product of a metal chelate compound, hydrolysis product of a metal cyclic oligomer compound, and polymer of hydrolysis product of a metal cyclic oligomer compound. Then, it is found that the surface-treated infrared absorbing fine particles have excellent moisture/heat resistance.

The present inventors also found the infrared absorbing transparent substrate with a coating layer in which the surface-treated infrared absorbing fine particles are dispersed. It is also found that the surface-treated infrared absorbing fine particle dispersion liquid in which the surface-treated infrared absorbing fine particles are dispersed in a predetermined liquid medium is suitable as a coating liquid for forming the coating layer. Thus, the present invention is completed.

[0021]

Namely, in order to solve the above-described problem, a first invention provides a surface-treated infrared absorbing fine particle dispersion liquid in which surface treated infrared absorbing fine particles are dispersed in a liquid medium, wherein the surface-treated infrared absorbing fine particles are infrared absorbing fine particles, each surface of which is coated with a coating layer containing at least one selected from the group consisting of a hydrolysis product of a metal chelate compound, a polymer of the hydrolysis product of the metal chelate compound, a hydrolysis product of a metal cyclic oligomer compound, and a polymer of the hydrolysis product of the metal cyclic oligomer compound. the coating layer has a hydroxyl group or a carboxyl group, and the metal chelate compound or the metal cyclic oligomer compound contains at least one metal element selected from the group consisting of Al, Zr, Ti, and Zn.

A second invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to the first invention, wherein the metal chelate compound or the metal cyclic oligomer compound contains Zn.

A third invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to the first or second invention, wherein the metal chelate compound or the metal cyclic oligomer compound has at least one selected from the group consisting of an ether bond, an ester bond, an alkoxy group, and an acetyl group.

A fourth invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to any one of the first to third inventions, wherein the infrared absorbing fine particles are the infrared absorbing fine particles represented by a general formula WyOz (where W is tungsten, O is oxygen, satisfying $2.2 \leq z / y \leq 2.999$), and/or a general formula MxWyOz (where M is one or more elements selected from the group consisting of H, He, alkali metal, alkaline earth metal, rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, I, Yb, and W is tungsten, O is oxygen, satisfying $0.001 \leq x / y \leq 1$, $2.0 \leq z / y \leq 3.0$).

A fifth invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to the fourth invention, wherein the M is one or more elements selected from the group consisting of Cs, K, Rb, Tl, In and Ba.

A sixth invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to any one of the first to fifth inventions, wherein the infrared absorbing fine particles are tungsten oxide fine particles

and/or composite tungsten oxide fine particles, each having a hexagonal crystal structure.

A seventh invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to any one of the first to sixth inventions, wherein the surface-treated infrared absorbing fine particle dispersion liquid further contains a glass coating agent.

A eighth invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to the seventh invention, wherein the liquid medium is at least one selected from the group consisting of aromatic hydrocarbons, ketones, ethers, alcohols, and water, and

the glass coating agent is at least one selected from the group consisting of silane coupling agents and silane-based alkoxides.

A nineth invention provides the surface-treated infrared absorbing fine particle dispersion liquid according to the seventh invention, wherein the liquid medium is at least one selected from the group consisting of aromatic hydrocarbon, ketone, and ether, and

the glass coating agent is at least one selected from the group consisting of polysilazane and polyorganosilane.

The tenth invention provides an infrared absorbing transparent substrate having a coating film on at least one surface of one or more transparent substrates,

wherein the coating film contains surface-treated infrared absorbing fine particles, and

the surface-treated infrared absorbing fine particles are infrared absorbing fine particles, each surface of which is coated with a coating layer containing at least one selected from the group consisting of a hydrolysis

product of a metal chelate compound, a polymer of the hydrolysis product of the metal chelate compound, a hydrolysis product of a metal cyclic oligomer compound, and a polymer of the hydrolysis product of the metal cyclic oligomer compound, the coating layer has a hydroxyl group or a carboxyl group, and the metal chelate compound or the metal cyclic oligomer compound contains at least one metal element selected from the group consisting of Al, Zr, Ti, and Zn.

The eleventh invention provides the infrared absorbing transparent substrate according to the tenth invention, wherein the metal chelate compound or the metal cyclic oligomer compound contains Zn.

The twelfth invention provides the infrared absorbing transparent substrate according to the tenth or eleventh invention, wherein the metal chelate compound or the metal cyclic oligomer compound has at least one type selected from the group consisting of an ether bond, an ester bond, an alkoxy group, and an acetyl group.

The thirteenth invention provides the infrared absorbing transparent substrate according to any one of the tenth to twelfth inventions, wherein the infrared absorbing fine particles are the infrared absorbing fine particles represented by a general formula WyOz (where W is tungsten, O is oxygen, satisfying $2.2 \leq z / y \leq 2.999$), and/or a general formula MxWyOz (where M is one or more elements selected from the group consisting of H, He, alkali metal, alkaline earth metal, rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, I, Yb, W is tungsten, O is oxygen, satisfying $0.001 \leq x / y \leq 1$, $2.0 \leq z / y \leq 3.0$).

The fourteenth invention provides the infrared absorbing

transparent substrate according to the thirteenth invention, wherein the M is one or more element selected from the group consisting of Cs, K, Rb, Tl, In and Ba.

The fifteenth invention provides the infrared absorbing transparent substrate according to any one of the tenth to fourteenth inventions, wherein the infrared absorbing fine particles are tungsten oxide fine particles and/or composite tungsten oxide fine particles, each having a hexagonal crystal structure.

The sixteenth invention provides the infrared absorbing transparent substrate according to any one of the tenth to fifteenth inventions, wherein the coating film further contains a glass coating agent.

The seventeenth invention provides the infrared absorbing transparent substrate according to the sixteenth invention, wherein the glass coating agent is at least one selected from the group consisting of a silane coupling agent, silane-based alkoxide, polysilazane, and polyorganosilane.

The eighteenth invention provides the infrared absorbing transparent substrate according to any one of the tenth to seventeenth inventions, wherein the transparent substrate is at least one selected from the group consisting of a transparent glass substrate and a transparent resin substrate.

Advantage of the Invention

[0022]

Surface-treated infrared absorbing fine particles and surface-treated infrared absorbing fine particles powder containing them according to the present invention, have excellent infrared absorption properties as well as

excellent moisture/heat resistance. As a result, by using the surface-treated infrared absorbing fine particle dispersion liquid containing the surface-treated infrared absorbing fine particles as a coating liquid, and by providing a coating layer on a given substrate, an infrared absorbing transparent substrate having excellent infrared absorption properties and also excellent moisture and heat resistance, can be obtained.

Brief Description of the Drawings

[0023]

FIG. 1 is a schematic plan view of a crystal structure of a composite

CLAIMS

1. A surface-treated infrared absorbing fine particle dispersion liquid in which surface treated infrared absorbing fine particles are dispersed in a liquid medium, wherein

the surface-treated infrared absorbing fine particles are infrared absorbing fine particles, each surface of which is coated with a coating layer containing at least one selected from the group consisting of a hydrolysis product of a metal chelate compound, a polymer of the hydrolysis product of the metal chelate compound, a hydrolysis product of a metal cyclic oligomer compound, and a polymer of the hydrolysis product of the metal cyclic oligomer compound,

the coating layer has a hydroxyl group or a carboxyl group, and

the metal chelate compound or the metal cyclic oligomer compound contains at least one metal element selected from the group consisting of Al, Zr, Ti, and Zn.

2. The surface-treated infrared absorbing fine particle dispersion liquid according to claim 1, wherein the metal chelate compound or the metal cyclic oligomer compound contains Zn.

3. The surface-treated infrared absorbing fine particle dispersion liquid according to claim 1 or 2, wherein the metal chelate compound or the metal cyclic oligomer compound has at least one selected from the group consisting of an ether bond, an ester bond, an alkoxy group, and an acetyl group.

4. The surface-treated infrared absorbing fine particle dispersion liquid according to any one of claims 1 to 3, wherein the infrared absorbing fine particles are the infrared absorbing fine particles represented by a general formula WyOz (where W is tungsten, O is oxygen, satisfying $2.2 \leq z / y \leq 2.999$), and/or a general formula MxWyOz (where M is one or more elements selected from the group consisting of H, He, alkali metal, alkaline earth metal, rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, I, and Yb, W is tungsten, O is oxygen, satisfying $0.001 \leq x / y \leq 1$, $2.0 \leq z / y \leq 3.0$).

5. The surface-treated infrared absorbing fine particle dispersion liquid according to claim 4, wherein the M is one or more elements selected from the group consisting of Cs, K, Rb, Tl, In and Ba.

6. The surface-treated infrared absorbing fine particle dispersion liquid according to any one of claims 1 to 5, wherein the infrared absorbing fine particles are tungsten oxide fine particles and/or composite tungsten oxide fine particles, each having a hexagonal crystal structure.

7. The surface-treated infrared absorbing fine particle dispersion liquid according to any one of claims 1 to 6, wherein the surface-treated infrared absorbing fine particle dispersion liquid further contains a glass coating agent.

8. The surface-treated infrared absorbing fine particle dispersion liquid according to claim 7, wherein the liquid medium is at least one selected from the group consisting of aromatic hydrocarbons, ketones, ethers, alcohols, and water, and

the glass coating agent is at least one selected from the group consisting of silane coupling agents and silane-based alkoxides.

9. The surface-treated infrared absorbing fine particle dispersion liquid according to claim 7, wherein the liquid medium is at least one selected from the group consisting of aromatic hydrocarbon, ketone, and ether, and

the glass coating agent is at least one selected from the group consisting of polysilazane and polyorganosilane.

10. An infrared absorbing transparent substrate having a coating film on at least one surface of one or more transparent substrates,

wherein the coating film contains surface-treated infrared absorbing fine particles, and

the surface-treated infrared absorbing fine particles are infrared absorbing fine particles, each surface of which is coated with a coating layer containing at least one selected from the group consisting of a hydrolysis product of a metal chelate compound, a polymer of the hydrolysis product of the metal chelate compound, a hydrolysis product of a metal cyclic oligomer compound, and a polymer of the hydrolysis product of the metal cyclic oligomer compound,

the coating layer has a hydroxyl group or a carboxyl group, and

the metal chelate compound or the metal cyclic oligomer compound contains at least one metal element selected from the group consisting of Al, Zr, Ti, and Zn.

11. The infrared absorbing transparent substrate according to claim 10, wherein the metal chelate compound or the metal cyclic oligomer compound contains Zn.

12. The infrared absorbing transparent substrate according to claim 10 to 11, wherein the metal chelate compound or the metal cyclic oligomer compound has at least one type selected from the group consisting of an ether bond, an ester bond, an alkoxy group, and an acetyl group.

13. The infrared absorbing transparent substrate according to any one of claims 10 to 12, wherein the infrared absorbing fine particles are the infrared absorbing fine particles represented by a general formula WyOz (where W is tungsten, O is oxygen, satisfying $2.2 \leq z / y \leq 2.999$), and/or a general formula MxWyOz (where M is one or more elements selected from the group consisting of H, He, alkali metal, alkaline earth metal, rare earth element, Mg, Zr, Cr, Mn, Fe, Ru, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ga, In, Tl, Si, Ge, Sn, Pb, Sb, B, F, P, S, Se, Br, Te, Ti, Nb, V, Mo, Ta, Re, Be, Hf, Os, Bi, I, and Yb, W is tungsten, O is oxygen, satisfying $0.001 \leq x / y \leq 1$, $2.0 \leq z / y \leq 3.0$).

14. The infrared absorbing transparent substrate according to claim 13, wherein the M is one or more element selected from the group consisting of Cs, K, Rb, Tl, In and Ba.

15. The infrared absorbing transparent substrate according to any one of claims 10 to 14, wherein the infrared absorbing fine particles are tungsten oxide fine particles and/or composite tungsten oxide fine particles, each having a hexagonal crystal structure.

16. The infrared absorbing transparent substrate according to any one of claims 10 to 15, wherein the coating film further contains a glass coating agent.

17. The infrared absorbing transparent substrate according to claim 16, wherein the glass coating agent is at least one selected from the group consisting of a silane coupling agent, silane-based alkoxide, polysilazane, and polyorganosilane.

18. The infrared absorbing transparent substrate according to any one of claims 10 to 17, wherein the transparent substrate is at least one selected from the group consisting of a transparent glass substrate and a transparent resin substrate.