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PROCESS OF COATING METALS

William T. Pearce, Lower Merion Township, Montgomery County, Pa., assignor to The Resinous Products & Chemical Company, Philadelphia, Pa., a corporation of Delaware

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This invention relates to a process for applying resinous surface-coatings to metals. It relates primarily to a method of applying unusually thick layers of certain resinous surface-coating materials in a single application.

It has been found that unusually thick uniform coatings of resinous materials on metal have far superior qualities such as chemical resistance, beauty, and durability, than thin films of the same material. Heretofore it has been customary to build up such a desirable thickness by the application of several individual coats, with the proper allowance of time between coats for drying of the individual coats. The obvious disadvantage of this latter method is that considerable time is required for the several applications. Furthermore, it has been found that a thick layer of resinous material which has been built up by the application of several individual coats in general does not have as high protective merit or insulating value as a single uniform layer of the same thickness applied in one single application. This may be due to such factors as lack of adhesion between coats, porosity of the thin individual layers, pin-holing, etc.

There are many coating materials which are of such high viscosity that they can be applied only in the form of relatively dilute solutions by ordinary means. When such dilute solutions are used, large volumes of solvent are lost unless expensive means are employed to recover the solvent. Also it is apparent that the resultant coats are of necessity very thin, due to the low solids-content of the dilute coating compositions. This is particularly true of lacquers based on cellulose ethers and esters. Attempts to employ such lacquers at higher solids-content in order to obtain thicker films have led to the so-called "hot-spray" method as recorded in U. S. Patent 2,150,096, issued March 7, 1939. However, this method cannot be employed universally for the application of resinous coatings due to the instability of some resins at the elevated temperatures and due to the tendency of others to "cob-web" or "feather" when they are sprayed. "Cob-webbing" or "feathering" is the term used when the sprayed material is not atomized but, rather, leaves the spraying equipment in the form of fine threads or fibers.

The present invention provides a method of applying uniform resinous films which are approximately five times as thick as ordinary films applied by conventional methods. It comprises heating the metal to be coated to an elevated temperature, and applying a resinous composition which is maintained at approximately the same temperature or a little higher. At the elevated temperature the viscosity of the resinous coating may be such as not to require the presence of any solvent. In any case less solvent will be necessary, for the required viscosity, than is needed at normal room-temperatures. This represents an economy. The coating may be applied by flooding, that is, by dipping or immersing the metal in the fluid coating composition or by pouring the same on the metal. After the coating is applied, the coated object is allowed to remain in the air until the excess fluid has drained off and the coating has become set, i. e., until the coating has ceased to flow. During this period some of the solvent which may be present will evaporate. Thereafter, the object is baked or stoved in order to liberate any volatile components, including solvents.

A film prepared in this manner is ordinarily very thick; and while the thickness may vary widely it has been found that a thickness of more than four mils is generally very satisfactory. Such films have definite advantages over thinner films or over films of equal thickness built up by the application of several coats. In addition to being more durable they have other merits resulting apparently from their uniformity. Their insulating value is far better, they are less porous, and there is an absence of pin-holing. Also such films are more resistant to the destructive action of, for example, water, alkalies, acids, greases, oils, and solvents. Consequently they provide better protection for the metal.

This method of coating is especially valuable in the case of resinous coating compositions which are very viscous and/or cannot be applied satisfactorily by ordinary means such as spraying or brushing. Such materials include the polymerized halides and esters of vinyl alcohol and the polymeric esters of such acids as acrylic and methacrylic acids. The latter may be described as polymeric esters which, in the monomeric

form, have the general formula $\text{CH}_2=\text{CRCOOR}'$ in which R is hydrogen or an alkyl group and R' is an alkyl group. Examples of these resins include polymethyl acrylate, polyethyl acrylate, polymethyl methacrylate, polyethyl methacrylate, polybutyl methacrylate, polycetyl methacrylate, etc. Due to their high viscosity even at relatively high temperatures, such resins can be applied by brushing or spraying only when diluted with large volumes of solvent, with the result that the solutions have very low solids-content and deposit very thin films. Furthermore when an attempt is made to build up thick layers by the application of several coats, for example by brushing, it is found that the solvent in the latter coats softens and dissolves some of the previous coat and the resultant very viscous mass defies spreading to a smooth surface. Also, many of the solutions "cob-web" or "feather" when applied by spraying. This can be avoided only by a very careful choice of the type and amount of the solvent and the conditions of spraying. Coating compositions based on these resins may obviously contain such materials as plasticizers, pigments, etc.

When the resinous coating material is applied to heated metal by the process herein described and is thereafter exposed to the air for a short time, it sets or dries on the surface while remaining relatively fluid beneath the surface and therefore has little if any tendency to form surface irregularities. On the other hand, if the heated resinous material is applied to cold metal, the surface remains fluid for the longer period and consequently tends to flow and cause wave-like accumulations which are known in the coating industry as "sags," "curtains," "runs," etc. If both metal and resin are at room temperature only thin coats may be applied due to the low solids-content resulting from the presence of the large volume of solvent employed to reduce the viscosity of the resinous composition low enough so that it may be applied.

Such coating materials are not to be confused with the so-called "hot-melt coatings" which are applied in the molten condition by means of calendering or knifing method. Hot-melts are wax-like in character, ordinarily contain large amounts of waxes, and may be smoothed during or after application by heating. In contrast, the resinous materials here involved are non-waxy but are sticky, tacky materials when in the dissolved, softened or fused state and consequently cannot be applied in the same way as hot-melt compositions.

The optimum temperature to which the metal and coating are heated depends upon the nature of the particular resinous material. In the case of the lower polymeric esters of acrylic and methacrylic esters, the preferred temperature is between about 150° F. and about 200° F. When a solvent is present, the temperature must be maintained below its boiling point in order to avoid ebullition and the formation of bubbles in the molten mass or in the film on the metal. The most satisfactory temperature is the minimum at which the resinous coating has sufficiently low viscosity as to flow and level out on the metal and thus provide a substantially smooth coating on the metal. With resins suitable for application in accordance with this invention, it has been found that 150° F. is the minimum preferred temperature and the maximum temperature is one which will reduce the viscosity of the composition to about 3 poises or less. The preferred temperature of the

metal at the time of applying the coating is slightly below that of the resinous material. If the temperature of the metal is markedly higher or lower than that of the resinous material the film does not have a uniform appearance. In no case should the metal be heated above the boiling point of any solvent present at the time of application due to the danger of forming bubbles or pin-holes in the film.

The following examples are specific illustrations of this invention.

Examples

A 40% solution of a resin composed of 25% polymethyl acrylate and 75% polyethyl methacrylate was prepared in toluene. At 40% resin-content the viscosity of this solution was 5.75 poises at 25° C. and 2.5 poises at 180° F. When the concentration was reduced to 15% resin-content with toluene for spraying at 25° C., the viscosity was less than 0.5 poise.

Steel panels were coated by conventional methods and by the process of this invention and the dried films were tested for various physical properties. The general appearance was noted visually. Oil-resistance was determined by immersing panels for thirty minutes in vegetable oil heated to 200° F. Pin-holing was determined by immersing coated panels in a copper-sulfate solution and noting the number of "copper trees" deposited on an area of six square inches at the points where "pin-holes" in the film permitted the copper-sulfate solution to come in contact with the metal.

The insulating value of the coatings were determined by standard A. S. T. M. tests D149-38T and D150-36T.

Panels were coated in the following ways:

(a) A steel panel was sprayed with the 15% solution. During the spraying operation there was a tendency for the material to "cob-web" or "feather." Five separate coats were applied with a two-minute interval between coats. The properties of this film and others are tabulated below.

It was impossible to spray a 20% solution of this resin due to excessive cob-webbing although the viscosity was only 0.5 poise.

(b) A steel panel at room temperature was dipped into a 40% solution of the resin, also maintained at room temperature. The panel passed through the dipping tank in the horizontal position and on removal was held at an angle of about 20 degrees to the horizontal for 30 seconds and was then held in the perpendicular position for 2 minutes after which the panel was stoved for 30 minutes at 225° F. while being held in the vertical position.

(c) A steel panel at room temperature was dipped into a 15% solution of the resin at room temperature and subsequently dried and stoved as in Example (b) above. The operation was repeated five times in order to build up a thick layer.

(d) A steel panel, heated to 150° F. was dipped into a 40% resin solution maintained at room temperature and was dried and stoved as above.

(e) A panel, at room temperature, was dipped into a 40% solution of the resin maintained at a temperature of 180° F. It was subsequently dried and stoved as above.

(f) A panel, heated to 150° F. was dipped into a 40% resin solution heated to 180° F. The drying and stoving operations were the same as described above.

The properties of the films prepared by these various methods are tabulated below:

which R is a member of the class consisting of hydrogen and alkyl groups and R' is an alkyl

Property	Panel (a)	Panel (b)	Panel (c)	Panel (d)	Panel (e)	Panel (f)
	Cold panel, cold soln. (15%), sprayed	Cold panel, cold soln. (40%), dipped	Cold panel, cold soln. (15%), dipped	Panel at 150° F., cold soln. (40%), dipped	Cold panel, 40% soln. at 180° F., dipped	Panel at 150° F., 40% soln. at 180° F., dipped
Appearance.....	Mottled surface....	Very uneven surface.	Very uneven surface.	Uneven surface....	Uneven surface....	Good.
Blistering.....	Slight.....	Very bad.....	Very bad.....	Slight.....	Bad.....	None.
Runs.....	None.....	do.....	do.....	Very bad.....	do.....	Do.
"Pin-holes".....	Many.....	Few.....	Many.....	Many.....	Few.....	Do.
Insulating properties.	Poor.....	Fair.....	Poor.....	Poor.....	Fair.....	Very good.
Oil-resistance.....	Fair.....	Good.....	Fair.....	Fair.....	Good.....	Do.

I claim:

1. The process of applying to metal a uniform, resinous, non-waxlike, protective coating of a thickness of at least four mils which comprises heating a resinous coating composition containing a member of the group consisting of polymeric vinyl halides, polymeric vinyl esters, and polymeric esters which in the monomeric form had the general formula $\text{CH}_2=\text{CRCOOR}'$ in which R is a member of the class consisting of hydrogen and alkyl groups and R' is an alkyl group, to a temperature between about 150° F. and the point of ebullition until the coating composition has a viscosity below about 3 poises, heating a metal to approximately the temperature of the coating composition, coating said hot metal with said heated coating composition of viscosity below 3 poises, allowing the thus coated material to remain in air until the coating is set, and heating said coated metal at a temperature below the ebullition point of said coating until the coating is freed substantially of volatile components.

2. The process of applying to metal a uniform, resinous, non-waxlike, protective coating of a thickness of at least four mils which comprises heating a resinous coating composition containing a member of the group consisting of polymeric vinyl halides, polymeric vinyl esters, and polymeric esters which in the monomeric form had the general formula $\text{CH}_2=\text{CRCOOR}'$ in which R is a member of the class consisting of hydrogen and alkyl groups and R' is an alkyl group, to a temperature between about 150° F. and the point of ebullition until the coating composition has a viscosity below about 3 poises, heating a metal to approximately the temperature of the coating composition, dipping said hot metal in said coating composition of viscosity below about 3 poises, removing the metal thus coated, allowing the coated metal to remain in air until the coating is set, and heating said coated metal at a temperature below the ebullition point of said coating until the coating is freed substantially of volatile components.

3. The process of applying to metal a uniform, resinous, non-waxlike, protective coating of a thickness of at least four mils which comprises heating a resinous coating composition containing a member of the group consisting of polymeric vinyl halides, polymeric vinyl esters, and polymeric esters which in the monomeric form had the general formula $\text{CH}_2=\text{CRCOOR}'$ in

group, to a temperature between about 150° F. and the point of ebullition until the coating composition has a viscosity below about 3 poises, heating a metal to approximately the temperature of the coating composition, flowing said coating composition of viscosity below about 3 poises on said hot metal, allowing the metal thus coated to remain in air until the coating is set, and heating said coated metal at a temperature below the ebullition point of said coating until the coating is freed substantially of volatile components.

4. The process of applying to metal a uniform, resinous, non-waxlike, protective coating of a thickness of at least four mils which comprises heating a resinous coating composition containing a polymeric ester which in the monomeric form had the general formula $\text{CH}_2=\text{CRCOOR}'$ in which R is a member of the class consisting of hydrogen and alkyl groups and R' is an alkyl group, to a temperature between about 150° F. and the point of ebullition until the coating composition has a viscosity below about 3 poises, heating a metal to approximately the temperature of the coating composition, coating said hot metal with said heated composition of viscosity below about 3 poises, allowing the thus coated material to remain in air until the coating is set, and heating said coated metal at a temperature below the ebullition point of said coating until the coating is freed substantially of volatile components.

5. The process of claim 2 in which the polymeric ester is a copolymer of polymethyl acrylate and polyethyl methacrylate.

6. The process of applying to metal a uniform, resinous, non-waxlike, protective coating of a thickness of at least four mils which comprises heating a resinous coating composition containing a polymeric vinyl ester to a temperature between about 150° F. and the point of ebullition until the coating composition has a viscosity below about 3 poises, heating a metal to approximately the temperature of the coating composition, dipping said hot metal in said coating composition of viscosity below about 3 poises, removing the metal thus coated, allowing the coated metal to remain in air until the coating is set, and heating said coated metal at a temperature below the ebullition point of said coating until the coating is freed substantially of volatile components.

WILLIAM T. PEARCE.