

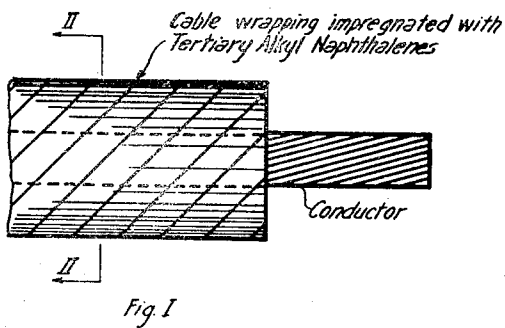
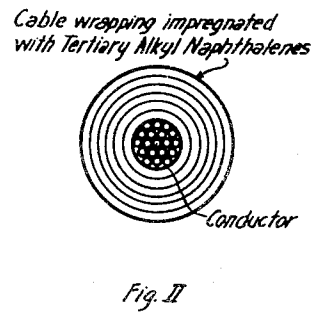
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ELECTRIC CABLE IMPREGNATED WITH TERTIARY ALKYL NAPHTHALENES

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ELECTRIC CABLE IMPREGNATED WITH
TERTIARY ALKYL NAPHTHALENESRobert G. Larsen, Berkeley, Calif., assignor to
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This invention relates to a hydrocarbon oil suitable particularly for impregnating cable-wrapping paper. This application is a continuation-in-part of my copending application, Serial Number 333,599, filed May 6, 1940, now abandoned.

Cables used in the transmission of electric power are frequently wrapped with a heavy paper which is impregnated with an oil for insulating purposes. When in operation, the temperature of this cable will vary considerably, depending upon the amount of current which goes through it. As the temperature of the cable changes, it expands and contracts. When it contracts under low loads and at low temperature, the metal of the cable has a tendency to draw away from the paper, frequently leaving under the paper small vacuum cups. As the current through the cable is increased, there is then a tendency to form silent electric discharges, in these vacuum cups, which discharges tend to decompose the oil used for impregnating the paper. During the decomposition, a small amount of gas is formed which fills the vacuum cup and causes the formation of an arc which destroys the paper, thereby breaking the insulation.

Gas may also enter into the vacuum cup if in the impregnation of the paper all the air adsorbed on the paper has not been displaced. Therefore, it is imperative that the cable-wrapping paper be thoroughly impregnated and all the adsorbed air be displaced therefrom.

In order to facilitate the impregnation, an oil of relatively low viscosity should be used. Yet at the same time, under normal conditions of operating the cable, the oil should not be so liquid as to cause the paper to feel oily to the touch. In other words, an oil is desirable which possesses a very low viscosity index such that it has a low viscosity at temperatures suitable for impregnation, but which is highly viscous, semi-solid or solid at normal room temperatures. Secondly, an impregnating oil should be substantially resistant to silent electric discharges, i. e., it should not liberate hydrogen or other gases when exposed to such discharges. Thirdly, the oil must be highly resistant to oxidation, and must possess a high dielectric strength.

No really satisfactory impregnating oil having

heretofore been produced, it is the purpose of this invention to produce an oil which meets all the demands stated above. Another purpose is to produce useful alkylated naphthalenes of improved oxidation stability and dielectric strength.

I have discovered that oils can be produced by the alkylation of naphthalenes which meet every requirement for cable oils in a highly satisfactory manner. My oils combine extraordinary oxidation stability and dielectric strength greatly surpassing those of the best commercial cable oils, and certain of my oils further have extremely low viscosity indexes below —100 down to about —1500.

It is already known that alkylation of naphthalenes can produce highly viscous oils. This alkylation may be carried out by reacting olefines or alkyl halides with naphthalene in the presence of a suitable Friedel-Crafts catalyst such as aluminum chloride. However, not all oils so produced are satisfactory for the impregnation of cable-wrapping papers. I have discovered that the resistance of the alkylated naphthalenes to oxidation, as well as to decomposition by silent electric discharges, depends largely upon the absence of primary or secondary aliphatic carbon atoms directly attached to the naphthalene ring, i. e., the carbon atoms which link the alkyl radicals to the ring must be tertiary carbon atoms carrying no hydrogen. It appears that the aliphatic carbon nearest to the aromatic ring is the most active of all the carbon atoms in the alkylated naphthalenes and loses hydrogen most easily when exposed to oxidizing conditions or to electric discharges, and by eliminating the hydrogen from the carbon nearest the ring this weakest link is also eliminated.

The tertiary alkyl naphthalenes of my invention can be produced by reacting, under the known conditions, naphthalene with tertiary base olefines, such as isobutylene, diisobutylene, triisobutylene, isoamylene, so-called hot acid octylenes produced by polymerizing isobutylenes with sulfuric acid at about 70° C., tertiary alkyl chlorides, tertiary alcohols, etc. The ratio of alkyl radicals to naphthalene in the reacted product should be greater than 2 and preferably between 3 to 5. To avoid excessive polymerization of olefines, if olefines are used for alkylation, it is

desirable to add the latter to the mixture as the reaction proceeds. The temperature of the reaction is preferably maintained between about 0°-150° C., depending on the alkylating agent used, and the amount of Friedel-Crafts catalyst employed is advantageously about 4% by weight of the naphthalene, although quantities from 1% to about 15% may be used.

Instead of a Friedel-Crafts catalyst, other alkylation catalysts, such as sulfuric or sulfonic acids, may also be used.

The oils produced in the reaction shown above comprise mixtures of polymerized olefines and various alkyl naphthalenes containing different numbers of tertiary alkyl side chains. These oils are subjected to high vacuum fractional distillation to produce one or several lower boiling fractions having end boiling points below about 200° C. at 3 mm. mercury absolute pressure; and one or several heavy fractions having initial boiling points above about 190° C. at 3 mm. mercury absolute pressure and end boiling points at the same pressure which may be in the cracking temperature range.

If a single lower boiling fraction is produced which boils up to about 200° C. at 3 mm. mercury, a relatively light oil is obtained having a viscosity index of around 30-70 and a fairly low dielectric strength. This fraction may, if desired, be divided into narrower fractions, some of which have relatively high, and others low viscosity indexes. Of these, the fractions boiling above about 150° C. at 3 mm. mercury have good dielectric strength varying from about 35-40 kv.

The heavier fractions having initial boiling points about 190° C. at 3 mm. mercury all have anomalous viscosity temperature behavior, i. e., their viscosity indexes are very low. At ordinary room temperature, they are extremely viscous or semi-solid, whereas at slightly elevated temperatures they become very fluid and of low viscosity. Their viscosity indexes normally vary from approximately -100 to -1500.

The oils having the peculiarly low viscosity indexes are believed to consist predominantly of a suspension of normally solid di- or tri-tertiary alkyl naphthalenes and an extremely viscous oil comprising tri- and higher tertiary alkyl naphthalenes. The trialkyl naphthalenes may be normally solid or liquid, depending on the relative position and length of the alkyl radicals in the naphthalene. The anomalous viscosity index is believed to be the result of formation of sub-microscopic aggregates due to the tertiary side chains which raise the setting point of the product.

The high oxidation stability of my oils in comparison to alkyl naphthalenes containing primary and/or secondary alkyl radicals is well illustrated by the following oxygen absorption data which give the milliliters O₂ absorbed per hundred grams of oil at 150° C. in a certain time:

Oil	Hours	O ₂ Absorbed
Polytertiary alkyl naphthalene.....	163	207
Polysecondary amyl naphthalene.....	80	1,060
Tertiary butyl alpha-methyl naphthalene.....	80	1,691

The dielectric strength of commercial insulating oils is generally of the order of about 25-35 kilovolts (kv.). The oils of my invention, however, have in general dielectric strength above

35 kv. and many of them above that of phenol-formaldehyde condensation product, which is the standard material used in the construction of the testing cell for the determination of dielectric strength of insulating oils. Thus some of the oils, particularly those boiling above 190° C. at 3 mm. mercury have a dielectric strength of above 50 kv.

These oils, however, are not suitable as general purpose electric insulating oils. For example, their low dielectric constant (2.3-2.5) precludes their utilization as dielectric oils for condensers or capacitors where a dielectric constant of from 5 to 6 is generally required. However, their low power factor and low viscosity index make them ideally suited for the specific use of impregnating cable wrappings. For example, a fraction of my alkylated naphthalenes boiling between 210 and 230° C. at 8 mm. Hg was oxidized 48 hours at 150° C. Under these conditions, General Cable Company specifies that the initial power factor (60 cycles) shall not be greater than 0.5% and the final power factor 7.0% at 100° C. My oil, carefully purified from traces of residual chlorine resulting from use of the aluminum chloride catalyst in its synthesis, compared favorably with these standards.

The accompanying drawings illustrate the article of the present invention, Figures I and II showing side and end views thereof, respectively.

Example I

An approximately equimolar mixture of naphthalene and hot acid octylenes was reacted with 4% aluminum chloride at 80°-90° C. An almost colorless oil was produced consisting predominantly of a mixture of various tertiary butyl naphthalenes, some tertiary octyl naphthalenes and some polyisobutylenes. This oil was fractionally distilled at an absolute pressure of 3 mm. mercury. A light fraction boiling from 178° to 193° C. was produced having a viscosity at 210° F. of 3.22 centistokes and at 130° F. of 11.88 centistokes, which is equivalent to a viscosity index of 65. A heavier fraction boiling from 193° to 205° C. at 3 mm. mercury had a viscosity at 210° F. of 9.40 centistokes, at 130° F. 89.19 centistokes and at 100° F. 418.63 centistokes. This is equivalent to a viscosity index of -358 over the temperature range of 130°-210° F., and a viscosity index of -418 over the temperature range of 100°-210° F. This heavier oil proved to be highly resistant toward oxidation, as well as to silent electric discharges.

In an oxygen absorption test in which a sample of oil is exposed to pure oxygen at atmospheric pressure for several days at a temperature of 130° C., it was found that the rate of oxygen absorption of the above oil was about one-fourth of the rate of oxygen absorption of oils having similar viscosities of 210° F. but containing primary or secondary alkyl radicals.

Example II

A mixture of naphthalene and diisobutylene was reacted as follows: To 5120 grams of naphthalene and 6720 grams of diisobutylene were slowly added 200 grams of AlCl₃ in small batches.

About 200 grams diisobutylene chloride were used as activators. The temperature of the extremely vigorous reaction was maintained at 80°-90° C. during the addition of the catalyst. Finally the mixture was stirred 3.5 hours at 100°-120° C. After removal of the aluminum chloride sludge,

the product was fractionally distilled. The following fractions were produced:

Fraction	Boiling Temp. at 3 mm. Hg	Percent Yield	Vis./100° F. S. U. S.	Vis./130° F. S. U. S.	Vis./210° F. S. U. S.	V. I.	Dielectric Strength
1	Less than 123° C.	8.5	42.63	39.90	6.89		Ks.
2	123-137°	12	67.75	47.54	33.8	-100	
3	137-156°	28	245.2	98.53	40.08	-326	
4	156-175°	21	600	355	52.91	-38	43.4
5	175-190°	13	2,000	650.5	93.37	+36	38.7
Residue		8					

The 9.5% distillation loss was probably due to polyisobutylene dissociating to isobutylene and the resulting escape of the gas from the reaction mixture.

The residue from the above distillation was then further distilled to produce several fractions, all of which had extremely low viscosity indexes and boiling temperatures in excess of 3 mm. mercury above 190° C. The properties of two typical fractions are shown below:

Boiling Temp. ° C.	Vis./100° F. S. U. S.	Vis./130° F. S. U. S.	Vis./210° F. S. U. S.	V. I.	Flash Point, ° F.
168°/0.75 mm. Hg.	35,256	3,729	127	-1230	370
161°/0.05 mm. Hg.	144,424	12,043	244.1	-1286	400

The dielectric strength of two random fractions obtained from the above residue was tested with the following results:

Boiling Temp., ° C.	Dielectric Strength
	Ks.
168°/1.1 mm. Hg.	50
163°/0.07 mm. Hg.	51

I claim as my invention:

1. An electric cable comprising a conductor, a wrapping of non-conducting porous material on said conductor, said material being impregnated with a viscous non-oxidizing hydrocarbon oil dielectric consisting of tertiary alkyl naphthalenes having a boiling temperature above 190° C. at 3 mm. of mercury and a viscosity index below -100.

2. The cable of claim 1 wherein the tertiary alkyl naphthalenes are poly-tertiary alkyl naphthalenes.

3. The cable of claim 1 wherein the alkyl naphthalenes are predominantly di-tertiary butyl naphthalenes.

4. The cable of claim 1 wherein the porous material is paper.

5. The cable of claim 1 wherein the alkyl naphthalenes are predominantly poly-tertiary amyl naphthalenes.

6. The cable of claim 1 wherein the oil dielectric consisting of tertiary alkyl naphthalenes comprises essentially tertiary alkyl naphthalenes that are liquid at normal room temperature.

7. The cable of claim 1 wherein the oil dielectric consisting of tertiary alkyl naphthalenes comprises essentially tertiary alkyl naphthalenes

that are semi-solid at normal room temperature.
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