

Nov. 21, 1950

J. M. SNYDER

2,530,546

ELECTROPHORETIC DEPOSITION OF INSULATING COATING

Filed June 8, 1946

FIG. 1

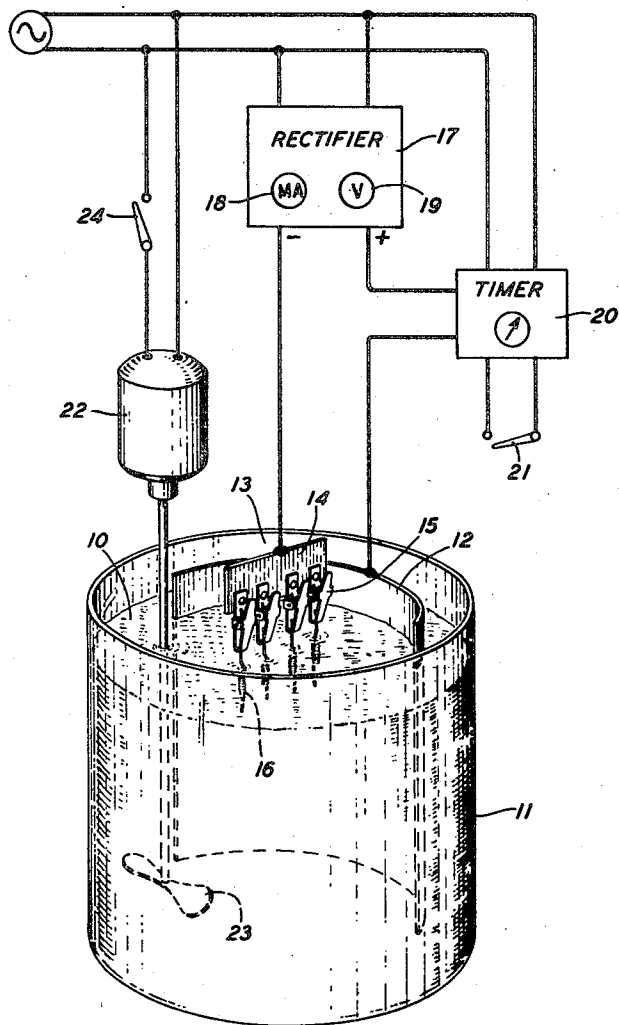


FIG. 2

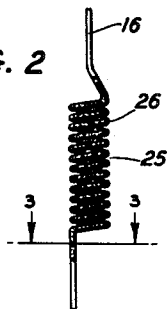


FIG. 3



INVENTOR
J. M. SNYDER
BY

Walter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

2,530,546

ELECTROPHORETIC DEPOSITION OF
INSULATING COATING

James M. Snyder, Long Island City, N. Y., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application June 8, 1946, Serial No. 675,345

4 Claims. (Cl. 204—181)

1

This invention relates to coating compositions and methods and more particularly to such compositions employed in electrophoretic deposition methods.

In many commercial applications and particularly in the electrical arts, metallic apparatus elements are provided with a protective film or layer to inhibit corrosion or wear and also to provide an insulating or dielectric surface thereon to prevent electrical breakdown of the element, for example a wire or conductor, under applied potentials. Similarly, when the basic element is an insulating substance, such as paper or cellulose, it is desirable in some instances to form a conductive metallic layer or lamina thereon, or several different metal layers superimposed on the insulating surface. In other applications, the metallic layers may be alternated with insulating layers on the basic element to build up a composite unitary coating for a desired purpose.

The general methods of deposition, namely, painting, spraying, electroplating, dipping, diffusion and the like, are sometimes inapplicable, either because of dimensional restrictions, lack of control of coating thickness or other physical and chemical characteristics of the base or coating vehicle.

For certain applications, the deposition of insulating materials on a basic element by cataphoresis offers a more reliable and controllable technique to overcome the deficiencies of the general deposition methods. However, a primary disadvantage of this method, which has deterred universal adoption heretofore, has been the low cataphoretic properties and precipitation efficiency of the electrolyte employed in such method.

An object of this invention is to enhance the precipitation efficiency of the electrolyte employed in cataphoretic deposition processes.

Another object of the invention is to improve the stability of the electrolyte so that uniform deposition is attained.

Another object of the invention is to increase the precipitation activity of the electrolyte so that greater coating speed is assured.

Still another object of the invention is to control the deposition rate at low operating potentials.

A further object is to eliminate the necessity for high technical skill in performing the coating operation so that superior results may be attained with relatively unskilled labor.

These objects may be realized, in accordance

2

with this invention, by the employment of an improved coating composition especially adapted for cataphoretic deposition processes. In an illustrative case, a hydrated metal oxide is associated with the normally inert compound or compounds held in suspension in the electrolyte and the combined solids are deposited on the base to be coated by precipitation at a low potential in a short interval of time. The coating attained is uniform in quality and the process may be readily utilized in mass production for numerous applications in industrial products.

Specifically, the coating composition of this invention is particularly advantageous in the cataphoretic coating of fine wire heater elements employed in electronic discharge devices. The heater element is insulated with a highly refractory material, such as vitrified aluminum oxide, which provides a sintered covering of high dielectric characteristics, to protect the heater element from contact with associate elements in the discharge device. While the aluminum oxide has the desired properties for the purposes described, it is normally deficient in cataphoretic properties so that a low efficiency deposition rate is attained when employed in electrolytes for coating by cataphoresis.

In accordance with a feature of this invention a cataphoretic activator material is added to the electrolyte to increase the deposition efficiency of the dielectric substance, in the form of a hydrous metal oxide, such as hydrated aluminum oxide of high purity, which not only increases the potency of the electrolyte so that a high deposition rate is accomplished but also the hydroxide material is of the same basic coating substance applied to the heater element and adds to the final coating without introducing extraneous or deleterious matter. Furthermore, the coating process may be performed at a low voltage and current consumption and at a relatively rapid rate of deposition to attain a uniform coating of controlled density without the employment of highly skilled labor.

Other hydrated metal oxides may be employed in the cataphoretic process and combined with dielectric material or metals for depositing a surface or film on metal or insulating bases for attaining the desired final coating on the base. The process may be utilized for the production of protective or decorative coatings on insulated wire or corrosion and wear resistant surfaces on metal products, for forming coatings on electrodes, such as emissive or electron inhibiting films in electronic discharge devices, for electro-

forming of parts from metals, ceramic or other materials, for film stripping production and for deposition of alloys of constant ratio predetermined by the constituents of the electrolyte.

An important advantage of the composition of this invention is the stability of the electrolyte and its tolerance for water without attendant deteriorating effects, since the electrolyte has low hygroscopicity under atmospheric conditions of operation and highly reproducible results may be attained regardless of the shape and size of the base element desired to be coated. Furthermore, the low current dissipated in the deposition technique and the low voltages sufficient for efficient deposition in short intervals of time facilitate the coating results without dangerous hazards to the operator.

The utility and advantages of the invention will be more apparent from the following detailed description when considered in connection with the accompanying drawing. In the drawing:

Fig. 1 is a partly diagrammatic view of a cathaphoretic coating apparatus suitable for carrying out the invention;

Fig. 2 is a view in elevation of a heater element provided with a uniform insulating coating in accordance with this invention; and

Fig. 3 is an enlarged cross-section view of the heater element taken along the line 3—3 of Fig. 2.

Referring to the drawing, the cathaphoretic method of coating involves an electrolyte 10 contained in a cell 11 in which a large surface anode 12 is submerged, the anode preferably being a metal plate, such as nickel. A cathode 13, which in one form may be a metallic support 14 having a plurality of metallic clips 15 depending therefrom, also is utilized, the clips supporting a number of heater elements 16, shown more clearly in Fig. 2. The electrodes of the cell 11 are connected to a direct current supply such as a rectifier 17 having a milliammeter 18 and a voltmeter 19 associated therewith for indicating the current consumption and operating voltage employed in the electrolytic cell 11. An adjustable timing device 20 is connected in series with the direct current supply from the rectifier and the circuit is controlled by a foot switch 21, the positive side of the circuit being connected to the anode 12 and the negative terminal to the cathode 13 of the cell. In addition, an agitator or stirring device 22 is provided so that a propeller 23 enters the electrolyte in the cell, the device 22 being controlled by another foot switch 24.

The heater element 16, as shown in Fig. 2, is preferably of tungsten, and in one form may be a single closely wound spiral 25 having the turns so close that it is not generally possible to uniformly apply an insulating coating on the turns by the usual methods of coating. Exceedingly uniform coatings are readily obtained in accordance with this invention to provide a relatively dense and accurately controlled insulating coating or surface 26, as shown in Fig. 3. Since the tungsten heater is intended for operation in a high power output electronic discharge device, the temperature of the heater is very close to the fusion temperature of the insulating coating, so that the dielectric constant and melting point of the ceramic material of the coating must be relatively high and no impurities must be permitted to enter the coating which will lower its melting point and, therefore, deleteriously affect the dielectric function of the coating on the heater element. A desirable ceramic material for the coating of the heater is sintered or fused

aluminum oxide particles 10 to 20 microns in diameter. While fused aluminum oxide when associated with a binder medium is highly efficacious as an insulating coating as applied by the usual coating technique of spraying or painting on the heater, this material is inert as to cathaphoretic properties when employed in a suspension medium in electrophoresis deposition methods, because of the absence of ions to influence conduction in an electrolyte medium. Consequently, practically no deposition or very low efficiency coating is obtained with the oxide alone in the electrolyte.

In order to activate the inert particles of aluminum oxide in the electrolyte, in accordance with a feature of this invention, an accelerator substance is added to the electrolyte in the form of a hydrated metal oxide, specifically aluminum hydroxide, in a highly purified state, to impart the necessary ionic action in the electrolyte so that a high deposition rate is attained in precipitating the solid particles out of suspension in the electrolyte and on the heater element 16, to form an adherent coating thereon. The advantages of the activator substance in the electrolyte include: The provision of a gelatinous material which is absorbed on the inert particles which breaks down under the applied potentials to supply hydrogen or hydroxyl ions; either in basic or acid reaction, the conduction of the current through the electrolyte thereby to precipitate the combined particles on the base element to be coated. Furthermore, the activator substance carried along with the inert particles and deposited on the heater element does not introduce any foreign material in the coating on the heater since, on final firing of the coating to vitrify the matrix on the heater, the hydroxide is converted to oxide so that the coating has a high dielectric constant. Another feature of the activator material is the binding effect produced by the gelatinous coating on the particles, whereby a compact and tenacious coating on the heater is realized.

Since impurities must be eliminated in the deposition of the coating on the heater element to prevent lowering the fusion point of the coating, it is recommended that the use of commercial metallic hydroxide be avoided in the electrolyte because of variable control of impurities in such compounds. For the purposes of the invention, in this specific aspect, the hydroxide activator may be prepared as follows: A quantity of aluminum nitrate $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, C. P., such as 144 grams, is dissolved in three liters of distilled water to provide a clear solution. A separate solution should also be prepared of approximately 46 grams of sodium hydroxide NaOH , C. P., in 100 cubic centimeters of water. After these solutions have been obtained, the sodium hydroxide solution is slowly added to the nitrate solution while vigorously stirring the mixture until the pH has attained a value of 7 ± 1 , when the addition of sodium hydroxide solution is stopped. The aluminum hydroxide suspension derived from the above reaction is vacuum filtered to separate a concentrated cake from the filter medium which is discarded. The resultant cake is broken in three liters of water and thoroughly dispersed, for example by a high speed agitator, after which the suspension is vacuum filtered and washed several times to produce a purified cake of aluminum hydrate which is finally reduced to a paste form and stored in a closed glass or porcelain container. The hy-

5

drated alumina is relatively pure since the above treatment removes the greater percentage of harmful ingredients, such as metallic impurities and sodium from the initial commercial products, and the activator material is especially suitable for inclusion in the electrolyte, according to this invention. The tolerable impurities permitted in the above composition should not be more than one per cent of metallic impurities nor more than one-tenth of one per cent of sodium based on the aluminum oxide equivalent concentration of the mixture. The sodium content is particularly important since the possibility of excess sodium vapor in a high vacuum electronic device would readily render the device unsuitable for efficient operation in a relatively short time.

While the employment of a highly purified hydrated activator is stressed in the heater coating technique in accordance with the invention, there may be circumstances in which the commercial type of metallic hydroxide would be suitable for use in the electrolyte where the amount of impurities would not adversely affect the coating procedure.

The preparation of the electrolyte 10 for coating a heater element, in accordance with this invention, is as follows:

Example 1.—Assuming the set-up shown in Fig. 1 is ready, the first step is to fill the cell to a desired depth with the electrolyte which is compounded in accordance with the following procedure. The ingredients are 30 grams of the purified aluminum hydroxide, as described above, 600 grams of insoluble aluminum oxide, 10 to 20 microns particle size, and a quantity of polar solvents, preferably distilled water and alcohol in the proportion of 360 milliliters of water and 840 milliliters of alcohol. The hydroxide paste is mixed with the fluid solvents until the paste is thoroughly dispersed in the suspension liquid. The mixture is passed through a homogenizer or colloid mill to gelatinize the particles and then the inert aluminum oxide particles are mixed with the liquid suspension and rolled in a sealed bottle for twenty-four hours. The gelatinous hydroxide is absorbed on the crystalline particles of aluminum oxide by the thorough mixing and the suspension forms a milky white vehicle suitable for the deposition process.

When the cell is filled with the electrolyte, the agitator 22 is started by closing switch 24 to maintain complete suspension of the coated particles of aluminum oxide in the electrolyte, since the particles being inert in the polar solvent, readily separate out of suspension in the cell. To initiate deposition on the heater element 16 immersed in the electrolyte, switch 21 is operated to apply a direct current potential of about 15 to 20 volts between the anode 12 and the cathode 13 supporting the heaters. The current flow through the electrolyte is approximately 15 milliamperes as indicated on the meter of the rectifier 17. At the same time, the timer 20 is adjusted to control the coating period which may be, for example, thirty seconds. During the coating period the agitator is stopped, or at least reduced in speed, since it has been found that a denser coating is more readily obtained when the electrolyte is quiescent or substantially so.

The reaction in the electrolyte under the low potential applied to the electrodes is to greatly increase the activity of the inert particles in suspension by the hydroxide accelerator absorbed

6

film thereon so that they acquire a positive charge of some magnitude and are readily drawn to the negative electrode and precipitated on the heater element 16 in a uniform coating. At the termination of the time interval of, say, 30 seconds, a dense uniform coating is formed on the convolute heater wire involving the minute particles of sintered aluminum oxide having an absorbed film of amorphous aluminum hydroxide compacted on the surface of the wire so that the coating matrix completely insulates the closely spaced turns of the helical heater element. The gelatinous nature of the metallic hydroxide film also serves as a binder for the coating on the heater.

The amorphous hydroxide film breaks down electrolytically in the cell either as an acid or base in the following manner to form positive ions on the surface of the inert oxide particles and thereby create cataphoretic properties in the particles so that they are precipitated on the cathode heater element in the electrolyte. In the basic reaction, positive charges of Al^{+++} and 3 hydroxyl negative ions are formed and in the acid reaction positive H^+ ions and AlO_2^- negative ions are formed so that the positive charges on the particles render them sufficiently active to travel to the cathode or negative electrode in the suspension to increase the build-up of coating on the heater elements.

The electrolyte involving the hydroxide activator is exceedingly stable on exposure in the atmosphere, has a low value of hygroscopicity and a greater tolerance for water so that the activity of the solids in the fluid medium is not altered by variation in moisture content of the electrolyte.

Furthermore, the composition of the electrolyte permits more accurate control of coating thickness and structure, gives more uniform coating distribution on the base to be coated and provides simpler equipment for attaining cataphoretic deposition of inert substances with greater rapidity than was possible heretofore. The combined coating on the heater element also has another advantage since the applied coating, while sufficiently tenacious to withstand ordinary handling, is not in such a state as to withstand rough manipulation. This is overcome by firing the coating at a temperature of $1700^\circ C.$ either in hydrogen or air, to vitrify the coating and during this treatment the hydroxide is converted to sintered aluminum oxide in situ, so that the final covering has a high melting point which is above the operating temperature of the heater element in use. Another advantage of the coating technique, in accordance with this invention, is the high quality of deposition attained with a minimum of technical skill of the operator and for some purposes in the economy of materials employed in the process.

The cataphoretic coating process of this invention is not limited to the specific heater element coating above described, since a wide range of utility may be realized in applying insulating and metallic films or layers to a variety of materials, both metal and non-metal, regardless of the configuration of the base, to attain the desired deposition of surfaces by electrophoresis. Furthermore, the invention is not limited to the inert particles being aluminum oxide since other inert insulating or dielectric materials may be employed in the process and a number of different hydrated metal oxides may be substituted for the aluminum hydroxide as the activator component

of the electrolyte. For example, other hydrous metal oxides may be introduced in the suspension to achieve the same result, such as hydroxides of the iron group, namely nickel, iron and cobalt, and also amphoteric hydroxides, such as chromium, manganese and beryllium and hydrous oxides of other metals having similar cataphoretic properties. In the class of inert substances suitable for use in the techniques of this invention are: Zirconium and copper and their compounds, alkaline earth carbonates, such as barium and strontium, powdered glass, carbon black, woodflour, and other dielectric and ceramic materials which are desired to be deposited on a base element, either of metal, insulating or other construction. Furthermore, the nature of the base which is to be coated does not have any influence on the deposition since satisfactory coating is equally possible on molybdenum, nickel, copper and other metals and also on a dielectric base, provided a conductive film is previously applied thereto for forming the ionized particles into a coherent matrix thereon. Similarly, the ionizing solvent of the electrolyte may be varied with the solids in suspension. Pure water has given satisfactory results in some applications, but in general mixtures of water with other polar solvents, such as methyl alcohol, ethyl alcohol, isopropanol, dioxane or ethylene glycol may be used. Mixtures with greater than 70 per cent organic solvent produce excellent results although at some higher ratio the suspensions pass their maximum efficiency.

The strength of the coating matrix may be increased by adding a binder material in the electrolyte, the binder substance being deposited along with the inert finely divided particles to provide adherence of the matrix on the base. Binders which may be employed are organic materials, such as polyvinyl alcohol, urea and similar substances for protecting the coating matrix against injury.

While the heater coating above described represents one example of the utility of the invention in the electronic art, there are several other applications which readily present themselves as of economic value in the deposition of coatings on electrodes in discharge devices. Some further examples of the variety of coating techniques will be described to indicate the scope of the invention as applied to other fields of industry, it being understood that other applications and modifications may be made within the scope and spirit of this invention.

Example 2.—The development of a uniform coating of definite thickness for a complex matrix on the surface of a filamentary or cylindrical cathode surface for the production of a highly emissive foundation is a definite problem which can be met by cataphoretic deposition, particularly if the filamentary cathode is in helical form. The general materials employed in relatively low emitters are the alkaline earth metals, particularly barium and strontium, applied to the cathode in the form of compounds and activated in the final processing of the device to influence copious emission of electrons in the coating on the cathode. The alkaline earth compounds, specifically barium and strontium carbonates, may be suspended in a polar solvent or mixture thereof, such as distilled water and alcohol, and a cataphoretic activator material of aluminum hydroxide, as described above, added to the suspension to be absorbed on the inert particles of carbonates in the electrolyte, to increase the

cataphoretic properties of the solids in the mixture. When the deposition is completed, the matrix coating on the cathode will be a mixture of barium and strontium carbonates and amorphous aluminum hydroxide, the latter breaking down to sintered aluminum oxide in the processing of the cathode, to serve as an inert separating material on the cathode which distributes the active component, i. e., barium, over the surface of the cathode to lower the diffusion rate of the active barium.

Example 3.—In another embodiment, the cataphoretic activator material may be nickel hydroxide which is deposited on the cathode along with the barium and strontium carbonates and on final processing the nickel compound is reduced to metallic nickel disseminated throughout the active oxide matrix, to serve as a metallic reservoir or depository for the barium metal within the cathode matrix. If desired, equal proportions of aluminum and nickel hydroxides may be employed as the activator material in the electrolyte to produce a complex coating matrix on the cathode. After processing the aluminum oxide particles act as a separating inert substance and the nickel as a metal reservoir component in the cathode coating. Of course, the deposition of the reservoir metal and inert separating oxide need not be confined to aluminum and nickel since other cataphoretic activating materials, such as metal hydroxides of chromium, iron, beryllium, cobalt, copper and similar hydroxyl or hydrogen generating media could be substituted to be converted in the final coating matrix of the cathode.

Another coating application by cataphoretic deposition, for which the invention is suitable, is the provision of heat radiating or electron inhibiting coating matrices on other electrodes in electronic discharge devices, such as the anode and control electrode or grid.

Example 4.—In the development of heat dissipating coating on anodes, the inert substance of the cataphoretic electrolyte may be carbon-black or graphite suspended in alcohol and water and the activated material introduced in the electrolyte may be alumina or zirconium hydroxide for increasing the activity of the suspension for the deposition of the coating on the anode surface, which will be the cathode in the electrolyte. The addition of zirconium to the coating matrix on the anode will increase the heat radiating properties of the anode coating since zirconium in combination with carbon will readily dissipate the heat energy generated in the anode during operation of the discharge device. If desired, the heat radiation coating may be a homogeneous matrix of zirconium powder and zirconium hydroxide applied to the anode for conversion to a sintered mass in hydrogen. The powder metal may be replaced by a compound such as zirconium hydride.

Similar coatings may be applied to the grid for inhibiting secondary emission of electrons by appropriate development of coatings on the grid wire surface to perform this function. This coating may be produced electrophoretically by deposition from an electrolyte including the polar solvent, inert inhibiting material, such as aluminum oxide or other metallic oxide, and the hydrated metal oxide, such as aluminum hydroxide, nickel hydroxide, chromium hydroxide or manganese hydroxide, which serves as the activator constituent of the electrolyte. The activator substance combined in the coating on the grid can

be converted to oxide or metal by appropriate heat treatment to produce a calorized coating or other complex inhibiting coating or film on the grid to eliminate secondary emission in the device.

The invention is not limited to the electronic art since it may be utilized in the preparation of corrosion and wear resistant surfaces on metal by application of calorizing or carburizing compounds on metal parts by cataphoresis by the use of appropriate electrolyte compositions involving the inert powdered material and the proper cataphoretic hydrated activator in the polar mixture to accomplish the results desired.

Another advantageous use of the electrolytic composition of this invention is in the deposition of a dielectric coating or film on conductors, of wire, plates, tubing or other forms on which a hard protective or decorative coating is required.

In addition to forming insulating coatings on metals, the invention may be utilized in fabricating complex films or matrices on formed metal parts, such as switch contacts, or on insulating or non-metal base objects, such as ceramic, paper or cellulose. A specific application relates to the provision of a wetting metallic surface on tungsten or molybdenum wire contacts for mercury switches. In this method the electrolyte may be prepared of 50 grams of nickel powder, 2½ grams nickel hydroxide, 30 cubic centimeters of water and 70 cubic centimeters of alcohol. After the coating is applied to the contact wire, the adherent matrix is fired in hydrogen to reduce the hydroxide to nickel and form a homogeneous nickel surface which readily amalgamates with mercury so that a positive contact therewith is assured.

In the deposition by electrophoretic methods it is necessary to provide the non-conductive base with a conducting surface film, similar to the procedure employed in the electroplating art on similar materials, and then proceed with the cataphoretic deposition process in accordance with this invention. If desired, the intermediate conducting film on the base may be destroyed or removed by heating to volatilize the film when a homogeneous dielectric coating is required on the ceramic base.

Another application of this invention is the production of laminated articles, such as condensers, by the electrophoretic deposition of metal and insulating layers on a base element, to form a compact, uniformly accurate build-up of the capacitor laminae, to insure positive control of the value of the condenser.

Similarly, the invention may be utilized in the production of strip films of definite proportions of metal constituents or dielectric properties depending on the composition of the electrolyte employed in the deposition. In the same manner, alloy coatings may be produced by controlling the proportions of materials in the electrolyte, the final product being attained by processing the coating matrix by heating in hydrogen to realize the final coating desired. The same technique can be employed in electroforming of metallic products simply by depositing the metallic powders by electrophoresis with the aid of the hydrated metal oxide activator and finally sintering the structure to form a concentrated metallic body of uniform quality and known composition.

In general, any finely divided material which is inert towards the solvents employed and which does not affect the cataphoretic properties of the hydrous oxide activator may be used in de-

veloping coating compositions for the purpose of attaining consistent matrix layers or films on any base element or material. In this category may be mentioned powdered substances, such as cellulose, natural and synthetic resins, pigments, glazes and viscous fluids, such as lacquers and other finishes if obtainable as stable emulsions.

The advantages of the methods and materials employed therein in comparison with other techniques depend somewhat upon the particular application. In general, the high quality and consistency of results obtainable with a minimum of skill on the part of the operator and the stability of the electrolyte under atmospheric conditions appear to recommend the proposed composition for maximum efficiency in producing rapid deposition by cataphoretic methods where other methods of coating are deficient or uneconomical. As compared to electroplating, cataphoretic coating has the advantage of rapid build-up of coating thickness and almost negligible current consumption. It gives a different type of surface which may be altered to approach that obtained in electroplating by suitable subsequent sintering treatment. For many applications, however, the two processes will not be interchangeable.

While the coatings applied in accordance with this invention contain a small proportion of the hydrous oxide used in the mixture, this inherent limitation may be unimportant in many applications, while in others it is necessary to choose the hydrous oxide activator with the final coating properties in mind. However, if the coated element is to receive subsequent heat treatment either to sinter the coating or to convert the compound in hydrogen, the effect of the starting material in the electrolyte does not present any difficulty. Furthermore, where heat treatment is practicable the mechanical strength of the coating can usually be improved to any desired extent within the limitations imposed by the base material.

What is claimed is:

1. The method of applying an insulating coating to a metallic base by electrophoresis which comprises, immersing said base in an electrolyte suspension of inert aluminum oxide, water, alcohol and purified aluminum hydroxide, and depositing the solids from said suspension on said base under a low potential.

2. The method of coating a base element by electrophoresis which comprises, preparing an electrolyte consisting of inert aluminum oxide particles suspended in a polar solvent mixture, adding a gelatinous activator of aluminum hydroxide to said electrolyte for adsorption on said inert particles thereby ionizing said particles to impart cataphoretic properties to said particles, agitating said electrolyte to maintain suspension of said particles in said mixture, immersing said base element in said electrolyte as a cathode, inserting a metallic anode in said electrolyte, and applying a low direct current potential between 15 to 20 volts at a current consumption of 15 milliamperes to said cathode and anode for an interval of 30 seconds, while discontinuing agitation of said electrolyte.

3. A coating suspension for electrophoresis deposition methods, consisting of 600 grams of aluminum oxide particles, distilled water and alcohol carrier in the ratio of approximately 1 to 2½, and 30 grams of aluminum hydroxide.

4. The method of applying an insulating coating

11

to a metallic base by electrophoresis which comprises immersing said base in an electrolytic suspension consisting of 600 grams of aluminum oxide particles, distilled water and alcohol carrier in the ratio of approximately 1 to 2½ and 30 grams of aluminum hydroxide, and depositing the solids from said suspension on said base under a low potential.

JAMES M. SNYDER. 10

REFERENCES CITED

The following references are of record in the file of this patent:

Number
1,507,379
1,640,710
1,897,902
2,215,167
2,307,018
2,321,439
2,386,634
2,421,652

12**UNITED STATES PATENTS**

Name	Date
Hoskins -----	Sept. 2, 1924
Miller -----	Aug. 3, 1927
Harsanyi -----	Feb. 14, 1933
Sumner et al. -----	Sept. 17, 1940
Cardell -----	Jan. 5, 1943
Verwey et al. -----	June 8, 1943
Robinson et al. -----	Oct. 9, 1945
Robinson et al. -----	June 3, 1947

FOREIGN PATENTS

Number	Country	Date
289,509	Great Britain -----	Nov. 23, 1927