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3,001,941
LUBRICANTS CONTAINING A DEPOSIT-CONTROL ADDITIVE

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This invention relates to a lubricating oil containing a novel class of additives which act to control deposits in the combustion zone and to minimize the effects of deposits resulting from the combustion of the fuel particularly under low temperature conditions. More specifically, this invention discloses that superior lubricating oils from the standpoint of removal of low temperature deposits are obtained by addition of a minor amount of polyglycol carbonate ester of prescribed composition.

As automobile manufacturers annually raise the compression ratio of their engines in the race for higher horsepower, the problem of engine deposits resulting from the fuel becomes increasingly more severe. Engine deposits which find their origin in the fuel are primarily responsible for surface ignition phenomena such as preignition and octane requirement increase (ORI) which is the tendency of spark ignition engines in service to require higher octane fuels for proper performance. There are two avenues by which this problem can be attacked. One approach is through the fuel and the other is through the lubricating oil. In a coassigned copending application filed of even date, Serial No. 554,925, now U.S. Patent No. 2,844,448, it is disclosed that superior hydrocarbon fuels from the standpoint of engine deposits result from the incorporation of polyglycol carbonate esters of prescribed composition. The subject application involves the discovery that the addition of a polyglycol carbonate ester of prescribed composition to a lubricating oil produces a lubricant marked by the ability to maintain a clean engine even with dirty fuels under low temperature conditions of operation.

Modern lubricating oils for internal combustion engines usually contain a combination of additives which impart detergent and dispersant properties as well as resistance to oxidation to lubricating oils. The detergent and dispersant properties are normally obtained by the addition of alkaline earth metal petroleum sulfonates, alkaline earth metal salts of alkyl-substituted aromatic compounds or derivatives of these compounds. The most commonly used antioxidant and inhibitor is a divalent metal dialkyl dithiophosphate. Lubricating oils containing additives of these types are compounded to a Supplement I level. Oils of Supplement I level are very satisfactory lubricants for modern automobile engines from all standpoints with the exception of effectiveness in controlling deposits formed under low temperature conditions. The lubricating compositions of this invention are particularly designed for control of deposits resulting at low temperature conditions of operation.

The improved lubricating oils of this invention contain a polyglycol carbonate ester of the general formula

$$R'OCOO(RO)_nCOOR''$$

wherein R is a divalent aliphatic radical containing at

least 2 carbon atoms, R' and R'' are aliphatic hydrocarbon radicals containing between 3 and 18 carbon atoms and *n* is an integer having a value of at least 2, in an amount sufficient to eliminate deposits formed during fuel combustion and to maintain a clean engine. The polyglycol carbonate ester is effective in the lubricating oils in concentrations as low as 0.2 volume percent but concentrations of 0.5 to 3.0 volume percent are normally employed. There is no critical upper limit of concentration, but economic considerations dictate that concentrations less than 5.0 volume percent polyglycol carbonate be present in the lubricating oil.

This invention also contemplates a process for maintaining an internal combustion engine free from deposits, particularly those formed during low temperature operation, by the presence of a polyglycol carbonate ester of the above described composition in the combustion zone. This can be effected by using a fuel containing polyglycol carbonate as disclosed in the aforedescribed copending application, by using a lubricant containing a polyglycol carbonate as described herein, by employing a fuel and lubricant both of which contain a polyglycol carbonate ester or by adding a polyglycol carbonate ester to either the fuel, lubricant or both during engine operation. In the latter mode of operation, the polyglycol carbonate ester is added to the gasoline in an amount to constitute 0.01 to 1.0 volume percent of the fuel and/or to the lubricant to constitute 0.2 to 5 volume percent of the lubricating oil.

The polyglycol carbonate esters which control the deposits formed under low temperature conditions are readily formed by a series of reactions involving the formation of an alcohol chloroformate by reaction of phosgene with an alcohol and subsequently reacting the alcohol chloroformate with a polyglycol in the presence of a hydrogen chloride acceptor such as pyridine or quinoline. An alternate reaction procedure involves formation of a polyglycol dichloroformate by reaction of polyglycol with phosgene and subsequent reaction of polyglycol dichloroformate with an aliphatic alcohol in the presence of a hydrogen chloride acceptor. The preparation of compounds of this type is disclosed in U.S. Patents 2,370,567 and 2,370,569.

The lubricating oil of this invention is effective in maintaining deposits at a low level with the result that an engine lubricated therewith shows exceptionally clean cylinder head, combustion space, valves and ring belt area. The low deposit level in the engine minimizes surface ignition in all its manifestations, mainly preignition and "knock." In addition, the low deposit level reduces the engine's octane requirement increase. Deposits on surfaces contacted by the additive-containing lubricating oil, such as piston skirts and cylinder walls, are very markedly reduced.

Polyglycol carbonate esters usable in the process of the invention are exemplified by the following: diethylene glycol bis(allyl carbonate), triethylene glycol bis(allyl carbonate), tetraethylene glycol bis(allyl carbonate), diethylene glycol bis(n-amyl carbonate), triethylene glycol bis(n-amyl carbonate), tetraethylene glycol bis(n-amyl carbonate), dipropylene glycol bis(n-amyl carbonate), polyglycol (av. mol wt. 300) bis(n-amyl carbonate), polyglycol (av. mol wt. 400) bis(2-ethylhexyl carbonate), tetraethylene glycol bis(2-ethyhexyl carbonate), diethylene glycol bis(2-ethylbutyl carbonate), diethylene glycol bis(n-

propyl carbonate), polyglycol (av. mol wt. 400) bis(n-amyl carbonate), diethylene glycol bis(4-pentenyl carbonate), diethylene glycol bis(isoamyl carbonate) and tripropylene glycol bis(2-ethylhexyl carbonate).

A surprising feature of this invention is that compounds closely related to compounds falling within the prescribed general formula shown above are ineffective in deposit-controlling engine deposits. For example, a monoglycol carbonate ester such as ethylene glycol bis(allyl carbonate) is ineffective while diethylene glycol carbonate esters such as diethylene glycol bis(allyl carbonate) are excellent deposit-control additives. Similarly, diethylene glycol bis(ethyl carbonate) is ineffective in controlling deposits while diethylene glycol bis-(allyl carbonate) is a very good deposit-control additive. As a result of intensive experimentation, the following generalizations have been made with regard to the properties required for a glycol carbonate ester to exhibit deposit-control properties.

The polyglycol carbonate esters that are effective as lubricating oil additives in controlling deposits are all characterized by boiling points above 650° F., a molecular weight above 270 and a carbon to oxygen ratio by weight below 2.50. Apparently, the polyglycol carbonate ester must possess all of these properties simultaneously in order to impart deposit-control properties to lubricating oils. In Table I below the boiling point, molecular weight and C to O ratio by weight for various glycol carbonate esters are shown.

TABLE I

	Approximate Boiling Pt., ° F.	Molecular Weight	Weight C to O Ratio
Ethylene glycol bis(allyl carbonate)	560	230	2.00
Diethylene glycol bis(allyl carbonate)	660	274	1.57
Diethylene glycol bis(n-amyl carbonate)	720	334	1.71
Diethylene glycol bis(methyl amyl carbonate)	700	362	1.93
Tetraethylene glycol bis(allyl carbonate)	790	362	1.33
Tetraethylene glycol bis(2-ethyl-hexyl carbonate)	(a)	506	2.18
Tetraethylene glycol bis(amyl carbonate)	795	422	1.67
Polyglycol (av. mol. wt. 300) bis(2-ethylhexyl carbonate)	(a)	644	2.05
Polyglycol (av. mol. wt. 400) bis(2-ethylhexyl carbonate)	(a)	744	1.80
Diethylene glycol bis(n-butyl carbonate)	670	306	1.50

(a) Not distilled—too high boiling.

In summary, the following conclusions can be made as to the requirements of each section of the additive molecule for the production of a glycol carbonate ester having deposit-control properties. The alkylene oxide unit, that is the $-(RO)_n-$ group, must contain at least 2 units; as many as 2 to 10 repeating units can be used in this portion of the molecule; ethylene and propylene oxide units are preferred from the standpoint of cost, availability and effectiveness. Two carbonate radicals are required since polyglycol monocarbonate ester compounds are ineffective as deposit-control lube additives. The terminal aliphatic radicals must contain at least three carbon atoms; aliphatic radicals containing 3 to 10 carbon atoms are preferred. In both the alkylene oxide group and in the terminal aliphatic radicals, straight chain radicals are preferred to the branched chain hydrocarbon radicals although if the overall molecule is large, moderate branching can be tolerated. Similarly, primary alkyl carbonate esters of the polyglycols are preferred to secondary and tertiary carbonate esters.

As a general rule, longer chain terminal radicals are combined with polyglycols containing a larger number of repeating alkylene oxide units while lower molecular weight terminal aliphatic radicals are combined with polyglycols containing a small number of repeating alkylene oxide units. Thus, a 2-ethylhexyl terminal radical is preferably used in the formulation of a tetraethylene glycol carbonate ester than in the formulation of a diethylene glycol carbonate ester. Formulating the polyglycol carbonate esters following this general rule assures that the resulting additive has a carbon to oxygen weight ratio less than 2.5.

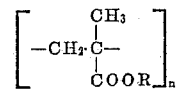
The polyglycol carbonate ester is effective as a deposit-control additive when it constitutes 0.2 volume percent of the lubricant. The concentration of the polyglycol carbonate ester usually falls between 0.5 and 3.0 volume percent of the lubricant. Since the improvement in concentrations higher than 5 volume percent are only marginal, a practical upper limit is about that level even though here is no critical upper limit. Economic considerations also dictate that the polyglycol carbonate ester be less than 5 percent.

The polyglycol carbonate esters of this invention are effective in controlling deposit formation in lubricants employed in spark ignition engines, diesel motors and gas turbines. However, the polyglycol carbonate esters of prescribed composition are normally used in motor oils for spark ignition engines wherein fuel derived deposits formed during low temperature operation are a particularly vexing problem. Diesel lubricants containing polyglycol carbonate esters are effective in eliminating deposits resulting from the use of the so-called "economy" diesel fuels, e.g. fuels having a high sulfur content or containing cracked or residual stocks. The polyglycol carbonate esters are also useful as deposit-control additives in gas turbine lubricants which are generally ester base lubricants. The polyglycol carbonate esters are useful in aviation oils which lubricate reciprocating aviation engines. The scope of the lubricating oils to which the polyglycol carbonate esters of the invention are added with the formation of superior lubricants from the standpoint of deposit-removal is broad and includes mineral oils, synthetic lubricating oils and mixtures thereof.

The hydrocarbon mineral oils usable in this invention can be paraffin base, naphthene base or mixed paraffin-naphthene base distillate or residual oils. Paraffin base distillate lubricating oil fractions are used in the formulation of premium grade motor oils such as are contemplated in this invention. The lubricating base generally has been subjected to solvent refining to improve its lubricity and viscosity temperature relationship as well as solvent dewaxing to remove waxy components and improve the pour of the oil. Broadly speaking, mineral lubricating oils having an SUS viscosity at 100° F. between 50 and 1,000 may be used in the formulation of the improved lubricants of this invention but usually the viscosity range falls between 70 and 300 at 100° F.

The mineral lubricating oils to which the polyglycol carbonate esters of this invention are added usually contain other additives designed to impart other desirable properties thereto. For example, VI improvers such as the polymethacrylates are normally included therein as are materials which act as detergents and dispersants for the removed combustion chamber deposits.

The VI improver normally used is a polymethacrylate of the general formula



wherein R is an aliphatic radical.

The most commonly used detergent-dispersant addi-

tive is an alkaline earth metal petroleum sulfonate such as calcium petroleum sulfonate or barium petroleum sulfonate. These products are so well known as detergent-dispersant additives they require no further description. Similarly, divalent metal alkyl phenolates are widely used as detergents either alone or in combination with the alkaline earth metal petroleum sulfonates.

The most commonly used inhibitor and antioxidant is a divalent metal alkyl dithiophosphate which results from the neutralization of a P_2S_5-alcohol reaction product with a divalent metal or divalent metal oxide. The most widely used inhibitors are barium and zinc alkyl dithiophosphates.

The synthetic lubricating bases are usually of the ester or ether type. High molecular weight, high boiling liquid aliphatic dicarboxylic acid esters possess excellent viscosity-temperature relationships and lubricating properties and are finding ever increasing utilization in lube oils adapted for high and low temperature lubrication; esters of this type are used in the formulation of jet engine oils. Examples of this class of synthetic lubricating bases are the diesters of acids such as sebacic, adipic, azelaic, alkenyl succinic, etc.; specific examples of these diesters are di-2-ethylhexyl sebacate, di-2-ethylhexyl azelate, di-2-ethylhexyl adipate, di-n-amyl sebacate, di-2-ethylhexyl n-dodecyl succinate, di-2-ethoxyethyl sebacate, di-2'-methoxy-2-ethoxyethyl sebacate (the methyl Carbitol diester), di-2'-ethyl-2-n-butoxyethyl sebacate (the 2-ethylbutyl Cellosolve diester), di-2-n-butoxyethyl azelate (the n-butyl Cellosolve diester) and di-2'-n-butoxy-2-ethoxyethyl-n-octyl succinate (the n-butyl Carbitol diester).

Polyester lubricants formed by a reaction of an aliphatic dicarboxylic acid of the type previously described, a glycol and a monofunctional aliphatic monohydroxy alcohol or an aliphatic monocarboxylic acid in specified mol ratios are also employed as the synthetic lubricating base in the compositions of this invention; polyesters of this type are described in U.S. 2,628,974. Polyesters formed by reaction of a mixture containing specified amounts of dipropylene glycol, sebacic acid and 2-ethylhexanol and of a mixture containing adipic acid, diethylene glycol and 2-ethylhexanoic acid illustrate this class of synthetic polyester lubricating bases.

Polyalkylene ethers as illustrated by polyglycols are also used as the lubricating base in the compositions of this invention. Polyethylene glycol, polypropylene glycol, polybutylene glycols and mixed polyethylene-polypropylene glycols are examples of this class of synthetic lubricating bases.

The sulfur analogs of the above-described diesters, polyesters and polyalkylene ethers are also used in the formulation of the lubricating compositions of this invention. Dithioesters are exemplified by di-2-ethylhexyl thiosebacate and di-n-octyl thioadipate; polyethylene thioglycol is an example of the sulfur analogs of the polyalkylene glycols; sulfur analogs of polyesters are exemplified by the reaction product of adipic acid, thioglycol and 2-ethylhexyl mercaptan.

The action of the polyglycol carbonate ester in improving the deposit-removing properties of a lubricating oil was demonstrated by a Modified Chevrolet Deposits Test—CRC–FL–2–650. The laboratory engines are operated under the standard conditions of this test with the exception that crankcase oil temperatures were 10° F. lower, the water jacket temperatures were 5° F. lower, and the crankcases of the test engines were ventilated. These modifications are in every case in the direction of making the test more severe and are intended to simulate low temperature conditions wherein deposit formation is most pronounced. After the termination of each run, the engine is disassembled and its parts are evaluated by a merit system adapted from the CRC–L–4–1252 test. This merit system involves visual examination of the engine part in question and their rating according to deposits by comparison with standards which have assigned ratings. For example, a rating of 10 on piston skirt designates a perfectly clean piston while a rating of zero represents the worst condition. Similarly, a rating of 100 on total engine deposits represents a perfectly clean engine, etc.

In Table II there are shown the results obtained in the foregoing test with a lubricating oil containing various concentrations of diethylene glycol bis(allyl carbonate). The fuel used in this test was a high quality regular grade gasoline comprising a mixture of thermal cracked stock, fluid catalytically cracked stock and straight run gasoline. This regular base fuel had an 87.0 ASTM Research Octane rating, contained 2.90 ml. of TEL per gallon, had an API gravity of 58.0 and a boiling range between 106° F. and 396° F.; the base fuel was negative in the copper corrosion test and had an oxidation stability in the ASTM test of 530 minutes minimum. The reference fuel also contained minor amounts of gasoline inhibitors, namely N,N'-di-secondary butyl-para-phenylene diamine, lecithin, and N,N'-disalicylidene 1,2-diamino propane.

The reference lubricating oil was a 20–20W heavy duty oil meeting Supplement I requirements. This reference oil contained a methacrylate VI improver and a balanced combination of additives which impart detergent, dispersant and antioxidant properties to the oil. The additive mixture comprised a barium petroleum sulfonate, and a zinc alkyl dithiophosphate in which the alkyl group is a methylcyclohexyl radical. The concentration of diethylene glycol bis(allyl carbonate) varied in this run from 1–5 weight percent.

TABLE II

Additive, volume percent	0	1	3	5
Visual Ratings:				
Piston Skirt	4.9	6.2	8.3	9.7
Total Engine	76.4	83.2	86.3	88.7

In Table III there are shown the results of incorporating polyethylene glycol (av. mol wt. 300) bis(2-ethylhexyl carbonate) in the same 20–20W grade heavy duty Supplement I motor oil; the same regular grade gasoline was used as a reference fuel.

TABLE III

Additive, volume percent	0	0.25	1	4
Visual Ratings:				
Piston Skirt	6.0	8.5	8.5	9.0
Total Engine	80.0	85.5	88.5	90.0

Runs illustrated in Tables II and III show that polyethylene glycol carbonate esters are effective deposit-control additives in lubricating oils. The data also show that the optimum concentration depends upon the particular polyglycol carbonate ester used. Polyethylene glycol (av. mol wt. 300) bis(2-ethylhexyl carbonate) is more effective then equivalent concentrations of diethylene glycol bis(allyl carbonate). The data in these tables also indicated that only minor improvement is obtained by increasing the concentration of polyglycol carbonate ester from about 3 to about 5 percent.

In Table IV are shown the results obtained in the modified Chevrolet deposits tests with lubricating oils which possessed various concentrations of polyglycol carbonate esters. In this series of experiments, the concentration of polyglycol carbonate esters in the lubricant was determined at the conclusion of the run by analysis.

TABLE IV

	Piston Skirt	Total Engine Deposits	Concentration of Additive in Oil at Run Termination, Vol. Percent
Reference oil	4.7	77.7	0
Reference oil containing concentrations of additives in oil:			
ethylene glycol bis(allyl carbonate)	3.5	70.5	0.75
diethylene glycol bis(allyl carbonate)	8.5	84.5	3.0
triethylene glycol bis(allyl carbonate)	8.7	86.7	3.5
tetraethylene glycol bis(allyl carbonate)	9.2	89.2	3.5
diethylene glycol bis(amyl carbonate)	8.8	87.8	4.0
tetraethylene glycol bis(amyl carbonate)	7.5	82.5	3.0
diethylene glycol bis(n-butyl carbonate)	8.5	87.5	4.5
diethylene glycol bis(2-ethylhexyl carbonate)	5.8	80.8	3.0
polyglycol (av. mol wt. 300) bis(2-ethylhexyl carbonate)	9.3	91.3	3.5
tetraethylene glycol bis(2-ethylhexyl carbonate)	6.8	84.0	3.0
triethylene glycol bis(allyl carbonate)	8.7	86.7	3.5
triethylene glycol bis(amyl carbonate)	9.0	91.0	4.0
polyglycol (av. mol wt. 400) bis(2-ethylhexyl carbonate)	8.7	87.7	3.0
polyglycol (av. mol wt. 300) bis(amyl carbonate)	9.5	89.5	5.0
polyglycol (av. mol wt. 400) bis(amyl carbonate)	9.2	87.2	3.0

The data in Table IV show that polyglycol carbonate esters of the prescribed formula are effective deposit-control lubricating additives. Ethylene glycol bis(allyl carbonate) was ineffective as a deposit-control additive and actually gave dirtier piston skirt and total engine ratings whereas clean engines were obtained when the lubricating oil had polyethylene glycol carbonate ester present during the runs.

It is also significant that higher molecular weight alkyl radicals in the carbonate ester are advantageously combined with polyglycols of a large number of alkylene oxide units than with lower molecular weight polyglycols. This result is evident from a comparison of the ratings obtained with diethylene glycol bis(2-ethylhexyl bonate) and polyglycol (av. mol. wt. 300) bis(2-ethylhexyl carbonate).

Specificity of the polyglycol carbonate ester structure is further shown by data shown in Table V. Numerous compounds were evaluated that contained portions of the preferred overall structure but in no case was a good deposit-control additive obtained. In some instances the additive degraded the deposit control and resulted in a dirtier engine.

TABLE V

Additive	Molecular Weight	Weight C to O Ratio	Piston Skirt Rating	Total Engine Rating
None			4.7	77.7
Diallyl ether	98	4.5	5.0	75.0
Diallyl ether			5.3	82.3
Diallyl ether of diethylene glycol	186	2.5	3.7	74.7
Dibutyl ether of tetraethylene glycol	306	2.4	5.0	76.0
Diethyl ether of diethylene glycol	162	2.0	5.0	71.0
Allyl alcohol	70	2.25	4.2	72.2
Diallyl carbonate	142	1.75	4.8	75.8

The effect of using a polyglycol ester in both the fuel and lubricating oil is illustrated in Table VI. The base fuel in these runs was the same regular grade gasoline used in Table II. The base lubricating oil in this run was the same 20–20W heavy duty oil of Supplement I level also employed in runs illustrated in Table II. The additive used in Table VI was diethylene glycol bis(allyl carbonate).

TABLE VI

Additive, volume percent:						
Fuel	0	0.1	0.0	0.025	0.05	0.05
Oil	0	0	1.0	1.0	0.5	1.0
Visual Ratings:						
Piston Skirt	4.9	8.5	6.2	7.8	7.7	9.0
Total Engine	74.9	84.5	83.2	81.8	82.7	89.0
Intake Manifold	9	9	9	9	9	9

These results show that the use of diethylene glycol bis(allyl carbonate) in both the fuel and the oil gave excellent results at a level of 0.05 percent in the fuel and 1 percent in the oil. These data also prove that conjoint use of the additive in both oil and fuel offers some advantage over the use of the additive in one medium.

Effect of additives on engine wear

Frequently, in the course of development of useful additives for improved lubricants and fuels, deleterious side effects are encountered. The deleterious effects may greatly overshadow the one or more advantages obtained from the use of the additive. Deleterious action is frequently encountered as increase in engine wear of such engine parts as piston rings, cylinder walls, bearings, and valves. The polyglycol carbonate esters described in this invention are unusual in that no deleterious effects have been encountered in the large amount of engine testing conducted. In fact, with respect to wear of vital engine parts, it has been found that wear is actually decreased under high temperature conditions which are most severe with respect to engine wear.

The test used for high temperature wear and corrosion is an extended versison of the CRC–L–4–1252 test. In the extended test, the total test time is 72 hours instead of the usual 36. This increase in test time makes the test more severe. Bearing weight loss is the criterion for possible corrosive or wear action. As indicated in Table VII, below, no deleterious effect was noted for a polyglycol carbonate ester.

The base fuel used in the results shown in Table VII was the high quality regular grade gasoline previously described in connection with the results shown in Table II. The lubricating oil was the 20–20W grade Supplement I level lubricating oil also described in connection with the results shown in Table II. Diethylene glycol bis(n-amyl carbonate) was the additive used in the run shown in Table VII.

TABLE VII

High temperature wear—CRC–L–4 extended test

	Additive, vol. percent		Bearing Wt. Loss in gms.
	Base Fuel	Base Oil	
(1)	0.0	0.0	0.215
(2)	0.05	1.0	0.100

The data in Table VII prove that decreased wear was obtained by the use of a polyglycol carbonate ester in both the fuel and lubricating oil. The wear in the run in which additive was present in both fuel and oil was less than ½ that obtained with no additive present.

In Table VIII are shown similar results for polyethylene glycol (av. mol wt. 300) bis (2-ethylhexyl carbonate). In the run shown in Table VIII the reference fuel was the L–4 reference fuel which has the following properties:

API gravity	62.0
ASTM Motor Octane	84.6
Ml./gal. TEL	2.92
Copper corrosion	1—
Boiling range, °F.	98–405
CD gum	8
ASTM gum	1

The reference lubricating oil was a high quality 30–30W grade Supplement I level paraffin base oil containing the same detergent-inhibitor combination employed in the 20–20W grade oil used in the previous examples.

TABLE VIII

High temperature wear—CRC–L–4 extended test

	Additive, vol. percent		Bearing Wt. Loss, gms.
	Base Fuel	Base Oil	
(1)	0	0	0.113
(2)	0	1.0	0.077

The foregoing data prove that lubricants containing polyglycol carbonate esters of prescribed composition are outstanding in controlling deposits. Moreover, polyglycol carbonate esters appear to fill the one main need of Supplement I detergent oils, namely ability to control low temperature deposits.

Obviously, many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and only such limitations should be imposed as are indicated in the appended claims.

We claim:

1. A lubricating oil containing a polyglycol carbonate ester having a carbon to oxygen ratio below 2.5, a boiling point above 650° F. and the following general formula

$$R'OCOO(RO)_nCOOR''$$

wherein R is a divalent aliphatic hydrocarbon radical containing at least 2 carbon atoms, R' and R'' are aliphatic hydrocarbon radicals containing between 3 and 18 carbon atoms and *n* is an integer having a value of 2 to 10, said glycol carbonate ester being present in an amount sufficient to impart deposit-control properties to said lubricating oil.

2. A lubricating oil according to claim 1 containing 0.2 to 5.0 volume percent polyglycol carbonate ester.

3. A lubricating oil according to claim 1 containing 0.5 to 3.0 volume percent polyglycol carbonate ester.

4. A lubricating oil according to claim 1 in which said polyglycol carbonate ester has terminal aliphatic radicals having 3 to 10 carbon atoms.

5. A mineral lubricating oil containing a polyglycol carbonate ester having a carbon to oxygen ratio below 2.5, a boiling point above 650° F. and the following general formula

$$R'OCOO(RO)_nCOOR''$$

wherein R is a divalent aliphatic hydrocarbon radical containing at least 2 carbon atoms, R' and R'' are aliphatic hydrocarbon radicals containing between 3 and 18 carbon atoms and *n* is an integer having a value of 2 to 10, said glycol carbonate ester being present in an amount sufficient to impart deposit-control properties to said mineral lubricating oil.

6. A lubricating oil according to claim 5 containing 0.2 to 5.0 volume percent polyglycol carbonate ester.

7. A lubricating oil according to claim 5 containing 0.5 to 3.0 volume percent polyglycol carbonate ester.

8. A mineral lubricating oil containing viscosity index improver, a detergent, corrosion inhibitor and a polyglycol carbonate ester having a carbon to oxygen weight ratio below 2.5, a boiling point above 650° F. and the following general formula

$$R'OCOO(RO)_nCOOR''$$

wherein R is a divalent aliphatic hydrocarbon radical containing at least 2 carbon atoms, R' and R'' are aliphatic hydrocarbon radicals containing between 3 and 18 carbon atoms and *n* is an integer having a value of 2 to 10, said glycol carbonate ester being present in an amount sufficient to impart deposit-control properties to said mineral lubricating oil.

9. A lubricating oil according to claim 8 containing 0.2 to 5.0 volume percent polyglycol carbonate ester.

10. A lubricating oil according to claim 8 containing 0.5 to 3.0 volume percent polyglycol carbonate ester.

11. A lubricating oil according to claim 8 containing diethylene glycol bis(allyl carbonate).

12. A lubricating oil according to claim 8 containing diethylene glycol bis(amyl carbonate).

13. A lubricating oil according to claim 8 containing tetraethylene glycol bis(allyl carbonate).

14. A lubricating oil according to claim 8 containing polyglycol bis(2-ethylhexyl carbonate).

15. A lubricating oil according to claim 8 containing triethylene glycol bis(allyl carbonate).

16. Di-2-ethylhexyl sebacate containing about 3 weight percent of a polyglycol carbonate ester having a carbon to oxygen ratio by weight below 2.5, a boiling point above 650° F., between 30 and 60 carbon atoms in the molecule, and the following general formula:

$$R'-O-\overset{O}{\overset{\|}{C}}-O-(RO)_n-\overset{O}{\overset{\|}{C}}-O-R''$$

wherein R is a divalent aliphatic hydrocarbon radical containing 2–3 carbon atoms, R' and R'' are aliphatic hydrocarbon radicals containing 6–11 carbon atoms and *n* is an integer having a value of 4–6, the composition of said sebacate containing said polyglycol carbonate having an ASTM pour point below about 35° F., a flash point above about 300° F., and a kinematic viscosity at 210° F. within the range of from 2 to 60 centistokes.

References Cited in the file of this patent

UNITED STATES PATENTS

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2,563,609	Matusak	Aug. 17, 1951
2,592,435	Lacomble	Apr. 8, 1953
2,651,657	Mikeska et al.	Sept. 8, 1953
2,673,185	Bartlett	Mar. 23, 1954

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,001,941 September 26, 1961

Kenneth L. Dille et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 46, after "bis(2-ethylhexyl" insert -- carbonate) and tetraethylene glycol bis(2-ethylhexyl car- --.

Signed and sealed this 27th day of February 1962.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents