

TITLE

COATING LIQUIDS FOR FORMING CONDUCTIVE COATINGS

FIELD OF THE INVENTION

This invention relates to coating liquids for forming conductive coatings and more particularly to coating liquids capable of forming on substrates such as glass, plastics, etc. transparent conductive coatings excellent in scratch resistance as well as in adhesion to the substrates.

In other aspects, the invention relates to glass or plastic substrates provided on the surface thereof with transparent conductive coatings formed by using the above-mentioned coating liquids, and particularly to display devices having front panels provided on the surface thereof with said transparent conductive coatings.

BACKGROUND OF THE INVENTION

Since glass or plastics which are used as transparent substrates of varied types including front panels for Cathode ray tube (CRT), liquid crystal display (LCD), etc. are insulating materials, the surface thereof is liable to static electrification and hence the substrate surface tends to attract dusts or the like. Furthermore, in electroddisplay devices such as LCD, etc.,

miss-performance is sometimes caused by the presence of static electricity. For solving such problems as referred to above, attempts have often been made to prevent such substrates as glass, plastics, etc. from their being electrostatically charged by virtue of imparting electrical conductivity to the surface thereof.

In order to impart electrical conductivity to substrates, metallic thin films or conductive inorganic oxide coatings are deposited on the surface of substrate by the vapor phase method such as CVD method, PVD vapor deposition method, etc. In an attempt to impart electrical conductivity to the substrate surface by the vapor phase method, however, there are such problems that vacuum deposition apparatuses are required therefor, and that a surface area or shape of the substrate on which a desired coating is formed is restricted by the size of said apparatuses to be employed.

In light of the above problems, a process for imparting electrical conductivity to substrates has been proposed, which process comprises coating the substrate on the surface thereof with conductive coating materials obtained by dispersing conductive substances in binder resins.

Where an attempt was made to form conductive coatings on substrates by using conductive coating

materials obtained by dispersing conductive substances in binder resins such as acrylic resins, butyral resins, vinyl chloride/vinyl acetate copolymer resins, etc., however, there were such serious problems that the conductive coatings formed thereby are found poor in transparency, scratch resistance, solvent resistance or in adhesion to the substrates, though said conductive coatings are excellent sufficiently in electrical conductivity.

Under such circumstances, there has earnestly been desired an advent of coating liquids for forming conductive coatings which are excellent in scratch resistance, solvent resistance and in adhesion to substrates as well as transparency.

Apart from the purpose of forming conductive coatings on substrates, however, Japanese Patent L-O-P Publn. No. 100943/1982 discloses silicon oxide coatings containing 1-30 mol% of zirconium oxide with the view of protecting the substrate surface and inhibiting reflection therefrom. In this publication, it is stated that in the zirconium oxide-silicon oxide coatings there are used, as the zirconium compounds, zirconium chloride such as ZrCl_2 , ZrCl_3 or ZrCl_4 ; zirconium nitrate such as $\text{Zr}(\text{NO}_3)_4 \cdot 5\text{H}_2\text{O}$; zirconium alkoxides and zirconium diketonates.

However, when an attempt is made to form the

zirconium oxide-silicon oxide coatings by using coating liquids containing zirconium chloride, zirconium nitrate, zirconium alkoxide or zirconium diketonate and silicon alkoxide, it has been found by the present inventors that there is such a serious problem that because of instability in water of zirconium chloride and zirconium nitrate, the coating liquids containing the same cannot be preserved over a long period of time and have a short pot-life. Moreover, even if zirconium oxide-silicon oxide coatings were formed by the use of the above-mentioned coating liquids containing zirconium chloride and the like, it was still necessary to fire the resultant coatings at a temperature of at least 450°C. Moreover, the coating liquids as described above involved such a problem that said coating liquids must be adjusted to pH 2-6 by a fresh addition thereto of a mineral acid such as hydrochloric acid at the time when silicon alkoxides contained therein is hydrolyzed.

On one hand, front panels of display devices are required in some cases to have a specular reflection reducing effect (hereinafter called non-glare) in order to inhibit glaring of said front panels, in addition to their antistatic effect. In order to impart non-glare and antistatic effect to front panels of display devices, a process designed for the purpose intended is disclosed,

for example, in Japanese Patent L-O-P Publ'n. No. 16452/1986, wherein the front panel composed of glass or plastics is previously heated, and a colloidal solution of silicon compound such as partially hydrolyzed silicic acid ester, a solution of reactive silicon compound such as silicon tetrachloride, or a solution prepared by mixing the above-mentioned solution with a water-soluble compound of inorganic metal such as platinum, gold, palladium, tin or the like is sprayed over said front panel to form thereon a finely irregular coating, followed by drying and firing.

Further, a process for forming a coating layer on a front panel of Braun tube is also disclosed, for example, in Japanese Utility Model L-O-P Publ'n. No. 168951/1984, wherein tin oxide or indium oxide and silicon oxide are mixed or laminated by the vacuum deposition or dip method to form the coating layer on the front panel.

In front panels of display devices processed by the above-mentioned processes, however, non-glare attained was found insufficient, antistatic effect expected varied depending on ambient temperature and humidity, and under certain circumstances resolving power of the display devices came to decrease by the presence of the coating formed on the front panel thereon. Further, the finely irregular coatings as formed were weak in adhesion to the

front panel and easily peeled off therefrom, were liable to scratching as being low in mechanical strength, and tended to peel off or elute as being lacking in permanence properties such as acid resistance, alkali resistance, resistance to saline solutions and to water, thus no non-glare and antistatic effect as expected could be maintained over a long period of time.

The present invention is intended to solve such problems associated with the prior art as mentioned above, and an object of the invention is to provide coating liquids for forming conductive coatings, said coating liquids being capable of forming on substrates such as glass, plastics, etc. the conductive coatings excellent in scratch resistance, permanence properties and adhesion to the substrates as well as in transparency and, at the same time, which are capable of being preserved with excellent stability over a long period of time.

A further object of the present invention is to provide glass or plastic substrates provided with transparent conductive coatings formed by the use of such coating liquids as mentioned above, said conductive coatings being excellent in transparency, scratch resistance, permanence properties, adhesion to the substrates and antistatic effect, or glass or plastic substrates provided likewise with transparent conductive

coatings having non-glare in addition to the above-mentioned functions. Another object of the present invention is to provide display devices having front panels provided with transparent conductive coatings having the above-mentioned functions.

DISCLOSURE OF THE INVENTION

The first coating liquid for forming conductive coating of the present invention is characterized in that a zirconium oxyacid salt and a conductive substance are homogeneously dissolved or dispersed in a mixed solvent comprising water, an inorganic solvent and a stabilizer.

The second coating liquid for forming conductive coating of the present invention is characterized in that a zirconium oxyacid salt, a non-precipitable silica and a conductive substance are homogeneously dissolved or dispersed in a mixed solvent comprising water, an organic solvent and a stabilizer.

The third coating liquid for forming conductive coating of the present invention is characterized in that a zirconium oxyacid salt, silicon alkoxide or its derivative and a conductive substance are homogeneously dissolved or dispersed in a mixed solvent comprising water and an organic solvent.

The fourth coating liquid for forming conductive

coating of the present invention is characterized in that a zirconium oxyacid salt, silicon alkoxide or its derivative, a non-precipitable silica and a conductive substance are homogeneously dissolved or dispersed in a mixed solvent comprising water, an organic solvent and a stabilizer.

The fifth coating liquid for forming conductive coating of the present invention is characterized in that diacetylacetonato-dialkoxide zirconium, a partial hydrolyzate of silicon alkoxide and a conductive substance are homogeneously dissolved or dispersed in a mixed solvent comprising water and an organic solvent.

The substrates of the present invention, on which transparent conductive coatings have been formed, are characterized by having a total light transmission of at least 80%, a haze of less than 10%, $10^3 \leq$ surface resistivity $\leq 10^{11}$, and a glossiness of less than 190% as measured at an angle of 60° in accordance with the glossiness measuring method stipulated in JIS K 7105-81.

The display device of the present invention, in which a transparent conductive coating has been formed on the surface of a front panel, is characterized in that the transparent conductive coating is composed of zirconium oxide, silicon oxide and a conductive substance, and the front panel, on the surface of which said transparent

conductive coating has been formed, has a glossiness of 30-100% as measured at an angle of 60° in accordance with the glossiness measuring method stipulated in JIS K 7105-81, a resolving power of at least 50 bars/cm, and a surface resistivity of $10^3-10^{11} \Omega / \square$.

The first process for manufacturing the display device of the present invention is characterized in that any one of the above-mentioned second to fifth coating liquids for forming conductive coatings of the present invention is coated by the spray method on a front panel of said display device previously heated to and maintained at $40-90^{\circ}\text{C}$, followed by drying and/or firing.

The second process for manufacturing the display device of the present invention is characterized in that any one of the above-mentioned coating liquids for forming conductive coatings is coated likewise on a front panel of said display device, dried and/or fired, and a coating liquid containing a transparent protective component is coated by the spray method on the front panel heated to and maintained at $40-90^{\circ}\text{C}$, followed by drying and/or firing.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 and 2 are schematic views for measuring a resolving power (bars/cm) of the display device of the

present invention.

BEST MODE FOR PRACTICE OF THE INVENTION

First, the coating liquids for forming conductive coatings of the present invention are illustrated below in the concrete.

The first coating liquid for forming conductive coating of the present invention comprises a homogeneous solution or dispersion of a zirconium oxyacid salt and a conductive substance in a mixed solvent comprising water, an inorganic solvent and a stabilizer. The components homogeneously dissolved or dispersed in the mixed solvent are illustrated hereinafter.

Useful as the zirconium oxyacid salts are zirconium oxychloride, zirconium oxynitrate, zirconium oxyacetate, zirconium oxyoxalate and the like. Of those exemplified above, particularly preferred are zirconium oxychloride and zirconium oxynitrate. Such zirconium oxyacid salts dissolve in water and organic solvents such as alcohols and the resulting solution is made acid when water is present therein.

The conductive substances used in the present invention are those which are known hitherto such as tin oxide, tin oxide doped with antimony, fluorine, phosphorus or the like, indium oxide or indium oxide doped with tin.

These conductive substances are preferably in the form of fine particle having an average particle diameter of less than 0.4 μ m.

In the application of the present first coating liquid to a front glass of display devices such as CRT, LCD and the like or to a glass for copying machines or the like where a high transparency with a low haze is required, it is preferable to use in said coating liquid the conductive substances having an average particle diameter of 0.01-0.1 μ m. Even though an average particle diameter of the conductive substance contained in the coating liquid is less than 0.1 μ m, however, the substrate to which said coating liquid has been applied will decrease in transparency if the major proportion of particles of said conductive substance has a particle diameter exceeding 0.1 μ m and, therefore, it is preferable that at least 60% of the total of the particles is occupied by those having an average particle diameter of less than 0.1 μ m.

In the present invention, it is particularly preferable to use as the conductive substances the products which are obtained on the basis of the process disclosed in a publication titled "Process for preparing conductive fine particles" (Japanese Patent Appln. No. 51008/1987) or a publication titled "Tin oxide sol and

process for preparation thereof" (Japanese Patent Appln. No. 75283/1986), both filed by the present applicant.

That is, preferably useful as the first conductive substances of the above-mentioned products are conductive metallic oxide fine particles which are obtained by the above-cited process, wherein an aqueous solution of a tin or indium compound is maintained under the condition of pH 8-12, the compound in the solution is gradually hydrolyzed to form a sol containing colloidal particles, and the resulting sol is dried and fired followed by pulverization.

The starting materials used in the above process are tin or indium compounds which are water soluble and capable of hydrolysis in the pH range of 8-12, and usable are in the concrete such tin compounds as potassium stannate, sodium stannate and the like, or such indium compounds as indium nitrate, indium sulfate and the like.

When a metallic seed present in an aqueous solution of a tin or indium compound (hereinafter sometimes called the starting solution) is either one of tin or indium, the resulting fine particles are composed of tin oxide or indium oxide. In that case, however, conductive fine particles doped with a foreign element can be obtained by dissolving small amounts of a compound containing said foreign element in the starting solution.

For instance, conductive fine particles composed of tin oxide doped with antimony or fluorine can be obtained by dissolving small amounts of tartar emetic (antimonyl potassium tartarate) or ammonium chloride in the starting solution containing a tin compound, and conductive fine particles composed of indium oxide doped with tin can be obtained by dissolving small amounts of a tin compound in the starting solution containing an indium compound.

Conductive particles doped with foreign metallic elements may also be prepared by the following processes. That is, conductive fine particles composed of a tin compound doped with antimony, phosphorus, fluorine and the like can be prepared by a process which comprises using an aqueous solution of a tin compound as the starting solution, gradually hydrolyzing the tin compound in the solution under the aforementioned pH condition to form a sol, recovering colloidal particles from the resulting sol, impregnating the recovered colloidal particles with an aqueous solution of at least one of an antimony compound, phosphorus compound and fluorine compound, and thereafter drying the thus impregnated colloidal particles, followed by firing. Furthermore, conductive fine particles composed of an indium compound doped with tin and/or fluorine can be prepared by a process which comprises using an aqueous solution of an indium compound

as the starting solution, forming a sol in the same manner as above, recovering colloidal particles from the thus formed sol, impregnating the recovered colloidal particles with an aqueous solution of a tin compound and/or a fluorine compound, and then drying the thus pregated particles, followed by firing. In cases where the starting solution, even of an aqueous solution of a tin compound or an indium compound, is used, when by-product salts are formed during the source of forming a sol, not only colloidal particles formed in the sol tend to agglomerate but also a specific resistivity of the conductive fine particles obtained becomes higher by virtue of admixture with the by-product salts formed. It is therefore recommended that where formation of by-product salts is expected, the by-products salts as formed are washed to remove from colloidal particles recovered from the sol formed by hydrolysis, prior to impregnation of the colloidal particles with an aqueous solution of the metallic compound.

Generally speaking, a concentration of the tin or indium compound contained in the starting solution is preferably in the range of 5-30% by weight, though the concentration may be selected optionally.

Usually, the reaction temperature of the hydrolysis may be selected at choice in the range of

temperature between 30° and 90° C.

After preparation of the sol liquid, colloidal particles formed therein are recovered by filtration therefrom, and the colloidal particles recovered are rinsed to remove by-product salts and the like attached to said particles, dried, fired and then pulverized to obtain conductive fine particles. The fine particles thus obtained are sintered to a certain extent during the firing step and an average particle diameter of the particles becomes about 20-50 μ m but the particles are easily released from their sintered state when subjected to the subsequent pulverizing step, and the fine particles are then processed by an ordinary pulverization means to give conductive fine particles answering the objects of the present invention, which have an average particle diameter of less than about 0.4 μ m when they are incorporated into coating materials. The fine particles obtained in the manner now described are found to contain only small amounts of coarse particles, for example, those having a particle diameter of larger than 0.8 μ m.

Pulverization of the conductive substances may be carried out before or after mixing thereof with other components such as zirconium oxyacid salts and the like. The conductive substances can be pulverized by conventionally known methods, for example, those utilizing

an attritor, sand mill, ball mill, triple roll or the like devices.

The conductive substances thus obtained may be used, when they are particles, as they are, or they can also be used after dispersing them in water or organic solvents.

The second conductive substance preferably used in the present invention is a conductive tin oxide sol obtained by heat treatment of fine particles of tin oxide or tin oxide doped with foreign elements in aqueous acid or alkali solutions.

The fine particles of tin oxide or tin oxide doped with foreign elements used herein may be those obtained by the first process mentioned previously, or those obtained by conventionally known methods.

This conductive tin oxide sol may be obtained by heat treatment of the above-mentioned fine particles of tin oxides in aqueous solutions of acids such as mineral acids or organic acids or aqueous solutions of alkalis such as alkali metal hydroxides or quaternary ammonium salts. The heating temperature employed in this case is preferably less than about 200°C. Suitable amounts of the acids or alkalis used in the aqueous solutions is at least 5% by weight based on the fine particles to be treated. An average particle diameter of particles dispersed in the

conductive tin oxide sol thus obtained is less than 0.1 μ m, and more than 60% of the total particles is occupied by particles having an average particle diameter of less than 0.1 μ m.

The above-mentioned conductive tin oxide sol is usually an aqueous sol, but it may also be used as an organic sol, if necessary, in which a part or whole of water has been replaced by an organic solvent such as alcohol or the like.

Organic solvents used in the coating liquids for forming conductive coatings of the present invention are alcohol such as methanol, ethanol, n-propanol, i-propanol, n-butanol, i-butanol, t-butanol, etc., esters such as methyl acetate, ethyl acetate, etc., ethers such as diethyl ether, etc., ketones such as methyl ethyl ketone, etc., ethylene glycol monomethyl ether and the like, which are used either singly or in combination.

The stabilizers used in the present coating liquids, either singly or in combination, are ethylene glycol, N-methyl-2-pyrrolidone, morpholine, ethyl cellosolve, methyl cellosolve, N,N-dimethylformamide, etc.

In the first coating liquid for forming conductive coating of the present invention which contains the above-mentioned components, the molar ratio of the stabilizer to, the zirconium oxyacid salt in terms of ZrO_2

(stabilizer / ZrO_2) is 1-25, preferably 2-25. If a value of this ratio is less than 1, gellation of the coating liquid for forming conductive coating these components tends to occur undesirably and, on one hand, when this value exceeds 25, the coating liquid inhomogeneously cures when it is coated on a substrate to cure, whereby the conductive coating formed undesirably poor in permanence properties.

Further, the weight of water present in the coating liquid is preferably less than 40% of the whole weight of said coating liquid with the condition that the weight ratio of the water to the zirconium oxyacid salt in terms of ZrO_2 (water/ ZrO_2) satisfactorily falls within the range of 0.1-40. If the above-mentioned ratio of water/ ZrO_2 is less than 0.1, gellation of the zirconium oxyacid salt occur undesirably and, on one hand, when said ratio exceeds 40, the addition effect of the stabilizer disappears, with the result that adhesion of the coating liquid for forming conductive coating to a substrate becomes poor undesirably. Furthermore, the weight of the water exceeds 40% of the whole weight of the coating liquid, the addition effect of the stabilizer disappears likewise, with the result that adhesion of the coating liquid for forming conductive coating to a substrate becomes poor undesirably.

The sum total of the conductive substance and zirconium oxyacid salt in terms of ZrO_2 is preferably 0.1-10% by weight based on the whole weight of the coating liquid for forming conductive coating. It is not economical to use these two components in an amount of less than 0.1% by weight and, on one hand, if said amount exceeds 10% by weight, gelation of the coating liquid for forming conductive coating tends to occur undesirably and no possibility of the long-term preservation of said coating liquid can be expected.

Still further, the weight ratio of the conductive substance to zirconium oxyacid salt in terms of ZrO_2 (conductive substance/ ZrO_2) is preferably 1-5. If this value is less than 1, the resulting conductive coating becomes poor in electrical conductivity and, on one hand, when the value exceeds 5, adhesion between a substrate and the conductive coating formed thereon undesirably decreases.

The coating liquids for forming conductive coatings as illustrated above may be prepared by mixing an aqueous solution of a zirconium oxyacid salt with a conductive substance and a stabilizer and, if necessary, removing part of the water present in the mixture therefrom by distillation or ultrafiltration, and thereafter adding an organic solvent to the mixture,

followed by homogeneous mixing.

The second coating liquid for forming conductive coating of the present invention is illustrated hereinafter.

This coating liquid for forming conductive coating comprises a homogeneous solution or dispersion of a zirconium oxyacid salt, non-sedimentary silica and conductive substance in a mixed solvent comprising water, organic solvent and stabilizer. The zirconium oxyacid salt, conductive substance, water, organic solvent and stabilizer used in the coating liquid are the same as those used in the first coating liquid for forming conductive coating of the present invention as illustrated above, and hence herein illustrated is the non-sedimentary silica.

The non-sedimentary silica used in the present invention is intended to designate such a liquid of non-sedimentary silica that when an aqueous solution containing 2.0% by weight of the non-sedimentary silica in terms of SiO_2 is subjected for 1 hour at 250,000 G to centrifugal sedimentation, the sediment left thereby is less than 30% by weight. Such non-sedimentary silica liquid is an aqueous alkali solution of silicic acid, from which the greater part of the alkali has been removed, said non-sedimentary silica liquid being obtained by

replacement of alkali with hydrogen in the aqueous alkali solution of silicic acid by means of the ion exchange method, dialysis method or the like. The stabilizer is used in the non-sedimentary silica liquid in an amount of at least 0.5 mole based on 1 mole of the non-sedimentary silica.

Such a growth inhibitor as the stabilizer mentioned above plays a role in the stabilization of non-sedimentary silica in the liquid by inhibiting gellation of said silica.

In this non-sedimentary silica, it is desirable that the amount of residual alkali represented by the $\text{SiO}_2/\text{M}_2\text{O}$ ratio (in which M represents an alkali metal) is at least 200, preferably at least 1000.

Such non-sedimentary silica as referred to above is illustrated in detail in Japanese Patent Appln. No. 187835/1986 filed previously by the present applicant.

In the second coating liquid for forming conductive coating of the present invention which contains the components as mentioned above, the molar ratio (stabilizer/ $\text{ZrO}_2 + \text{SiO}_2$) of the number of moles of the stabilizer to the number of the sum total of moles of the zirconium oxyacid salt in terms of ZrO_2 and of SiO_2 present in the non-sedimentary silica is 1-25, preferably 2-25. If this value is less than 1, gellation of the

coating liquid tends to occur and a pot life (useful life) of said coating liquid becomes short and, on one hand, when said value exceeds 25, the coating liquid does not cure homogeneously when it is coated on a substrate, with the result that the conductive coating formed becomes poor in permanence properties.

In this second coating liquid, the amount of water present is preferably less than 50% by weight based on the weight of the coating liquid with the condition that the weight ratio (water/ ZrO_2) of the water to zirconium oxyacid salt in terms of ZrO_2 is 0.1-40. If the water/ ZrO_2 weight ratio mentioned above is less than 0.1, the zirconium oxyacid salt undesirably tends to gel and, on one hand, if said weight ratio exceeds 40, the addition effect of the growth inhibitor disappears and the coating liquid undesirably becomes poor in adhesion to a substrate. Furthermore, if the amount of water used exceeds 50% by weight of the coating liquid, the addition effect of the growth inhibitor disappears likewise and the coating liquid undesirably becomes poor in adhesion to a substrate.

The sum total of the conductive substance, SiO_2 present in the non-sedimentary silica and the zirconium oxyacid salt in terms of ZrO_2 is 0.1-20%, preferably 0.1-10% by weight of the coating liquid. If a value of the

said sum total is less than 0.1% by weight, the use of such coating liquid is not economical and, on one hand, if said value exceeds 20% by weight, undesirably the coating liquid tends to gel and cannot be preserved for a long period of time.

The weight ratio (conductive substance/ $\text{ZrO}_2 + \text{SiO}_2$) of the conductive substance to the sum total of the zirconium oxyacid salt in terms of ZrO_2 and SiO_2 contained in the non-sedimentary silica is preferably 1-5. If a value of this weight ratio is less than 1, the resulting coating becomes poor in electrical conductivity or does not become porous and, if this value exceeds 5, the resulting coating becomes poor in adhesion to a substrate.

The coating liquid for forming conductive coating as illustrated above may be prepared by mixing together an aqueous solution of the zirconium oxyacid salt, the conductive substance and a dispersion of the non-sedimentary silica and, if necessary, removing a part of water therefrom by distillation or ultrafiltration, followed by homogeneously mixing the resulting mixture with an organic solvent.

The third coating liquid for forming conductive coating of the present invention is illustrated hereinafter.

This coating liquid for forming conductive coating

comprises a homogeneous solution or dispersion of a zirconium oxyacid salt, silicon alkoxide or its derivative and a conductive substance in a mixed solvent comprising water and an organic solvent. The zirconium oxyacid salt, conductive substance, water and organic solvent used in the coating liquid are the same as those used in the first coating liquid for forming conductive coating of the present invention, and hence herein illustrated is the silicon alkoxide or its derivative used in this coating liquid.

The silicon alkoxide or its derivative used in the present invention includes compounds or condensates (up to pentamers) having 1-4 alkoxy groups of 1 to 8 carbon atoms, said compounds or condensates being represented by $\text{SiH}_a(\text{OR})_b$ ($a=0-3$, $b=1-4$, $a+b=4$, and R is alkyl), $(\text{R}'\text{O})_a\text{Si}(\text{OR})_b$ or $\text{R}'_a\text{Si}(\text{OR})_b$ ($a=0-3$, $b=1-4$, $a+b=4$, and R and R' are each alkyl), or derivatives of the compounds or condensates represented by the above-mentioned formulas in which a part of H has been substituted with Cl, vinyl or the like group. Of those mentioned above, preferred are mixture of one or two or more compounds represented by the formula $\text{Si}(\text{OR})_4$ (wherein R is CH_3 , C_2H_5 , n- and iso- C_3H_7 , or n-, iso-, sec- and tert- C_4H_9).

In the third coating liquid for forming conductive coating of the present invention, which contains the

components as mentioned above, the zirconium oxyacid salt and silicon alkoxide or its derivative are used in such an amount so that ZrO_2/SiO_2 (molar ratio) of the zirconium oxyacid salt in terms of oxide to silicon alkoxide or its derivative in terms of oxide is in the range of 0.05-2.0, preferably 0.2-1.0. If a value of this ZrO_2/SiO_2 (molar ratio) is less than 0.05, the resulting coating undesirably becomes poor in permanence properties and, on one hand, if this value exceeds 2.0, the resulting coating undesirably decreases in adhesion to a substrate and optical characteristics (haze, total light transmittance).

The presence of water in the coating liquid is necessary for hydrolysis reaction of silicon alkoxide. It is preferable to decide the amount of water in the coating liquid according to the amount of the silicon alkoxide or its derivative in the mixture, and desirably the water is contained in the coating liquid in such an amount so that the H_2O/SiO_2 molar ratio in the mixture of the water to silicon alkoxide or its derivative in terms of SiO_2 is at least 2. If a value of this ratio is less than 2, no coating is obtained since undecomposed silicon alkoxide or its derivative remains, as it is, even after formation of the coating.

The content of the conductive substance, when expressed as MOx in terms of oxide, is preferably in such

an amount so that $MO_x/(SiO_2 + ZrO_2)$ (weight ratio) is 0.5-5.0. If a value of this weight ratio is less than 0.5, undesirably the resulting conductive coating becomes excessively low in electrical conductivity and, on one hand, if this value exceeds 5.0, undesirably the resulting conductive coating becomes poor in adhesion to a substrate.

When the solids content (conductive substance + $ZrO_2 + SiO_2$) in the conductive coating liquid is less than about 20% by weight, a coating answering the objects of the present invention is obtained. However, if this solids concentration exceeds 20% by weight, the coating liquid becomes poor in stability and cannot be fit for a long-term preservation. If this solids concentration is excessively low, such an inconvenience that the coating operation of the conductive coating liquid must be repeated several times to obtain a desired coating is experienced and hence a practically useful solids concentration is at least about 0.1% by weight.

Since water and an organic solvent such as alcohol or the like are present in this conductive coating liquid as mentioned above, the zirconium oxyacid salt dissolves in the water and organic solvent, whereby the coating liquid comes to exhibit acidic properties with a pH of less than 2. On that account, there is no need of

incorporating into the coating liquid an acid catalyst such as hydrochloric acid, nitric acid or the like with the purpose of hydrolyzing the silicon alkoxide or its derivative.

The fourth coating liquid for forming conductive coating of the present invention is illustrated hereinafter.

This coating liquid for forming conductive coating contains a non-sedimentary silica and a stabilizer in addition to such components as used in the above-mentioned third coating liquid for forming conductive coating. The non-sedimentary silica and stabilizer used in this coating liquid are the same as those used in the second coating liquid for forming conductive coating of the present invention.

When this non-sedimentary silica is used together with the silicon alkoxide or its derivative in the coating liquid for forming conductive coating, all light transmittance of the resulting conductive coating is increased and transparency of said coating is improved and, moreover, permanence properties of the coating is not marred.

The non-sedimentary silica is preferably used in such an amount so that the weight ratio (SiO_2 in non-sedimentary silica/ SiO_2 in silicon alkoxide or its

derivative) of SiO_2 in the non-sedimentary silica to the silicon alkoxide or its derivative in terms of SiO_2 is less than 9. If a value of this weight ratio exceeds 9, such a new problem that the firing temperature of the resulting coating must be increased to about 300°C or higher in order to improve permanence properties of the coating arises undesirably, though transparency of the coating is further improved.

Even in the case where the non-sedimentary silica is used, the operation conditions to be employed therein, such as the ratio of ZrO_2 to total SiO_2 in the coating liquid and the like, are the same as those employed in the aforementioned case where only the silicon alkoxide or its derivative is used.

Illustrated below are the processes by which the above-mentioned third and fourth coating liquids for forming conductive coatings of the present invention are prepared.

The zirconium oxyacid salt, silicon alkoxide or its derivative and conductive substance, if necessary, the non-sedimentary silica and stabilizer, are homogeneously mixed together in a mixture of water and an organic solvent. In that case, the order of dissolving or dispersing these components is not particularly limited, for instance, an aqueous solution of the zirconium oxyacid

salt may be mixed with an organic solvent such as alcohol or the like, and the resulting mixture may be incorporated with an alcohol solution of the silicon alkoxide or its derivative, or these solutions mentioned above may be mixed together at a stroke. It is also possible to increase stability of the dispersed particles of the components by incorporating the coating liquid with a surfactant at the time when the above-mentioned solutions are mixed together.

The fifth coating liquid for forming conductive coating of the present invention is illustrated hereinafter.

The fifth coating liquid for forming conductive coating of the present invention a homogeneous solution or dispersion of diacetylacetonato-dialkoxy zirconium, a partial hydrolyzate of silicon alkoxide and a conductive substance in a mixed solvent comprising water and an organic solvent. The conductive substance, water and organic solvent used in this coating liquid, however, are the same as those used in the aforementioned first coating liquid for forming conductive coating of the present invention, and hence herein illustrated are the diacetylacetonato-dialkoxy zirconium and partial hydrolyzate of silicon alkoxide.

The diacetylacetonato-dialkoxy zirconium may be

sufficiently useful if its alkoxy group, preferably butoxy group, has 1 to 8 carbon atoms. This diacetylacetonato-dialkoxy zirconium plays a role in improving dispersibility and heat stability of the conductive substance, and this role is considered ascribable to the fact that the diacetylacetonato-dialkoxy zirconium acts as a protective colloid on the conductive substance.

The partial hydrolyzate of silicon alkoxide or its derivative used in this coating liquid may be obtained by partial hydrolysis of the silicon alkoxide or its derivative used in the third coating liquid for forming conductive coating of the present invention.

As the conditions under which the partial hydrolysis is carried out, there may be adopted a procedure generally employed for partial hydrolysis of silicon alkoxide or its derivative. For instance, such conditions may be adopted, wherein silicon alkoxide or its derivative is mixed with methanol or ethanol, and the mixture is incorporated with water and an acid to effect the partial hydrolysis of the silicon alkoxide or its derivative. However, the partial hydrolysis conditions particularly preferred are such that the acid used is preferably hydrochloric acid, nitric acid, phosphoric acid or acetic acid, and the mixing ratio of the acid to silicon alkoxide or its derivative (acid/SiO₂) is

preferably 0.01-0.5 (the weight ratio of the acid to silicon alkoxide or its derivative in terms of SiO_2). If a value of this ratio is less than 0.01, large amounts of unreacted silicon alkoxide remain to exist in the mixture, which undesirably mars electrical conductivity of the resulting coating and, on one hand, if this value exceeds 0.5, the rate of the partial hydrolysis becomes excessively rapid and undesirably the resulting coating liquid decreases in continuous productivity and preservability. The mixing ratio of water to silicon alkoxide (molar ratio) is preferably at least 2. If a value of this ratio is less than 2, unreacted silicon alkoxide remains in the resulting coating which will undesirably decrease in adhesion to substrate, scratch resistance and alkali resistance. The partial hydrolysis temperature employed is preferably 30-60°C.

The fifth coating liquid for forming conductive coating of the present invention illustrated above may be prepared by adding the diacetylacetonato-dialkoxy zirconium to a mixture of water and the organic solvent in which the conductive substance has been dispersed, thereby improving dispersibility and heat stability of the conductive substance, and then incorporating the resulting mixture with the partial hydrolyzate of silicon alkoxide or its derivative. The incorporation of the partial

hydrolyzate of silicon alkoxide or its derivative into the above-mentioned mixture, prior to the addition of the diacetylacetonato-dialkoxy zirconium to said mixture, is not desirable since the conductive substance dispersed in the mixture comes to agglomerate.

The coating liquid for forming transparent conductive coating thus prepared has such advantages as will be mentioned below. First, the conductive coating formed therefrom is excellent in transparency and electrical conductivity since the conductive substance dispersed in the coating liquid is left in a monodisperse state by the protective colloidal action of the diacetylacetonato-dialkoxy zirconium added to said coating liquid. Second, the coating liquid is improved in stability and hence no gellation thereof occur and the stabilized coating liquid can be preserved for a long period of time even at room temperature of about 30°C. Furthermore, the diacetylacetonato-dialkoxy zirconium together with the partial hydrolyzate of silicon alkoxide or its derivative forms a matrix of the resulting conductive coating, whereby said coating is increased in scratch resistance and alkali resistance, and because of the presence of said diacetylacetonato-dialkoxy zirconium and said partial hydrolyzate of silicon alkoxide or its derivative in the coating liquid, a desired conductive

coating can be formed when said coating liquid as applied is fired at the temperature of about 150°C , and the conductive coating further improved in electrical conductivity is obtained when the coating liquid is fired at above 200°C .

In the fifth coating liquid for forming conductive coating of the present invention which contains the components as illustrated above, the diacetylacetonato-dialkoxo zirconium and the conductive substance are preferably used in such an amount so that the ZrO_2/MO_x weight ratio of these two components in terms of oxide is 0.01-1 (MO_x represents the conductive substance as an oxide). If a value of this ratio is less than 0.01, undesirably the conductive substance decreases in dispersibility and heat stability, the resulting conductive coating becomes poor in transparency and adhesion to a substrate, and the coating liquid becomes poor in preservability and continuous productivity. If this value exceeds 1, on one hand, undesirably the resulting conductive coating becomes poor in transparency and adhesion to a substrate and decreases in electrical conductivity.

The diacetylacetonato-dialkoxo zirconium and silicon alkoxide are preferably used in such an amount so that the $\text{ZrO}_2/\text{SiO}_2$ weight ratio of these two components in

terms of oxide is 0.05-1. If a value of this ratio is less than 0.05, the resulting conductive coating is not sufficient in alkali resistance and, on one hand, if this value exceeds 1, undesirably the resulting conductive coating decreases in adhesion to substrate and transparency.

The diacetylacetonato-dialkoxo zirconium and silicon alkoxide are preferably used in such an amount so that the $\text{ZrO}_2/\text{SiO}_2$ weight ratio of these two components in terms of oxide is 0.05-1. If a value of this ratio is less than 0.05, undesirably the resulting conductive coating is not sufficient in alkali resistance and, on one hand, if this value exceeds 1, the resulting conductive coating decreases in adhesion to a substrate and transparency.

The conductive substance and other two components are preferably used in such an amount so that the $\text{MO}_x/(\text{SiO}_2 + \text{ZrO}_2)$ weight ratio of the components in terms of oxide is 0.5-5. If a value of this ratio is less than 0.5, undesirably the resulting conductive coating is not sufficient in electrical conductivity and, on one hand, if this value exceeds 5, the resulting conductive coating decreases in adhesion to a substrate, transparency and scratch resistance.

Furthermore, if the solids concentration ($\text{MO}_x +$

$\text{SiO}_2 + \text{ZrO}_2$) in the coating solution is less than 15% by weight, the conductive coating answering the objects of the present invention may be obtained. If the above-mentioned solids concentration exceeds 15% by weight, undesirably the coating liquid becomes poor in preservability. If this solids concentration is excessively low, it becomes necessary to repeat the coating operation several times in order to the desired conductive coating, and hence a practically useful solids concentration is at least 0.1% by weight.

The thus obtained first to fifth coating liquids for forming conductive coatings of the present invention are coated on substrates such as glass or plastics according to the conventionally known methods such as spinner, spray, bar coater, role coater and the like methods. Subsequently, a film of the coating formed on the substrate is dried to cure at a temperature of from ordinary temperature to about 120°C , whereby the desired conductive coating excellent in adhesion to the substrate, scratch resistance and transparency is obtained. When the conductive coating thus obtained is further fired, the resulting coating is further improved in permanence properties such as alkali resistance and the like.

The substrate on which a transparent conductive coating has been formed, said conductive coating

comprising zirconium oxide, conductive substance and silicon oxide, has a glossiness of less than 190% as measured at an angle of measurement of 60° according to the method of measurement of glossiness stipulated in JIS K 7105-81, such excellent electrical conductivity as evidenced by its surface resistivity of $10^3-10^{11} \Omega / \square$, such excellent transparency as evidenced by its all light transmittance of at least 80% and haze of less than 10% and, moreover, has excellent permanence properties such as adhesion to the conductive coating, scratch resistance, alkali resistance and the like.

The display device of the present invention and process for manufacturing the same are illustrated hereinafter.

The present display device comprises a front panel as a substrate, on the surface of which a transparent conductive coating has been formed, said transparent conductive coating comprising zirconium oxide, silicon oxide and a conductive substance, and said front panel having a glossiness of 30-100% as measured at an angle of measurement of 60° according to the method of measurement of glossiness stipulated in JIS K 7105-81, a resolving power of at least 50 bars/cm, and a surface resistivity of $10^3-10^{11} \Omega / \square$.

The glossiness of the front panel is represented

by a value of glossiness as measured at an angle of measurement of 60° according to the method of measurement of glossiness stipulated in JIS K7105-81, as mentioned above. If this value is less than 30%, undesirably the front panel decreases in transparency and, on one hand, if the value exceeds 90%, regular reflection of the coating is not decreased and the front panel glares, therefore the glossiness is preferably less than 90%, though the upper limit of this value is not particularly defined.

The front panel has a resolving power of at least 50 bars/cm, as mentioned above. If this value is less than 50 bars/cm, undesirably the front panel becomes poor in transparency.

In the present specification, the resolving power of the front panel was expressed by way of the number of bars per cm in a bar chart, said number of bars being capable of being counted distinctly by visual observation of the chart. That is, the resolving power is determined by using a box of 50 by 30 centimeters wherein a front panel having attached a bar chart as shown in Fig.1 to the side on which no coating is coated is arranged at one wall of the box in the manner as shown in Fig. 2 so that the coated side of the panel faces outward, and the front panel thus arranged is visually observed at a distance of 30 cm from the coated side to count the number of bars per

cm in the bar chart that can be distinctly confirmed. In that case, the box is provided with 20 W fluorescent lamps at both ends of the other wall of the box provided with no front panel, and the surface of the wall of the box provided with no front panel is colored white. The bar chart used included those in which the number of bars is increased every 5 bars/cm, for example, 10 bars/cm, 15 bars/cm, 20 bars/cm, 25 bars/cm and the like.

In the bar charts thus used, 1 is a bar printed, 2 is a space between the printed bars, and a width a of the printed bar is equal to a width b of the space.

In the display device of the present invention, an average surface roughness R_z (a ten-point average roughness as measured in accordance with JIS B0601-82) of the front panel is $0.2-5\mu\text{m}$, preferably $0.2-3\mu\text{m}$. If this average surface roughness is less than $0.2\mu\text{m}$, undesirably the front panel decreases in non-glare and no sufficient antistatic effect is obtained, though the panel is excellent in resolving power and transparency and, on one hand, if the average surface roughness exceeds $5\mu\text{m}$, undesirably the front panel decreases in resolving power and transparency.

The present display device may be prepared by using the second to fifth coating liquids for forming conductive coatings of the present invention mentioned

previously.

That is, the front panel of the present display device may be prepared by coating a front panel previously heated to and kept at 40-90°C, preferably 50-70°C, with any of the second to fifth coating liquids for forming conductive coatings of the present invention by the spray method, followed by drying and/or firing.

If a heating temperature of the front panel is less than 40°C, undesirably the liquid components of the coating liquid as coated will not dry sufficiently and undergo leveling, whereby no non-glare coating is obtained and, on one hand, if this temperature exceeds 90°C, undesirably the liquid components will dry rapidly, whereby the resulting coating becomes poor in adhesion to the panel, transparency and permanence properties. When the coating liquid is coated on the front panel by the spray method, therefore, the coating amount, coating speed and air pressure supplied to the spray should be controlled so that the heating temperature of the front panel does not deviate from the above-mentioned temperature range.

Subsequently, the display device of the present invention is obtained by drying the front panel thus coated by the spray method with the coating liquid for forming conductive coating. When a coating having higher

permanence properties and mechanical strength is needed, such coating may be obtained by firing the front panel as coated in the manner now described at a temperature of above 200°C but below the glass transition point of the front panel. In that case, the firing operation may be repeated many times so long as the firing temperature employed is below the glass transition point of the front panel. In cases where non-glare is not needed according to the purpose for which the display device is used, a desired coating having lesser non-glare or substantially no non-glare may be obtained by varying the spray conditions to be employed.

Furthermore, the front panel of the display device of the present invention may be prepared by coating the coating liquid for forming conductive coating on a front panel by the spray method in the manner now described, drying and/or firing the thus coated front panel, coating by the spray method a coating liquid comprising transparent components on the thus dried and/or fired front panel at 40-90°C, and then drying and/or firing the thus coated front panel.

Usable as the coating liquid comprising transparent protective components are the second to fifth coating liquids for forming conductive coatings, from which the conductive substance has been excluded.

As the coating liquid comprising transparent protective components, moreover, there may also be used a liquid prepared by homogeneously dissolving or dispersing a binder resin in an organic solvent. Useful binder resins include silicon resins, melamine resins, urethane resins and the like.

The present invention is illustrated below with reference to examples, but it should be construed that the invention is in no way limited to those examples.

Example 1

(Preparation of conductive tin oxide sol)

A starting liquid was prepared by dissolving 316 g of potassium stannate and 38.4 g of tartar emetic in 686 g of water. The starting liquid together with nitric acid was added over 12 hours to 100 g of water warmed at 50°C with stirring and subjected to hydrolysis while maintaining a pH of the system at 8.5, whereby a sol liquid was obtained. Colloidal particles were separated by filtration from the sol liquid, washed to remove by-product salts therefrom, dried, fired at 350°C for 3 hours in air, and then further fired at 650°C for 2 hours in air to obtain fine powder (I). To 1600 g of an aqueous potassium solution (containing 40 g of KOH) was added 400 g of the fine powder (I), and the mixture kept at 30°C was stirred for 3 hours with a sand mill to obtain conductive

tin oxide colloid.

Subsequently, this conductive tin oxide colloid was treated with an ion exchange resin to obtain dealkalized conductive tin oxide colloid (a conductive sol liquid). This dealkalized conductive sol liquid contained no precipitate, had a solids concentration of 20% by weight and colloidal particles having an average particle diameter of 0.07 μ m. The amount of colloidal particles having a particle diameter of less than 0.1 μ m was 87% of the total amount of colloidal particles.

In this connection, the measurement of average particle diameter of the colloidal particles was conducted with an ultracentrifugal granulometer (CAPA-5000 manufactured and sold by Horiba Seisakusho K.K.), wherein a test specimen was adjusted to a solids concentration of 0.5% by weight and subjected to centrifugal sedimentation at 5000 rpm. (The same shall apply hereinafter)

A mixture comprising 250 g of the conductive sol liquid obtained above, 225 g of N-methyl-2-pyrrolidone (hereinafter called NMP) and 100 g of an aqueous solution of 25% by weight of zirconium oxychloride in terms of ZrO_2 (hereinafter called ZOC) was heated at 80°C with a rotary evaporator under reduced pressure, thereby distilling off 75 g of water. The liquid obtained was cooled and then thoroughly mixed with 1000 g of a mixture of MeOH/BuOH

(1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Example 2

A mixture comprising 100 g of the conductive sol liquid obtained in Example 1, 45 g of NMP and 20 g of ZOC was heated at 80°C with a rotary evaporator under reduced pressure to distill off 15 g of water. The liquid obtained was cooled and thoroughly mixed with 350 g of a mixture of MeOH/EtOH (1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Example 3

Following substantially the same procedure as described in Example 1, a coating liquid for forming conductive coating was obtained, except that in place of the ZOC used in Example 1, there was used an aqueous solution of zirconium oxynitrate (hereinafter called ZON) in terms of ZrO_2 .

Example 4

A homogeneous mixture comprising 100 g of the conductive sol liquid obtained in Example 1, 90 g of NMP and 40 g of ZOC was heated at 80°C with a rotary evaporator under reduced pressure to distill off 15 g of water. The liquid obtained was cooled and thoroughly mixed with 2800 g of a mixture of MeOH/EtOH (1/1 weight ratio) to obtain a coating liquid for forming conductive

coating.

Example 5

A homogeneous mixture comprising 250 g of the conductive sol liquid obtained in Example 1, 150 g of NMP and 100 g of ZOC was heated at 80°C with a rotary evaporator under reduced pressure and thoroughly mixed with 425 g of a mixture of MeOH/EtOH (1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Example 6

Following substantially the same procedure as described in Example 1, a coating liquid for forming conductive coating was obtained, except that in place of the NMP used in Example 1, there was used 225 g of methyl cellosolve.

Example 7

Following substantially the same procedure as described in Example 1, a coating liquid for forming conductive coating was obtained, except that in place of the NMP used in Example 1, there was used 225 g of ethylene glycol.

Example 8

Following substantially the same procedure as described in Example 1, a coating liquid for forming conductive coating was obtained, except that in place of the NMP used in Example 1, there was used 225 g of N,N-

dimethylformamide.

Example 9

A mixture comprising 83.3 g of a liquid prepared by diluting the conductive sol liquid obtained in Example 1 with water to 12% by weight, 60 g of NMP, 100 g of 5% by weight of ZOC in terms of ZrO_2 , and 256.7 g of a mixture of MeOH/EtOH (1/1 weight ratio) was thoroughly blended to obtain a coating liquid for forming coating.

Example 10

A mixture of 50 g of the fine powder (I) obtained in Example 1 and 200 g of water was fed to a sand mill, and the mixture was subjected for 3 hours to pulverization with media of 1-2 mm ϕ media. After the pulverization, an average particle diameter of particles in the liquid was 0.25 μ m.

Following substantially the same procedure as described in Example 1, a coating liquid for forming conductive coating was obtained except that there was used the conductive sol dispersion obtained in the manner now described was used.

Example 11

To a sand mill was fed a mixture comprising 50 g of the fine powder (I) obtained in Example 1, which had been classified into the powder having a particle diameter of less than 1 μ m, and 200 g of water, and the mixture was

subjected to pulverization for 3 hours with 0.3-1 mm ϕ media to obtain a conductive sol dispersion. Following substantially the same procedure as described in Example 1, a coating liquid for forming conductive coating was obtained except that there was used the conductive sol dispersion obtained above was used.

In this connection, an average particle diameter of particles in the dispersion after the pulverization was 0.08 μ m, and the amount of particles having a particle diameter of less than 0.1 μ m was 65% of the amount of total particles.

Example 12

There were prepared a solution of 79.9 g of indium nitrate in 686 g of water and a solution of 12.7 g of potassium stannate in an aqueous solution of 10% by weight of potassium stannate. Both indium nitrate and potassium stannate solutions obtained above were added to 1000 g of water warmed at 50°C with stirring and subjected to hydrolysis while maintaining a pH of the system at 11, whereby a sol liquid was obtained.

Colloidal particles present in the sol liquid were separated therefrom by filtration, washed to remove by-product salts therefrom, dried, fired at 350°C for 3 hours in air, and then further fired at 600°C for 2 hours in air to obtain a fine powder (II).

Following substantially the same procedure as described in Example 9, a coating liquid for forming conductive coating was obtained except that 50 g of the fine powder (II) obtained above was used.

In this connection, an average particle diameter of particles in the liquid after pulverization was 0.29 μ m.

Comparative Example 1

A homogeneous mixture comprising 25 g of the conductive sol liquid obtained in Example 1, 90 g of NMP and 40 g of ZOC was heated at 80°C under reduced pressure with a rotary evaporator to distill off 25 g of water. The liquid obtained was cooled and thoroughly mixed with 170 g of a mixture of MeOH/EtOH (1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Comparative Example 2

A homogeneous mixture comprising 175 g of the conductive sol liquid obtained in Example 1, 45 g of NMP and 20 g of ZOC was heated at 80°C under reduced pressure with a rotary evaporator to distill off 14 g of water. The liquid obtained was cooled and thoroughly mixed with 574 g of a mixture of MeOH/EtOH (1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Comparative Example 3

A homogeneous mixture comprising 250 g of the

conductive sol liquid obtained in Example 1, 4 g of NMP and 100 g of ZOC was heated at 80°C under reduced pressure, and 200 g of water was distilled off therefrom, whereupon gellation occurred.

Comparative Example 4

A mixture comprising 100 g of the conductive sol liquid obtained in Example 1, which had been diluted with water to 10% by weight, 60 g of NMP, 100 g of 3% by weight of ZOC in terms of ZrO_2 , and 256.7 g of a mixture of MeOH/EtOH (1/1 weight ratio) was thoroughly blended to obtain a coating liquid for forming conductive coating.

In Table 1, the composition of liquid and ratio of components used in each of the foregoing examples and comparative examples were shown.

Using a spinner operated at a rate of 2000 rpm, coated individually on a glass plate were the coating liquids for forming conductive coatings obtained respectively in Examples 1-7, 9, 11 and 12, and Comparative Examples 1, 2 and 4, and on an acrylic resin plate was the coating liquid for forming conductive coating obtained in Example 8.

Respective coatings were obtained on the glass plates thus coated by drying them at 110°C for 10 minutes, followed by firing at 300°C for 30 minutes, and on the acrylic resin plate thus coated by drying at 110°C for 30

minutes. Evaluation of the coatings thus obtained was conducted with respect to the test items mentioned below. The results obtained are shown in Tables 2 and 3.

- (1) Transparency: Total light transmittance (Tt) and haze (H) were measured with a haze computer (manufactured and sold by Suga Shikenki K.K.).
- (2) Glossiness: Glossiness (G) was measured at an angle of measurement of 60° in accordance with the method of measurement of glossiness stipulated in JIS K7105-81. This glossiness is represented by a relative value of the test specimen to the reflectance of the standard plate, and stands in such relationships that the higher is the reflectance, the higher is the glossiness, and the lower is the reflectance, the lower is the glossiness.
- (3) Adhesion: A part of piece of commercially available cellophane tape of 12 mm in width was allowed to stick on the coating while holding the remaining part of the tape perpendicular to the coating, and then the tape is

instantaneously peeled off therefrom to visually observe whether the coating remained undetached or not.

- (4) **Hardness:** Hardness of the coating was measured by subjecting to the pencil hardness test stipulated in JIS D0202-71.
- (5) **Surface resistance:** Surface resistance of the coating was measured with an electrode cell (manufactured and sold by YHP).
- (6) **Permanence properties:** The coated plate was immersed in the following four kinds of liquids to evaluate adhesion of the coating to the plate, and the glossiness and surface resistance of the coating as determined before the test with those as measured after the test.
- 1) Immersion of the plate in 15% by weight ammonia water at room temperature for 120 hours.
 - 2) Immersion of the plate in 10% by weight aqueous NaCl solution at room temperature for 120 hours.
 - 3) Immersion of the plate in boiling water for 30 minutes.
 - 4) Immersion of the plate in 50% by

weight aqueous acetic acid solution
at room temperature for 120 hours.

Table 1

Composition of liquid							Ratio of components						
Example	ZrO ₂	Particle (Note 1)	H ₂ O	Stabi- lizer	Organic solvent	Total	Solids content (Note 2)	Particle ZrO ₂	H ₂ O	H ₂ O ZrO ₂	Stabi- lizer	Stabilizer ZrO ₂	Pot life (R.T)
	(g)	(g)	(g)	(g)	(g)	(g)	(wt%)	(g/g)	(wt%)	(g/g)	(wt%)	(mol/mol)	
1	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	11.2	>3 months
2	5.0	20.0	80.0	45.0	350.0	500.0	5.0	4.0	16.0	16.0	9.0	11.2	>3 months
3	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	11.2	>3 months
4	10.0	20.0	80.0	90.0	2800.0	3000.0	1.0	2.0	2.7	8.0	3.0	11.2	>3 months
5	25.0	50.0	100.0	150.0	425.0	750.0	10.0	2.0	13.3	4.0	20.0	7.5	>3 months
6	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	14.6	>3 months
7	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	17.9	>3 months
8	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	15.1	>3 months
9	5.0	10.0	168.3	60.0	256.7	500.0	3.0	2.0	33.7	33.7	12.0	14.9	>3 months
10	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	11.2	>3 months
11	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	11.2	>3 months
12	25.0	50.0	200.0	225.0	1000.0	1500.0	5.0	2.0	13.3	8.0	15.0	11.2	>3 months
Compar. Example													
1	10.0	5.0	25.0	90.0	170.0	300.0	5.0	0.5	8.3	2.5	30.0	11.2	>3 months
2	5.0	35.0	141.1	45.0	574.0	800.0	5.0	7.0	17.6	28.2	5.6	11.2	>3 months
3	25.0	50.0	75.0	4.0	-	-	-	2.0	-	3.0	-	0.2	gelation
4	3.0	10.0	187.0	15.0	218.0	433.0	3.0	3.3	43.2	62.3	3.5	6.2	>3 months

Note 1) Particle: Conductive substance

Note 2) Solids content: (ZrO₂+conductive substance)

/((ZrO₂+conductive substance+H₂O+stabilizer+diluent)

Table 2

Item No. Example	Transparency		Glossiness	Conductivity	Adhesion	Hardness
	IT (%)	H (%)	G (%)	($\Omega/\square$)		
1	91.5	2.0	136	3×10^6	o	>9H
2	91.0	2.0	131	8×10^5	o	>9H
3	92.0	2.0	140	1×10^6	o	>9H
4	92.5	1.5	131	8×10^6	o	>9H
5	90.0	3.0	126	5×10^5	o	>9H
6	91.0	2.0	134	5×10^6	o	>9H
7	91.3	2.0	130	2×10^6	o	>9H
8	91.0	2.0	133	1×10^6	o	8H
9	92.2	2.5	125	5×10^6	o	>9H
10	89.0	6.5	89	2×10^7	o	9H
11	91.8	1.8	138	2×10^6	o	>9H
12	84.0	8.8	78	2×10^4	o	9H
Compar. Ex. 1	92.0	2.0	145	1×10^{11}	o	>9H
2	90.0	3.0	125	2×10^8	x	7H

Adhesion: The specimen was rated o when its coating did not peel off, and rated x when the coating peeled off.

Table 3

No.	Item	Ammonia water	NaCl	Boiling water	Acetic acid -water
Example 1	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 2	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 3	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 4	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 5	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 6	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 7	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 8	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	146 No change o	No change --- ---	--- --- ---	--- --- ---
Example 9	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 10	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 11	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Example 12	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change No change o	--- --- ---	--- --- ---	--- --- ---
Compar. Ex. 1	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	No change 5×10^{10} o	--- 4×10^{10} ---	--- 2×10^{11} ---	--- 2×10^{10} ---
Ex. 2	Glossiness (%) Surface resistance ($\Omega/\square$) Adhesion	Peeled 10^{13} or more x	No change 5×10^8 ---	Peeled 10^{13} or more ---	No change 2×10^8 ---

The specimen which did not change before and after the test was denoted "no change", and when it changed, a numerical value measured after the test was indicated.

Example 13

Into a hydrogen type ion exchange resin column was passed through at a space velocity of $SV=5$, 2000 g of 5% by weight in terms of SiO_2 of sodium silicylate ($SiO_2/Na_2O = 3$ moles/mole) while keeping at $15^{\circ}C$, whereby a non-sedimentary silica liquid was obtained. This non-sedimentary silica solution as obtained was diluted with water to 2% by weight and subjected for 1 hour to centrifugal sedimentation at 250,000 G, whereupon the precipitates formed were 8% by weight based on the total amount of SiO_2 .

A mixture comprising 50 g of the non-sedimentary silica liquid obtained above, 50g of the conductive sol liquid obtained in Example 1, 20 g of NMP, 10 g of ZOC and 170 g of MeOH/BtOH (1/1 weight ratio) was thoroughly blended to obtain a coating liquid for forming conductive coating.

Example 14

A mixture comprising 50 g of the non-sedimentary silica liquid obtained in Example 13, 200 g of the conductive sol liquid obtained in Example 1, 10 g of NMP, 40 g of ZOC and 1400 g of MeOH/EtOH (1/1 weight ratio) was thoroughly blended to obtain a coating liquid for forming conductive coating.

Example 15

Following substantially the same procedure as

described in Example 13, a coating liquid for forming conductive coating was obtained except that 10 g of the NMP and 380 g of MeOH/BuOH (1/1 weight ratio) were used.

Example 16

A mixture comprising 50 g of the non-sedimentary silica liquid obtained in Example 13, 220 g of the conductive sol liquid obtained in Example 1, 110 g of NMP, 100 g of ZOC and 345 g of MeOH/EtOH (1/1 weight ratio) was thoroughly blended to obtain a coating liquid for forming conductive coating.

Example 17

A homogeneous mixture comprising 50 g of the non-sedimentary silica liquid obtained in Example 13, 100 g of the conductive sol liquid obtained in Example 1, 150 g of N,N-dimethylformamide and 30 g of ZOC was heated at 80°C under reduced pressure with a rotary evaporator to distill off 135 g of water. The liquid obtained was cooled and thoroughly mixed with 405 g of MeOH/BuOH (1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Example 18

Following substantially the same procedure as described in Example 13, a coating liquid for forming conductive coating was obtained except that in place of the NMP used in Example 13, there was used 20 g of methyl

cellosolve.

Example 19

Following substantially the same procedure as described in Example 13, a coating liquid for forming conductive coating was obtained except that in place of the NMP used in Example 13, there was used 20 g of morpholine.

Comparative Example 5

A homogeneous mixture comprising 200 g of the non-sedimentary silica liquid obtained in Example 13, 125 g of the conductive sol liquid obtained in Example 1, 50 g of NMP and 10 g of ZOC was heated at 80°C under reduced pressure with a rotary evaporator to distill off 210 g of water. The liquid obtained was cooled and thoroughly mixed with MeOH/BuOH (1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Comparative Example 6

A mixture comprising 100 g of the non-sedimentary silica liquid obtained in Example 13, 25 g of the conductive sol liquid obtained in Example 1, 40 g of NMP, 20 g of ZOC and 115 g of MeOH/BuOH (1/1 weight ratio) was thoroughly blended to obtain a coating liquid for forming conductive coating.

Comparative Example 7

A homogeneous mixture comprising 100 g of the non-

sedimentary silica liquid obtained in Example 13, 350 g of the conductive sol liquid obtained in Example 1, 40 g of NMP and 20 g of ZOC was heated at 80°C under reduced pressure with a rotary evaporator to distill off 250 g of water. The liquid obtained was cooled and thoroughly mixed with 1340 g of MeOH/BuOH (1/1 weight ratio) to obtain a coating liquid for forming conductive coating.

Comparative Example 8

A homogeneous mixture comprising 500 g of the non-sedimentary silica liquid obtained in Example 13, 500 g of the conductive sol liquid obtained in Example 1, 6 g of NMP and 100 g of ZOC was heated at 80°C under reduced pressure with a rotary evaporator to distill off 900 g of water, whereupon gellation occurred.

Comparative Example 9

A mixture comprising 100 g of the non-sedimentary silica liquid obtained in Example 13, 100 g of the conductive sol liquid obtained in Example 1, 25 g of NMP, 100 g of 5% by weight in terms of ZrO_2 of ZOC and 75 g of MeOH/BuOH (1/1 weight ratio) was thoroughly blended to obtain a coating liquid for forming conductive coating.

In Table 4, the composition of liquid and ratio of components used in each of the foregoing examples and comparative examples were shown.

Using a spinner operated at a rate of 2000 rpm,

coated individually on a glass plate were the coating liquids for forming conductive coatings obtained respectively in Examples 13-17 and Comparative Examples 4-7, and 9, and on an acrylic resin plate were the coating liquids for forming conductive coatings obtained in Examples 18 and 19. Respective coatings were obtained on the glass plates thus coated by drying at 110°C for 10 minutes, followed by firing at 300°C for 30 minutes, and on the acrylic resin plates thus coated by drying them at 110°C for 30 minutes.

Separately, a panel for 14-inch Braun tube kept at 60°C was spray coated with 20 ml of the coating liquid for forming conductive coating obtained in Example 13 under a spray pressure of 3.0 kg/cm². Thereafter, the panel thus coated was dried at 110°C for 10 minutes and then fired at 450°C for 30 minutes to obtain a coating thereon. This example is taken as Example 13 b.

The coatings thus formed were evaluated in the same manner as in Example 1. The results obtained are shown in Tables 5 and 6, respectively.

Table 4

Composition of liquid

Ratio of components

Sample	ZrO ₂	SiO ₂	Conduc- tive Colloid	H ₂ O	Stabi- lizer	Organic Solvent	Total Wt.	Solids content weight (Note 1)	SiO ₂ ZrO ₂	Conductive particle ZrO ₂ +SiO ₂	H ₂ O Total weight	H ₂ O ZrO ₂	Growth inhibitor Total wt.	Growth inhibitor Total wt.	Pot life
	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(wt%)	(g/g)	(g/g)	(wt/%)	(g/g)	(wt/%)	(mol/mol)	
13	2.5	2.5	10.0	95.0	20.0	170.0	300.0	5.0	1.00	2.0	31.7	38.0	6.7	3.3	>3 months
13b	2.5	2.5	10.0	95.0	20.0	170.0	300.0	5.0	1.00	2.0	31.7	38.0	6.7	3.3	>3 months
14	10.0	2.5	40.0	227.5	10.0	1400.0	1700.0	3.1	0.25	3.2	14.0	23.8	0.6	0.8	>3 months
15	2.5	2.5	10.0	95.0	10.0	380.0	500.0	3.0	1.00	2.0	19.0	38.0	2.0	1.6	>3 months
16	25.0	2.5	44.0	298.5	130.0	345.0	825.0	8.7	0.10	1.6	36.2	11.9	13.3	4.5	>3 months
17	7.5	2.5	20.0	15.0	150.0	405.0	600.0	5.0	0.33	2.0	2.5	2.0	25.0	20.0	>3 months
18	2.5	2.5	10.0	95.0	20.0	170.0	300.0	5.0	1.00	2.0	31.7	38.0	6.7	4.3	>3 months
19	2.5	2.5	10.0	95.0	20.0	170.0	300.0	5.0	1.00	2.0	31.7	38.0	6.7	3.7	>3 months
Compar. Example:															
5	2.5	10.0	25.0	87.5	50.0	1075.0	1250.0	3.0	4.0	2.0	7.0	135.0	4.0	2.7	>3 months
6	5.0	5.0	5.0	130.0	40.0	115.0	300.0	5.0	1.0	0.5	43.3	26.0	13.3	3.3	>3 months
7	5.0	5.0	70.0	140.0	40.0	1340.0	1600.0	5.0	1.0	7.0	8.8	28.0	2.5	3.3	>3 months
8	25.0	25.0	100.0	50.0	6.0				1.0	2.0		2.0		0.1	gelation
9	5.0	5.0	20.0	270.0	25.0	75.0	400.0	7.5	1.0	2.0	67.5	54.0	6.3	2.0	>3 months

Note 1) Solids content (ZrO₂+SiO₂+Conductive tin oxide colloid)
 Percentage of solids: Solids weight/Total weight

Table 5

Item No.	Transparency		Glossi- ness G (%)	Conduc- tivity ($\Omega/\square$)	Adhe- sion	Hardness	Coating process
	Tt (%)	H (%)					
Example 13	93.2	2.0	135	5×10^5	o	>9H	Spinner
13b	92.0	5.0	58	8×10^6	o	9H	Spray
14	92.0	2.5	138	7×10^6	o	>9H	Spinner
15	93.0	2.0	133	8×10^6	o	>9H	Spinner
16	90.0	3.0	128	4×10^5	o	>9H	Spinner
17	91.5	2.0	138	5×10^6	o	>9H	Spinner
18	92.5	2.0	133	3×10^7	o	8H	Spinner
19	92.0	2.5	136	4×10^7	o	8H	Spinner
Compr. Ex. 5	93.0	1.5	130	5×10^6	o	>9H	Spinner
6	92.0	1.5	138	5×10^{11}	o	>9H	Spinner
7	89.0	3.5	123	8×10^7	x	7H	Spinner

Adhesion: The specimen rated o when its coating did not peel off, and rated x when the coating peeled off.

Table 6

No.	Item	Ammonia water	NaCl	Boiling water	Acetic acid -water
Example 13	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑
Example 13b	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑
Example 14	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑
Example 15	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑
Example 16	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑
Example 17	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑
Example 18	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑
Example 19	Glossiness (%) Surface resistance (1/1) Adhesion	No change No change o	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑

Table 6 (continued)

No.	Item	Ammonia water	NaCl	Boiling water	Acetic acid -water
Compar. Ex. 5	Glossiness (%)	95	110	108	No change
	Surface resistance($\Omega/\square$)	1×10^{11}	$\leftarrow$	$\leftarrow$	No change
	Adhesion	x	$\leftarrow$	$\leftarrow$	o
Compar. Ex. 6	Glossiness (%)	No change	$\leftarrow$	$\leftarrow$	$\leftarrow$
	Surface resistance($\Omega/\square$)	6×10^{10}	9×10^9	6×10^{11}	3×10^{11}
	Adhesion	o	$\leftarrow$	$\leftarrow$	$\leftarrow$
Compar. Ex. 7	Glossiness (%)	Peeled off	Peeled off	Peeled off	No change
	Surface resistance($\Omega/\square$)	10^{13} or more	10^{13} or more	10^{13} or more	5×10^8
	Adhesion	x	$\leftarrow$	$\leftarrow$	$\leftarrow$

The specimen which did not change before and after the test was denoted "No change", and if it changed, a numerical value measured after the test was indicated.

Notes: Panels for Braun tube processed by the spary method.

Example 20

(Preparation of coating liquid for forming conductive coating)

A coating liquid (liquid A), which is a base liquid, was prepared by mixing 100 g of ethyl silicate 28, 112 g of ZON, 84 g of pure water and 824 g of ethanol together with stirring.

A tin oxide dispersion (liquid B) was prepared by mixing with stirring 560 g of the conductive sol liquid obtained in Example 1 with 1,680 g of ethanol.

The liquids A and B thus obtained were mixed together to obtain a coating liquid for forming conductive coating.

Example 21

Following substantially the same procedure as described in Example 20, a coating liquid for forming conductive coating was obtained except that the liquids A and B used in Example 20 were replaced by those which contained 50 g of ethyl silicate 40, 10 g of ZOC, 688.5 g of a methanol-butanol mixture (weight ratio = 1:1) and 1.5 g of pure water, and which contained 562.5 g of the conductive sol liquid obtained in Example 1 and 3,187.5 g of a methanol-butanol mixture, respectively.

Example 22

Following substantially the same procedure as

described in Example 20, a coating liquid for forming conductive coating was obtained except that the liquids A and B used in Example 20 were replaced by those which contained 30 g of ethyl silicate 28, 55 g of ZON, and 137 g of a methyl cellosolve-ethyl acetate mixture (weight ratio = 1:1), and which contained 66.6 g of the conductive sol liquid and 66.4 g of a methyl cellosolve-ethyl acetate mixture, respectively.

Example 23

(Preparation of dispersion of conductive tin oxide fine powder)

The powder (I) obtained in Example 1 was dispersed in pure water, and the dispersion was treated for 3 hours to obtain a water dispersion of conductive tin oxide having an average particle diameter of 0.2 μ m, said dispersion having a solids concentration of 20% by weight.

(Preparation of coating liquid for forming conductive coating)

A mixture (liquid A) comprising 50 g of ethyl silicate 28, 137.8 g of ZOC, 16.8 g of pure water and 763.4 g of ethanol was prepared.

A mixture (liquid B) comprising 484 g of the conductive tin oxide dispersion obtained above and 1936 g of ethanol was prepared.

The liquid A and liquid B were mixed together with

stirring to obtain a coating liquid for forming conductive coating.

Example 24

(Preparation of conductive indium oxide fine powder)

The fine powder (II) obtained in Example 12 was dispersed in methyl cellosolve, and the dispersion was treated for 3 hours with a sand mill to obtain a methyl cellosolve dispersion of conductive indium oxide having an average particle diameter of 0.3 μ m, said dispersion having a solids concentration of 30% by weight.

(Preparation of coating liquid for forming conductive coating)

A mixture (liquid B) comprising 50 g of ethyl silicate 40, 295 g of ZON, 48 g of pure water and 2733.5 g of methyl cellosolve was prepared. The above-mentioned conductive indium oxide dispersion (liquid A) was further mixed thoroughly with 8842 g of methyl cellosolve, and then the mixture was mixed with stirring with the above-mentioned mixture (liquid B) to obtain a coating liquid for forming conductive coating.

Example 25

(Preparation of non-sedimentary silica liquid)

To the non-sedimentary silica liquid obtained in Example 13 was added and mixed therewith 44.5 g, based on 100 g of the non-sedimentary silica liquid, of NMP as a

growth inhibitor, and the mixture was then heated at 80°C with a rotary evaporator to distill off the greater part of water, whereby a stabilized non-sedimentary silica liquid (liquid C) was obtained. This liquid had the SiO₂ concentration of 10% by weight and the water content of 1.0% by weight.

(Preparation of coating liquid for forming conductive coating)

A mixture (liquid D) comprising 100 g of ethyl silicate 28, 112 g of ZON, 939 g of ethanol, 84 g of pure water and 31 g of the above-mentioned liquid C.

Separately, a mixture (liquid E) comprising 591 g of the conductive sol liquid obtained in Example 1 and 1773 g of ethanol was prepared.

The liquids D and E were mixed together with stirring to obtain a coating liquid for forming conductive coating.

Example 26

Following substantially the same procedure as described in Example 25, a coating liquid for forming conductive coating was obtained except that of the components of the liquid D, the ethanol used was 1104 g and the liquid C used was 280 g, and of the components of the liquid E, the conductive sol liquid used was 840 g and

the ethanol used was 3192 g.

Example 27

Following substantially the same procedure as described in Example 25, a coating liquid for forming conductive coating was obtained except that of the components of the liquid D, the ethanol used was 3344 g and the liquid C used was 2520 g, and of the components of the liquid E, the conductive sol liquid used was 3080 g and the ethanol used was 9240 g.

Properties of the coating liquids for forming conductive coatings obtained in the foregoing examples are shown in Table 7.

Table 7

Example	ZrO ₂ /SiO ₂ (Molar ratio)	MO _x / (ZrO ₂ +SiO ₂) (weight ratio)	Solids conc. (wt%)	SiO ₂ /SiO ₂ (weight ratio)	pH	Pot life
20	0.49	2.0	5.0	-	1.5	3 months or more
21	0.06	5.0	3.0	-	1.9	3 months or more
22	0.80	0.6	10.0	-	1.4	3 months or more
23	1.20	2.0	5.0	-	1.2	3 months or more
24	1.80	3.0	3.0	-	1.1	3 months or more
25	0.44	2.0	5.0	1/9	1.6	3 months or more
26	0.24	2.0	5.0	1/1	1.8	3 months or more
27	0.05	2.0	5.0	9/1	1.9	3 months or more

MO_x : Conductive substance

Solids conc.: MO_x + ZrO₂ + SiO₂

SiO₂/SiO₂ : (SiO₂ of non-sedimentary/(SiO₂ of silicon alkoxide)
sillica liquid)

The conductive coating liquids obtained respectively in Examples 20-27 were individually coated on glass plates using a spinner at a rate of 2000 rpm, and the glass plates thus coated were dried at 110°C and then dried at 250°C to form their respective conductive coatings thereon.

The coatings thus obtained were evaluated in the same manner as in Example 1. The results obtained are shown in Table 8.

Table 8

Example	Tt (%)	G (%)	H (%)	Surface resistance ($\Omega/\square$)	tape test	Hardness	Permanence property test	
							Tt	Adhesion
20	91.5	150	1.5	8×10^5	Accepted	>9H	No change	Accepted
21	92.0	145	1.1	3×10^6	Accepted	>9H	No change	Accepted
22	91.0	156	1.6	2×10^8	Accepted	>9H	No change	Accepted
23	88.0	110	8.0	1×10^7	Accepted	8H	No change	Accepted
24	89.5	100	7.5	2×10^4	Accepted	8H	No change	Accepted
25	91.8	146	1.3	7×10^5	Accepted	>9H	No change	Accepted
26	92.5	140	1.1	5×10^5	Accepted	>9H	No change	Accepted
27	93.2	131	1.1	5×10^5	Accepted	>9H	No change	Accepted

Example 28

(Preparation of partial hydrolyzate of silicon alkoxide)

Liquid A

To 100 g of ethyl silicate-28 was added with stirring 110 g of ethanol and then added 70 g of an aqueous solution of 5% by weight of nitric acid. The mixture was then heated at 60°C and kept at that temperature for 1 hour.

Liquid B

To 100 g of ethyl silicate-40 was added with stirring 200 g of ethanol and then added 100 g of an aqueous solution of 1.0% by weight of acetic acid. The mixture was then heated at 40°C and kept at that temperature for 30 minutes.

(Preparation of conductive substance)

Liquid C

In 100 g of water was dispersed 20 g of the fine powder (I) obtained in Example 1 and pulverized for 3 hours with a sand mill to obtain a dispersion of the fine powder having an average particle diameter of 0.3 μm.

Liquid D

The conductive sol liquid obtained in Example 1 was used as liquid D.

Liquid E

In 100 g of water was dispersed 20 g of the fine

powder (II) obtained in Example 12 and pulverized for 3 hours with a sand mill to obtain a dispersion of the fine powder having an average particle diameter of 0.3 μ m.

Subsequently, to 100 g of the liquid D obtained above was added 11.9 g of ethanol and further added with stirring 3.1 g of 13% by weight of diacetylacetonato-dibutoxy zirconium (ABZ). To the mixture was added 70 g of the liquid A and thoroughly dispersed to obtain a coating liquid for forming conductive coating.

Examples 29-33 and Comparative Example 10

Substantially the same procedure as described in Example 28 was followed except for a change in composition of the coating liquid used in each example as shown in Table 9.

Comparative Example 11

To a mixture comprising 100 g of the liquid D and 11.9 g of ethanol was added with stirring 70 g of the liquid A. In the mixture was then dispersed 3.1 g of 13% by weight of ABZ, whereupon aggregation of colloidal particles took place several minutes after dispersing and the aggregated particles precipitated.

Comparative Example 12

To 35.7 g of ethyl silicate 28 was added with stirring 447.3 g of ethanol followed by further addition of 4 g of ZON and 22 g of water. In the mixture was

thoroughly dispersed 100 g of the liquid D.

The coating liquids thus obtained were individually coated on substrates as shown in Table 10 by the spinner or roll coater method to form their respective coatings thereon.

Evaluation of the coatings thus formed was conducted in the same manner as in Example 1.

In this connection, scratch resistance was measured in the following manner.

That is, an eraser for office use (equivalent to No. 50-50, a product of LION K.K.) was placed on the coating formed on PC (a polycarbonate plate) or glass plate fixed onto a platform scale, and said coating was rubbed 300 times with the eraser under a load of 2 kg to measure all light transmittance and surface resistivity.

The results obtained are shown in Table 10.

Table 9

Example	MO _x (g)	Solvent (g)	AAZ (g)	Silicon alkoxide (g)	Solids concn. (wt%)	$\frac{\text{ZrO}_2}{\text{MO}_x}$ (wt/wt)	$\frac{\text{ZrO}_2}{\text{SiO}_2}$ (wt/wt)	$\frac{\text{MO}_x}{\text{SiO}_2 + \text{ZrO}_2}$ (wt/wt)	Average particle dian. in coating liquid (μm)	Pot life at 30°C
28	liquid D 100	EtOH 11.9	ABZ 3.1	liquid A 100	14.8	0.02	0.057	2.7	0.07	>3 months
29	liquid D 100	EtOH 402.9	ABZ 6.9	liquid A 100	5.1	0.45	0.09	1.8	0.07	>6 months
30	liquid D 100	BuOH/MeOH 2265	ABZ 15.4	liquid B 20	1.0	0.1	1.0	5.0	0.07	>6 months
31	liquid D 100	EtOH/meth- ycello 296.2	ABZ 153.8	liquid A 200	8.0	1.0	1.0	0.5	0.07	>6 months
32	liquid C 100	EtOH 402.9	ABZ 6.9	liquid A 100	5.1	0.45	0.09	1.8	0.3	>6 months
33	liquid E 100	EtOH 402.9	ABZ 6.9	liquid A 100	5.1	0.45	0.09	1.8	0.3	>6 months
Compar. Example	liquid D 100	EtOH 769.2	ABZ 230.8	liquid A 100	5.0	1.5	3.0	0.5	0.07	>3 months
10	liquid D 100	EtOH 11.9	ABZ 3.1	liquid A 100	14.8	0.02	0.057	2.7	-	Aggregated
11	liquid D 100	EtOH 447.3	zircon nitrate 4.0	ES-28 35.7	5.1	0.05	0.1	1.8	0.16	7 days

1. AAZ=Diacetylacetonate-dialkoxy zirconium 2. ABZ=Diacetylacetonate-dibutoxy zirconium
 3. Methycello=Methyl cellosolve 4. Zirco nitrate=Zirconium nitrate 5. ES-28=Ethyl silicate-28

Table 10

Example	Coating process	Substrate	Firing temp. (°C)	Rs ($\Omega/\square$)	Tt (%)	H (%)	G (%)	Adhesion	Scratch resistance		Alkali resistance	
									Tt (%)	Rs ($\Omega/\square$)	Adhesion	Rs ($\Omega/\square$)
28	Spinner	PC	150	2×10^6	90.2	1.2	154	0	90.2	2×10^6	0	2×10^6
29	Roll coater	glass	150	1×10^7	90.8	0.9	153	0	90.5	1×10^7	0	1×10^7
29	Roll coater	glass	200	5×10^6	90.5	0.9	152	0	90.2	5×10^6	0	5×10^6
29	Roll coater	glass	450	5×10^6	90.0	0.9	156	0	90.0	5×10^6	0	5×10^6
30	Roll coater	glass	250	3×10^9	92.5	2.5	148	0	92.3	3×10^9	0	3×10^9
31	Roll coater	glass	400	5×10^8	90.6	1.0	156	0	91.8	5×10^8	0	5×10^8
32	Roll coater	glass	200	5×10^6	92.1	4.0	128	0	91.8	6×10^6	0	5×10^6
33	Roll coater	glass	200	3×10^3	90.5	5.1	131	0	90.1	6×10^3	0	3×10^3
Compar. Example												
10	Roll coater	glass	200	1×10^{12}	Blushed	Blushed	Blushed	X	-	-	-	-
12	Spinner	glass	150	8×10^6	90.7	1.1	143	0	90.2	3×10^8	X	2×10^9
12	Spinner	glass	300	6×10^6	90.4	1.3	147	0	90.1	6×10^6	0	6×10^6
12	Roll coater	glass	150	1×10^{10}	90.8	2.8	126	0	91.0	1×10^{10}	X	1×10^{10}
12	Roll coater	glass	300	5×10^9	90.4	3.0	130	0	91.0	5×10^9	0	5×10^9
12	Roll coater	glass	450	1×10^9	90.0	3.0	135	0	90.7	1×10^9	0	1×10^9

PC= a polycarbonate plate, Glass= a glass plate, and the number of rotation of the spinner is 2000 rpm.

Example 34

A panel for 14-inch Braun tube kept at 60°C was spray coated under a spray pressure of 3.0 kg/cm² with 20 ml of the coating liquid for forming conductive coating obtained in Example 13. Thereafter, the panel thus coated was dried at 110°C and then fired at 450°C for 30 minutes.

Example 35

Example 34 was repeated except that the panel for 14-inch Braun tube was kept at 70°C.

Example 36

Example 34 was repeated except that in place of the panel for 14-inch Braun tube, an acrylic resin plate was used, and the plate was dried at 110°C for 30 minutes without subjecting it to subsequent firing.

Example 37

A panel spray coated with the coating liquid for forming conductive coating of Example 34 and dried at 110°C for 30 minutes was kept at 60°C, and the panel was then spray coated under a spray pressure of 3.0 kg/cm² with 20 ml of a coating liquid containing transparent protective components, which coating liquid had been obtained by homogeneously mixing together 100 g of ethyl silicate 28 (a product of Tama Kagaku K.K.), 749 g of isopropanol, 84 g of water and 0.5 g of 35% by weight of hydrochloric acid. Thereafter, the panel thus coated was

dried at 110°C for 10 minutes and then fired at 450°C for 30 minutes.

Example 38

A homogeneous mixture comprising 50 g of the non-sedimentary silica dispersion obtained in Example 13 and 43 g of NMP was heated at 80°C to distill off 93 g of water. The liquid obtained was cooled and mixed with 120 g of ethanol to obtain a coating liquid containing transparent protective components.

The panel obtained in Example 34 was kept at 60°C and spray coated under a spray pressure of 3.0 kg/cm² with 20 ml of the coating liquid containing transparent protective components obtained above. Thereafter, the panel thus coated was dried at 110°C for 10 minutes and then fired at 250°C for 30 minutes.

Example 39

A coating liquid containing transparent protective components was obtained by mixing 10 g of 50% by weight of silicon resin (a xylene-diluted product of Kanegafuchi Kagaku Industry Co., Ltd. under a trade name of Cemlack) with 157 g of methyl ethyl ketone.

The panel obtained in Example 13 was kept at 60°C and spray coated under a spray pressure of 3.0 kg/cm² with 20 ml of the coating liquid containing transparent

protective components obtained above. Thereafter, the panel thus coated was dried at 110°C for 10 minutes.

Comparative Example 13

Example 34 was repeated except that the panel for 14-inch Braun tube was kept at 110°C.

Comparative Example 14

Example 34 was repeated except that the coating liquid for forming conductive coating obtained by thoroughly mixing together 100 g of the non-sedimentary silica liquid obtained in Example 13, 50 g of the conductive sol liquid obtained in Example 1, 25 g of NMP and 125 g of ethanol was used. That is no oxyacid salt of zirconium was used.

Comparative Example 15

With the purpose of preparing a coating liquid for forming conductive coating, 100 g of the non-sedimentary silica liquid obtained in Example 13, 100 g of the conductive sol liquid obtained in Example 1, 20 g of ZON and 380 g of MeOH/EtOH (1/1 weight ratio) were thoroughly mixed together, whereupon gellation occurred 30 minutes thereafter. (No growth inhibitor was used.)

Comparative Example 16

In the coating liquid for forming conductive coating obtained in Example 13 was immersed a glass plate (200 x 200 x 3 mm), and the plate was then pulled up

therefrom at a rate of 5 cm/min. Thereafter, the plate thus treated was dried at 110°C for 30 minutes and then fired at 450°C for 30 minutes.

Evaluation of the foregoing examples and comparative examples was conducted in the same manner as in Example 1.

The resolving power was measured by the method as described in the present specification. Rz was measured in accordance with the method of measurement of Rz stipulated in JIS B0601-82 using a feeler type membrane pressure gage (manufactured and sold by Frank Tyler Hobsson Co., under a trade name of Taristep).

Evaluation of the coating film strength was conducted in the following manner. That is, an eraser for office use (equivalent to No. 50-50, a product of LION K.K.) placed on the coating of the panel or acrylic resin plate fixed onto a platform scale was allowed to move under a load of 2 kg back and forth between two points on said coating separated by a definite distance until the surface of said panel or acrylic resin plate is exposed, and the number of times of reciprocating movements of the eraser required for was sought, on the basis of which the coating film strength was determined.

In addition to the Example 1 of the test for permanence properties described previously in the present

specification, the test for permanence properties conducted herein included 5) immersion of the plate in acetone at room temperature for 1 week, 6) immersion of the plate in ethanol at room temperature for 1 week, and 7) immersion of the plate in n-propanol at room temperature for 1 week.

The results obtained are shown in Tables 11 and 12, respectively.

Table 11

Item No.	Resolving power (Bar/cm)	Glossi- ness G (%)	Surface resistance ($\Omega/\square$)	Adhe- sion	Film strength (No. of times)	Average roughness Rz (μm)
Example						
34	65	62	8×10^6	o	100	0.95
35	65	63	7×10^6	o	100	0.98
36	65	60	8×10^7	o	50	1.10
37	70	54	9×10^6	o	300	1.55
38	70	53	8×10^6	o	200	1.63
39	65	57	2×10^7	o	150	1.48
Compar. Ex. 13	20	20	5×10^6	x	<25	6.20
14	65	60	5×10^6	o	150	1.20
15	-	-	-	-	-	-
16	75	142	2×10^6	o	250	0.10

Notes: In Comparative Example 15, the coating liquid for forming conductive coating gelled and no coating was formed.

Table 12

Sample	Ammonia water	H ₂ O	Boiling water	Acetic acid-water	Acetone	Ethanol	n-Propanol
33							
Glossiness(%)	60	61	62	60	61	61	61
Surface(Ω/□)	No change	←	←	←	←	←	←
Resistance							
Adhesion	0	←	←	←	←	←	←
34							
Glossiness(%)	60	62	63	61	62	61	62
Surface(Ω/□)	No change	←	←	←	←	←	←
Resistance							
Adhesion	0	←	←	←	←	←	←
35							
Glossiness(%)	57	59	58	56	59	59	59
Surface(Ω/□)	No change	←	←	←	←	←	←
Resistance							
Adhesion	0	←	←	←	←	←	←
36							
Glossiness(%)	53	54	54	53	54	54	54
Surface(Ω/□)	No change	←	←	←	←	←	←
Resistance							
Adhesion	0	←	←	←	←	←	←
37							
Glossiness(%)	51	52	50	54	53	53	53
Surface(Ω/□)	No change	←	←	←	←	←	←
Resistance							
Adhesion	0	←	←	←	←	←	←
38							
Glossiness(%)	55	56	55	57	57	57	57
Surface(Ω/□)	No change	←	←	←	←	←	←
Resistance							
Adhesion	0	←	←	←	←	←	←
Compar. Example 13							
Glossiness(%)	Peeled off	←	←	←	←	←	←
Surface(Ω/□)	peeled off	←	←	←	←	←	←
Resistance							
Adhesion	peeled off	←	←	←	←	←	←
14							
Glossiness(%)	Peeled off	170	85	60	60	60	60
Surface(Ω/□)	peeled off	2×10^{13}	5×10^8	No change	←	←	←
Resistance							
Adhesion	peeled off	X	X	0	←	←	←
16							
Glossiness(%)	140	141	142	140	141	141	141
Surface(Ω/□)	No change	←	←	←	←	←	←
Resistance							
Adhesion	0	←	←	←	←	←	←

COMMERCIAL POSSIBILITY OF THE INVENTION

Glass or plastic substrates provided with transparent conductive coatings formed by the use of the coating liquid for forming conductive coatings of the present invention are utilizable in the field of the articles of manufacture where antistatic function and non-glare are required, such as front panels for display devices such as CRT or LCD, glass plates for duplicators, panels for instruments, glass for clean rooms, transparent digitizers, telewriting terminals and the like.



What is claimed is:

1. A coating liquid for forming conductive coating, characterized by containing a zirconium oxyacid salt and a conductive substance dissolved or dispersed homogeneously in a mixed solvent comprising water, an organic solvent and a stabilizer.
2. A coating liquid for forming conductive coating, characterized by containing a zirconium oxyacid salt, non-sedimentary silica and a conductive substance dissolved or dispersed homogeneously in a mixed solvent comprising water, an organic solvent and a stabilizer.
3. A coating liquid for forming conductive coating, characterized by containing a zirconium oxyacid salt, silicon alkoxide or its derivative and a conductive substance dissolved or dispersed homogeneously in a mixed solvent comprising water and an organic solvent.
4. A coating liquid for forming conductive coating, characterized by containing a zirconium oxyacid salt, silicon alkoxide or its derivative and a conductive substance dissolved or dispersed homogeneously in a mixed solvent comprising water, an organic solvent and a stabilizer.
5. A coating liquid for forming conductive coating, characterized by containing diacetylacetonato-dialkoxy zirconium, a partial hydrolyzate of silicon alkoxide or



its derivative, and a conductive substance dissolved or dispersed homogeneously in a mixed solvent comprising water and an organic solvent.

6. The coating liquid for forming conductive coating as claimed in any of claims 1-5 wherein the conductive substance is tin oxide, tin oxide doped with antimony, fluorine or phosphorus, indium oxide, or indium oxide doped with tin or fluorine.

7. The coating liquid for forming conductive coating as claimed in any of claims 1-6 wherein the organic solvent is selected from alcohols, esters, ethers, and ketones.

8. The coating liquid for forming conductive coating as claimed in any of claims 1-7 wherein the zirconium oxyacid salt is zirconium oxychloride, zirconium oxynitrate, zirconium oxyacetate or zirconium oxyoxalate.

9. The coating liquid for forming conductive coating as claimed in claim 1 or 2, or in any of claims 6-8, wherein the stabilizer is ethylene glycol, N-methyl-2-pyrrolidone, ethyl cellosolve, methyl cellosolve or N,N-dimethylformamide.

10. The coating liquid for forming conductive coating as claimed in claim 2 or 4, or in any of claims 6-9, wherein the non-sedimentary silica is such as to give a sediment of less than 30% by weight of the total amount of



SiO_2 when an aqueous solution of 2.0% by weight in terms of SiO_2 of the non-sedimentary silica is subjected for 1 hour at 250,000 G to centrifugal sedimentation.

11. The coating liquid for forming conductive coating as claimed in any of claims 3-8 wherein the silicon alkoxide or its derivative is a compound or its condensates having 1 to 4 alkoxy groups of 1 to 8 carbon atoms represented by $\text{SiH}_a(\text{OR})_b$ ($a=0-3$, $b=1-4$, $a+b=4$, and R is alkyl), or $(\text{R}'\text{O})_a\text{Si}(\text{OR})_b$ or $\text{R}'_a\text{Si}(\text{OR})_b$ ($a=0-3$, $b=1-4$, $a+b=4$, and R and R' are each alkyl), or its derivative in which a part of H has been substituted with Cl, vinyl or the like group.

12. A glass or plastic substrate on which a transparent conductive coating has been formed, characterized by having a glossiness of less than 190% as measured at an angle of measurement of 60°C . in accordance with the method of measurement of glossiness stipulated in JIS K 7105-81, a surface resistance of $10^3-10^{11} \Omega/\square$, a total light transmittance of at least 80% and a haze of less than 10%.

13. The glass or plastic substrate on which a transparent conductive coating has been formed as claimed in claim 12 wherein the transparent conductive coating comprises zirconium oxide and a conductive substance.

14. The glass or plastic substrate on which a



transparent conductive coating has been formed as claimed in claim 12 wherein the transparent conductive coating comprises zirconium oxide, silicon oxide and a conductive substance.

15. The glass or plastic substrate on which a transparent conductive coating has been coated as claimed in any of claims 12-14 wherein the transparent conductive coating is formed from the coating liquid for forming a transparent conductive coating as claimed in any of claims 1-11.

16. A display device comprising a front panel having formed on the surface thereof a transparent conductive coating, characterized in that the transparent conductive coating comprises zirconium oxide, silicon oxide and a conductive substance and has a surface resistivity of $10^3 - 10^{11} \Omega / \square$.

17. A display device comprising a front panel having formed on the surface thereof a transparent conductive coating, characterized in that the transparent conductive coating comprises zirconium oxide, silicon oxide and a conductive substance, and the front panel having formed said transparent conductive coating thereon has a glossiness of 30-100% as measured at an angle of measurement of 60° in accordance with the method of measurement of glossiness stipulated in JIS K 7105-81, a



resolving power of at least 50 bars/cm, and surface resistivity of $10^3-10^{11} \Omega / \square$.

18. The display device as claimed in claim 16 or 17 wherein the transparent conductive coating comprises 0.8-65.9% by weight of zirconium oxide, 0.8-65.9% by weight of silicon oxide and 33.3-83.3% by weight of a conductive substance.

19. A method of processing a front panel for display device, characterized in that the front panel previously heated to and kept at $40-90^{\circ}\text{C}$ is coated by the spray method with a coating for forming conductive coating, followed by drying and/or firing.

20. A method of processing a front panel for display device, characterized in that the front panel previously heated to and kept at $40-90^{\circ}\text{C}$ is coated by the spray method with a coating liquid for forming conductive coating followed by drying and/or firing, thereafter the resulting front panel is heated to and kept at $40-90^{\circ}\text{C}$ and coated by the spray method with a coating liquid comprising transparent protective components.

21. The method of processing a front panel for display device as claimed in claim 19 or 20 wherein the coating liquid for forming conductive coating is the one claimed in any of claims 2-5.

22. The method of processing a front panel for display



device as claimed in claim 20 wherein the coating liquid comprising transparent protective component is homogeneous dispersion of silicon alkoxide in water, an acid and an organic solvent.

23. The method of processing a front panel for display device as claimed in claim 20 wherein the coating liquid comprising transparent protective components is the coating liquid claimed in any of claims 2-5, from which the conductive substance has been excluded.