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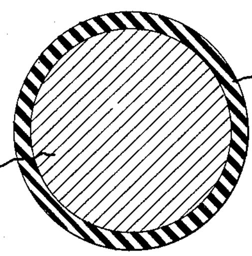

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INSULATED ELECTRICAL CONDUCTOR

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This invention relates to conductors insulated with resinous compositions and more particularly to insulated electrical conductors having improved solvent resistance.

Patnode and Flynn Patent 2,085,995, assigned to the assignee of the present invention, discloses insulated conductors provided with coating compositions comprising polyvinyl acetal resins. Although such insulated conductors have distinct advantages over conductors insulated with conventional oil-type enamels, the resinous compositions utilized therein are costly, and comparatively high-priced solvents are required for the production of suitable wire enamels therefrom. Jackson and Hall Patent 2,307,-588, also assigned to the assignee of the present invention, discloses insulated conductors provided with an improved and less expensive resinous composition, which additionally is soluble in relatively inexpensive solvents. Accordingly, in the manner of the Jackson and Hall patent, insulated conductors having properties practically the same, and in certain respects even better than those described in the above Patnode et al. patent, can be made and at a substantially lower cost by combining suitable phenol-aldehyde resins with the polyvinyl acetal resin.

Although conductors insulated with the Jackson and Hall compositions are eminently satisfactory for most applications, they do not possess the required solvent resistance necessary in certain instances, as, for example, when used in hermetically sealed motors of refrigerators in which Freon is employed as the refrigerant. The attainment of adequate solvent resistance in addition to abrasion and heat resistance, as well as dielectric strength and other qualities possessed by the aforementioned Patnode and Flynn, and Jackson and Hall compositions, has presented a problem, particularly to the magnet wire industry.

In accordance with the present invention, it has unexpectedly been found that all of the useful advantages of the Patnode and Flynn, and Jackson and Hall insulated conductors are retained, and markedly improved solvent resistance obtained, by incorporating into each of the specific resins a definite, small amount of melamine or a derivative of melamine. The addition of such a small amount, for example, from about 0.3 per cent to about 1.2 per cent by weight, based on the polyvinyl acetal resin content, results unexpectedly in an insulated conductor having improved solvent resistance.

Although it has heretofore been disclosed that the curing properties of resins of the polyvinyl acetal type may be improved to the extent that the curing of the resin in bulk form to the infusible, insoluble state is enhanced by the addition of an aminotriazine-aldehyde reaction product (see, for instance, Dunlop Patent 2,466,399), there is concurrently produced a decrease in flow point in the cured mass with attendant increase in inherent rigidity of the resinous product and decreased flexibility and elongation characteristics. Accordingly, there was no indication and moreover it was completely unexpected, that such resinous compositions having these characteristics in bulk form, could successfully be applied in film

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form to a conductor, and when so applied that the insulated conductor would exhibit the highly important physical properties of flexibility and elongation while retaining excellent solvent resistance and curing characteristics.

The invention will be understood more readily from the following description when considered in connection with the accompanying drawing, in which the single figure is a cross-sectional view of an electrical conductor provided with insulation in accordance with this invention.

The additives found eminently suitable for improving the solvent resistance properties of the insulated conductors of the present invention may be classed generally as aminotriazines and aminotriazine derivatives. More specifically, the additives which may be employed include aminotriazines such as melamine, condensation reaction products of aminotriazines such as melamine with aldehydes, and alkylated condensation reaction products of aminotriazines such as melamine with aldehydes obtained by reacting melamine and an aldehyde in the presence of an alcohol.

Aminotriazines and aminotriazine derivatives found eminently suitable in producing insulated electrical conductors of the present invention having improved solvent resistance must be soluble and compatible with the resin composition comprising the insulation. Additives having these properties and coming within the scope of the present invention include melamine and melamine-aldehyde condensation products. The melamine-aldehyde reaction products may be prepared by reacting at least two mols of an aldehyde, such as formaldehyde, with one mol of melamine under alkaline conditions. The number of substituted methylol groups occurring in the product is generally dependent upon the mol ratio of the reactants. Thus, it is possible to react formaldehyde or another aldehyde with melamine in mol ratios sufficient to give mono-, di-, tri-, tetra-, penta- and hexamethylol melamines or mixtures thereof. Any of these derivatives or mixtures thereof are satisfactory in preparing the insulation of this invention.

The alkylated condensation reaction products of aminotriazines with aldehydes useful in producing the insulated electrical conductors of the invention are etherified melamine-aldehyde reaction products. They may be prepared by reacting melamine, an aldehyde such as formaldehyde and an alcohol, preferably a monohydric alcohol. Generally, they may be prepared by reacting the melamine-aldehyde products disclosed previously with a monohydric alcohol.

The polyvinyl acetal resins employed in the process of this invention are hydrolyzed, polymerized vinyl ester aldehyde condensation products, which may be produced from various aldehydes and various polyvinyl esters, as set forth in said Patnode et al. patent, and more fully described in Reissue Patent 20,430 to Morrison et al.

Aldehydes other than formaldehyde may be used in making polyvinyl acetal resins, for example, acetaldehyde, propionic aldehyde, butyric aldehyde, benzaldehyde and the like. Likewise, polyvinyl esters other than polyvinyl acetate may be employed, for instance, polyvinyl propionate, polyvinyl butyrate and the like. The properties of polyvinyl acetal resins may be varied through a wide range by varying the viscosity and the extent of the hydrolysis of the polyvinyl ester, the amount and the character of the aldehyde reacted with the hydrolyzed polymerized vinyl ester, and the character and the amount of the acid catalyst used.

In order that those skilled in the art better may understand how this invention may be carried into effect, the following examples are given to illustrate the preparation of polyvinyl acetal enamels and phenolic-modified polyvinyl acetal enamels useful in preparing the insulated electrical conductors of the present invention wherein an additive of the foregoing description is employed to improve the solvent resistance of the conductors. In order to show the improved solvent resistance, the prepared enamels were used to coat wires, and four lengths of each coated wire approximately 2 feet long were immersed in a boiling solvent mixture to test their solvent resistance. As previously mentioned, one of the end uses of wire insulatingly coated with resinous compositions of the type herein contemplated, is in hermetically-sealed motors used in refrigerators, which it is subject to the deleterious action of refrigerants, such as Freon.

Test methods involving the effects of Freon per se on insulation are long and tedious, requiring special apparatus. Through a series of tests, it was found that there was a correlation between the effects of a fifty-fifty mixture of solvents, such as, for example, ethanol and toluene, upon insulation of the present description and the action thereon of Freon. This test was more severe than any other conditions which similarly insulated wires may encounter in use. Due to the ease of testing and the closeness in effect of such a mixture to that of Freon, a fifty-fifty mixture of ethanol and toluene was used in all of the tests which follow. The test involved immersing the lengths of wires in a boiling mixture of 50 parts of alcohol, for example, ethanol, and 50 parts of toluene for a total of 10 minutes, after which time the wires were inspected for signs of visible attack.

In the following examples, given by way of illustration and not by way of limitation, all parts and percentages are by weight.

Example 1

This is an example illustrating a typical phenolaldehyde-modified polyvinyl acetal resin, which may be modified with an additive in accordance with the present invention. An enamel having a solids content of 16 per cent was prepared employing the following formulation:

	Per cent by weight
Cresol-formaldehyde resin [1]	5.33
Polyvinyl formal resin	10.67
Solvents, 84% formal composed of:	
Cresol [2]	25.20
Naphtha	58.80

[1] A phenol-aldehyde resin of the type disclosed in Jackson et al. Patent 2,307,588 which disclosure is incorporated herein by reference.
[2] NOTE.—A part of this cresol is added to the dehydrated resin in the reaction vessel.

The proper amounts of naphtha and cresol were weighed into a mixing tank and agitated, a 50–50 cresol solution of cresol-formaldehyde resin added, and the whole well mixed. The solid polyvinyl formal resin was added slowly, and the mixture stirred until the polyvinyl formal resin was completely dissolved. To the resulting enamel was added 0.6 per cent melamine, based on the weight of polyvinyl formal resin. The additive-containing composition was then agitated with a stirrer for approximately one hour to insure good blending. It may be dyed, if desired, by adding a small amount of a suitable dye during the stirring; preferably, the enamel is filtered through a pressure filter prior to use in enameling wire.

This enamel was used to coat 0.0508″ wire at varying speeds ranging from 14 feet per minute to 21 feet per minute, to give an insulation thickness of approximately 5 mils, and was then tested for solvent resistance in accordance with the test set forth above. In every case, the solvent resistance of each of the wires was excellent.

Example 2

This example illustrates the modification of a polyvinyl acetal resin by the addition thereto of an additive of the invention. In formulating an enamel with such a resin,

polyvinyl formal resin and solvent were mixed in the following proportions:

	Per cent by weight
Polyvinyl formal resin	11.27
Cresol	26.62
Naphtha	62.11

Melamine was added to this enamel in an amount corresponding to 0.6 per cent, by weight of the resin, and the resulting composition was agitated with a stirrer in the manner described in Example 1.

Solvent resistance was determined by coating wires in accordance with the manner described in Example 1, and testing the insulated wires in the same manner. Again, in each case the solvent resistance was excellent.

Example 3

To the enamel of Example 1 were added varying amounts of a butylated melamine-formaldehyde condensate, specifically in amounts from about 0.3 per cent to 1.2 per cent, by weight of the polyvinyl acetal resin. The resulting enamels were applied to .0508″ wire at speeds ranging from 14 to 21 feet per minute. On each of the wires, the added insulation was 5 to 6 mils. Using the solvent resistance test previously described, solvent resistance was excellent in each case.

Example 4

To the enamel of Example 2 varying amount of a butylated melamine-formaldehyde condensate, specifically from 0.3 per cent to 1.2 per cent, by weight of the resin, were added and processed, i. e., by stirring, etc., as in the previous examples. Wires coated with these enamels proved to have excellent solvent resistance when tested in the manner of the preceding examples.

Example 5

This example illustrates the solvent resistance of a polyvinyl acetal containing enamel not modified with an additive of the invention. For this purpose, the enamel of Example 2 minus the additive was used as insulation. This enamel was applied to .0508″ wire at speeds of 14 and 18 feet per minute. The added insulation in each case amounted to approximately 5 mils. When evaluated in accordance with the test described above, the enamel showed poor solvent resistance.

Example 6

This example illustrates the solvent resistance of wires coated with a phenol-formaldehyde-modified polyvinyl formal resin not having an additive of the invention. For purposes of comparison, the enamel prepared in Example 1 without additive was used to insulate wires in the manner described in Example 1. Wires so coated were given the same solvent resistance test. Each of the wires coated with this enamel was poor in solvent resistance.

While the invention has been described with particular reference to cresol as the phenolic ingredient in the modified polyvinyl acetal resin, it will be obvious to those skilled in the art that other phenolic bodies also may be used. Thus, phenolic bodies disclosed in Jackson et al. Patent 2,307,588 (hereinabove incorporated by reference) may be used, including, for example, xylenols, mixtures of phenol and cresol, or mixtures of phenol or cresol, or phenol and cresol together with wood oil phenolic bodies of the kind described more fully in Patent 2,221,511 to Fiedler et al. dated November 12, 1940 and assigned to the same assignee as the present invention. Additional phenolic bodies which may be employed include the petro-alkyl type phenols, which petro-alkyl phenols may be used as the sole phenolic body or in combination with coal-tar phenol, cresols and other phenolic substances. Likewise, active methylene-containing bodies, other than formaldehyde, may be used, either in solid or solution state.

The properties of the phenol-aldehyde resin, and accordingly the properties of the additive-modified phenol-aldehyde-polyvinyl acetal resinous compositions may be varied by varying the ratios of the phenolic body and the aldehyde. For example, resins containing 0.7 or more mols formaldehyde will convert to a substantially infusible, insoluble state when heated at elevated temperatures, whereas those containing 0.5 or 0.6 mol formaldehyde are thermoplastic. While for certain applications such thermoplastic resins may be used as modifying agents of the polyvinyl acetal resin in general, it is preferred to use in the preparation of wire enamels those phenolic resins which are produced by reacting 1 mol phenolic body with from 0.7 to 2.0 mols of an active methylene-containing body, such as formaldehyde or other suitable aldehyde. No particular advantage is gained by using more than 2 mols formaldehyde to 1 mol of the phenolic body, since the excess formaldehyde is volatilized during the cooking of the resin.

The insulated electrical conductors of the invention are prepared by drawing clean wire, for example, clean copper wire, through a body of wire enamel comprising the polyvinyl acetal resin, or a phenol-aldehyde modified polyvinyl acetal resin, solvent and additive. When a phenol-aldehyde modified polyvinyl acetal resin is employed, the proportions of the phenolic resin and polyvinyl acetal resin may be varied, for example, by weight from about 5 to 50 parts phenolic resin to from about 95 to 50 parts of polyvinyl acetal resin. The total resin to solvent proportions also may be varied, for instance, from about 5 to 25 parts resin to about 95 to 75 parts solvent. When a phenolic resin-modified polyvinyl acetal resin is employed, it is preferred to use a phenolic resin-polyvinyl acetal resin ratio and a total resin-solvent ratio such as described under Example 1, since the particular combination of ingredients there described has been found to produce a wire enamel which is more readily and effectively applied to wire, and to yield an insulated electrical conductor having the most desirable combination of properties.

The percentage of an additive which may be employed in modifying the resins of this invention may vary within certain limits. Excellent results have been obtained by employing from about 0.1 to about 5.0 per cent, by weight, based on the weight of resin solids represented by the polyvinyl acetal resin. A preferred range is from about 0.3 to about 1.2 per cent, by weight, based on the weight of resin solids represented by the polyvinyl acetal resin employed.

Various other solvents are equally as effective in the preparation of the herein-described enamels and are essentially the solvents disclosed in the aforesaid Jackson et al. patent.

The additives coming within the scope of the present invention are those aminotriazines and aminotriazine derivatives which are substantially completely soluble in the enamel and compatible therewith. Materials which are not soluble or only slightly soluble, or which are incompatible with the enamel, are ineffective for the present purposes. Although the invention has been described more fully in connection with melamine and the specific melamine derivatives of the examples, it is not limited thereto. Obviously, any one of the melamine-aldehyde condensates or an ether thereof herein described may be substituted for those of the examples, provided it is substantially completely soluble and compatible with the enamel.

The method employed for coating wire is in accordance with the procedure disclosed in the Jackson et al. patent. For example, after the wire has been passed through a bath containing the particular modified enamel, the coated wire is subjected to heat by introducing it into a suitable oven at a temperature of about 250° to 500° C. wherein the coating is baked simultaneously with the annealing of the copper. As previously mentioned, the wire is drawn through the bath at various speeds ranging from 14 feet per minute to 21 feet per minute. Usually, it is necessary to run the wire successively through the enamel bath and baking oven several times at a constant speed, in order to provide adequate insulation thereon. When a phenol-aldehyde-modified polyvinyl acetal resin is employed, baking at the previously mentioned temperatures advances the phenol-aldehyde component of the mixed or combined resin film to the insoluble, infusible state, and likewise improves the properties of the polyvinyl acetal resin component. The hardness, abrasion resistance, and resistance of the resin film to attack by oils, solvents, varnishes and various chemicals are improved by such treatment. Wires coated with the instantly described enamels give results comparable with those resulting from the tests described and illustrated in Patent No. 2,307,588 on the phenol-aldehyde-modified polyvinyl acetal enamels therein described. However, and as pointed out in the examples, there is a substantial improvement in the solvent resistance of the enamels. Whereas prior enamels fail completely under the solvent resistance tests herein employed, each of the present enamels containing as an additive a melamine or a melamine derivative show excellent solvent resistance under the same conditions. Additionally, it should be noted that the solvent resistance test employed in the instant process is a far more rigorous test than that described in the above Jackson et al. patent.

It is to be understood that this invention is not limited to the application of the insulating composition directly upon the conductor as illustrated in the accompanying drawing, but also may be applied in accordance with the methods described and illustrated in the Jackson et al. patent.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An insulated copper conductor in which the outer insulation therefor comprises essentially a hard, flexible, tough, abrasion-resistant and Freon-resistant coating, said coating being the heat-treated product of a mixture of ingredients consisting essentially, by weight, of (1) from 50 to 95% of a polyvinyl formal resin obtained by condensing formaldehyde with a product of hydrolysis of polyvinyl acetate, (2) from 5 to 50% of a heat-hardenable resin obtained by condensing a phenol selected from the class consisting of phenol, cresol, xylenol, and mixtures thereof, with formaldehyde in the ratio of 1 mol of the phenol to 0.7 to 2 mols of the formaldehyde in the presence of an alkaline catalyst, (3) from 0.3 to 1.2%, based on the weight of the polyvinyl formal resin, of an additive selected from the class consisting of melamine and melamine-formaldehyde condensation products and, (4) a solvent in which (1), (2) and (3) are soluble composed of a mixture of cresol and naphtha, the solids content of the treating solution for the conductor being composed, by weight, of from 5 to 25 parts of the above-described resinous ingredients to about 75 to 95 parts of the cresol-naphtha solvent.

2. The insulated electrical conductor of claim 1 in which the additive contained in the insulation comprises melamine.

3. The insulated electrical conductor of claim 1 in which the additive contained in the insulation comprises a butylated melamine-formaldehyde condensate.

References Cited in the file of this patent

UNITED STATES PATENTS

2,307,588	Jackson et al.	Jan. 5, 1943
2,466,399	Dunlop	Apr. 5, 1949

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