METHOD OF FORMING AN ELECTRICAL WINDING

Filed June 14, 1952

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.
METHOD OF FORMING AN ELECTRICAL WINDING

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Application June 14, 1952, Serial No. 293,552

3 Claims. (Cl. 154—80)

This invention relates to wire coating compositions and to electrical windings insulated therewith. More particularly, this invention relates to improved electrical insulating compositions comprising mixtures of polymerized vinylidene aromatic hydrocarbons and copolymers of vinylidene aromatic hydrocarbons with conjugated dienes, and to electrical conductors insulated therewith.

When an electrical winding is prepared, it is necessary that each turn of wire be insulated from adjoining turns and the core material in order to prevent short-circuits. Conventionally this is accomplished by completely surrounding the conductor or wire with insulating material. However, the same results can be obtained by providing an insulating material that covers only the lower half of the wire. With such a construction, only half as much insulating material is required, and in addition it is not necessary to use pregrooved coils, spacing winders, or other mechanical aids in preparing the winding. The use of electrical wires insulated in this fashion is extremely beneficial in the preparation of electrical devices such as rheostats where it is necessary that a portion of the conductor be exposed, and improved results are obtained when coils such as magnet coils, relay coils, magneto coils, etc. are prepared using this type of structure.

Accordingly, an object of the present invention is the provision of novel wire coating compositions having good electrical insulating properties, flexibility, a relatively low shear strength, and a well-defined cleavage plane. Another object of this invention is the provision of a novel method of preparing coils and windings utilizing cleavable wire coating compositions.

Still another object of this invention is the provision of electrical conductors that may be wound into a coil without the use of pregrooved cores or other mechanical spacing devices.

These and other objects are attained through the use of insulating compositions comprising a mixture of a polymerized vinylidene aromatic hydrocarbon such as polystyrene and a copolymer of a vinylidene aromatic hydrocarbon and a conjugated diene such as styrene butadiene copolymer.

The manner in which these objects are attained will be readily apparent to those skilled in the art from the following specification and drawing illustrating schematically a preferred form of our invention. In the drawing,

Figure 1 is a plan view, partly in section, of a coil wound with a wire prepared in accordance with our invention;

Figure 2 is a cross-section of the coil shown in Figure 1 taken along with lines 2—2 of Figure 1;

Figure 3 is an end view of a coil illustrating the method by which the coil is prepared;

Figure 4 is a cross-sectional view of a wire insulated with our insulating material prior to winding; and

Figure 5 is a cross-sectional view of the same wire subsequent to winding.

Referring now in detail to the drawing, a coil prepared in accordance with the present invention comprises a core 12 about which has been wound an electrical conductor or wire 14 coated with insulating material 16. As will be more readily apparent from an inspection of Figure 2, only the radially inner half of the wire 14 carries insulating material, the outer portion of the wire 14 being exposed. As a result, the exposed portions of the wire 14 form spaces or grooves 18 between adjacent turns of the wire. Accordingly, during the winding operation the turns of each layer of winding naturally fall into the grooves 18 of the previous layer.

From this it is apparent that the individual turns of the winding are naturally spaced and completely insulated one from another. Such windings are more compact than conventional windings and only half as much insulating material is required.

A coil, as shown, is prepared by first completely coating a suitable conductor wire with the novel insulating material comprising a part of our invention and to be described hereinafter. The insulating material may be applied to the wire by any suitable means, as for example by extruding the material onto the wire from a conventional extruder (not shown). As illustrated in Figures 3 and 4, the insulating material 16 initially completely surrounds the conductor 14 at this time. As shown in Figure 5, as the thus coated wire is wound about the core 12, the insulating material 16 cleaves in half along a plane in a direction generally tangential to the circumference and parallel to the longitudinal axis of the core. Consequently, the top or outer half of the insulating material 16 splits off during the winding operation and the inner half remains on the wire, thereby providing the only insulator, therefore. However, it will be apparent that only the inner portion of the insulating material is needed because it completely insulated each turn of wire from adjacent turns and from the material lying beneath the wire. The outer portion of the insulating material that is split off from the conductor during the winding operation may be readily reclaimed and reused.

The ability of the insulating material to cleave during the winding operation in this fashion without shattering or otherwise deteriorating is unique to a special class of materials, and this class of materials comprises an important part of our invention.

A preferred insulating material prepared in accordance with the present invention comprises, by weight, approximately 80% monovinyl aromatic hydrocarbon polymer and approximately 20% vinylidene aromatic hydrocarbon-conjugated diene copolymer.

As a specific example illustrating one satisfactory composition and a satisfactory method of preparing a coil or winding using this composition, a No. 20 copper wire having a diameter of 0.032 inch was coated with a mixture comprising by weight 80% polystyrene and 20% of a copolymer containing equimolar proportions of styrene and butadiene. The wire was coated by extruding the mixture of insulating material onto the wire from a conventional extrusion machine, and a coated wire having an external diameter of 0.065 inch was thus prepared.

The wire was completely surrounded with insulating material at the end of this operation. The insulating material hardened rapidly at room temperature and after the coating had hardened, the coated wire was wound about a core having a radius of 1/4 inch. During this operation, the radially outer half of the insulating material split from the wire and was reclaimed for re-use in the extruder. It was noted that the coating material cleaved along a plane passing through the center of the wire and that cleavage commenced at the time the wire was first curved (i.e., bent) by contact with the core. The wire spaced itself properly about the core without
the use of any mechanical aid other than the insulation
carried by it, and the inner half of the insulating ma-
terial was bent around the core along with the wire and
remained attached to the wire. This inner portion was
not damaged by the winding operation and the only rup-
ture of the insulating material occurred along the above
identified plane thus indicating that the material pos-
sessed the inherent resilience required of an insulating
material.

While the above mentioned proportions proved highly
satisfactory when a No. 20 wire and a core having a
radius of $\frac{3}{4}$ inch were used, it is necessary that the propor-
tion of styrene to butadiene in the copolymer be varied
so that substantial differences exist with respect to the size of
the wire, the thickness of the coating, or the diameter of
the core.

The shear strength of our novel compositions is sym-
bolic with the hardness of the coating material, the thick-
ness of the coating, and the diameter of the wire, and is
anisotropic with respect to the diameter of the core about
which the material is wound (i.e., the shear strength in-
creases with an increase in the hardness of the material,
the thickness of the coating or the diameter of the wire,
and decreases as the diameter of the core increases).
This relationship is indicated by the following propor-
tionality equation.

\[
\text{Hardness} \quad \text{Thickness} \quad \text{Diameter}
\]

\[
\text{of Coating} \times \quad \text{of Coating} \times \quad \text{of Core}
\]

\[
\text{Shear} \quad \text{Strength} \quad \text{Diameter} \quad \text{of Core}
\]

The hardness of the material is governed by the amount of
styrene present in the copolymer, increased amounts of
styrene increasing the degree of hardness of the insu-
lating material. Accordingly, when different sizes of
wire, different thicknesses of insulating material, or cores
of different diameters are to be used, the shear strength of
the insulating material may be adjusted by varying the
mol percentage of styrene present in the copolymer.

Thus, for example, if a core having a diameter of one
inch is to be used, the mol percentage of styrene in the
styrene-butadiene copolymer is increased, and con-
versely, if the size of the wire or the thickness of the coat-
ing is to be increased, the mol percentage of styrene
in the copolymer is decreased. Accordingly, in this manner,
it is possible to prepare an insulating material having a
proper shear strength as the result of which the insulating
material will cleave along the desired plane when a wire
coated with the material is wound about a core.

Satisfactory results are obtained when the percentage
of butadiene in the copolymer is varied from about 2% to
about 80%, although at least about 2% butadiene
must be present in the copolymer if the desired cleav-
ability is to be obtained.

When a comparatively large percentage of butadiene is
present in the copolymer, as for example when a relatively
thick coating of material or a relatively large wire is
used, it is frequently desirable to reduce the resilience or
stiffness of the mixture of polymer and copolymer,
and this is accomplished by incorporating into the mix-
ture a minor amount of a metallic oxide pigment such as
titanium oxide. Generally, not more than about 1% by
weight of pigment will be required for this purpose.
Thus, for example, if the copolymer comprises approxi-
mately 75 mol percent butadiene, it is desirable to add
about one part of pigment per 100 parts of polymer-
copolymer mixture in order to prevent lateral distortion
of the insulating material during the winding operation.

It is possible to use vinylidene aromatic hydrocarbons
other than styrene and conjugated dienes other than buta-
diene in preparing the insulating material. Thus, the
butadiene may be replaced by conjugated dienes such as
isoprene, chloroprene, cyclopentadiene, dimethyl buta-
diene, etc., and a combination of two or more of the
diennes may be used.

Similarly, the styrene may be replaced in whole or in
part with polymers or copolymers of other polymerizable
vinylidene aromatic hydrocarbons, as for example, ring-
substituted styrenes such as mono- or polychlorostyrenes,
mono- or polyalkyl styrenes, etc., or side-chain-substi-
tuted alkyl styrenes such as alpha-methyl styrene, etc.

However, it is necessary to the practice of our inven-
tion that the insulating material contain approximately
20% copolymer, and unsatisfactory results will be ob-
tained if the percentage of copolymer is less than 10% or
more than about 30%.

The polystyrene used in the practice of our invention should have a molecular
weight of from 40,000 to 200,000 as determined by the
Staudinger equation.

From the foregoing it is apparent that we have dis-
covered a new class of insulating compositions that have
a high degree of utility in the preparation of electrical
coils or windings and that the proper proportion of in-
gredients for the many circumstances that may be en-
countered is readily determinable by one skilled in the
art.

Having thus described our invention, what we claim is:

1. A method for preparing an electrical winding in-
cluding, a core and an electrically conductive winding
having a partially insulated and a partially exposed elec-
trical conductor, which comprises the steps of completely
surrounding the electrical conductor with an insulating
plastic composition of from about 10% to 30% by
weight of a copolymer of a monovinylidene aromatic
hydrocarbon with a conjugated diene and from 70% to
90% by weight of a polymerized monovinylidene hydro-
carbon, hardening said composition, then winding the
thus coated electrical conductor about a core, splitting
the insulation surrounding the electrical conductor into a
radially outer half and a radially inner half as said con-
ductor is initially bent around said core, and removing
the radially outer half of said insulation from the wound
core, said monovinylidene hydrocarbon being taken from
the group consisting of styrene, side-chain substituted
alkyl styrene, and ring-substituted alkyl and chlo-
rostyrenes.

2. A process as in claim 1 wherein the insulating ma-
terial comprises a mixture of 20% by weight of a cop-
olymer of equi-molar portions of styrene and butadiene
and 80% by weight of polystyrene.

3. A process as in claim 1 wherein the insulating ma-
terial is applied to said electrical conductor by extruding
said insulating material onto said electrical conductor.

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