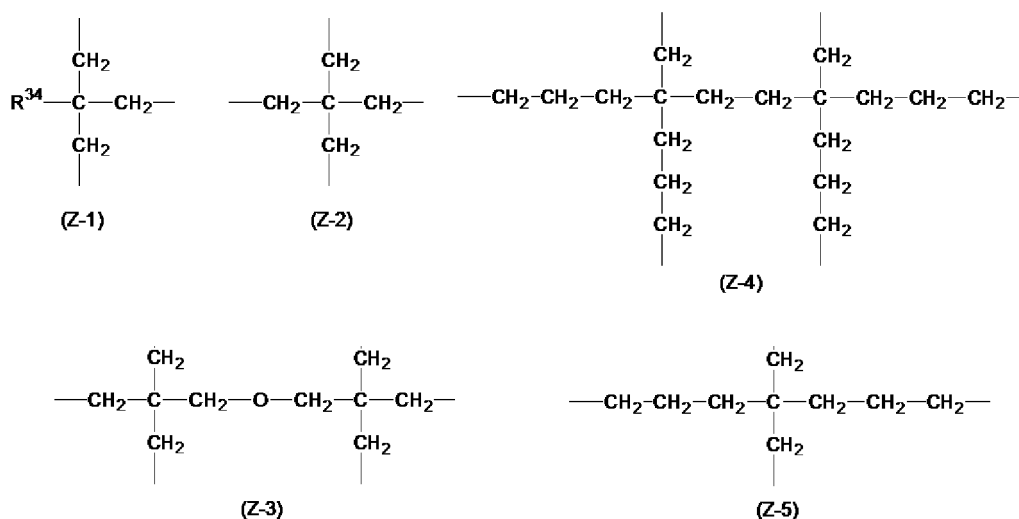


[0304] In the formula (3-2), A, X, m, Q^a, Q^b, R, and L are as defined for the respective groups in the formulae (3-1) and (3-1A).

[0305] Z³² is a (j32+h32) valent hydrocarbon group or a (j32+h32) valent hydrocarbon group having at least 2 carbon atoms and having at least one etheric oxygen atom between carbon atoms.

[0306] Z³² is preferably a residue having a hydroxy group removed from a polyhydric alcohol having a primary hydroxy group.

[0307] Z³² is, in view of availability of materials, preferably a group represented by the formulae (Z-1) to (Z-5). In the formula, R³⁴ is an alkyl group, preferably a methyl group or an ethyl group.



[0308] j32 is an integer of at least 2, and in that the film will be more excellent in water/oil repellency, preferably an integer of from 2 to 5.

[0309] h32 is an integer of at least 1, and in that the film will be more excellent in abrasion resistance, preferably an integer of from 2 to 4, more preferably 2 or 3.

[0310] As specific examples of the fluorinated ether compound, for example, compounds as disclosed in the following documents may be mentioned.

[0311] Perfluoropolyether-modified aminosilanes described in JP-A-H11-029585 and JP-A-2000-327772,

silicon-containing organic fluorinated polymers described in Japanese Patent No. 2874715,

organic silicon compounds described in JP-A-2000-144097,

fluorinated siloxanes described in JP-A-2002-506887,

organic silicone compounds described in JP-A-2008-534696,

fluorinated modified hydrogenated polymers described in Japanese Patent No. 4138936,

compounds described in U.S. Patent Application No. 2010/0129672, WO2014/126064 and JP-A-2014-070163,

organosilicon compounds described in WO2011/060047 and WO2011/059430,

fluorinated organosilane compounds described in WO2012/064649,

fluoroxyalkylene group-containing polymers described in JP-A-2012-72272,

fluorinated ether compounds described in WO2013/042732, WO2013/121984, WO2013/121985, WO2013/121986,

WO2014/163004, JP-A-2014-080473, WO2015/087902, WO2017/038830, WO2017/038832, WO2017/187775,

WO2018/216630, WO2019/039186, WO2019/039226, WO2019/039341, WO2019/044479, WO2019/049753,

WO2019/163282 and JP-A-2019-044158,

perfluoro(poly)ether-containing silane compounds described in JP-A-2014-218639, WO2017/022437,

WO2018/079743 and WO2018/143433,

perfluoro(poly)ether group-containing silane compounds described in WO2018/169002,

fluoro(poly)ether group-containing silane compounds described in WO2019/151442,

(poly)ether group-containing silane compounds described in WO2019/151445,

perfluoropolyether group-containing compounds described in WO2019/098230,
fluoropolyether group-containing polymer-modified silanes described in JP-A-2015-199906, JP-A-2016-204656, JP-A-2016-210854 and JP-A-2016-222859, and
fluorinated compounds described in WO2019/039083 and WO2019/049754.

5
[0312] As commercial products of the fluorinated ether compound, KY-100 series (KY-178, KY-185, KY-195, etc.), manufactured by Shin-Etsu Chemical Co., Ltd., Afluid (registered trademark) S550 manufactured by AGC Inc., OPTOOL (registered trademark) DSX, OPTOOL (registered trademark) AES, OPTOOL (registered trademark) UF503, OPTOOL (registered trademark) UD509, etc., manufactured by DAIKIN INDUSTRIES, LTD. may, for example, be mentioned.

10
[Method for producing water/oil repellent layer-provided substrate]

[0313] The water/oil repellent layer-provided substrate of the present invention preferably has an undercoat layer obtained by deposition method or wet coating method. Now, each of preferred embodiments of the method for producing a water/oil repellent layer-provided substrate will be described.

(First embodiment)

20
[0314] The method for producing a water/oil repellent layer-provided substrate of the present invention according to a first embodiment is an embodiment of forming the undercoat layer by deposition method.

[0315] Specifically, according to the first embodiment, provided is a method for producing a water/oil repellent layer-provided substrate comprising a substrate, an undercoat layer and a water/oil repellent layer in this order, which comprises forming on the substrate the undercoat layer containing an oxide containing silicon and at least one element of boron and phosphorus, the ratio of the total molar concentration of boron and phosphorus in the undercoat layer to the molar concentration of silicon in the undercoat layer being from 0.003 to 9, by deposition method using the deposition material (described hereinafter) and forming on the undercoat layer the water/oil repellent layer comprising a condensate of a fluorinated compound having a reactive silyl group (hereinafter sometimes referred to as "fluorinated compound").

25
[0316] The substrate, the undercoat layer and the water/oil repellent layer are as described for the above water/oil repellent layer-provided substrate of the present invention and their descriptions are omitted.

30
[0317] As specific examples of the deposition method using a deposition material, vacuum deposition method may be mentioned. The vacuum deposition method is a method of evaporating the deposition material in a vacuum chamber to make it attached to the surface of the substrate.

[0318] The temperature at the time of deposition (for example, in a case where a vacuum deposition apparatus is used, the temperature of the boat on which the deposition material is placed) is preferably from 100 to 3,000°C, particularly preferably from 500 to 3,000°C.

35
[0319] The pressure at the time of deposition (for example, in a case where a vacuum deposition apparatus is used, the pressure in the chamber in which the deposition material is placed) is preferably at most 1 Pa, particularly preferably at most 0.1 Pa.

[0320] When the undercoat layer is formed by using the deposition material, one deposition material may be used, or two or more deposition materials containing different elements may be used.

40
[0321] As specific examples of the method of evaporating the deposition material, resistance heating method in which the deposition material is melted and evaporated on a high melting metal boat for resistance heating, or electron gun method in which electron beams are applied to the deposition material to directly heat the deposition material and to melt its surface thereby to evaporate it, may be mentioned. As the method of evaporating the deposition material, electron gun method is preferred in that a high melting substance can be evaporated since local heating is possible, and reaction with the container and inclusion of impurities are less likely to occur since the temperature of the portion not irradiated with the electron beams is low.

45
[0322] As the method of evaporating the deposition material, a plurality of boats may be used, or the entire deposition material may be put in a single boat. The deposition method may be co-deposition, alternating deposition or the like. Specifically, an example in which silica and a boron source (such as boron oxide, boric acid, boron simple substance, boron carbide, boron nitride or borax) are mixed in a single boat, an example in which silica and the boron source are put in separate boats and subjected to co-deposition, or an example in which they are put in separate boats and subjected to alternating deposition, may be mentioned. The deposition conditions, order, and the like are properly selected depending upon the structure of the undercoat layer.

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[0323] In order to prevent contamination of a region or portion (for example, the rear side of the substrate) on which the deposition material should not be deposited, at the time of deposition, such region or portion may be covered with a protective film.

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[0324] After deposition, with a view to improving the film quality, it is preferred to conduct humidification. The temper-

ature at the time of humidification is preferably from 25 to 160°C. The relative humidity is preferably at least 40%, and the treatment time is preferably at least 1 hour.

[0325] The water/oil repellent layer may be formed either by dry coating or wet coating, using a fluorinated compound or a composition containing a fluorinated compound and a liquid medium (hereinafter sometimes referred to as "composition").

[0326] As specific examples of the liquid medium contained in the composition, water and an organic solvent may be mentioned. As specific examples of the organic solvent, a fluorinated organic solvent and a non-fluorinated organic solvent may be mentioned. The organic solvents may be used alone or in combination of two or more.

[0327] As specific examples of the fluorinated organic solvent, a fluorinated alkane, a fluorinated aromatic compound, a fluoroalkyl ether, a fluorinated alkylamine and a fluoroalcohol may be mentioned.

[0328] The fluorinated alkane is preferably a compound having 4 to 8 carbon atoms, and may, for example, be $C_6 F_{13} H$ (AC-2000, trade name, manufactured by AGC Inc.), $C_6 F_{13} C_2 H_5$ (AC-6000, trade name, manufactured by AGC Inc.), or $C_2 F_5 CHFCHFCF_3$ (Vertrel, trade name, manufactured by DuPont).

[0329] As specific examples of the fluorinated aromatic compound, hexafluorobenzene, trifluoromethylbenzene, perfluorotoluene, 1,3-bis(trifluoromethyl)benzene, and 1,4-bis(trifluoromethyl)benzene may be mentioned.

[0330] The fluoroalkylether is preferably a compound having from 4 to 12 carbon atoms, and may, for example, be $CF_3 CH_2 OCF_2 CF_2 H$ (AE-3000, trade name, manufactured by AGC Inc.), $C_4 F_9 OCH_3$ (Novec-7100, trade name, manufactured by 3M), $C_4 F_9 OC_2 H_5$ (Novec-7200, trade name, manufactured by 3M), and $C_2 F_5 CF(OCH_3)C_3 F_7$ (Novec-7300, trade name, manufactured by 3M).

[0331] As specific examples of the fluorinated alkylamine, perfluorotripropylamine and perfluorotributylamine may be mentioned.

[0332] As specific examples of the fluoroalcohol, 2,2,3,3-tetrafluoropropanol, 2,2,2-trifluoroethanol and hexafluoroisopropanol may be mentioned.

[0333] The non-fluorinated organic solvent is preferably a compound consisting solely of hydrogen atoms and carbon atoms, or a compound consisting solely of hydrogen atoms, carbon atoms and oxygen atoms, and may be specifically a hydrocarbon organic solvent, a ketone organic solvent, an ether organic solvent, an ester organic solvent or an alcohol organic solvent.

[0334] As specific examples of the hydrocarbon organic solvent, hexane, heptane and cyclohexane may be mentioned.

[0335] As specific examples of the ketone organic solvent, acetone, methyl ethyl ketone and methyl isobutyl ketone may be mentioned.

[0336] As specific examples of the ether organic solvent, diethyl ether, tetrahydrofuran and tetraethylene glycol dimethyl ether may be mentioned.

[0337] As specific examples of the ester organic solvent, ethyl acetate and butyl acetate may be mentioned.

[0338] As specific examples of the alcohol organic solvent, isopropyl alcohol, ethanol and n-butanol may be mentioned.

[0339] The content of the fluorinated compound in the composition is, to the total mass of the composition, preferably from 0.01 to 50 mass%, particularly preferably from 1 to 30 mass%.

[0340] The content of the liquid medium in the composition is, to the total mass of the composition, preferably from 50 to 99.99 mass%, particularly preferably from 70 to 99 mass%.

[0341] The water/oil repellent layer may be produced, for example, by the following method.

- A method of treating the surface of the undercoat layer by dry coating method using the fluorinated compound, to form the water/oil repellent layer on the surface of the undercoat layer.

- A method of applying the composition to the surface of the undercoat layer by wet coating method, followed by drying to form the water/oil repellent layer on the surface of the undercoat layer.

[0342] As specific examples of the dry coating method, vacuum deposition method, CVD method and sputtering method may be mentioned. Among them, with a view to suppressing decomposition of the fluorinated compound and in view of simplicity of the apparatus, vacuum deposition method is preferred. At the time of vacuum deposition, a pellet-form substance having a metal porous body of e.g. iron or steel impregnated with the fluorinated compound or a pellet-form substance having a metal porous body impregnated with the composition, followed by drying, may be used.

[0343] As specific examples of the wet coating method, spin coating method, wipe coating method, spray coating method, squeeze coating method, dip coating method, die coating method, ink-jet method, flow coating method, roll coating method, casting method, Langmuir-Blodgett method and gravure coating method may be mentioned.

[0344] The drying temperature after applying the composition by wet coating is preferably from 20 to 200°C, particularly preferably from 80 to 160°C.

[0345] In order to improve abrasion resistance of the water/oil repellent layer, as the case requires, an operation to accelerate the reaction between the fluorinated compound having a reactive silyl group and the undercoat layer may be conducted. Such an operation may, for example, be heating, humidification or light irradiation. For example, the undercoat

layer-provided substrate having a water/oil repellent layer formed thereon may be heated in the air containing moisture to accelerate e.g. hydrolysis of the reactive silyl group into a silanol group, formation of a siloxane bond by condensation reaction of the silanol groups, or condensation reaction of the silanol group on the surface of the undercoat layer and the silanol group of the fluorinated compound.

[0346] After the surface treatment, the compound in the water/oil repellent layer, which is not chemically bonded to other compound or the silicon oxide layer, may be removed as the case requires. As a specific method, for example, a method of rinsing the water/oil repellent layer with a solvent, a method of wiping the water/oil repellent layer with cloth impregnated with a solvent, or a method of washing the surface of the water/oil repellent layer with an acid may be mentioned.

<deposition material>

[0347] The deposition material for forming the undercoat layer of the water/oil repellent layer-provided substrate of the present invention contains an oxide containing silicon and at least one element of boron and phosphorus, and the ratio of the total molar concentration of boron and phosphorus to the molar concentration of silicon is from 0.003 to 9.

[0348] In the present disclosure, the deposition material means a material to be used for deposition. The deposition material is suitably used for forming the undercoat layer of the water/oil repellent layer-provided substrate.

[0349] The oxide contained in the deposition material may contain both of boron and phosphorus, or may contain only one of them. The oxide preferably contains one of boron and phosphorus, and in a case where it contains both of them, the proportion of boron to the total content of them is preferably from 20 to 80 mol%.

[0350] The oxide contained in the deposition material may be a mixture of oxides each containing only one of the above elements (silicon, boron and phosphorus) (for example, a mixture of silicon oxide and at least one of boron oxide and phosphorus oxide), may be a composite oxide containing two or more of the above elements, or may be a mixture of the oxide containing one of the above elements and the composite oxide.

[0351] The content of the oxide in the deposition material is, based on the total mass of the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at least 80 mass%, more preferably at least 95 mass%, particularly preferably 100 mass% (the deposition material is entirely formed of the oxide).

[0352] The content of oxygen in the deposition material is, as the molar concentration (mol%) of oxygen atoms to all the elements in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 40 to 70 mol%, more preferably from 50 to 70 mol%, particularly preferably from 60 to 70 mol%. The content of oxygen in the deposition material is measured e.g. by XPS with respect to a sample having the deposition material sufficiently ground and pelletized.

[0353] The ratio of the total molar concentration of boron and phosphorus in the deposition material to the molar concentration of silicon in the deposition material is from 0.003 to 9, and in that the water/oil repellent layer will be more excellent in abrasion resistance and water resistance, preferably from 0.003 to 2, particularly preferably from 0.003 to 0.5.

[0354] The content of silicon in the deposition material is, as the molar concentration (mol%) of silicon to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 10 to 99.8 mol%, more preferably from 15 to 99.8 mol%, particularly preferably from 20 to 99.7 mol%.

[0355] The content of silicon in the deposition material is, as the mass percent concentration (mass%) of silicon to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 10 to 99.9 mass%, more preferably from 20 to 99.9 mass%, particularly preferably from 30 to 99.8 mass%.

[0356] The total content of boron and phosphorus in the deposition material is, as the total molar concentration (mol%) of boron and phosphorus to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 0.003 to 90 mol%, more preferably from 0.003 to 80 mol%, particularly preferably from 0.003 to 50 mol%.

[0357] The total content of boron and phosphorus in the deposition material is, as the total mass percent concentration (mass%) of boron and phosphorus to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably from 0.001 to 90 mass%, more preferably from 0.001 to 80 mass%, particularly preferably from 0.001 to 70 mass%.

[0358] The oxide contained in the deposition material may further contain aluminum, whereby the water/oil repellent layer will be more excellent in abrasion resistance.

[0359] Aluminum may be present in the form of an oxide of aluminum by itself, or may be present in the form of a composite oxide of aluminum and the above element (silicon, boron or phosphorus).

[0360] In a case where the oxide contained in the deposition material contains aluminum, the ratio of the molar concentration of aluminum in the deposition material to the molar concentration of silicon in the deposition material is, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 0.5, particularly preferably from 0.001 to 0.1.

[0361] In a case where the oxide contained in the deposition material contains aluminum, the content of aluminum in the deposition material is, as the molar concentration (mol%) of aluminum to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 30 mol%, more preferably at most 25 mol%, particularly preferably from 0.1 to 20 mol%.

[0362] In a case where the oxide contained in the deposition material contains aluminum, the content of aluminum in the deposition material is, as the mass percent concentration (mass%) of aluminum to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 40 mass%, more preferably at most 30 mass%, particularly preferably from 0.1 to 25 mass%.

[0363] The oxide contained in the deposition material may further contain an alkali metal element, in that the water/oil repellent layer will be more excellent in abrasion resistance. The preferred embodiments of the alkali metal element are the same as those for the undercoat layer and their descriptions are omitted.

[0364] The alkali metal element may be present in the form of an oxide of one type of alkali metal element, or may be present in the form of a composite oxide of one or more types of alkali metal elements and the above element (silicon, boron or phosphorus).

[0365] In a case where the oxide contained in the deposition material contains the alkali metal element, the ratio of the total molar concentration of the alkali metal element in the deposition material to the molar concentration of silicon in the deposition material is, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 1.0, particularly preferably from 0.001 to 0.5.

[0366] In a case where the oxide contained in the deposition material contains the alkali metal element, the content of the alkali metal element in the deposition material is, as the total molar concentration (mol%) of the alkali metal element to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 30 mol%, more preferably at most 20 mol%, particularly preferably from 0.1 to 15 mol%.

[0367] In a case where the oxide contained in the deposition material contains the alkali metal element, the content of the alkali metal element in the deposition material is, as the total mass percent concentration (mass%) of the alkali metal element to all the elements excluding oxygen in the deposition material, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 40 mass%, more preferably at most 30 mass%, particularly preferably from 0.1 to 20 mass%.

[0368] The oxide contained in the deposition material may further contain at least one metal element selected from the group consisting of nickel, iron, titanium, zirconium, molybdenum and tungsten, within a range where they will not be contained in the undercoat layer obtained by deposition.

[0369] The metal element may be present in the form of an oxide of one type of element, or may be present in the form of a composite oxide of one or more types of metal elements and the above element (silicon, boron or phosphorus).

[0370] In a case where the oxide contained in the deposition material contains the metal element, the ratio of the total molar concentration of the metal element in the deposition material to the molar concentration of silicon in the deposition material is, in that the water/oil repellent layer will be more excellent in abrasion resistance, preferably at most 0.01, particularly preferably at most 0.001.

[0371] In a case where the oxide contained in the deposition material contains the metal element, the content of the metal element in the deposition material is, as the total molar concentration (mol%) of the metal element to all the elements excluding oxygen in the deposition material, preferably at most 1 mol%, particularly preferably at most 0.1 mol%. When the content of the metal element in the deposition material is at most 1 mol%, the metal element will hardly be contained in the undercoat layer obtained by deposition, or even if contained, the amount is small, whereby performance of the water/oil repellent layer and the undercoat layer is less likely to be impaired.

[0372] The content of the metal element means, when one type of the metal element is contained, the content of the one element, and when two or more types of the metal elements are contained, the total content of the respective elements.

[0373] As specific examples of the form of the deposition material, a powder, a molten body, a sintered body, granules and a pulverized body may be mentioned, and in view of handling efficiency, a molten body, a sintered body and granules are preferred.

[0374] The molten body means a solid obtained by melting a powder of the deposition material at high temperature and cooling and solidifying it. The sintered body means a solid obtained by firing a powder of the deposition material and as the case require, formed product obtained by pressing the powder may be used, instead of the powder of the deposition material. Granules mean a solid obtained by kneading a powder of the deposition material and a liquid medium (such as water or an organic solvent) to obtain particles, and drying the particles.

[0375] The deposition material may be produced, for example, by the following method. · A method of mixing a powder of silicon oxide and a powder of an oxide of at least one element of boron and phosphorus to obtain a powder of the deposition material. · A method of kneading a powder of the deposition material and water to obtain particles, and drying the particles to obtain granules of the deposition material.

[0376] To increase the yield at the time of granulation and to uniformize element distribution during granulation, the

diameter of the silicon oxide powder as the material is preferably from 0.1 μm to 100 μm . In a case where a silicon oxide powder of 100 μm or larger is used as the material, it is used preferably as ground. To increase the strength of the granules and to avoid adhesion at the time of firing when the sintered body is to be obtained, the drying temperature is preferably at least 60°C. Further, to completely remove moisture, drying in a reduced pressure state (absolute pressure of at most 50 kPa) is preferred. · A method of drying a mixture of a powder containing silicon (for example, a powder consisting of silicon oxide, silica sand or silica gel), a powder of at least one element of boron and phosphorus (for example, a powder of the oxide of the element, boric acid, boron simple substance, boron carbide, boron nitride or borax) and water, and firing the dried mixture, a formed product obtained by pressing the mixture, or the granules, to obtain a sintered body.

[0377] To lower moisture absorption property of the sintered body after firing, the firing temperature is preferably at least 900°C, more preferably at least 1,000°C. To prevent breakage of a carrier container (packaging bag) and to prevent contamination from the container at the time of carrying the sintered body, particles having no protrusion are preferred, and spherical particles are more preferred. To remove the protrusions, it is preferred to add protrusions removal process. · A method of melting a powder containing silicon (for example, a powder consisting of silicon oxide, silica sand or silica gel) and a powder of at least one element of boron and phosphorus (for example, a powder of the oxide of the element, or boric acid) at high temperature, and cooling and solidifying the melt to obtain the molten body.

(Second embodiment)

[0378] The method for producing a water/oil repellent layer-provided substrate of the present invention according to a second embodiment is an embodiment of forming the undercoat layer by wet coating method.

[0379] Specifically, according to the second embodiment, provided is a method for producing a water/oil repellent layer-provided substrate comprising a substrate, an undercoat layer and a water/oil-repellent layer in this order, which comprises forming on the substrate the undercoat layer containing an oxide containing silicon and at least one element of boron and phosphorus, the ratio of the total molar concentration of boron and phosphorus to the molar concentration of silicon being from 0.003 to 9, by wet coating method using a coating fluid containing a compound containing silicon, at least one of a compound containing boron and a compound containing phosphorus, and a liquid medium, and forming on the undercoat layer the water/oil repellent layer comprising a condensate of a fluorinated compound having a reactive silyl group.

[0380] The substrate, the undercoat layer and the water/oil repellent layer are as defined for the water/oil repellent layer-provided substrate of the present invention, and their descriptions are omitted.

[0381] The specific examples of the wet coating method to form the undercoat layer are the same as those for forming the water/oil repellent layer by wet coating method according to the first embodiment, and their descriptions are omitted.

[0382] After applying the coating fluid by wet coating, the coating film is preferably dried. The drying temperature of the coating film is preferably from 20 to 200°C, particularly preferably from 80 to 160°C.

[0383] The method for forming the water/oil repellent layer according to the second embodiment is the same as the method for forming the water/oil repellent layer according to the first embodiment, and its description is omitted.

[0384] Further, in the second embodiment also, an operation to improve abrasion resistance of the water/oil repellent layer as described for the first embodiment may be conducted.

<Coating fluid to be used for forming undercoat layer >

[0385] The coating fluid to be used for forming the undercoat layer contains a compound containing silicon, at least one of a compound containing boron and a compound containing phosphorus, and a liquid medium.

[0386] As specific examples of the silicon compound, silicon oxide, silicic acid, a partial condensate of silicic acid, an alkoxy silane, and a partially hydrolyzed condensate of an alkoxy silane may be mentioned.

[0387] The content of the silicon compound may properly be set so that the content of silicon in the undercoat layer will be within the above range.

[0388] Specific examples of the compound containing boron, boron oxide, boric acid, an alkoxyborane, and a partially hydrolyzed condensate of an alkoxyborane may be mentioned.

[0389] The content of the compound containing boron may properly be set so that the ratio of the total molar concentration of boron and phosphorus to the molar concentration of silicon in the undercoat layer will be within the above range.

[0390] As specific examples of the compound containing phosphorus, phosphorus oxide and phosphoric acid may be mentioned.

[0391] The content of the compound containing phosphorus may properly be set so that the ratio of the total molar concentration of boron and phosphorus to the molar concentration of silicon in the undercoat layer will be within the above range.

[0392] The coating fluid may further contain a compound containing aluminum.

[0393] As specific examples of the compound containing aluminum, aluminum oxide, an aluminum alkoxide, and a partially hydrolyzed condensate of an aluminum alkoxide may be mentioned.

[0394] The content of the compound containing aluminum may properly be set so that the ratio of the molar concentration of aluminum to the molar concentration of silicon in the undercoat layer will be within the above range.

[0395] The coating fluid may further contain a compound containing an alkali metal element.

[0396] As the compound containing an alkali metal element, an oxide of an alkali metal element, an alkoxide of an alkali metal element and a partially hydrolyzed condensate of an alkali metal element may be mentioned.

[0397] The content of the compound containing an alkali metal element may properly be set so that the ratio of the molar concentration of the alkali metal element to the molar concentration of silicon in the undercoat layer will be within the above range.

[0398] Specific examples of the liquid medium contained in the coating fluid are the same as those mentioned for formation of the water/oil repellent layer according to the first embodiment, and their descriptions are omitted.

[0399] The content of the liquid medium is, to the total mass of the coating fluid to be used for forming the undercoat layer, preferably from 0.01 to 20 mass%, particularly preferably from 0.01 to 10 mass%.

EXAMPLES

[0400] Now, the present invention will be described in further detail with reference to Examples. However, it should be understood that the present invention is by no means restricted thereto. Ex. 1 to 16 and 21 to 43 are Examples of the present invention, and Ex. 17 to 20 are Comparative Examples.

[Physical properties and evaluation]

(Content of each element in undercoat layer)

[0401] In Ex. other than Ex. 13, a depth profile of the molar concentration (mol%) of each element was obtained by X-ray photoelectron spectroscopy (XPS) using Ar ion sputtering. In Ex. 13, a depth profile of the molar concentration (mol%) of each element was obtained by X-ray photoelectron spectroscopy (XPS) using C_{60} ion sputtering. The point where the molar concentration (mol%) of fluorine derived from the water/oil repellent layer to all the elements detected by XPS analysis is 5 mol% or lower as observed from the surface side of the depth profile of the water/oil repellent layer-provided substrate, was taken as the starting point A. Further, the point where the molar concentration (mol%) of an optional element present only in the substrate to all the elements detected by XPS analysis exceeds 30% of the molar concentration (mol%) in the substrate for the first time, was taken as the end point B. The region from the starting point A to the end point B is defined as the undercoat layer, and the ratio of the average of the molar concentration (mol%) of the element to be measured to the average of the molar concentration (mol%) of silicon in the undercoat layer was calculated. In a case where an alkali metal element is contained in the undercoat layer as in Ex. 13, it is preferred to employ C_{60} ion sputtering. Further, in Ex. other than Ex. 16, aluminum was selected as an optional element present only in the substrate, and in Ex. 16, potassium was selected as an optional element present only in the substrate. In a case where aluminum is not contained in the undercoat layer and aluminum is contained in the substrate, it is preferred to select aluminum as an optional element present only in the substrate.

Ex. other than Ex. 13:

<Apparatus>

[0402] X-ray photoelectron spectroscope: Quantera-SXM manufactured by ULVAC-PHI, Inc.

<Measurement conditions>

[0403]

X-ray source: monochromatized $AlK\alpha$ ray

Beam diameter of X-ray: about 100 $\mu m\phi$

Photoelectron detection angle: 45 degrees to sample surface

Pass energy: 224 eV

Step energy: 0.4 eV/step

Sputter ion: Ar ion with accelerating voltage of 1 kV

Raster size of sputtering gun: $3 \times 3 \text{ mm}^2$

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Sputtering interval: one minute

Sputtering rate as calculated as SiO₂ of sputtering gun on silicon wafer: 0.78 nm/min

Ex. 13:

5

<Apparatus>

[0404] X-ray photoelectron spectroscope: ESCA-5500 manufactured by ULVAC-PHI, Inc.

10

<Measurement conditions>

[0405]

X-ray source: monochromatized AlK α ray

15

Photoelectron detection angle: 45 degrees to sample surface

Pass energy: 117.4 eV

Step energy: 0.5 eV/step

Sputter ion: C₆₀ ion with accelerating voltage of 10 kV

Raster size of sputtering gun: 3×3 mm²

20

Sputtering interval: 0.4 minute

Sputtering rate as calculated as SiO₂ of sputtering gun on silicon wafer: 2.20 nm/min

(Content of each element in deposition material)

25

[0406] 3 to 10 g of a deposition material sample was preliminarily sufficiently ground and pulverized and subjected to silicon/boron and aluminum/phosphorus/alkali metal element analysis.

<Silicon/boron>

30

[0407] 0.5 to 1.0 g of sodium hydroxide was put in a zirconia crucible, melted by a burner and air-cooled. 100 mg of the pulverized sample was added on the sodium hydroxide and melted by a burner at a burning temperature of about 600°C for one minute. After air-cooling, the crucible was put in a beaker or a plastic container. Pure water was added to the crucible for dissolution by heating. The melt was put in the beaker or the plastic container, and 20 mL of 6M hydrochloric acid was added all at once. The volume was adjusted to 100 mL, and after dilution, silicon and boron were quantitatively determined by ICP atomic emission spectrometry (measurement apparatus: PS3500UVDDII, trade name, manufactured by Hitachi High-Tech Science Corporation). For quantitative determination, analytical curve (matrix matching) method was employed.

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[0408] And, the ratio (mass ratio) of the content (mass%) of the element to be measured to the content (mass%) of silicon was calculated, and the molar ratio was obtained from the mass ratio using the atomic weight of each element.

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<Aluminum/phosphorus/alkali metal element>

[0409] 100 mg of the pulverized sample was decomposed with hydrofluoric acid/sulfuric acid or hydrofluoric acid/perchloric acid, silicon and boron were removed, and nitric acid or hydrochloric acid was added to form a solution. The volume was adjusted to 100 mL, and after dilution, aluminum and phosphorus were quantitatively determined by ICP atomic emission spectrometry (measurement apparatus: PS3500UVDDII, trade name, manufactured by Hitachi High-Tech Science Corporation). The alkali metal element was quantitatively determined by atomic absorption spectrometry (measurement apparatus: ZA3300, trade name, manufactured by Hitachi High-Tech Science Corporation). For quantitative determination, analytical curve (matrix matching) method was employed.

45

[0410] And, the ratio (mass ratio) of the content (mass%) of the element to be measured to the content (mass%) of silicon was calculated, and the molar ratio was obtained from the mass ratio using the atomic weight of each element.

50

(Abrasion resistance 1)

55

[0411] With respect to the water/oil repellent layer, after abrasion with steel wool for 4,000 reciprocations in accordance with JIS L0849: 2013 (ISO 105-X12: 2001) using a reciprocating traverse testing machine (manufactured by KNT Co.), wherein steel wool BON STAR (yarn number: #0000, dimensions: 5 mm × 10 mm × 10 mm) was reciprocated under a load of 9.8N at a rate of 80 rpm, the water contact angle of the water/oil repellent layer was measured, and the abrasion

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resistance was evaluated in accordance with the following evaluation standards. The smaller the decrease in the water contact angle after abrasion, the smaller the decrease in performance due to abrasion, and the more excellent the abrasion resistance.

5 ⊙: Water contact angle of at least 105°

 ○: Water contact angle of at least 100° and less than 105°

10 × : Water contact angle of less than 100°

(Abrasion resistance 2)

[0412] Conducted in the same manner as for evaluation of abrasion resistance 1, except that the number of reciprocations was 12,000.

15

 ⊙: Water contact angle of at least 105°

 ○: Water contact angle of at least 100° and less than 105°

20 × : Water contact angle of less than 100°

(Abrasion resistance 3)

[0413] Conducted in the same manner as for evaluation of abrasion resistance 1, except that the number of reciprocations was 16,000.

25

 ⊙: Water contact angle of at least 100°

 ○: Water contact angle of at least 90° and less than 100°

30

 △: Water contact angle of at least 80° and less than 90°

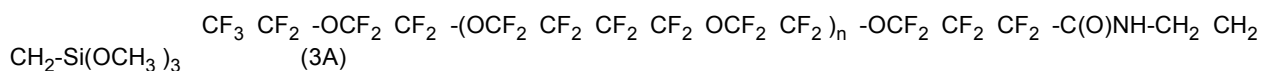
 × : Water contact angle of less than 80°

35 [Preparation of fluorinated compound]

[Preparation Example 1]

[0414] Compound (3A) was obtained with reference to the method for producing compound (ii-2) described in WO2014/126064.

40

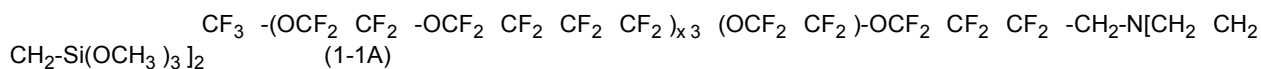


45 **[0415]** Average of number n of units: 13, number average molecular weight of compound (3A): 4,920

[Preparation Example 2]

[0416] Compound (1-1A) was obtained in accordance with the method described in Ex. 3 of WO2017/038832.

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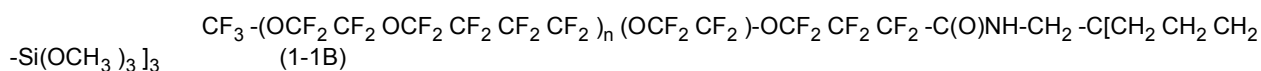
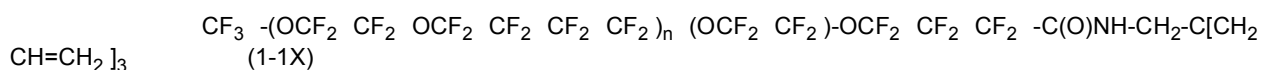
[0417] Average of number x3 of units:13, Mn of compound (1-1A):5,020

55

[Preparation Example 3]

[0418] Compounds (1-1X) and (1-1B) were obtained in accordance with the method described in Ex. 11 of

WO2017/038830.



[0419] Average of number n of units: 13, Mn of compound (1-1B): 5,400

[Preparation Example 4]

[0420] Compound (1-1C) was obtained in accordance with the method described in Preparation Example 15 of Japanese Patent No. 5761305.



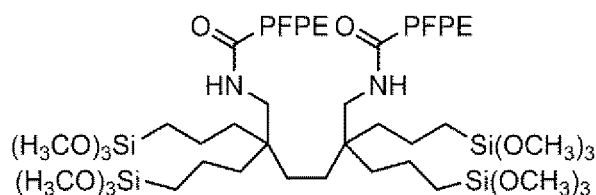
Mn of compound (1-1C): 3,600

[Preparation Example 5]

[0421] Compound (1-2A) was obtained in accordance with Ex. 16 in WO2017/187775.

[0422] The group represented by "PFPE" in the formula (1-2A) is $\text{CF}_3 (\text{OCF}_2 \text{CF}_2 \text{OCF}_2 \text{CF}_2 \text{CF}_2 \text{CF}_2)_x \text{OCF}_2 \text{CF}_2 \text{OCF}_2 \text{CF}_2 \text{CF}_2 -$. In the formula, the average of the number X3 of units is 13.

[0423] Mn of compound (1-2A):10,100

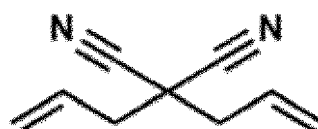


(1-2A)

[Preparation Example 6]

[0424] Compound (1-2B) was prepared as follows.

[0425] Into a reactor the interior of which was replaced with nitrogen, 21.8 g of NaH weighed in a box the interior of which was replaced with nitrogen was charged to 100 g of dehydrated THF (tetrahydrofuran), followed by stirring in an ice bath, and 40 g of a 50 mass% malononitrile solution having malononitrile dissolved in dehydrated THF was added, and then 80.6 g of allyl bromide was added, followed by stirring in an ice bath for 4 hours. Diluted aqueous hydrochloric acid solution was added and the reaction was terminated, followed by washing with water and a saturated salt solution, and an organic phase was recovered. The recovered solution was concentrated by an evaporator to obtain a crude product. The crude product was subjected to silica gel column chromatography to obtain 42 g of compound (X5-1).

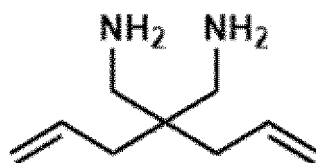


(X5-1)

[0426] Into an eggplant flask having a capacity of 300 mL, the interior of which was replaced with nitrogen, 31.1 g of LiAlH_4 and 100 g of dehydrated THF were added, followed by stirring in an ice bath until the temperature reached 0 °C.

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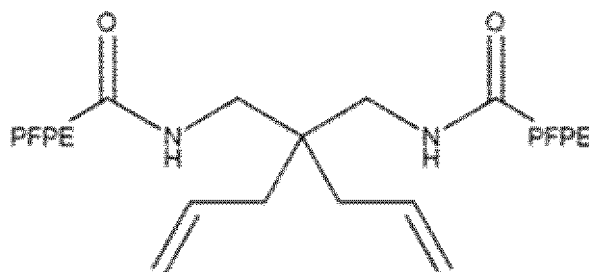
40 g of compound (X5-1) was slowly added dropwise. Disappearance of compound (X5-1) was confirmed by thin layer chromatography, and to the reaction crude liquid, $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ was slowly added for quenching, followed by filtration with celite, and by washing with water and a saturated salt solution. The recovered organic layer was distilled under reduced pressure and purified by column chromatography to obtain 32.5g of compound (X5-2).



(X5-2)

[0427] Into a 50 mL eggplant flask, 0.4 g of compound (X5-2) and 27 g of $\text{CF}_3(\text{OCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CF}_2\text{CF}_2)_{13}\text{OCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CF}_2-\text{C}(\text{O})-\text{CH}_3$ were added, followed by stirring for 12 hours. It was confirmed by NMR that compound (X5-2) was entirely converted to compound (X5-3). Further, methanol was formed as a by-product. The obtained solution was diluted with 9.0 g of AE-3000 and purified by silica gel column chromatography (developing solvent: AE-3000) to obtain 16.3 g (yield: 66%) of compound (X5-3).

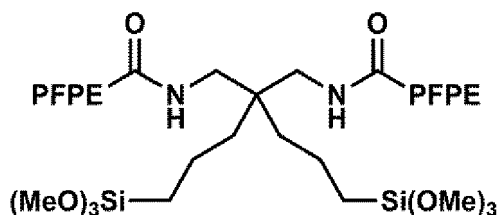
[0428] In the following formula, PFPE means $\text{CF}_3(\text{OCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CF}_2\text{CF}_2)_{13}\text{OCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CF}_2-$.



(X5-3)

[0429] Into a 100 mL PFA eggplant flask, 5.0 g of compound (X5-3), 0.5 g of a xylene solution (platinum content: 2%) of platinum/1,3-divinyl-1,1,3,3-tetramethyldisiloxane complex, 0.3 g of $\text{HSi}(\text{OCH}_3)_3$, 0.02g of dimethyl sulfoxide and 5.0 g of 1,3-bis(trifluoromethyl)benzene (manufactured by Tokyo Chemical Industry Co., Ltd.) were put, followed by stirring at 40°C for 10 hours. After completion of the reaction, the solvent and the like were distilled off under reduced pressure, and the residue was subjected to filtration through a membrane filter having a pore size of 0.2 μm to obtain compound (1-2B) having two allyl groups of compound (X5-3) hydrosilylated. The degree of conversion of hydrosilylation was 100%, and no compound (X5-3) remained.

[0430] In the following formula, PFPE means $\text{CF}_3(\text{OCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CF}_2\text{CF}_2)_{13}\text{OCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CF}_2-$.



(1-2B)

[0431] Mn of compound (1-2B): 9,800

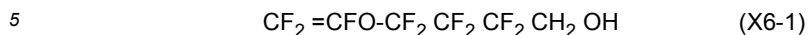
[Preparation Example 7]

[0432] Mixture (M1) containing the following compounds (1-3A) and (1-1D) was prepared as follows.

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(Preparation Example 7-1)

[0433] Compound (X6-1) was obtained in accordance with the method described in Ex. 1-1 of WO2013-121984.

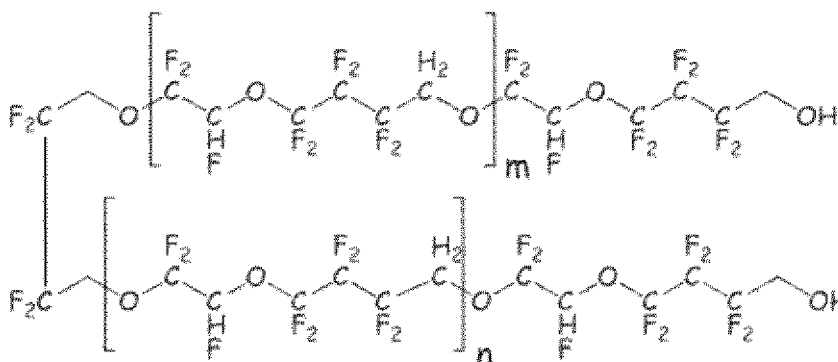


(Preparation Example 7-2)

10 [0434] Into a 200 mL eggplant flask, 16.2 g of HO-CH₂-CF₂-CF₂-CH₂-OH and 13.8 g of potassium carbonate were put, followed by stirring at 120°C, and 278 g of compound (X4-1) was added, followed by stirring at 120°C for 2 hours. The temperature was returned to 25°C, and 50 g of AC-2000 (trade name, manufactured by AGC Inc., C₆F₁₃H) and 50 g of hydrochloric acid were put, followed by liquid separation, and the resulting organic phase was concentrated. The obtained reaction crude liquid was purified by column chromatography to obtain 117.7 g (yield: 40%) of compound (X6-2).

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(X6-2)

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NMR spectrum of compound (X6-2):

[0435] ¹H-NMR (300.4MHz, solvent: CDCl₃, reference: tetramethylsilane (TMS)) δ(ppm):6.0(12H), 4.6(20H), 4.2(4H), 4.1(4H).

35 [0436] ¹⁹F-NMR (282.7MHz, solvent: CDCl₃, reference: CFCl₃) δ(ppm):-85(24F), -90(24F), -120(20F), -122(4F), -123(4F), -126(24F), -144(12F)

Average of number m+n of units: 10

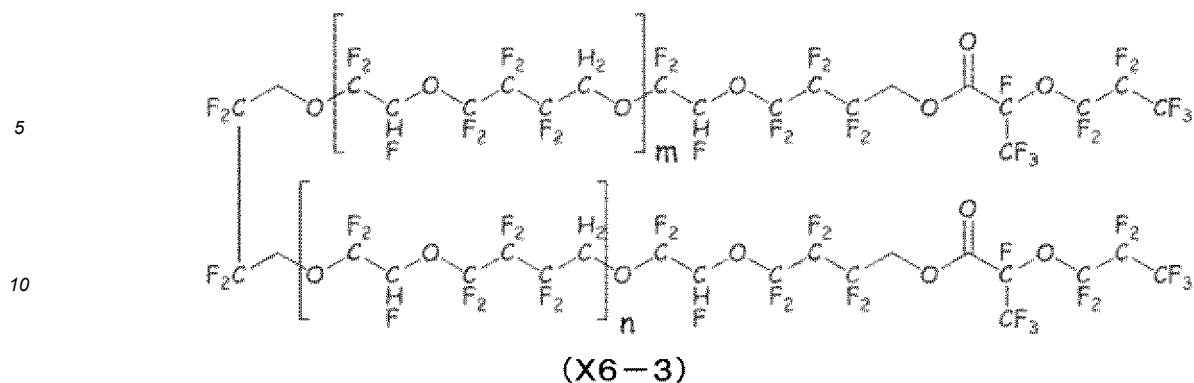
(Preparation Example 7-3)

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[0437] Into a 50 mL eggplant flask to which a reflux condenser was connected, 20 g of compound (X6-2) obtained in Preparation Example 7-2, 2.4 g of a sodium fluoride powder, 20 g of AC-2000 and 18.8 g of CF₃-CF₂-CF₂-OCF(CF₃)-COF were added. In a nitrogen atmosphere, the content in the flask was stirred at 50°C for 24 hours. The system was cooled to room temperature, the sodium fluoride powder was removed by a pressure filter, and excess CF₃-CF₂-CF₂-OCF(CF₃)-COF and AC-2000 were distilled off under reduced pressure to obtain 24 g (yield: 100%) of compound (X6-3)

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15 NMR spectrum of compound (X6-3):

[0438] $^1\text{H-NMR}$ (300.4MHz, solvent: CDCl_3 , reference: tetramethylsilane (TMS)) δ (ppm):6.0(12H), 5.0(4H), 4.6(20H), 4.2(4H).

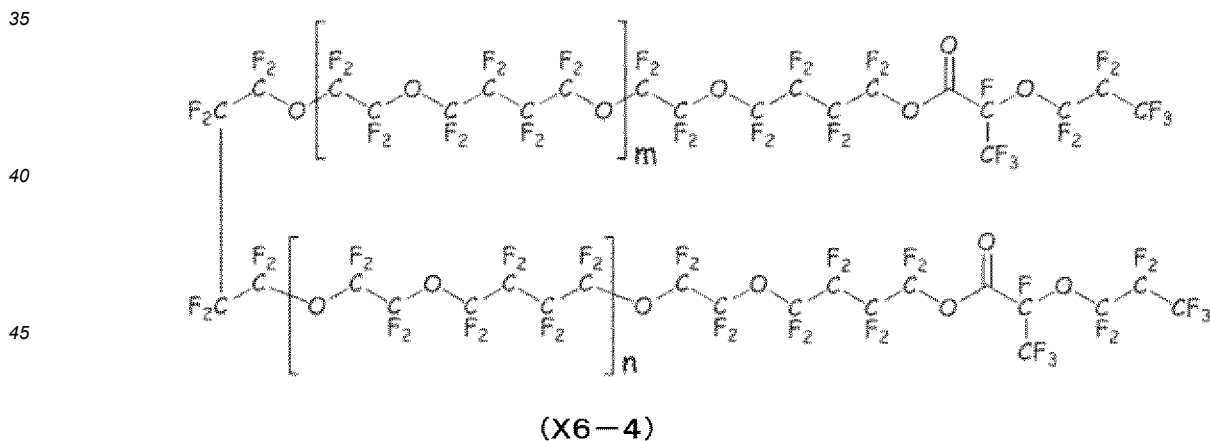
20 [0439] $^{19}\text{F-NMR}$ (282.7MHz, solvent: CDCl_3 , reference: CFCl_3) δ (ppm):-79(4F), -81(6F), -82(6F), -85(24F), -90(24F), -119(4F), -120(20F), -122(4F), -126(24F), -129(4F), -131(2F), -144(12F).

[0440] Average of number m+n of units: 10.

(Preparation Example 7-4)

25 [0441] Into a 500 mL nickel reactor, 250 mL of $\text{ClCF}_2\text{CFCICF}_2\text{OCF}_2\text{CF}_2\text{Cl}$ (hereinafter referred to as "CFE-419") was put, followed by bubbling with nitrogen gas. After the oxygen gas concentration was sufficiently lowered, bubbling with 20 vol% fluorine gas diluted with nitrogen gas was conducted for 1 hour. A CFE-419 solution (concentration: 10 mass%, compound (X6-3): 24g) of compound (X6-3) obtained in Preparation Example 7-3 was charged over a period of 6 hours. The ratio of the rate (mol/hour) of introduction of fluorine gas to the rate (mol/hour) of introduction of hydrogen atom in the compound (X6-3) was controlled to be 2:1. After the charge of the compound (X6-3) was completed, a CFE-419 solution of benzene (concentration: 0.1 mass%, benzene: 0.1g) was intermittently charged. After completion of the charge of the benzene, bubbling with fluorine gas was conducted for one hour, and finally, the system in the reactor was sufficiently replaced with nitrogen gas. The solvent was distilled off to obtain 25.3 g (yield: 90%) of compound (X6-4).

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50 NMR spectrum of compound (X6-4):

[0442] $^{19}\text{F-NMR}$ (282.7MHz, solvent: CDCl_3 , reference: CFCl_3) δ (ppm):-79(4F), -81(6F), -82(6F), -83(48F), -87(44F), -124(48F), -129(4F), -131(2F).

[0443] Average of number m+n of units:10

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(Preparation Example 7-5)

[0444] Into a 50 mL eggplant flask, 25.3 g of compound (X6-4) obtained in Preparation Example 7-4, 2.2 g of sodium

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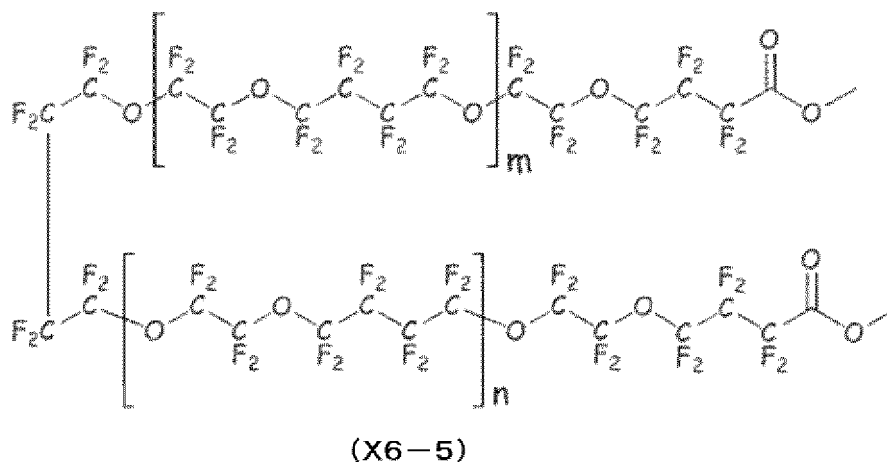
fluoride and 25 mL of AC-2000 were put, followed by stirring in an ice bath. 1.7 g of methanol was put, followed by stirring at 25°C for 1 hour. After filtration, the filtrate was purified by column chromatography. 15 g (yield: 80%) of compound (X6-5) was obtained.

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NMR spectrum of compound (X6-5):

[0445] ¹H-NMR (300.4MHz, solvent: CDCl₃, reference: tetramethylsilane (TMS)) δ(ppm):4.2(6H).

[0446] ¹⁹F-NMR (282.7MHz, solvent: CDCl₃, reference: CFC1₃) δ(ppm):-83(44F), - 87(44F), -119(4F), -124(44F).

[0447] Average of number m+n of units: 10

(Preparation Example 7-6)

[0448] Into a 50 mL eggplant flask, 15 of compound (X6-5) obtained in Preparation Example 7-5, 3.2 g of H₂ NCH₂ C(CH₂ CH=CH₂)₃ and 15 mL of AC-2000 were put, followed by stirring at 0°C for 24 hours. The reaction crude liquid was purified by column chromatography to obtain three fractions each containing the desired product. 11.2 g (yield: 70%) of compound (X6-6) was obtained in total. The respective three fractions are taken as (C4-6a), (C4-6b) and (C4-6c). The fraction (C4-6c) was again purified by column chromatography to obtain fraction (C4-6d).

[0449] The fractions (C4-6a) to (C4-6c) contained compounds (X6-6) and (X6-7). Using the respective fractions, the ratio (CF₃/CF₂) was obtained by ¹⁹F-NMR. CF₃ in the ratio means the number of moles of the -CF₃ group present at one terminal of compound (X6-7) (-CF₃ group surrounded by the dotted line in the formula), and is observed at -85 to -87ppm in the ¹⁹F-NMR spectrum. Further, CF₂ in the ratio means the total number of moles of the -CF₂- group present in the vicinity of one terminal of compound (X6-7) (-CF₂- group surrounded by the dotted line in the formula) and the -CF₂- groups present in the vicinity of both terminals of compound (X6-6) (-CF₂- groups surrounded by dotted line in the formula), and is observed at -120 ppm in the ¹⁹F-NMR spectrum. It was confirmed that no compound (X6-7) was detected in the fraction (C4-6d).

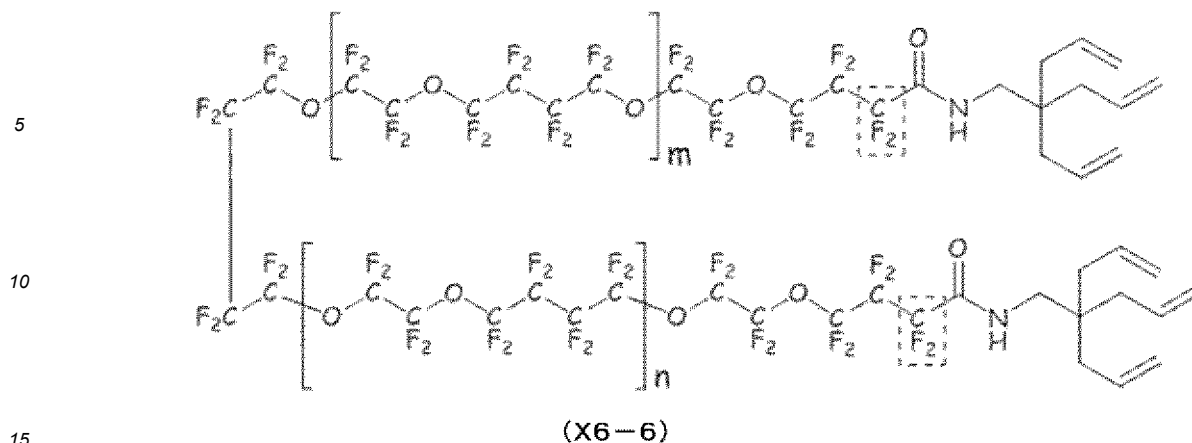
CF₃/CF₂ in the fraction (C4-6a)=0.11

CF₃/CF₂ in the fraction (C4-6b)=0.06

CF₃/CF₂ in the fraction (C4-6c)=0.05

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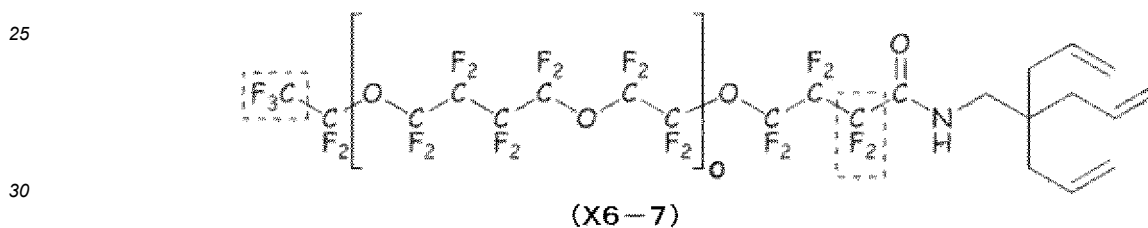


NMR spectrum of compound (X6-6):

20 [0450] $^1\text{H-NMR}$ (300.4MHz, solvent: CDCl_3 , reference: tetramethylsilane (TMS)) δ (ppm):6.1(6H), 5.2(12H), 3.4(4H), 2.1(12H).

[0451] $^{19}\text{F-NMR}$ (282.7MHz, solvent: CDCl_3 , reference: CFCl_3) δ (ppm):-83(44F), -87(44F), -120(4F), -124(44F).

[0452] Average of number m+n of units: 10

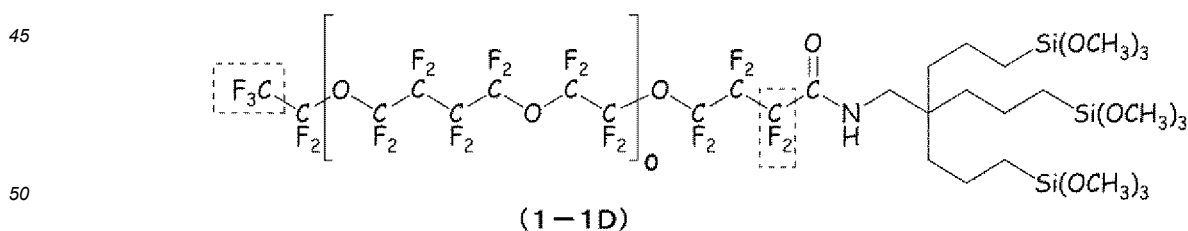


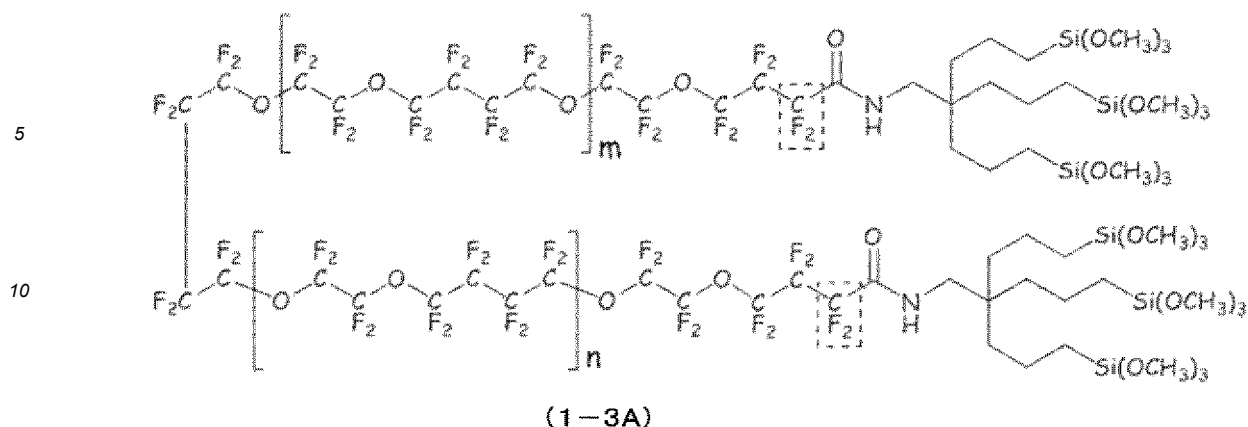
(Preparation Example 7-7)

35 [0453] Into a 50 mL eggplant flask, 1 g of fraction (C4-6a) obtained in Preparation Example 7-6, 0.21 g of trimethoxysilane, 0.001 g of aniline, 1.0 g of AC-6000 and 0.0033 g of platinum/1,3-divinyl-1,1,3,3-tetramethyldisiloxane complex were put, followed by stirring at 25°C overnight. The solvent and the like were distilled off under reduced pressure to obtain 1.2 g (yield: 100%) of mixture (M1).

[0454] Mixture (M1) contained compounds (1-1D) and (1-3A).

40 [0455] Using mixture (M1), by $^{19}\text{F-NMR}$, the ratio (CF_3/CF_2) was obtained in the same manner as in Preparation Example 7-6. The groups surrounded by the dotted line in the formulae are groups to be measured by $^{19}\text{F-NMR}$. CF_3/CF_2 in the mixture (M1)=0.11





NMR spectrum of compound (1-3A):

[0456] $^1\text{H-NMR}$ (300.4MHz, solvent: CDCl_3 , reference: tetramethylsilane (TMS)) δ (ppm):3.6(54H), 3.4(4H), 1.3(24H), 0.9(12H).

[0457] $^{19}\text{F-NMR}$ (282.7MHz, solvent: CDCl_3 , reference: CFCl_3) δ (ppm):-83(44F), -87(44F), -120(4F), -124(44F).

[0458] Average of number $m+n$ of units: 10, Mn of compound (1-3A): 5,200

[0459] In the same manner as in Preparation Example 7-7, using the fraction (C4-6d) as the material, compound (1-4A) differing in the molecular weight from compound (1-3A) was obtained. Of compound (1-4A), peaks at -85 to -87ppm were not detected in $^{19}\text{F-NMR}$.

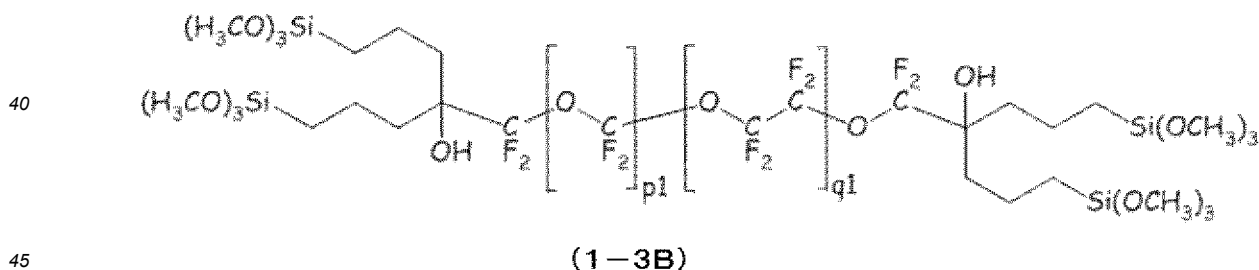
[0460] Average of number $m+n$ of units: 9, Mn of compound (1-4A): 4,900

[0461] With reference to Ex. 11-3 in WO2017/038830, into a 50 mL eggplant flask, 5 g of a mixture of compound (1-1X) (shown in Preparation Example 3) and the fraction (C4-6c) in a mass ratio of 1:1, 0.60 g of trimethoxysilane, 0.005 g of aniline, 5.0 g of AC-6000 and 0.01 g of platinum/1,3-divinyl-1,1,3,3-tetramethyldisiloxane complex were put, followed by stirring at 25°C overnight. The solvent and the like were distilled off under reduced pressure to obtain 5.1 g of mixture (M4).

[0462] Mixture (M4) contained compounds (1-1B) and (1-3A).

[Preparation Example 8]

[0463] In accordance with Example 4 in JP-A-2015-199906, compound (1-3B) was obtained.

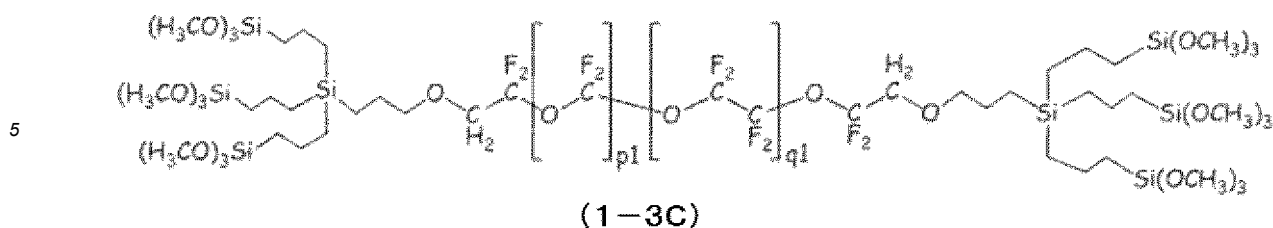


[0464] In the above formula (1-3B), $p1 : q1 \approx 47:53$, $p1+q1 \approx 43$.

[0465] Mn of compound (1-3B): 4,800

[Preparation Example 9]

[0466] Compound described in JP-A-2015-037541, paragraph [0048] was used as compound (1-3C).

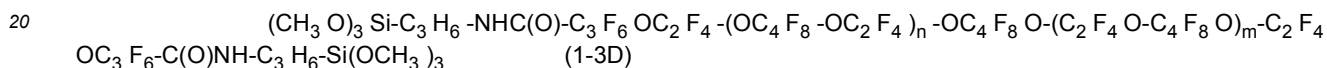


10 **[0467]** In the above formula (1-3C), $p1/q1=1.0$, $p1+q1=45$.

[0468] Mn of compound (1-3C): 5,390

[Preparation Example 10]

15 **[0469]** Into a 100 mL round bottom flask, 5 g of compound X6-5 obtained in accordance with Preparation Example 7-5, and 0.61 g of 3-aminopropyltrimethoxysilane were put, followed by stirring at room temperature for 3 hours. After completion of the reaction, unreacted compound and by-product were distilled off under reduced pressure to obtain compound (1-3D).



Mn of compound (1-3D): 5,390

25 [Ex. 1]

[0470] 20 g of boron oxide (manufactured by JUNSEI CHEMICAL CO., LTD.), 20 g of M.S.GEL-D-100-60A (trade name, manufactured by AGC Si-Tech Co., Ltd., spherical porous silica gel having an average particle size of 50 to 300 μm , hereinafter referred to as "MS gel") and 24 g of distilled water were mixed and dried at 25°C for 8 hours, and formed by a press mold (50 MPa for 2 seconds), and the obtained formed product was fired at 1,000°C for 1 hour to obtain sintered body 1 (pellets).

[0471] On a molybdenum boat in a vacuum deposition apparatus (manufactured by ULVAC KIKO, Inc., VTR-350M), 10 of the sintered body 1 and 0.5 g of compound (3A) as deposition materials (deposition source) were disposed. In the vacuum deposition apparatus, a glass substrate (manufactured by AGC Inc., Dragontrail (registered trademark)) was disposed, and the vacuum deposition apparatus was evacuated of air until the pressure became 5×10^{-3} Pa or lower.

[0472] The boat on which the sintered body 1 was placed was heated to 2,000°C so that the sintered body 1 was vacuum-deposited on the glass substrate to form an undercoat layer having a thickness of 10 nm.

[0473] Further, the boat on which the compound (3A) was placed was heated to 700°C so that the compound (3A) was vacuum-deposited on the surface of the undercoat layer to form a water/oil repellent layer having a thickness of 10 nm. In such a manner, the water/oil repellent layer-provided substrate in Ex. 1 was obtained.

[Ex. 2 and 3]

[0474] The water/oil repellent layer-provided substrates in Ex. 2 and 3 were obtained in the same manner as in Ex. 1 except that a sintered body obtained by adjusting the amounts of the boron oxide and the MS gel so that the ratio of the total molar concentration of boron and phosphorus in the sintered body to the molar concentration of silicon in the sintered body would be as identified in Table 1, was used.

[Ex. 4]

50 **[0475]** 47.05 g of boric acid (Optibor: trade name, manufactured by HAYAKAWA & Co., LTD.) and 73.5 g of silica particles SC5500-SQ (trade name, manufactured by Admatechs Company Limited, amorphous silica, hereinafter referred to as "amorphous silica") were preliminarily uniformly mixed to obtain a mixed power, which was put into a platinum crucible and fired at 1,480°C for 1 hour to obtain sintered body 4.

55 **[0476]** The water/oil repellent layer-provided substrate in Ex. 4 was obtained in the same manner as in Ex. 1 except that the sintered body 4 was used instead of the sintered body 1.

[Ex. 5 to 7]

5 [0477] The water/oil repellent layer-provided substrates in Ex. 5 to 7 were obtained in the same manner as in Ex. 4 except that a sintered body obtained by adjusting the amounts of the boric acid and the amorphous silica so that the ratio of the total molar concentration of boron and phosphorus in the sintered body to the molar concentration of silicon in the sintered body would be as identified in Table 1, was used.

[Ex. 8]

10 [0478] The firing temperature at the time of producing the deposition material was changed as identified in Table 1, and the molten material was cooled and solidified to obtain glass (molten body). The amounts of boric acid and amorphous silica were adjusted so that the ratio of the total molar concentration of boron and phosphorus in the molten body to the molar concentration of silicon in the molten body would be as identified in Table 1. The water/oil repellent layer-provided substrate in Ex. 8 was obtained in the same manner as in Ex. 4 except that the obtained molten body was used instead of the sintered body.

[Ex. 9]

20 [0479] Into Eirich Intensive Mixer EL-1 (manufactured by Nippon Eirich Co., Ltd., hereinafter referred to as "EL-1"), 23 g of boric acid (Optibor: trade name, manufactured by HAYAKAWA & Co., LTD.) and 244 g of amorphous silica were added, followed by stirring and mixing at 2,400 rpm for 30 seconds. The stirring rate was changed to 4,800 rpm, and 23 g of distilled water was added with stirring, followed by stirring at 4,800 rpm further for 60 seconds. Finally, stirring was conducted at 600 rpm for 5 minutes. The obtained particles were taken out from EL-1 and dried at 150°C for 30 minutes and further fired at 1,000°C for 1 hour to obtain a sintered body.

25 [0480] The water/oil repellent layer-provided substrate in Ex. 9 was obtained in the same manner as in Ex. 1 except that the obtained sintered body was used instead of the sintered body 1.

[Ex. 10 to 12, Ex. 21 to 23]

30 [0481] The water/oil repellent layer-provided substrates in Ex. 10 to 12 and 21 to 23 were obtained in the same manner as in Ex. 9 except that a sintered body obtained by adjusting the amounts of the boric acid and the amorphous silica so that the ratio of the total molar concentration of boron and phosphorus in the sintered body to the molar concentration of silicon in the sintered body would be as identified in Table 1 or 2, and adjusting the firing temperature to be as identified in Table 1 or 2, was used.

35 [Ex. 13]

40 [0482] Into EL-1, 23 g of boric acid (Optibor: trade name, manufactured by HAYAKAWA & Co., LTD.), 11 g of soda ash (manufactured by Soda Ash Japan Co., Ltd.) and 228 g of amorphous silica were added, followed by stirring and mixing at 2,400 rpm for 30 seconds. The stirring rate was changed to 4,800 rpm, and 39 g of distilled water was added with stirring, followed by stirring at 4,800 rpm further for 60 seconds. Finally, stirring was conducted at 600 rpm for 5 minutes. The obtained particles were taken out from EL-1 and dried at 150°C for 30 minutes and further fired at 1,000°C for 1 hour to obtain a sintered body.

45 [0483] The water/oil repellent layer-provided substrate in Ex. 13 was obtained in the same manner as in Ex. 1 except that the obtained sintered body was used instead of the sintered body 1.

[Ex. 14]

50 [0484] To 20 g of an isopropyl alcohol solution of 0.347 mass% tetraethyl orthosilicate, 20 g of an isopropyl alcohol solution of 0.419 mass% triethyl borate was added, followed by stirring for 10 minutes to obtain a coating fluid for forming undercoat layer.

[0485] One surface of a glass substrate (Dragontrail (registered trademark), manufactured by AGC Inc.) was subjected to corona discharge treatment by a high frequency power supply (CG102A: trade name, manufactured by Kasuga Electric Works Ltd.) under conditions of 80V and 3.5 A.

55 [0486] To the surface of the glass substrate subjected to the corona discharge treatment, the coating fluid for forming undercoat layer was applied by spin coating at a number of revolutions of 3,000 rpm for a rotation time of 20 seconds to form a wet film, which was fired at 300°C for 30 minutes to form an undercoat layer-provided substrate (thickness of the undercoat layer: 10 nm).

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5 [0487] On a molybdenum boat in a vacuum deposition apparatus (VTR-350M: trade name, manufactured by ULVAC KIKO, Inc.), 0.5 g of compound (3A) as a deposition material (deposition source) was disposed. In the vacuum deposition apparatus, the undercoat layer-provided substrate was disposed, and the vacuum deposition apparatus was evacuated of air until the pressure became 5×10^{-3} Pa or lower. The boat was heated to 700°C so that the compound (3A) was vacuum-deposited on the surface of the undercoat layer to form a water/oil repellent layer having a thickness of 10 nm. In such a manner, the water/oil repellent layer-provided substrate in Ex. 14 was obtained.

[Ex. 15, Ex. 24 to 26]

10 [0488] The water/oil repellent layer-provided substrate in Ex. 15 was obtained in the same manner as in Ex. 9 except that a sintered body obtained by using phosphoric acid (manufactured by JUNSEI CHEMICAL CO., LTD., H_3PO_4) instead of boric acid and by adjusting the amounts of the phosphoric acid and the amorphous silica so that the ratio of the total molar concentration of boron and phosphorus in the sintered body to the molar concentration of silicon in the sintered body would be as identified in Table 1, was used.

15 [Ex. 16]

20 [0489] The water/oil repellent layer-provided substrate in Ex. 16 was obtained in the same manner as in Ex. 9 except that a sintered body obtained by using aluminum borate (manufactured by Terada Chemische Fabrik, $AlBO_3$) instead of boric acid and by adjusting the amounts of the aluminum borate and the amorphous silica so that the ratio of the total molar concentration of boron and phosphorus in the sintered body to the molar concentration of silicon in the sintered body would be as identified in Table 1, was used.

25 [Ex. 17]

[0490] On a molybdenum boat in a vacuum deposition apparatus (manufactured by ULVAC KIKO, Inc., VTR-350M), 30 g of silicon oxide (manufactured by Canon Optron, Inc.) and 0.5 g of compound (3A) as deposition materials (deposition source) were disposed. In the vacuum deposition apparatus, a glass substrate was disposed, and the vacuum deposition apparatus was evacuated of air until the pressure became 5×10^{-3} Pa or lower.

30 [0491] The boat on which silicon oxide was placed was heated to 2,000°C so that the silicon oxide was vacuum-deposited on the glass substrate to form an undercoat layer having a thickness of 10 nm.

[0492] Further, the boat on which the compound (3A) was placed was heated to 700°C so that the compound (3A) was vacuum-deposited on the surface of the undercoat layer to form a water/oil repellent layer having a thickness of 10 nm. In such a manner, the water/oil repellent layer-provided substrate in Ex. 17 was obtained.

35 [Ex. 18]

40 [0493] The water/oil repellent layer-provided substrate in Ex. 18 was obtained in the same manner as in Ex. 1 except that a sintered body obtained by adjusting the amounts of the boron oxide and the MS gel so that the ratio of the total molar concentration of boron and phosphorus in the sintered body to the molar concentration of silicon in the sintered body would be as identified in Table 1, was used.

[Ex. 19]

45 [0494] The water/oil repellent layer-provided substrate in Ex. 19 was obtained in the same manner as in Ex. 9 except that granules obtained by using boron oxide (manufactured by JUNSEI CHEMICAL CO., LTD.) instead of boric acid, using ethanol instead of water as the solvent, adjusting the amounts of the boron oxide and the amorphous silica so that the ratio of the total molar concentration of boron and phosphorus in the granules to the molar concentration of silicon in the granules would be as identified in Table 1, and changing the drying temperature to be as identified in Table 1, was used.

50 [Ex. 20]

[0495] On a molybdenum boat in a vacuum deposition apparatus (manufactured by ULVAC KIKO, Inc., VTR-350M), 20 g of boron oxide (manufactured by Toshiba Manufacturing Co., Ltd.) and 5 g of compound (3A) as deposition materials (deposition source) were disposed. In the vacuum deposition apparatus, a glass substrate was disposed, and the vacuum deposition apparatus was evacuated of air until the pressure became 5×10^{-3} Pa or lower.

[0496] The boat on which boron oxide was placed was heated to 1,000°C so that boron oxide was vacuum-deposited

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on the glass substrate to form an undercoat layer having a thickness of 10 nm.

[0497] Further, the boat on which the compound (3A) was placed was heated to 700°C so that the compound (3A) was vacuum-deposited on the surface of the undercoat layer to form a water/oil repellent layer having a thickness of 10 nm. In such a manner, the water/oil repellent layer-provided substrate in Ex. 20 was obtained.

[Ex. 27]

[0498] To 297.65 g of water, 2.08 g of tetraethyl orthosilicate, 0.27 g of boric acid, 4.16 g of an isopropyl alcohol (IPA) solution containing 1 mass% of silicon surfactant (BYK348, manufactured by BYK) and 2.08 g of a 0.1 mol/L aqueous nitric acid solution were added, followed by stirring to obtain a coating fluid for forming undercoat layer.

[0499] One surface of a glass substrate (Dragontrail (registered trademark), manufactured by AGC Inc.) was subjected to corona discharge treatment by a high frequency power supply (CG102A: trade name, manufactured by Kasuga Electric Works Ltd.) under conditions of 80V and 3.5 A.

[0500] To the surface of the glass substrate subjected to the corona discharge treatment, the coating fluid for forming undercoat layer was applied by spraying (fluid discharge rate: 4 cm³/min) to form an undercoat layer. To the undercoat layer, a Novoc7200 (manufactured by 3M) solution containing 0.1 mass% of compound (3A) was further applied by spraying (fluid discharge rate: 8 cm³/min), and the obtained wet film was dried at 140°C for 30 minutes to obtain a water/oil repellent layer-provided substrate.

[Ex. 28]

[0501] To 297.82 g of water, 2.08 g of tetraethyl orthosilicate, 0.10 g of phosphoric acid, 4.16 g of an IPA solution containing 1 mass% of BYK348 and 1.04 g of a 0.1 mol/L aqueous nitric acid solution were added, followed by stirring to obtain a coating fluid for forming undercoat layer.

[0502] One surface of a glass substrate (Dragontrail (registered trademark), manufactured by AGC Inc.) was subjected to corona discharge treatment by a high frequency power supply (CG102A: trade name, manufactured by Kasuga Electric Works Ltd.) under conditions of 80V and 3.5 A.

[0503] To the surface of the glass substrate subjected to the corona discharge treatment, the coating fluid for forming undercoat layer was applied by spraying (fluid discharge rate: 4 cm³/min) to form an undercoat layer. To the undercoat layer, a Novoc7200 solution containing 0.1 mass% of compound (3A) was further applied by spraying (fluid discharge rate: 8 cm³/min), and the obtained wet film was dried at 140°C for 30 minutes to obtain a water/oil repellent layer-provided substrate.

[Ex. 29 to 43]

[0504] The water/oil repellent layer-provided substrate was obtained in the same manner as in Ex. 1 except that compound as identified in Table 2 was used instead of compound (3A) as the fluorinated compound, and that the undercoat layer was formed by using the materials as identified in Table 2.

[0505] Mixture (M2) is a mixture containing 50 mass% each of compound (1-1A) and compound (1-2B). Mixture (M3) is a mixture containing 50 mass% each of compound (1-4A) and compound (1-1A). Mixture (M5) is a mixture containing 70 mass% of compound (1-3B) and 30 mass% of compound (1-4B). Mixture (M6) is a mixture containing 40 mass% of (M1) and 60 mass% of compound (1-1C).

[0506] The above measurement of physical properties and evaluation were conducted in each Ex. The evaluation results are shown in Tables 1 and 2.

[0507] In Tables, "boron and phosphorus/silicon (molar ratio)" means the ratio of the total molar concentration of boron and phosphorus in the deposition material, the coating fluid or the undercoat layer to the molar concentration of silicon in the deposition material, the coating fluid or the undercoat layer. Further, "aluminum/silicon (molar ratio)" means the ratio of the molar concentration of aluminum in the deposition material, the coating fluid or the undercoat layer to the molar concentration of silicon in the deposition material, the coating fluid or the undercoat layer. Further, "sodium/silicon (molar ratio)" means the ratio of the molar concentration of sodium in the deposition material, the coating fluid or the undercoat layer to the molar concentration of silicon in the deposition material, the coating fluid or the undercoat layer.

TABLE 1

Material for forming undercoat layer						
Fluorinated compound	Material species	Form	Firing or drying temperature at the time of forming deposition material	Boron and phosphorus/ silicon (molar ratio)	Aluminum/ silicon (molar ratio)	Sodium/ silicon (molar ratio)
Ex. 1	MS gel	Sintered body	1000°C	1.724	0.00	0.00
Ex. 2		Sintered body	1000°C	0.431	0.00	0.00
Ex. 3		Sintered body	1000°C	0.091	0.00	0.00
Ex. 4	B ₂ O ₃	Sintered body	1480°C	0.621	0.00	0.00
Ex. 5		Sintered body	1480°C	0.093	0.00	0.00
Ex. 6		Sintered body	1480°C	0.235	0.00	0.00
Ex. 7	Amorphous silica	Sintered body	1480°C	3.145	0.00	0.00
Ex. 8		Glass (molten body)	1550°C	1.149	0.00	0.00
Ex. 9		Sintered body	1000°C	0.091	0.00	0.00
Ex. 10	Boric acid	Sintered body	1000°C	0.431	0.00	0.00
Ex. 11		Sintered body	600°C	1.149	0.00	0.00
Ex. 12		Sintered body	600°C	6.895	0.00	0.00

(continued)

		Material for forming undercoat layer							
Ex.	Fluorinated compound	Material species			Form	Firing or drying temperature at the time of forming deposition material	Boron and phosphorus/ silicon (molar ratio)	Aluminum/ silicon (molar ratio)	Sodium/ silicon (molar ratio)
		Amorphous silica	Boric acid	Soda ash					
Ex. 13	3A	Amorphous silica	Boric acid	Soda ash	Sintered body	1000°C	0.091	0.00	0.09
Ex. 14	3A	Si (OCH ₂ CH ₃) ₄	B(OCH ₂ CH ₃) ₃		Coating fluid	-	1.723	0.00	0.00
Ex. 15	3A	Amorphous silica	H ₃ PO ₄	Sintered body	1000°C	0.462	0.00	0.00	
Ex. 16	3A	Amorphous silica	AlBO ₃	Sintered body	1000°C	0.600	0.60	0.00	
Ex. 17	3A	SiO ₂	-	Commercial deposition source	-	0.000	0.00	0.00	
Ex. 18	3A	MS gel	B ₂ O ₃		1000°C	0.002	0.00	0.00	
Ex. 19	3A	Amorphous silica	Granules		25°C	10.800	0.00	0.00	
Ex. 20	3A	B ₂ O ₃	Commercial deposition source		-	-	0.00	0.00	
Ex. 21	3A	Amorphous silica	Boric acid		1000°C	8.900	0.00	0.00	
Ex. 22	3A	Amorphous silica	Sintered body		1000°C	0.280	0.00	0.00	

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(continued)

	Undercoat layer			Evaluation results		
	Boron and phosphorus/silicon (molar ratio)	Aluminum/silicon (molar ratio)	Sodium/silicon (molar ratio)	Abrasion resistance 1	Abrasion resistance 2	Abrasion resistance 3
Ex. 1	0.129	0.00	0.00	⊙	○	×
Ex. 2	0.055	0.00	0.00	⊙	○	×
Ex. 3	0.026	0.00	0.00	⊙	○	×
Ex. 4	0.279	0.00	0.00	⊙		
Ex. 5	0.027	0.00	0.00	⊙		
Ex. 6	0.100	0.00	0.00	⊙		
Ex. 7	1.235	0.00	0.00	○		
Ex. 8	0.555	0.00	0.00	○		
Ex. 9	0.031	0.00	0.00	⊙		
Ex. 10	0.152	0.00	0.00	⊙		
Ex. 11	0.943	0.00	0.00	○		
Ex. 12	5.859	0.00	0.00	○		
Ex. 13	0.038	0.00	0.01	○		

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	Undercoat layer			Evaluation results		
	Boron and phosphorus/silicon (molar ratio)	Aluminum/silicon (molar ratio)	Sodium/silicon (molar ratio)	Abrasion resistance 1	Abrasion resistance 2	Abrasion resistance 3
Ex. 14	1.274	0.00	0.00	○		
Ex. 15	0.207	0.00	0.00	⊙	○	×
Ex. 16	0.155	0.01	0.00	⊙	○	×
Ex. 17	0.000	0.00	0.00	×	×	×
Ex. 18	0.002	0.00	0.00	×	×	×
Ex. 19	9.467	0.00	0.00	×	×	×
Ex. 20	-	0.00	0.00	×	×	×
Ex. 21	8.791	0.00	0.00	○	○	×
Ex. 22	0.350	0.00	0.00	⊙	○	×

Table 2

Material for forming undercoat layer									
Fluorinated compound	Material species	Form	Firing or drying temperature at the time of forming deposition material	Boron and phosphorus/ silicon (molar ratio)	Aluminum/ silicon (molar ratio)	Sodium/ silicon (molar ratio)			
Ex. 23	3A	Sintered body	1000°C	0.004	0.00	0.00			
Ex. 24	3A	Sintered body	1000°C	0.094	0.00	0.00			
Ex. 25	3A	Sintered body	1000°C	8.900	0.00	0.00			
Ex. 26	3A	Sintered body	1000°C	0.004	0.00	0.00			
Ex. 27	3A	Coating fluid	-	0.431	0.00	0.00			
Ex. 28	3A	Coating fluid	-	0.106	0.00	0.00			
Ex. 29	1-1A	Sintered body	1000°C	0.095	0.00	0.00			
Ex. 30	1-1B	Sintered body	1000°C	0.283	0.00	0.00			
Ex. 31	1-1C	Sintered body	1000°C	0.276	0.00	0.00			
Ex. 32	1-2A	Coating fluid	-	0.432	0.00	0.00			
Ex. 33	1-2B	Coating fluid	-	0.107	0.00	0.00			
Ex. 34	1-3B	Sintered body	1000°C	0.278	0.00	0.00			

(continued)

		Material for forming undercoat layer							Evaluation results		
Ex.	Fluorinated compound	Material species		Form	Firing or drying temperature at the time of forming deposition material	Boron and phosphorus/silicon (molar ratio)	Aluminum/silicon (molar ratio)	Sodium/silicon (molar ratio)	Abrasion resistance 1	Abrasion resistance 2	Abrasion resistance 3
		Si (OCH ₂ CH ₃) ₄	Amorphous silica								
Ex. 35	1-3C	Si (OCH ₂ CH ₃) ₄	H ₃ PO ₄	Coating fluid	-	0.107	0.00	0.00	○		×
Ex. 36	1-4A	Amorphous silica	H ₃ PO ₄	Sintered body	1000°C	0.092	0.00	0.00	○		×
Ex. 37	M1	MS gel	B ₂ O ₃	Sintered body	1000°C	0.433	0.00	0.00	○		×
Ex. 38	M2	Si (OCH ₂ CH ₃) ₄	H ₃ PO ₄	Coating fluid	-	0.107	0.00	0.00	○		×
Ex. 39	M3		Boric acid	Sintered body	1000°C	0.285	0.00	0.00	○		×
Ex. 40	M4		Boric acid	Sintered body	1000°C	0.281	0.00	0.00	○		×
Ex. 41	M5	Amorphous silica	AlBO ₃	Sintered body	1000°C	0.605	0.60	0.00	○		×
Ex. 42	M6		AlBO ₃	Sintered body	1000°C	0.605	0.60	0.00	○		×
Ex. 43	1-3D		Boric acid	Sintered body	1000°C	0.281	0.00	0.00	○		×
Undercoat layer											
Ex. 23	Boron and phosphorus/silicon (molar ratio)	Aluminum/silicon (molar ratio)	Sodium/silicon (molar ratio)	Abrasion resistance 1		Abrasion resistance 2			○		×
Ex. 24	0.003	0.00	0.00	○					○		×
	0.055	0.00	0.00	⊙					○		×

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	Undercoat layer			Evaluation results		
	Boron and phosphorus/silicon (molar ratio)	Aluminum/silicon (molar ratio)	Sodium/silicon (molar ratio)	Abrasion resistance 1	Abrasion resistance 2	Abrasion resistance 3
Ex. 25	8.900	0.00	0.00	○	○	×
Ex. 26	0.004	0.00	0.00	○	○	×
Ex. 27	0.220	0.00	0.00	⊙		
Ex. 28	0.102	0.00	0.00	⊙		
Ex. 29	0.056	0.00	0.00	⊙	⊙	○
Ex. 30	0.351	0.00	0.00	⊙	⊙	○
Ex. 31	0.348	0.00	0.00	⊙	⊙	○
Ex. 32	0.221	0.00	0.00	⊙	⊙	△
Ex. 33	0.103	0.00	0.00	⊙	⊙	△
Ex. 34	0.034	0.00	0.00	⊙	○	○
Ex. 35	0.103	0.00	0.00	⊙	○	
Ex. 36	0.054	0.00	0.00	⊙	○	
Ex. 37	0.056	0.00	0.00	⊙	○	⊙

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	Undercoat layer			Evaluation results		
	Boron and phosphorus/silicon (molar ratio)	Aluminum/silicon (molar ratio)	Sodium/silicon (molar ratio)	Abrasion resistance 1	Abrasion resistance 2	Abrasion resistance 3
Ex. 38	0.110	0.00	0.00	⊙	○	○
Ex. 39	0.352	0.00	0.00	⊙	○	⊙
Ex. 40	0.358	0.00	0.00	⊙	○	⊙
Ex. 41	0.156	0.01	0.00	⊙	○	⊙
Ex. 42	0.150	0.01	0.00	⊙	⊙	○
Ex. 43	0.352	0.00	0.00	○	×	×

[0508] As shown in Table 1, it was confirmed that the water/oil repellent layer-provided substrate having a water/oil repellent layer excellent in abrasion resistance was obtained by using an undercoat layer which contains an oxide containing silicon and at least one element of boron and phosphorus, and has a ratio of the total molar concentration of boron and phosphorus in the undercoat layer to the molar concentration of silicon in the undercoat layer of from 0.003 to 9.

INDUSTRIAL APPLICABILITY

[0509] The water/oil repellent layer-provided substrate of the present invention is useful for various applications for which it is required to impart water/oil repellency. For example, it may be used for a display input device such as a touch panel, a transparent glass or transparent plastic member, a lens of eyeglasses or the like, a kitchen antifouling member, a water repellent moistureproof member or antifouling member of electronic device, a heat exchanger or a battery, a toiletry antifouling member, a member which requires liquid repellency while conducting electricity, a water repellent/waterproof/water sliding member of a heat exchanger, or a surface low-friction member for a vibrating strainer or the inside of a cylinder, etc. More specific examples of application include a front protective plate, an antireflection plate, a polarizing plate, an antiglare plate or a surface thereof having an antireflection film, of a display, an apparatus having a display input device of which the screen is operated by human fingers or hands, such as a touch panel sheet or a touch panel display of an apparatus such as a mobile phone (e.g. a smartphone), a personal digital assistant, a gaming machine or a remote controller (for example, glass or film to be used for e.g. display portion, or glass or film to be used for exterior member other than the display portion). In addition, a decorative building material for restroom, bathroom, lavatory, kitchen and the like, a waterproof member for a wiring board, a water repellent/waterproof/water sliding member of a heat exchanger, a water repellent member of a solar cell, a waterproof/water repellent member of a printed wiring board, a waterproof/water repellent member of an electronic equipment casing or an electronic member, an insulating property-improving member of a power transmission line, a waterproof/water repellent member of a filter, a waterproof member of an electromagnetic wave absorption material or an acoustic material, an antifouling member for bathroom, kitchen instrument and toiletry, a surface low-friction member of a vibrating strainer or the inside of a cylinder, a surface protective member of a machine component, a vacuum apparatus component, a bearing component, a member for a transport such as an automobile, an industrial tool, etc. may be mentioned.

REFERENCE SYMBOLS

[0510]

10: water/oil repellent layer-provided substrate
 12: substrate
 14: undercoat layer
 16: water/oil repellent layers

Claims

1. A water/oil repellent layer-provided substrate comprising a substrate, an undercoat layer and a water/oil repellent layer in this order,

wherein the water/oil repellent layer comprises a condensate of a fluorinated compound having a reactive silyl group,
 the undercoat layer contains an oxide containing silicon and at least one element of boron and phosphorus, and the ratio of the total molar concentration of boron and phosphorus in the undercoat layer to the molar concentration of silicon in the undercoat layer is from 0.003 to 9.
2. The water/oil repellent layer-provided substrate according to Claim 1, wherein the oxide is an oxide containing silicon, and boron or phosphorus.
3. The water/oil repellent layer-provided substrate according to Claim 1 or 2, wherein the oxide further contains aluminum.
4. The water/oil repellent layer-provided substrate according to Claim 3, wherein the ratio of the molar concentration of aluminum to the molar concentration of silicon is at most 0.5.

5. The water/oil repellent layer-provided substrate according to any one of Claims 1 to 4, wherein the oxide further contains an alkali metal element.
6. The water/oil repellent layer-provided substrate according to Claim 5, wherein the ratio of the molar concentration of the alkali metal element to the molar concentration of silicon is at most 1.0.
7. The water/oil repellent layer-provided substrate according to any one of Claims 1 to 6, wherein the fluorinated compound is a fluorinated ether compound having a poly(oxyfluoroalkylene) chain and a reactive silyl group.
8. A method for producing a water/oil repellent layer-provided substrate comprising a substrate, an undercoat layer and a water/oil-repellent layer in this order,

which comprises forming on the substrate the undercoat layer containing an oxide containing silicon and at least one element of boron and phosphorus, the ratio of the total molar concentration of boron and phosphorus to the molar concentration of silicon being from 0.003 to 9, by deposition method using a deposition material comprising an oxide containing silicon and at least one element of boron and phosphorus, wherein the ratio of the total molar concentration of boron and phosphorus to the molar concentration of silicon is from 0.003 to 9, and forming on the undercoat layer the water/oil repellent layer comprising a condensate of a fluorinated compound having a reactive silyl group.

9. A method for producing a water/oil repellent layer-provided substrate comprising a substrate, an undercoat layer and a water/oil-repellent layer in this order,

which comprises forming on the substrate the undercoat layer containing an oxide containing silicon and at least one element of boron and phosphorus, the ratio of the total molar concentration of boron and phosphorus to the molar concentration of silicon being from 0.003 to 9, by wet coating method using a coating fluid containing a compound containing silicon, at least one of a compound containing boron and a compound containing phosphorus, and a liquid medium, and forming on the undercoat layer the water/oil repellent layer comprising a condensate of a fluorinated compound having a reactive silyl group.

Patentansprüche

1. Mit einer wasser-/ölabweisenden Schicht versehenes Substrat, umfassend ein Substrat, eine Grundierungsschicht und eine wasser-/ölabweisende Schicht in dieser Reihenfolge,
- wobei die wasser-/ölabweisende Schicht ein Kondensat einer fluorierten Verbindung mit einer reaktiven Silylgruppe umfasst,
- die Grundierungsschicht ein Oxid, enthaltend Silicium und mindestens ein Element aus Bor und Phosphor, enthält, und
- das Verhältnis der gesamten molaren Konzentration von Bor und Phosphor in der Grundierungsschicht zu der molaren Konzentration von Silicium in der Grundierungsschicht von 0,003 bis 9 beträgt.
2. Mit einer wasser-/ölabweisenden Schicht versehenes Substrat nach Anspruch 1, wobei das Oxid ein Silicium und Bor oder Phosphor enthaltendes Oxid ist.
3. Mit einer wasser-/ölabweisenden Schicht versehenes Substrat nach Anspruch 1 oder 2, wobei das Oxid ferner Aluminium enthält.
4. Mit einer wasser-/ölabweisenden Schicht versehenes Substrat nach Anspruch 3, wobei das Verhältnis der molaren Konzentration von Aluminium zu der molaren Konzentration von Silicium höchstens 0,5 beträgt.
5. Mit einer wasser-/ölabweisenden Schicht versehenes Substrat nach einem der Ansprüche 1 bis 4, wobei das Oxid ferner ein Alkalimetallelement enthält.
6. Mit einer wasser-/ölabweisenden Schicht versehenes Substrat nach Anspruch 5, wobei das Verhältnis der molaren Konzentration des Alkalimetallelements zu der molaren Konzentration von Silicium höchstens 1,0 beträgt.

7. Mit einer wasser-/ölabweisenden Schicht versehenes Substrat nach einem der Ansprüche 1 bis 6, wobei die fluorierte Verbindung eine fluorierte Etherverbindung mit einer Poly(oxyfluoralkylen)-Kette und einer reaktiven Silylgruppe ist.

8. Verfahren zur Herstellung eines mit einer wasser-/ölabweisenden Schicht versehenen Substrats, umfassend ein Substrat, eine Grundierungsschicht und eine wasser-/ölabweisende Schicht in dieser Reihenfolge,

welches das Bilden der Grundierungsschicht, enthaltend ein Oxid, enthaltend Silicium und mindestens ein Element aus Bor und Phosphor, wobei das Verhältnis der gesamten molaren Konzentration von Bor und Phosphor zu der molaren Konzentration von Silicium von 0,003 bis 9 beträgt, auf dem Substrat durch ein Abscheidungsverfahren unter Verwendung eines Abscheidungsmaterials, umfassend ein Oxid, enthaltend Silicium und mindestens ein Element aus Bor und Phosphor, wobei das Verhältnis der gesamten molaren Konzentration von Bor und Phosphor zu der molaren Konzentration von Silicium von 0,003 bis 9 beträgt, und das Bilden der wasser-/ölabweisenden Schicht, umfassend ein Kondensat einer fluorierten Verbindung mit einer reaktiven Silylgruppe, auf der Grundierungsschicht umfasst.

9. Verfahren zur Herstellung eines mit einer wasser-/ölabweisenden Schicht versehenen Substrats, umfassend ein Substrat, eine Grundierungsschicht und eine wasser-/ölabweisende Schicht in dieser Reihenfolge,

welches das Bilden der Grundierungsschicht, enthaltend ein Oxid, enthaltend Silicium und mindestens ein Element aus Bor und Phosphor, wobei das Verhältnis der gesamten molaren Konzentration von Bor und Phosphor zu der molaren Konzentration von Silicium von 0,003 bis 9 beträgt, auf dem Substrat durch ein Nassbeschichtungsverfahren unter Verwendung einer Beschichtungsflüssigkeit, enthaltend eine Silicium enthaltende Verbindung, mindestens eine aus einer Bor enthaltenden Verbindung und einer Phosphor enthaltenden Verbindung und ein flüssiges Medium, und das Bilden der wasser-/ölabweisenden Schicht, umfassend ein Kondensat einer fluorierten Verbindung mit einer reaktiven Silylgruppe, auf der Grundierungsschicht umfasst.

Revendications

1. Substrat pourvu d'une couche hydrofuge/oléofuge comprenant un substrat, une sous-couche et une couche hydrofuge/oléofuge dans cet ordre,

dans lequel la couche hydrofuge/oléofuge comprend un condensat d'un composé fluoré ayant un groupe silyle réactif, la sous-couche contient un oxyde contenant du silicium et au moins un élément parmi le bore et le phosphore, et le rapport de la concentration molaire totale en bore et phosphore dans la sous-couche sur la concentration molaire en silicium dans la sous-couche va de 0,003 à 9.

2. Substrat pourvu d'une couche hydrofuge/oléofuge selon la revendication 1, dans lequel l'oxyde est un oxyde contenant du silicium, et du bore ou du phosphore.

3. Substrat pourvu d'une couche hydrofuge/oléofuge selon la revendication 1 ou 2, dans lequel l'oxyde contient en outre de l'aluminium.

4. Substrat pourvu d'une couche hydrofuge/oléofuge selon la revendication 3, dans lequel le rapport de la concentration molaire en aluminium sur la concentration molaire en silicium est d'au plus 0,5.

5. Substrat pourvu d'une couche hydrofuge/oléofuge selon l'une quelconque des revendications 1 à 4, dans lequel l'oxyde contient en outre un élément de métal alcalin.

6. Substrat pourvu d'une couche hydrofuge/oléofuge selon la revendication 5, dans lequel le rapport de la concentration molaire en l'élément de métal alcalin sur la concentration molaire en silicium est d'au plus 1,0.

7. Substrat pourvu d'une couche hydrofuge/oléofuge selon l'une quelconque des revendications 1 à 6, dans lequel le composé fluoré est un composé d'éther fluoré ayant une chaîne de poly(oxyfluoroalkylène) et un groupe silyle réactif.

8. Procédé de production d'un substrat pourvu d'une couche hydrofuge/oléofuge comprenant un substrat, une sous-

couche et une couche hydrofuge/oléofuge dans cet ordre,

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qui comprend former sur le substrat la sous-couche contenant un oxyde contenant du silicium et au moins un élément parmi le bore et le phosphore, le rapport de la concentration molaire totale en bore et phosphore sur la concentration molaire en silicium allant de 0,003 à 9, par procédé de dépôt utilisant un matériau de dépôt comprenant un oxyde contenant du silicium et au moins un élément parmi le bore et le phosphore, dans lequel le rapport de la concentration molaire totale en bore et phosphore sur la concentration molaire en silicium va de 0,003 à 9, et

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former sur la sous-couche la couche hydrofuge/oléofuge comprenant un condensat d'un composé fluoré ayant un groupe silyle réactif.

9. Procédé de production d'un substrat pourvu d'une couche hydrofuge/oléofuge comprenant un substrat, une sous-couche et une couche hydrofuge/oléofuge dans cet ordre,

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qui comprend former sur le substrat la sous-couche contenant un oxyde contenant du silicium et au moins un élément parmi le bore et le phosphore, le rapport de la concentration molaire totale en bore et phosphore sur la concentration molaire en silicium allant de 0,003 à 9, par procédé d'enrobage par voie humide utilisant un fluide d'enrobage contenant un composé contenant du silicium, au moins un d'un composé contenant du bore et d'un composé contenant du phosphore, et un milieu liquide, et

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former sur la sous-couche la couche hydrofuge/oléofuge comprenant un condensat d'un composé fluoré ayant un groupe silyle réactif.

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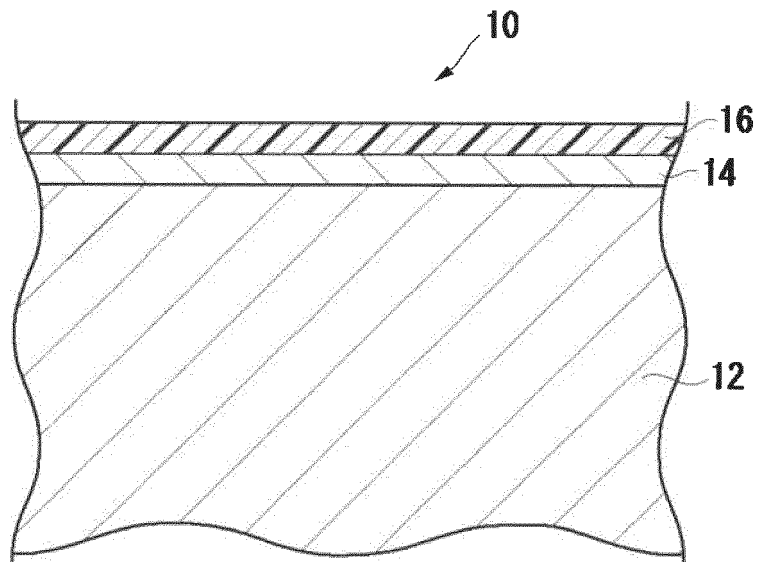
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Fig. 1



REFERENCES CITED IN THE DESCRIPTION

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