

UNITED STATES PATENT OFFICE

2,668,157

ABRASION RESISTANT WIRE ENAMELS

Fred J. Emig and Michael J. Muth, Chicago, Ill.,
assignors to E. I. du Pont de Nemours & Com-
pany, Wilmington, Del., a corporation of Dela-
ware

No Drawing. Application March 15, 1951,
Serial No. 215,874

10 Claims. (Cl. 260—23)

1

This invention relates to wire enamels and more specifically to wire enamels which are highly resistant to abrasion and scraping.

In manufacturing armatures, stators, electro-magnets, coils and similar electrical equipment in which the wire is wound around a removable form or an iron core, the enameled wire repeatedly scrapes the metal parts of the winding machine and the article on which it is wound. If the insulating enamel coating is not highly resistant to scrape abrasion, it may be damaged and fail to perform its normal function satisfactorily.

Enameled wire is also subjected to vibration with resultant abrasion in many uses. It will be apparent that scrape abrasion resistance is highly desirable in all wires and conductors having a coating of enamel insulation.

An improvement in the abrasion resistance of polyvinyl formal wire enamels is disclosed in the copending patent application of E. Q. Bullock and F. J. Emig, Serial No. 73,228, filed January 27, 1949, which became Patent 2,615,001 on October 21, 1952, in which a polymer of ethylene is incorporated into wire enamels containing a polyvinyl acetal resin and a phenol-formaldehyde resin. The effect of abrasion resistance and other properties of a wire enamel by the addition of a polymer of ethylene is unpredictable, for example, if a dispersion of such a polymer is added to a nylon wire enamel, a heterogeneous composition is produced, since the ingredients are incompatible. Nylon wire enamels have many valuable properties, and an improvement in their abrasion resistance is highly desirable. Such an improvement is also desirable in other wire enamels including oleoresinous enamels.

It is, therefore, the principal object of this invention to provide organic insulating enamels which, when applied by conventional means to a wire or similar conductor, are highly resistant to scrape abrasion. Another object is the provision of electrical conductors coated with such enamels. Other objects will appear as the description of the invention proceeds.

These objects are accomplished by dispersing a very small percentage of polytetrafluoroethylene, in the form of colloidal particles, in an organic insulating enamel which otherwise has a conventional composition comprising, as its essential ingredient, a polyvinyl formal type

2

resin, or an oleoresinous varnish, or a linear polyamide (nylon).

The linear polyamides shown in certain of the examples and referred to elsewhere herein are those described in U. S. Patents Nos. 2,071,250, 2,130,523 and 2,130,948 and are commercially known as nylon. Hereinafter these polyamides are referred to generically as nylon.

Polytetrafluoroethylene is disclosed in Plunkett U. S. Patent No. 2,230,654, issued February 4, 1941. Polytetrafluoroethylene in the form of an aqueous colloidal dispersion is disclosed in Renfrew U. S. Patent No. 2,534,058, issued December 12, 1950. Relatively concentrated aqueous colloidal dispersions of polytetrafluoroethylene are disclosed in Berry U. S. Patent No. 2,478,229, issued August 9, 1949; and these dispersions are the most convenient form for use in this invention.

The invention is illustrated but not limited by the following examples in which the parts are by weight:

EXAMPLE I

Nylon wire enamel

High boiling petroleum hydrocarbon (B. P. 229°-294° C.)	206.00
Mixture of commercial phenols and cresols	518.00
Hexamethylene diammonium adipate polymer (nylon)	153.00
Polytetrafluoroethylene dispersion in water	2.55
	879.55

The polytetrafluoroethylene dispersion in water has the following composition:

Colloidal polytetrafluoroethylene	60.0
Wetting agent	0.6
Water	39.4
	100.0

The wetting agent in this composition is the sodium salt of the sulfuric acid ester of a mixture of long chain alcohols, predominately lauryl alcohol. Other suitable wetting agents may be substituted in quantities sufficient to stabilize the dispersion.

3

The polytetrafluoroethylene concentration is 1% based on the nylon polymer and 0.173% on the total composition.

The wire enamel of this example was made by dissolving the nylon polymer in a mixture of the hydrocarbon and cresylic acid, and thereafter mixing in the polytetrafluoroethylene dispersion with moderate agitation, followed by filtration to remove lumps and foreign matter.

Six coats of this wire enamel were applied to #18 gauge (American wire gauge) copper wire by conventional means which involve passing the wire through a bath of the wire enamel and then through an oven. Each coat was baked at 575°-585° F.

The test used for abrasion resistance is one adopted by the National Electrical Manufacturers' Association and consists essentially of repeatedly scraping the surface of a coated wire with a rigid steel wire .016" in diameter, held at a right angle to the axis of the wire being tested and rubbed back and forth over the coated surface of the wire being tested under a weight to force the steel wire against the test section of the coated wire. The scrape abrasion resistance is rated by the number of cycles, i. e. one forward plus one backward scrape, required to wear through the enamel coating and cause a metal to metal contact as indicated by the completion of an electrical circuit connected to the two wires.

Scrape abrasion tests as described above showed that test samples of the wire coated with this nylon wire enamel containing polytetrafluoroethylene withstood an average of 71 cycles under a 700 gram weight as compared to 20 cycles for the same product containing no polytetrafluoroethylene. Other properties were substantially equal.

Other suitable formulas for nylon wire enamels, to which polytetrafluoroethylene may be added as described above in the amount of 0.1% and 1% based on the film-forming solids, are disclosed in U. S. Patent No. 2,328,398.

EXAMPLE II

High boiling petroleum hydrocarbon (B. P. 229°-294° C.)	206.00
Mixture of commercial phenols and cresols	518.00
Hexamethylene diammonium adipate polymer (nylon)	153.00
Polytetrafluoroethylene dispersion in water	1.27
	878.28

The above composition was prepared in the same manner as in Example I and contained the same aqueous dispersion of polytetrafluoroethylene, except that the polytetrafluoroethylene is present in the amount of 0.5% based on the nylon polymer and 0.087% based on the total composition. A #18 gauge copper wire was coated by conventional means with six coats of a wire enamel having the above composition. The coated wire was baked as indicated in Example I and subsequently subjected to the above described scrape abrasion test in which a 700 gram weight was used. Under the test the coating failed at the end of 42 cycles as compared with 20 cycles for the same product containing no polytetrafluoroethylene. The other properties of the enamels were substantially equal.

4

EXAMPLE III

Oleo-resinous wire enamel

China-wood oil	233.73
Linseed oil	23.19
WG rosin	136.16
Metal resinate driers	10.20
High boiling high solvency petroleum hydrocarbons	404.01
Phenolic inhibitor	2.32
Polytetrafluoroethylene dispersion in water	6.72
	816.33

The polytetrafluoroethylene dispersion has the same composition as that used in Example I. The polytetrafluoroethylene concentration is 1% based on the oleoresinous solids of the composition and 0.5% based on the total composition.

The wire enamel of this example was made by heating the oils and rosin to 560°-585° F. with agitation, cooling to about 500° F., adding the metal resins, and agitating to dissolve them. Then the hydrocarbons and phenolic inhibitor were added and mixed in uniformly; and the batch was cooled to room temperature. The polytetrafluoroethylene dispersion was added with moderate agitation and the batch was then filtered.

The resulting enamel was reduced with about 1 volume of high solvency hydrocarbon solvent for each four volumes of wire enamel to obtain proper application viscosity.

Three coats of the thinned wire enamel were applied to #18 gauge (American wire gauge) copper wire, each coat being baked for 30-60 seconds in an oven at about 750° F. and further cured for about 4 hours at 265°-275° F.

Scrape abrasion tests, as described in Example I, showed that test samples of wire coated with this oleoresinous wire enamel containing polytetrafluoroethylene withstood an average of 233 cycles under a 200 gram weight, as compared to 60 cycles for the same product containing no polytetrafluoroethylene. Other properties were substantially equal.

EXAMPLE IV

Polyvinyl formal wire enamel

High boiling petroleum hydrocarbon (B. P. 229°-294° C.)	376.50
High solvency petroleum hydrocarbon (B. P. 150°-184° C.)	125.50
Commercial cresylic acid	204.50
Polyvinyl formal resin	86.00
Phenol-formaldehyde resin	42.50
Polytetrafluoroethylene dispersion in water	2.13
	837.13

The polyvinyl formal resin is a product of the concurrent hydrolysis and condensation of a vinyl ester with an aldehyde as described in U. S. Reissue No. 20,430 to Morrison et al. and in U. S. Patent No. 2,307,588 to Jackson and Hall.

The phenol-formaldehyde resin is a heat-reactive (i. e., heat-hardenable, thermosetting, or heat-convertible), soluble, 100% phenol-formaldehyde resin obtainable on the open market and commonly used in coating compositions.

The polytetrafluoroethylene dispersion is the same as that used in Example I.

The polytetrafluoroethylene concentration is

1% based on the resin solids of the composition and 0.15% based on the total composition.

The wire enamel of this example was made by first dissolving the two resins in a mixture of the solvents, i. e. the two hydrocarbons and the cresylic acid. Then the polytetrafluoroethylene dispersion was added slowly, and moderate agitation was continued until the batch was homogeneous, after which it was filtered.

The resulting wire enamel was applied by conventional means to #18 gauge (American wire gauge) copper wire and baked at 575°-585° F. This coating process was repeated until six baked coats of enamel had been applied.

In scrape abrasion tests as described in Example I, samples of the wire coated with the polyvinyl formalphenol-formaldehyde wire enamel of this example containing polytetrafluoroethylene withstood an average of 145 cycles under a 700 gram weight as compared to an average of only 72 cycles for the same product containing no polytetrafluoroethylene. Other properties were substantially equal.

EXAMPLE V

A wire enamel was made exactly as in Example IV except that 0.213 part of polytetrafluoroethylene dispersion was used in place of the 2.13 parts of Example IV. This lower concentration amounts to 0.1% polytetrafluoroethylene on the resin solids.

Samples of wire coated with the product of this example containing 0.1% polytetrafluoroethylene withstood an average of 92 scrape abrasion cycles under a 700 gram weight, as compared to an average of 72 cycles for the same product containing no polytetrafluoroethylene. Other properties were substantially equal.

The 60% polytetrafluoroethylene dispersion shown in these examples is a convenient concentration, but the concentration of the added dispersion is not critical; and dispersions at other concentrations such as between 25% and 75% may be substituted on the basis of an equivalent polytetrafluoroethylene content in the finished wire enamel. Also, dispersions of polytetrafluoroethylene in other materials such as volatile organic liquids (for instance, octane) may be used.

Polytetrafluoroethylene concentrations from .1% up to 1% based on the resin solids of wire enamel are shown in the examples. It is to be understood that this is the preferred range and that the resultant compositions represent a delicate balance among several important insulating enamel properties including compatibility, stability, applicability, electrical properties, abrasion resistance, adhesion to copper and other electrical conductors, etc. It will be obvious to those skilled in the art that higher percentages of polytetrafluoroethylene may be used where such high concentrations are compatible and are innocuous to the other essential properties of the resultant enamel.

The above examples illustrate the invention with respect to clear organic insulating enamels. It is to be understood, however, that pigments which do not impair the other essential properties of the enamels may be added, to prepare colored enamels or for other purposes. For example, in the preparation of a green enamel, phthalocyanine green pigment may be added to the extent of 1½% of the entire composition. The pigment is usually dispersed or ground into

a portion of the vehicle until a smooth dispersion is obtained and this dispersion is mixed uniformly in the main bulk of the enamel.

The nylon polymer used in Examples I and II may be replaced by other similar polyamide polymers which are soluble in the type of solvents shown, such as the reaction product of hexamethylene diamine and sebacic acid.

A combination of drying oils (i. e. China-wood oil and linseed oil) is shown in Example III. Other drying oils may be used either individually or as mixtures of more than one.

Natural or synthetic gums other than those specifically disclosed may be used, such as congo, amino-aldehyde, or alkyd resins.

In Examples IV and V polyvinyl formal resin is present in a weight proportion approximately twice that of the phenol-formaldehyde resin. The weight ratio of polyvinyl formal resin to phenol-formaldehyde resin may vary from about 1:1 to about 19:1. Any polyvinyl acetal or polyvinylal resin of the type described in U. S. Reissue No. 20,430 to Morrison et al. or U. S. Patent No. 2,307,588 to Jackson and Hall may be substituted for the polyvinyl formal resin used in Examples IV and V.

In each of the examples, the solvent materials represent only one combination of organic liquids which is suitable for the purpose. It is not intended that the invention be limited to the particular combinations disclosed.

It will be obvious to those skilled in the art that infinite variation is possible within the spirit of this invention in the solvents and resins suitable for wire enamels which may be substituted for those disclosed in the examples. However, the combinations shown therein have been found to be particularly adaptable for organic insulating coatings (oleoresinous varnishes, linear polyamides and combinations of heat-hardenable phenol-formaldehyde resins with a polyvinyl formal resin).

The wire enamels of this invention are useful wherever insulating type organic coating compositions are employed, but they are particularly useful where high scrape abrasion resistance is required either in ultimate service or in the original fabrication of electrical apparatus from insulated components such as wire.

It is apparent that many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

We claim:

1. An electrical insulating liquid organic coating composition consisting essentially of an organic film-forming material of the group which consists of (1) a combination of heat-hardenable phenol-formaldehyde resin and polyvinyl formal resin, (2) a linear polyamide and (3) an oleoresinous varnish, and colloidal polytetrafluoroethylene dispersed uniformly throughout said coating composition, in a concentration between about 0.1% and about 1% by weight based on said film-forming material, to increase the scrape abrasion resistance.

2. The composition of claim 1 in which the organic film-forming material is a combination of heat-hardenable phenol-formaldehyde resin and polyvinyl formal resin.

3. The composition of claim 1 in which the organic film-forming material is a linear polyamide.

4. The composition of claim 1 in which the organic film-forming material is oleoresinous.

7

5. An electrical conductor having a dry adherent coating thereon of the composition of claim 1.

6. An electrical conductor having a dry adherent coating thereon of the composition of claim 2.

7. An electrical conductor having a dry adherent coating thereon of the composition of claim 3.

8. An electrical conductor having a dry adherent coating thereon of the composition of claim 4.

9. An abrasion resistant wire enamel having the following composition in parts by weight:

High boiling petroleum hydrocarbon boiling between 229°-294° C. 206.00

Mixture of commercial phenols and cresols 518.00

Hexamethylene diammonium adipate polymer 153.00

60% polytetrafluoroethylene dispersion in water 2.55

879.55 20

8

10. An electrical conductor having a baked adherent coating of the composition of claim 9 on its surface.

FRED J. EMIG.
MICHAEL J. MUTH.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
10 2,478,229	Berry	Aug. 9, 1949
2,518,462	Gowing et al.	Aug. 15, 1950

FOREIGN PATENTS

Number	Country	Date
15 588,697	Great Britain	May 30, 1947