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LUBRICATING OIL

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Our invention relates to lubricating oils and specifically comprises such products as new compositions of matter. This is a continuation-in-part of our co-pending application, Serial No. 330,950, filed April 22, 1940.

Present-day mechanical devices require lubricating oils of high film strength and of high oiliness characteristics. It has been found that the present-day hydrocarbon lubricants of the very highest quality are deficient in these two very important characteristics. These two properties are of vital importance under conditions of thin film lubrication where the lubricant has been squeezed from between the friction surfaces due to high pressures, slow speeds, and other causes. It is readily seen that the viscosity or the body of the lubricant plays no part in this type of lubrication and that the remaining film of oil should tend to keep the coefficient of friction as low as possible and must have a very high film strength and be of high oiliness value to prevent rupture of the film of the lubricant, which would cause seizure.

Mechanical devices are being designed for higher pressure operation, and the film strength of the best quality straight hydrocarbon lubricants has been found to be too low and not sufficient; therefore an invention which provides the means of improving the film strength of these lubricants is of great importance to the art of lubricant manufacture and to the designer and fabricator of mechanical devices.

Substantially all machines operate in part or at times totally under conditions of boundary or thin film lubrication, under which conditions the oiliness or unctuosity of the lubricant is the first and primary requisite of efficient operation. Those skilled in the art of lubricant manufacture or machine manufacture will readily appreciate the value of an invention that will improve the oiliness of these otherwise high quality lubricants. Under some circumstances, a very small amount of an addition agent will stabilize a hydrocarbon oil against formation of corrosive oxidation compounds or sludge-forming compounds, and as little as 0.001 is often sufficient.

In starting idle mechanical equipment which is lubricated from a sump by pumping or circulating the lubricant, there is always a short period of time during which the rubbing surfaces must operate under conditions of dry friction if ordinary hydrocarbon lubricants are used. With dry friction, the wear on friction surfaces is extreme; and during cold weather when the lubricant is sluggish or during periods when the lubricating system is not functioning properly for one reason or another, rubbing surfaces may not only suffer considerable wear but may be damaged to the point where they must be replaced. The product of our invention has the very important property of reacting with the metal surfaces, penetrating or adsorbing on the metal, and leaving a film of lubricant with high oiliness character which remains on the metal surface irrespective of the length of time the machine is idle.

This high oiliness film is very even and results in smooth operation which may be easily discerned by the experienced operator and lubricating engineer.

When the hydrocarbon lubricants are diluted with unburned fuel or with other light hydrocarbons, the small degree of oiliness of the original hydrocarbon lubricant is greatly decreased. We have found that the addition of the product of our invention to hydrocarbon lubricants more than compensates for the loss in oiliness and load-carrying ability by dilution.

One object of our invention is to provide a lubricating composition having improved film strength and extreme pressure characteristics.

Other and further objects of our invention will appear from the following description.

We have found that certain compounds are adsorbed or absorbed by metals forming a plurality of layers or films on the surface of the metal, which films are very tenacious (they have a high film strength) and have the property of reducing the coefficient of friction to a greater extent than any known lubricant. The compounds which most readily are adsorbed by metals are ones consisting of polar molecules, that is, molecules of unsymmetrical electrical character which contain an atom or group of atoms exhibiting a secondary or residual valance. These polar compounds tend to produce regimentation of the molecules of hydrocarbon oil when added thereto. If a metal is immersed in a strongly polar compound, a regimentation or cybotaxis of the molecules will take place in the adsorbed film, the molecules being oriented with respect to the surface of the metal by which they are adsorbed. The films of polar compounds, adsorbed by a metal, can be plainly seen and the orientation of the polar molecules on the metal surface ascertained by X-ray diffraction methods, in which a mono-chromatic X-ray beam is passed through the adsorbed films at an angle. The series of films acts as a diffraction grating, and a diffracted beam will be reflected from the planes

of the films and can be recorded photographically. The X-ray photographs will clearly show the orientation of the molecules by characteristic pictures.

X-ray investigation has shown that strongly polar molecules form adsorbed films of unusual thickness and regularity of arrangement. Thicknesses of films of 9,000 Angstrom units have been obtained, which are of enormous magnitude when compared with molecular dimensions.

In general, our invention comprises the addition of relatively small amounts, suitably from 0.001 to 10 per cent, of certain boron compounds to hydrocarbon lubricants. For some purposes, we use from 0.1 to 2 per cent of the organic boron compound in the hydrocarbon oil. For other purposes we use from 0.001 to 0.1 per cent of the organic boron compound in the lubricant. The hydrocarbon portion of our compound may be comparatively viscous or nonviscous, refined or unrefined, natural or synthetic. In order words, any hydrocarbon oil may be used within the scope of our invention.

In practicing our invention we use certain organic boron compounds which may contain other inorganic elements, such as halogen, oxygen, hydrogen, sulphur, phosphorus, et cetera. The boron compounds particularly suited to our invention are of two classes, as follows:

R_2BOR', in which R and R' are organic radicals, at least one of which contains a carboxylic ester group, $—CO_2R''$. An example of this type is diethylboric acid carboethoxy-undecyl ester $(C_2H_5)_2BOCH(CO_2C_2H_5)C_{10}H_{21}$.

$RB(OR')_2$, in which R and R' are organic radicals, at least one of which contains a carboxylic ester group, $—CO_2R''$. An example of this type is phenylboric acid di (carboethoxy-undecyl) ester, $C_6H_5B[OCH(CO_2C_2H_5)C_{10}H_{21}]_2$.

These two types of organo-boron esters have the general formula $R_nB(OR')_{3-n}$, where n is an integer less than 3, the valence of boron. They contain at least one carbon-boron bond and at least one organic radical is removable by saponification. R and R' are organic radicals at least one of which contains carbon, hydrogen, and oxygen, the latter in the form of the carboxylic ester group, $—CO_2R''$. Oxygen may also be present in other forms as well as various forms of sulfur, halogen, phosphorus, or metals. Other examples of our compounds are diamyl-boric acid carbomethoxy-heptadecyl ester made by the condensation of sodium diamylborate with methyl alpha-chlorostearate:

$$(C_5H_{11})_2B.ONa+C_{16}H_{33}CHClCO_2CH_3\rightarrow (C_5H_{11})_2B.OCH(CO_2CH_3)C_{16}H_{33}+NaCl$$

Other examples similarly prepared are amyl boric acid di (carbomethoxy-heptadecyl) ester, chlorophenyl boric acid di (carbomethoxy-undecyl) ester, dicyclohexyl boric acid thio-carbomethoxy-heptadecyl ester, and the like. Of all the organo-boron compounds, these esters are especially suitable for addition to lubricants because they combine the carboxylic ester groups with the organo-metallic boric acid esters in the same molecule. They are more stable, more effective, and more readily oil-soluble than simpler organo-boron compounds not containing the additional carboxylic ester group.

It is sometimes advantageous to combine more than one of these compounds in a blend to obtain particular properties. We accomplish this by mixing two or more of these compounds together and blending the mixture with hydrocarbon oil, or by blending one in the hydrocarbon oil, blending the second into this mixture, and so on until the composition is complete.

We have found that the organic boron compounds above set forth may be more effective in some compositions if a comparatively small amount of halogen-free, oxygen-containing carbon compound is included in the composition. The oxygen-containing carbon compound may be of aliphatic, aromatic, or hetero-cyclic nature and may be blended with the organic boron compound in amounts ranging from 5 to 50 per cent. Such compounds include esters of oxidized petroleum hydrocarbons such as wax, methyl ricinoleate, diphenyl ether, diphenylene oxide (dibenzofuran), and many others.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in details within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, we claim:

1. A lubricant comprising in combination a major proportion of hydrocarbon oil and a minor proportion of an organo-boron ester having the formula $R_nB(OR')_{3-n}$, in which R is an organic radical, R' is an organic radical containing a corboxylic ester group, and n is an integer less than 3.

2. A lubricant comprising in combination a major proportion of hydrocarbon oil and a minor proportion of an organo-boron ester having the formula $RB(OR')_2$, in which R is an organic radical and R' is an organic radical containing a carboxylic ester group.

3. A lubricant comprising in combination a major proportion of hydrocarbon oil and a minor proportion of an organo-boron ester having the formula $R_2B.OR'$, in which R is an organic radical and R' is an organic radical containing a carboxylic ester group.

4. A lubricant comprising in combination a major proportion of hydrocarbon oil and a minor proportion of diethylboric acid carboethoxy-undecyl ester.

5. A lubricant comprising in combination a major proportion of hydrocarbon oil and a minor proportion of phenylboric acid di (carbo-ethoxy-undecyl) ester.

6. A lubricant comprising in combination a major proportion of hydrocarbon oil and a minor proportion of diamylboric acid carbomethoxy-heptadecyl ester.

7. A lubricant comprising in combination a hydrocarbon oil and from 0.001 to 10 per cent of an organo-boron ester having the formula $R_nB(OR')_{3-n}$, in which R is an organic radical, R' is an organic radical containing a corboxylic ester group, and n is an integer less than 3.

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