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ELECTRICAL CONDUCTOR COATED WITH HIGH TEMPERATURE
INSULATING VARNISHES

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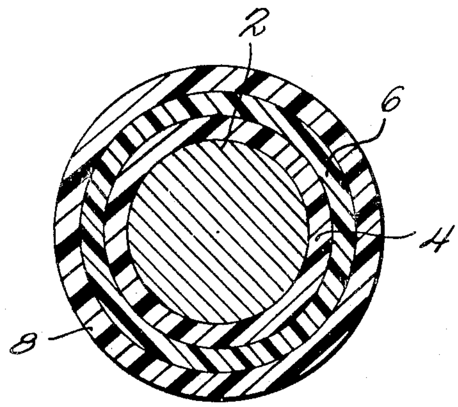

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ELECTRICAL CONDUCTOR COATED WITH HIGH TEMPERATURE INSULATING VARNISHES

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ABSTRACT OF THE DISCLOSURE

Electrical conductors having improved properties at high temperature are produced by providing such conductors with three resinous coatings, the second coating being polyethylene terephthalate or linear polyimide-polyamides.

This invention relates to oil-modified alkyd resins and insulating varnishes containing such resins as well as to electrical conductors coated with such varnishes.

It has previously been proposed to prepare insulating varnishes from short oil-modified glyceryl isophthalate and an oil-soluble phenol-formaldehyde resin, Thielking Pat. No. 3,080,331. Such a varnish is quite valuable but, unfortunately, cannot be employed where the final product must be classified as 180° C. (Class H) in the AIEE No. 57 heat life test.

It is an object of the present invention to prepare a novel oil-modified alkyd resin.

Another object is to prepare an insulating varnish suitable for continuous use at 180° C.

An additional object is to develop an improved wire having an polyester or polyimide under coat and a Dacron top coat and a protective coat of insulating varnish over the top coat.

A further object is to prepare an enameled wire having improved properties in the burnout test.

Still further objects and the entire scope of applicability of the present invention will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

It has now been found that these objects can be attained by preparing insulating varnishes containing alkyd resin from isophthalic acid, tris (2-hydroxyethyl) isocyanurate and drying oil acids. Preferably the drying oil acids do not have substantially more unsaturation than soybean oil acids. In addition to the oil-modified alkyd resin there should be present an oil-soluble phenol-formaldehyde resin in an amount of 10 to 80% of the total of the alkyd resin and phenolic resin. In place of isophthalic acid less preferably there can be used terephthalic acid in the higher oil length ranges, e.g. a 55% oil length.

A portion of the tris (2-hydroxyethyl) isocyanurate (THEI) can be replaced by another polyol, e.g. glycerine or pentaerythritol. Thus, the THEI can be 50 to 100% of the total polyol. However, it should be realized that replacing part of the THEI by another polyol will impair to some extent the improved thermal properties of the varnishes of the present invention.

As the drying oil acids there can be used soybean oil acids, cottonseed oil acids, corn oil acids, whale oil acids, safflower oil acids or sunflower oil acids, or less preferably, linseed oil acids, tung oil acids, oiticica oil acids, perilla oil acids.

A portion of the drying or semi-drying oil acids can

be replaced by non-drying oil acids such as coconut oil fatty acids, oilve oil acids, castor oil acids, peanut oil acids and rapeseed oil acids.

When a portion of the THEI is replaced by glycerine the latter need not be added as such but can be added in the form of an oil, e.g. soybean oil, corn oil, linseed oil, or the like. In such case, of course, the oil supplies part or all of the oil fatty acid component.

The oil-modified alkyd resin can include 20 to 65% of the fatty acids but preferably contains 30 to 55% of the fatty acids, e.g. soybean fatty acids.

Unless otherwise indicated, all parts and percentages are by weight.

The invention will be understood best in connection with the drawings wherein the single figure is a cross-sectional view of an electrical conductor having an insulating coating according to the invention.

Referring more specifically to the drawings, there is provided an electrical conductor, e.g. a wire **2** having a first (or under coat) continuous coating **4** of a polymeric ester of terephthalic acid and tris (2-hydroxyethyl) isocyanurate, a second (or top coat) continuous coating **6** of polyethylene terephthalate and a protective coat **8** of soybean oil fatty acid modified polymeric ester of isophthalic acid and tris (2-hydroxyethyl) isocyanurate admixed with p-t-butylphenol formaldehyde resin.

As the under coat there is employed a polyester or polyimide suitable for continuous use at 180° C. or above.

The polyester employed in forming the under coat is the reaction product of a polymeric ester of terephthalic acid or isophthalic acid with THEI. A portion of the THEI, up to 50% of the total polyhydric alcohol on a weight basis can be replaced by a modifying polyhydric alcohol such as ethylene glycol, butanediol-1,4, pentanediol 1,5, butene-2-diol-1,4, butyne-2-diol-1,4; 2,2,4,4-tetramethyl-1,3-cyclobutanediol, 1,4-cyclohexanedimethanol, hydroquinone di-β-hydroxyethyl ether, glycerine, trimethylolethane, 1,1,1-trimethylolpropane, pentaerythritol, dipentaerythritol, sorbitol or mannitol.

A portion of the terephthalic acid or isophthalic acid up to 50 equivalent percent of the acid component can be replaced by a modifying polycarboxylic acid such as o-phthalic anhydride, adipic acid, sebacic acid, hemimellitic acid, trimellitic acid, trimesic acid, succinic acid, tetrachlorophthalic anhydride or hexachloroendomethylene tetrahydrophthalic acid.

The total number of hydroxyl groups on the alcohols normally is 1 to 1.6 times the total number of carboxyl groups on the acids in the under coat.

The polyester can also be modified by adding an organo titanate and/or a polyisocyanate.

As the titanate there can be used tetraalkyl titanates such as tetraisopropyl titanate, tetrabutyl titanate, tetramethyl titanate, tetrahexyl titanate and tetrapropyl titanate. The titanate is used in an amount of 0.001 to 4.0% titanium metal on the total solids of the under coat.

As the polyisocyanate there can be used 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, hexamethylene diisocyanate, blocked isocyanates such as the reaction product of three mols of mixed 2,4- and 2,6-tolylene diisocyanates with trimethylol propane and blocked by esterification with phenol (Mondur S), and the cyclic trimers of 2,4- and 2,6-tolylene diisocyanates having the three free isocyanate groups blocked by esterification with m-cresol (Mondur SH). There can be used any of the polyisocyanates, including the blocked isocyanates, set forth in Sheffer et al. Pat. No. 2,982,754, or in Meyer et al. Pat. No. 3,211,585. Usually 1 to 40% of the total solids are polyisocyanates.

The polyester under coat can be applied to the electrical conductor in the manner disclosed in Meyer et al. Pat. No. 3,211,585, and Meyer et al. Pat. No. 3,201,276. As the polyester under coat there can be used any of the THEI containing terephthalates of the two Meyer et al. patents as well as the corresponding isophthalates.

In place of using a polyester as an under coat, there can be used a polyester-polyimide in which at least 20%, and preferably at least 50%, of the alcohol component of the polyester is THEI and the polybasic acid component comprises terephthalic acid, isophthalic acid or benzophenone dicarboxylic acid. The polyimide component of the molecule normally has a member of the group consisting of benzene and naphthalene rings joined to two carbon atoms of a heterocyclic imide ring having 5 to 6 members in the ring, one of the atoms in the heterocyclic ring being nitrogen and the balance carbon.

The usual components of the polyester-polyimide are (1) an aromatic or aliphatic diamine, e.g. methylene dianiline, oxydianiline, benzidine, 3,3'-diamino-diphenyl, p-phenylene diamine, 1,4-diamino-naphthalene, α, W-nonamethylene diamine, 4,4-diaminodiphenyl ether, heptamethylene diamine, diamino-diphenyl ketone, hexamethylene diamine, ethylene diamine, diamino-diphenyl sulfone, 4,4'-dicyclohexylmethane diamine, (2) an anhydride having 3 to 4 carboxyl groups such as trimellitic anhydride, pyromellitic dianhydride, benzophenone 2,3-, 2',3'-tetracarboxylic dianhydride, 2,3,6,7-naphthalene dianhydride and 3,3',4,4'-diphenyl tetracarboxylic dianhydride, (3) a dibasic acid such as terephthalic acid, isophthalic acid or benzophenone dicarboxylic acid, and (4) a polyhydric alcohol containing at least 20% THEI. The polyester-polyimide preferably contains 5 to 50% polyimide groups based on the total of the polyester and polyimide groups.

There can be employed any of the polyester-polyimides disclosed in Meyer et al. application Ser. No. 457,474, filed May 20, 1965, now Pat. 3,426,098, and the under coat can be applied to the electrical conductor as set forth in that application. As disclosed in that Meyer et al. application, there can be employed as modifiers the same polyisocyanates in an amount of 1 to 25% and alkyl titanates in an amount of 1 to 10% as mentioned in the Meyer et al. Pat. No. 3,211,585 and Sheffer et al. Pat. No. 2,982,754.

The under coat, whether it is a polyester of polyester-polyimide, also usually contains 1 to 5% based on the total solids of a melamine-formaldehyde resin or a phenolic resin such as phenol-formaldehyde, cresol-formaldehyde or xylenol-formaldehyde resin.

As the top coat there is preferably employed polyethylene terephthalate. It is applied from a solvent solution, as set forth in Meyer et al. Pat. No. 3,201,276. The preferred solvent contains 30 to 50% of monochlorophenol and the balance a cresol or mixture of cresol with phenol.

In place of polyethylene terephthalate there can be employed as the top coat polyimide-polyamides, polyester-polyimidamides, straight polyimides and other linear polymers. Thus, there can be used the pyromellitimide available commercially as Pyre-ML as well as other polyimides such as the reaction product of 3,3'-diamino-diphenyl and pyromellitic anhydride, the reaction product of oxydianiline with pyromellitic anhydride, the reaction product of methylene dianiline with pyromellitic anhydride or the polyimides disclosed in Edwards Pat. No. 3,179,634, the polyester-polyimide-polyamide from ethylene glycol, terephthalic acid, methylene dianiline and pyromellitic anhydride, etc. There can also be used polyesters such as polyhexamethylene glycol terephthalate and other linear polyesters.

The insulating varnishes of the present invention can be applied directly to electrical conductors but are preferably employed as a protective coat over the under coat and top coat formulations just described. The insulating varnishes can be used to coat copper, aluminum and silver wires and to impregnate armature and field coils of motors and for both power and distribution transformers of either the oil or dry type where long life at high operating temperatures is required. While the insulating varnishes of Thielking Pat. No. 3,080,331 are indicated as being suitable only at temperatures of up to 150° C. the insulating varnishes of the present invention are suitable for continuous use at temperatures of 180° C. and higher.

In addition to the higher fatty acid modified THEI polyester as indicated the varnish also includes an oil-soluble phenol-formaldehyde resin. The preferred phenols for forming these phenol-formaldehyde resins are ortho and para alkyl substituted phenols, 2,2-bis (p-hydroxyphenyl) propane and 4,4-bis (p-hydroxyphenyl) propane.

As examples of suitable phenols for making the resin, mention can be made of p-t-butylphenol, p-t-amylphenol, p-t-octylphenol, p-phenylphenol, o-t-butylphenol, and the phenols of Honel Pat. No. 1,800,296. Any of the oil-soluble phenol aldehyde resins set forth in the Thielking patent can be employed.

The insulating varnish contains conventional varnish solvents in addition to the resin components. Such solvents include one or more of xylene, mineral spirits, isophorone, naphtha, toluene and benzene.

EXAMPLE 1

762 grams of soybean oil fatty acids (Emery 610 soy oil fatty acids), 945 grams of tris(2-hydroxyethyl) isocyanurate and 597 grams of isophthalic acid were loaded in a flask, the temperature raised in one hour to 440° F. and held in the 440°–470° F. range for 3.5 hours until the acid number was 25. The batch was thinned with 2000 grams of xylene to Z7 viscosity at 50% solids to give a 41% oil length alkyd resin.

To 575 grams of the alkyd resin was added 145 grams of p-t-butylphenol-formaldehyde resin (46B phenolic resin) at 50% solids in xylene and 80 grams of additional xylene. The final viscosity of the insulating varnish thus obtained was T (550 cps.) at 45% solids.

EXAMPLE 2

1344 grams of soybean oil fatty acids (Emery 610 soy oil fatty acids), 885 grams of THEI and 348 grams of isophthalic acid were loaded in a flask and the temperature raised to 480° F. in 3.5 hours. The batch was then heated in the 480–520° F. for 4.5 hours until the acid number was 6. The batch was thinned with 1350 grams of aromatic naphtha to Z viscosity at 65% solids.

To 1158 grams of this alkyd resin were added 1500 grams of p-t-butylphenol-formaldehyde resin and 342 grams of aromatic naphtha. The final viscosity of the insulating varnish thus produced was G at 50% solids.

EXAMPLE 3

An insulating varnish was prepared similar to that of Example 1 but using an alkyd resin made from 387 grams of soybean oil fatty acids, 243 grams of coconut oil fatty acids, 597 grams of isophthalic acid and 945 grams of THEI.

EXAMPLE 4

A motor stator was impregnated with the insulating varnish of Example 1 in a dip tank operation. The varnish was cured by baking in an oven at 395° F. for 1 hour.

EXAMPLE 5

No. 18 copper wire was coated with Isonel 200E and then given a top coat of polyethylene terephthalate (Isonel 17) in conventional fashion. Isonel 200E is the mixture of (a) 86 parts of the polyester from 4400 parts of THEI, 481 parts of ethylene glycol and 5019 parts of dimethyl terephthalate, (b) 5 parts of Mondur SH, (c) 5 parts of tetraisopropyl titanate and (d) 5 parts of m-p-cresol-formaldehyde resin (made from 3440 parts of m-p-cresol and 1962 parts of 37% aqueous formaldehyde).

The thus coated wire was dipped twice through the insulating varnish prepared in Example 1 with curing at 395° F. for 1 hour after each dip. The wire having the three coatings was tested by AIEE No. 57 twisted pairs with the following results:

Temp. C.:	Hours to failure at 1000 volts
280	268
260	598
240	798
222	3557

This data extrapolates to 180° C. for 20,000 hours which shows that the system of the fatty acid alkyd insulating varnish, polyethylene terephthalate top coat and Isonel 200 under coat had a Class H rating. The product had improved bonding strength and less weight loss than a conventional top coated Isonel 200 wire enamel which was not further coated with the fatty acid modified alkyd resin varnish.

EXAMPLE 6

The same procedure as that of Example 5 was repeated but using the insulating varnish of Example 2 to obtain a coated wire which had a Class H rating.

EXAMPLE 7

It was also found that the insulating varnish of Example 2 applied to wire coated with Isonel 200E and topcoated with polyethylene terephthalate (Isonel 17) gave improved results in the burnout test. The burnout test is run by twisting pairs of the enameled wire, dipping in the varnish and curing for 1 hour at 400° F. Then 33 amperes is applied for four minutes and the breakdown voltage of the system tested. The results obtained in the burnout tests were as follows, final voltages were expressed in kilovolts.

	Without varnish	With varnish
Isonel 17 over Isonel 200 E	4.98	8.6
Isonel 17 over Isomid	0.77	2.38
Isomid	0.75	1.16

It is clear that the insulating varnish upgrades the system—base coat/overcoat/insulating varnish.

Isomid is a commercial polyester-polyimide made from trimellitic anhydride, methylene dianiline, dimethyl terephthalate, ethylene glycol and THEI as taught in Meyer et al. application, Ser. No. 457,474, now Pat. 3,426,098, Example 9. The Isomid formulation used for the base coat included 210 parts of the polyester-polyimide, 8 parts of tetraisopropyl titanate, 22 parts of Mondur SH and 10 parts of phenol-formaldehyde.

I claim:

1. An electrical conductor provided with a first coating of a member of the group consisting of (1) a polymeric ester of tris (2-hydroxyethyl) isocyanurate and an aromatic dicarboxylic acid and (2) a polyester polymide wherein at least 20% of the alcohol component of the polyester is tris (2-hydroxyethyl) isocyanurate, a second coating selected from the group consisting of (1) linear polyethylene terephthalate, (2) and linear polyimide-polyamides, and a third coating of an insulating varnish including (a) an alkyd resin selected from the group consisting of unsaturated higher fatty acid modified tris (2-hydroxyethyl) isocyanurate isophthalate and unsaturated higher fatty acid modified tris (2-hydroxyethyl) isocyanurate terephthalate, said resin having 20 to 65% of higher fatty acids, and (b) an oil soluble phenol-formaldehyde resin, the phenol-formaldehyde resin being present in an amount of 80 to 15% of the total of the alkyd resin and phenol-formaldehyde resin over said coating.

2. An electrical conductor according to claim 1, wherein the second coating is polyethylene terephthalate, said conductor having said three coatings, having a heat life at 180° C. of at least 20,000 hours.

3. An electrical conductor according to claim 2, wherein the alkyd resin is an isophthalate.

4. An electrical conductor according to claim 2, wherein the first coating is a continuous coating of a polyester-polyimide.

5. An electrical conductor according to claim 2, wherein the first coating is a continuous coating of a polyester of an aromatic acid selected from the group consisting of terephthalic acid, isophthalic acid and benzophenone dicarboxylic acid.

6. An electrical conductor according to claim 1, wherein the second coating is a linear polyimide-polyamide.

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