

UNITED STATES PATENT OFFICE

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ELECTRICAL OIL

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This invention relates to electrical oils, and has for its object the provision of certain improvements in the treatment of such oils, as well as the provision, as a new article of commerce, of an improved electrical oil.

Electrical oils are highly refined mineral oils especially prepared for electrical usage. One extensive and important use for such oils is in impregnating the paper insulation in oil-paper electric cables. The failure in service of such cables has been the subject of exhaustive investigations, and many theories have been advanced to explain the causes of failure. Deterioration of the oil is generally believed to be the initial cause of failure, and the ultimate break down or puncture of the paper appears to be a consequence of the oil deterioration. Oxidation and ionization have heretofore been considered the primary causes of deterioration of the oil. Oxidation of the oil results from residual air in the cable and the heat developed in its normal use, and ionization or electron bombardment results from the inclusion or formation of gas bubbles or air gaps in the cable.

As a result of an exhaustive investigation of oil-paper cable failures, I have confirmed the belief that micro-organisms, such as bacteria or fungi, are present in electrical oils, and the presence of these micro-organisms exercises a marked deteriorating effect upon the oil. It is my belief that the cellulose-destroying, gas-producing micro-organisms, probably thermophilic in character, are particularly deleterious in electrical oils. These micro-organisms are probably introduced into the oil by contact with air and other media in which they abound, and they appear to incubate more readily in paraffin base oils although they are present and active in naphthene base oils. To the best of my knowledge, this deleterious action of micro-organisms in electrical oils has not heretofore been recognized in the industry to the extent that corrective agents or processes are used commercially. It now seems likely that the greater activity of these micro-organisms in paraffin base oils may have contributed to the present-day usual selection of and preference for a naphthene base oil for electrical usage. I have not only proven the presence of micro-organisms in insulation oils by incubation tests on agaragar, but I have demonstrated that the micro-organisms present in electrical oils cause the formation of the characteristic gases, water, acids and solids which are generally believed to be the initial and primary causes of cable failures. I have in fact found striking

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similarity in the gases, water, acids and solids resulting from the presence and action of micro-organisms in other organic media (mostly soils) and the gases, water, acids and solids formed during the aging of electrical oils.

Based on the foregoing discoveries, the present invention involves treating the oil with naphthoquinone and thereby inhibiting the deleterious action of the micro-organisms. I have tested a large number of anti-oxidants, fungicides and bacteriacides; and while I have found that the micro-organisms are easily rendered innocuous, the inhibitor impairs the electrical characteristics of the cable insulation to an intolerable extent. Naphthoquinone, however, has little or no effect upon the electrical characteristics of the insulation, while completely inhibiting the micro-organisms. The following table illustrates the superior and substantially perfect action of naphthoquinone, as contrasted with a currently popular bacteriacide and rosin. The power-factor (P. F.) test is that customary in cable testing, being carried out at a temperature of 85° C., with 50 volts per mil wall thickness of insulation. The insulation resistance (I. R.) is expressed in megohms per centimeter raised to the 10⁵ power. The oil specimens were heated for 10 days in an open beaker at 85° C. (the standard 10 day aging test), and following the aging test only the oil containing naphthoquinone responded favorably to the electrical tests, showing practically as good electrical properties as the initial untreated and unaged oil.

Specimen	P. F.	I. R.
Untreated Electrical Oil, Initial Test.....	0.17	104.0
Untreated Electrical Oil, After aging ¹	0.328	57.3
Oil containing 0.2% Naphthoquinone, After aging ¹	0.191	102.5
Oil containing 0.2% bacteriacide, After aging ¹	0.378	48.5
Oil containing 0.5% Rosin, After aging ¹	0.562	29.3

¹ Aging 10 days at 85° C. in open 1000 cc. beaker.

The increase in power factor and the decrease in insulation resistance of the untreated oil and the oils treated with bacteriacide and rosin, after aging, is indicative of the deterioration of these oils as a result of aging. Such deterioration is responsible for the failure in service of the insulation of paper-oil cables. The improved electrical oil of the invention, containing naphthoquinone, suffers practically no deterioration in aging. It is outstanding in the following three respects:

1. The electrical properties are substantially

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unchanged after aging, showing good electrical stability.

2. Aging results in the formation of no deleterious oxidation products, indicating good chemical stability.

3. The activity of both fungi and bacteria is effectively inhibited, as shown by the fact that no fungi or bacteria was incubated on agaragar in three days at 37° C., indicating high immunization against micro-organism activity.

Naphthoquinone (C₁₀H₆O₂) is a crystalline solid at ordinary temperatures, and is available in two isomeric forms, namely alpha-(1,4) naphthoquinone and beta-(1,2) naphthoquinone. Both isomers are suitable inhibitors in practicing the invention, although I now believe that alpha-naphthoquinone is the better. The amount of naphthoquinone used is relatively small, being from 0.05 to 0.2%, and preferably about 0.1% of the oil treated. This amount of naphthoquinone is readily incorporated or dissolved in the oil by first warming the oil to a temperature of from 125 to 150° F., and then introducing the naphthoquinone. The naphthoquinone dissolves slowly in the oil and warming reduces the viscosity of the oil and promotes solution. It is now my preferred practice to permit the warm mixture to stand for about one-half hour, with intermittent stirring if desired, at which time the naphthoquinone is adequately incorporated in the oil.

Any refined mineral oil possessing the necessary characteristics for electrical usage may be advantageously treated in accordance with the invention. Because of the present preference for naphthenic base oils, I prefer to use such oils in preparing treated oils for cable insulation. However, the invention renders paraffin base oils suitable for electrical usage, since naphthoquinone effectively inhibits the action of micro-organisms in such oils, in spite of the fact that paraffin hydrocarbons are more susceptible to break-down or deterioration through the action of micro-organisms than are the naphthene hydrocarbons.

While I have herein more particularly referred to the use of electrical oils in oil-paper cables, the

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treated oil of the invention is adapted for general electrical usage.

I claim:

1. An improved electrical insulating oil consisting of a highly refined mineral oil suitable for use as an insulating medium in electrical equipment which has been stabilized against the deleterious action of micro-organisms therein by incorporation in the oil of about 0.05 to 0.2% by weight of naphthoquinone.

2. An impregnant for use in oil-filled electric cables consisting of a highly refined mineral oil suitable for use as an insulating medium in electrical equipment which has been stabilized against the deleterious action of micro-organisms therein by incorporation in the oil of about 0.05 to 0.2% by weight of naphthoquinone.

3. In oil-filled electric cables wherein a paper covering about a conductor is impregnated with an electrical insulating oil, the improvement which comprises the use of an impregnant consisting of a highly refined mineral oil suitable as an electrical insulating medium stabilized against the deleterious action of micro-organisms therein by the incorporation in the oil of about 0.05 to 0.2% by weight of naphthoquinone.

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