

[54] **FLUORINATED HYDROCARBON COATING METHOD**

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[63] Continuation-in-part of Ser. No. 278,099, Aug. 4, 1972, abandoned.

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[58] **Field of Search**..... 117/94, 128.4, 132 CF,
117/113, 119.2, 232, 119.6; 128/348-351

[56] **References Cited**

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[57] **ABSTRACT**

This invention is directed to a method of forming an unbroken uniform transparent coating of a fluorinated hydrocarbon resin on a flexible coil spring, wire or similar substrate by immersing the substrate in a dispersion of the selected resin and removing the dispersion coated substrate therefrom, initially drying the dispersion coated substrate, heating same to a predetermined temperature over a predetermined period of time, and then slowly cooling the thus heated coated substrate over a predetermined period of time to a temperature as low as or lower than a predetermined lower temperature.

9 Claims, No Drawings

FLUORINATED HYDROCARBON COATING METHOD

RELATED APPLICATION

This application is a continuation-in-part of application Ser. No. 278,099, filed Aug. 4, 1972, now abandoned.

THE INVENTION

This invention relates generally to new and useful improvements in the application of fluorinated hydrocarbon coatings to metallic substrates and particularly seeks to provide a novel method of applying and firmly bonding such coatings to the exteriors of small diameter springs of the types included in the construction of spring guides used in surgical catheterization procedures, and to the exteriors of extremely fine flexible conducting wires of either circular or rectangular cross-section, such as those used in the indwelling sensing electrodes for cardiac monitoring instruments or in the connecting electrodes for cardiac pacemakers.

These spring guides, regardless of their internal construction, generally include a small diameter elongated body formed as a continuously wound helical spring with the helices thereof in contact with each other. The exterior of the spring body should be either sheathed within a tube of inert flexible plastic having a low coefficient of friction or coated by a similar type of plastic. In either case, it is desirable that the sheathing or coating be as thin as possible, consistent with the required end use so that the ultimate outside diameter of the completed spring guide, on a size-for-size basis, is kept at a practicable minimum.

Furthermore, since these spring guides are to be introduced into and advanced through the blood or other vessels of animate beings, their outer surfaces must be flexible and of a completely uniform character with no crazing, intermittent breaks or other types of discontinuities, nor should the outer surfaces be such as to become powdery or separable as discrete particles or flakes.

In the case of the above-mentioned conducting wires, the fluorinated hydrocarbon coatings serve as flexible external insulators having smooth unbroken surface characteristics and being of sufficient thinness as to enable a substantial number of such wires to be assembled into a bundle of very small total cross-section for insertion into and retention by a correspondingly small diameter flexible sheath formed from a tube of a similar type of fluorinated hydrocarbon.

It is believed that, at the present time, a hexafluoropropylene-tetrafluoroethylene copolymer resin of the type commercially designated as "Teflon" FEP and a tetrafluoroethylene resin of the type commercially designated as "Teflon" TFE (sometimes PTFE) are the best available for such purposes. Although it is known that these materials have been used in the past for coating many different types of substrates, mostly rigid metallic articles, observation of several different makes of spring guides coated or sheathed with such materials, and similarly coated fine wires, indicates that none of them have been fabricated in such a manner as to properly meet either the end use requirements or to avoid the problems mentioned above.

However, through the use of this invention it is possible to apply and firmly bond such types of coatings to the exteriors of surgical spring guides, fine wires or

comparable substrates in a completely uniform manner and as unbroken continuous films having thicknesses ranging from a low micron measurement up to about 1 mil.

Therefore, an object of this invention is to provide a novel method for applying a fluorinated hydrocarbon coating or sheath to the exterior of an elongated, small diameter object such as the body of a spring guide used for surgical catheterization procedures, or a conducting wire to be contained within an instrument electrode.

Another object of this invention is to provide a method of the character stated in which the object to be coated is first slowly immersed in a dispersion or emulsion of the selected fluorinated hydrocarbon, slowly removed therefrom, subjected to a preliminary drying at moderate temperatures for a short time, then subjected to a higher temperature curing for a somewhat longer time, and then cooled slowly.

Another object of this invention is to provide a method of the character stated in which the immersion of the object to be coated preferably is maintained for a matter of minutes; the initial drying preferably takes place at a temperature of about 180°F for about one half hour; the higher temperature curing takes place within a temperature range of from about 545° - 700°F, preferably for about 1-½ hours; and the final cooling takes place preferably over a period of about 2 hours to reduce the temperature to at least as low as about 150°F, after which the coated object may be removed to the ambient temperature of the atmosphere.

Another object of this invention is to provide a method of the character stated in which the resultant coating is a transparent film.

A further object of this invention is to provide a method of the character stated in which the temperatures and treating times are such as to prevent any substantial degradation of the physical and mechanical qualities of the substrate such as loss of resiliency or major discoloration.

With these and other objects, the nature of which will become apparent, the invention will be more fully understood from the following detailed description and the appended claims.

A typical spring guide that may be coated in accordance with this invention is disclosed in the U.S. Pat. No. 3,749,086, granted July 31, 1973, to William M. Kline and Charles C. Roach.

Both FEP and TFE (or PTFE) types of fluorinated hydrocarbons and probably others, are suitable for use in the method of this invention and are commercially available from DuPont in dispersions, for example, as "Teflon" 120 for the FEP dispersion and "Teflon" 30B for the TFE dispersion.

The following example describes a preferred method of this invention:

EXAMPLE

1. A spring guide, fine wire or its equivalent, to be coated first has its exterior subjected to a degreasing (cleaning) operation.

2. The spring guide or fine wire is then slowly immersed in the selected fluorinated hydrocarbon dispersion, under non-agitated conditions, for a sufficient time to permit full coating at least of the exterior of the spring guide or fine wire with the dispersion, which time generally is within the range of from 2-30 minutes, preferably about 10 minutes. The dispersion (on a

100-part basis by weight) should contain about 10-40 parts by weight, preferably about 20, of the selected fluorinated hydrocarbon resin.

3. The spring guide or fine wire is then slowly removed from the dispersion and at least partly dried in a nonturbulent atmosphere at about 180°F for about 10-120 minutes, preferably about ½ hour, and removed from that drying atmosphere and cooled to an ambient temperature not greater than about 90°F.

4. The thus at least partly dried spring guide or fine wire then is placed in an oven at the approximate 90°F ambient temperature and the temperature of the oven then is raised slowly over a period of 10-180 minutes, preferably about 1-½ hours, to a range of 550°-600°F, preferably about 575°F, for the FEP dispersion coating; or to a range of 650°-700°F, preferably about 675°F, for the TFE dispersion coating. In either case, the temperature then is slowly reduced over a period of 30-180 minutes, preferably about 2 hours, to at least as low as 150°F in order to produce a clear, unbroken film, after which the thus coated or sheathed spring guide is removed to the ambient temperature of the open atmosphere. In this manner, through the controlled applications of heat, followed by controlled coolings, the non-resin portions of the selected dispersion or emulsion are driven off and the remaining resin forms a hot melt that becomes annealed and firmly bonded to the coils of the spring substrate as an unbroken transparent flexible and virtually colorless film. The final slow cooling from the 550°-700°F heating range (exact temperatures are, of course, dependent upon the selected type of resin) down to at least as low as 150°F is the most critical part of this process, since appreciably faster cooling to 150°F or lower will not produce either the desired fully bonded unbroken flexible film or a film that remains fully bonded and unbroken when the substrate to which it is applied subsequently is subjected to a physical distortion such as flexing.

It also should be mentioned that at a temperature below about 545°F for the FEP resin or below about 645°F for the TFE resin, the applied coating will be non-uniform and will readily powder off. Furthermore, if the temperatures exceed the stated maximums, i.e. 600°F for FEP or 700°F for TFE, the coating will char and become discontinuous as by crazing or flaking. In neither event is the coating completely and firmly bonded to the substrate.

Here, the film, under the stated conditions, forms a melt after the emulsifier has been driven off by heat as the temperature progressively rises; and the resultant unbroken clear film becomes annealed and firmly bonded to the substrate during the above described slow cooling. Furthermore, the temperatures and times of heating are such that the strength and resiliency of the spring or wire substrate are substantially unaffected nor does the substrate become appreciably discolored.

The method described in the foregoing Example produces a coating film or sheath whose thickness is in the low micron range; but if it is desired to increase the ultimate thickness of the applied film, the coating procedures may be repeated in their entirety, one or more times until the desired ultimate coating thickness, up to about 1 mil, has been achieved.

Although, in the appended claims, the phrase "liquid dispersion" has been used to define the physical state

of the solids-containing liquid to be applied to the substrate, it will be understood that this phrase also is intended to include emulsions and other types of solids-containing liquids.

It also should be understood that while the above description generally relates to a method of coating coil springs or single wires of circular or rectangular cross-section, the method is equally effective for coating small diameter wires of either twisted or braided multi-strand construction.

I claim:

1. A method of applying and firmly bonding a fluorinated hydrocarbon resin coating to the exposed surface of a clean flexible metallic substrate selected from the group consisting of a coil spring in which the helices thereof are in mutual contact and a fine conducting wire of small area cross-section and comprising the steps of: supplying a liquid dispersion bath of a fluorinated hydrocarbon resin selected from the group consisting of hexafluoropropylene-tetrafluoroethylene copolymer and tetrafluoroethylene; slowly immersing said substrate in said dispersion bath under non-agitated conditions for about 2-30 minutes to effect a coating of said dispersion thereon and then slowly removing said substrate from said dispersion bath; then subjecting said removed dispersion coated substrate to a preliminary heating in a non-turbulent atmosphere at a temperature not exceeding about 180°F for about 10-120 minutes; then cooling said preliminarily heated dispersion coated substrate to about the ambient temperature of the atmosphere; then subjecting said preliminarily heated and cooled dispersion coated substrate to a further heating to a temperature of about 545°-700° F for about 10-180 minutes whereby to drive off any non-resin portions of said dispersion coating and to cause the resin thereof to form as a hot melt in contact with said substrate; and then slowly cooling the thus further heated resin coated substrate to a temperature at least as low as about 150°F over a period of about 30-180 minutes, whereby to cause the resin coating thereof to become firmly bonded thereto as an unbroken flexible transparent film.

2. The method of claim 1 in which said liquid dispersion on a 100 parts by weight basis contains about 10-40 parts by weight of said resin.

3. The method of claim 2 in which said liquid dispersion contains about 20 parts by weight of said resin.

4. The method of claim 1 in which said further heating of said hexafluoropropylene-tetrafluoroethylene copolymer dispersion coated substrate is performed over a period of about ninety minutes at a temperature of about 545°-600°F.

5. The method of claim 4 in which said further heating temperature is about 575°F.

6. The method of claim 1 in which said further heating of said tetrafluoroethylene dispersion coated substrate is performed over a period of about ninety minutes at a temperature of about 645°-700°F.

7. The method of claim 6 in which said further heating temperature is about 675°F.

8. The method of claim 1 in which said substrate is a coil spring in which the helices thereof are in mutual contact.

9. The method of claim 1 in which said substrate is a fine conducting wire of small area cross-section.

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