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LUBRICATING OIL CONTAINING A COPOLYMER OF AN ESTER OF AN UNSATURATED ACID AND A N-HYDROCARBON AMIDE OF AN UNSATURATED ACID

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17 Claims. (Cl. 252—51.5)

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This invention relates to lubricants and, more particularly, to lubricating oil compositions having improved lubricating qualities. This application is a continuation-in-part of applicant's copending application Serial No. 111,349, filed August 19, 1949, now abandoned.

Lubricating oils have the undesirable characteristic of decreasing in viscosity as the temperature of the oil is increased. The rate of change of viscosity with temperature varies with the nature of the particular oil. Oils with a low rate of change of viscosity with temperature are desired for lubrication purposes, especially in applications where widely varying temperature conditions are encountered. Hence, numerous materials have been proposed as additives to oils to minimize their change in viscosity with temperature.

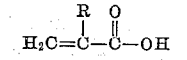
Measurements of the suitability of a lubricating oil for use over a wide range of operating temperatures are afforded by the viscosity index and by the slope calculated from the viscosity-temperature characteristics of the oil. The viscosity index is calculated from the measured viscosities of the oil at two temperatures, 100° F. and 210° F., by the standard A. S. T. M. method identified as D567–41. By this method of calculation oils having the least change in viscosity with a given increase in temperature have the highest viscosity index. An increase of 5 viscosity index units is a significant improvement. The slope of an oil is calculated as the quotient of the viscosity increase of the oil at 100° F. divided by that at 210° F. In this calculation oils having the lowest values for the slope exhibit the least change in viscosity with change in temperature. A decrease of 0.5 in slope is a significant improvement.

Many of the additives which hitherto have been proposed for improving lubricating oils increase the viscosity index of the oil to an appreciable extent. However, some of the most effective of these additives, which are polymeric materials, have too great a thickening effect on oil. To be useful at extremely low temperatures a lubricating oil must also be capable of flowing at such temperatures, and for these applications a four-point depressant, i. e., a material capable of lowering the temperature at which the wax in the oil solidifies, must also be added to it. Therefore, the most desirable lubricating oils are those which flow readily at low temperatures, e. g., the low temperatures encountered in starting an engine in winter, and which at the same time possess a high viscosity index, or low slope, so that at the operating temperature of the engine there will be only a small decrease in the viscosity of the oil.

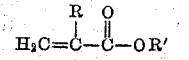
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This invention has as an object an improved lubricating oil which possesses the extremely desirable combination of high viscosity index with a minimum thickening of the oil. Further objects reside in methods for obtaining these improved lubricating oils. Other objects will appear hereinafter.

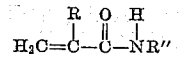
The above objects are accomplished by incorporating in lubricating oil a small proportion of an oil-soluble copolymer of an alkyl ester of an unsaturated aliphatic acid, which is either acrylic acid or an alpha-alkylacrylic acid, and an N-monohydrocarbon amide of such an unsaturated aliphatic acid. In these esters and amides from which the copolymers are obtained, the ester alkyl group in the ester contains from 4 to 18 carbon atoms, and the hydrocarbon radical attached to the nitrogen in the N-hydrocarbon amide can be any alkyl, cycloalkyl, or aryl radical containing from 4 to 18 carbon atoms. The sum of the carbon atoms in the alkyl and N-hydrocarbon radicals should be between 14 and 30 to provide the best solubility of the copolymer in mineral oil. As indicated previously the ester and amide components of the copolymer can be derived from either acrylic acid or an alpha-alkylacrylic acid, that is from an acid of the formula



where R is H in the case of acrylic acid or an alkyl group in the case of an alpha-alkylacrylic acid. The copolymers most useful for the present purpose are obtained when the ester and amide components are derived from acrylic acid or from an alpha-alkylacrylic acid where R in the above formula is a lower alkyl group, i. e., an alkyl group of one to three carbon atoms. The preferred copolymers are thus copolymers of



and



where R is hydrogen or an alkyl radical of 1 to 3 carbon atoms, R′ is an alkyl radical of 4 to 18 carbon atoms, and R″ is a monovalent hydrocarbon radical of 4 to 18 carbon atoms. The amide-nitrogen content of the copolymers useful in the practice of this invention is between 0.2% and 7.0% by weight of the copolymer.

Copolymers of N-arylacrylamides, and particularly of N-phenylmethacrylamide, are especially useful as the lubricant additives of the present invention since they are very effective in increasing the viscosity index and decreasing the slope value of a lubricating oil. Copolymers of N-alkylacrylamides in which the alkyl group contains from twelve to eighteen carbon atoms, and particularly N-octadecylmethacrylamide, are also especially effective in lowering the pour-point of the lubricating oil at the same time they are increasing the viscosity index of the oils. Copolymers in which the alkyl group of the N-alkylacrylamide component is highly branched, e. g., N-(1,1,3,3-tetramethylbutyl) methacrylamide obtained by reaction of diisobutylene and methacrylonitrile in the presence of glacial acetic acid and concentrated sulfuric acid, followed by hydrolysis, are also especially effective additives for lubricating oils, since the branched chain imparts better solubility in hydrocarbon oils. Copolymers in which the acrylic ester component is an ester of technical lauryl alcohol are especially effective in the lubricating oil compositions of this invention, and are, therefore, the preferred modification.

The copolymers defined above are used in lubricating oils in amounts ranging from 0.1% to 10% of the weight of the oil. Usually amounts of from 1% to 5% are preferred, the optimum amount of any particular copolymer being dependent on the particular substituent groups in the ester and amide components of the copolymer, the particular type of oil being treated, and the degree of increase in viscosity index desired in the oil. Lubricating oils containing the above proportions, i. e., 0.1% to 10%, of these copolymers are useful for hydraulic oils and for torque converter fluids.

The lubricating oils with which the copolymers defined above are effective viscosity index improvers include all types of oils obtained from petroleum, i. e., the paraffin base, naphthenic base and mixed base oils, and also the ester type of lubricants, e. g., alkyl esters of aliphatic dicarboxylic acid such as di-2-ethylhexyl sebacate. The lubricating oils may also contain in solution or suspension conventional lubricating oil modifiers which impart other desirable characteristics to the oil, e. g., antioxidants, etc.

The copolymers may be incorporated in the oils by simply blending with stirring at ordinary temperatures, or, if desired, a mixture of oil and copolymer may be heated to elevated temperature, e. g., 100° to 130° C., with agitation, to form the compositions of this invention.

The alkyl acrylate/N-hydrocarboacrylamide copolymers employed in accordance with this invention can be prepared by the copolymerization of monomeric alkyl acrylates and N-hydrocarboacrylamides of the above-defined types by customary bulk or solution polymerization methods in the presence of known addition polymerization catalysts. Oxygen-yielding catalysts such as benzoyl peroxide and azo catalysts such as alpha,alpha'-azodiisobutyronitrile are suitable polymerization catalysts. The polymerization is usually carried out in an inert atmosphere, e. g., in an atmosphere of nitrogen or carbon dioxide, at temperatures ranging from 30° to 150° C., depending on the catalyst used, and preferably at temperatures between 50° and 70° C. when alpha,alpha'-azodiisobutyronitrile is used as catalyst. The preparation of polymers suitable for use in the lubricating compositions of this invention is illustrated further by the following description of the copolymerization of a mixture of lauryl methacrylate and N-phenylmethacrylamide consisting of 15% by weight of the amide ingredient: A mixture of 17 parts of lauryl methacrylate, 3 parts of N-phenylmethacrylamide and 0.15 part of alpha,alpha'-azodiisobutyronitrile is polymerized by heating for 2 hours in a flask held at 55° to 60° C. Stirring is effected and an inert atmosphere is maintained by passing oxygen-free nitrogen through the mixture. The resulting polymer is clear and homogeneous in appearance and is completely soluble in hydrocarbon lubricating oils of both naphthenic and paraffinic types. The copolymers of methacrylanilide, i. e., N-phenylmethacrylamide, with alkyl esters of acrylic and methacrylic acids are more fully disclosed and claimed in applicant's copending application Serial No. 170,271, filed June 24, 1950, now Patent No. 2,584,968, issued February 12, 1952.

The N-phenylmethacrylamide used in the polymerization described above is conveniently prepared as follows: To a cooled, preferably below 30° C., and stirred slurry of 186 parts of aniline, 184.8 parts of sodium bicarbonate and 0.5 part of m-dinitrobenzene in 1000 parts of water is added, during the course of an hour, 228 parts of methacrylyl chloride. After standing over night at room temperature the reaction mixture is filtered. The solid reaction product is recrystallized from a mixture of equal parts by volume of water and methanol. There is obtained, after vacuum drying, 284 parts, 91% of theory, of white crystalline N-phenylmethacrylamide, melting at 87° C.

Polymers of extremely high molecular weight are less desirable than similar copolymers of lower molecular weight because the high molecular weight copolymers cause an undesirable degree of thickening when added to the lubricating oil, and also because extremely high molecular weight copolymers are subject to greater changes in properties when subjected to mechanical shear than is the case with lower molecular weight copolymers. For these reasons the copolymers best used in the practice of this invention range in molecular weight from about 200,000 to about 1,200,000, these being weight-average molecular weights determined by light scattering of polymer solutions. Intrinsic viscosities, determined in bromobenzene solution, should preferably be between 0.3 and 1.2. A sample which shows excellent properties as a lubricant additive has a weight-average molecular weight of 580,000 and an intrinsic viscosity in bromobenzene solution at 100° F. of 0.74 and at 210° F. of 0.70. The molecular weight or degree of polymerization of the copolymer can be controlled by regulating the polymerization procedure or by after-treatment of a high molecular weight polymer. For example, the degree of polymerization of the copolymer is reduced by polymerizing the comonomers in the presence of a neutral white mineral oil amounting to about 50% of the weight of the comonomers. The molecular weight of a copolymer too high in molecular weight to impart optimum properties to a lubricant can be reduced by milling the copolymer on a two-roll differential speed mill at 95° to 110° F. Modifiers such as antioxidants and/or mercaptans may be added during this operation.

The invention is illustrated further by the following examples in which the proportions of ingredients are expressed in parts by weight un-

less otherwise specified. In these examples the alkyl acrylate/N-hydrocarboacrylamide copolymers are blended with the lubricating oil by stirring the indicated proportion of copolymer with the oil, e. g., one part of polymer with 49 parts of oil to give a composition containing 2% of copolymer, while warming the mixture to 100° to 130° C. The viscosities of the modified oil compositions are determined by standard methods at temperatures of 100° F. and 210° F. and the results are expressed in centistokes. The viscosity index is calculated by the method identified as A. S. T. M. method D567–41. The slope values for the oil compositions of this invention are calculated from the observed viscosities, in centistokes, of the unmodified base oil and the oil solution of the copolymer by means of the following equation:

$$\text{Slope} = \frac{\text{solution viscosity at 100° F.} - \text{base oil viscosity at 100° F.}}{\text{solution viscosity at 210° F.} - \text{base oil viscosity at 210° F.}}$$

from a commercial lauryl alcohol obtained by reduction of coconut oil fatty acids, and having the following approximate composition:

	Per cent
$C_{10}H_{21}OH$	3
$C_{12}H_{25}OH$	61
$C_{14}H_{29}OH$	23
$C_{16}H_{33}OH$	11
$C_{18}H_{37}OH$	2

There are also included in Table I, for purposes of comparison, the viscosity data for lubricating compositions consisting of the same mixed base oil and the same proportions, 1.5%, of lauryl methacrylate polymer, N-phenylmethacrylamide polymer, and lauryl methacrylate/N-phenylmethacrylamide coploymers having amide nitrogen contents outside the preferred range for this type of polymer, as well as the viscosity data for the mixed base oil containing no modifier.

Examples 5, 6, 7, 8 and 9 listed in Table II illustrate the use of lauryl methacrylate/N-phenylmethacrylamide coploymers containing different proportions of the two components in 3% (by weight) concentration in a solvent extracted paraffin base lubricating oil. Also included in this table for purposes of comparison are the viscosity data for the unmodified oil and for the same oil modified with homopolymers of lauryl methacrylate of different molecular weights.

TABLE I

Lauryl methacrylate/N-phenylmethacrylamide copolymers (1.5%) in mixed base lubricating oil

Example No.	Copolymer		Viscosity in centistokes—		Viscosity Index	Slope
	Ester: Amide ratio (by weight)	Amide N, Percent	at 100° F.	at 210° F.		
1	90:10	0.87	20.07	5.33	187	3.08
2	85:15	1.31	19.23	5.40	193	2.66
3	80:20	1.74	17.89	4.99	197	2.54
4	75:25	2.18	16.63	4.70	203	2.25
	70:30	2.61	13.95	3.54	155	2.15
	[1] 60:40	3.48	15.15	3.67	149	3.31
	Lauryl methacrylate		21.38	4.96	168	4.25
	N-phenylmethacrylamide (completely insoluble in oil)					
	Control oil (no modifier)		12.53	2.88	82	

[1] Incompletely soluble in the oil.

Examples 1 to 4 listed in Table I illustrate the use of lauryl methacrylate/N-phenylmethacrylamide copolymers having different proportions, within the specified range, of amide component. In these examples, 0.75 part of the modifier is blended with 49 parts of a low viscosity Mid-Continent pale oil. The lauryl methacrylate portion of the copolymers described in Table I and in other places in this application is prepared

TABLE II

Lauryl methacrylate/N-phenylmethacrylamide copolymers (3.0%) in solvent extracted paraffin base lubricating oil

Example No.	Copolymer		Viscosity in centistokes—		Viscosity Index	Slope
	Ester: Amide ratio (by weight)	Amide N, Percent	at 100° F.	at 210° F.		
5	97.7:2.3	0.2	106.7	17.0	141	5.89
6	95:5	0.43	101	17.4	145	5.02
7	92.5:7.5	0.65	97.8	18.3	148	4.33
8	90:10	0.87	99.8	19.0	149	4.24
9	85:15	1.31	96.2	19.3	150	3.91
	Lauryl Methacrylate	0	102	14.9	136	6.53
	do	0	131	19.5	138	6.52
	Control oil (no modifier)		46.5	6.5	98	

Examples 10, 11 and 12 illustrate the use of lauryl methacrylate/octadecylmethacrylamide copolymers containing different proportions of the two components in 2% (by weight) concentration in a naphthenic base SAE 10 W commercial oil. The composition of the copolymers and the viscosity data for the oil compositions containing the copolymer modifiers are summarized in Table III. Also included in this table for purposes of comparison are the viscosity data for the unmodified oil and for the same oil modified with the homopolymers of lauryl methacrylate and N-octadecylmethacrylamide.

TABLE III

Lauryl methacrylate/N-octadecylmethacrylamide copolymers (2.0%) in SAE 10 W naphthenic base lubricating oil

Example No.	Copolymer		Viscosity in centistokes—		Viscosity Index	Slope
	Ester:Amide ratio (by weight)	Amide N, Percent	at 100° F.	at 210° F.		
10	80:20	0.83	61.42	11.05	146.2	5.22
11	60:40	1.66	43.61	8.44	150.2	4.34
12	40:60	2.49	34.40	6.85	151.5	3.59
	Laurylmethacrylate		55.50	9.08	136	6.05
	N-octadecylmethacrylamide		29.11	4.66	74	6.40
	Control oil (no modifier)		23.28	3.75	12	

The lauryl methacrylate/N-octadecylmethacrylamide copolymers of Examples 10, 11 and 12, in addition to being effective viscosity index improvers, are pour-point depressants for wax-containing oils. The pour-point of such an oil is lowered from +20° F. to −10° F. by the incorporation in it of 0.33% of any of the above three copolymers having ester : amide ratios of 80 : 20 to 40 : 60.

The lauryl methacrylate/N-octadecylmethacrylamide copolymers of Examples 10, 11 and 12 are also effective viscosity index improvers in ester lubricants. Examples of 13, 14 and 15 illustrate the use of these three copolymers in 2%, by weight, concentration in di-2-ethylhexyl sebacate. The details of the compositions and the viscosity data for these examples are summarized in Table IV. There are also included in Table IV for purposes of comparison the corresponding data for the unmodified di-2-ethylhexyl sebacate lubricant and compositions containing the same proportions (2%) of homopolymers of lauryl methacrylate and N-octadecylmethacrylamide.

TABLE IV

Lauryl methacrylate/N-octadecylmethacrylamide copolymers (2%) in di-2-ethylhexyl sebacate

Example No.	Copolymer		Viscosity in centistokes—		Viscosity Index	Slope
	Ester:Amide ratio (by weight)	Amide N, Percent	at 100° F.	at 210° F.		
13	80:20	0.83	30.56	8.52	176	3.45
14	60:40	1.66	24.96	7.25	183	3.14
15	40:60	2.49	19.06	5.89	198	2.49
	Control, no modifier		12.75	3.36	156	
	Laurylmethacrylate		28.29	7.60	176	3.67
	N-octadecylmethacrylamide		15.66	4.07	184	4.10

Examples 16, 17, 18, 19, 20, 21 and 22 illustrate the use of other copolymers of alkyl esters of an acrylic acid and N-hydrocarbon amides of an acrylic acid of the previously defined types as modifiers for the mixed base lubricating oil used in Examples I to IV. These examples are summarized in Table V.

TABLE V

Alkyl methacrylate/N-hydrocarboacrylamide copolymers (1.5%) in mixed base lubricating oil

Example No.	Copolymer			Viscosity in centistokes		Viscosity Index	Slope
	Ingredients	Ratio, by wt.	Amide N, Percent	at 100° F.	at 210° F.		
16	Laurylmethacrylate/N-p-tolyl-methacrylamide.	85:15	1.20	20.85	5.85	189.2	2.80
17	Lauryl methacrylate/N-phenyl-methacrylamide/styrene.	75:15:10	1.31	18.84	4.92	187.5	3.10
18	Lauryl acrylate/N-phenyl-methacrylamide.	85:15	1.31	19.56	4.85	179.2	3.57

TABLE V—Continued

Example No.	Copolymer			Viscosity in centistokes		Viscosity Index	Slope
	Ingredients	Ratio, by wt.	Amide N, Percent	at 100° F.	at 210° F.		
19	Laurylacrylate/N-phenyl-acrylamide.	85:15	1.43	18.56	4.35	165.0	4.11
20	Octyl methacrylate/N-phenyl-methacrylamide.	85:15	1.31	25.44	13.03	184.2	1.27
21	n-Hexyl methacrylate/N-(1, 1, 3, 3-tetramethylbutyl)-methacrylamide.	50:50	3.55	16.49	4.19	181.0	3.02
22	n-Hexyl methacrylate/N-(1, 1, 3, 3-tetramethylbutyl)-methacrylamide.	75:25	1.77	18.64	4.87	187.9	3.07
	Control, no modifier			12.53	2.88	82	
	N-(1, 1, 3, 3-tetramethylbutyl)-methacrylamide.[1]		7.1	18.63	4.35	164.1	4.15

[1] Incompletely soluble in the oil.

As indicated previously, copolymers of extremely high molecular weight are less desirable than those of somewhat lower molecular weight since the extremely high molecular weight copolymers cause undesirable degrees of thickening and since they are subjected to greater changes in properties when subjected to mechanical shear than is the case with the lower molecular weight products. Examples 23, 24 and 25, summarized in Table VI, illustrate this effect of molecular weight. In Example 24 a high molecular weight copolymer of lauryl methacrylate and N-phenylmethacrylamide prepared from a 85 : 15 ratio of monomers is milled for seven minutes on a two-roll differential speed mill at 95° to 110° F. with 0.25% added dodecyl mercaptan and 0.25% phenyl-beta-naphthylamine. The milled copolymer is incorporated, in 1.5% concentration, in the mixed base oil of the type used in Examples 1 to 4. In Example 25 a mixture of 85% of lauryl methacrylate monomer and 15% of N-phenylmethacrylamide monomer is copolymerized in the presence of alpha,alpha'-azodiisobutyronitrile and one part of a low viscosity, highly acid-treated white oil from a Pennsylvania crude stock per two parts of monomer ingredient for 20 hours at 55° to 60° C. in an atmosphere of carbon dioxide. The resulting polymer is incorporated in 1.5% concentration in a mixed base lubricating oil of the type used in Examples 1 to 4. The viscosity data for these two modified polymers are tabulated in Table VI together with the corresponding data for the unmodified copolymer (Example 23).

TABLE VI

Modified lauryl methacrylate/N-phenylmethacrylamide (85 : 15) copolymers (1.5%) in mixed base lubricating oil

Example No.	Copolymers	Viscosity, in centistokes of 1.5% solution in oil—		Viscosity Index	Slope
		At 100° F.	At 210° F.		
23	Unmodified	22.93	6.72	189	2.71
24	Milled Copolymer	17.99	4.93	195	2.66
25	Copolymer prepared in presence of white oil.	16.95	4.53	194	2.67

The copolymer of lauryl methacrylate and N-phenylmethacrylamide may be used to convert a base oil to an oil having viscosities and a viscosity index in the range acceptable for torque converter fluids, and, moreover, this can be effected by using a lower concentration of the given polymer than of commercial viscosity-index improvers. The value of these copolymers for this purpose is shown by the following Table VII:

TABLE VII

Oil	Polymer, wt. percent A. I.	Viscosity of oil—			Viscosity Index	Slope
		210°, SUS	210°, cs.	100°, cs.		
Base Oil (low viscosity Mid-Continent).	0	40.14	4.24	23.16	93	
Base Oil+Commercial viscosity-index Improver A.	2.84	55.86	9.02	47.15	150	5.00
Base Oil+Commercial viscosity-index improver B.	4.30	55.99	9.06	47.28	150	5.00
Base Oil+Copolymer of 85 parts lauryl methacrylate and 15 parts N-phenylmethacrylamide.	1.75	54.28	8.56	36.32	165	3.09

In the above table the heading A. I. of the first column represents the active ingredient. In connection with this column it may be noted that the commercial viscosity improvers are sold as solutions of the polymer in oil. In the remaining headings SUS refers to Sayholt Universal seconds, and cs. to centistokes. Improvers A and B are commercial products and are oil solutions of lauryl methacrylate polymer which differ in the molecular weight of the polymer.

The present requirements for a torque converter fluid for automotive transmissions and the like are a viscosity index of at least 150, with a SUS viscosity at 210° F. of 54–56 seconds. It will be apparent from the data given in the above table that the polymers used in the practice of this invention are so efficient that only small amounts are needed to arrive at the desired viscosity range, and that the viscosity index so obtained is very high.

In addition to the specific copolymers mentioned in the examples, other copolymers of alkyl acrylates and N-hydrocarboacrylamides having the composition defined previously are operable in the lubricating oil compositions of this invention. Specific examples of suitable alkyl radicals in the alkyl acrylate component include butyl, hexyl, octyl, decyl, dodecyl, tetradecyl, hexadecyl and octadecyl radicals. As indicated previously acrylates containing four to eighteen carbon atoms must be employed in the copolymers used in this invention. When the hydrocarbon group of the N-monohydrocarbon acrylamide component of the copolymer is an aryl group or a straight chain alkyl group, the alkyl group of the alkyl acrylate component preferably contains twelve to eighteen carbon atoms since copolymers of this type are more soluble in hydrocarbon oils than copolymers of acrylates having four to ten carbon atoms in the alkyl radical. On the other hand, when the hydrocarbon group in the acrylamide component of the copolymer is a highly branched alkyl group such as the 1,1,3,3-tetramethylbutyl group, the lower alkyl acrylates, i. e., those in which the alkyl groups contain four to ten carbon atoms are preferred, since the high branching of the alkyl group in the amide component imparts better oil solubility to the copolymer than straight-chain derivatives of the same carbon content. It is not necessary that the alkyl radical in the acrylate component of the copolymer be derived from a pure alcohol. Technical grades of alcohols having an average carbon content within the range specified above are entirely suitable. Alkyl radicals derived from the commercially available alcohols such as the technical lauryl alcohol obtained by reduction of the fatty acids in coconut oil, and the analogous products made by hydrogenation of carbon monoxide, are especially suitable. Specific examples of the hydrocarbon radicals attached to the amide nitrogen of the acrylamide component of the copolymer defined previously include alkyl radicals such as t-butyl, hexyl, octyl, decyl, tetradecyl, octadecyl; cycloalkyl radicals such as cyclohexyl; and aryl radicals such as phenyl, p-tolyl, o-tolyl, and naphthyl (however, the latter tends to give products of lower monomer and polymer solubility than does the preferred phenyl radical). More specific illustrations of other copolymers which can be used in the oil compositions of this invention include: octadecyl acrylate/N-phenylacrylamide, isobutyl methacrylate/N-(1,1,3,3-tetramethylbutyl) acrylamide, n-decyl α-(n-propyl) acrylate/N-dodecylacrylamide, lauryl methacrylate/N-cyclohexylacrylamide, lauryl acrylate/N-phenyl-α-(n-propyl) acrylamide, and lauryl methacrylate/N-t-butylmethacrylamide.

As mentioned previously, the proportion of the acrylate ester and the acrylamide components of the copolymers operable in this invention must be such that the amide-nitrogen content of the copolymer is between 0.2 and 7.0% by weight. The particular amide-nitrogen content which is selected for best results depends on the particular type of hydrocarbon group in the acrylamide component of the copolymer. Thus, copolymers of acrylamides in which the N-hydrocarbon substituent is an aryl or straight-chain alkyl group are most effective as additives for lubricants when the amide-nitrogen content is between 0.2 and 2.2%. On the other hand, when the hydrocarbon substituent on the acrylamide is a highly branched alkyl group higher amide-nitrogen contents are preferred, copolymers of this type containing 1.5 to 3.6% amide-nitrogen being very effective.

Furthermore, the particular monomeric ingredients and their proportions, and the polymerization conditions are selected so that the resulting polymer is homogeneous and is soluble in the lubricating oil. In order to obtain homogeneous copolymers, it is necessary to employ a N-hydrocarboacrylamide which is soluble in the monomeric ester component at the polymerization temperature. If an amide monomer which is not completely soluble in the ester monomer is used, the copolymer obtained contains some amide homopolymer which is insoluble in lubricating oil. For example, N-phenylacrylamide (15%) is not completely soluble in lauryl acrylate or in lauryl methacrylate at 60° C. However, at 90–95° C. solution is complete; and homogeneous, clear, water-white, oil-soluble copolymers are obtained from this particular amide using a catalyst chosen for effectiveness at the higher temperature, e. g., 1,1'-azodicyclohexanecarbonitrile. Also, the higher N-arylacrylamides, e. g., N-alpha-naphthylmethacrylamide, have poor solubility in lauryl methacrylate at 60° C.

From the viscosity data obtained with the lubricating oil compositions of the examples, it is evident that the copolymers of alkyl acrylates and N-hydrocarboacrylamides impart an unexpected improvement in viscosity characteristics to lubricating oils containing them in comparison with the same properties possessed by oil compositions containing homopolymers of the alkyl acrylates or of the N-hydrocarboacrylamides. This makes the oil compositions of this invention especially valuable for lubricating purposes and as hydraulic oils and torque converter fluids. Furthermore, lubricating oil compositions containing the copolymers of this invention possess better viscosity characteristics than the same oil containing commercially available modifiers such as the alkyl methacrylates and the alkylated polystyrenes. Thus, oils having higher viscosity indices and lower slopes can be obtained with the aid of preferred copolymers of this invention than can be obtained at an equal degree of thickening with alkyl methacrylates or commercially known hydrocarbon polymers. It is quite surprising that copolymers of the type used in this invention having as little as 0.2% amide-nitrogen produce a substantial decrease in the slope of an oil composition.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not limited to the specific embodiments thereof except as defined in the appended claims.

The invention claimed is:

1. A lubricating oil containing from 0.1% to 10% by weight of an oil-soluble copolymer of an alkyl ester, in which the alkyl ester group contains from four to eighteen carbon atoms, of an unsaturated aliphatic acid, and a N-hydrocarbon amide of an unsaturated aliphatic acid in which the hydrocarbon radical attached to the nitrogen atom has from four to eighteen carbon atoms, said unsaturated acid in each instance being selected from the group consisting of acrylic acid and alpha-alkylacrylic acids in which the alkyl group contains from 1 to 3 carbon atoms, the amide-nitrogen content of said copolymer ranging from 0.2% to 7.0% by weight.

2. The lubricating oil defined in claim 1 in which said N-hydrocarbon amide is an N-arylacrylamide, and the amide-nitrogen content of said copolymer is from 0.2% to 2.2% by weight.

3. The lubricating oil defined in claim 1 in which said N-hydrocarbon amide is N-phenylmethacrylamide, and the amide-nitrogen content of said copolymer is from 0.2% to 2.2% by weight.

4. The lubricating oil defined in claim 1 in which said N-hydrocarbon amide is an N-alkylacrylamide in which the alkyl group contains from four to eighteen carbon atoms.

5. The lubricating oil defined in claim 1 in which said N-hydrocarbon amide is N-(1,1,3,3-tetramethylbutyl) - methacrylamide, and the amide-nitrogen content of said copolymer ranges from 1.5% to 3.6% by weight.

6. The lubricating oil defined in claim 1 in which said alkyl ester is the ester of lauryl alcohol with said unsaturated aliphatic acid.

7. A lubricating oil containing from 0.1% to 10% by weight of the copolymer of N-phenylmethacrylamide and the ester of lauryl alcohol with an acid selected from the group consisting of acrylic acid and alpha-alkylacrylic acids in which the alkyl group contains from 1 to 3 carbon atoms, the amide-nitrogen content of said copolymer ranging from 0.2% to 2.2% by weight.

8. The lubricating oil defined in claim 7 in which said lubricating oil contains said copolymer in amount of from 1% to 5% by weight.

9. A lubricating oil containing from 0.1% to 10% by weight of the copolymer of N-phenylmethacrylamide and lauryl methacrylate, the amide-nitrogen content of said copolymer ranging from 0.2% to 2.2% by weight.

10. The lubricating oil defined in claim 9 in which said lubricating oil contains said copolymer in amount of from 1% to 5% by weight.

11. A lubricating oil containing from 0.1% to 10% by weight of the copolymer of N-(1,1,3,3-tetramethylbutyl)-methacrylamide and the ester of hexyl alcohol with an acid selected from the group consisting of arcylic acid and alpha-alkylacrylic acids in which the alkyl group contains from 1 to 3 carbon atoms, the amide-nitrogen content of said copolymer ranging from 1.5% to 3.6% by weight.

12. The lubricating oil defined in claim 11 in which said lubricating oil contains said copolymer in amount of from 1% to 5% by weight.

13. A lubricating oil containing from 0.1% to 10% by weight of the copolymer of N-(1,1,3,3-tetramethylbutyl) methacrylamide and hexyl methacrylate, the amide-nitrogen content of said copolymer ranging from 1.5% to 3.6% by weight.

14. The lubricating oil defined in claim 13 in which said lubricating oil contains said copolymer in amount of from 1% to 5% by weight.

15. A lubricating oil containing from 0.1% to 10% by weight of the copolymer of N-octadecylmethacrylamide and lauryl methacrylate, the amide-nitrogen content of said copolymer ranging from 0.2% to 2.2% by weight.

16. A lubricating oil containing from 0.1% to 10% by weight of the copolymer of N-phenylmethacrylamide and lauryl acrylate, the amide-nitrogen content of said copolymer ranging from 0.2% to 2.2% by weight.

17. A lubricating oil containing from 0.1% to 10% by weight of the copolymer of N-phenylmethacrylamide and octyl methacrylate, the amide-nitrogen content of said copolymer ranging from 0.2% to 2.2% by weight.

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