

A diesel motor having improved properties

The present application relates to a diesel motor having improved properties. Furthermore the present invention
5 describes a use of polymers to improve the low temperature performance of a lubricant comprising biodiesel fuel.

Fuels are nowadays mostly obtained from fossil sources. However, these resources are limited, so that replacements
10 are being sought. Therefore, interest is rising in renewable raw materials which can be used to produce fuels. A very interesting replacement is in particular biodiesel fuel.

15 The term biodiesel is in many cases understood to mean a mixture of fatty acid esters, usually fatty acid methyl esters (FAMES), with chain lengths of the fatty acid fraction of 12 to 24 carbon atoms with 0 to 3 double bonds. The higher the carbon number and the fewer double bonds are
20 present, the higher is the melting point of the FAME. Typical raw materials are vegetable oils (i.e. glycerides) such as rapeseed oils (canola oils), sunflower oils, soya oils, palm oils, coconut oils and, in isolated cases, even used vegetable oils. Another typical source for Biodiesel
25 is animal fat. The raw materials are converted to the corresponding FAMES by transesterification, usually with methanol under basic catalysis. However, their use is accompanied by a number of deficiencies and limitations which must be addressed if they are to become viable
30 alternatives to mineral oil based diesel.

In view of the declining ecological quality and decreasing world crude oil reserves, the use of pure biodiesel has been an important target in many countries. However, many
5 issues, ranging from different combustion characteristic to corrosion of seal materials, have been reported as hindrances to the use of biodiesel as a replacement for fossil diesel. Another major obstacle is the regeneration of the diesel particulate filter. Regeneration is the
10 process of removing the accumulated soot from the filter. Dependent on the use of the vehicle, the temperature of the particulate filter could be too low to burn the particulate being filtered by the particulate filter. This problem usually occurs if the vehicle is used on short hauls
15 leading to an accumulation of soot in the particulate filter.

Typically a computer monitors one or more sensors that measure back pressure and/or temperature, and based on pre-
20 programmed set points the computer makes decisions on when to activate the regeneration cycle. Running the cycle too often while keeping the back pressure in the exhaust system low will use extra fuel. Not running the regeneration cycle soon enough increases the risk of engine damage and/or
25 uncontrolled regeneration (from an excess of accumulated soot) and possible DPF failure. Quality regeneration software is a necessity for longevity of the active DPF system.

30 In order to regenerate additional fuel can be injected into the engine in order to increase the exhaust gas temperature. Such regeneration type does not need an engineering effort and, hence, is relatively cheap.

However, such cycles may lead to an oil dilution. On the other hand, it is possible to use a vaporizer. However, such device is expensive and may cause failure. Therefore, the most of the cars are equipped with a motor control unit
5 being able to inject fuel to the engine in order to increase the exhaust temperature.

The problems mentioned above depend of the type of use of the passenger car. Using the car on very short range
10 circles lead to very critical problems resulting in short time lubricant changes. Furthermore, the issues are more critical to motors having a high sophisticated emission control system and further technical approaches for fuel savings. The more sophisticated the motor the more
15 sensitive the motor on lubricant decline, e.g. based on undue biodiesel content.

Lubricant decline, especially high biodiesel content and insufficient low temperature performance have detrimental
20 effects on various properties of the motor. These are especially critical for motors having biodiesel compatibility. Insufficient low temperature performance usually may cause problems regarding cold start and cold run characteristics of the motor. In addition thereto, the
25 life time and the fuel consumption of the motor are negatively influenced by an insufficient low temperature performance of the lubricant.

There have been many attempts to date to improve cold start
30 and cold run characteristics of the motors by engineering techniques and new facilities. However, these options are connected with disadvantages based on high costs and the fact that usually only the latest cars can benefit from

such improvements. Therefore, further opportunities to improve the cold start and cold run characteristics, the life time and the fuel consumption of the motor would be helpful.

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In view of the prior art, it was thus an object of the present invention to provide a solution which is not limited to new motor designs and can be applied to existing biodiesel motors. Especially the cold start and cold run characteristics of biodiesel motors should be improved. Furthermore, the improvement of life time and fuel consumption is a further object of the present invention. These improvements should be achieved without environmental drawbacks.

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It was a further object of the invention to provide additives for lubricating oils which provide improved cold start and cold run characteristics of biodiesel motors. In addition thereto the additive should improve the life time and the fuel consumption of biodiesel motors.

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Furthermore, the additives should be producible in a simple and inexpensive manner, and especially commercially available components should be used. In this context, they should be producible on the industrial scale without new plants or plants of complicated construction being required for this purpose.

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It was a further aim of the present invention to provide an additive which brings about a multitude of desirable properties in the lubricant. This can minimize the number of different additives.

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Furthermore, the additive should not exhibit any adverse effects on the fuel consumption or the environmental compatibility of the lubricant.

- 5 Moreover, the additive should improve the features of lubricating oils comprising a high amount biodiesel.

These objects and also further objects which are not stated explicitly but are immediately derivable or discernible
10 from the connections discussed herein by way of introduction are achieved by a motor having all features of claim 1. Appropriate modifications to the inventive motor are protected in the claims referring back to claim 1.

- 15 The present invention accordingly provides a motor designed for biodiesel compatibility comprising a particulate filter, a motor control unit being able to inject fuel to the engine in order to increase the exhaust temperature, and a lubricant composition, characterized in that the
20 lubricant composition comprises at least one ester group containing polymer.

It is thus possible in an unforeseeable manner to provide a motor designed for biodiesel compatibility having an
25 improved cold start and cold run characteristics. In addition thereto, the motor of the present invention shows an enhanced life time and lowered fuel consumption.

In addition thereto, the motor of the present invention
30 enables extended oil change intervals. Thus the motor provides significant improvements in economic aspects based on lower amounts of motor oil based on a specific mileage.

The motor of the present invention does not need complex design in order to regenerate the particulate filter. Furthermore, the regeneration does not decline the run characteristics of the motor.

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Moreover, the solution presented by the present invention is not limited to new motor designs and can be applied to existing biodiesel motors having an appropriate motor control unit being able to inject fuel to the engine in order to increase the exhaust temperature.

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Furthermore, the motor of the present invention can have a very high compression without being detrimental effected regarding the cold start and cold run characteristics and life time and the fuel consumption of biodiesel motors.

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Furthermore, the additives used in order to obtain a lubricant being able to solve the problems mentioned above can be prepared in a simple and inexpensive manner, and it is possible to use commercially available components in particular. At the same time, production is possible on the industrial scale, without new plants or plants of complex construction being required for that purpose.

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Furthermore, the polymers for use in accordance with the invention exhibit a particularly favorable profile of properties. For instance, the polymers can be configured so as to be surprisingly shear-stable, such that the lubricants have a very long service life. In addition, the additive for use in accordance with the invention may bring about a multitude of desirable properties in the lubricant. For example, it is possible to produce lubricants with outstanding low-temperature properties or viscosity

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properties, which comprise the present polymers comprising ester groups. This allows the number of different additives to be minimized. Furthermore, the present polymers comprising ester groups are compatible with many additives.

5 This allows the lubricants to be adjusted to a wide variety of different requirements.

Furthermore, the additives for use do not exhibit any adverse effects on fuel consumption or the environmental

10 compatibility of the lubricant.

Surprisingly, present polymers comprising ester groups improve the low temperature performance of lubricants comprising high amounts of biodiesel.

15 In addition thereto, the dispersing ability of the lubricant can be improved by using special embodiments of the inventive polymers. Considering these aspects, some of the biodiesel fuel comprises high amounts of ethylenically

20 unsaturated bonds being sensitive to oxidation. These oxidation products are merely soluble in the motor oil and may cause significant problems. Particulates and sludge formed in motor oil having no biodiesel content have different properties and, furthermore, motor oil having no

25 biodiesel content generates a lower amount of such impurities. These impurities are one of the reasons for a motor oil change.

Furthermore, the present motor comprises a lower corrosion

30 based on the ability of the present motor oil to neutralize the acids being formed on degeneration of the biodiesel fuel.

The present invention provides a new motor designed for biodiesel compatibility. These motors are usually part of biodiesel vehicles.

- 5 A biodiesel vehicle can usually use a mixture of biodiesel and petroleum based diesel. Preferred biodiesel engines are capable of burning any proportion of the resulting blend in the combustion chamber as fuel injection and spark timing are adjusted automatically according to the actual blend
10 detected by electronic sensors.

The biodiesel vehicle comprises a particulate filter. A diesel particulate filter, sometimes called a DPF, is a device designed to remove diesel particulate matter or soot
15 from the exhaust gas of a diesel engine. Wall-flow diesel particulate filters usually remove 85% or more of the soot, and can at times (heavily loaded condition) attain soot removal efficiencies of close to 100%. A diesel-powered vehicle equipped with functioning filter will emit no
20 visible smoke from its exhaust pipe.

Preferably the particulate filter has a porosity in the range from 30% to 60%, more preferably in the range of 40% to 50%. The porosity is the ratio of the pore volume to the
25 total volume of the particulate filter.

Preferably the particulate filter is made of an inorganic material, such as a silicate, a titanate, especially Tialite (Al_2TiO_5), a carbide, a ceramic or a metallic
30 material.

According to a preferred embodiment, the particulate filter is a wall-flow filter. More preferably, the particulate filter removes of at least 70 %, especially at least 85%
5 and more preferably at least 95% of the particulate.

Preferably a cordierite wall flow filter, a silicon carbide wall flow filter, a ceramic fiber filter, a metal fiber flow through filters can be used.
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Preferably the filter can be made of cordierite. Cordierite is a special ceramic material known in the art. Cordierite filters provide excellent filtration efficiency and are inexpensive.
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According to a further aspect the filter can be made of silicon carbide (SiC).

Fibrous ceramic filters are made from several different types of ceramic fibers that are mixed together to form a porous media. Fibrous filters have an advantage over wall flow design of producing lower back pressure.
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Some cores are made from metal fibers - generally the fibers are "woven" into a monolith. Such cores have the advantage that an electrical current can be passed through the monolith to heat the core for regeneration purposes, allowing the filter to regenerate at low exhaust temperatures and/or low exhaust flow rates.
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The particulate filters may have a coating being able to lower the burning temperature of the soot, e.g.

- 5 Additional information and specifications of the particulate filter are mentioned in Engine Bench and Vehicle Durability Test of Si bonded SiC Particulate Filters: A. Schäfer-Sindlinger, et al.. SAE 2004-01-0952. The document is enclosed herewith by reference for the
10 purpose of disclosure.

Furthermore, the motor of the present invention may comprise a catalyst to remove NO_x and other harmful components of the exhaust gas.

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In addition thereto, the motor comprises a motor control unit being able to inject fuel to the engine in order to increase the exhaust temperature.

- 20 According to a very preferred embodiment, the motor can be based on a common rail system for injecting the fuel into the combustion chamber.

- The term "common rail" refers to the fact that all of the
25 fuel injectors are supplied by a common fuel rail which is nothing more than a pressure accumulator where the fuel is stored at high pressure. This fuel reservoir is supplied by a high pressure pump providing a high pressure up to and above 2,500 bars. The fuel reservoir provides the fuel to
30 multiple fuel injectors. This simplifies the purpose of the high pressure pump in that it only has to maintain a commanded pressure at a target (either mechanically or electronically controlled). The fuel injectors are

typically ECU-controlled. When the fuel injectors are electrically activated a hydraulic valve (consisting of a nozzle and plunger) is mechanically or hydraulically opened and fuel is sprayed into the cylinders at the desired
5 pressure. Since the fuel pressure energy is stored remotely and the injectors are electrically actuated the injection pressure at the start and end of injection is very near the pressure in the accumulator (rail), thus producing a square
10 injection rate. If the accumulator, pump, and plumbing are sized properly, the injection pressure and rate will be the same for each of the multiple injection events.

Preferably, the diesel fuel can be injected by multiple injection steps during each burning cycle, such that a pre-
15 injection is made into the cylinder to warm the combustion chamber before delivering the main fuel charge.

Astonishing improvements can be achieved with a needle valve operating with a solenoid. Furthermore, piezoelectric
20 injectors could be used for improved motor control.

Preferably, the fuel pressure in the common rail system comprises at least 800 bar, especially at least 1,000 bar, more preferably at least 1,500 bar and most preferably at
25 least 1,800 bar.

Though technology exists to allow biodiesel engines to run on any mixture of petroleum based diesel and biodiesel, from pure gasoline up to 100% biodiesel (B100), North
30 American and European biodiesel vehicles are optimized to run on a maximum blend of 80% mineral diesel with 20% biodiesel (called B20 fuel). This limit in the biodiesel

content is set to avoid cold starting problems during cold weather, at temperatures lower than 11 °C (52 °F).

Preferably, the motor of the present invention is designed
5 to fuels comprising at least 5%, especially at least 10%,
particularly 20%, more especially at least 50% and more
preferably at least 80% by volume of biodiesel, e.g. FAME.
Furthermore, the motor of the present invention is
preferably designed to fuels comprising at least 5%,
10 especially at least 10%, particularly 20%, more especially
at least 50% and more preferably at least 80% by volume of
mineral diesel.

Preferably, the motor comprises a compression of at least
15 12, more preferably at least 16. According to a preferred
embodiment, the compression is preferably at most 26, more
preferably at most 23.

According to a special aspect of the present invention, the
20 motor may comprise a fuel injection pump.

Unforeseeable advantages can be achieved by a motor
comprising a multi valve technique.

25 Furthermore, the motor of the present invention may
comprise an exhaust gas recirculation. The exhaust gas
recirculation can preferably be cooled.

Preferably, the motor comprises an engine management
30 for optimization of the fuel injection and the spark
timing.

Moreover, the motor can preferably comprise a turbocharger and/or a supercharger. According to a preferred embodiment of the present invention, the motor may comprise a variable geometry turbocharger (VGT).

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Preferred motor of the present invention meet the requirements of exhaust emission standard Euro 5, more preferably EURO 6 as defined in Directive No. 715/2007/EC. The motor can also meet other requirements in order to

10 comply with national or regional standards such as TIER II in the US.

Additional information and specifications of specific components as mentioned above of the diesel motor of the

15 present invention are mentioned in Handbuch Dieselmotoren: Mollenhauer, Tschöke; Springer Verlag; 2007 and Otto- und Dieselmotoren: Grohe, Ruß; Vogel Buch Verlag; 2007. The documents are enclosed herewith by reference for the purpose of disclosure.

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The motor of the present invention comprises a lubricant composition including at least one ester group containing polymer.

25 The present invention describes polymers which preferably have a high oil solubility. The term "oil-soluble" means that a mixture of a base oil and a polymer comprising ester groups is preparable without macroscopic phase formation, which has at least 0.1% by weight, preferably at least 0.5%

30 by weight, of the polymers. The polymer may be present in dispersed and/or dissolved form in this mixture. The polymer may be added to a fresh oil and/or to an aged oil. Furthermore, the polymer may be added to a biodiesel and be

introduced into the lubricant oil by dilution of the oil. The oil solubility depends especially on the proportion of the lipophilic side chains and on the base oil. This property is known to those skilled in the art and can be
5 adjusted readily for the particular base oil via the proportion of lipophilic monomers.

Of particular interest, among others, are polymers which comprise ester groups, preferably polyalkyl(meth)acrylates
10 and preferably have a weight-average molecular weight M_w in the range from 2000 to 2 000 000 g/mol, especially from 7500 to 1 000 000 g/mol, more preferably 10 000 to 600 000 g/mol and most preferably 15 000 to 80 000 g/mol.

15 The number-average molecular weight M_n may preferably be in the range from 2000 to 1 000 000 g/mol, especially from 5000 to 800 000 g/mol, more preferably 7500 to 500 000 g/mol and most preferably 10 000 to 80 000 g/mol.

20 According to a special embodiment of the present invention, the ester group containing polymer, preferably a polyalkyl(meth)acrylate may have a weight-average molecular weight M_w in the range from 2000 to 1 000 000 g/mol, especially from 20 000 to 800 000 g/mol, more preferably
25 40 000 to 500 000 g/mol and most preferably 60 000 to 250 000 g/mol.

According to a further aspect of the present invention, the ester group containing polymer, preferably a
30 polyalkyl(meth)acrylate may have a number average molecular weight M_n in the range from 2 000 to 100 000 g/mol, especially from 4 000 to 60 000 g/mol and most preferably 5 000 to 30 000 g/mol.

Polymers having a high molecular weight are especially useful as viscosity index improvers. Polymers having a low molecular weight are especially useful as pour point
5 depressants and flow improvers.

Without intending any limitation by the following description, the polymers which comprise ester groups preferably exhibit a polydispersity, given by the ratio of
10 the weight average molecular weight to the number average molecular weight M_w/M_n , in the range of 1 to 15, more preferably 1.1 to 10, especially preferably 1.2 to 5. The polydispersity may be determined by gel permeation chromatography (GPC).

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The polymer comprising ester groups may have a variety of structures. For example, the polymer may be present as a diblock, triblock, multiblock, comb and/or star copolymer which has corresponding polar and nonpolar segments. In
20 addition, the polymer may especially be present as a graft copolymer.

Polymers comprising ester groups are understood in the context of the present invention to mean polymers
25 obtainable by polymerizing monomer compositions which comprise ethylenically unsaturated compounds having at least one ester group, which are referred to hereinafter as ester monomers. Ester monomers are known per se. They include especially (meth)acrylates, maleates and fumarates,
30 which may have different alcohol radicals. The expression "(meth)acrylates" encompasses methacrylates and acrylates, and mixtures of the two. These monomers are widely known.

Accordingly, these polymers contain ester groups as part of the side chain.

5 The polymer comprising ester groups can be used singly or as a mixture of polymers having different molecular weights, different compositions of repeating units and/or different ester group containing monomers, for example. E.g. some of the polymers may have properties of pour point depressants while other polymers are viscosity index
10 improvers. Preferably, a mixture comprising one or more pour point depressants and one or more viscosity index improvers can be used.

The polymer comprising ester groups comprises preferably at
15 least 40% by weight, more preferably at least 60% by weight, especially preferably at least 80% by weight and most preferably at least 90% by weight of repeat units derived from ester monomers.

20 According to a preferred embodiment of the present invention, the ester group containing polymer may include polyalkyl (meth)acrylates (PAMAs), polyalkyl fumarates and/or polyalkyl maleates. More preferably, the ester group containing polymer is an alkyl (meth)acrylate polymer.

25 Ester monomers for the manufacture of polyalkyl (meth)acrylates (PAMAs), polyalkyl fumarates and/or polyalkyl maleates are known per se. They include especially (meth)acrylates, maleates and fumarates, which
30 may have different alcohol parts. The expression "(meth)acrylates" includes methacrylates and acrylates, and mixtures of the two. These monomers are widely known. In

this context, the alkyl part may be linear, cyclic or branched. The alkyl part may also have known substituents.

5 The term "repeating unit" is widely known in the technical field. The present polymers comprising ester groups can preferably be obtained by means of free-radical polymerization of monomers, the controlled radical process techniques of ATRP, RAFT and NMP, which will be explained later, being counted among the free-radical processes in
10 the context of the invention, without any intention that this should impose a restriction. In these processes, double bonds are opened up to form covalent bonds. Accordingly, the repeat unit is obtained from the monomers used.

15 The polymers comprising ester groups preferably contain repeating units derived from ester monomers having 7 to 4000 carbon atoms in the alcohol part. Preferably, the polymer comprises at least 40 % by weight, especially at
20 least 60 % by weight and more preferably at least 80 % by weight of repeating units derived from ester monomers having 7 to 4000 carbon atoms, preferably 7 to 300 carbon atoms and more preferably 7 to 30 carbon atoms in the alcohol part.

25 According to a preferred embodiment the polymer may comprise repeating units derived from ester monomers having 16 to 4000 carbon atoms, preferably 16 to 300 carbon atoms and more preferably 16 to 30 carbon atoms in the alcohol
30 part, and repeating units derived from ester monomers having 7 to 15 carbon atoms in the alcohol part.

The polymer comprising ester groups may contain 5 to 100% by weight, especially 20 to 98% by weight and more preferably 30 to 60% by weight of repeat units derived from ester monomers having 7 to 15 carbon atoms in the alcohol
5 part.

In a particular aspect, the polymer comprising ester groups may contain 0 to 90% by weight, preferably 5 to 80% by weight and more preferably 40 to 70% by weight of repeat
10 units derived from ester monomers having 16 to 4000, preferably 16 to 30 carbon atoms in the alcohol part.

Preferably, the polymer may comprise repeating units derived from ester monomers having 23 to 4000 carbon atoms,
15 preferably 23 to 400 carbon atoms and more preferably 23 to 300 carbon atoms in the alcohol part.

In addition, the polymer comprising ester groups may contain 0.1 to 60% by weight, especially 0.5 to 40% by
20 weight, preferably 1 to 30% by weight and more preferably 2 to 20% by weight, of repeat units derived from ester monomers having 1 to 6 carbon atoms in the alcohol part.

According to a preferred embodiment the polymer may
25 comprise repeating units derived from ester monomers having 23 to 4000 carbon atoms, preferably 23 to 400 carbon atoms and more preferably 23 to 300 carbon atoms in the alcohol part, and repeating units derived from ester monomers having 1 to 6 carbon atoms in the alcohol part.

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The polymer comprising ester groups comprises preferably at least 40% by weight, more preferably at least 60% by weight, especially preferably at least 80% by weight and

very particularly at least 95% by weight of repeat units derived from ester monomers.

Mixtures from which the inventive polymers comprising ester groups are obtainable may contain 0 to 40% by weight, especially 0.1 to 30% by weight and more preferably 0.5 to 20% by weight of one or more ethylenically unsaturated ester compounds of the formula (I)



in which R is hydrogen or methyl, R¹ is a linear or branched alkyl radical having 1 to 6 carbon atoms, R² and R³ are each independently hydrogen or a group of the formula -COOR' in which R' is hydrogen or an alkyl group having 1 to 6 carbon atoms.

Examples of component (I) include (meth)acrylates, fumarates and maleates which derive from saturated alcohols, such as methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, tert-butyl (meth)acrylate and pentyl (meth)acrylate, hexyl (meth)acrylate; cycloalkyl (meth)acrylates, such as cyclopentyl (meth)acrylate, cyclohexyl (meth)acrylate.

The compositions to be polymerized preferably contain 0 to 100% by weight, particularly 5 to 98% by weight, especially 20 to 90% by weight and more preferably 30 to 60% by weight of one or more ethylenically unsaturated ester compounds of the formula (II)



in which R is hydrogen or methyl, R⁴ is a linear or branched alkyl radical having 7 to 15 carbon atoms, R⁵ and R⁶ are each independently hydrogen or a group of the formula -COOR'' in which R'' is hydrogen or an alkyl group having 7 to 15 carbon atoms.

Examples of component (II) include:

(meth)acrylates, fumarates and maleates which derive from saturated alcohols, such as 2-ethylhexyl (meth)acrylate, heptyl (meth)acrylate, 2-tert-butylheptyl (meth)acrylate, octyl (meth)acrylate, 3-isopropylheptyl (meth)acrylate, nonyl (meth)acrylate, decyl (meth)acrylate, 2-Propylheptyl(meth)acrylate, undecyl (meth)acrylate, 5-methylundecyl (meth)acrylate, dodecyl (meth)acrylate, 2-methyldodecyl (meth)acrylate, tridecyl (meth)acrylate, 5-methyltridecyl (meth)acrylate, tetradecyl (meth)acrylate, pentadecyl (meth)acrylate; (meth)acrylates which derive from unsaturated alcohols, for example oleyl (meth)acrylate; cycloalkyl (meth)acrylates such as 3-vinylcyclohexyl (meth)acrylate, bornyl (meth)acrylate; and the corresponding fumarates and maleates.

In addition, preferred monomer compositions comprise 0 to 100% by weight, particularly 0.1 to 90% by weight, preferably 5 to 80% by weight and more preferably 40 to 70% by weight of one or more ethylenically unsaturated ester compounds of the formula (III)



in which R is hydrogen or methyl, R⁷ is a linear or branched alkyl radical having 16 to 4000, preferably 16 to 400 and more preferably 16 to 30 carbon atoms, R⁸ and R⁹ are each independently hydrogen or a group of the formula -

5 COOR''' in which R''' is hydrogen or an alkyl group having 16 to 4000, preferably 16 to 400 and more preferably 16 to 30 carbon atoms.

Examples of component (III) include (meth)acrylates which derive from saturated alcohols, such as hexadecyl

- 10 (meth)acrylate, 2-methylhexadecyl (meth)acrylate, heptadecyl (meth)acrylate, 5-isopropylheptadecyl (meth)acrylate, 4-tert-butyl octadecyl (meth)acrylate, 5-ethyloctadecyl (meth)acrylate, 3-isopropyloctadecyl (meth)acrylate, octadecyl (meth)acrylate, nonadecyl
- 15 (meth)acrylate, eicosyl (meth)acrylate, cetyleicosyl (meth)acrylate, stearyleicosyl (meth)acrylate, docosyl (meth)acrylate and/or eicosyltetratriacontyl (meth)acrylate;
- cycloalkyl (meth)acrylates such as 2,4,5-tri-t-butyl-
- 20 3-vinylcyclohexyl (meth)acrylate, 2,3,4,5-tetra-t-butylcyclohexyl (meth)acrylate, and the corresponding fumarates and maleates.

- Furthermore, the monomers according formula (III)
- 25 especially include long chain branched (meth)acrylates as disclosed inter alia in US 6,746,993, filed 07.08.2002 with the United States Patent Office (USPTO) having the application number 10/212,784; and US 2004/077509, filed 01.08.2003 with the United States Patent Office (USPTO)

having the application number 10/632,108. The disclosure of these documents, especially the (meth)acrylate monomers having at least 16, preferably at least 23 carbon atoms are enclosed herewith by reference.

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In addition thereto, the C₁₆-C₄₀₀₀ alkyl (meth)acrylate monomers, preferably the C₁₆-C₄₀₀ alkyl (meth)acrylate monomers include polyolefin-based macromonomers. The polyolefin-based macromonomers comprise at least one group which is derived from polyolefins. Polyolefins are known in the technical field, and can be obtained by polymerizing alkenes and/or alkadienes which consist of the elements carbon and hydrogen, for example C₂-C₁₀-alkenes such as ethylene, propylene, n-butene, isobutene, norbornene, and/or C₄-C₁₀-alkadienes such as butadiene, isoprene, norbornadiene. The polyolefin-based macromonomers comprise preferably at least 70% by weight and more preferably at least 80% by weight and most preferably at least 90% by weight of groups which are derived from alkenes and/or alkadienes, based on the weight of the polyolefin-based macromonomers. The polyolefinic groups may in particular also be present in hydrogenated form. In addition to the groups which are derived from alkenes and/or alkadienes, the alkyl (meth)acrylate monomers derived from polyolefin-based macromonomers may comprise further groups. These include small proportions of copolymerizable monomers. These monomers are known per se and include, among other monomers, alkyl (meth)acrylates, styrene monomers, fumarates, maleates, vinyl esters and/or vinyl ethers. The proportion of these groups based on copolymerizable monomers is preferably at most 30% by weight, more preferably at most 15% by weight, based on the weight of the polyolefin-based macromonomers. In addition, the

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polyolefin-based macromonomers may comprise start groups and/or end groups which serve for functionalization or are caused by the preparation of the polyolefin-based macromonomers. The proportion of these start groups and/or end groups is preferably at most 30% by weight, more preferably at most 15% by weight, based on the weight of the polyolefin-based macromonomers.

The number-average molecular weight of the polyolefin-based macromonomers is preferably in the range from 500 to 50 000 g/mol, more preferably from 700 to 10 000 g/mol, in particular from 1500 to 8000 g/mol and most preferably from 2000 to 6000 g/mol.

In the case of preparation of the comb polymers via the copolymerization of low molecular weight and macromolecular monomers, these values arise through the properties of the macromolecular monomers. In the case of polymer-analogous reactions, this property arises, for example, from the macroalcohols and/or macroamines used taking account of the converted repeat units of the main chain. In the case of graft copolymerizations, the proportion of polyolefins formed which have not been incorporated into the main chain can be used to conclude the molecular weight distribution of the polyolefin.

The polyolefin-based macromonomers preferably have a low melting point, which is measured by means of Differential Scanning Calorimetry (DSC). The melting point of the polyolefin-based macromonomers is preferably less than or equal to -10°C , especially preferably less than or equal to -20°C , more preferably less than or equal to -40°C . Most preferably, no DSC melting point can be measured for the

repeat units which are derived from the polyolefin-based macromonomers in the polyalkyl(meth)acrylate copolymer.

Polyolefin-based macromonomers are disclosed in the
5 publications DE 10 2007 032 120 A1, filed 09.07.2007 at the German Patent Office (Deutsches Patentamt) having the application number DE102007032120.3; and DE 10 2007 046 223 A1, filed 26.09.2007 at the German Patent Office (Deutsches Patentamt) having the application number DE 102007046223.0;
10 which documents are enclosed herein by reference.

The ester compounds with a long-chain alcohol part, especially components (II) and (III), can be obtained, for example, by reacting (meth)acrylates, fumarates, maleates
15 and/or the corresponding acids with long-chain fatty alcohols, which generally gives rise to a mixture of esters, for example (meth)acrylates with different long-chain hydrocarbons in the alcohol parts. These fatty alcohols include Oxo Alcohol® 7911, Oxo Alcohol® 7900, Oxo
20 Alcohol® 1100; Alfol® 610, Alfol® 810, Lial® 125 and Nafol® types (Sasol); Alphanol® 79 (ICI); Epal® 610 and Epal® 810 (Afton); Linevol® 79, Linevol® 911 and Neodol® 25E (Shell); Dehydad®, Hydrenol® and Lorol® types (Cognis); Acropol® 35 and Exxal® 10 (Exxon Chemicals); Kalcol® 2465 (Kao
25 Chemicals).

Among the ethylenically unsaturated ester compounds, the (meth)acrylates are particularly preferred over the maleates and fumarates, i.e. R^2 , R^3 , R^5 , R^6 , R^8 and R^9 of the
30 formulae (I), (II) and (III) in particularly preferred embodiments are each hydrogen.

The weight ratio of units derived from ester monomers having 7 to 15 carbon atoms, preferably of the formula (II), to the units derived from ester monomers having 16 to 4000 carbon atoms, preferably of the formula (III), may be within a wide range. The weight ratio of repeat units derived from ester monomers having 7 to 15 carbon atoms in the alcohol part to repeat units derived from ester monomers having 16 to 4000 carbon atoms in the alcohol part is preferably in the range from 30:1 to 1:30, more preferably in the range from 5:1 to 1:5, especially preferably 3:1 to 1.1:1. According to a further preferred embodiment, the weight ratio of repeat units derived from ester monomers having 7 to 15 carbon atoms in the alcohol part to repeat units derived from ester monomers having 16 to 4000 carbon atoms in the alcohol part is preferably in the range from 4:1 to 1:4, more preferably in the range from 3:1 to 1:3, especially preferably 2.4:1 to 1.1:1.

The polymer may contain units derived from comonomers as an optional component. These comonomers include aryl (meth)acrylates like benzyl (meth)acrylate or phenyl (meth)acrylate, where the acryl residue in each case can be unsubstituted or substituted up to four times;

(meth)acrylates of halogenated alcohols like 2,3-dibromopropyl (meth)acrylate, 4-bromophenyl (meth)acrylate, 1,3-dichloro-2-propyl (meth)acrylate, 2-bromoethyl (meth)acrylate, 2-iodoethyl (meth)acrylate, chloromethyl (meth)acrylate;

- nitriles of (meth)acrylic acid and other nitrogen-containing (meth)acrylates like N-(methacryloyloxyethyl)diisobutylketimine, N-
- 5 (methacryloyloxyethyl)dihexadecylketimine, (meth)acryloylamidoacetonitrile, 2-methacryloyloxyethylmethylcyanamide, cyanomethyl (meth)acrylate;
- 10 vinyl halides such as, for example, vinyl chloride, vinyl fluoride, vinylidene chloride and vinylidene fluoride;
- vinyl esters like vinyl acetate;
- 15 vinyl monomers containing aromatic groups like styrene, substituted styrenes with an alkyl substituent in the side chain, such as α -methylstyrene and α -ethylstyrene, substituted styrenes with an alkyl substituent on the ring such as vinyltoluene and p-methylstyrene, halogenated
- 20 styrenes such as monochlorostyrenes, dichlorostyrenes, tribromostyrenes and tetrabromostyrenes;
- vinyl and isoprenyl ethers;
- 25 maleic acid and maleic acid derivatives such as mono- and diesters of maleic acid, maleic anhydride, methylmaleic anhydride, maleinimide, methylmaleinimide;
- fumaric acid and fumaric acid derivatives such as, for
- 30 example, mono- and diesters of fumaric acid;
- methacrylic acid and acrylic acid.

According to a special aspect of the present invention, the ester group containing polymer comprises dispersing monomers.

5 Dispersing monomers are understood to mean especially monomers with functional groups, for which it can be assumed that polymers with these functional groups can keep particles, especially soot particles, in solution (cf. R.M. Mortier, S.T. Orszulik (eds.): "Chemistry and Technology of
10 Lubricants", Blackie Academic & Professional, London, 2nd ed. 1997). These include especially monomers which have boron-, phosphorus-, silicon-, sulfur-, oxygen- and nitrogen-containing groups, preference being given to oxygen- and nitrogen-functionalized monomers.

15

Appropriately, it is possible to use especially heterocyclic vinyl compounds and/or ethylenically unsaturated, polar ester compounds of the formula (IV)



in which R is hydrogen or methyl, X is oxygen, sulfur or an
20 amino group of the formula -NH- or -NR^a- in which R^a is an alkyl radical having 1 to 40 and preferably 1 to 4 carbon atoms, R¹⁰ is a radical which comprises 2 to 1000, especially 2 to 100 and preferably 2 to 20 carbon atoms and has at least one heteroatom, preferably at least two
25 heteroatoms, R¹¹ and R¹² are each independently hydrogen or a group of the formula -COX'R^{10'} in which X' is oxygen or an amino group of the formula -NH- or -NR^{a'}- in which R^{a'} is an alkyl radical having 1 to 40 and preferably 1 to 4 carbon atoms, and R^{10'} is a radical comprising 1 to 100, preferably

1 to 30 and more preferably 1 to 15 carbon atoms, as dispersing monomers.

The expression "radical comprising 2 to 1000 carbon" denotes radicals of organic compounds having 2 to 1000 carbon atoms. Similar definitions apply for corresponding terms. It encompasses aromatic and heteroaromatic groups, and alkyl, cycloalkyl, alkoxy, cycloalkoxy, alkenyl, alkanoyl, alkoxycarbonyl groups, and also heteroaliphatic groups. The groups mentioned may be branched or unbranched. In addition, these groups may have customary substituents. Substituents are, for example, linear and branched alkyl groups having 1 to 6 carbon atoms, for example methyl, ethyl, propyl, butyl, pentyl, 2-methylbutyl or hexyl; cycloalkyl groups, for example cyclopentyl and cyclohexyl; aromatic groups such as phenyl or naphthyl; amino groups, hydroxyl groups, ether groups, ester groups and halides.

According to the invention, aromatic groups denote radicals of mono- or polycyclic aromatic compounds having preferably 6 to 20 and especially 6 to 12 carbon atoms. Heteroaromatic groups denote aryl radicals in which at least one CH group has been replaced by N and/or at least two adjacent CH groups have been replaced by S, NH or O, heteroaromatic groups having 3 to 19 carbon atoms.

Aromatic or heteroaromatic groups preferred in accordance with the invention derive from benzene, naphthalene, biphenyl, diphenyl ether, diphenylmethane, diphenyldimethylmethane, bisphenone, diphenyl sulfone, thiophene, furan, pyrrole, thiazole, oxazole, imidazole, isothiazole, isoxazole, pyrazole, 1,3,4-oxadiazole, 2,5-diphenyl-1,3,4-oxadiazole, 1,3,4-thiadiazole,

- 1,3,4-triazole, 2,5-diphenyl-1,3,4-triazole,
1,2,5-triphenyl-1,3,4-triazole, 1,2,4-oxadiazole, 1,2,4-
thiadiazole, 1,2,4-triazole, 1,2,3-triazole,
1,2,3,4-tetrazole, benzo[b]thiophene, benzo[b]furan,
5 indole, benzo[c]thiophene, benzo[c]furan, isoindole,
benzoxazole, benzothiazole, benzimidazole, benzisoxazole,
benzisothiazole, benzopyrazole, benzothiadiazaole,
benzotriazole, dibenzofuran, dibenzothiophene, carbazole,
pyridine, bipyridine, pyrazine, pyrazole, pyrimidine,
10 pyridazine, 1,3,5-triazine, 1,2,4-triazine,
1,2,4,5-triazine, tetrazine, quinoline, isoquinoline,
quinoxaline, quinazoline, cinnoline, 1,8-naphthyridine,
1,5-naphthyridine, 1,6-naphthyridine, 1,7-naphthyridine,
phthalazine, pyridopyrimidine, purine, pteridine or
15 quinolizine, 4H-quinolizine, diphenyl ether, anthracene,
benzopyrrole, benzoxathiadiazaole, benzoxadiazole, benzo-
pyridine, benzopyrazine, benzopyrazidine, benzopyrimidine,
benzotriazine, indolizine, pyridopyridine,
imidazopyrimidine, pyrazinopyrimidine, carbazole,
20 aciridine, phenazine, benzoquinoline, phenoxazine,
phenothiazine, acridizine, benzopteridine, phenanthroline
and phenanthrene, each of which may also optionally be
substituted.
- 25 The preferred alkyl groups include the methyl, ethyl,
propyl, isopropyl, 1-butyl, 2-butyl, 2-methylpropyl, tert-
butyl radical, pentyl, 2-methylbutyl, 1,1-dimethylpropyl,
hexyl, heptyl, octyl, 1,1,3,3-tetramethylbutyl, nonyl,
1-decyl, 2-decyl, undecyl, dodecyl, pentadecyl and the
30 eicosyl group.

The preferred cycloalkyl groups include the cyclopropyl,
cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl and the

cyclooctyl group, each of which is optionally substituted with branched or unbranched alkyl groups.

The preferred alkanoyl groups include the formyl, acetyl,
5 propionyl, 2-methylpropionyl, butyryl, valeroyl, pivaloyl, hexanoyl, decanoyl and the dodecanoyl group.

The preferred alkoxy carbonyl groups include the methoxycarbonyl, ethoxycarbonyl, propoxycarbonyl, butoxy-
10 carbonyl, tert-butoxycarbonyl, hexyloxycarbonyl, 2-methylhexyloxycarbonyl, decyloxycarbonyl or dodecyl-oxycarbonyl group.

The preferred alkoxy groups include alkoxy groups whose
15 hydrocarbon radical is one of the aforementioned preferred alkyl groups.

The preferred cycloalkoxy groups include cycloalkoxy groups whose hydrocarbon radical is one of the aforementioned preferred cycloalkyl groups.

20

The preferred heteroatoms which are present in the R^{10} radical include oxygen, nitrogen, sulfur, boron, silicon and phosphorus, preference being given to oxygen and nitrogen.

25

The R^{10} radical comprises at least one, preferably at least two, preferentially at least three, heteroatoms.

The R^{10} radical in ester compounds of the formula (IV)
30 preferably has at least 2 different heteroatoms. In this case, the R^{10} radical in at least one of the ester compounds of the formula (IV) may comprise at least one nitrogen atom and at least one oxygen atom.

Examples of ethylenically unsaturated, polar ester compounds of the formula (IV) include aminoalkyl (meth)acrylates, aminoalkyl (meth)acrylamides, hydroxyalkyl (meth)acrylates, (meth)acrylates of ether alcohols, heterocyclic (meth)acrylates and/or carbonyl-containing (meth)acrylates.

The hydroxyalkyl (meth)acrylates include
2-hydroxypropyl (meth)acrylate,
3,4-dihydroxybutyl (meth)acrylate,
2-hydroxyethyl (meth)acrylate,
3-hydroxypropyl (meth)acrylate,
2,5-dimethyl-1,6-hexanediol (meth)acrylate and
1,10-decanediol (meth)acrylate.

(Meth)acrylates of ether alcohols include tetrahydrofurfuryl (meth)acrylate, methoxyethoxyethyl (meth)acrylate, 1-butoxypropyl (meth)acrylate, cyclohexyloxyethyl (meth)acrylate, propoxyethoxyethyl (meth)acrylate, benzyloxyethyl (meth)acrylate, furfuryl (meth)acrylate, 2-butoxyethyl (meth)acrylate, 2-ethoxy-2-ethoxyethyl (meth)acrylate, 2-methoxy-2-ethoxypropyl (meth)acrylate, ethoxylated (meth)acrylates, 1-ethoxybutyl (meth)acrylate, methoxyethyl (meth)acrylate, 2-ethoxy-2-ethoxy-2-ethoxyethyl (meth)acrylate, esters of (meth)acrylic acid and methoxy polyethylene glycols.

Appropriate carbonyl-containing (meth)acrylates include, for example,
2-carboxyethyl (meth)acrylate,
carboxymethyl (meth)acrylate,
oxazolidinylethyl (meth)acrylate,

- N-(methacryloyloxy)formamide,
acetonyl (meth)acrylate,
mono-2-(meth)acryloyloxyethyl succinate,
N-(meth)acryloylmorpholine,
5 N-(meth)acryloyl-2-pyrrolidinone,
N-(2-(meth)acryloyloxyethyl)-2-pyrrolidinone,
N-(3-(meth)acryloyloxypropyl)-2-pyrrolidinone,
N-(2-(meth)acryloyloxypentadecyl)-2-pyrrolidinone,
N-(3-(meth)acryloyloxyheptadecyl)-2-pyrrolidinone and
10 N-(2-(meth)acryloyloxyethyl)ethyleneurea.
2-Acetoacetoxyethyl (meth)acrylate

- The heterocyclic (meth)acrylates include
2-(1-imidazolyl)ethyl (meth)acrylate,
15 2-(4-morpholinyl)ethyl (meth)acrylate and
1-(2-(meth)acryloyloxyethyl)-2-pyrrolidone.

- Of particular interest are additionally aminoalkyl
(meth)acrylates and aminoalkyl (meth)acrylamides, for
20 example
dimethylaminopropyl (meth)acrylate,
dimethylaminodiglykol (meth)acrylate,
dimethylaminoethyl (meth)acrylate,
dimethylaminopropyl(meth)acrylamide,
25 3-diethylaminopentyl (meth)acrylate and
3-dibutylaminohexadecyl (meth)acrylate.

- In addition, it is possible to use phosphorus-, boron-
and/or silicon-containing (meth)acrylates as dispersing
30 units, such as
2-(dimethylphosphato)propyl (meth)acrylate,
2-(ethylenephosphito)propyl (meth)acrylate,
dimethylphosphinomethyl (meth)acrylate,

dimethylphosphonoethyl (meth)acrylate,
diethyl (meth)acryloyl phosphonate,
dipropyl (meth)acryloyl phosphate, 2-(dibutylphosphono)ethyl
(meth)acrylate,
5 2,3-butylene(meth)acryloylethyl borate,
methyldiethoxy(meth)acryloylethoxysilane,
diethylphosphatoethyl (meth)acrylate.

The preferred heterocyclic vinyl compounds include
10 2-vinylpyridine, 3-vinylpyridine, 2-methyl-5-vinylpyridine,
3-ethyl-4-vinylpyridine, 2,3 dimethyl-5-vinylpyridine,
vinylpyrimidine, vinylpiperidine, 9-vinylcarbazole,
3-vinylcarbazole, 4-vinylcarbazole, 1-vinylimidazole, N-
vinylimidazole, 2-methyl-1-vinylimidazole,
15 N-vinylpyrrolidone, 2-vinylpyrrolidone, N-vinylpyrrolidine,
3-vinylpyrrolidine, N-vinylcaprolactam,
N-vinylbutyrolactam, vinyloxolane, vinylfuran,
vinylthiophene, vinylthiolane, vinylthiazoles and
hydrogenated vinylthiazoles, vinyloxazoles and hydrogenated
20 vinyloxazoles, particular preference being given to using
N-vinylimidazole and N-vinylpyrrolidone for
functionalization.

The monomers detailed above can be used individually or as
25 a mixture.

Of particular interest are especially polymers which
comprise ester groups and are obtained using 2-
hydroxypropyl methacrylate, 2-hydroxyethyl methacrylate,
30 mono-2-methacryloyloxyethyl succinate,
N-(2-methacryloyloxyethyl) ethyleneurea,
2-acetoacetoxyethyl methacrylate, 2-(4-morpholinyl)ethyl
methacrylate, dimethylaminodiglycol methacrylate,

dimethylaminoethyl methacrylate and/or
dimethylaminopropylmethacrylamide.

Special improvements can be achieved with ester groups
5 comprise polymers being obtained using N-vinyl-2-
pyrrolidine and/or N-vinyl-2-pyrrolidone.

The dispersing and non-dispersing monomers can be
statistically distributed within the ester group comprising
10 polymer. The proportion of dispersing repeat units in a
statistical polymer, based on the weight of the polymers
comprising ester groups, is preferably in the range from 0
% by weight to 20% by weight, more preferably in the range
from 1% by weight to 15% by weight and most preferably in
15 the range from 2.5% by weight to 10% by weight.

More preferably, the dispersing repeating unit can be
selected from dimethylaminopropylmethacrylamide (DMPMA)
and/or dimethylaminoethylmethacrylate (DMAEMA) and the
20 amount of dispersing repeating based on the weight of the
polymers comprising ester groups, is preferably in the
range from 0.5 % by weight to 10% by weight, more
preferably in the range from 1.2 % by weight to 5% by
weight.

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More preferably, the dispersing repeating unit can be
selected from 2-(4-morpholinyl)ethylmethacrylate (MOEMA),
2-hydroxyethyl (meth)acrylate (HEMA) and/or
hydroxypropylmethacrylate (HPMA) and the amount of
30 dispersing repeating based on the weight of the polymers
comprising ester groups, is preferably in the range from 2
% by weight to 20% by weight, more preferably in the range
from 5 % by weight to 10% by weight.

- According to another aspect of the present invention, the ester group containing polymer may comprise only a low amount of dispersing repeating units. According such
- 5 aspect, the proportion of the dispersing repeat units is preferably at most 5 %, more preferably at most 2 % and most preferably at most 0.5 %, based on the weight of the polymers comprising ester groups.
- 10 According to a special aspect of the present invention, the lubricant used in the motor may preferably comprise a mixture of polymers and at least one of the polymers comprises a considerable amount of dispersing repeating units and at least one of the polymers comprises a low
- 15 amount of dispersing repeating units as mentioned above.

- According to a preferred embodiment of the present invention, the ester group containing polymer is a graft copolymer having an non-dispersing alkyl (meth)acrylate
- 20 polymer as graft base and an dispersing monomer as graft layer. Preferably non-dispersing alkyl (meth)acrylate polymer essentially comprises (meth)acrylate monomer units according formulae (I), (II) and (III) as defined above and below. The proportion of dispersing repeat units in a graft
- 25 or block copolymer, based on the weight of the polymers comprising ester groups, is preferably in the range from 0 % by weight to 20% by weight, more preferably in the range from 1% by weight to 15% by weight and most preferably in the range from 2.5% by weight to 10% by weight.
- 30 The dispersing monomer preferably is a heterocyclic vinyl compound as mentioned above and below.

According to a further aspect of the present invention the ester group containing polymer is an alkyl (meth)acrylate polymer having at least one polar block and at least one hydrophobic block.

5

Preferably, the polar block comprises at least three units derived from monomers of the formula (IV) and/or from heterocyclic vinyl compounds, which are bonded directly to one another.

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Preferred polymers comprise at least one hydrophobic block and at least one polar block, said polar block having at least eight repeat units and the proportion by weight of dispersing repeat units in the polar block being at least 30%, based on the weight of the polar block.

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Preferred inventive polymers may have polar and hydrophobic blocks. The term "block" in this context denotes a section of the polymer. The blocks may have an essentially constant composition composed of one or more monomer units. In addition, the blocks may have a gradient, in which case the concentration of different monomer units (repeat units) varies over the segment length. The polar blocks differ from the hydrophobic block via the proportion of dispersing monomers. The hydrophobic blocks may have at most a small proportion of dispersing repeat units (monomer units), whereas the polar block comprise a high proportion of dispersing repeat units (monomer units).

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The polar block may preferably comprise at least 8, especially preferably at least 12 and most preferably at least 15 repeat units. At the same time, the polar block comprise at least 30% by weight, preferably at least 40% by

weight, of dispersing repeat units, based on the weight of the polar block. In addition to the dispersing repeat units, the polar block may also have repeat units which do not have any dispersing effect. The polar block may have a random structure, such that the different repeat units have a random distribution over the segment length. In addition, the polar block may have a block structure or a structure in the form of a gradient, such that the non-dispersing repeat units and the dispersing repeat units within the polar block have an inhomogeneous distribution.

The hydrophobic block may comprise a small proportion of dispersing repeat units, which is preferably less than 20% by weight, more preferably less than 10% by weight and most preferably less than 5% by weight, based on the weight of the hydrophobic block. In a particularly appropriate configuration, the hydrophobic block comprises essentially no dispersing repeat units.

The hydrophobic block of the polymer comprising ester groups may have 5 to 100% by weight, especially 20 to 98% by weight, preferably 30 to 95 and most preferably 70 to 92% by weight of repeat units derived from ester monomers having 7 to 15 carbon atoms in the alcohol radical.

In a particular aspect, the hydrophobic block of the polymer comprising ester groups may have 0 to 80% by weight, preferably 0.5 to 60% by weight, more preferably 2 to 50% by weight and most preferably 5 to 20% by weight of repeat units derived from ester monomers having 16 to 4000 carbon atoms in the alcohol radical.

In addition, the hydrophobic block of the polymer comprising ester groups may have 0 to 40% by weight, preferably 0.1 to 30% by weight and more preferably 0.5 to 20% by weight of repeat units derived from ester monomers having 1 to 6 carbon atoms in the alcohol radical.

The hydrophobic block of the polymer comprising ester groups comprises preferably at least 40% by weight, more preferably at least 60% by weight, especially preferably at least 80% by weight and most preferably at least 90% by weight of repeat units derived from ester monomers.

The length of the hydrophobic and hydrophobic blocks may vary within wide ranges. The hydrophobic block preferably possess a weight-average degree of polymerization of at least 10, especially at least 40. The weight-average degree of polymerization of the hydrophobic block is preferably in the range from 20 to 5000, especially from 50 to 2000.

The proportion of dispersing repeat units, based on the weight of the polymers comprising ester groups, is preferably in the range from 0.5% by weight to 20% by weight, more preferably in the range from 1.5% by weight to 15% by weight and most preferably in the range from 2.5% by weight to 10% by weight. At the same time, these repeat units preferably form a segment-like structure within the polymer comprising ester groups, such that preferably at least 70% by weight, more preferably at least 80% by weight, based on the total weight of the dispersing repeat units, are part of a polar block.

Preferably, the weight ratio of said hydrophobic block and said polar block is in the range from 100:1 to 1:1, more

preferably in the range from 30:1 to 2:1 and most preferably in the range from 10:1 to 4:1.

5 The preparation of the ester group containing polymers from the above-described compositions is known per se. Thus, these polymers can be obtained in particular by free-radical polymerization and related processes, for example ATRP (= Atom Transfer Radical Polymerization) or RAFT (= Reversible Addition Fragmentation Chain Transfer).

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Customary free-radical polymerization is described, inter alia, in Ullmann's Encyclopedia of Industrial Chemistry, Sixth Edition. In general, a polymerization initiator and a chain transfer agent are used for this purpose. The usable
15 initiators include the azo initiators widely known in the technical field, such as AIBN and 1,1-azobiscyclohexanecarbonitrile, and also peroxy compounds such as methyl ethyl ketone peroxide, acetylacetone peroxide, dilauryl peroxide, tert-butyl per-2-ethylhexanoate, ketone peroxide, 20 tert-butyl peroctoate, methyl isobutyl ketone peroxide, cyclohexanone peroxide, dibenzoyl peroxide, tert-butyl peroxybenzoate, tert-butyl peroxyisopropylcarbonate, 2,5-bis(2-ethylhexanoylperoxy)-2,5-dimethylhexane, tert-butyl peroxy-2-ethylhexanoate, tert-butyl peroxy-3,5,5-trimethylhexanoate, dicumyl peroxide, 1,1-bis(tert-butylperoxy)cyclohexane, 1,1-bis(tert-butylperoxy)-3,3,5-trimethylcyclohexane, cumyl hydroperoxide, tert-butyl
25 hydroperoxide, bis(4-tert-butylcyclohexyl) peroxydicarbonate, mixtures of two or more of the
30 aforementioned compounds with one another, and mixtures of the aforementioned compounds with compounds which have not been mentioned but can likewise form free radicals. Suitable chain transfer agents are in particular oil-

soluble mercaptans, for example n-dodecyl mercaptan or 2-mercaptoethanol, or else chain transfer agents from the class of the terpenes, for example terpinolene.

5 The ATRP process is known per se. It is assumed that it is a "living" free-radical polymerization, without any intention that the description of the mechanism should impose a restriction. In these processes, a transition metal compound is reacted with a compound which has a transferable atom group. This transfers the transferable atom group to the transition metal compound, which oxidizes the metal. This reaction forms a radical which adds onto ethylenic groups. However, the transfer of the atom group to the transition metal compound is reversible, so that the atom group is transferred back to the growing polymer chain, which forms a controlled polymerization system. The structure of the polymer, the molecular weight and the molecular weight distribution can be controlled correspondingly.

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This reaction is described, for example, by J-S. Wang, et al., J. Am. Chem. Soc., vol. 117, p. 5614-5615 (1995), by Matyjaszewski, Macromolecules, vol. 28, p. 7901-7910 (1995). In addition, the patent applications WO 96/30421, WO 97/47661, WO 97/18247, WO 98/40415 and WO 99/10387 disclose variants of the ATRP explained above.

In addition, the inventive polymers may be obtained, for example, also via RAFT methods. This process is presented in detail, for example, in WO 98/01478 and WO 2004/083169, to which reference is made explicitly for the purposes of disclosure.

In addition, the inventive polymers are obtainable by NMP processes (nitroxide-mediated polymerization), which are described, inter alia, in US 4581429.

5 These methods are described comprehensively, in particular with further references, inter alia, in K. Matyjaszewski, T.P. Davis, Handbook of Radical Polymerization, Wiley Interscience, Hoboken 2002, to which reference is made explicitly for the purposes of disclosure.

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The polymerization may be carried out at standard pressure, reduced pressure or elevated pressure. The polymerization temperature is generally in the range of -20° - 200°C , preferably 0° - 160°C and more preferably 60° - 140°C .

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The polymerization may be carried out with or without solvent. The term solvent is to be understood here in a broad sense.

20 The polymerization is preferably carried out in a nonpolar solvent. These include hydrocarbon solvents, for example aromatic solvents such as toluene, benzene and xylene, saturated hydrocarbons, for example cyclohexane, heptane, octane, nonane, decane, dodecane, which may also be present
25 in branched form. These solvents may be used individually and as a mixture. Particularly preferred solvents are mineral oils, diesel fuels of mineral origin, natural vegetable and animal oils, biodiesel fuels and synthetic oils (e.g. ester oils such as dinonyl adipate), and also
30 mixtures thereof. Among these, very particular preference is given to mineral oils and mineral diesel fuels.

According to a special aspect of the present invention, polymers based on ethyl vinyl acetate can be used as an ester group containing polymer. Preferred polymers based on ethyl vinyl acetate are described in EP 0 739 971 B1, 5 EP 0 721 492 B2 and EP 0 741 181 B1. The documents EP 0 739 971 B1 filed with the European Patent Office June 29, 1993 under the Application number 96202136.6; EP 0 721 492 B2 filed with the European Patent Office July 22, 1994 under the Application number 94924280.4 and 10 EP 0 741 181 B1 filed with the European Patent Office June 29, 1993 under the Application number 96202137.4 are enclosed herein by reference.

Preferably a mixture of the different Ethylene Vinyl 15 Acetate (EVA) based polymers can be used in order to improve the properties of the lubricating oil comprising biodiesel impurities. The first EVA based polymer may comprise ethylene, vinyl acetate and a alkyl ester of a (meth)acrylate, a fumarate and/or a maleate. The alkyl 20 ester preferably contains 6 to 20, more preferably 7 to 12 carbon atoms in the alkyl residue. As to the fumarates and/or a maleates, the diesters are preferred. The first EVA polymer preferably has an ethylene content in the range of 50 to 90 mol% and a vinyl acetate content in the range 25 of 10 to 40 mol%. The amount of alkyl ester being derived from a (meth)acrylate, a fumarate and/or a maleate is preferably in the range of 1 to 20 mol%, more preferably in the range of 2 to 10 mol%. The weight average molecular weight Mw of the first EVA polymer can preferably be 30 situated in the range of 10000 to 50000 g/mol. The polydispersity Mw/Mn of the first EVA polymer is preferably in the range of 1.1 to 5, more preferably 1.5 to 3. The second EVA polymer preferably has an ethylene content in

the range of 60 to 95 mol% and a vinyl acetate content in the range of 5 to 40 mol%. The weight average molecular weight Mw of the second EVA polymer can preferably be situated in the range of 1000 to 10000 g/mol. The
5 polydispersity Mw/Mn of the second EVA polymer is preferably in the range of 1.1 to 5, more preferably 2.0 to 4.

Preferably, the lubricant comprises a mixture of at least
10 two polymers comprising ester groups. More preferably, the lubricant comprises an alkyl (meth)acrylate polymer and a ethylene vinyl acetate polymer as mentioned above and below.

15 According to a special aspect of the present invention, the lubricant of the inventive motor preferably comprises an ester group containing polymer and a olefinic polymer which preferably have a viscosity index-improving or thickening effect. Such polyolefins have long been known and are
20 described in the documents mentioned in the prior art.

These polyolefins include in particular polyolefin copolymers (OCP) and hydrogenated styrene/diene copolymers (HSD).

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The polyolefin copolymers (OCP) to be used according to the invention are known per se. They are primarily polymers synthesized from ethylene-, propylene-, isoprene-, butylene- [sic] and/or further -olefins [sic] having 5 to
30 20 C atoms, as are already recommended as VI improvers. Systems which have been grafted with small amounts of oxygen- or nitrogen-containing monomers (e.g. from 0.05 to 5% by weight of maleic anhydride) may also be used. The

copolymers which contain diene components are generally hydrogenated in order to reduce the oxidation sensitivity and the crosslinking tendency of the viscosity index improvers.

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The molecular weight Mw is in general from 10 000 to 300 000, preferably between 50 000 and 150 000. Such olefin copolymers are described, for example, in the German Laid-Open Applications DE-A 16 44 941, DE-A 17 69 834, DE-A

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19 39 037, DE-A 19 63 039 and DE-A 20 59 981.

Ethylene/propylene copolymers are particularly useful and terpolymers having the known ternary components, such as ethylidene-norbornene (cf. Macromolecular Reviews, Vol. 10

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(1975)) are also possible, but their tendency to crosslink must also be taken into account in the aging process. The distribution may be substantially random, but sequential polymers comprising ethylene blocks can also advantageously be used. The ratio of the monomers ethylene/propylene is

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variable within certain limits, which can be set to about 75% for ethylene and about 80% for propylene as an upper limit. Owing to its reduced tendency to dissolve in oil, polypropylene is less suitable than ethylene/propylene copolymers. In addition to polymers having a predominantly

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atactic propylene incorporation, those having a more pronounced isotactic or syndiotactic propylene incorporation may also be used.

Such products are commercially available, for example under

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the trade names Dutral[®] CO 034, Dutral[®] CO 038, Dutral[®] CO 043, Dutral[®] CO 058, Buna[®] EPG 2050 or Buna[®] EPG 5050.

The hydrogenated styrene/diene copolymers (HSD) are likewise known, these polymers being described, for example, in DE 21 56 122. They are in general hydrogenated isoprene/styrene or butadiene/styrene copolymers. The ratio
5 of diene to styrene is preferably in the range from 2:1 to 1:2, particularly preferably about 55:45. The molecular weight Mw is in general from 10 000 to 300 000, preferably between 50 00 and 150 000. According to a particular aspect
10 of the present invention, the proportion of double bonds after the hydrogenation is not more than 15%, particularly preferably not more than 5%, based on the number of double bonds before the hydrogenation.

Hydrogenated styrene/diene copolymers can be commercially
15 obtained under the trade name SHELLVIS[®] 50, 150, 200, 250 or 260.

According to a very preferred embodiment of the present invention the ester group containing polymer is a block
20 copolymer comprising a block of ester group containing units and an olefinic block. Preferably, the olefinic block is derived from HSD polymers and/or OCP polymers.

Block copolymer comprising a block of ester group
25 containing units and an olefinic block are disclosed in the publications DE 33 39 103 A1, filed 28.10.1983 at the German Patent Office (Deutsches Patentamt) having the application number P 33 39 103.3; and DE 29 05 954 A1, filed 16.02.1979 at the German Patent Office (Deutsches
30 Patentamt) having the application number P 29 05 954.9; which documents are enclosed herein by reference.

In addition to the ester group containing polymer the lubricant used in the motor of the present invention includes base oil. Preferred base oils include especially mineral oils, synthetic oils and natural oils.

5

Mineral oils are known per se and commercially available. They are generally obtained from mineral oil or crude oil by distillation and/or refining and optionally further purification and finishing processes, the term mineral oil
10 including in particular the higher-boiling fractions of crude or mineral oil. In general, the boiling point of mineral oil is higher than 200°C, preferably higher than 300°C, at 5000 Pa. The production by low-temperature carbonization of shale oil, coking of bituminous coal,
15 distillation of brown coal with exclusion of air, and also hydrogenation of bituminous or brown coal is likewise possible. Accordingly, mineral oils have, depending on their origin, different proportions of aromatic, cyclic, branched and linear hydrocarbons.

20

In general, a distinction is drawn between paraffin-base, naphthenic and aromatic fractions in crude oils or mineral oils, in which the term paraffin-base fraction represents longer-chain or highly branched isoalkanes, and naphthenic
25 fraction represents cycloalkanes. In addition, mineral oils, depending on their origin and finishing, have different fractions of n-alkanes, isoalkanes having a low degree of branching, known as mono-methyl-branched paraffins, and compounds having heteroatoms, in particular
30 O, N and/or S, to which a degree of polar properties are attributed. However, the assignment is difficult, since individual alkane molecules may have both long-chain branched groups and cycloalkane radicals, and aromatic

parts. For the purposes of the present invention, the assignment can be effected to DIN 51 378, for example. Polar fractions can also be determined to ASTM D 2007.

- 5 The proportion of n-alkanes in preferred mineral oils is less than 3% by weight, the fraction of O-, N- and/or S-containing compounds less than 6% by weight. The fraction of the aromatics and of the mono-methyl-branched paraffins is generally in each case in the range from 0 to 40% by
- 10 weight. In one interesting aspect, mineral oil comprises mainly naphthenic and paraffin-base alkanes which have generally more than 13, preferably more than 18 and most preferably more than 20 carbon atoms. The fraction of these compounds is generally $\geq 60\%$ by weight, preferably $\geq 80\%$ by
- 15 weight, without any intention that this should impose a restriction. A preferred mineral oil contains 0.5 to 30% by weight of aromatic fractions, 15 to 40% by weight of naphthenic fractions, 35 to 80% by weight of paraffin-base fractions, up to 3% by weight of n-alkanes and 0.05 to 5%
- 20 by weight of polar compounds, based in each case on the total weight of the mineral oil.

An analysis of particularly preferred mineral oils, which was effected by means of conventional processes such as

25 urea separation and liquid chromatography on silica gel, shows, for example, the following constituents, the percentages relating to the total weight of the particular mineral oil used:

- n-alkanes having approx. 18 to 31 carbon atoms:
- 30 0.7-1.0%,
slightly branched alkanes having 18 to 31 carbon atoms:
1.0-8.0%,

aromatics having 14 to 32 carbon atoms:

0.4-10.7%,

iso- and cycloalkanes having 20 to 32 carbon atoms:

60.7-82.4%,

5 polar compounds:

0.1-0.8%,

loss:

6.9-19.4%.

- 10 An improved class of mineral oils (reduced sulfur content, reduced nitrogen content, higher viscosity index, lower pour point) results from hydrogen treatment of the mineral oils (*hydroisomerization, hydrocracking, hydrotreatment, hydrofinishing*). In the presence of hydrogen, this
- 15 essentially reduces aromatic components and builds up naphthenic components.

- Valuable information with regard to the analysis of mineral oils and a list of mineral oils which have a different
- 20 composition can be found, for example, in T. Mang, W. Dresel (eds.): "Lubricants and Lubrication", Wiley-VCH, Weinheim 2001; R.M. Mortier, S.T. Orszulik (eds.): "Chemistry and Technology of Lubricants", Blackie Academic & Professional, London, 2nd ed. 1997; or J. Bartz:
- 25 "Additive für Schmierstoffe", Expert-Verlag, Renningen-Malmsheim 1994. Preferably, the mineral oil can be selected from group I, group II and/or group III oil, wherein group II and group III oil are preferred.
- 30 Synthetic oils include organic esters, for example diesters and polyesters, polyalkylene glycols, polyethers, synthetic hydrocarbons, especially polyolefins, among which preference is given to polyalphaolefins (PAOs), silicone

oils and perfluoroalkyl ethers. In addition, it is possible to use synthetic base oils originating from *gas to liquid* (GTL), *coal to liquid* (CTL) or *biomass to liquid* (BTL) processes. They are usually somewhat more expensive than
5 the mineral oils, but have advantages with regard to their performance.

Natural oils are animal or vegetable oils, for example neatsfoot oils or jojoba oils.

10

Base oils for lubricant oil formulations are divided into groups according to API (American Petroleum Institute). Mineral oils are divided into group I (non-hydrogen-treated) and, depending on the degree of saturation, sulfur
15 content and viscosity index, into groups II and III (both hydrogen-treated). PAOs correspond to group IV. All other base oils are encompassed in group V.

These lubricant oils may also be used as mixtures and are
20 in many cases commercially available.

The concentration of the polymers comprising ester groups in the lubricant oil composition is preferably in the range of 0.01 to 30% by weight, more preferably in the range of
25 0.1-20% by weight and most preferably in the range of 0.5-10% by weight, based on the total weight of the composition.

The polymers comprising ester groups can be mixed with the
30 lubricant oil. Furthermore, the polymers can be prepared in the lubricant oils as mentioned above. In addition thereto, the polymers comprising ester groups can be used as a concentrate or as component of an additive package. The

polymer comprising ester groups may be added to a fresh oil and/or to an aged oil. Furthermore, polymer comprising ester groups can be added directly in the engine oil or indirectly through dilution effect using a diesel mixture
5 comprising these polymers.

In addition to the polymers comprising ester groups for use in accordance with the invention, the lubricant oil compositions detailed here may also comprise further
10 additives. These additives include viscosity index improvers, pour point improvers and DI additives (dispersants, detergents, defoamers, corrosion inhibitors, antioxidants, antiwear and extreme pressure additives, friction modifiers).

15 The additionally usable VI improvers include poly(iso)butenes (PIB), fumarate-olefin copolymers, styrene-maleate copolymers, hydrogenated styrene-diene copolymers (HSD) and olefin copolymers (OCP).

20 Compilations of VI improvers and pour point improvers for lubricant oils are also detailed in T. Mang, W. Dresel (eds.): "Lubricants and Lubrication", Wiley-VCH, Weinheim 2001; R. M. Mortier, S. T. Orszulik (eds.): "Chemistry and
25 Technology of Lubricants", Blackie Academic & Professional, London, 2nd ed. 1997; or J. Bartz: "Additive für Schmierstoffe", Expert-Verlag, Renningen-Malmsheim 1994.

Appropriate dispersants include poly(isobutylene) derivatives, e.g. poly(isobutylene)succinimides (PIBSIs);
30 ethylene-propylene oligomers with N/O functionalities.

The preferred detergents include metal-containing compounds, for example phenoxides; salicylates; thio-phosphonates, especially thiopyrophosphonates, thio-phosphonates and phosphonates; sulfonates and carbonates.

5 As metals, these compounds may comprise especially calcium, magnesium and barium. These compounds may be used preferably in neutral or overbased form.

Of particular interest are additionally defoamers, which
10 are in many cases divided into silicone-containing and silicone-free defoamers. The silicone-containing defoamers include linear poly(dimethylsiloxane) and cyclic poly(dimethylsiloxane). The silicone-free defoamers which may be used are in many cases polyethers, for example
15 poly(ethylene glycol) or tributyl phosphate.

In a particular embodiment, the inventive lubricant oil compositions may comprise corrosion inhibitors. These are in many cases divided into antirust additives and metal
20 passivators/deactivators. The antirust additives used may, inter alia, be sulfonates, for example petroleum sulfonates or (in many cases overbased) synthetic alkylbenzenesulfonates, e.g. dinonylnaphthenesulfonates; carboxylic acid derivatives, for example lanolin (wool
25 fat), oxidized paraffins, zinc naphthenates, alkylated succinic acids, 4-nonylphenoxy-acetic acid, amides and imides (N-acylsarcosine, imidazoline derivatives); amine-neutralized mono- and dialkyl phosphates; morpholine, dicyclohexylamine or diethanolamine. The metal
30 passivators/deactivators include benzotriazole, tolyltriazole, 2-mercaptobenzothiazole, dialkyl-2,5-dimercapto-1,3,4-thiadiazole; N,N'-disalicylideneethylenediamine, N,N'-disalicyli-

denepropylenediamine; zinc dialkyldithiophosphates and dialkyl dithiocarbamates.

A further preferred group of additives is that of
5 antioxidants. The antioxidants include, for example, phenols, for example 2,6-di-tert-butylphenol (2,6-DTB), butylated hydroxytoluene (BHT), 2,6-di-tert-butyl-4-methylphenol, 4,4'-methylenebis(2,6-di-tert-butylphenol); aromatic amines, especially alkylated diphenylamines,
10 N-phenyl-1-naphthylamine (PNA), polymeric 2,2,4-trimethyldihydroquinone (TMQ); compounds containing sulfur and phosphorus, for example metal dithiophosphates, e.g. zinc dithiophosphates (ZnDTP), "OOS triesters" = reaction products of dithiophosphoric acid with activated
15 double bonds from olefins, cyclopentadiene, norbornadiene, α -pinene, polybutene, acrylic esters, maleic esters (ashless on combustion); organosulfur compounds, for example dialkyl sulfides, diaryl sulfides, polysulfides, modified thiols, thiophene derivatives, xanthates,
20 thioglycols, thioaldehydes, sulfur-containing carboxylic acids; heterocyclic sulfur/nitrogen compounds, especially dialkyldimercaptothiadiazoles, 2-mercaptobenzimidazoles; zinc and methylene bis(dialkyldithiocarbamate); organophosphorus compounds, for example triaryl and trialkyl
25 phosphites; organocopper compounds and overbased calcium- and magnesium-based phenolates and salicylates.

The preferred antiwear (AW) and extreme pressure (EP) additives include phosphorus compounds, for example
30 trialkyl phosphates, triaryl phosphates, e.g. tricresyl phosphate, amine-neutralized mono- and dialkyl phosphates, ethoxylated mono- and dialkyl phosphates, phosphites,

phosphonates, phosphines; compounds containing sulfur and phosphorus, for example metal dithiophosphates, e.g. zinc C₃₋₁₂dialkyldithiophosphates (ZnDTPs), ammonium dialkyldithiophosphates, antimony dialkyldithiophosphates, 5 molybdenum dialkyldithiophosphates, lead dialkyldithiophosphates, "OOS triesters" = reaction products of dithiophosphoric acid with activated double bonds from olefins, cyclopentadiene, norbornadiene, α -pinene, polybutene, acrylic esters, maleic esters, 10 triphenylphosphorothionate (TPPT); compounds containing sulfur and nitrogen, for example zinc bis(amyl dithiocarbamate) or methylenebis(di-n-butyl dithiocarbamate); sulfur compounds containing elemental sulfur and H₂S-sulfurized hydrocarbons (diisobutylene, 15 terpene); sulfurized glycerides and fatty acid esters; overbased sulfonates; chlorine compounds or solids such as graphite or molybdenum disulfide.

More preferably the antiwear additive and/or extreme 20 pressure additive is selected from phosphorous compounds, compounds comprising sulfur and phosphorous, compounds comprising sulfur and nitrogen, sulfur compounds comprising elemental sulfur and H₂S-sulfurized hydrocarbons, sulfurized glycerides and fatty acid esters, overbased 25 sulfonates, chlorine compounds, graphite or molybdenum disulfide.

A further preferred group of additives is that of friction modifiers. The friction modifiers used may include 30 mechanically active compounds, for example molybdenum disulfide, graphite (including fluorinated graphite), poly(trifluoroethylene), polyamide, polyimide; compounds

which form adsorption layers, for example long-chain carboxylic acids, fatty acid esters, ethers, alcohols, amines, amides, imides; compounds which form layers through tribochemical reactions, for example saturated fatty acids, phosphoric acid and thiophosphoric esters, xanthogenates, sulfurized fatty acids; compounds which form polymer-like layers, for example ethoxylated dicarboxylic acid partial esters, dialkyl phthalates, methacrylates, unsaturated fatty acids, sulfurized olefins or organometallic compounds, for example molybdenum compounds (molybdenum dithiophosphates and molybdenum dithiocarbamates MoDTC) and their combinations with ZnDTPs, copper-containing organic compounds.

Some of the additives detailed above may fulfill multiple functions. ZnDTP, for example, is primarily an antiwear additive and extreme pressure additive, but also has the character of an antioxidant and corrosion inhibitor (here: metal passivator/deactivator).

20

The additives detailed above are described in more detail, inter alia, in T. Mang, W. Dresel (eds.): "Lubricants and Lubrication", Wiley-VCH, Weinheim 2001; J. Bartz: „Additive für Schmierstoffe", Expert-Verlag, Renningen-Malmsheim 1994; R.M. Mortier, S.T. Orszulik (eds.): "Chemistry and Technology of Lubricants", Blackie Academic & Professional, London, 2nd ed. 1997.

Preferred lubricant oil compositions have a viscosity, measured at 40°C to ASTM D 445, in the range of 10 to 120 mm²/s, more preferably in the range of 20 to 100 mm²/s. The kinematic viscosity KV₁₀₀ measured at 100°C is preferably at least 3.5 mm²/s, especially at least

4.0 mm²/s, more preferably at least 5.0 mm²/s and most preferably at least 5.4 mm²/s.

In a particular aspect of the present invention, preferred
5 lubricant oil compositions have a viscosity index determined to ASTM D 2270 in the range of 100 to 400, more preferably in the range of 125 to 325 and most preferably in the range of 150 to 250.

10 Furthermore, lubricant compositions for the use in the motor of the present invention may preferably comprise a High Temperature High Shear (HTHS) viscosity of at least 2.4 mPas, more preferably at least 2.6 mPas as measured at 150°C according to ASTM D4683. According to a further
15 aspect of the present invention the lubricant may preferably comprise a high temperature high shear of at most 10 mPas, especially at most 7 mPas more preferably at most 5 mPas as measured at 100°C according to ASTM D4683. The difference between the High Temperature High Shear
20 (HTHS) viscosities as measure at 100°C and 150°C $HTHS_{100} - HTHS_{150}$ preferably comprises at most 4 mPas, especially at most 3.3 mPas and more preferably at most 2.5 mPas. The ratio of the High Temperature High Shear (HTHS) viscosity measured at 100°C ($HTHS_{100}$) to the High Temperature High
25 Shear (HTHS) viscosity measured at 150°C ($HTHS_{150}$) $HTHS_{100}/HTHS_{150}$ preferably comprises at most at most 2.0 mPas, especially at most 1.9 mPas. High Temperature High Shear (HTHS) viscosity can be determined according to D4683.

30

In addition thereto, the lubricant useful as component of the present motor may comprises a high shear stability index (SSI). According to a useful embodiment of the

present invention, the shear stability index (SSI) as measured according to ASTM D2603 Ref. B (12.5 minutes sonic treatment) could preferably amount to 35 or less, more preferably to 20 or less. Preferably, lubricants comprising
5 a shear stability index (SSI) as measured according to DIN 51381 (30 cycles Bosch-pump) of at most 5, especially at most 2 and more preferably at most 1 could be used.

The lubricant useful for the present invention can
10 preferably designed to meet the requirements of the SAE classifications as specified in SAE J300. E.g. the requirements of the viscosity grades 0W, 5W, 10W, 15W, 20W, 25W, 20, 30, 40, 50, and 60 (single-grade) and 0W-40, 10W-30, 10W-60, 15W-40, 20W-20 and 20W-50 (multi-grade) could
15 be adjusted.

Surprisingly, the lubricant of the present invention may contain at least about 1 %, especially at least 5 %, particularly at least 10 %, more particularly at least 20 %
20 by volume of biodiesel. Astonishingly, such high amounts of water do not impart unduly high lowering of the motor characteristics such as life time, cold run performance and fuel consumption.

25 Astonishingly, the fuel dilution of the motor oil does only have an acceptable influence on properties such as viscosity and viscosity index, and low temperature performance. In addition thereto, the additives do have a high compatibility with the biodiesel fuel impurities in
30 the motor oils, such that the efficiency of these additives is not unduly declined. Furthermore, particulates and sludge formed by the biodiesel fuel can be dispersed in the lubricant in an astonishing manner, especially if polymers

having dispersing groups are used. Regarding the influence of the biodiesel component, canola oil methyl ester (RME) usually has a high amount of unsaturated groups. Therefore, lubricants having dispersing units are preferred. On the other hand palm oil methyl ester (PME) usually has a detrimental influence on low temperature performance. Such influence can surprisingly be nullified by the present motor and the ester group containing polymers, respectively.

10

Pumpability of an oil at low temperatures, as measured by the mini-rotary viscometer (MRV), relates to viscosity under low shear conditions at engine startup. Since the MRV test is a measure of pumpability, the engine oil must be fluid enough so that it can be pumped to all engine parts after engine startup to provide adequate lubrication. ASTM D-4684-08 deals with viscosity measurement in the temperature range of -10 to -40 °C and describes the TP-1 MRV test. SAE J300 Engine Oil Viscosity Classification (December 1999) allows a maximum of 60 pascal*seconds (pa*sec) or 600 poise at -35 °C for SAE 5W-30 oil using the ASTM D-4684-08 test procedure. Another aspect of low temperature performance measured by the TP-1 MRV test is yield stress (recorded in pascals); the target value for yield stress is "zero" pascals, although any value less than 35 pascals (limit of sensitivity of equipment) is recorded as "zero" yield stress. Yield stress values greater than 35 pascals signify increasing degrees of less desirable performance.

30

The improvements achievable by the present motor could be evaluated by using aged samples of engine oil. Aged samples could be either prepared by following the test method

procedure as reported by the CEC (Coordinating European Council), or by GFC (Groupement Francais de Coordination) method A or B, or by ROBO (Romaszewski Oil Bench Oxidation) Test or by standard oxidation tests for engine oils.

5

The invention is illustrated in more detail below by examples and comparison examples, without intending to limit the invention to these examples. All amounts are displayed in weight percent unless otherwise stated.

10

Example 1 and Comparative Example 1

Fresh motor oil has been used over a long period of time in a diesel motor. The content of biodiesel in this aged motor oil had been determined to at least 5.5 % by weight (comparative example 1).

15

Although the motor oil originally met the specification SAE 5W-30 the aged oil failed the specification, especially with regard to the low temperature performance. The aged motor oil has been modified by adding 0.1 % by weight of a pour point depressant being based on a polyalkyl (meth)acrylate composition comprising about 67.8 % by weight LMA, 32.0% by weight SMA and 0.2 % by weight DPMA example 1).

20

25

LMA (lauryl-myristyl methacrylate) is a methacrylate mixture comprising 12 and 14 carbon atoms in the alkyl residue which is linear.

DPMA (dodecyl-pentadecyl methacrylate) is a methacrylate mixture comprising 12 to 15 carbon atoms in the alkyl residue comprising about 20 % by weight of branched alkyl residues and about 80 % by weight of linear alkyl residues;

30

SMA (cetyl-stearyl methacrylate) is a methacrylate mixture comprising predominantly 16 and 18 carbon atoms in the alkyl residue which is linear.

- 5 The polyalkyl (meth)acrylate composition is commercially available from Evonik Industries AG under the trademark VISCOPLEX®.

- 10 MRV-TP1 measurements according to ASTM D-4684-08 have been made. In addition the kinematic viscosities at 40°C ((KV₄₀) and 100°C (KV₁₀₀) have been measured according to ASTM D 445. The results achieved are shown in Table 1.

Table 1

15

	KV ₄₀ [mm ² /s]	KV ₁₀₀ [mm ² /s]	VI	MRV TP1 [mPas]
fresh oil 5W-30	56.28	9.822	161	7700 (Yield: <35 Pa)
Comparative Example 1	25.34	5.633	172	37400 (Yield: <245 Pa)
Example 1	26.18	5.789	174	4600 (Yield: <35 Pa)

- 20 The Example 1 clearly shows that the addition of ester group containing polymers, especially polyalkyl (meth)acrylate improves the cold start performance of an aged oil to the features of a fresh oil. Regarding the viscosity data, please consider that the aged oil is within the specification of a SAE J300 5W-30 oil.

Comparative Examples 2 and 3

A commercially available 15W-40 motor oil has been oxidized according to a modified GFC specification at 170°C for 72 h on a larger volume. In addition thereto a mixture of 10 % by weight of biodiesel (B100, rapeseed oil methyl ester) and 90 % by weight of the same SAE 15W-40 motor oil has been prepared and oxidized in the same manner. The low temperature performance has been evaluated using MRV-TP1 measurements according to ASTM D-4684-08 at a temperature of -25°C.

Table 2

		Before Oxidation MRV		After Oxidation MRV	
		Yield stress (Pa)	Viscosity (mPa)	Yield stress (Pa)	Viscosity (mPa)
Comparative Example 2	Without biodiesel	< 35	14900	< 35	17800
Comparative Example 3	B100 (10%)	< 35	6890	< 105	17900

15

Examples 2 and 3

Oil mixtures comprising about 90 % by weight of a commercially available 15W-40 motor oil, about 10 % by weight of biodiesel (B100) as mentioned in Comparative Example 3 has been treated with small amounts of a pour point depressant being based on a polyalkyl (meth)acrylate composition comprising about 66.2 % by weight LMA and 33.8%

20

by weight SMA. The pour point depressant being based on a polyalkyl (meth)acrylate composition is commercially available from Evonik Industries AG.

- 5 The oil mixtures have been oxidized according to the modified GFC specification at 170°C for 72 h.

The amount of pour point depressant (PPD) given in % by weight and the results achieved are mentioned in table 3.

10

Example 4

- An oil mixture comprising about 90 % by weight of a commercially available 15W-40 motor oil, about 10 % by weight of biodiesel (B100) as mentioned in Comparative Example 3 has been treated with 0.3 % by weight of a pour point depressant being based on a polyalkyl (meth)acrylate composition comprising about 57.5 % by weight LMA and 42.5 % by weight SMA. The pour point depressant being based on a polyalkyl (meth)acrylate composition is commercially available from Evonik Industries AG.
- 15
- 20

- The oil mixture has been oxidized according to the modified GFC specification at 170°C for 72 h. The results achieved are mentioned in table 3.
- 25

Table 3

		Before Oxidation MRV		After Oxidation MRV	
	Amount of PPD	Yield stress (Pa)	Viscosity (mPa)	Yield stress (Pa)	Viscosity (mPa)
Example 2	0.1 wt.%	< 35	6880	< 35	10400
Example 3	0.2 wt.%	< 35	6740	< 35	9390
Example 4	0.3 wt.%	< 35	7170	< 35	9900

- 5 The results of Examples 2 to 4 clearly show that the addition of low amounts of ester group containing polymers, especially polyalkyl (meth)acrylate retains the cold start performance of oils.
- 10 Examples 5 to 9
- SAE 15W-40 motor oil mixture comprising about 85.8 % by weight of a base oil mixture, 8.7 % by weight of a DI-package and 5.5 % by weight of a polyalkyl (meth)acrylate
- 15 composition improving viscosity index and pour point. This composition comprises about 82.6 % by weight IDMA, about 5.2 % by weight MMA, about 5.6 % by weight SMA, about 3.8 % by weight NVP and about 2.73 % by weight LMA.
- 20 IDMA (isodecyl methacrylate) is a methacrylate mixture comprising about 10 carbon atoms in the alkyl residue being branched.
- MMA is methyl methacrylate and NVP is N-vinyl-2-pyrrolidone.

The polyalkyl (meth)acrylate composition is commercially available from Evonik Industries AG.

- 5 The oil mixture comprising 5.5 % by weight of a polyalkyl (meth)acrylate composition improving viscosity index and pour point as mentioned above has been treated with different amounts of biodiesel (B100 according to FAME EN 14214).

10

The oil mixtures have been oxidized according to the modified GFC specification at 170°C for 72 h. The amount of biodiesel given in % by weight given in % by weight and the results achieved are mentioned in table 4.

15

Table 4

		Before Oxidation		After Oxidation	
		MRV		MRV	
	Amount of B100 wt. %	Yield stress (Pa)	Viscosity (mPa)	Yield stress (Pa)	Viscosity (mPa)
Example 5	0	< 35	21100	< 35	24600
Example 6	0.99	< 35	18500	< 35	22700
Example 7	2.9	< 35	15700	< 35	19600
Example 8	4.8	< 35	13100	< 35	17700
Example 9	6.5	< 35	11100	< 35	16200

Examples 10 to 13

5 The oil mixture comprising 5.5 % by weight of a polyalkyl (meth)acrylate composition improving viscosity index and pour point as mentioned above has been treated with different amounts of a mineral diesel comprising about 15 % by volume biodiesel (B15 according to FAME EN 14214).

10 The oil mixtures have been oxidized according to the modified GFC specification at 170°C for 72 h. The amount of biodiesel given in % by weight given in % by weight and the results achieved are mentioned in table 5.

15 Table 5

		Before Oxidation		After Oxidation	
		MRV		MRV	
	Amount of B15 wt. %	Yield stress (Pa)	Viscosity (mPa)	Yield stress (Pa)	Viscosity (mPa)
Example 10	4.8	< 35	13800	< 35	17300
Example 11	9	< 35	9680	< 35	12500
Example 12	13	< 35	6900	< 35	9470
Example 13	17	< 35	5040	< 35	7390

Examples 14 to 22

20 An SAE 5W-30 motor oil mixture comprising about 83.4 % by weight of a base oil mixture, 13.3 % by weight of a DI-package and 3.3 % by weight of a polyalkyl (meth)acrylate composition improving viscosity index and pour point.

This composition comprises about 82.6 % by weight IDMA, about 5.2 % by weight MMA, about 5.6 % by weight SMA, about 3.8 % by weight NVP and about 2.73 % by weight LMA.

5

The polyalkyl (meth)acrylate composition improving viscosity index and pour point comprises about 3.7 % by weight of the pour point depressant and 96.3 % by weight of the VI improver. The polyalkyl (meth)acrylate composition
10 is commercially available from Evonik Industries AG.

The oil mixture comprising 3.3 % by weight of a polyalkyl (meth)acrylate composition improving viscosity index and pour point as mentioned above has been treated with
15 different amounts of biodiesel (B100 according to FAME EN 14214).

The oil mixtures have been oxidized according to the modified GFC specification at 170°C for 72 h. The amount of
20 biodiesel given in % by weight given in % by weight and the results achieved are mentioned in table 6.

Table 6

		Before Oxidation		After Oxidation	
		MRV		MRV	
	Amount of B100 wt. %	Yield stress (Pa)	Viscosity (mPa)	Yield stress (Pa)	Viscosity (mPa)
Example 14	0	< 35	14100	< 35	13200
Example 15	0.99	< 35	12800	< 35	13800
Example 16	2.9	< 35	10800	< 35	13300
Example 17	4.8	< 35	9610	< 35	12500
Example 18	6.5	< 35	8470	< 35	11900

- 5 The oil mixture comprising 3.3 % by weight of a polyalkyl (meth)acrylate composition improving viscosity index and pour point as mentioned above has been treated with different amounts of a mineral diesel comprising about 15 % by volume biodiesel (B15 according to FAME EN 14214).
- 10 The oil mixtures have been oxidized according to the modified GFC specification at 170°C for 72 h. The amount of biodiesel given in % by weight and the results achieved are mentioned in table 7.

Table 7

		Before Oxidation MRV		After Oxidation MRV	
	Amount of B15 wt. %	Yield stress (Pa)	Viscosity (mPa)	Yield stress (Pa)	Viscosity (mPa)
Example 19	4.8	< 35	10600	< 35	12000
Example 20	9	< 35	8410	< 35	10300
Example 21	13	< 35	7330	< 35	9430
Example 22	17	< 35	5840	< 35	7880

5 The Examples 5 to 22 show that also ester group containing polymers, especially polyalkyl (meth)acrylate compositions improving viscosity index and pour point, retain the cold start performance of oils.

Patent claims

1. A motor designed for biodiesel compatibility comprising a particulate filter, a motor control unit being able to inject fuel to the engine in order to increase the exhaust temperature, and a lubricant composition, characterized in that the lubricant composition comprises at least one ester group containing polymer.
2. The motor according to claim 1 characterized in that the motor meets the requirements of exhaust emission standard EURO 5.
3. The motor according to claim 1 or 2 characterized in that the motor comprises a common rail system.
4. The motor according to at least one of the preceding claims characterized in that the motor comprises an exhaust gas recirculation.
5. The motor according to at least one of the preceding claims characterized in that said particulate filter is a wall-flow filter.
6. The motor according to at least one of the preceding claims characterized in that the ester group containing polymer is an alkyl (meth)acrylate polymer.
7. The motor according to at least one of the preceding claims characterized in that the lubricant comprises a mixture of at least two polymers comprising ester groups.

8. The motor according to at least one of the preceding claims characterized in that the lubricant comprises an alkyl (meth)acrylate polymer and a ethylene vinyl acetate polymer.

5

9. The motor according to at least one of the preceding claims characterized in that the lubricant comprises a ester group containing polymer and a olefinic polymer.

- 10 10. The motor according to at least one of the preceding claims characterized in that the ester group containing polymer is an alkyl (meth)acrylate polymer having dispersing groups.

- 15 11. The motor according to at least one of the preceding claims characterized in that the ester group containing polymer is an alkyl (meth)acrylate polymer having units being derived from (meth)acrylates having 23 to 4000 carbon atoms.

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12. The motor according to at least one of the preceding claims characterized in that the ester group containing polymer is a graft copolymer having an nonpolar alkyl (meth)acrylate polymer as graft base and an dispersing monomer as graft layer.

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13. The motor according to at least one of the preceding claims characterized in that the polymer comprising ester groups has a weight-average molecular weight in the range from 10 000 to 600 000 g/mol.

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14. The motor according to at least one of the preceding claims characterized in that the ester group containing polymer is obtainable by polymerizing a monomer composition which comprises

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a) 0 to 40% by weight, based on the weight of the monomer composition for preparing the polymer, of one or more ethylenically unsaturated ester compounds of the formula (I)



10 in which R is hydrogen or methyl, R¹ is a linear or branched alkyl radical having 1 to 6 carbon atoms, R² and R³ are each independently hydrogen or a group of the formula -COOR' in which R' is hydrogen or an alkyl group having 1 to 6 carbon atoms,

15 b) 5 to 100% by weight, based on the weight of the monomer composition for preparing the polymer, of one or more ethylenically unsaturated ester compounds of the formula (II)



20 in which R is hydrogen or methyl, R⁴ is a linear or branched alkyl radical having 7 to 15 carbon atoms, R⁵ and R⁶ are each independently hydrogen or a group of the formula -COOR'' in which R'' is hydrogen or an alkyl group having 7 to 15 carbon atoms,

25 c) 0 to 80% by weight, based on the weight of the monomer composition for preparing the polymer, of one

or more ethylenically unsaturated ester compounds of the formula (III)



- in which R is hydrogen or methyl, R⁷ is a linear or branched alkyl radical having 16 to 4000 carbon atoms, R⁸ and R⁹ are each independently hydrogen or a group of the formula -COOR''' in which R''' is hydrogen or an alkyl group having 16 to 4000 carbon atoms,
- d) 0 to 50% by weight, based on the weight of the monomer composition for preparing the polymer, of comonomer.
15. The motor according to at least one of the preceding claims characterized in that the ester group containing polymer comprises units derived from ester monomers having 7 to 15 carbon atoms in the alcohol part and units derived from ester monomers having 16 to 4000 carbons in the alcohol part, wherein weight ratio of units derived from ester monomers having 7 to 15 carbon atoms in the alcohol part to the units derived from ester monomers having 16 to 4000 carbon atoms in the alcohol part is in the range from 3:1 to 1.1:1.
16. The motor according to claim 15 characterized in that the polar block of said polymer the dispersing repeat units are derived from one or more heterocyclic vinyl compounds and/or ethylenically unsaturated polar ester compounds of the formula (IV)



in which R is hydrogen or methyl, X is oxygen, sulfur
 or an amino group of the formula -NH- or -NR^a- in which
 R^a is an alkyl radical having 1 to 40 carbon atoms, R¹⁰
 is a radical which comprises 2 to 1000 carbon atoms and
 5 has at least one heteroatom, R¹¹ and R¹² are each
 independently hydrogen or a group of the formula -
 COX'R^{10'} in which X' is oxygen or an amino group of the
 formula -NH- or -NR^{a'}-, in which R^{a'} is an alkyl radical
 having 1 to 40 carbon atoms, and R^{10'} is a radical
 10 comprising 1 to 100 carbon atoms, and/or from
 heterocyclic vinyl compounds.

17. The motor according to at least one of the claims 15 or
 16, characterized in that the weight ratio of said
 15 hydrophobic block and said polar block is in the range
 from 100:1 to 1:1.

18. The motor according to at least one of the preceding
 claims characterized in that the ester group containing
 20 polymer is a block copolymer comprising a block of
 ester group containing units and an olefinic block.

19. The motor according to at least one of the preceding
 claims characterized in that said lubricant composition
 25 comprises at least one additive.

20. The motor as claimed in claim 19, characterized in that
the additive is a viscosity index improver, pour point
improver, dispersant, detergent, defoamer, corrosion
5 inhibitor, antioxidant, antiwear additive, extreme
pressure additive and/or friction modifier.

21. The motor as claimed in claim 20, characterized in that the antiwear additive and/or extreme pressure additive is selected from phosphorous compounds, compounds
5 comprising sulfur and phosphorous, compounds comprising sulfur and nitrogen, sulfur compounds comprising elemental sulfur and H₂S-sulfurized hydrocarbons, sulfurized glycerides and fatty acid esters, overbased sulfonates, chlorine compounds, graphite or molybdenum
10 disulfide.
22. A use of an ester group containing polymer in a motor according to at least one of the claims 1 to 21 to improve the low temperature performance of a lubricant
15 containing biodiesel.