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A POLYMER USEFUL AS VISCOSITY INDEX IMPROVER

(57) Abstract:

The present invention describes a polymer useful as viscosity index improver comprising units derived from one or more ethylenically unsaturated ester compounds of formula (I), where R is hydrogen or methyl, R1 means a linear, branched or cyclic alkyl residue with 1-6 carbon atoms, R2 and R3 independently represent hydrogen or a group of the formula -COOR', where R' means hydrogen or a alkyl group with 1-6 carbon atoms, units of one or more ethylenically unsaturated ester compounds of formula (II), where R is hydrogen or methyl, R4 means a 2-alkyl branched alkyl residue with 12-18 carbon atoms, R5 and R6 independently are hydrogen or a group of the formula -COOR'', where R'' means hydrogen or an alkyl group with 12-18 carbon atoms, and units of one or more ethylenically unsaturated ester compounds of formula (III), where R is hydrogen or methyl, R7 means a linear alkyl residue with 12-24 carbon atoms, R8 and R9 independently are hydrogen or a group of the formula -COOR''', where R''' means hydrogen or an alkyl group with 12-24 carbon atoms wherein said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (I), based on the total weight of the polymer, said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (II), based on the total weight of the polymer, and said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (III), based on the total weight of the polymer.

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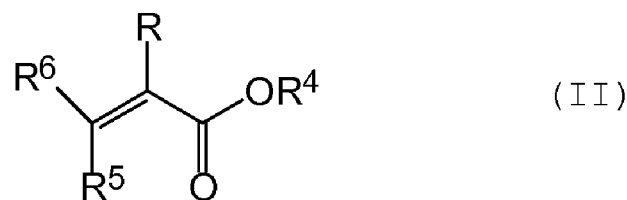
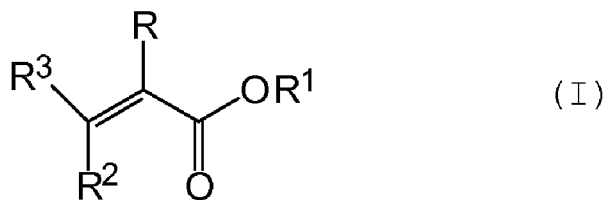
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(54) Title: A POLYMER USEFUL AS VISCOSITY INDEX IMPROVER



(57) Abstract: The present invention describes a polymer useful as viscosity index improver comprising units derived from one or more ethylenically unsaturated ester compounds of formula (I), where R is hydrogen or methyl, R¹ means a linear, branched or cyclic alkyl residue with 1-6 carbon atoms, R² and R³ independently represent hydrogen or a group of the formula -COOR', where R' means hydrogen or an alkyl group with 1-6 carbon atoms, units of one or more ethylenically unsaturated ester compounds of formula (II), where R is hydrogen or methyl, R⁴ means a 2-alkyl branched alkyl residue with 12-18 carbon atoms, R⁵ and R⁶ independently are hydrogen or a group of the formula -COOR'', where R'' means hydrogen or an alkyl group with 12-18 carbon atoms, and units of one or more ethylenically unsaturated ester compounds of formula (III), where R is hydrogen or methyl, R⁷ means a linear alkyl residue with 12-24 carbon atoms, R⁸ and R⁹ independently are hydrogen or a group of the formula -COOR''', where R''' means hydrogen or an alkyl group with 12-24 carbon atoms wherein said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (I), based on the total weight of the polymer, said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (II), based on the total weight of the polymer, and said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (III), based on the total weight of the polymer.

weight units derived from one or more ethylenically unsaturated ester compounds of formula (III), based on the total weight of the polymer.



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A polymer useful as viscosity index improver

The present application relates to polymers useful as viscosity index improvers and to lubricant compositions
5 comprising said polymers.

For more than 50 years, improvements in the temperature-viscosity properties of lubricating oils have been achieved via addition of relatively high molecular weight polymers.
10 The automotive lubricant industry commonly measures these temperature-viscosity properties as the viscosity index (VI). Lubricants with higher values of VI have viscosities which change less with changes in temperature.

15 There are a number of factors which must be considered when selecting or developing a polymer for applications as a viscosity index improver (VII). The primary requirement is stability and solubility of the polymer in the target oil at varying concentrations and temperatures. It is further
20 preferred that the polymer is soluble in a variety of liquids. For automotive lubricant applications, solubility can be related to the nature of the base oil.

Also well known and commonly understood is that the
25 molecular weight of the additive polymer influences the value of VI. The higher the molecular weight the more effective the polymer becomes at increasing the VI. Increasing the VI in this manner is limited, because as the molecular weight of the polymer increases so does the
30 tendency to degrade under shear stresses. A polymer's ability to withstand degradation via mechanical shear stress is referred to as the shear stability or permanent

shear stability index (PSSI). It is very common for an application to have a specified shear stability limit.

Further increases in VI can be obtained through

5 modification of the polymer composition. The effectiveness of a VII is closely related to interactions between the polymer and lubricant oil. The addition of comonomers which can affect these interactions can lead to improved or reduced performance of the VI.

10

The document JP 2008 031459 A discloses a polymer useful as viscosity index improver. The viscosity index improver consists of copolymer having weight average molecular weight of 5000-1000000 and containing essential monomer of

15 $\text{CH}_2=\text{C}(\text{R}^1)-\text{COO}(\text{A}-\text{O})_n-(\text{CH}_2)_p-\text{CH}(\text{R}^2)-\text{R}^3$; where R^1 is H or Me, R^2 and R^3 are independent C_1 - C_{16} linear alkyl or C_3 - C_{34} branched alkyl (≤ 16 of sequential methylene group, 18-36 of total carbon of R^2 , R^3 , and $(\text{CH}_2)_p$), A is C_2 - C_4 alkylene, n and p are integers of 0-20 and 0-15, respectively. Similar

20 viscosity index improvers are disclosed in JP 2008-024908 A, JP 2003-292938 A, US 2004/0077509 A1 and EP -A- 2 009 074.

The known polymers show a good efficiency as viscosity

25 index improvers. Accordingly, most of these polymers exhibit a satisfactory property profile. However, there is a permanent effort to improve the relationship of thickening action, viscosity index and shear stability in order to achieve a desired viscosity with minimum use of

30 additive in lubricant oils over a wide temperature range without impairing this property through premature degradation of the polymers.

Furthermore, the polymers 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
5 plants or plants of complicated construction being required for this purpose.

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 polymers having all features of claim 1. Appropriate modifications to the inventive polymers are protected in the claims referring back to claim 1. With regard to the lubricant composition, claim 20
15 provides a solution to the underlying problem.

The present invention accordingly provides a polymer useful as viscosity index improver comprising units derived from one or more ethylenically unsaturated ester compounds of
20 formula (I)



where R is hydrogen or methyl, R¹ means a linear, branched or cyclic alkyl residue with 1-6 carbon atoms, R² and R³ independently represent hydrogen or a group of the formula -COOR', where R' means hydrogen or a alkyl group with 1-6
25 carbon atoms,
units of one or more ethylenically unsaturated ester compounds of formula (II)

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where R is hydrogen or methyl, R⁴ means a 2-alkyl branched alkyl residue with 12-18 carbon atoms, R⁵ and R⁶ independently are hydrogen or a group of the formula -COOR'', where R'' means hydrogen or an alkyl group with 12-18 carbon atoms, and units of one or more ethylenically unsaturated ester compounds of formula (III)



where R is hydrogen or methyl, R⁷ means a linear alkyl residue with 12-24 carbon atoms, R⁸ and R⁹ independently are hydrogen or a group of the formula -COOR'', where R'' means hydrogen or an alkyl group with 12-24 carbon atoms, characterized in that

said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (I), based on the total weight of the polymer,

said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (II), based on the total weight of the polymer, and

said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (III), based on the total weight of the polymer.

The present polymers provide a high efficiency as viscosity index improvers while retaining high shear stability. At the same time, the inventive polymers allow a series of further advantages to be achieved. These include:

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The inventive polymers have a particularly high viscosity index-improving effectiveness in lubricant oils. These properties are achieved by low treating rates and high shear stabilities. The polymers of the present invention

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can be prepared in a particularly easy and simple manner.

It is possible to use customary industrial scale plants.

Furthermore, the present polymers impart fuel efficiency to vehicles using the inventive lubricants. In addition,

hydraulic fluids comprising the present polymers show very

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low fuel consumption. Moreover, the present polymers have a high compatibility with very different base oils. This is especially true with regard to high performance base oils and GTL base oils.

20

Moreover, the present polymers show an astonishing low temperature performance.

The polymer according to the present invention comprises units derived from one or more ethylenically unsaturated

25

ester compounds of formula (I)



where R is hydrogen or methyl, R¹ means a linear, branched or cyclic alkyl residue with 1-6 carbon atoms, especially 1 to 5 and preferably 1 to 3 carbon atoms, R² and R³ independently represent hydrogen or a group of the formula

-COOR', where R' means hydrogen or a alkyl group with 1 to 6 carbon atoms.

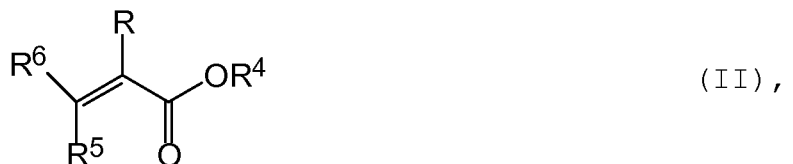
Monomers according to formula (I) enclose (meth)acrylates, fumarates and maleates, with alkyl methacrylates having 1
5 to 5, especially 1 to 3 carbon atoms in the alkyl residue being preferred. The term methacrylates includes (meth)acrylates and acrylates as well as mixtures thereof. These monomers are well known in the art. The alkyl residue
10 of the ester compounds can be linear, cyclic or branched.

Examples of monomers according to formula (I) are, among others, (meth)acrylates, fumarates and maleates, which derived from saturated alcohols such as methyl
15 (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, tert-butyl (meth)acrylate, pentyl (meth)acrylate and hexyl (meth)acrylate; cycloalkyl (meth)acrylates, like cyclopentyl (meth)acrylate and
20 cyclohexyl (meth)acrylate. Preferably, the polymer comprises units being derived from methyl (meth)acrylate.

The polymer of the present invention comprises at least 10 % by weight units derived from one or more ethylenically
25 unsaturated ester compounds of formula (I), based on the total weight of the polymer. According to a preferred aspect of the present invention, the polymer preferably comprises about 15 to 85% by weight, more preferably about 25 to 45 % by weight and most preferably about 32 to 40 %
30 by weight of units derived from monomers according to formula (I). Preferably, the polymer comprises at least 25 % by weight and particularly at least 32 % by weight of units being derived from methyl methacrylate.

The polymer may be obtained preferably by free-radical polymerization. Accordingly the weight fraction of the units of the polymer as mentioned in the present application is a result of the weight fractions of corresponding monomers that are used for preparing the inventive polymer.

In addition to the units derived from the monomers according to formula (I), the polymer of the present invention comprises units of one or more ethylenically unsaturated ester compounds of formula (II)



where R is hydrogen or methyl, R⁴ means a 2-alkyl branched alkyl residue with 12-18 carbon atoms, R⁵ and R⁶ independently are hydrogen or a group of the formula -COOR', where R' means hydrogen or an alkyl group with 12-18 carbon atoms.

Examples of monomers according to formula (II) are, among others, (meth)acrylates, fumarates and maleates, which derived from saturated alcohols, such as 2-methylpentadecyl (meth)acrylate, 2-ethyltetradecyl (meth)acrylate, 2-propyltridecyl (meth)acrylate, 2-butyl dodecyl (meth)acrylate, 2-methyl hexadecyl (meth)acrylate, 2-pentyl dodecyl (meth)acrylate, 2-butyl hexadecyl (meth)acrylate, 2-hexyl decyl (meth)acrylate or 2-hexyl undecyl (meth)acrylate.

Especially preferred compounds include 2-hexyldecyl (meth)acrylate and 2-hexylundecyl (meth)acrylate.

5 Astonishing improvements could be achieved with polymers comprising a mixture of units derived from ethylenically unsaturated ester compounds of formula (II) and the mixture preferably comprises units having a 2-methyl branched alkyl residue as residue R^4 and units having a 2-ethyl branched alkyl residue as residue R^4 .

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According to a special aspect of the present invention the polymer may comprise a mixture of units derived from ethylenically unsaturated ester compounds of formula (II) and the mixture may particularly comprise units having a 2-15 propyl branched alkyl residue as residue R^4 and units having a 2-butyl or higher branched alkyl residue as residue R^4 .

20

With further preference the polymer according to the present invention may comprise units of one or more ethylenically unsaturated ester compounds of formula (II) having a 2- methyl branched alkyl residue as residue R^4 and the units having a 2- methyl branched alkyl residue as residue R^4 may especially comprise at least 10 % by weight,25 more preferably at least 20 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).

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Preferably, the polymer according to the present invention may comprise units of one or more ethylenically unsaturated ester compounds of formula (II) having a 2- ethyl branched alkyl residue as residue R^4 and the units having a 2- ethyl branched alkyl residue as residue R^4 may especially

comprise at least 10 % by weight, more preferably at least 20 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).

- 5 Moreover, the polymer according to the present invention may comprise units of one or more ethylenically unsaturated ester compounds of formula (II) having a 2-propyl branched alkyl residue as residue R⁴ and the units having a 2-propyl branched alkyl residue as residue R⁴ may especially
- 10 comprise at least 10 % by weight, more preferably at least 20 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).

- Particularly, the polymer according to the present
- 15 invention may comprise units of one or more ethylenically unsaturated ester compounds of formula (II) having a 2-butyl or higher branched alkyl residue as residue R⁴ and the units having a 2-butyl or higher branched alkyl residue as residue R⁴ may especially comprise at least 10 % by
- 20 weight, more preferably at least 20 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).

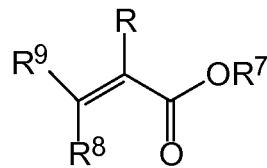
- According to a preferred embodiment of the present
- 25 invention the units of one or more ethylenically unsaturated ester compounds of formula (II) comprise units having residues R⁴ with 12 to 16 carbon atoms and the units having residues R⁴ with 12 to 16 carbon atoms may preferably comprise at least 50 % by weight, more
- 30 preferably at least 70 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).

The type of branching and the position of the branching can be determined via Nuclear magnetic resonance spectroscopy (NMR). Preferably, the monomers being used for preparing the polymers are employed and, if these monomers are a mixture, the mixture can be preferably separated before analyzing. Especially ^{13}C - and ^1H -NMR experiments may be performed and analysed. Useful information is provided in „Determination of the Oligomer Distribution in Ethoxylated Linear and Branched Alkanols using ^{13}C -NMR“, Li Yang et al. Eur. Polym. J. Vol. 33 (2), 143 (1997) und “Quantitative assessment of Alkyl Chain Branching in Alcohol-Based Surfactants by Nuclear Magnetic Resonance“, J. Duynhoven, A. Leika and P.C. van der Hoeven, J. of Surfactants and Detergents Vol 8 (1) , 73 (2005). Using the NMR method usually does not provide any distinction between butyl branching and pentyl- oder hexyl branching. Therefore, the expression 2-butyl or higher branched alkyl residue includes 2-pentyl and 2-hexyl branched residues.

The polymer of the present invention comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (II), based on the total weight of the polymer. According to a preferred aspect of the present invention, the polymer comprises preferably about 10 to 75% by weight, especially 20 to 55 % by weight, more preferably about 25 to 45 % by weight of units derived from monomers according to formula (II).

In addition to the units derived from the monomers according to formula (I) and (II), the polymer of the present invention comprises units of one or more ethylenically unsaturated ester compounds of formula (III)

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(III),

where R is hydrogen or methyl, R⁷ means a linear alkyl residue with 12-24 carbon atoms, R⁸ and R⁹ independently are hydrogen or a group of the formula -COOR'', where R'' means hydrogen or an alkyl group with 12-24 carbon atoms.

5

Examples of monomers according to formula (III) are, among others, (meth)acrylates, fumarates and maleates which are derived from saturated alcohols, such as n-dodecyl (meth)acrylate, n-tetradecyl (meth)acrylate, n-pentadecyl (meth)acrylate, n-hexadecyl (meth)acrylate, n-octadecyl (meth)acrylate, n-eicosyl (meth)acrylate, n-docosyl (meth)acrylate or n-tetracosyl (meth)acrylate.

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The polymer of the present invention comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (III), based on the total weight of the polymer. According to a preferred aspect of the present invention, the polymer comprises preferably about 10 to 75% by weight, especially about 20 to 40 % by weight, more preferably about 25 to 35 % by weight of units derived from monomers according to formula (III).

15

20

The ester compounds with a long-chain alcohol residue, especially monomers according to formula (II) and (III), can be obtained, for example, by reacting (meth)acrylates, fumarates, maleates and/or the corresponding acids with long chain fatty alcohols, where in general a mixture of esters such as (meth)acrylates with different long chain

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alcohol residues results. These fatty alcohols include, among others, Oxo Alcohol® 7911 and Oxo Alcohol ® 7900, Oxo Alcohol® 1100 (Monsanto); Alphanol® 79 (ICI); Nafol® 1620, Alfol® 610 and Alfol® 810 (Sasol); Epal® 610 and Epal® 810
5 (Ethyl Corporation); Linevol® 79, Linevol® 911 and Dobanol® 25L (Shell AG); Lial 125 (Sasol); Dehydad® and Dehydad® and Lorol® (Cognis).

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

15 According to a special aspect of the present invention, the weight ratio of the units derived from one or more ethylenically unsaturated ester compounds of formula (II) and the units derived from one or more ethylenically unsaturated ester compounds of formula (III) is preferably
20 in the range of 8:1 to 1:8, especially in the range of 4:1 to 1:4, and more preferably in the range of 2:1 to 1:2.

The proportion of the units of formula (II) and formula (III) including the amount of the carbon atom number and
25 the amount of branching can be determined by conventional methods, especially using the ethylenically unsaturated ester compounds of formula (II) and formula (III), respectively. These methods include gas chromatography (GC) and NMR.

30

The polymer may contain units derived from comonomers as an optional component. The comonomers include, among others, ethylenically unsaturated ester compounds being different

to the ethylenically unsaturated ester compounds of formula (I), (II) and (III).

These monomers embrace ethylenically unsaturated ester
5 compounds of formula (IV)



where R is hydrogen or methyl, R¹⁰ means a linear, branched or cyclic alkyl residue with 7-11 carbon atoms, R¹¹ and R¹² independently are hydrogen or a group of the formula -
10 COOR'', where R'' means hydrogen or an alkyl group with 7-11 carbon atoms.

Among these are (meth)acrylates, fumarates and maleates derived from saturated alcohols, such as 2-ethylhexyl
15 (meth)acrylate, heptyl (meth)acrylate, 2-tert-butylheptyl (meth)acrylate, n-octyl methacrylate, 3-isopropylheptyl (meth)acrylate, nonyl (meth)acrylate, decyl (meth)acrylate or undecyl (meth)acrylate;

20 cycloalkyl (meth)acrylates such as cyclohexyl (meth)acrylate having a ring substituent, such as tert-butylcyclohexyl (meth)acrylate and trimethylcyclohexyl (meth)acrylate, bornyl (meth)acrylate and isobornyl (meth)acrylate; and the corresponding fumarates and
25 maleates.

Of the ethylenically unsaturated ester compounds, the (meth)acrylates are particularly preferred over the

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maleates and fumarates, i.e. R^{11} , R^{12} of formula (IV) represent hydrogen in particularly preferred embodiments.

Furthermore, the polymer may contain units of one or more
5 ethylenically unsaturated ester compounds of formula (V)



where R is hydrogen or methyl, R^{13} means a 3- branched alkyl residue with 12-18 carbon atoms, R^{14} and R^{15} independently are hydrogen or a group of the formula -COOR'', where R'' means hydrogen or an alkyl group with 12-
10 18 carbon atoms.

Examples of monomers according to formula (v) are, among others, (meth)acrylates, fumarates and maleates, which derived from saturated alcohols, such as 3-methylpentadecyl
15 (meth)acrylate, 3-ethyltetradecyl (meth)acrylate, 3-propyltridecyl (meth)acrylate, 3-butyl dodecyl (meth)acrylate, 3-methyl hexadecyl (meth)acrylate, 3-pentyl dodecyl (meth)acrylate, 3-butylhexadecyl (meth)acrylate, 3-hexyldecyl (meth)acrylate or 3-
20 hexylundecyl (meth)acrylate.

Of the ethylenically unsaturated ester compounds, the (meth)acrylates are particularly preferred over the maleates and fumarates, i.e. R^{14} , R^{15} of formula (IV)
25 represent hydrogen in particularly preferred embodiments.

Moreover, useful comonomers include hydroxyalkyl (meth)acrylates such as 3-hydroxypropyl (meth)acrylate,

3,4-dihydroxybutyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 2,5-dimethyl-1,6-hexanediol (meth)acrylate, 1,10-decanediol (meth)acrylate;

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aminoalkyl methacrylates and aminoalkyl methacrylamides like dimethylaminopropyl (meth)acrylamide, diethylaminopentyl (meth)acrylate, dibutylaminohexadecyl (meth)acrylate and morpholinoethyl (meth)acrylate;

10

nitriles of (meth)acrylic acid and other nitrogen-containing (meth)acrylates like N-(methacryloyloxyethyl)diisobutylketimine, N-(methacryloyloxyethyl)dihexadecylketimine,

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(meth)acryloylamidoacetonitrile, 2-methacryloyloxyethylmethylcyanamide, cyanomethyl (meth)acrylate;

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acryl (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;

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carbonyl-containing (meth)acrylates like 2-carboxyethyl (meth)acrylate, carboxymethyl (meth)acrylate,

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oxazolidinylethyl (meth)acrylate, N-methacryloyloxy)formamide, acetyl (meth)acrylate, N-methacryloylmorpholine, N-methacryloyl-2-pyrrolidinone, N-(2-methacryloyloxyoxyethyl)-2-pyrrolidinone, N-(3-methacryloyloxypropyl)-2-pyrrolidinone, N-(2-methacryloyloxy)pentadecyl (-2-pyrrolidinone, N-(3-methacryloyloxyheptadecyl-2-pyrrolidinone;

(meth)acrylates of ether alcohols like tetrahydrofurfuryl (meth)acrylate, vinyloxyethoxyethyl (meth)acrylate, methoxyethoxyethyl (meth)acrylate, 1-butoxypropyl (meth)acrylate, 1-methyl-(2-vinyloxy)ethyl (meth)acrylate, 5 cyclohexyloxymethyl (meth)acrylate, methoxymethoxyethyl (meth)acrylate, benzyloxymethyl (meth)acrylate, furfuryl (meth)acrylate, 2-butoxyethyl (meth)acrylate, 2-ethoxyethoxymethyl (meth)acrylate, 2-ethoxyethyl (meth)acrylate, ethoxylated (meth)acrylates, allyloxymethyl 10 (meth)acrylate, 1-ethoxybutyl (meth)acrylate, methoxymethyl (meth)acrylate, 1-ethoxyethyl (meth)acrylate, ethoxymethyl (meth)acrylate;

(meth)acrylates of halogenated alcohols like 2,3- 15 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;

20 oxiranyl (meth)acrylate like 2, 3-epoxybutyl (meth)acrylate, 3,4-epoxybutyl (meth)acrylate, 10,11 epoxyundecyl (meth)acrylate, 2,3-epoxycyclohexyl (meth)acrylate, oxiranyl (meth)acrylates such as 10,11- epoxyhexadecyl (meth)acrylate, glycidyl (meth)acrylate;

25 phosphorus-, boron- and/or silicon-containing (meth)acrylates like 2-(dimethylphosphato)propyl (meth)acrylate, 2-(ethylphosphito)propyl (meth)acrylate, 2-dimethylphosphinomethyl (meth)acrylate, 30 dimethylphosphonoethyl (meth)acrylate, diethylmethacryloyl phosphonate, dipropylmethacryloyl phosphate, 2-(dibutylphosphono)ethyl (meth)acrylate, 2,3-butylene methacryloyl ethyl borate,

methyldiethoxymethacryloylethoxysiliane,
diethylphosphatoethyl (meth)acrylate;

5 sulfur-containing (meth)acrylates like ethylsulfinyethyl
(meth)acrylate, 4-thiocyanatobutyl (meth)acrylate,
ethylsulfonyethyl (meth)acrylate, thiocyanatomethyl
(meth)acrylate, methylsulfinylmethyl (meth)acrylate,
bis(methacryloyloxyethyl) sulfide;

10 heterocyclic (meth)acrylates like 2-(1-imidazolyl)ethyl
(meth)acrylate, 2-(4-morpholinyl)ethyl (meth)acrylate and
1-(2-methacryloyloxyethyl)-2-pyrrolidone;

15 vinyl halides such as, for example, vinyl chloride, vinyl
fluoride, vinylidene chloride and vinylidene fluoride;

vinyl esters like vinyl acetate;

20 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
styrenes such as monochlorostyrenes, dichlorostyrenes,
25 tribromostyrenes and tetrabromostyrenes;

heterocyclic vinyl compounds like 2-vinylpyridine, 3-
vinylpyridine, 2-methyl-5-vinylpyridine, 3-ethyl-4-
vinylpyridine, 2,3-dimethyl-5-vinylpyridine,
30 vinylpyrimidine, vinylpiperidine, 9-vinylcarbazole, 3-
vinylcarbazole, 4-vinylcarbazole, 1-vinylimidazole, 2-
methyl-1-vinylimidazole, N-vinylpyrrolidone, 2-
vinylpyrrolidone, N-vinylpyrrolidine, 3-vinylpyrrolidine,

N-vinylcaprolactam, N-vinylbutyrolactam, vinyloxolane, vinylfuran, vinylthiophene, vinylthiolane, vinylthiazoles and hydrogenated vinylthiazoles, vinyloxazoles and hydrogenated vinyloxazoles;

5

vinyl and isoprenyl ethers;

maleic acid derivatives such as maleic anhydride, methylmaleic anhydride, maleinimide, methylmaleinimide;

10

fumaric acid and fumaric acid derivatives such as, for example, mono- and diesters of fumaric acid.

Monomers that have dispersing functionality can also be used as comonomers. These monomers are well known in the art and contain usually hetero atoms such as oxygen and/or nitrogen. For example the previously mentioned hydroxyalkyl (meth)acrylates, aminoalkyl (meth)acrylates and aminoalkyl (meth)acrylamides, (meth)acrylates of ether alcohols, heterocyclic (meth)acrylates and heterocyclic vinyl compounds are considered as dispersing comonomers.

20

The polymer according to the present invention may preferably comprise 0 to 70 % by weight, especially 0.1 to 50 % by weight, more preferably 1 to 20 % by weight of units derived from comonomers.

25

Preferably, the polymer may comprise 0 to 20 % by weight, more preferably 0 to 10 % by weight of units derived from one or more ethylenically unsaturated ester compounds of formula (IV) based on the weight of the polymer.

30

According to a special aspect of the present invention the polymer may preferably comprise 0 to 20 % by weight of units more preferably 0 to 10 % by weight derived from one or more ethylenically unsaturated ester compounds of
5 formula (V) based on the weight of the polymer.

According to a preferred embodiment, the polymer comprises units derived from one or more ethylenically unsaturated ester compounds being different to the ethylenically
10 unsaturated ester compounds of formula (I), (II) and (III) as mentioned above. Preferably, the weight ratio of the units derived from one or more ethylenically unsaturated ester compounds of formula (I) and the units derived from one or more ethylenically unsaturated ester compounds being
15 different to the ethylenically unsaturated ester compounds of formula (I), (II) and (III) may be situated in the range of 100:1 to 1:1, more preferably in the range of 20:1 to 2:1 and most preferably in the range of 15:1 to 4:1.

20 The polymers according to the present invention have a molecular weight in the range of 5,000 to 2,000,000 g/mol, preferably in the range of range of 20,000 g/mol to 200,000 and more preferably in the range of 50,000 to 100,000 g/mol. These values refer to the weight average molecular
25 weight of the polymers.

Without intending any limitation by this, the polymers of the present invention exhibit a polydispersity, given by the ratio of the weight average molecular weight to the
30 number average molecular weight M_w/M_n , in the range of 1 to 15, preferably 1.1 to 10, especially preferably 1.2 to 5. The polydispersity and the weight average molecular weight

may be determined by gel permeation chromatography (GPC) using a polymethyl methacrylate standard.

The polymers can be obtained by polymerizing mixtures
5 comprising the monomers described above by any known method. Conventional radical initiators can be used to perform a classic radical polymerization. These initiators are well known in the art. Examples for these radical
10 initiators are azo initiators like 2,2'-azodiisobutyronitrile (AIBN), 2,2'-azobis(2-methylbutyronitrile) and 1,1 azobiscyclohexane carbonitrile; peroxide compounds, e.g. methyl ethyl ketone peroxide, acetyl acetone peroxide, dilauryl peroxide, tert.-butyl per-2-ethyl hexanoate, ketone peroxide, methyl
15 isobutyl ketone peroxide, cyclohexanone peroxide, dibenzoyl peroxide, tert.-butyl perbenzoate, tert.-butyl peroxy isopropyl carbonate, 2,5-bis(2-ethylhexanoyl-peroxy)-2,5-dimethyl hexane, tert.-butyl peroxy 2-ethyl hexanoate, tert.-butyl peroxy- 3,5,5-trimethyl hexanoate, dicumene
20 peroxide, 1,1 bis(tert. butyl peroxy) cyclohexane, 1,1 bis(tert. butyl peroxy) 3,3,5-trimethyl cyclohexane, cumene hydroperoxide and tert.-butyl hydroperoxide.

Low molecular weight polymers, especially
25 poly(meth)acrylates can be obtained by using chain transfer agents. This technology is ubiquitously known and practiced in the polymer industry and is described in Odian, Principles of Polymerization, 1991. Examples of chain transfer agents are sulfur containing compounds such as
30 thiols, e.g. n- and t - dodecanethiol, 2-mercaptoethanol, and mercapto carboxylic acid esters, e.g. methyl-3-mercaptopropionate. Preferred chain transfer agents contain up to 20, especially up to 15 and more preferably up to 12

carbon atoms. Furthermore, chain transfer agents may contain at least 1, especially at least 2 oxygen atoms.

Furthermore, the low molecular weight polymers, especially
5 poly(meth)acrylates can be obtained by using transition metal complexes, such as low spin cobalt complexes. These technologies are well known and for example described in USSR patent 940,487-A and by Heuts, et al., *Macromolecules* 1999, pp 2511-2519 and 3907-3912.

10

Furthermore, novel polymerization techniques such as ATRP (Atom Transfer Radical Polymerization) and or RAFT (Reversible Addition Fragmentation Chain Transfer) can be applied to obtain useful polymers derived from alkyl
15 esters. These methods are well known. The ATRP reaction method is described, for example, by J-S. Wang, et al., *J. Am. Chem. Soc.*, Vol. 117, pp. 5614-5615 (1995), and by Matyjaszewski, *Macromolecules*, Vol. 28, pp. 7901-7910 (1995). Moreover, the patent applications WO 96/30421, WO
20 97/47661, WO 97/18247, WO 98/40415 and WO 99/10387 disclose variations of the ATRP explained above to which reference is expressly made for purposes of the disclosure. The RAFT method is extensively presented in WO 98/01478, for example, to which reference is expressly made for purposes
25 of the disclosure.

30

The polymerization can be carried out at normal pressure, reduced pressure or elevated pressure. The polymerization temperature is also not critical. However, in general it
lies in the range of -20-200°C, preferably 0-130°C and especially preferably 60-120°C, without any limitation intended by this.

The polymerization can be carried out with or without solvents. The term solvent is to be broadly understood here. Illustrative of suitable solvents are hydrocarbon solvents, for example, aromatic solvents (aromatic C₆₋₁₅ hydrocarbons, such as benzene, toluene, xylene, ethylbenzene, C₉₋₁₅ alkyl benzenes, trimethyl benzene, ethyl toluene and mixtures of them), mineral oils (such as paraffinic oils, naphthenic oils, solvent-refined oils, isoparaffin-containing high VI oils and hydrocracked high VI oils), and synthetic hydrocarbon lubricants (such as poly- α -olefin synthetic lubricant); ketone solvents, such as butanone and methyl ethyl ketone; and ester solvents, including, fatty oils, and synthetic ester lubricants (for example, di-C₄₋₁₂ alkyl C₄₋₁₂ dicarboxylates, such as dioctyl sebacate and dioctyl adipate, polyol poly-C₄₋₁₂ alkanates, such as pentaerythritol tetra-caproate; and tri-C₄₋₁₂ hydrocarbyl phosphates, such as tri-2-ethylhexyl phosphate, dibutyl phenyl phosphate, di-2-ethylhexyl phenyl phosphate, 2-ethylhexyl diphenyl phosphate and tricresyl phosphate).

20

According to a preferred embodiment, the polymer is obtainable by a polymerization in API Group I, Group II, Group III, Group IV or Group V oils.

25

The inventive polymer can preferably be used in a lubricant oil composition. A lubricant oil composition comprises at least one type of lubricant oil. The lubricant oils include especially mineral oils, synthetic oils and natural oils.

30

Preferably, the lubricant oil is based on mineral oil from API Group I, II, or III. According to a preferred embodiment of the present invention, a mineral oil containing at least 90 % by weight saturates and at most

about 0.03 % sulfur measured by elemental analysis is used. Especially, API Group II or Group III oils are preferred.

Mineral oils are known per se and commercially available.

- 5 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 including in particular the higher-boiling fractions of crude or mineral oil. In general, the boiling point of
- 10 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, distillation of brown coal with exclusion of air and also hydrogenation of bituminous or brown coal is likewise
- 15 possible. Accordingly, mineral oils have, depending on their origin, different proportions of aromatic, cyclic, branched and linear hydrocarbons. In general, a distinction is drawn between paraffin-base, naphthenic and aromatic fractions in crude oils or mineral oils, in which the term
- 20 paraffin-base fraction represents longer-chain or highly branched isoalkanes, and naphthenic fraction represents cyclo-alkanes.

- Valuable information with regard to the analysis of mineral
- 25 oils and a list of mineral oils which have a different composition can be found, for example, in Ullmann's Encyclopedia of Industrial Chemistry, 5th Edition on CD-ROM, 1997, under "lubricants and related products".

- 30 Synthetic oils are, among other substances, organic esters, for example diesters and polyesters, like carboxylic esters and phosphate esters; organic ethers like silicone oils, perfluoro-alkyl ethers and polyalkylene glycol; and

synthetic hydrocarbons, especially polyolefins and Gas to liquids oils (GTL), among which preference is given to polyalphaolefins (PAO) and GTL oils. They are for the most part somewhat more expensive than the mineral oils, but
5 they have advantages with regard to performance.

Especially polyalphaolefins (PAO) are preferred. These compounds are obtainable by polymerization of alkenes, especially alkenes having 3 to 12 carbon atoms, like propene, hexene-1, octene-1, and dodecene-1. Preferred PAOs
10 have a number average molecular weight in the range of 200 to 10000 g/mol, more preferably 500 to 5000 g/mol.

Furthermore, GTL oils are useful as base fluid. These synthetic oils are obtained by a special refinery process converting natural gas or other gaseous hydrocarbons into
15 longer-chain hydrocarbons such as gasoline or diesel fuel.

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

20 For an explanation reference is made to the 5 API classes of base oil types (API: American Petroleum Institute).

American Petroleum Institute (API) Base Oil Classifications

Base stock Group	Viscosity Index	Sulfur (weight %)	Saturates (weight %)
Group I	80-120	>0.03	<90
Group II	80-120	<0.03	>90
Group III	> 120	<0.03	>90
Group IV all synthetic Polyalphaolefins (PAO)	> 120	<0.03	>99
Group V all not included in Groups I-IV, e.g. esters, polyalkylene glycols	> 120	<0.03	

Base oils preferably have a kinematic viscosity

- 5 (hereinafter referred to as KV) of 1-15 mm²/s, particularly 2-5 mm²/s, at 100° C.

Base oils preferably have a VI of at least 80, particularly at least 100 and preferably at least 120. Especially, the

- 10 VI of the base oil may be 180 or less, particularly 150 or less and more preferably 140 or less. Base oils preferably have a cloud point (defined in JIS K2269) of -5° C. or less, particularly -10° C. or less, more particularly -15° C. or less, in view of low-temperature viscosity behavior,
- 15 with little wax deposition at low temperature.

These lubricant oils may also be used as mixtures and are in many cases commercially available. The concentration of the inventive polymer in the lubricant oil composition is preferably in the range from 0.5 to 40% by weight, more preferably in the range from 1 to 23% by weight, based on the total weight of the composition. The amount of base oil in the lubricant is usually at least 60 % by weight, more preferably at least 75 % by weight.

10

In addition to the aforementioned components, a lubricant oil composition may comprise further additives.

These additives include antioxidants, corrosion inhibitors, antifoams, antiwear components, dyes, dye stabilizers, detergents, pour point depressants and/or DI additives.

In addition, these additives encompass further viscosity index improvers, dispersing assistants and/or friction modifiers, which are more preferably based on a polyalkyl(meth) acrylate. These polyalkyl(meth)acrylates are different to the present polymers and are described especially in the prior art discussed by way of introduction, and these polymers may have dispersing monomers. Preferred polymers useful as viscosity improvers and methods for their preparation are disclosed in US 2003/0104955 filed August 3, 2002 with the USPTO having the application number US 10/212784 and JP 2008-031459 A filed June 29, 2007 with the Japanese Patent Office having the application number JP 2007-172420, both of which are incorporated herein by reference.

Preferred lubricant oil compositions have a viscosity in the range from 10 to 120 mm²/s, more preferably in the range from 22 to 100 mm²/s measured at 40° C according to ASTM D 445.

5

In a particular aspect of the present invention, preferred lubricant oil compositions have a viscosity index, determined to ASTM D 2270, in the range from 100 to 400, more preferably in the range from 150 to 350 and most preferably in the range from 200 to 300.

10

The present lubricant composition can be used, for example, as engine oils (oils used in engines such as an engine for means of transportation and engine for machine tools); gear oils; transmission lube oils, particularly automatic transmission fluid (ATF), such as stepped automatic transmission fluid and continuously variable transmission fluid (CVTF); and traction oils, shock-absorber oils, power steering oils, hydraulic oils and the like.

15
20

The invention will be illustrated in detail hereinafter with reference to examples, without any intention that this should impose a restriction. All amounts are displayed in weight percent unless otherwise stated.

25

Examples 1 to 5

30

A 4-neck glass round bottom flask equipped with condenser and glass stirrer was initially charged with a 375 g of monomer(s), 2.8 g of n-DDM and 30 g of Calumet's Hydrocal 3145. The reaction mixture was heated to 110°C and a free radical initiator solution of 0.94 g of t-butyl peroctoate and 60.0 g of Hydrocal 3145 was added to the flask over 165

minutes. 10% of this free radical initiator solution was added in the first 60 minutes, followed by 20% in the next 60 minutes and the remainder in the final 45 minutes. The reaction mixture was held 60 minutes after complete
5 addition of the initiator mixture and then diluted with Hydrocal 3145 to obtain the desired polymer concentration.

The compositions of monomer mixtures according to the Examples are shown in table 1.

10

List of Abbreviations:

MMA = methyl meth acrylate

L125MA = alkyl meth acrylate prepared from Sasol's LIAL
125; the alkyl residue is a mixture of linear and
15 branched residues

(about 12 wt.% branched C₁₂; about 11,3 wt.% linear
C₁₂;

about 17,3 wt.% branched C₁₃; about 13,5 wt.% linear
C₁₃;

20

about 15,7 wt.% branched C₁₄; about 11,9 wt.% linear
C₁₄;

about 9,8 wt.% branched C₁₅; about 6,2 wt.% linear
C₁₅;

2-methyl branching about 14 %, 2-ethyl branching

25

about 10 %, 2-propyl branching about 10 %, 2-butyl
and higher 2- alkyl branching about 17 %, based on
the total of the linear and branched residues)

L167MA = alkyl meth acrylate prepared from Sasol's LIAL
167; the alkyl residue is a mixture of linear and
30 branched residues

(about 4,7 wt.% linear C₁₅;

about 39,5 wt.% branched C₁₆; about 22,3 wt.% linear
C₁₆;

about 22,4 wt.% branched C₁₇; about 10,3 wt.% linear C₁₇)

I167MA = alkyl meth acrylate prepared from Sasol's ISALCHEM 167, the alkyl residue is a mixture of predominately branched residues

5

(about 1,3 wt.% linear C₁₅;
about 60,7 wt.% branched C₁₆; about 1,4 wt.% linear C₁₆;
about 34,6 wt.% branched C₁₇)

10 A1618MA = stearyl meth acrylate prepared from Condea's Alfol 1618; the alkyl residue is a mixture of predominantly linear residues

(about 30 wt.% linear C₁₆; about 70 wt.% linear C₁₈)

15 The proportion of linear and branched alkyl residues had been determined via GC and GC and ¹³C- und ¹H-NMR.

The C13-Spectra were taken at 30 °C using conventional pulse-sequences for quantitative determining of ¹³C peaks.

20 To ensure quantitative accuracy, a relaxation delay of at least 10 sec between pulses had been used and pulse schemes had been applied in order to suppress Nuclear-Overhauser-Effects. At least 10000 scans had been taken to achieve an appropriate S/N-ratio.

25

The ¹³C-NMR-data sets were processed by using a line broadening of 3 Hz to improve the S/N-ratio. ¹³C-NMR-Signals were assigned using 2D-NMR experiments and ¹³C-shift increment calculations (e.g. software package

30 MestreNova from MestreLab Research). The integrals of one of the following ¹³C-signal-area are used to calculate the isomer-distribution:

30

Substructure	¹³C-Chemical Shift
Unbranched n-alkanol	62.93 ppm (C1)
2-Methyl-1-alkanol:	69.30 ppm (C1), 16.68 ppm (C1, side chain)
2-Ethyl-1-alkanol	65.23 ppm (C1), 42.12 ppm (C2)
2-Propyl-1-alkanol	20.10 ppm (C2, side chain), 40.43 ppm (C2)
2-Butyl+* -1-alkanol *Butyl and chains >C4	65.61 ppm(C1) includes 2-Propyl(C1), 40.64 ppm (C2)

The peak areas had been normalized by setting the sum of the averaged peak areas to 100 % to get the distribution of the branched alkanols in percent. Due to the fact, that

5 the chemical shift is sensitive to structural changes in the range of 4 bonds away from the observed nucleus. The results had been cross-validated by Proton-NMR. Especially the degree of branching had been checked by the ratio of the peak area of □-Methyls (0.88 ppm) to □-C H₂ (3.3-3.7

10 ppm) .

Substructure	¹H-Chemical Shift
Unbranched n-Alkanol	3.61 ppm (2H, t)
2-Methyl-1-alkanol	3.37 ppm (1H, B-Part of the ABX-system)
All other branched alkanols	3.50 ppm (2H, d)

MMA had been obtained from Evonik Röhm GmbH. The long chain methacrylates had been obtained by transesterification of MMA with appropriate alcohols. For preparation of L125MA a
5 mixture of alcohols had been used being available from Sasol North America Inc. under the trade name Lial 125 having an average molecular weight of 207 g/mol. For preparation of L167MA a mixture of alcohols had been used being available from Sasol North America Inc. under the
10 trade name Lial 167 having an average molecular weight of 246 g/mol. For preparation of I167MA a mixture of alcohols had been used being available from Sasol North America Inc. under the trade name Isalchem 167 having an average molecular weight of 242 g/mol. For preparation of A1618MA a
15 mixture of alcohols had been used being available from Condea under the trade name Alfol 1618 having an average molecular weight of 354 g/mol.

Moreover, the weight average molecular weights had been
20 determined by GPC in tetrahydrofuran at 35°C using a polymethyl (meth)acrylate calibration curve composed of a broad molecular weight standard. A combination of two Waters Styragel 5E columns was used.

25 Table 1: Viscosity index improver compositions which illustrate the inventive nature of the claims

Application Examples	6	1	21	6.8	241	9.1	5700
	7	2	23	6.8	251	7.9	7300
	8	3	21	6.8	236	6.5	70000
	9	4	22	6.8	251	6.5	20300
	10	5	17	6.8	249	10.0	10200

The Examples clearly indicate that the polymers of the present invention provide excellent properties. These include a high viscosity index, a low treating rate, a high shear stability and exceptional low temperature performance.

5

Patent claims

1. A polymer useful as viscosity index improver
 comprising units derived from one or more
 5 ethylenically unsaturated ester compounds of formula
 (I)



- where R is hydrogen or methyl, R¹ means a linear,
 branched or cyclic alkyl residue with 1-6 carbon
 atoms, R² and R³ independently represent hydrogen or a
 10 group of the formula -COOR', where R' means hydrogen
 or a alkyl group with 1-6 carbon atoms,
 units of one or more ethylenically unsaturated ester
 compounds of formula (II)



- where R is hydrogen or methyl, R⁴ means a 2-alkyl
 15 branched alkyl residue with 12-18 carbon atoms, R⁵ and
 R⁶ independently are hydrogen or a group of the
 formula -COOR'', where R'' means hydrogen or an alkyl
 group with 12-18 carbon atoms, and
 units of one or more ethylenically unsaturated ester
 20 compounds of formula (III)



- where R is hydrogen or methyl, R⁷ means a linear alkyl residue with 12-24 carbon atoms, R⁸ and R⁹ independently are hydrogen or a group of the formula -COOR'', where R'' means hydrogen or an alkyl group with 12-24 carbon atoms
- 5 characterized in that said polymer comprises at least 10 % by weight units derived from one or more compounds of formula (I), based on the total weight of the polymer,
- 10 said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (II), based on the total weight of the polymer, and
- 15 said polymer comprises at least 10 % by weight units derived from one or more ethylenically unsaturated ester compounds of formula (III), based on the total weight of the polymer.
2. The polymer according to claim 1 wherein the polymer
- 20 comprises 25 to 45 % by weight of units derived from one or more ethylenically unsaturated ester compounds of formula (I) based on the weight of the polymer.
3. The polymer according to at least one of the preceding
- 25 claims wherein the polymer comprises 20 to 55 % by weight of units derived from one or more ethylenically unsaturated ester compounds of formula (II) based on the weight of the polymer.
- 30 4. The polymer according to at least one of the preceding claims wherein the polymer comprises 25 to 35 % by weight of units derived from one or more ethylenically

unsaturated ester compounds of formula (III) based on the weight of the polymer.

5. The polymer according to at least one of the preceding
5 claims wherein said polymer has a weight average
molecular weight in the range of 5,000 to 2,000,000
g/mol
6. The polymer according to at least one of the preceding
10 claims wherein the weight ratio of the units derived
from one or more ethylenically unsaturated ester
compounds of formula (II) and the units derived from
one or more ethylenically unsaturated ester compounds
of formula (III) is in the range of 4:1 to 1:1.
7. The polymer according to at least one of the preceding
15 claims wherein units derived from ethylenically
unsaturated ester compounds of formula (II) are a
mixture and the mixture comprises units having a 2-
20 methyl branched alkyl residue as residue R⁴ and units
having a 2-ethyl branched alkyl residue as residue R⁴.
8. The polymer according to at least one of the preceding
25 claims wherein units derived from ethylenically
unsaturated ester compounds of formula (II) are a
mixture and the mixture comprises units having a 2-
propyl branched alkyl residue as residue R⁴ and units
having a 2-butyl or higher branched alkyl residue as
30 residue R⁴.
9. The polymer according to at least one of the preceding
claims wherein the units of one or more ethylenically
unsaturated ester compounds of formula (II) comprises

- 5 units having a 2- methyl branched alkyl residue as residue R^4 and the units having a 2- methyl branched alkyl residue as residue R^4 comprises at least 10 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).
10. 10 The polymer according to at least one of the preceding claims wherein the units of one or more ethylenically unsaturated ester compounds of formula (II) comprises units having a 2-ethyl branched alkyl residue as residue R^4 and the units having a 2-ethyl branched alkyl residue as residue R^4 comprises at least 10 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).
- 15 11. The polymer according to at least one of the preceding claims wherein the units of one or more ethylenically unsaturated ester compounds of formula (II) comprises units having a 2-propyl branched alkyl residue as residue R^4 and the units having a 2-propyl branched alkyl residue as residue R^4 comprises at least 10 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).
- 20 12. The polymer according to at least one of the preceding claims wherein the units of one or more ethylenically unsaturated ester compounds of formula (II) comprises units having a 2-butyl or higher branched alkyl residue as residue R^4 and the units having a having a 2-butyl or higher branched alkyl residue as residue R^4 comprises at least 10 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).
- 25 30

13. The polymer according to at least one of the preceding claims wherein said units of one or more ethylenically unsaturated ester compounds of formula (II) comprise units having residues R⁴ with 12 to 16 carbon atoms and the units having residues R⁴ with 12 to 16 carbon atoms comprises at least 50 % by weight based on the units derived from ethylenically unsaturated ester compounds of formula (II).
14. The polymer according to at least one of the preceding claims wherein the polymer comprises 0.1 to 50 % by weight of units derived from comonomers.
15. The polymer according to at least one of the preceding claims wherein the polymer comprises units derived from one or more ethylenically unsaturated ester compounds being different to the ethylenically unsaturated ester compounds of formula (I), (II) and (III).
16. The polymer according to claim 15 wherein the polymer comprises units of one or more ethylenically unsaturated ester compounds of formula (IV)



- where R is hydrogen or methyl, R¹⁰ means a linear, branched or cyclic alkyl residue with 7-11 carbon atoms, R¹¹ and R¹² independently are hydrogen or a

group of the formula $-\text{COOR}'$, where R' means hydrogen or an alkyl group with 7-11 carbon atoms,

5 17. The polymer according to claim 16 wherein the polymer comprises 0 to 20 % by weight of units derived from one or more ethylenically unsaturated ester compounds of formula (IV) based on the weight of the polymer.

10 18. The polymer according to claim 15 wherein the polymer comprises units of one or more ethylenically unsaturated ester compounds of formula (V)



15 where R is hydrogen or methyl, R^{13} means a 3- branched alkyl residue with 12-18 carbon atoms, R^{14} and R^{15} independently are hydrogen or a group of the formula $-\text{COOR}'$, where R' means hydrogen or an alkyl group with 12-18 carbon atoms.

20 19. The polymer according to claim 18 wherein the polymer comprises 0 to 20 % by weight of units derived from one or more ethylenically unsaturated ester compounds of formula (V) based on the weight of the polymer.

25 20. A lubricant composition comprising at least one of the polymers according to claims 1 to 19.

21. The lubricant composition according to claim 20 wherein the lubricant comprises 0.5 to 40% by weight polymer.

22. The lubricant composition according to claim 20 or 21 wherein the lubricant comprises at least 60 % by weight of at least one base fluid.

5

23. The use of a lubricant composition according to claims 20 to 22 as an automatic transmission fluid (ATF).