Meanwhile, there has been proposed a method in which a metal alkoxide is hydrolyzed in a solvent, followed by polycondensation to form a polymetalloxane, and the polymetalloxane is coated and cured to obtain a high refractive index thin film. However, when the metal alkoxide is hydrolyzed, the hydrolyzate aggregates and becomes insoluble in the organic solvent. For this reason, a polymetalloxane, which stably exists in a transparent and uniform state in a solution and can form a homogeneous cured film, has not been industrialized at present.

[0005]

In the past literatures, there has been reported technology in which aggregation of a hydrolysate is prevented by carefully carrying out the hydrolysis under special conditions (see, for example, Patent Literatures 1 and 2).

[Citation List]

[Patent Literature]

[0006]

[Patent Literature 1] JP 1-129032 A

[Patent Literature 2] JP 2015-3896 A

[Summary]

[Technical Problem]

[0007]

As a method of hydrolyzing a metal alkoxide in a solvent, technology mentioned in Patent Literature 1 is a method in which the temperature of a metal alkoxide solution is maintained at 70°C

and water for hydrolysis is added in the amount of 1 mol or more and 1.7-fold mols or less based on 1 mol of a titanium alkoxide to obtain a ladder-like polytitanoxane which is soluble in an organic solvent. However, such a method had a problem that the addition of water at a temperature lower than 70°C or an increase in amount of water leads to precipitation due to aggregation of the hydrolyzate. Because of low degree of the hydrolysis, numerous alkoxy groups remain in the resulting polytitanoxane and the alkoxy group is hydrolyzed by moisture in the air during formation of a coating film, thus failing to form a homogeneous film by crack generation due to the elimination,.

[0008]

Technology mentioned in Patent Literature 2 is technology in which a titanium compound is reacted with water in an alcohol solution in the presence of a special hydrochloride to produce a titanium compound oligomer. However, such a method also had a problem that an increase in amount of water leads to precipitation due to aggregation of the hydrolysate. Therefore, a high molecular weight polymetalloxane cannot be obtained, leading to crack generation during formation of a coating film, thus failing to form a homogeneous film.

[0009]

An object of the embodiments disclosed herein is to provide a polymetalloxane which stably exists in a transparent and uniform state in a solution and can form a homogeneous cured film.

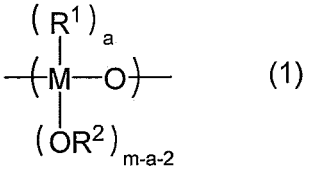
[Solution to Problem]

[0010]

The present disclosure is directed to a polymetalloxane including a constituent unit represented by the following general formula (1):

[0011]

[Chemical Formula 1]



(1)

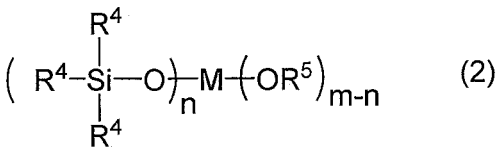
[0012]

wherein R^1 is an organic group, at least one of R^1 is an ($R^3{}_3SiO$-) group, R^3 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, an aromatic group having 6 to 30 carbon atoms, a group having a siloxane bond, or a group having a metalloxane bond, R^2 is optionally selected from a hydrogen atom, an alkyl group having 1 to 12 carbon atoms, or a group having a metalloxane bond, when plural R^1, R^2, and R^3 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal atom M, and a is an integer of 1 to (m - 2).

The present disclosure is directed to, a method for producing a polymetalloxane, which including the step of polycondensing a compound represented by the following general formula (2):

[0013]

[Chemical Formula 2]



(2)

[0014]

wherein R^4 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, or an aromatic group having 6 to 30 carbon atoms, R^5 is optionally selected from a hydrogen atom or an alkyl group having 1 to 12 carbon atoms, when plural R^4 and R^5 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal atom M, and n is an integer of 1 to (m - 1), or a hydrolysate thereof.

[Advantageous Effects]

[0015]

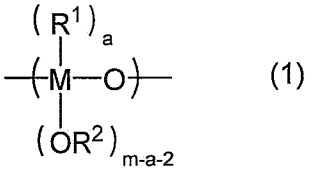
The polymetalloxane of the present disclosure stably exists in a transparent and uniform state in a solution. According to

the polymetalloxane of the present disclosure, it is possible to provide a cured film having high transparency and high refractive index.

[0015a]

In an aspect, there is provided a polymetalloxane comprising a constituent unit represented by the following general formula (1):

[Chemical Formula 1]



(1)

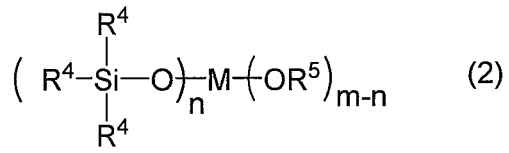
wherein R^1 is an organic group, at least one of R^1 is an ($R^3{}_3SiO$-) group, at least one of R^1 in the polymetalloxane is a hydroxy group, R^3 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, an aromatic group having 6 to 30 carbon atoms, a group having a siloxane bond, or a group having a metalloxane bond, R^2 is optionally selected from a hydrogen atom, an alkyl group having 1 to 12 carbon atoms, or a group having a metalloxane bond, when plural R^1, R^2, and R^3 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal atom M, and

a is an integer of 1 to (m - 2).

[015b]

In another aspect, there is provided a method for producing a polymetalloxane compound, which comprises the step of polycondensing a compound represented by the following general formula (2):

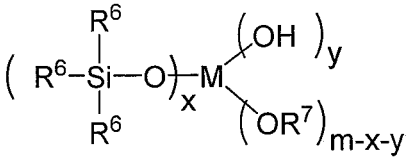
[Chemical Formula 2]



(2)

wherein R^4 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, or an aromatic group having 6 to 30 carbon atoms, R^5 is optionally selected from a hydrogen atom or an alkyl group having 1 to 12 carbon atoms, when plural R^4 and R^5 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal atom M, and n is an integer of 1 to (m - 1), or a hydrolysate thereof, wherein the compound represented by the general formula (2) is the compound as defined above which is a compound represented by the following compound represented by the general formula (3):

[Chemical Formula 3]



(3)

wherein R^6 is the same as R^4 in the general formula (1), R^7 is an alkyl group having 1 to 12 carbon atoms, m is an integer indicating a valence of a metal atom M, x is an integer of 1 to (m - 1), y is an integer of 1 to (m - 1), and $x + y \leq m$.

[015c]

In another aspect, there is provided a composition comprising the polymetalloxane as defined above.

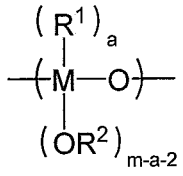
[015d]

In another aspect, there is provided a composition comprising the polymetalloxane as defined above and inorganic particles.

[015e]

In another aspect, there is provided a cured film of a polymetalloxane comprising a constituent unit represented by the following general formula (1):

[Chemical Formula 1]



(1)

wherein R^1 is an organic group, at least one of R^1 is an ($R^3{}_3SiO$-) group, R^3 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having

5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, an aromatic group having 6 to 30 carbon atoms, a group having a siloxane bond, or a group having a metalloxane bond, R^2 is optionally selected from a hydrogen atom, an alkyl group having 1 to 12 carbon atoms, or a group having a metalloxane bond, when plural R^1, R^2, and R^3 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal atom M, and a is an integer of 1 to (m - 2).

[015f]

In another aspect, there is provided a cured film of the polymetalloxane as defined above.

[015g]

In another aspect, there is provided a cured film of the composition as defined above.

[015h]

In another aspect, there is provided a method for producing a cured film, which comprises the step of heating the polymetalloxane as defied above or the composition as defined above.

[015i]

In another aspect, there is provided a member comprising the cured film as defined above.

[015j]

In another aspect, there is provided a method for producing a lens, which comprises the steps of forming the cured film as defined above on a substrate, forming a photoresist pattern on the cured film, and dry-etching the photoresist pattern and the cured film.

[015k]

In another aspect, there is provided an electronic component comprising the member as defined above.

[015l]

In another aspect, there is provided a building material comprising the polymetalloxane as defined above.

[015m]

In another aspect, there is provided a column packed with the polymetalloxane as defined above.

[015n]

In another aspect, there is provided a radionuclide generator comprising the column as defined above.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0016]

FIG. 1 is a schematic view showing the production process of a transparent conductive film pattern, a transparent insulating film, and a wiring.

FIG. 2 is a schematic view showing a cross section of a substrate for evaluation of visibility of a transparent conductive film.

[Description of Embodiments]

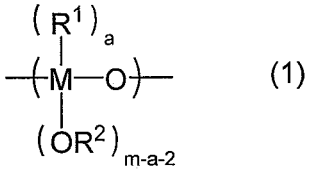
[0017]

(Polymetalloxane)

The present invention is directed to a polymetalloxane including a constituent unit represented by the following general formula (1).

[0018]

[Chemical Formula 3]



(1)

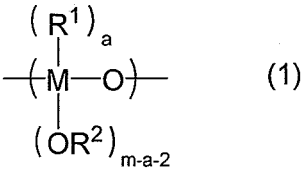
[0019]

R^1 is an organic group, at least one of R^1 is an ($R^3{}_3SiO$-) group. R^3 is optionally selected from a hydroxy group, an alkyl group

[CLAIMS]

1. A polymetalloxane comprising a constituent unit represented by the following general formula (1):

[Chemical Formula 1]



(1)

wherein R^1 is an organic group, at least one of R^1 is an ($R^3{}_3SiO$-) group, at least one of R^1 in the polymetalloxane is a hydroxy group, R^3 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, an aromatic group having 6 to 30 carbon atoms, a group having a siloxane bond, or a group having a metalloxane bond, R^2 is optionally selected from a hydrogen atom, an alkyl group having 1 to 12 carbon atoms, or a group having a metalloxane bond, when plural R^1, R^2, and R^3 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal atom M, and a is an integer of 1 to (m - 2).

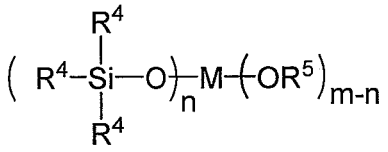
2. The polymetalloxane according to claim 1, wherein R^1 is a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, an aromatic group having 6 to 30 carbon

atoms, an ($R^3{}_3SiO$-) group, a group having a siloxane bond, or a group having a metalloxane bond, and at least one of R^1 is an ($R^3{}_3SiO$-) group, and at least one of R^1 in the polymetalloxane is a hydroxy group.

3. The polymetalloxane according to claim 1 or 2, wherein M includes one or more metal atoms selected from the group consisting of Al, Ti, Zr, and Sn.

4. A method for producing a polymetalloxane compound, which comprises the step of polycondensing a compound represented by the following general formula (2):

[Chemical Formula 2]

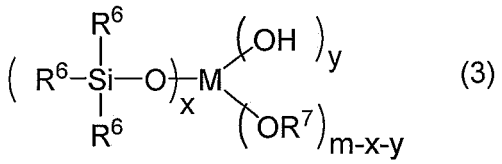


(2)

wherein R^4 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, or an aromatic group having 6 to 30 carbon atoms, R^5 is optionally selected from a hydrogen atom or an alkyl group having 1 to 12 carbon atoms, when plural R^4 and R^5 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal

atom M, and n is an integer of 1 to (m - 1), or a hydrolysate thereof, wherein the compound represented by the general formula (2) is the compound according to claim 1 which is a compound represented by the following compound represented by the general formula (3):

[Chemical Formula 3]



(3)

wherein R^6 is the same as R^4 in the general formula (1), R^7 is an alkyl group having 1 to 12 carbon atoms, m is an integer indicating a valence of a metal atom M, x is an integer of 1 to (m - 1), y is an integer of 1 to (m - 1), and $x + y \leq m$.

5. The method for producing a polymetalloxane according to claim 4, wherein y in the general formula (3) is an integer of 2 to (m - 1).

6. The method for producing a polymetalloxane according to claim 4 or 5, wherein M in the general formula (2) includes one or more metal atoms selected from the group consisting of Al, Ti, Zr, and Sn.

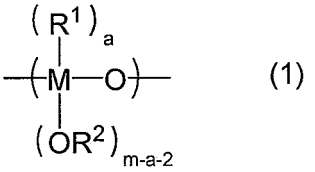
7. A composition comprising the polymetalloxane according to any one of claims 1 to 3.

8. A composition comprising the polymetalloxane according to any one of claims 1 to 3 and inorganic particles.

9. The composition according to claim 8, wherein the inorganic particles are metal compound particles.

10. A cured film of a polymetalloxane comprising a constituent unit represented by the following general formula (1):

[Chemical Formula 1]



(1)

wherein R^1 is an organic group, at least one of R^1 is an ($R^3{}_3SiO$-) group, R^3 is optionally selected from a hydroxy group, an alkyl group having 1 to 12 carbon atoms, an alicyclic alkyl group having 5 to 12 carbon atoms, an alkoxy group having 1 to 12 carbon atoms, an aromatic group having 6 to 30 carbon atoms, a group having a siloxane bond, or a group having a metalloxane bond, R^2 is optionally selected from a hydrogen atom, an alkyl group having 1 to 12 carbon atoms, or a group having a metalloxane bond, when plural R^1, R^2, and R^3 exist, they may be the same or different, M represents a metal atom selected from the group consisting of Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, Zr, Nb, Mo, Ru, Rh, Pd, Ag, In, Sn, Sb, Hf, Ta, W, Re, Os, Ir, Pt, Au, Tl, and Bi, m is an integer indicating a valence of a metal atom M, and a is an integer of 1 to (m - 2).

11. A cured film of the polymetalloxane according to any one of claims 1 to 3.

12. A cured film of the composition according to any one of claims 7 to 9.

13. The cured film according to claim 10 or 12, wherein a light transmittance per 1 μm of a film thickness at a wavelength of 400 nm is 90% or more.

14. The cured film according to any one of claims 10 to 13, wherein a refractive index at a wavelength of 550 nm is 1.58 to 2.20.

15. A method for producing a cured film, which comprises the step of heating the polymetalloxane according to any one of claims 1 to 3 or the composition according to any one of claims 7 to 9.

16. A member comprising the cured film according to any one of claims 10 to 14.

17. The member according to claim 16, which has a portion in which a transparent conductive thin film (I) and the cured film (II) according to any one of claims 10 to 14 are laminated in this order from the upper surface of a transparent underlying base material.

18. The member according to claim 17, which has a portion in which a silicon oxide thin film (III) and/or a transparent pressure-sensitive adhesive thin film (IV) having a refractive

index of 1.46 to 1.53 are laminated on the upper surface of the cured film (II) according to any one of claims 10 to 14.

19. The member according to claim 17 or 18, wherein the transparent underlying base material is a glass substrate or an optical film.

20. The member according to claim 16, the member is a lens.

21. A method for producing a lens, which comprises the steps of forming the cured film according to any one of claims 10 to 14 on a substrate, forming a photoresist pattern on the cured film, and dry-etching the photoresist pattern and the cured film.

22. An electronic component comprising the member according to any one of claims 16 to 20.

23. The electronic component according to claim 22, which is a touch sensor.

24. The electronic component according to claim 22, which is an image sensor.

25. The electronic component according to claim 22, which is an organic EL element.

26. The electronic component according to claim 22, which is an organic EL lighting.

27. A building material comprising the polymetalloxane according to any one of claims 1 to 3.

28. A column packed with the polymetalloxane according to any one of claims 1 to 3.

29. A radionuclide generator comprising the column according

to claim 28.