

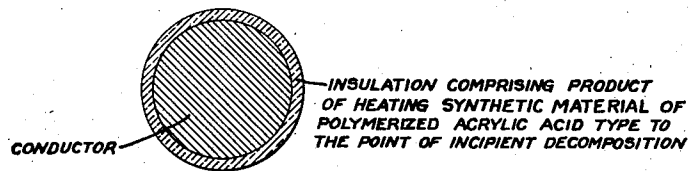
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ELECTRICAL INSULATION

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ELECTRICAL INSULATION

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This invention relates to electrical insulation and more particularly to organically insulated electrical conductors. The invention is especially concerned with improvements in coating materials (for example, so-called "wire enamels") comprising synthetic compositions of the polymerized acrylic acid type or kind, such as polymerized acrylic acid or its homologues, or polymerized derivatives, for example esters, nitrile, etc., of acrylic acid or its homologues. Such synthetic materials may be used either separately or mixed with one another. They also may be mixed with other synthetic materials of a related type or with natural or synthetic materials of a different type.

For some time it has been attempted to an increasing extent to use synthetic instead of oleo-resinous coating compositions for insulating purposes in the electrical industry, for instance in the manufacture of varnished or enameled wires. This growing tendency is due in part to the fact that the oleo-resinous varnishes are not entirely resistant to mineral oil and mineral oil-containing materials, and since it is now known that many varnishes comprising synthetic materials are more resistant to oils and impregnating compounds which contain oil (such as mineral oil-resin compounds) than are the oleo-resinous varnishes.

Many different derivatives of polyacrylic acid are among the numerous highly polymerized compounds which frequently have been used in making liquid coating compositions. It has been found, however, that compositions of the polyacrylic acid type have poor heat and moisture resistance and that their dielectric properties are inadequate for many purposes. In addition, the complete lack of color of most varnishes produced from such synthetic materials causes serious manufacturing difficulties, since the lack of color makes it impossible to judge the quality of the applied coating. Additions of coloring materials in many varying forms lead to a further reduction in the dielectric properties of the varnish.

Although in electrical engineering many synthetic resins have been used as components of insulating varnishes, it has not been possible up to the present, for the above indicated reasons, to replace the oleo-resinous varnishes to any great extent since, despite the frequently better chemical properties of varnishes comprising synthetic resins, they do not in general attain the quality of the oleo-resinous varnishes in mechanical or electrical respects.

It is an object of the present invention to provide a method for improving the physical and electrical properties of varnishes, enamels and the like comprising synthetic materials of the polymerized acrylic acid type or kind such, for instance, as polymerized acrylic acid and its homologues, polymerized derivatives of acrylic acid, for example, methyl, ethyl, propyl, butyl polyacrylates and the like, polymerized methyl alpha methacrylate, ethyl alpha methacrylate and the like, polymerized acrylonitrile and the like, and similar polymerized derivatives of homologues of acrylic acid, as well as separately or conjointly polymerized mixtures of substances such as aforementioned. Synthetic materials of the kind described are designated, generally, in the appended claims as "polymerized acrylic compound."

Another object of this invention is to provide an improved insulated electrical conductor comprising a metallic conducting core such, for example, as plain or tinned copper wire, and a superposed adhering layer of insulation of the polymerized acrylic acid type, which insulation is highly resistant to heat, oil, moisture, solvents and various chemicals, and has flexibility and insulation resistance of a high order.

The above objects are attained in accordance with the present invention by heating the solid base material of the varnish or the applied solvent-free varnish film to the point of incipient decomposition, that is to a point at, or closely approaching, the beginning of its dissociation. The material, however, is not heated to a point at which substantial decomposition or dissociation occurs. The heat treatment in all cases must be conducted in a manner such as to avoid the formation of carbon and other dissociation products which would affect detrimentally the mechanical and electrical properties of the varnish film.

The accompanying drawing illustrates in cross section a conductor provided with insulation comprising a product of heating a material of the polymerized acrylic acid type to the point of incipient decomposition thereof.

Heretofore the formation of a film of varnish, of the kind to which this invention relates, was accomplished by means of a heat treatment which was relatively low in comparison with that employed in applying an oleo-resinous varnish to a base material such as wire. Such heat treatment was intended merely to accelerate the evaporation of the solvent. The temperatures employed were always below the temperature of

incipient decomposition of the varnish film. The material was not heated to the point of incipient decomposition, since it was assumed that the changes occurring in the material, or the dissociation thereof, would lead to considerable deterioration of its physical and electrical properties.

Unexpectedly it was found that when varnishes made from synthetic materials of the polymerized acrylic acid type were heated beyond the temperature that corresponds to their normal heat resistivity, that is to or at the point of their incipient decomposition, but not materially thereabove, the resultant varnish films have physical and electrical properties of an outstanding order. The improvement, which will be described more fully hereinafter, is so pronounced as to indicate that a material which is different in kind from the starting material is formed. The heat, moisture and oil resistances, and the dielectric values, are improved to such an extent that varnishes so produced constitute a high grade insulating material for use throughout the entire electrical industry.

In carrying this invention into effect a discoloration of the varnished product takes place, as a result of the material change caused by the heating. The varnished films assume an increasing color from bright to dark when the heating is increased, while the transparency is retained. In the heating treatment the time and the temperatures employed exert an important influence. For instance, if a varnish film be heated for from about 3 to 4 hours at about 180° C. the same change is effected as by heating for about one to two minutes at about 300° C. These values, of course, depend to a certain extent upon the particular varnish utilized and the mass or film thickness that is heat treated.

A specific example illustrative of the marked improvement in the physical and electrical properties of compositions treated in accordance with this invention follows.

Without a heat treatment in accordance with this invention, a varnish comprising polymerized acrylonitrile when applied to wire and freed of solvent in accordance with conventional practice could withstand at most an operating temperature of only about 65° to 70° C. The same varnish yielded a product which was able to withstand operating temperatures up to about 150° C. for one minute, without changing its properties after cooling to room temperature, when it was heated according to the invention at, for example, about 300° C. for about one to two minutes.

The moisture resistance of the material was also investigated. The insulation resistance of test pieces one meter long, and twisted in pairs, was measured from conductor to conductor for one minute with a voltage of 200 volts, and the loss factor was measured at 800 cycles under room conditions. The wire which had not been treated according to the invention had a mean insulation resistance of 55,000 megohms per meter after it had been pre-dried for a short time; a loss factor tangent δ of 14.0×10^{-3} was found. After the wire had been stored for eight days at room temperature in air with a relative humidity of 80 per cent, the insulation resistance was 45,000 megohms per meter and the loss factor was 23×10^{-3} . As compared therewith, the wire treated according to the invention had a mean insulation resistance of 700,000 megohms per

meter and a mean loss factor of 8.8×10^{-3} . After this wire had been stored for eight days at room temperature in air with a relative humidity of 80 per cent, the wire showed the same mean insulation resistance and the same mean loss factor as at the start of the test.

From the results of the above-described tests it will be noted that electrical insulation comprising the residue of heating a polymerized acrylic compound to incipient decomposition, but not materially thereabove, has an electrically insulating value and moisture resistance higher than that of the same starting acrylic compound heated under conditions insufficient to cause incipient decomposition.

The resistance against oils and impregnating compounds containing oil were further investigated in a mechanically stressed condition. The wire which had not been treated according to the invention showed that it could not always be called resistant to attack by oil and the like when wound on cores of small diameter, that is, as small as one millimeter. Wire treated according to this invention is resistant to attack by the above-mentioned impregnating and other compounds even when the material is stressed very sharply as by such winding.

The comparative values show that varnishes comprising synthetic compositions of the polymerized acrylic acid type or kind, obtain by the method of this invention properties which make them highly suitable as an insulating material for the requirements of the electrical industry and particularly for the manufacture of varnished wire.

The thermal treatment according to the invention that provides the improvement of the physical and electrical qualities of varnishes of the kind herein set forth may be given, as desired or as may be required, on the raw synthetic material, that is, without solvent being present during any stage of the treatment. The heat-treated product then may be made into a liquid coating composition by dissolving it in a suitable solvent. Preferably the hereindescribed heat treatment is given either during the film-forming period or thereafter by heating the varnished object. When the method of treatment comprises heating the solvent-free synthetic material at, or approaching, incipient decomposition before making the same into a varnish, it is necessary to use, in applying the varnish to the object to be varnished, only such temperatures as may be required for the evaporation of the solvent, since the varnish has obtained its valuable physical and electrical properties before its manufacture.

A preferred method of providing a conductor with electrical insulation in accordance with this invention comprises coating a bare conductor, such as copper wire, with liquid composition comprising a solvent solution of synthetic composition of the polymerized acrylic acid type. The coated conductor is then heated at a temperature and for a period of time sufficient to evaporate the solvent and to leave an adhering solvent-free coating of the aforesaid composition on the conductor. The thus coated conductor is then heated further to the point of incipient decomposition of said composition but not materially thereabove.

The same method herein described also may be utilized in other ways, for instance in the manufacture of varnished cambrics for the wire and cable industry, in which case colored bases

can be used on account of the transparency of the varnish film. Consequently, by a suitable selection of the duration and temperature of heating the varnish and of a suitably colored base, many different color effects may be obtained.

Of course it will be understood that varnishes produced or applied to wires in accordance with this invention may contain materials in addition to the hereindescribed synthetic composition and solvent therefor. For example, they may contain dyes, plasticizers for the synthetic material as well as other addition or modifying agents.

Synthetic materials of the polymerized acrylic acid type to which the present invention is particularly applicable include polymerized methyl and ethyl esters of acrylic acid, polymerized acrylonitrile, separately or conjointly polymerized mixtures of methyl and ethyl esters of acrylic acid and separately or conjointly polymerized mixtures of either or both of said esters with acrylonitrile.

In the co-pending application Serial No. 159,972 of Paul Nowak, Hermann Hofmeier and Carlos Tobis, filed concurrently herewith and assigned to the same assignee as the present invention, is disclosed and claimed electrical insulation comprising synthetic composition consisting of mixed polymerizate of acrylic acid ester and acrylic acid nitrile (acrylonitrile) heated to the point of dissociation (incipient decomposition) thereof.

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

1. An electrical conductor insulated with a covering comprising the residue of heating to incipient decomposition, but not materially thereabove, a polymerized acrylic compound, said residue having an electrically insulating value and moisture resistance higher than that of the same starting acrylic compound heated under conditions insufficient to cause incipient decomposition.

2. An insulated electrical conductor comprising a metallic conducting core and a layer of insulation superposed thereon, said layer comprising a coating which is the residue of heating a polymerized acrylic compound to incipient decomposition, but not materially thereabove, said residue having an electrically insulating value and moisture

resistance higher than that of the same starting acrylic compound heated under conditions insufficient to cause incipient decomposition.

3. Electrical insulation comprising the residue of heating a polymerized acrylic compound to incipient decomposition, but not materially thereabove, said residue having an electrically insulating value and moisture resistance higher than that of the same starting acrylic compound heated under conditions insufficient to cause incipient decomposition.

4. A liquid composition for coating wires and the like, said composition comprising a volatile solvent and the residue of heating, to incipient decomposition but not materially thereabove, a polymerized acrylic compound, said residue having an electrically insulating value and moisture resistance higher than that of the same starting acrylic compound heated under conditions insufficient to cause incipient decomposition.

5. The method of improving the physical and electrical properties of a polymerized acrylic compound which comprises heating the material to incipient decomposition, but not materially thereabove.

6. The method of providing a conductor with electrical insulation which comprises coating a bare conductor with a liquid composition comprising a solvent solution of a polymerized acrylic compound, heating the coated conductor at a temperature and for a period of time sufficient to evaporate the solvent and to leave an adhering solvent-free coating of the said compound on the conductor, and further heating the thus coated conductor to incipient decomposition of the said compound but not materially thereabove.

7. An electrical conductor provided with a high dielectric strength, heat-, oil-, and moisture-resistant, flexible coating which is the residue of heating a composition comprising polymerized acrylonitrile to incipient decomposition, but not materially thereabove, said residue having an electrically insulating value and heat-, oil- and moisture-resistance higher than that of the same starting composition comprising polymerized acrylonitrile heated under conditions insufficient to cause incipient decomposition of the said acrylonitrile.

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