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STEAM TURBINE LUBRICANT

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8 Claims. (Cl. 252—56)

This invention relates to steam turbine lubricants and, more particularly, it relates to such lubricants which are especially resistant to rust and the formation of stable emulsions. In a still more particular consideration, it relates to additives which may be used in very small proportions to impart the above-mentioned properties to steam turbine lubricants.

The problems associated with steam turbine lubricants are considerably different and in some respects more severe than those which are encountered in other types of lubrication. The problems encountered are those which arise from the presence in steam cylinder lubricants of significant quantities of water and, furthermore, from the alternating high and low temperatures of the oil which tend to promote such accumulation of moisture. A still further aggravating condition arises from the rapid circulation of the oil such that it is unduly exposed to conditions of oxidation.

All of these conditions impose severe limitations upon lubricants which are intended for use in steam turbines and as a consequence thereof, it is necessary to compound with such lubricants certain minimum amounts of additives by which the lubricants are enabled to withstand the severe conditions.

Two of the very important requirements of a steam cylinder lubricant are, as indicated above, the ability to withstand the formation of rust and the resistance of such lubricants to the formation of stable emulsions. Specific laboratory tests have been devised to measure each of these properties and the commercial acceptance of any present-day steam cylinder lubricant is predicated to a large extent upon the results of such tests.

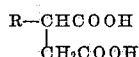
It is accordingly a principal object of the present invention to provide a lubricant which is adaptable for use in steam turbine engines.

It is a further object of the invention to provide a lubricant which is resistant both to the formation of rust and the formation of stable emulsions.

It is another object of the present invention to provide novel lubricant additives.

These and other objects are accomplished by the hereinafter described process by which there is made available a class of substituted succinic acid derivatives. The process comprises the reaction of:

(a) An aliphatic hydrocarbon-substituted acid having the structure



in which R is an aliphatic hydrocarbon radical having at least 10 carbon atoms, with

(b) From about 1 to about 75 percent on a molar basis of an alkylene oxide.

The product which is available from the above process has the ability to impart valuable properties to a lubricant which is adapted for use in steam turbines. The product is fully oil-soluble in mineral oils and is effective for the purposes for which it is intended in very small amounts.

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The nature of the R group of the substituted succinic acid of (a) is as indicated that of an aliphatic hydrocarbon radical and as such it may be either an alkenyl or an alkyl group. In most cases, and solely for reasons of economy, such an R group will be an alkenyl radical.

The presence and nature of this R group depends to a large extent upon the reaction by which the aliphatic hydrocarbon substituted succinic acid is prepared. The reaction involves addition of an olefin to maleic acid or, as is more usually the case, to maleic anhydride. In such a reaction the double bond of the maleic acid anhydride becomes saturated and there remains in the hydrocarbon portion of the adduct an olefinic double bond.

If it is so desired, the alkenyl succinic acid or anhydride may be converted to the corresponding alkyl-substituted succinic compound by hydrogenation and this hydrogenated product then used to prepare the turbine oil additives of this invention.

When the above addition reaction is used for the purposes of this invention, it is frequently desirable to use as the olefinic hydrocarbon reactant a low molecular weight polymer of a C_2-C_4 olefin. Such polymers are represented by tetrapropylene, triisobutylene, tetraiso-butylene, etc. Such polymeric hydrocarbons are monolefins and have a branched-chain structure and are quite useful in the process herein described.

A particularly preferred method of preparing the reactant (a) in the process involves the addition of tetrapropylene to maleic anhydride followed subsequently by hydrolysis of this adduct to the corresponding dodecenyl succinic acid.

Component (b), the alkylene oxide, is preferably a low molecular weight epoxide. The commercially available and economical propylene oxide and ethylene oxide are preferred and in some particular instances higher alkylene oxides may also be used with satisfactory results.

The relative amounts of reactants (a) and (b) are critical. It is essential that the substituted succinic acid be reacted with at least one percent (on a molar basis) of alkylene oxide and it is also essential, surprisingly enough, that less than a molar amount of an alkylene oxide be used based on the substituted succinic acid. It is essential in other words that the amount of alkylene oxide used be considerably less than sufficient to provide a neutral product.

The reaction of a substituted succinic acid with an alkylene oxide is, of course, an esterification reaction and as such involves a reduction in the acid number in the substituted succinic acid. It is apparent, therefore, that the reaction of equivalent quantities of alkylated succinic acid and alkylene oxide will result in a substantially neutral product. Such a product, while useful to a certain extent as a turbine oil additive, is outside the scope of this invention.

A particularly preferred ratio of reactants is about one mole of substituted succinic acid per 0.2–0.5 mole of alkylene oxide.

Generally the reaction is carried out by adding the alkylene oxide portionwise to the substituted succinic acid at somewhat elevated temperatures. Temperatures within the range of 50 to 100° C., for example, are satisfactory and the alkylene oxide may be added conveniently beneath the surface of the substituted succinic acid. The alkylene oxide reacts immediately as it is added, and when it has all been added, the reaction is essentially complete. It is not necessary to purify the product obtained in this fashion as it is suitable for use as such.

The invention will be illustrated in more detail by the following examples:

Example 1

A sample of dodecenyl succinic acid was warmed to

80° C. and treated portionwise throughout a period of one hour with 0.22 mole of propylene oxide. The propylene oxide was added beneath the surface of the dodecenyl succinic acid and the temperature was maintained at 80–85° C. throughout the addition and for one hour thereafter. The resulting product had an acid number of 215.

Example 2

A sample of dodecenyl succinic acid was heated to 80° C. and treated portionwise throughout a period of 30 minutes with 0.44 mole of ethylene oxide. The ethylene oxide was added beneath the surface of the dodecenyl succinic acid and the temperature was maintained at 80–90° C. throughout the addition and for an additional hour. The product showed an acid number of 195.

Example 3

A sample of dodecenyl succinic acid was heated to 80° C. and treated portionwise over a period of 30 minutes with 0.22 mole of ethylene oxide. The ethylene oxide was added beneath the surface of the dodecenyl succinic acid and the temperature was maintained during this addition and for an hour thereafter at 80–85° C. The product had an acid number of 212.

Example 4

To a sample of dodecenyl succinic acid at 80° C. there was added portionwise over a period of one hour 0.44 mole of propylene oxide. The propylene oxide was added beneath the surface of the acid and the temperature was maintained at 80–85° C. throughout this period and for an additional hour. The product had an acid number of 197.

All of the above products when incorporated in a mineral oil to the extent of 0.03 percent, imparted to that oil the ability to resist both the formation of rust and the tendency to form stable emulsions.

The first-mentioned property of resisting the formation of rust is measured by the following test: A mixture of 300 ml. of the lubricant and 30 ml. of sea water is stirred at 140° F. with a piece of steel immersed therein for 24 hours. At the conclusion of this time, the steel is inspected visually for rust spots. If there is any rust at all on the steel, the lubricant is adjudged a failure.

Lubricants which contained 0.03 percent of each of the products prepared as in the above examples passed this test.

Products available from the reaction of equimolar amounts of an alkyl or alkenyl succinic acid with an alkylene oxide proved to be unsatisfactory for use in a steam turbine lubricant because such products tended to settle out of solution upon cooling of the reaction mixture. Likewise, the product of the reaction of one mole of an alkenyl succinic acid with two moles of an alkylene oxide proved to be unsatisfactory for use because of the failure of such products to pass the above-described rust test. Thus, the criticality of the upper limit upon the molar amount of alkylene oxide for use in the herein described process is apparent.

Lubricants containing 0.03% of dodecenyl succinic acid fail the rust test, so that the criticality of the lower limit upon the amount of alkylene oxide to be used in the herein described process likewise is apparent.

The property of a lubricant to resist the formation of stable emulsions is measured by the following test: A mixture of 40 ml. each of lubricant and distilled water is placed in a 100 ml. glass cylinder immersed in a heating bath maintained at about 130° F. When the contents have reached 130° F., they are stirred vigorously for 5

minutes by means of a copper paddle (¾" wide by 4¾" long) revolving at 1500 r.p.m. The time required, after stirring has been stopped, for the volume of emulsion to recede to 3 ml. is taken as a measure of the lubricant's resistance to the formation of stable emulsions. If the time is more than 30 minutes, the lubricant is adjudged a failure.

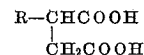
Lubricants which contained 0.03 percent of each of the products prepared as in the above examples passed this test also.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

1. A steam turbine lubricant comprising a major amount of a mineral oil and a minor but effective amount sufficient to inhibit the formation of rust and stable emulsions of an acidic product prepared by the process which comprises the reaction at a temperature within the range of about 50° C. to about 100° C. of:

(a) An aliphatic hydrocarbon substituted succinic acid having the structure



in which R is an aliphatic hydrocarbon radical having at least 10 carbon atoms, with

(b) From about 1 to about 75 percent on a molar basis of an alkylene oxide.

2. The lubricant of claim 1 characterized further in that the aliphatic hydrocarbon radical of (a) is an alkenyl radical.

3. The lubricant of claim 1 characterized further in that the aliphatic hydrocarbon substituted succinic acid of (a) is prepared by the hydrolysis of the reaction product of an olefin with maleic anhydride.

4. The lubricant of claim 1 characterized further in that the aliphatic hydrocarbon substituted succinic acid of (a) is dodecenyl succinic acid.

5. The lubricant of claim 1 characterized further in that the aliphatic hydrocarbon substituted succinic acid of (a) is prepared by hydrolysis of the reaction product of tetrapropylene with maleic anhydride.

6. The lubricant of claim 1 characterized further in that the alkylene oxide is selected from the class consisting of ethylene oxide and propylene oxide.

7. A steam turbine lubricant comprising a major amount of a mineral oil and a minor but effective amount sufficient to inhibit the formation of rust and stable emulsions of an acidic product prepared by the process which comprises the reaction at a temperature within the range of about 50° C. to about 100° C. of:

(a) Dodecenyl succinic acid; with
(b) From about 1 to about 75 percent on a molar basis of propylene oxide.

8. The lubricant of claim 7 characterized further in that the ratio of (a) to (b) is 1 to 0.2–0.5.

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