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INSULATING OIL

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This invention relates to insulating oils; and it is particularly concerned with an improved transformer oil having high resistance to deterioration by oxidation and sludging, comprising a highly refined petroleum oil, a small amount of a water and alkali insoluble alkylated phenol antioxidant, particularly 2,6-di-tertiary-butyl-4-methyl phenol, and a small amount of N-tetra-hydrofurfuryl-p-aminophenol; all as more fully hereinafter set forth and as claimed.

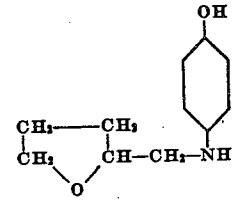
In many types of electrical transformers the core and windings are immersed in a suitable petroleum oil, which serves as an insulating oil and for carrying heat away from the core and windings. The requirements of a transformer oil include good dielectric properties, low viscosity to facilitate heat transfer by convection, low pour point to avoid solidification of the oil by cold, high flash and fire points to minimize danger of fire and explosion and low volatility to reduce evaporation losses. In addition the oil must be resistant to oxidation and sludging, and must be of such character as to resist emulsification with water.

Transformer oils ordinarily are distillate oils refined in such manner as to secure the specified characteristics to as great an extent as possible. Achievement of satisfactory oxidation resistance is difficult, for while oxidational changes are slow, transformer oils are ordinarily expected to remain in service over long periods. Oxidational changes may result in the formation of insoluble matter or sludge. The sludge tends to render the oil more miscible with water, with production of emulsions in the presence of condensed water and a consequent degradation of the dielectric properties of the oil body. The sludge also deposits on the windings and core with reduction of the efficiency of heat transfer. Oxidation of transformer oils tends to be promoted by contact with metals, especially copper, and with the usual varnishes and insulating materials.

Various materials have been proposed for incorporation into transformer oils with the object of inhibiting oxidation, and some of these have come into use. The usual anti-oxidants may be divided in two principal classes: (1) those which are associated with a lengthening of the induction period, that is the time which elapses before appearance of sludge in the oil subject to oxidation, and (2) those which reduce the rate at which sludge is formed after it once begins to form. In evaluating oils containing anti-oxidants, the most useful criterion is a value which takes into account both these characteristics, viz., the time required, under the test conditions, to form a definite amount of sludge, say 0.1 per cent by weight of the oil.

The 2,4,6-tri-alkylated monohydroxy phenols having four or more carbon atoms in the alkyl groups ortho to the hydroxyl group and which are substantially insoluble in water and in dilute aqueous alkali, have proved particularly satisfactory as anti-oxidants in transformer oils in lengthening the induction period before sludge begins to form. The compound 2,6-di-tertiary-butyl-4-methyl phenol is quite effective for this purpose. It has been found however that after the induction period in a transformer oil containing a compound of this class, the rate of sludge formation is sometimes greater than in the original oil. Thus the total time required to form 0.1 per cent of sludge in the oil is often shorter than would be expected in view of the prolonged induction period.

I have discovered that this difficulty can be overcome by incorporating in a transformer oil along with the 2,6-di-tertiary-butyl-4-methyl phenol or other alkylated phenol anti-oxidant of this class, a small amount of N-tetrahydrofurfuryl-p-aminophenol having the formula:



I have found that a transformer oil composition thus produced has an extraordinarily low rate of sludge formation in addition to a long induction period so that the useful life of the oil is substantially increased. The N-tetrahydrofurfuryl-p-aminophenol modifies the action of the 2,6-di-tertiary-butyl-4-methyl phenol during the induction period, and the rate of sludge formation after the induction period is lower than is obtainable with either of the anti-oxidants alone.

Only very small amounts of N-tetrahydrofurfuryl-p-aminophenol are required to effectively stabilize transformer oils containing for example 2,6-di-tertiary-butyl-4-methyl phenol in the usual amounts of 0.1 to 1.0 per cent by weight. In general amounts of N-tetrahydrofurfuryl-p-aminophenol corresponding to about 0.003 to 0.05 per cent by weight have proved sufficient although larger amounts may be used without deleterious effect. The amount which may be used is substantially limited by the saturation solubility of the N-tetrahydrofurfuryl-p-aminophenol in the oil, which is usually about 0.08 per cent by weight, this compound being substantially more soluble in oil than most other furfuryl-p-amino compounds.

In the following table comparative test results on sludge formation are shown for an untreated

transformer oil, the same oil containing 2,6-di-tertiary-butyl-4-methyl phenol, the same oil containing N-tetrahydrofurfuryl-p-aminophenol and the same oil containing 2,6-di-tertiary-butyl-4-methyl phenol together with N-tetra-hydrofurfuryl-p-aminophenol. The test data were obtained in accordance with the sludge formation test for mineral transformer oil, described by F. M. Clark and E. A. Snyder in their paper entitled "Testing for Sludge Formation in Mineral Transformer Oil" presented at the thirty-ninth annual meeting for the American Society for Testing Materials. The test procedure described in the aforesaid paper was developed in collaboration with the laboratories of a considerable number of firms engaged in oil refining and in the manufacture of electrical equipment.

In this test, samples of oil are maintained in tubes containing copper wire at a constant temperature of 120° C. ± 0.5° C. The tubes are open at the top to an enclosed air space and dry air is passed at a controlled rate of 1½ to 2 cubic feet per hour through the enclosed space above the same tubes. Into each tube is introduced 22 grams of oil or oil composition to be tested, a number of tubes being employed. At prescribed intervals the tubes are successively removed and the amount of sludge determined. The results of these tests are reported in terms of the induction period, the percent of sludge formed per day and the total number of days taken to form 0.1 per cent of sludge.

The oil employed in all of the tests set forth hereinbelow was a typical petroleum transformer oil, commonly used for the purpose indicated.

Test No.	Oil composition	Induction period	Rate of sludge formation in 0.01 percent per day after induction period	Time to form 0.1 percent sludge
		Days		*Days*
1	Oil (no inhibitor)	0.5	1.00	10
2	Oil+(A)	12.5	2.05	18
3	Oil+(B)	0	0.30	34
4	Oil+(A)+(B)	6	0.22	50

(A) = 0.3% 2,6-di-tertiary-butyl-4-methyl phenol.
(B) = 0.02% N-tetrahydrofurfuryl-p-aminophenol.

It will be observed from these results that while the rate of sludge formation after the induction period was substantially increased by 2,6-di-tertiary-butyl 4-methyl phenol and was substantially decreased by N-tetra-hydrofurfuryl-p-aminophenol the two reagents together have a rate lower even than that for the N-tetra-hydrofurfuryl-p-aminophenol alone; and while the N-tetrahydrofurfuryl-p-aminophenol decreased the induction period of the oil containing 2,6-di-tertiary-butyl-4-methyl phenol the net result of the combined action of the 2,6,-di-tertiary-butyl-4-methyl phenol and the N-tetrahydrofurfuryl-p-aminophenol was to give an oil having a greatly prolonged useful life.

While my invention has been described herein with particular reference to transformer oil compositions, the combination of 2,6-di-tertiary-butyl-4-methyl phenol with N-tetrahydrofurfuryl-p-aminophenol is equally effective in stabilizing other forms of electrical insulating oils against oxidational deterioration, and insulating oils generally containing stabilizing amount of these compounds are included within the scope of my invention.

What I claim is:

1. An electrical insulating oil composition comprising a petroleum oil having a stabilizing amount of an alkali insoluble 2,4,6-tri-alkylated mono-hydroxy phenol and a stabilizing amount of N-tetrahydrofurfuryl-p-aminophenol dissolved therein.

2. An electrical insulating oil composition comprising a petroleum oil having a small amount of 2,6-di-tertiary-butyl-4-methyl phenol and a small amount of N-tetrahydrofurfuryl-p-aminophenol dissolved therein.

3. A transformer oil composition comprising a petroleum oil having a small amount of 2,6-di-tertiary-butyl-4-methyl phenol and a small amount of N-tetrahydrofurfuryl-p-aminophenol dissolved therein.

4. A transformer oil composition comprising a petroleum oil having 0.1 to 1.0 per cent by weight of 2,6-di-tertiary-butyl-4-methyl phenol and 0.003 to 0.08 per cent by weight of N-tetrahydrofurfuryl-p-aminophenol dissolved therein.

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