

ROOM-TEMPERATURE CURABLE INORGANIC COATING AND MANUFACTURING METHOD THEREOF

Technical Field of the Invention

The present invention relates to coating and in particular, to a room-temperature curable inorganic coating and manufacturing method thereof. More particularly, alkoxy-silane and SiO_2 particles are dispersed in water, react with each other by hydrolysing first and then condensation-polymerizing. Then, for giving the physical-chemical property, add the fillers, inorganic pigment powder, and other curing catalysts, form a room-temperature curable inorganic coating.

Background of the Invention

The paint or coating in prior art is used to protect the structures and buildings, prolong life of the structures and buildings, and maintain beauty of the structures and buildings over a long period of time. Thus, paint or coating should be easy to use and odourless. The film formed by the coating should have better gloss, maintain the film for long time, should have good chemical resistance, for example, solvent resistance, corrosion resistance, weather resistance, water resistance, antibacterial, and should have good physical properties, for example, non-flammable, flame-retardant, waterproof, high adhesive force, insulation, and so on, and should be not harmful to human body and not cause environmental pollution, insure the safety. These properties are the final goal of paint or coating.

Traditional anti-corrosion coatings or building coatings are made by organic compound that is extracted from crude oil and mixed with a variety of chemicals, so it contains a large amount of organic materials. When the paint or coating is applied, over a period of time, the cracks will appear on the surface of the film formed by coating. Microorganisms will propagate in the cracks, and the film will peel off. If being exposed to ultraviolet light for a long time, the film will be discoloured, and the pollution resistance will go down. In addition, most paints contain various pollutants

that are harmful to humans, such pollutant will cause skin diseases, headaches, vomiting sickness and other environmental diseases. Moreover, the petroleum storage is limited, but the demand is sharply increased. The supply of raw materials of the paint production is also getting more and more intense. At the same time, in order to solve problem of the traditional coatings above mentioned, various inorganic coatings are provided. The inorganic coating mainly comprises binders, pigments, solvents, and additives. The conventional ceramic coatings contain binders, which including organic polymers such as silicon, epoxy resin, or terylene resin, ceramic filling powder, or organic solvents such as acetone, benzene, toluene, xylene and ethyl acetate, and most of the additives are organic material as well.

Additionally, most of the traditional ceramic coating has high hardness, is easy to break and appear serious cracks, is not easy to coat on the surface of the basement. Especially, some kinds of inorganic ceramic coating need heating to 200 °C for drying. The said operation on site will meet many questions.

Summary of the Invention

In order to solve the problems of the organic coating is harmful for the environment, the traditional ceramic coatings has strong hardness and is inconvenient for cured on site, the present invention provides a room-temperature curable inorganic coating and manufacturing method thereof. The inorganic coating is able to cure under ambient condition and the film formed by it will not release the harmful organic gas.

In order to solve the abovementioned technical problem, the present invention provides a room-temperature curable inorganic coating. The said coating comprising:

70-80wt% of solution;

5-10wt% of first functional additive selected from potassium titanate, alumina or mixtures thereof;

10-20wt% of inorganic pigment;

0.5-2.0wt% other functional additives;

wherein the solution comprises 30-40wt% of organic alkoxy-silane(aslo called alkoxy-silane, or organic silane), 15-20wt% of organic solvent, and 25-30wt% of silica sol;

wherein said percent is weight percent of each component based on total weight of inorganic coating.

The present invention provides a room-temperature curable inorganic coating. The said coating comprising:

70-80wt% inorganic solution;

5-10wt% first functional additive selected from potassium titanate, alumina or mixtures thereof;

10-20wt% inorganic pigment;

0.5-2.0wt% other functional additives;

The said inorganic solution comprising: 30-40wt% organic alkoxy-silane, 15-20wt% organic solvent, 25-30wt% silica sol;

wherein said percent is weight percent of each component based on total weight of inorganic coating.

Further, the inorganic coating comprises deionized water.

The inorganic coating may be called inorganic ceramic coating.

The alkoxy-silane may be represented by formula $R^1_m Si(OR^2)_{4-m}$, where R^1 and R^2 represent alkyl group comprising $C_n H_{2n+1}$; n is a positive integer, m is a non-negative integer, where n is 1-10 and m is 0-3, the total number of " R^1 " and " OR^2 " is 4.

The alkoxy-silane include at least one of selected from the group including methyl, ethyl, phenyl, $CF_3CH_2CH_2$, $CF_3(CF_2)_5CH_2CH_2$, and $CF_3(CF_2)_7CH_2CH_2$.

The alkoxy-silane may be represented by formula $R^1_m Si(OR^2)_{4-m}$, m is a non-negative integer, and m is 0-3. R^1 may be at least one of selected from the group including

methyl, ethyl, phenyl, $\text{CF}_3\text{CH}_2\text{CH}_2$, $\text{CF}_3(\text{CF}_2)_5\text{CH}_2\text{CH}_2$, and $\text{CF}_3(\text{CF}_2)_7\text{CH}_2\text{CH}_2$. R^2 may be at least one of selected from the group including methyl, ethyl, phenyl, $\text{CF}_3\text{CH}_2\text{CH}_2$, $\text{CF}_3(\text{CF}_2)_5\text{CH}_2\text{CH}_2$, and $\text{CF}_3(\text{CF}_2)_7\text{CH}_2\text{CH}_2$.

Further, the silica sol may comprise 20-40wt% silica (SiO_2) particles. The particle size of the silica is from nano-size to micron-size.

Further, the inorganic pigment is at least one of selected from the group including titanium oxide, yellow chrome, iron blue, cadmium red, cadmium yellow, carbon black, iron oxide red, or iron oxide yellow.

The other functional additive may be selected from tourmaline, rare-earth ore or a mixture thereof.

Preferably, the first functional additive comprises 3-5wt% potassium titanate. The potassium titanate has a needle like shape, and is with a particle size of 1 to 100nm.

Further, in the inorganic coating, the "OR²" is hydrolysable alkoxy-silane, which is hydrolyzed by water (water in coating, water in the air or on the surface of the substrate), creating "silicon-hydroxyl" (Si-OH) group, which strongly bonds with the surfaces (M-OH) of the substrate through Si-O-M bond, M represents substrate.

Further, in the inorganic coating, the alkoxy-silane is at least one of selected from the group including methyl-trimethoxy silane, tetraethoxy silane, and phenyl-trimethoxy silane; the said organic solvent is at least one of selected from the group including methanol, ethanol, and isopropanol.

The present invention provides a method for preparing the inorganic coating, by combining components of the inorganic coating to prepare a main agent and a curing agent,

wherein a method for preparing the main agent comprises stirring a silica sol, adding an organic solvent, stirring continuously, adding deionized water again and stirring continuously, wherein the reaction temperature is controlled not to exceed 50 °C, and wherein said organic solvent is selected from methanol, ethanol, isopropanol or a mixture thereof, and

wherein a method for preparing the curing agent comprises adding an organic alkoxy-silane, a first functional additive, an inorganic pigment and other functional additives to deionized water, stirring and mixing homogeneously.

Further, the method for preparing the inorganic coating, by combining components of the inorganic coating to prepare a main agent and a curing agent,

wherein a method for preparing the main agent comprises stirring a silica sol, adding the organic solvent little by little, stirring continuously, adding deionized water little by little, stirring continuously; when the silica sol mixed with deionized water, heat produced, need to control the temperature in reactor not to exceed 50°C, aforesaid organic solvent is at least one of selected from the group including methanol, ethanol, and isopropanol, usually, the organic solvent will influence the speed for drying, but it may remedy the defect of dry speed and improve the storage ability;

The viscosity of the main agent is usually tested by the Ford Cup. The viscosity is 14-15 seconds usually.

Wherein a method for preparing the curing agent comprises adding an organic alkoxy-silane, a first functional additive, an inorganic pigment, and other functional additives into deionized water; and stirring and mixing homogeneously.

In operation, the main agent and the curing agent are mixed according to 1:1 together and filtered through a 325-1000 mesh net to remove the bigger particles and get the inorganic coating.

Further, in the method for preparing the inorganic coating, the method for preparing the mixture comprising silica sol, deionized water, and ethanol comprises stirring the silica sol first, adding ethanol little by little, stirring continuously, adding deionized water little by little. When the silica sol mixed with deionized water, heat produced, need to control the reactor temperature not to exceed 50°C. The above mentioned main agent may also comprise methanol, or isopropanol. Usually, the methanol or isopropanol will influence the drying speed of the coating film, but in present invention, it may remedy the defect of dry speed and improve the storage ability;

The present invention provides another method for preparing the inorganic coating, wherein the method comprises the following steps:

- (1) preparing a solution by mixing 30-40wt% alkoxy-silane, with 15-20wt% of an organic solvent, and 25-30% of a silica sol, stirring the mixture under 40-50 °C for 5-10 minutes to get a solution in sol state;
- (2) preparing an inorganic ceramic mixture by putting the solution got in step (1), 5-10wt% of a first functional additive, 10-20wt% of an inorganic pigment, and 0.5-2.0wt% of other functional additives together, stirring the mixture to get the inorganic ceramic mixture;
- (3) putting the inorganic ceramic mixture got in step (2) in a homogenizer; and stirring it at a high speed for 1-2 hours to make the particles homogenized; and
- (4) filtering the homogenized matter got in step (3) pass through a 325-1000 mesh net, and the matter after filtering is the inorganic coating.

Preferably, in the step (1) above mentioned, preparing the inorganic solution: mix the 30-40wt% alkoxy-silane, with the 15-20wt% organic solvent, and 25-30% silica sol, stirring the mixture under 40-50 °C for 5-10 minutes to obtain inorganic solution in sol state;

Preferably, the method including the steps as below:

- (1) preparing the inorganic solution: mix the 30-40wt% alkoxy-silane, with the 15-20wt% organic solvent, and 25-30% silica sol, stir the mixture under 40-50 °C for 5-10 minutes, when the alkoxy-silane react with silica sol in the mixed solution, heat produced, the mixture turn to be transparent from turbid state gradually; the purpose of adding the organic solvent is modulate the viscosity of the solution and the react speed. Obtaining inorganic solution in sol state by the process above mentioned;
- (2) stirring the inorganic ceramic mixture: put 60-70wt% the inorganic solution got in step (1), 5-10wt% potassium titanate or alumina, 10-20wt% pigment, and 0.5-2.0wt% other functional additives together, stir the mixture to get the inorganic ceramic mixture;

(3) putting the inorganic ceramic mixture got in step (2) in a homogenizer; stirring it at a high speed for 1-2 hours to make the particles homogenized; and

(4) having the homogenized matter got in step (3) pass through a 325-1000 mesh net, and the matter after filtering is the inorganic coating.

To improve the flexibility of the film formed by the inorganic coating, add the potassium titanate with fibre-likely shape. Thus, the potassium titanate is able to improve the flexibility of the materials. The inorganic pigment may be metallic oxide.

The silane may be at least one of selected from the group including methyl-trimethoxy silane, methyl-triethoxy silane, phenyl-trimethoxy silane.

The aforesaid inorganic coating may be called inorganic ceramic coating.

Further, the method for preparing the inorganic ceramic coating is as below:

Phase 1, preparing the inorganic solution in sol state: mix the 30-40wt% one kind, or mixture of at least two kinds of alkoxy-silane, with the 25-30% silica sol, stir the mixture under 40-50°C for 5-10 minutes to get inorganic solution in sol state; phase 2, stirring and mixing: put 70-80wt% inorganic solution got in phase 1, 5-10wt% potassium titanate and/or alumina, 10-20wt% pigment powder of titanium oxide, and 0.5-2.0wt% other functional additives together, stir and mix them to get the inorganic ceramic mixture; phase 3, put the inorganic ceramic mixture got in phase 2 in a homogenizer; stir it at a high speed for 1-2 hours to make the particles homogenized; phase 4, filtering: have the homogenized matter got in phase 3 pass through a 325-1000 mesh net to eliminate the bigger particles, and get the inorganic ceramic coating.

Further, in the phase for preparing inorganic solution, add methanol, ethanol, isopropanol or mixture thereof to modulate the viscosity of the solution and the react speed. Further, in the phase 2, 5-10wt% first functional additive comprise 3-5wt% potassium titanate, the particle size of the potassium titanate is 1-100nm.

The structure and theory of the film formed by the inorganic coating is as below:

The (Si-OH) group strongly bonds with the surfaces (M-OH) of the substrate through Si-O-M bond. As shown in table 1, the Si-O bond has higher bond energy than other bonds. Thus, the inorganic coating film shows the features of weather resistance, chemical resistance, abrasive resistance, high hardness, meanwhile owing to the flexibility and resilience of the silicon-oxygen bond, the inorganic coating film also has the features of cold resistance and tolerance to repeating heat shock.

Table 1 The bond energy and length of each bond

Bond	Bond energy (Kcal/mol)	Bond length (Å)
Si-H	76	1.48
Si-O	108	1.63
Si-F	135	1.54
C-C	83	

Å is the length unit.

In the present invention, the organic silane forms an inorganic solution through hydrolysis and condensation polymerization under the presence of silicon dioxide (SiO₂). The inorganic solution has “silicon-hydroxyl” (Si-OH) group, and this group generates Si-O-M bond, which has strong bond energy, thereby, the inorganic solution itself can play the role as a strong binder.

Further, the organic silane is tetraethoxysilane, or methyl-trimethoxy silane, or a mixture thereof, add 20-30% silica sol, and stir the mixture to get the inorganic solution above mentioned. In case the amount of silica sol deviates from the above range, it may weaken the bind force of the Si-O-M, then, the film will peel off under a high-temperature.

At the same time, in the preparation of the inorganic solution, in order to modulate the viscosity of the solution and the react speed, may add at least one of the group including methanol, ethanol, and isopropanol.

In addition, in order to improve the physical-chemical characteristics of the film formed by coating, potassium titanate or alumina may be used as first functional additive. Since the particles of these materials are needle-shaped or plate-shaped, they may prevent cracks, and control the viscosity of coating. The amount of the first functional additive will be in the range of 5-10wt%. If adding the first functional additive less than 5wt%, the properties of the film will degrade, and the surface of the film will be rough. If adding the first functional additive more than 10wt%, gloss and adhesive force of the film will be reduced.

The inorganic ceramic coating composition in the present invention may be used as a substitute of the paints in prior art. To this end, it must have many kinds of colour. In order to get a variety of colour, the coating in prior art uses the organic pigments or dye, but, these organic matters will cause various problems. Accordingly, the inorganic ceramic coating composition in the present invention use pigment of metallic oxide to get a variety of colour. It is desirable to contain 10-20wt% pigment. In case the amount of pigment added is less than the range, the gloss will be lower; and in case the amount of pigment added is more than the range, the adhesive force between the film and the substrate will be reduced. In addition, to give more properties to the film, the inorganic ceramic coating composition in the present invention contains 0.5-2.0wt% other functional additive.

For example, titanium oxide may be added in the inorganic coating in order to get photocatalysis effects. As titanium oxide is activated by light, it can change various pollutants into innocuous matters.

In addition, according to the necessary, in order to release negative ions or radiate far infrared rays, may add the other function additives into the inorganic coating. The other function additives comprise the matter which can release negative ions. Generally, tourmalines and rare-earth ores are used as matters which can release negative ions.

Preferably, the manufacturing method of the inorganic ceramic coating composition including four phases as below:

Phase 1, preparing the inorganic solution: Select at least one kind of organic silane. Especially, select at least one of the group including methyl trimethoxy silane, tetraethoxy silane. Mix the 30-40wt% organic silane, with the 15-20wt% ethanol, and the 25-30% silica sol, stir the mixture under 40-50°C for 5-10 minutes, when the organic silane react with silica sol in the mixed solution, heat produced, the mixture turn to be transparent from turbid state gradually. In order to modulate the viscosity of the solution and the react speed, add the organic solvent. The organic solvent is at least one of selected from the group including methanol, ethanol, and isopropanol. Then obtain the inorganic solution in sol state.

Phase 2, stirring and mixing: put 70-80wt% inorganic solution got in phase 1, 5-10wt% potassium titanate or alumina, 10-20wt% pigment powder of titanium oxide, and 0.5-2.0wt% other functional additives together, stir and mix them to get the inorganic ceramic mixture.

Phase 3, put the inorganic ceramic mixture in a homogenizer; and stir it at a high speed for 1-2 hours to make the particles homogenized;

Phase 4, filtering: have the homogenized matter got in phase 3 pass through a 325-1000 mesh net to eliminate the bigger particles, and get the inorganic coating.

Adding first function additives gives the coating film flexibility, prevents cracks, and solves the problem of thick film. In order to prepare a room-temperature curable inorganic coating, use the condensation-polymerizing reaction between silica sol and alkoxy-silane, to realize curable under room-temperature. The film has excellent properties, and is environmentally safe.

Compared with the prior art, the room-temperature curable inorganic coating in present invention has excellent properties which do not exist in the prior art. That is, the present invention solves the difficult problem of curing under room-temperature for the inorganic coating, which can be used on the surface of big building or device. The present invention does not need big baking device, thus does not need boiler, and so on, improves the production efficiency, also saves the fee for fuel, is beneficial to the environment. In addition, the inorganic coating in present invention do not comprise

the harmful organic material, easy to use, no smell, have excellent chemical and physical resistance, can maintain the film long time, is not harmful to the human body, will not pollute the environment, ensure the safety, and provide useful result. Further, the film may prevent the release of the harmful substances such as VOCs or formaldehyde, and may reduce the occurrence of the sick house syndromes. In addition, the ingredients of the film are inorganic materials, thus, the film will influence environment at the lowest degree when the film is discarded, for the properties of heat and ultraviolet rays resistance, prevent the exfoliation and discoloration, can maintain the beautiful appearance long time.

Detailed Description of the Invention

Describe the room-temperature curable inorganic coating detailed by the examples, the target is not limit the protect scope of the invention.

Example 1

The present invention provides an inorganic coating. The manufacturing method thereof is as below:

(1) preparing inorganic solution: 30wt% silica sol is mixed with 30wt% of organic silane and 15wt% ethanol, and the mixed solution is stirred under 40-50°C for 5-10 minutes. The organic silane is methyl trimethoxy silane, tetraethoxy silane, or a mixture thereof. The mixed solution of organic silane and silica sol create chemical reaction, the heat is produced, and the mixed solution changes from a turbid state to a transparent state. At this time, add methanol, or ethanol, or isopropanol, or the mixture thereof to control the viscosity of the solution and the reaction speed. Then get an inorganic solution in sol state.

(2) stirring the mixed solution: the inorganic solution got in step (1), 9wt% first functional additive, which are potassium titanate or alumina, 15wt% pigment powders of titanium oxide, and 1wt% other functional additives are put in a reactor and mixed and stirred to form an inorganic ceramic mixture.

(3) homogenizing: the solution got in step (2) is put in a homogenizer, and is stirred at a high speed for 1-2 hours to homogenize the particles.

(4) filtering the coatings: the homogenized matter is passed through a mesh net and remove bigger particles, get the inorganic coating.

Example 2

The present invention provides an inorganic coating. The coating comprises the ingredients as below:

70wt% inorganic solution. The said inorganic solution comprising 30wt% tetraethoxysilane, 15wt% ethanol, and 25wt% silica sol;

10wt% first functional additive, which is mixture of potassium titanate and alumina, wherein the amount of potassium titanate is 3wt%.

19.5wt% inorganic pigment;

0.5wt% tourmaline;

wherein said percent is weight percent of each component based on total weight of inorganic coating.

Example 3

The present invention provides an inorganic coating. The coating comprises the ingredient as below:

80wt% inorganic solution. The said inorganic solution comprises 40wt% the mixture of tetraethoxysilane and methyl trimethoxysilane, the ratio of tetraethoxysilane and methyl trimethoxysilane is 1:1 by weight, 15wt% ethanol, 25wt% silica sol;

5wt% first functional additive, which are a mixture of potassium titanate and alumina, wherein the amount of potassium titanate is 4wt%;

13wt% inorganic pigment;

2wt% tourmaline.

Example 4

The present invention provides an inorganic coating. The coating comprises the ingredients as below:

80wt% inorganic solution. The said inorganic solution comprises 30wt% methyl trimethoxysilane, 20wt% ethanol, 30wt% silica sol;

6wt% first functional additive, which are a mixture of potassium titanate and alumina, wherein the amount of potassium titanate is 5wt%;

13wt% inorganic pigment;

1wt% rare-earth ore.

Example 5

The present invention provides an inorganic coating. The coating comprises the ingredients as below:

74.5wt% inorganic solution, the said inorganic solution comprises 30wt% methyl triethoxy silane, 15wt% ethanol, 29.5wt% silica sol;

5wt% potassium titanate;

20wt% inorganic pigment;

0.5wt% rare-earth ore.

Example 6

The present invention provides an inorganic coating. The coating comprises the ingredients as below:

77wt% inorganic solution. The said inorganic solution comprises 35wt% organic alkoxy-silane, 15wt% ethanol, 27wt% silica sol;

7wt% first functional additive, which are potassium titanate;

15wt% of inorganic pigment;

1wt% other functional additives, the other functional additive is the mixture of tourmaline and rare-earth ore, the ratio of tourmaline and rare-earth ore is 1:1 by weight.

The alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^2 " is phenyl, m is 0.

Example 7

An inorganic coating as shown in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is $CF_3CH_2CH_2$, the " R^2 " is $CF_3CH_2CH_2$, m is 1.

Example 8

An inorganic coating as provided in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is $CF_3(CF_2)_5CH_2CH_2$, the " R^2 " is $CF_3(CF_2)_5CH_2CH_2$, m is 2.

Example 9

An inorganic coating as provided in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is $CF_3(CF_2)_7CH_2CH_2$, the " R^2 " is $CF_3(CF_2)_7CH_2CH_2$, m is 3.

Example 10

An inorganic coating as shown in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is methyl, the " R^2 " is phenyl, m is 1.

Example 11

An inorganic coating as shown in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is ethyl, the " R^2 " is $CF_3CH_2CH_2$, m is 1.

Example 12

An inorganic coating as shown in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is phenyl, the " R^2 " is $CF_3(CF_2)_7CH_2CH_2$, m is 2.

Example 13

An inorganic coating as shown in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is $CF_3CH_2CH_2$, the " R^2 " is methyl, m is 3.

Example 14

An inorganic coating as shown in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is $CF_3(CF_2)_5CH_2CH$, the " R^2 " is methyl and ethyl respectively, m is 2.

Example 15

An inorganic coating as shown in the example 6, wherein, the organic alkoxy-silane is represented by molecular formula " $R^1_mSi(OR^2)_{4-m}$ ", the " R^1 " is $CF_3(CF_2)_7CH_2CH_2$, the " R^2 " is phenyl, m is 1.

Example 16

An inorganic coating as shown in example 6, wherein the organic alkoxy-silane is phenyl trimethoxysilane.

Coat the inorganic coating provided by the examples on the substrate, form a coating film, the thickness of the film is $30\pm 5\mu m$, the substrate is aluminum plate. The size of the aluminum plate is 15 cm $\times$ 7.5cm, the coating is curing under room-temperature for 7 days, form hard film.

The test result and the test data of the film formed by the inorganic coating provided by the example 1-16 are shown in table 2 and table 3.

Table 2 summarizes the test conditions for testing of films formed by the inorganic coating provided by example 1-16.

Test item	Test result	Test condition
Gloss	0-70	Gloss test device (60°standard)
Pencil hardness	7-9H	Mitsubishi pencil
Adhesive force	100/100	one hundred grid method, 1m/m
Shock resistance	no abnormality	1kg ball, 50cm height
abrasive resistance	99.99	abrasive coefficient
Pollution resistance	non-pollution	5E Max
Acid resistance	no abnormality	5% H_2SO_4 , 48 hours
Alkali resistance	no abnormality	5% Na_2CO_3 /15 minutes×4times
Boiling water resistance	no abnormality	98°C×2 hours
Heat resistance	no abnormality	300°C×1 hours
Salt water resistance,	no abnormality	5% NaCl ×1000 hours
Weather resistance	no abnormality	WeatheR1-O-MeteR1, 1000 hours
Color	Many kinds	-

Table 3 shows the test data of the films formed by the inorganic coating provided by example 1-16.

No.	Gloss	Pencil hardness	Adhesive force
example1	45-55	7-9H	0 grade
example2	45-55	7-9H	0 grade
example3	35-45	8-9H	1 grade
example4	45-55	7-9H	1 grade

example5	40-50	7-9H	0 grade
example6	40-50	7-9H	0 grade
example7	40-50	7-9H	0 grade
example8	45-55	7-9H	0 grade
example9	30-35	6-9H	0 grade
example10	30-35	6-9H	1 grade
example11	45-50	7-9H	0 grade
example12	45-55	7-9H	0 grade
example13	25-30	6-8H	1 grade
example14	30-35	7-8H	0 grade
example15	40-50	7-9H	0 grade
example16	40-50	7-9H	0 grade

Pencil hardness test: fix the Mitsubishi pencil on the hardness test device at 45° angle, apply force of 1Kg on the pencil and push the pencil moving forward.

Adhesive force test: use the one hundred grid method.

Abrasive test: use the abrasive test device (Model KPM-042), the wheel used is CS-10 wheel, put the sample on the test device, load 500g of gravity and turn 500 circles. Then, use the UV spectrophotometer to test the absorbance of the surface of the sample at 370 nm, observe whether the surface turn to indistinct or not. Test the abrasive resistance at last.

Concluding from the test data, the coating in present invention may cured under the room-temperature, and the film formed by the coating has strong hardness, better acid resistance, better alkali resistance, better salt water resistance, better weather resistance, and better adhesive force. The room-temperature curable inorganic coating in present invention may widely used as anti-corrosion coatings or building coatings.

Example 17

The present invention provides an inorganic coating. The coating comprises the ingredients as below:

75wt% solution, the said solution comprises 35wt% methyl trimethoxy silane, 15wt% propanol, 25wt% silica sol;

5wt% potassium titanate;

19.5wt% inorganic pigment;

0.5wt% rare-earth ore.

Test the film formed by the coating provided in Example 17 as below:

Hazard of Explosion: According to the 《the United Nations Recommendations on the Transport of Dangerous Goods- test and standard manual》(the 5 revised edition), the said film do not belong Explosion product.

Hazard of Oxidation: According to the 《the United Nations Recommendations on the Transport of Dangerous Goods- test and standard manual》(the 5 revised edition), the said film do not belong Oxidation agent.

Coat the coating provided by the Example 17 on the surface of the metal pan and formed film. The film meets the requirement about the content of extracted materials in resin and polymer coatings issued by the FDA in the United States of America.

The test method is according to the rule of FDA 21 CFR 175.300.

Table 4 shows the test data of the extracted material of the film

common Simulated liquid	Time	Temperature	the max permit limit value	the value of the extracted material of the film (Total)
distilled water	2.0 hours	250°F	18mg/inch ²	<0.1 mg/inch ²
n-heptane	2.0 hours	150°F	18mg/inch ²	0.2mg/inch ²

Example 18

The present invention provides an inorganic coating. The coating comprises the ingredients as below:

80wt% inorganic solution, the said inorganic solution comprises 30wt% tetraethoxysilane, 20wt% ethanol, 30wt% silica sol;

6wt% first functional additive, which is the mixture of potassium titanate and alumina, wherein the amount of potassium titanate is 5wt%;

13.5wt% inorganic pigment;

0.5wt% tourmaline.

Coat the coating provided by Example 18 on the surface of the metal pan and formed film. Test the film according to the rule 30 and 31 of LFGB in Germany, the rule of AP (2004) 1 issued by European Commission, LI2006APR1 and DIN51032:1986 from BFR. The result shows that the film meets the requirement about sense under the rule 30 and 31 of LFGB and the rules of AP (2004) 1, and meets the requirement of the safety limit under the PFOS, PFOA, and meets the requirement of safety limit value about extracted lead, cadmium, and cobalt from the ceramic.

1) sense test

Test method: according to DIN 10955:1983(2004)

Test condition: 100°C, 20 hours

Test medium: deionized water

Total Number of the persons: 6

Table 5 Test result of Sense

Test item	Test result	Permit limit value
Smell sense (grade)	0	2.5
Taste sense (grade)	0	2.5

Comments on the grades:

0: There no difference with the original smell and taste;

1: There little difference with the original smell and taste;

2: There week difference with the original smell and taste;

3: There obvious difference with the original smell and taste;

4: There bigger difference with the original smell and taste;

2) The extracted lead, cadmium, and cobalt (four film samples for the test)

Test method: Refer to the testing method in EN1388-1/2:1995 Test of the extracted lead, cadmium, and cobalt from the ceramic containers or the surface of silicate, analysis by the Atomic Absorption Spectroscopy instrument.

Table 6 Test result of the extracted lead, cadmium, and cobalt

Flat container	Result				Limit value
	1	2	3	4	
The extracted lead (mg/dm ²)	<0.1	<0.1	<0.1	<0.1	See the table 7
The extracted cadmium (mg/dm ²)	<0.01	<0.01	<0.01	<0.01	

The extracted cobalt (mg/dm ²)	<0.01	<0.01	<0.01	<0.01	0.1
4% acetic acid volum (ml)	120	120	120	120	...
surface area (dm ²)	0.33	0.33	0.33	0.33	...

Cite the permit limit value of lead, cadmium from DIN51032:1986.

Table 7 The permit limit value of extracted lead, cadmium from the surface of the ceramic, glass or enamel

Item		flat container		Hollware	
		lead mg/dm ²	cadmium mg/dm ²	lead mg/l	cadmium mg/l
flatware	ceramic, glass, glass ceramic die	0.8*	0.07*	4.0*	0.3*
	with colored glaze	0.8	0.07	0.8	0.07
Container repeat used for the food storage or boilling	ceramic, glass, glass ceramic die	0.4	0.05	1.5*	0.1*
	with colored glaze	0.1	0.05	0.4	0.07
part of the container with colored glaze and water-heater		0.1	0.05	-	-

* is consistent with the rule of the European Union.

3) Test of the extracted PFOA.

Test method: extract the sample with olive oil for 120 minutes under 175°C. Analyze the extracted solution with the High Performance Liquid Chromatography.

Table 8 Test result of the extracted PFOA

Test item	Test result	The max permit limit value
The extracted PFOA, mg/dm ²	<0.005	0.005

4) Test of the extracted PFOS.

Test method: Refer to EPA3550C:2007, analyze the extracted solution with the High Performance Liquid Chromatography.

Table 9 Test result of the extracted PFOS

Test item	Test result	The max permit limit value
The extracted PFOS, $\mu\text{g}/\text{m}^2$	<1	1

Concluding from the test result of the film formed by the coating provided by example 17 and 18, the film formed by the inorganic coating in present invention meet the food safety standard, has high safety, may be used to the kitchen ware and tableware.

It is to be understood that while the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended to illustrate and not limit the scope of the invention. Other aspects, advantages, and modifications according to the present invention are within the scope of the following claims.

Claims

1. A room-temperature curable inorganic coating comprising:

70-80wt% of a solution, wherein the solution comprises 30-40wt% of an alkoxy-silane, 15-20wt% of an organic solvent, and 25-30wt% of a silica sol;

5-10wt% of a first functional additive selected from potassium titanate, alumina or mixtures thereof;

10-20wt% of an inorganic pigment; and

0.5-2.0wt% other functional additive;

wherein said percent is weight percent of each component based on total weight of inorganic coating.
2. The inorganic coating of claim 1, wherein the alkoxy-silane is represented by formula $R^1_mSi(OR^2)_{4-m}$, where R^1 is selected from alkyl group, and R^2 is selected from alkyl group, the alkyl group is represented with general formula of " C_nH_{2n+1} ", wherein n is a positive integer, and n is 1-10; the total number of " R^1 " and " OR^2 " is 4, m is a non-negative integer, and m is 0-3.
3. The inorganic coating of claim 1, wherein alkoxy-silane comprises at least one of selected from the group including methyl, ethyl, phenyl, $CF_3CH_2CH_2$, $CF_3(CF_2)_5CH_2CH_2$, and $CF_3(CF_2)_7CH_2CH_2$.
4. The inorganic coating of claim 1, wherein the silica sol comprises 20-40wt% silica (SiO_2) particles, the particle size of the silica is from nano-size to micron-size; the inorganic coating also comprises deionized water.

5. The inorganic coating of claim 1, wherein the other functional additive is tourmaline, rare-earth ore or a mixture thereof.
6. The inorganic coating of claim 1, wherein the first functional additive comprises 3-5wt% potassium titanate.
7. The inorganic coating of claim 2, wherein the "OR²" is hydrolyzable alkoxy group, which is hydrolyzed by water, creating "silicon-hydroxyl" (Si-OH) group, which bonds with the surfaces of the substrate through Si-O-M bond, M represents substrate.
8. The inorganic coating of claim 1, wherein the alkoxy-silane is selected from methyl trimethoxy silane, tetraethoxysilane, phenyl trimethoxy silane, or a mixture thereof.
9. The inorganic coating of claim 1, the coating comprising:

70-80wt% of an inorganic solution, wherein the inorganic solution comprises 30-40wt% of an alkoxy-silane, 15-20wt% of an organic solvent, and 25-30wt% of a silica sol;

5-10wt% of a first functional additive selected from potassium titanate, alumina or mixtures thereof;

10-20wt% of an inorganic pigment; and

0.5-2.0wt% other functional additives;

wherein said percent is weight percent of each component based on total weight of inorganic coating.

10. A method for preparing the inorganic coating of claim 1, by combining components of the inorganic coating to prepare a main agent and a curing agent, wherein a method for preparing the main agent comprises stirring a silica sol, adding an organic solvent, stirring continuously, adding deionized water again and stirring continuously, wherein the reaction temperature is controlled not to exceed 50 °C, and wherein said organic solvent is at least one selected from the group including methanol, ethanol, isopropanol; and
- wherein a method for preparing the curing agent comprises adding an organic alkoxy-silane, a first functional additive, an inorganic pigment, and other functional additives to deionized water, stirring and mixing homogeneously.
11. A method for preparing the inorganic coating of claim 1, wherein the method comprises the following steps:
- (1) preparing an inorganic solution by mixing 30-40wt% alkoxy-silane, with 15-20wt% of an organic solvent, and 25-30% of a silica sol, stirring the mixture under 40-50 °C for 5-10 minutes, getting an inorganic solution in sol state;
 - (2) preparing an inorganic coating mixture by putting the inorganic solution got in step (1), 5-10wt% of a first functional additive, 10-20wt% of an inorganic pigment, and 0.5-2.0wt% of other functional additives together, and stirring the mixture to get the inorganic ceramic mixture;
 - (3) putting the inorganic ceramic mixture got in step (2) in a homogenizer; and stirring it at a high speed for 1-2 hours to make the particles homogenized; and
 - (4) filtering the homogenized matter got in step (3) pass through a 325-1000 mesh net, and the matter after filtering is the said inorganic coating.