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(54) Titre : COMPOSITION D'ADDITIF A BASE D'HUILE LUBRIFIANTE ET METHODE DE PRODUCTION CONNEXE

(54) Title: A LUBRICATING OIL ADDITIVE COMPOSITION AND METHOD OF MAKING THE SAME

(57) **Abrégé/Abstract:**

An oil-soluble lubricating oil additive composition comprising (I) an oil-soluble lubricating oil additive prepared by the process which comprises reacting a copolymer, with at least one ether compound and with at least one aromatic amine and (II) at least one ashless dispersant other than the lubricating oil additive of (I), the method of making the same, a lubricating oil composition comprising the lubricating oil additive composition and a major amount of an oil of lubricating viscosity, and a method of making the same.



ABSTRACT

An oil-soluble lubricating oil additive composition comprising (I) an oil-soluble lubricating oil additive prepared by the process which comprises reacting a
5 copolymer, with at least one ether compound and with at least one aromatic amine and (II) at least one ashless dispersant other than the lubricating oil additive of (I), the method of making the same, a lubricating oil composition comprising the lubricating oil additive composition and a major amount of an oil of lubricating viscosity, and a method of making the same.

A LUBRICATING OIL ADDITIVE COMPOSITION AND METHOD OF MAKING THE SAME

FIELD OF THE INVENTION

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The present invention is directed to a lubricating oil additive composition, a lubricating oil composition, and methods of making the same. More particularly the present invention is directed to such a lubricating oil additive and a lubricating oil composition which are suitable as an engine oil and highly effective in dispersing soot
10 in an engine.

BACKGROUND OF THE INVENTION

It is known to employ nitrogen containing dispersants and/or detergents in the
15 formulation of lubricating oil compositions. Many of the known dispersant/detergent compounds are based on the reaction of an alkenylsuccinic acid or anhydride with an amine or polyamine to produce an alkenylsuccinimide or an alkenyl succinamic acid as determined by selected conditions of reaction. One problem facing the lubricant manufacturer is dispersancy of particulate matter in internal combustion engines.
20 Failure to have adequate particulate matter dispersancy may result in filter plugging, sludge accumulation, and oil thickening. Often a formulator has to use multiple dispersants to improve dispersancy and reduce sludge and deposit formation.

DESCRIPTION OF THE RELATED ART

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Yagishita et al., U.S. Patent Application Publication No. US2002/0119896 A1, discloses a lubricant composition which comprises a base oil, and (A) a mono substituted amide type bissuccinimide in an amount from 0.5 to 20 percent by mass, (B) zinc dithiophosphate in an amount from 0.05 to 0.3 percent by mass of
30 phosphorous, and (C) a metal-based detergent in an amount from about 0.5 to 4.0 percent by mass of sulfated ash, based on the total mass of the composition. The lubricant compositions therein preferably further comprise (D) a dispersant type viscosity index improver in an amount from 0.1 to 20 percent by mass, based on the total mass of the composition.

Liu et al., U.S. Patent No. 6,117,825, discloses a lubricating oil composition that comprises a major amount of an oil of lubricating viscosity; and a minor amount of a synergistic combination of an antioxidant-dispersant additive and a dispersant
5 additive, said combination comprising: (i) a polyisobutylene succinimide (PIBSAD) and (ii) an ethylene-propylene succinimide (LEPSAD).

Nalesnik, U.S. Patent No. 5,138,688, discloses an additive composition comprising an oxidized ethylene copolymer or terpolymer of a C₃-C₁₀ alpha-monoolefin and,
10 optionally, a non-conjugated diene or triene which has been reacted with a formaldehyde compound and with an amino-aromatic polyamine compound.

Günther et al., U.S. Patent No. 6,512,055, discloses a copolymer obtained by free radical copolymerization of at least one monoethylenically unsaturated
15 C₄-C₆ dicarboxylic acid or anhydride thereof, an oligomer, and one monoethylenically unsaturated compound.

Günther et al., U.S. Patent No. 6,284,716, discloses a lubricating oil composition comprising a lubricant oil and a copolymer obtained by free radical copolymerization
20 of at least one monoethylenically unsaturated C₄-C₆ dicarboxylic acid or anhydride thereof, an oligomer, and one monoethylenically unsaturated compound, wherein the copolymer is further reacted with an amine.

Harrison et al., U.S. Patent No. 5,792,729, discloses a dispersant terpolymer and
25 polysuccinimide compositions derived from the terpolymers. The terpolymer is obtained by free radical copolymerization of an unsaturated acidic reagent, a 1-olefin, and a 1,1-disubstituted olefin in the presence of a free radical initiator.

Barr et al., U.S. Patent No. 5,670,462, discloses a lubricating oil additive composition
30 that is the reaction product of (i) a copolymerized olefin and unsaturated carboxylic acylating agent monomer with a free radical initiator and (ii) a succinimide prepared from an acyclic hydrocarbyl substituted succinic acylating agent and a polyamine wherein the hydrocarbyl substituted succinic acylating agent is prepared by reacting a

polyolefin and an acylating agent under conditions such that at least 75 mole % of the starting polyolefin is converted to the hydrocarbyl-substituted succinic acylating agent.

- 5 Harrison et al., U.S. Patent No. 6,451,920, discloses copolymerizing a polyalkene and an unsaturated acidic reagent, followed by reacting any unreacted polyalkene with the unsaturated acidic reagent at elevated temperatures in the presence of a strong acid.

- 10 Chung et al., U.S. Patent Nos. 5,427,702 and 5,744,429, disclose a mixture of derivatized ethylene-alpha olefin copolymers, wherein functional groups are grafted onto the copolymer. The functionalized copolymer is mixed with at least one of an amine, alcohol, including polyol, amino alcohol etc. to form multi-functional viscosity index improver additive components.

- 15 Harrison et al., U.S. Patent No. 5,112,507, discloses novel copolymers of unsaturated acidic reactants and high molecular weight olefins wherein at least 20% of the total high molecular weight olefin comprises the alkylvinylidene isomer which copolymers are useful as dispersants in lubricating oils and fuels and also may be used to prepare polysuccinimides and other post-treated additives useful in lubricating oils and fuels.

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SUMMARY OF THE INVENTION

In its broadest embodiment, the present invention is directed to a lubricating oil additive composition comprising:

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- I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting

(A) at least one of the following copolymers:

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- (i) a copolymer obtained by free radical copolymerization of components comprising:

15

- (a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;

20

- (b) at least one 1-olefin comprising about 2 to 40 carbon atoms or at least one polyolefin comprising about 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and

25

- (c) at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:

30

- (1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy

substituted or is unsubstituted, and
containing 1 to 40 carbon atoms;

5

- (2) an alkyl amine and an N-alkylamide of a
monoethylenically unsaturated mono- or
dicarboxylic acid of 3 to 10 carbon
atoms where the alkyl substituent
contains 1 to 40 carbon atoms;

10

- (3) an N-vinylcarboxamide of carboxylic
acids of 1 to 8 carbon atoms;

15

- (4) an N-vinyl substituted
nitrogen-containing heterocyclic
compound; and

20

- (5) at least one 1-olefin comprising about
2 to 40 carbon atoms or at least one
polyolefin comprising about 4 to about
360 carbon atoms and having a terminal
copolymerizable group in the form of a
vinyl, vinylidene or alkyl vinylidene
group or mixtures thereof, provided that
the olefin employed is not the same as
the olefin employed in (i)(b);

25

- (ii) a copolymer obtained by reacting compound (i)(a) and
compound(i)(b) in the presence of a free radical
initiator;

30

with

- (B) at least one ether compound selected from the group consisting of an ether polyamine, a polyether polyamine, a polyether amino alcohol, a polyether amino thiol, and a polyether polyol; and

5

- (C) at least one aromatic amine and

- II. at least one ashless dispersant other than the lubricating oil additive of I.

10

In another embodiment, the present invention is directed to a lubricating oil composition comprising a major amount of an oil of lubricating viscosity and a minor amount of a lubricating oil additive composition comprising:

- 15 I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting

- (A) at least one of the following copolymers:

- 20 (i) a copolymer obtained by free radical copolymerization of components comprising:

- 25 (a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;

- 30 (b) at least one 1-olefin comprising about 2 to 40 carbon atoms or at least one polyolefin comprising about 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and

- 5
- (c) at least one monoolefin compound which is
copolymerizable with the monomers of (a) and
(b) and is selected from the group consisting of:
- 10
- (1) an alkyl vinyl ether and an allyl alkyl
ether where the alkyl group is hydroxyl,
amino, dialkylamino or alkoxy
substituted or is unsubstituted, and
containing 1 to 40 carbon atoms;
- 15
- (2) an alkyl amine and an N-alkylamide of a
monoethylenically unsaturated mono- or
dicarboxylic acid of 3 to 10 carbon
atoms where the alkyl substituent
contains 1 to 40 carbon atoms;
- 20
- (3) an N-vinylcarboxamide of carboxylic
acids of 1 to 8 carbon atoms;
- (4) an N-vinyl substituted
nitrogen-containing heterocyclic
compound; and
- 25
- (5) at least one 1-olefin comprising about
2 to 40 carbon atoms or at least one
polyolefin comprising about 4 to about
360 carbon atoms and having a terminal
copolymerizable group in the form of a
vinyl, vinylidene or alkyl vinylidene
group or mixtures thereof, provided that
the olefin employed is not the same as
the olefin employed in (i)(b);
- 30

- (ii) a copolymer obtained by reacting compound (i)(a) and compound(i)(b) in the presence of a free radical initiator;

5

with

- (B) at least one ether compound selected from the group consisting of an ether polyamine, a polyether polyamine, a polyether amino alcohol, a polyether amino thiol, and a polyether polyol; and

10

- (C) at least one aromatic amine and

15

- II. at least one ashless dispersant other than the lubricating oil additive of I.

In another embodiment, the present invention is directed to a method of making a lubricating oil additive composition comprising mixing

20 a lubricating oil additive composition comprising:

- I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting

25

- (A) at least one of the following copolymers:

- (i) a copolymer obtained by free radical copolymerization of components comprising:

30

- (a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;

- 5 (b) at least one 1-olefin comprising about
2 to 40 carbon atoms or at least one polyolefin
comprising about 4 to 360 carbon atoms and
having a terminal copolymerizable group in the
form of a vinyl, vinylidene or alkyl vinylidene
group or mixtures thereof; and
- 10 (c) at least one monoolefin compound which is
copolymerizable with the monomers of (a) and
(b) and is selected from the group consisting of:
- 15 (1) an alkyl vinyl ether and an allyl alkyl
ether where the alkyl group is hydroxyl,
amino, dialkylamino or alkoxy
substituted or is unsubstituted, and
containing 1 to 40 carbon atoms;
- 20 (2) an alkyl amine and an N-alkylamide of a
monoethylenically unsaturated mono- or
dicarboxylic acid of 3 to 10 carbon
atoms where the alkyl substituent
contains 1 to 40 carbon atoms;
- 25 (3) an N-vinylcarboxamide of carboxylic
acids of 1 to 8 carbon atoms;
- 30 (4) an N-vinyl substituted
nitrogen-containing heterocyclic
compound; and
- (5) at least one 1-olefin comprising about
2 to 40 carbon atoms or at least one

5 polyolefin comprising about 4 to about
360 carbon atoms and having a terminal
copolymerizable group in the form of a
vinyl, vinylidene or alkyl vinylidene
group or mixtures thereof, provided that
the olefin employed is not the same as
the olefin employed in (i)(b);

10 (ii) a copolymer obtained by reacting compound (i)(a) and
compound(i)(b) in the presence of a free radical
initiator;

with

15 (B) at least one ether compound selected from the group consisting
of an ether polyamine, a polyether polyamine, a polyether
amino alcohol, a polyether amino thiol, and a polyether polyol;
and

20 (C) at least one aromatic amine and

II. at least one ashless dispersant other than the lubricating oil additive of
I.

In another embodiment, the present invention is directed to a method of improving soot dispersancy in an internal combustion engine which comprises operating the engine with a lubricating oil composition comprising a major amount of oil of lubricating viscosity and an effective amount of the lubricating oil additive
 5 composition comprising:

I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting

10 (A) at least one of the following copolymers:

(i) a copolymer obtained by free radical copolymerization of components comprising:

15 (a) at least one monoethylenically unsaturated C_3 - C_{28} monocarboxylic acid or ester thereof, or C_4 - C_{28} dicarboxylic acid, anhydride or ester thereof;

20 (b) at least one 1-olefin comprising about 2 to 40 carbon atoms or at least one polyolefin comprising about 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene
 25 group or mixtures thereof; and

(c) at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:

30

(1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy

substituted or is unsubstituted, and
containing 1 to 40 carbon atoms;

5

- (2) an alkyl amine and an N-alkylamide of a
monoethylenically unsaturated mono- or
dicarboxylic acid of 3 to 10 carbon
atoms where the alkyl substituent
contains 1 to 40 carbon atoms;

10

- (3) an N-vinylcarboxamide of carboxylic
acids of 1 to 8 carbon atoms;

15

- (4) an N-vinyl substituted
nitrogen-containing heterocyclic
compound; and

20

- (5) at least one 1-olefin comprising about
2 to 40 carbon atoms or at least one
polyolefin comprising about 4 to about
360 carbon atoms and having a terminal
copolymerizable group in the form of a
vinyl, vinylidene or alkyl vinylidene
group or mixtures thereof, provided that
the olefin employed is not the same as
the olefin employed in (i)(b);

25

- (ii) a copolymer obtained by reacting compound (i)(a) and
compound(i)(b) in the presence of a free radical
initiator;

30

with

(B) at least one ether compound selected from the group consisting of an ether polyamine, a polyether polyamine, a polyether amino alcohol, a polyether amino thiol, and a polyether polyol; and

5 (C) at least one aromatic amine and

II. at least one ashless dispersant other than the lubricating oil additive of I.

Accordingly, the present invention relates to multi-functional lubricating oil additive compositions and lubricating oil compositions which are useful as dispersants in an
10 internal combustion engine.

According to another aspect, there is provided a lubricating oil additive composition comprising:

I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting

15 (A) at least one of the following copolymers:

(i) a copolymer obtained by free radical copolymerization of components comprising:

(a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;
20

(b) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and
25

(c) at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:
30

- 5
- (1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy substituted or is unsubstituted, and containing 1 to 40 carbon atoms;
- 10
- (2) an alkyl amine and an N-alkylamide of a monoethylenically unsaturated mono- or dicarboxylic acid of 3 to 10 carbon atoms where the alkyl substituent contains 1 to 40 carbon atoms;
- (3) an N-vinylcarboxamide of carboxylic acids of 1 to 8 carbon atoms;
- 15
- (4) an N-vinyl substituted nitrogen-containing heterocyclic compound; and
- (5) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof, provided that the olefin employed is not the same as the olefin employed in (i)(b);
- 20
- 25
- (ii) a copolymer obtained by reacting compound (i)(a) and compound(i)(b) in the presence of a free radical initiator; or
- 30
- (iii) a copolymer obtained by (a) reacting compound (i)(a) with compound (i)(b) or (i)(c) in a non-free radical catalyzed reaction in the presence of copolymer (i) or copolymer (ii) or both; or by (b) contacting copolymer (i) or copolymer (ii) or both with the non-free radical

catalyzed reaction product of compound (i)(a) and
compound (i)(b) or (i)(c);

with

5 (B) at least one ether compound selected from the group consisting
of an ether polyamine, a polyether polyamine, a polyether
amino alcohol, a polyether amino thiol, and a polyether polyol;
and

(C) at least one aromatic amine and

10 II. at least two ashless dispersants other than the lubricating oil additive of
I.

According to a further aspect, there is provided a lubricating oil composition
comprising a major amount of an oil of lubricating viscosity and a minor amount of a
lubricating oil additive composition comprising:

15 I. an oil-soluble lubricating oil additive prepared by the process which
comprises reacting

(A) at least one of the following copolymers:

(i) a copolymer obtained by free radical copolymerization
of components comprising:
20 (a) at least one monoethylenically unsaturated
C₃-C₂₈ monocarboxylic acid or ester thereof, or
C₄-C₂₈ dicarboxylic acid, anhydride or ester
thereof;
25 (b) at least one 1-olefin comprising 2 to 40 carbon
atoms or at least one polyolefin comprising 4 to
360 carbon atoms and having a terminal
copolymerizable group in the form of a vinyl,
vinylidene or alkyl vinylidene group or mixtures
thereof; and
30 (c) at least one monoolefin compound which is
copolymerizable with the monomers of (a) and
(b) and is selected from the group consisting of:

- 5
- (1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy substituted or is unsubstituted, and containing 1 to 40 carbon atoms;
- 10
- (2) an alkyl amine and an N-alkylamide of a monoethylenically unsaturated mono- or dicarboxylic acid of 3 to 10 carbon atoms where the alkyl substituent contains 1 to 40 carbon atoms;
- (3) an N-vinylcarboxamide of carboxylic acids of 1 to 8 carbon atoms;
- 15
- (4) an N-vinyl substituted nitrogen-containing heterocyclic compound; and
- (5) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal
- 20
- copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof, provided that the olefin employed is not the same as the olefin employed in (i)(b);
- 25
- (ii) a copolymer obtained by reacting compound (i)(a) and compound(i)(b) in the presence of a free radical initiator; or
- (iii) a copolymer obtained by (a) reacting compound (i)(a) with compound (i)(b) or (i)(c) in a non-free radical
- 30
- catalyzed reaction in the presence of copolymer (i) or copolymer (ii) or both; or by (b) contacting copolymer (i) or copolymer (ii) or both with the non-free radical catalyzed reaction product of compound (i)(a) and compound (i)(b) or (i)(c);

with

- 5 (B) at least one ether compound selected from the group consisting of an ether polyamine, a polyether polyamine, a polyether amino alcohol, a polyether amino thiol, and a polyether polyol; and

(C) at least one aromatic amine and

- II. at least two ashless dispersants other than the lubricating oil additive of I.

10 According to another aspect, there is provided a method of making a lubricating oil additive composition comprising mixing

- I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting

(A) at least one of the following copolymers:

- 15 (i) a copolymer obtained by free radical copolymerization of components comprising:

- 20 (a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;
- (b) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and
- 25

- (c) at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:

- 30 (1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy

- substituted or is unsubstituted, and
containing 1 to 40 carbon atoms;
- 5 (2) an alkyl amine and an N-alkylamide of a
monoethylenically unsaturated mono- or
dicarboxylic acid of 3 to 10 carbon
atoms where the alkyl substituent
contains 1 to 40 carbon atoms;
- (3) an N-vinylcarboxamide of carboxylic
acids of 1 to 8 carbon atoms;
- 10 (4) an N-vinyl substituted
nitrogen-containing heterocyclic
compound; and
- (5) at least one 1-olefin comprising 2 to
40 carbon atoms or at least one
15 polyolefin comprising 4 to 360 carbon
atoms and having a terminal
copolymerizable group in the form of a
vinyl, vinylidene or alkyl vinylidene
group or mixtures thereof, provided that
20 the olefin employed is not the same as
the olefin employed in (i)(b);
- (ii) a copolymer obtained by reacting compound (i)(a) and
compound (i)(b) in the presence of a free radical
initiator; or
- 25 (iii) a copolymer obtained by (a) reacting compound (i)(a)
with compound (i)(b) or (i)(c) in a non-free radical
catalyzed reaction in the presence of copolymer (i) or
copolymer (ii) or both; or by (b) contacting copolymer
(i) or copolymer (ii) or both with the non-free radical
30 catalyzed reaction product of compound (i)(a) and
compound (i)(b) or (i)(c);
- with
- (B) at least one ether compound selected from the group consisting
of an ether polyamine, a polyether polyamine, a polyether

amino alcohol, a polyether amino thiol, and a polyether polyol;
and

(C) at least one aromatic amine and

II. at least two ashless dispersants other than the lubricating oil additive of

5

I.

DETAILED DESCRIPTION OF THE INVENTION

While the invention is susceptible to various modifications and alternative forms,
specific embodiments thereof and are herein described in detail. It should be
understood, however, that the description herein of specific embodiments is not
10 intended to limit the invention to the particular forms disclosed, but on the contrary,
the intention is to cover all modifications, equivalents, and alternatives falling within
the scope of the invention as defined by the appended claims.

Definitions

The following terms used with the description are defined as such:

15 The term "PIB" is an abbreviation for polyisobutene.

The term "PIBSA" is an abbreviation for polyisobutenyl succinic anhydride.

The term "degree of polymerization" refers to the average number of repeating structural units in the polymer chain.

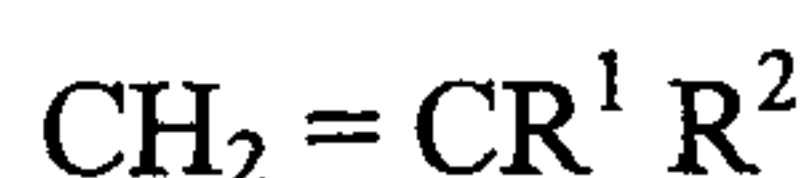
The term "terpolymer" refers to a polymer derived from the free radical
5 copolymerization of at least 3 monomers.

The term "1-olefin" refers to a monounsaturated olefin that has the double bond in the 1-position. They can also be called alpha-olefins, and have the following structure:



where R is the rest of the olefin molecule.

The term "1,1-disubstituted olefin" refers to a disubstituted olefin, also called a
15 vinylidene olefin, that has the following structure:

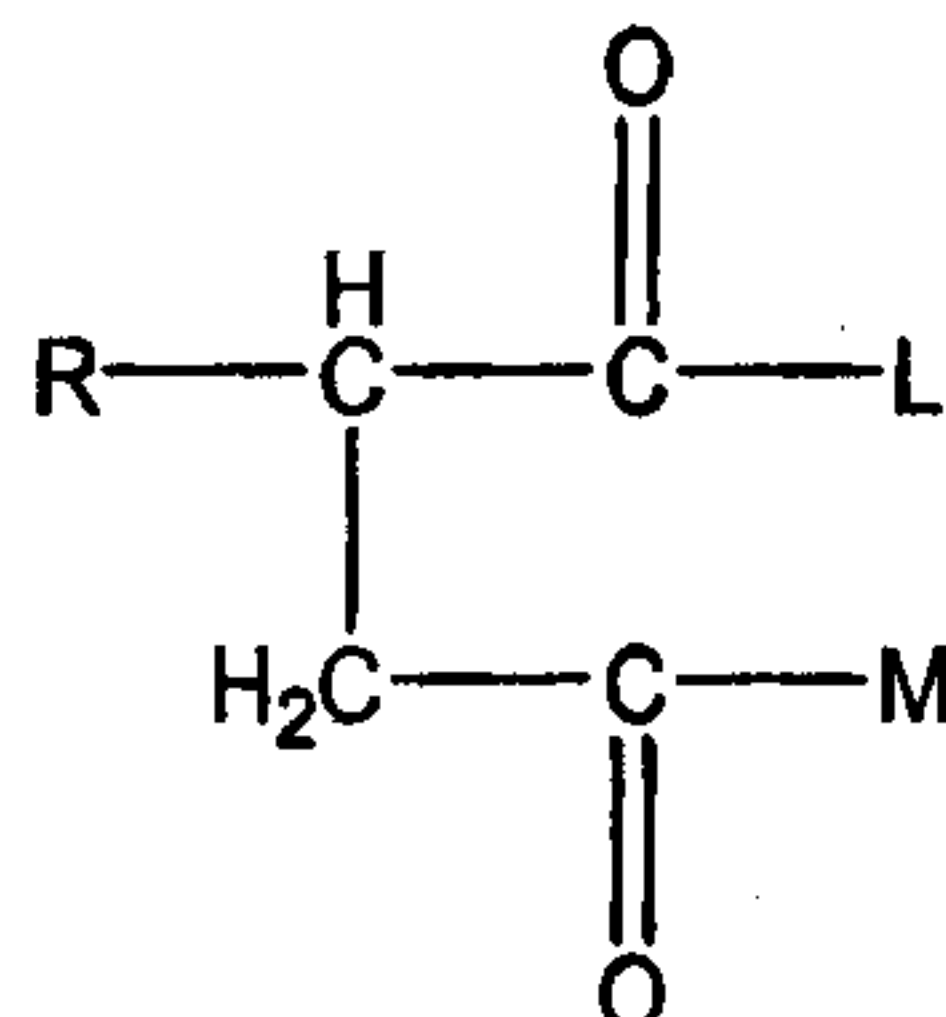


where R^1 and R^2 are the same or different, and constitute the rest of the olefin
20 molecule. Preferably, either R^1 or R^2 is a methyl group, and the other is not.

The term "succinimide" is understood in the art to include many of the amide, imide, etc. species which are also formed by the reaction of a succinic anhydride with an amine. The predominant product, however, is succinimide and this term has been
25 generally accepted as meaning the product of a reaction of an alkenyl- or alkyl-substituted succinic acid or anhydride with an amine. Alkenyl or alkyl succinimides are disclosed in numerous references and are well known in the art. Certain fundamental types of succinimides and related materials encompassed by the term of art "succinimide" are taught in U.S. Patent Nos. 2,992,708; 3,018,291;
30 3,024,237; 3,100,673; 3,219,666; 3,172,892; and 3,272,746.

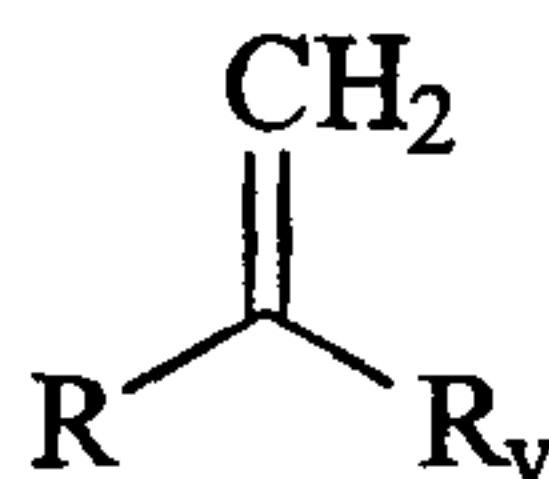
The term "polysuccinimide" refers to the reaction product of a succinic group-containing copolymer with an amine.

5 The term "alkenyl or alkylsuccinic acid derivative" refers to a structure having the formula:



10 wherein L and M are independently selected from the group consisting of --OH, --Cl, --O--, lower alkyl or taken together are --O-- to form an alkenyl or alkylsuccinic anhydride group.

15 The term "alkylvinylidene" or "alkylvinylidene isomer" refers to high molecular weight olefins and polyalkylene components having the following vinylidene structure:



20 wherein R is alkyl or substituted alkyl of sufficient chain length to give the resulting molecule solubility in lubricating oils and fuels, thus R generally has at least about 30 carbon atoms, preferably at least about 50 carbon atoms and R_v is lower alkyl of about 1 to about 6 carbon atoms.

25 The term "soluble in lubricating oil" refers to the ability of a material to dissolve in aliphatic and aromatic hydrocarbons such as lubricating oils or fuels in essentially all proportions.

The term "high molecular weight olefins" refers to olefins (including polymerized olefins having a residual unsaturation) of sufficient molecular weight and chain length to lend solubility in lubricating oil to their reaction products. Typically olefins having about 30 carbons or more suffice.

5

The term "high molecular weight polyalkyl" refers to polyalkyl groups of sufficient molecular weight such that the products prepared having such sufficient molecular weight are soluble in lubricating oil. Typically these high molecular weight polyalkyl groups have at least about 30 carbon atoms, preferably at least about 50 carbon atoms.

10 These high molecular weight polyalkyl groups may be derived from high molecular weight polyolefins.

The term "amino" refers to $-NR_1R_2$ wherein R_1 and R_2 are independently hydrogen or a hydrocarbyl group.

15

The term "alkyl" refers to both straight- and branched-chain alkyl groups.

The term "lower alkyl" refers to alkyl groups having 1 to about 6 carbon atoms and includes primary, secondary and tertiary alkyl groups. Typical lower alkyl groups
20 include, for example, methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, t-butyl, n-pentyl, n-hexyl and the like.

The term "polyalkyl" refers to an alkyl group that is generally derived from polyolefins which are polymers or copolymers of mono-olefins, particularly
25 1-mono-olefins, such as ethylene, propylene, butylene, and the like. Preferably, the mono-olefin employed will have 2 to about 24 carbon atoms, and more preferably, about 3 to 12 carbon atoms. More preferred mono-olefins include propylene, butylene, particularly isobutylene, 1-octene and 1-decene. Preferred, polyolefins prepared from such mono-olefins include polypropylene, polybutene, especially
30 polyisobutene.

The Lubricating Oil Additive Composition

One embodiment of the present invention is a lubricating oil additive composition comprising

5

(I) an oil-soluble lubricating oil additive prepared by the process which comprises reacting

(A) at least one of the following copolymers:

10

(i) a copolymer obtained by free radical copolymerization of components comprising:

15

(a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;

20

(b) at least one 1-olefin comprising about 2 to 40 carbon atoms or at least one polyolefin comprising about 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and

25

(c) at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:

30

(1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy substituted or is unsubstituted, and containing 1 to 40 carbon atoms;

- 5 (2) an alkyl amine and an N-alkylamide of a
monoethylenically unsaturated mono- or
dicarboxylic acid of 3 to 10 carbon atoms where
the alkyl substituent contains 1 to 40 carbon
atoms;
- 10 (3) an N-vinylcarboxamide of carboxylic acids of
1 to 8 carbon atoms;
- (4) an N-vinyl substituted nitrogen-containing
heterocyclic compound; and
- 15 (5) at least one 1-olefin comprising about
2 to 40 carbon atoms or at least one polyolefin
comprising about 4 to about 360 carbon atoms
and having a terminal copolymerizable group in
the form of a vinyl, vinylidene or alkyl
vinylidene group or mixtures thereof, provided
20 that the olefin employed is not the same as the
olefin employed in (i)(b);
- (ii) a copolymer obtained by reacting compound (i)(a) and
compound(i)(b) in the presence of a free radical initiator;
- 25 (iii) a copolymer obtained by (a) reacting compound (i)(a) with
compound (i)(b) or (i)(c) in a non-free radical catalyzed
reaction in the presence of copolymer (i) or copolymer (ii) or
both; or by (b) contacting copolymer (i) or copolymer (ii) or
30 both with the non-free radical catalyzed reaction product of
compound (i)(a) and compound (i)(b) or (i)(c); with

(B) at least one ether compound selected from the group consisting of an ether polyamine, a polyether polyamine, a polyether amino alcohol, a polyether amino thiol, and a polyether polyol; and

5 (C) at least one aromatic amine; and,

(II) at least one ashless dispersant other than the lubricating oil additive of I.

10 I. The Oil-Soluble Lubricating Oil Additive

Component I of the oil-soluble lubricating oil additive composition employed in the present invention is prepared by reacting at least one of copolymers (i), (ii) and (iii) with at least one ether compound and at least one aromatic amine.

15

Copolymer (i)

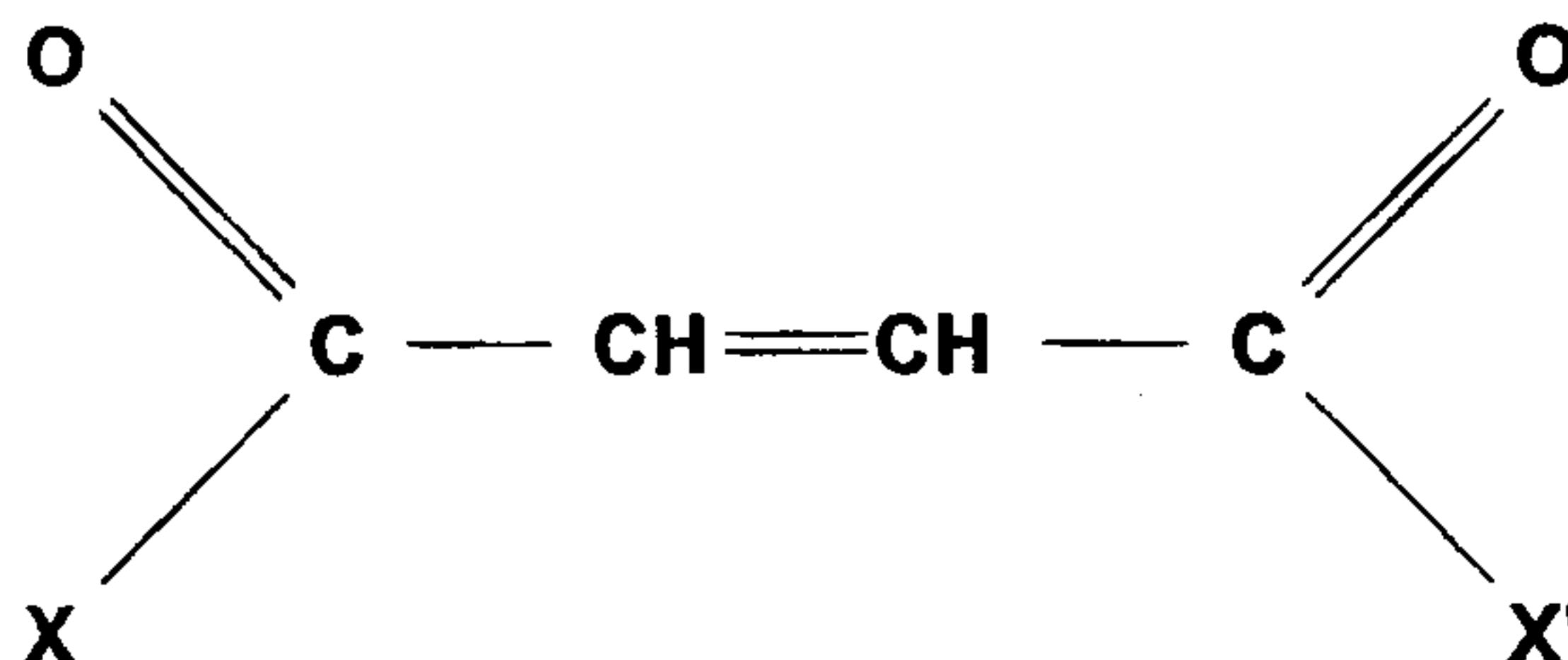
(a) The Monoethylenically Unsaturated Monocarboxylic Acid or Ester Thereof or Dicarboxylic Acid, Anhydride or Ester Thereof

20

In the present invention, at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof is used to prepare the copolymers of copolymer (i). Preferably the at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof is a dicarboxylic acid, anhydride or ester thereof.

25

The general formula of the preferred dicarboxylic acid, anhydride or ester thereof is as follows:



5

wherein X and X' are the same or different, provided that at least one of X and X' is a group that is capable of reacting to esterify alcohols, form amides or amine salts with ammonia or amines, form metal salts with reactive metals or basically reacting metal compounds and otherwise function as acylating agents. Typically, X and/or X' is

10 --OH, --O-hydrocarbyl, OM⁺ where M⁺ represents one equivalent of a metal, ammonium or amine cation, --NH₂, --Cl, --Br, and taken together X and X' can be --O-- so as to form an anhydride. Preferably X and X' are such that both carboxylic functions can enter into acylation reactions. Maleic anhydride is a preferred reactant. Other suitable reactants include electron-deficient olefins such as monophenyl maleic

15 anhydride; monomethyl, dimethyl, monochloro, monobromo, monofluoro, dichloro and difluoro maleic anhydride; N-phenylmaleimide and other substituted maleimides, isomaleimides; fumaric acid, maleic acid, alkyl hydrogen maleates and fumarates, dialkyl fumarates and maleates, fumaronilic acids and maleanic acids; and maleonitrile and fumaronitrile.

20

Suitable monomers for (a) are monoethylenically unsaturated dicarboxylic acids or anhydrides of 4 to 28 carbon atoms selected from the group comprising maleic acid, fumaric acid, itaconic acid, mesaconic acid, methylenemalonic acid, citraconic acid, maleic anhydride, itaconic anhydride, citraconic anhydride and methylenemalonic

25 anhydride and mixtures of these with one another, among which maleic anhydride is preferred.

Other suitable monomers are monoethylenically unsaturated C₃-C₂₈-monocarboxylic acids selected from the group comprising acrylic acid, methacrylic acid, dimethacrylic

acid, ethylacrylic acid, crotonic acid, allylacetic acid and vinylacetic acid, among which acrylic and methacrylic acid are preferred. Another group of suitable monomers is C_1 - C_{40} alkyl esters of monoethylenecially unsaturated C_3 - C_{10} mono- or dicarboxylic acids such as ethyl acrylate, butyl acrylate, 2-ethyl acrylate, decyl acrylate, dodecyl acrylate, octadecyl acrylate and the esters of industrial alcohol mixtures of 14 to 28 carbon atoms, ethyl methacrylate, 2-ethylhexyl methacrylate, decyl methacrylate, octadecyl methacrylate, monobutyl maleate, dibutyl maleate, monodecyl maleate, didodecyl maleate, monooctadecyl maleate, and dioctadecyl maleate.

10

(b) The 1-Olefin or Polyolefin

In the present invention at least one 1-olefin comprising about 2 to 40 carbon atoms or at least one polyolefin comprising about 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of vinyl, vinylidene or alkyl vinylidene group is employed.

Suitable 1-olefins for preparing copolymer (i) comprise about 2 to 40 carbon atoms, preferably 6 to 30 carbon atoms, such as decene, dodecene, octadecene and mixtures of C_{20} - C_{24} 1-olefins and C_{24} - C_{28} 1-olefins, more preferably 10 to 20 carbon atoms. Preferably 1-olefins, which are also known as alpha olefins, with molecular weights in the range 100-4,500 or more are preferred, with molecular weights in the range of 200-2,000 being more preferred. For example, alpha olefins obtained from the thermal cracking of paraffin wax. Generally, these olefins range from 5 to 20 carbon atoms in length. Another source of alpha olefins is the ethylene growth process which gives even number carbon olefins. Another source of olefins is by the dimerization of alpha olefins over an appropriate catalyst such as the well known Ziegler catalyst. Internal olefins are easily obtained by the isomerization of alpha olefins over a suitable catalyst such as silica. Preferably, 1-olefins from C_6 - C_{30} are used because these materials are commercially readily available, and because they offer a desirable balance of the length of the molecular tail, and the solubility of the terpolymer in nonpolar solvents. Mixtures of olefins may also be employed.

Suitable polyolefins for preparing copolymer (i) are polyolefins comprising about 4 to about 360 carbon atoms. These polymers have an average molecular weight (M_n) of from about 56 to about 5000 g/mol. Examples of these are oligomers of ethylene, of butene, including isobutene, and of branched isomers of pentene, hexene, octene and decene, the copolymerizable terminal group of the oligomer being present in the form of a vinyl, vinylidene or alkylvinylidene group, oligopropenes and oligopropene mixtures of 9 to 200 carbon atoms and in particular oligoisobutenes, as obtainable, for example, according to DE-A 27 02 604, corresponding U.S. Patent No. 4,152,499, are preferred. Mixtures of the stated oligomers are also suitable, for example, mixtures of ethylene and other alpha olefins. Other suitable polyolefins are described in U.S. Patent No. 6,030,930 which is herein incorporated by reference. The molecular weights of the oligomers may be determined in a conventional manner by gel permeation chromatography.

- 15 The copolymerizable polyolefin that is reacted with the unsaturated mono- or di-carboxylic reactant are polymers comprising a major amount of C_2 - C_8 mono-olefin, e.g., ethylene, propylene, butylene, isobutylene and pentene. These polymers can be homopolymers such as polyisobutylene as well as copolymers of 2 or more such olefins such as copolymers of: ethylene and propylene, butylene, and isobutylene, etc.
- 20 Other copolymers include those in which a minor amount of the copolymer monomers, e.g., 1 to 20 mole % is a C_4 - C_8 nonconjugated diolefin, e.g., a copolymer of isobutylene and butadiene or a copolymer of ethylene, propylene and 1,4-hexadiene, etc.
- 25 The polyolefin polymer usually contains from about 4 to 360 carbon atoms, although preferably 8 to 200 carbon atoms; and more preferably 12 to 175 carbon atoms.

Since the high molecular weight olefins used to prepare the copolymers of the present invention are generally mixtures of individual molecules of different molecular weights, individual copolymer molecules resulting will generally contain a mixture of high molecular weight polyalkyl groups of varying molecular weight. Also, mixtures of copolymer molecules having different degrees of polymerization will be produced.

The copolymers of the present invention have an average degree of polymerization of 1 or greater, preferably from about 1.1 to about 20, and more preferably from about 1.5 to about 10.

5 (c) The Mono-Olefin Compound

The present invention employs at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:

10

(1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy substituted or is unsubstituted, and containing 1 to 40 carbon atoms;

15

(2) an alkyl amine and an N-alkylamide of a monoethylenically unsaturated mono- or dicarboxylic acid of 3 to 10 carbon atoms where the alkyl substituent contains 1 to 40 carbon atoms;

(3) an N-vinylcarboxamide of carboxylic acids of 1 to 8 carbon atoms;

20

(4) an N-vinyl substituted nitrogen-containing heterocyclic compound; and

(5) at least one 1-olefin comprising about 2 to 40 carbon atoms or at least one polyolefin comprising about 4 to about 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof, provided that the olefin employed is not the same as the olefin employed in (i)(b);

25

(1) Suitable monomers include the following: vinyl and allyl alkyl ethers where the alkyl radical is of 1 to 40 carbon atoms are also suitable, and the alkyl radical may carry further substituents, such as hydroxyl, amino, dialkylamino or alkoxy. Examples are methyl vinyl ether, ethyl vinyl ether, propyl vinyl ether, isobutyl vinyl ether, 2-ethylhexyl vinyl

30

ether, decylvinyl ether, dodecyl vinyl ether, octadecyl vinyl ether, 2-(diethylamino)ethyl vinyl ether, 2-(di-n-butylamino)ethyl vinyl ether, and the corresponding allyl ethers.

- 5 (2) Another group of monomers comprises C_1 - C_{40} alkyl amines and C_1 - C_{40} -N- alkylamides of monoethylenically unsaturated C_3 - C_{10} -mono- or dicarboxylic acids, such as dimethylaminoethyl acrylate, diethylaminoethyl acrylate, dibutylaminoethyl methacrylate, acrylamide, methacrylamide, N-tert-butylacrylamide,
10 N-octylacrylamide, N,N'-dibutylacrylamide, N-dodecylmethacrylamide and N-octadecylmethacrylamide.
- (3) Another group of monomers includes the following:
N-vinylcarboxamides of carboxylic acids of 1 to 8 carbon atoms, such
15 as N-vinylformamide, N-vinyl-N-methylformamide, N-vinylacetamide, N-vinyl-N-methylacetamide, N-vinyl-N-ethylacetamide, N-vinyl-N-methylpropionamide and N-vinylpropionamide.
- 20 (4) Another group of monomers includes the following: N-vinyl compounds of nitrogen-containing heterocycles, such as N-vinylimidazole, N-vinylmethylimidazole, N-vinylpyrrolidone and N-vinylcaprolactam.
- 25 (5) Suitable 1-olefins comprise about 2 to 40 carbon atoms, preferably 8 to 30 carbon atoms, such as decene, dodecene, octadecene and mixtures of C_{20} - C_{24} -1-olefins and C_{24} - C_{28} -1-olefins. Preferably 1-olefins, which are also known as alpha olefins, with molecular weights in the range of 28-560 are preferred, with molecular weights in
30 the range of 112-420 being more preferred. For example, alpha olefins obtained from the thermal cracking of paraffin wax may be employed. Generally, these olefins range from 5 to 20 carbon atoms in length. Another source of alpha olefins is the ethylene growth process which

gives even number carbon olefins. Another source of olefins is by the dimerization of alpha olefins over an appropriate catalyst such as the well known Ziegler catalyst. Internal olefins are easily obtained by the isomerization of alpha olefins over a suitable catalyst such as silica.

5 Preferably, 1-olefins from C₁₀-C₃₀ are used because these materials are commercially readily available, and because they offer a desirable balance of the length of the molecular tail, and the solubility of the terpolymer in nonpolar solvents. Mixtures of olefins are also suitable.

10 *Preparation of Copolymer (i)*

Copolymer reactant (i) may be prepared from well known methods which are described in the art including, but not limited to, those methods which are disclosed in the following patents: Harrison et al., U.S. Patent No. 5,792,729; Günther et al., U.S.
15 Patent No. 6,284,716; and Günther et al., U.S. Patent No. 6,512,055.

In one embodiment of the present invention the copolymer reactant is a polyalkenyl succinic anhydride terpolymer. These terpolymers are composed of at least one of
20 monomers (a) to (c) as described herein.

Typically, the terpolymers of this invention contain at least one of monomers (a) to (c) three components comprising of a monocarboxylic acid or ester thereof, or a dicarboxylic acid or anhydride or ester thereof; a branched olefin; and a monoolefin.
25 In general, these components react to form terpolymers which can be random terpolymers or alternating terpolymers or block terpolymers and can be prepared by known procedures for making copolymers. The monocarboxylic acid or ester thereof or dicarboxylic acid or anhydride or ester thereof is selected from those which were previously disclosed, preferably maleic anhydride.

30

The degree of polymerization of the terpolymers can vary over a wide range. In general, terpolymers of high molecular weight can be produced at low temperatures, and terpolymers of low molecular weight can be produced at high temperatures.

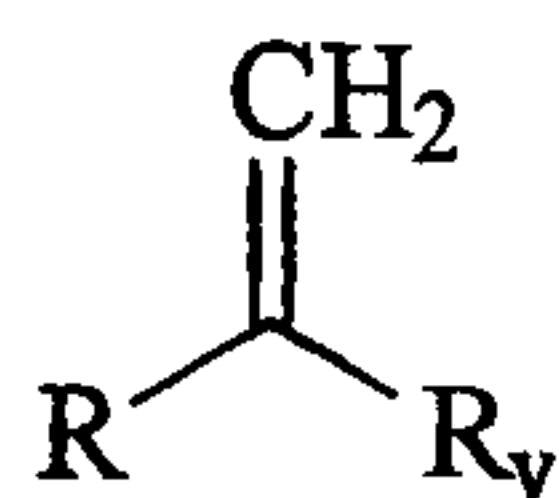
The terpolymerization is conducted in the presence of a suitable free radical initiator. Examples of suitable polymerization initiators are peroxide compounds, such as terybutyl perpivalate, terybutyl perneocecanoate, tery-butylperethylhexanoate, 5 tertbutylperisobutyrate, di-tert-butyl peroxide, di-tert-amyl peroxide, diacetyl peroxydicarbonate and dicyclohexyldicarbonate, or azo compounds, such as 2,2' -azobisisobutyronitrile. The initiators may be used alone or as a mixture with one another. Redox co-initiators may also be present. Preferably, the initiator is a peroxide type initiator, e.g., di(t-butyl) peroxide, dicumyl peroxide or azo type initiator, 10 e.g., isobutylnitrile type initiators. Procedures for preparing poly 1-olefin copolymers are, for example, described in U.S. Pat. Nos. 3,560,455 and 4,240,916. Those procedures could be used to prepare terpolymers. Both patents also describe a variety of initiators.

15 Copolymer (i), wherein a second olefin is employed in the reaction, can be prepared in the same manner as copolymer (ii) which is described below.

Copolymer (ii)

20 In another embodiment of the present invention, the copolymer reactant is a copolymer obtained by reacting (a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or a C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof and (b) at least one copolymerizable polymer composed of at least 3 olefin molecules of propene or of a branched 1-olefin of 4 to 10 carbon atoms, 25 having a number average molecular weight M_n of from about 112 to about 5000, and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group in the presence of a free radical initiator.

Thus, preferred copolymers of the present invention are prepared by reacting a "reactive" high molecular weight olefin in which a high proportion of unsaturation, at least about 20% is in the alkylvinylidene configuration, e.g.,



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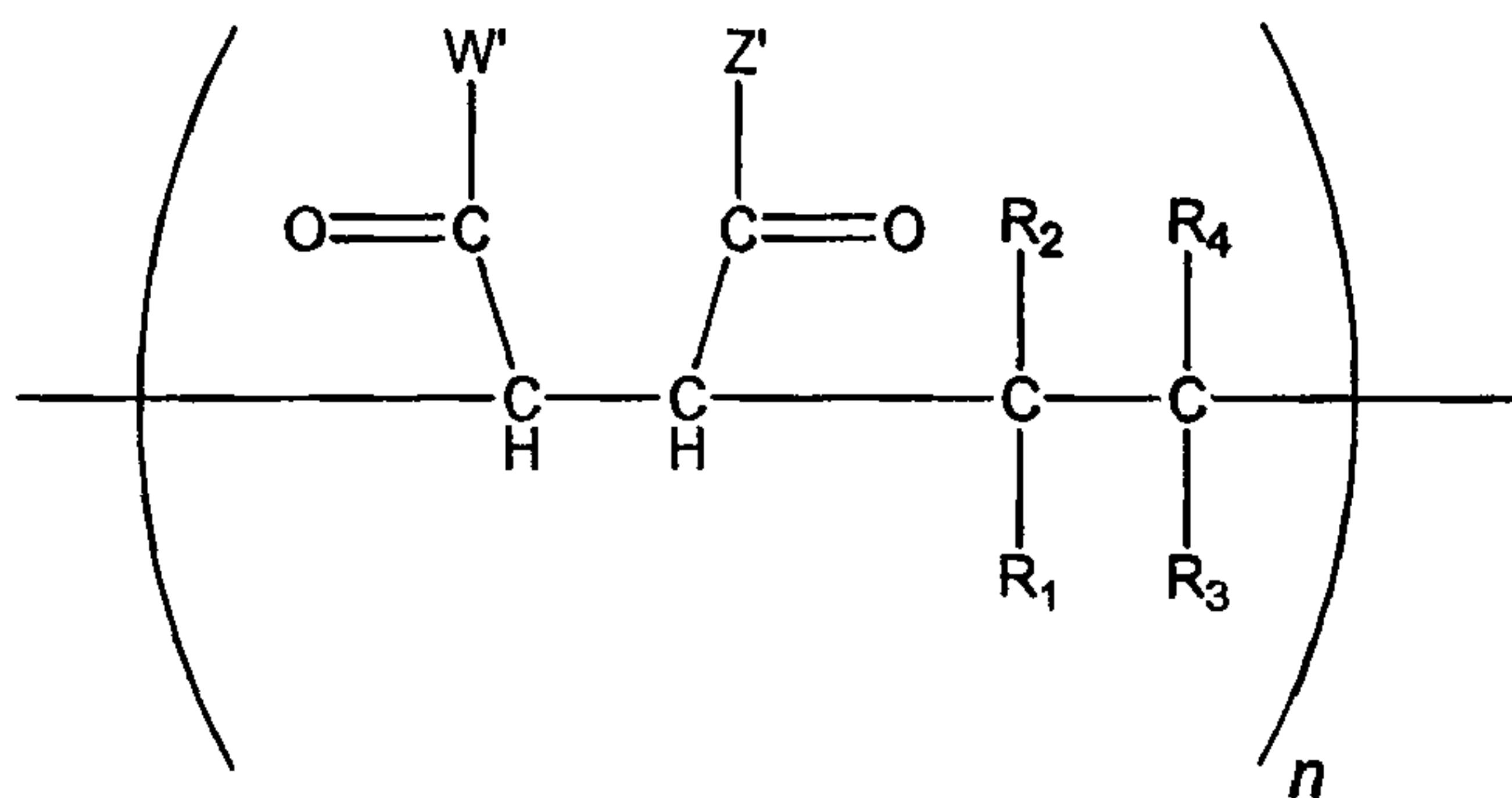
wherein R and R_v is an alkyl or substituted alkyl of sufficient chain length to give the resulting molecule stability in lubricating oils and fuels, thus R generally has at least about 30 carbon atoms, preferably at least about 50 carbon atoms and R_v is a lower alkyl of about 1 to about 6 carbon atoms, with an unsaturated acidic reactant in the presence of a free radical initiator.

10

The product copolymer has alternating polyalkylene and succinic groups and has an average degree of polymerization of 1 or greater.

15

The preferred copolymers (ii) of the present invention have the general formula:



20

wherein W' and Z' are independently selected from the group consisting of --OH, --O-- lower alkyl or taken together are --O-- to form a succinic anhydride group, n is one or greater; and R₁, R₂, R₃ and R₄ are selected from hydrogen, lower alkyl of 1 to 6 carbon atoms, and high molecular weight polyalkyl wherein either R₁ and R₂ are hydrogen and one of R₃ and R₄ is lower alkyl and the other is high molecular

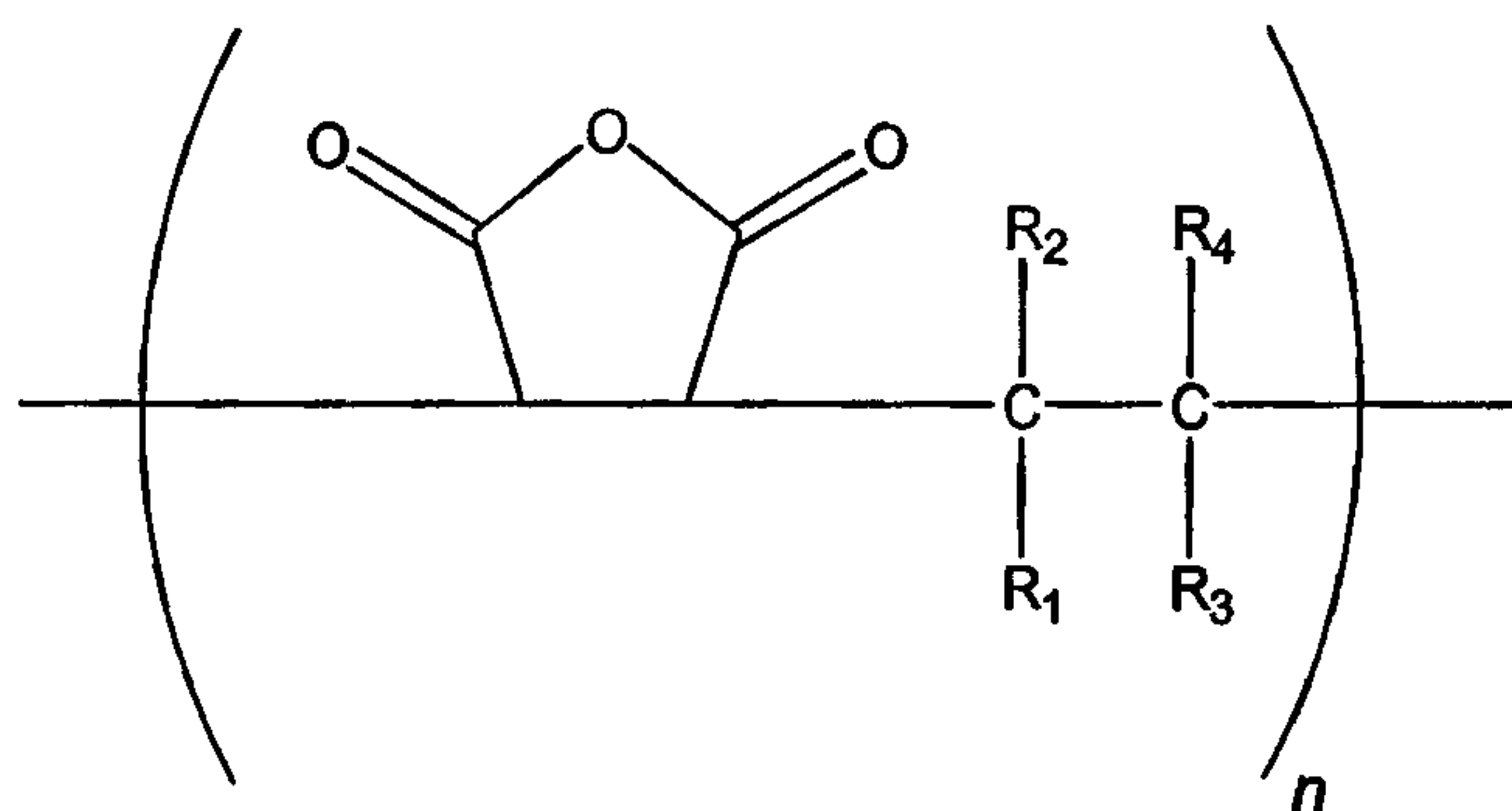
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weight polyalkyl, or R_3 and R_4 are hydrogen and one of R_1 and R_2 is lower alkyl and the other is high molecular weight polyalkyl.

Copolymer (ii) may be alternating, block, or random.

5

In a preferred embodiment, when maleic anhydride is used as the reactant, the reaction produces copolymers predominately of the following formula:



10

wherein n is about 1 to about 100, preferably about 2 to about 20, more preferably 2 to 10, and R_1 , R_2 , R_3 and R_4 are selected from hydrogen, lower alkyl of about 1 to 6 carbon atoms and higher molecular weight polyalkyl, wherein either R_1 and R_2 are hydrogen and one of R_3 and R_4 is lower alkyl and the other is high molecular weight polyalkyl or R_3 and R_4 are hydrogen and one of R_1 and R_2 is lower alkyl and the other is high molecular weight polyalkyl.

15

Preferably, the high molecular weight polyalkyl group has at least about 30 carbon atoms (preferably at least about 50 carbon atoms). Preferred high molecular weight polyalkyl groups include polyisobutyl groups. Preferred polyisobutyl groups include those having average molecular weights of about 500 to about 5000, more preferably from about 900 to about 2500. Preferred lower alkyl groups include methyl and ethyl; especially preferred lower alkyl groups include methyl.

20

A particularly preferred class of olefin polymers comprises the polybutenes, which are prepared by polymerization of isobutene. These polybutenes are readily available commercial materials well known to those skilled in the art. Disclosures thereof will

25

be found, for example, in U.S. Patent Nos. 4,152,499 and 4,605,808, of suitable polybutenes.

Preferably, 1,1-disubstituted olefins are used to provide a high molecular weight, oil
5 soluble tail in the terpolymer. Preferably the 1,1-disubstituted olefin has an average M_n of from 500 to 5000. One particularly useful 1,1-disubstituted olefin is a 1,1-disubstituted polyisobutylene, such as methylvinylidene polyisobutylene.

Preferably the copolymerizable polymer comprises a high molecular weight polyalkyl
10 group which is derived from a high molecular weight olefin. The high molecular weight olefins used in the preparation of the copolymers of the present invention are of sufficiently long chain length so that the resulting composition is soluble in and compatible with mineral oils, fuels and the like; and the alkylvinylidene isomer of the high molecular weight olefin comprises at least about 20% of the total olefin
15 composition.

Such high molecular weight olefins are generally mixtures of molecules having different molecular weights and can have at least one branch per 6 carbon atoms along the chain, preferably at least one branch per 4 carbon atoms along the chain, and
20 particularly preferred that there be about one branch per 2 carbon atoms along the chain. These branched chain olefins may conveniently comprise polyalkenes prepared by the polymerization of olefins of from 3 to 6 carbon atoms, and preferably from olefins of from 3 to 4 carbon atoms, and more preferably from propylene or isobutylene. The addition-polymerizable olefins employed are normally 1-olefins. The
25 branch may be of from 1 to 4 carbon atoms, more usually of from 1 to 2 carbon atoms and preferably methyl.

The preferred alkylvinylidene isomer comprises a methyl- or ethylvinylidene isomer, more preferably the methylvinylidene isomer.
30

The especially preferred high molecular weight olefins used to prepare the copolymers of the present invention are polyisobutenes which comprise at least about 20% of the more reactive methylvinylidene isomer, preferably at least 50% and more

preferably at least 70%. Suitable polyisobutenes include those prepared using BF_3 catalysis. The preparation of such polyisobutenes in which the methylvinylidene isomer comprises a high percentage of the total composition is described in U.S. Patent Nos. 4,152,499 and 4,605,808.

5

Preparation of Copolymer (ii)

As noted above, copolymer (ii) of the present invention is prepared by reacting an olefin and an unsaturated acidic reactant in the presence of a free radical initiator. The process of the preparation of copolymer (ii) is described in Harrison, U.S. Patent No. 5,112,507.

10

The reaction may be conducted at a temperature of about -30°C to about 210°C , preferably from about 40°C to about 160°C . The degree of polymerization is inversely proportional to temperature. Accordingly, for the preferred high molecular weight copolymers, it is advantageous to employ lower reaction temperatures. For example, if the reaction is conducted at about 138°C , an average degree of polymerization of about 1.3 was obtained. However, if the reaction was conducted at a temperature of about 40°C , an average degree of polymerization of about 10.5 was obtained.

15

20

The reaction may be conducted neat, that is, both the high molecular weight olefin, acidic reactant and the free radical initiator are combined in the proper ratio, and then stirred at the reaction temperature.

Alternatively, the reaction may be conducted in a diluent. For example, the reactants may be combined in a solvent. Suitable solvents include those in which the reactants and free radical initiator are soluble and include acetone, tetrahydrofuran, chloroform, methylene chloride, dichloroethane, toluene, dioxane, chlorobenzene, xylenes, or the like. After the reaction is complete, volatile components may be stripped off. When a diluent is employed, it is preferably inert to the reactants and products formed and is generally used in an amount sufficient to ensure efficient mixing.

25

30

In the preparation of polyPIBSA, improved results are obtained by using PIBSA or polyPIBSA as a solvent for the reaction.

In general, the copolymerization can be initiated by any free radical initiator. Such
5 initiators are well known in the art. However, the choice of free radical initiator may be influenced by the reaction temperature employed.

The preferred free-radical initiators are the peroxide-type polymerization initiators and the azo-type polymerization initiators. Radiation can also be used to initiate the
10 reaction, if desired.

The peroxide-type free-radical initiator can be organic or inorganic, the organic having the general formula: $R_3 OOR'_3$ where R_3 is any organic radical and R'_3 is selected from the group consisting of hydrogen and any organic radical. Both R_3 and
15 R'_3 can be organic radicals, preferably hydrocarbon, aroyl, and acyl radicals, carrying, if desired, substituents such as halogens, etc. Preferred peroxides include di-tert-butyl peroxide, dicumyl peroxide, and di-tert-amyl peroxide.

Examples of other suitable peroxides, which in no way are limiting, include benzoyl
20 peroxide; lauroyl peroxide; other tertiary butyl peroxides; 2,4-dichlorobenzoyl peroxide; tertiary butyl hydroperoxide; cumene hydroperoxide; diacetyl peroxide; acetyl hydroperoxide; diethylperoxycarbonate; tertiary butyl perbenzoate; and the like.

25 The azo-type compounds, typified by alpha,alpha'-azobisisobutyronitrile, are also well-known free-radical promoting materials. These azo compounds can be defined as those having present in the molecule group $--N=N$ wherein the balances are satisfied by organic radicals, at least one of which is preferably attached to a tertiary carbon. Other suitable azo compounds include, but are not limited to,
30 p-bromobenzenediazonium fluoroborate; p-tolyldiazoaminobenzene; p-bromobenzenediazonium hydroxide; azomethane and phenyldiazonium halides. A suitable list of azo-type compounds can be found in U.S. Patent No. 2,551,813, issued May 8, 1951 to Paul Pinkney.

The amount of initiator to employ, exclusive of radiation, of course, depends to a large extent on the particular initiator chosen, the high molecular olefin used and the reaction conditions. The initiator must, of course, be soluble in the reaction medium.

- 5 The usual concentrations of initiator are between 0.001:1 and 0.2:1 moles of initiator per mole of acidic reactant, with preferred amounts between 0.005:1 and 0.10:1.

- The polymerization temperature must be sufficiently high to break down the initiator to produce the desired free-radicals. For example, using benzoyl peroxide as the
10 initiator, the reaction temperature can be between about 75°C and about 90°C, preferably between about 80°C and about 85°C higher and lower temperatures can be employed, a suitable broad range of temperatures being between about 20°C and about 200°C, with preferred temperatures between about 50°C and about 150°C.

- 15 The reaction pressure should be sufficient to maintain the solvent in the liquid phase. Pressures can therefore vary between about atmospheric and 100 psig or higher, but the preferred pressure is atmospheric.

- The reaction time is usually sufficient to result in the substantially complete
20 conversion of the acidic reactant and high molecular weight olefin to copolymer. The reaction time is suitable between one and 24 hours, with preferred reaction times between 2 and 10 hours.

- s noted above, the subject reaction is a solution-type polymerization reaction. The
25 high molecular weight olefin, acidic reactant, solvent and initiator can be brought together in any suitable manner. The important factors are intimate contact of the high molecular weight olefin and acidic reactant in the presence of a free-radical producing material. The reaction, for example, can be conducted in a batch system where the high molecular weight olefin is added all initially to a mixture of acidic reactant,
30 initiator and solvent or the high molecular weight olefin can be added intermittently or continuously to the reactor. Alternatively, the reactants may be combined in other orders; for example, acidic reactant and initiator may be added to high molecular weight olefin in the reactor. In another manner, the components in the reaction

mixture can be added continuously to a stirred reactor with continuous removal of a portion of the product to a recovery train or to other reactors in series. In yet another manner, the reaction may be carried out in a batch process, wherein the high molecular weight olefin is added initially to the reactor, and then the acidic reactant and the initiator are added gradually over time. The reaction can also suitably take place in a coil-type reactor where the components are added at one or more points along the coil.

Copolymer (iii)

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In one embodiment, copolymer reactant (iii) is obtained by a copolymer obtained by (a) reacting compound (i)(a) with compound (i)(b) or (i)(c) in a non-free radical catalyzed reaction in the presence of copolymer (i) or copolymer (ii) or both; or by (b) contacting copolymer (i) or copolymer (ii) or both with the non-free radical catalyzed reaction product of compound (i)(a) and compound (i)(b) or (i)(c).

15

Preparation of Copolymer (iii)

A process for the preparation of copolymer (iii) is described, for example, in Harrison et al., U.S. Patent No. 6,451,920.

20

In process step (a) above, any unreacted olefin, generally the more hindered olefins, i.e., the beta-vinylidene, that do not react readily with the monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid or an anhydride or ester thereof, under free radical conditions, are reacted with monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid or an anhydride or ester thereof, under thermal conditions, i.e., at temperatures of about 180°C to 280°C. These conditions are similar to those used for preparing thermal process PIBSA. Optionally, this reaction takes place in the presence of a strong acid, such as sulfonic acid. See for example U.S. Patent No. 6,156,850.

25

30

Optionally, a solvent may be used to dissolve the reactants. The reaction solvent must be one which dissolves both the acidic reactant and the high molecular weight olefin. It is necessary to dissolve the acidic reactant and high molecular weight olefin so as to bring them into intimate contact in the solution polymerization reaction. It has been
 5 found that the solvent must also be one in which the resultant copolymers are soluble.

Suitable solvents include liquid saturated or aromatic hydrocarbons having from 6 to 20 carbon atoms; ketones having from 3 to 5 carbon atoms; and liquid saturated aliphatic dihalogenated hydrocarbons having from 1 to 5 carbon atoms per molecule,
 10 preferably from 1 to 3 carbon atoms per molecule. By "liquid" is meant liquid under the conditions of polymerization. In the dihalogenated hydrocarbons, the halogens are preferably on adjacent carbon atoms. By "halogen" is meant F, Cl and Br. The amount of solvent must be such that it can dissolve the acidic reactant and high molecular weight olefin in addition to the resulting copolymers. The volume ratio of solvent to
 15 high molecular weight olefin is suitably between 1:1 and 100:1 and is preferably between 1.5:1 and 4:1.

Suitable solvents include the ketones having from 3 to 6 carbon atoms and the saturated dichlorinated hydrocarbons having from 1 to 5, more preferably
 20 1 to 3, carbon atoms.

Examples of suitable solvents include, but are not limited to:

1. ketones, such as: acetone; methylethylketone; diethylketone; and
 25 methylisobutylketone;
2. aromatic hydrocarbons, such as: benzene; xylene; and toluene;
3. saturated dihalogenated hydrocarbons, such as: dichloromethane;
 30 dibromomethane; 1-bromo-2-chloroethane; 1,1-dibromoethane;
 1,1-dichloroethane; 1,2-dichloroethane; 1,3-dibromopropane;
 1,2-dibromopropane; 1,2-dibromo-2-methylpropane; 1,2-dichloropropane;

1,1-dichloropropane; 1,3-dichloropropane; 1-bromo-2-chloropropane;
1,2-dichlorobutane; 1,5-dibromopentane; and 1,5-dichloropentane; or

4. mixtures of the above, such as: benzenemethylethylketone.

5

The copolymer is conveniently separated from solvent and any unreacted acidic reactant by conventional procedures such as phase separation, solvent distillation, precipitation and the like. If desired, dispersing agents and/or co-solvents may be used during the reaction.

10

The polyisobutenyl succinic anhydride (PIBSA), which may be directly added to copolymer reactant (i) or (ii), is generally prepared by a number of well-known processes including the method disclosed within. For example, there is a well-known thermal process (see, e.g., U.S. Patent No. 3,361,673), an equally well-known chlorination process (see, e.g., U.S. Patent No. 3,172,892), a combination of the thermal and chlorination processes (see, e.g., U.S. Patent No. 3,912,764), catalytic strong acid processes (see, e.g., U.S. Patent Nos. 3,819,660 and 6,156,850), and free radical processes (see, e.g., U.S. Patent Nos. 5,286,799 and 5,319,030). Such compositions include one-to-one monomeric adducts (see, e.g., U.S. Patent Nos. 3,219,666 and 3,381,022), as well as high succinic ratio products, adducts having alkenyl-derived substituents adducted with at least 1.3 succinic groups per alkenyl-derived substituent (see, e.g., U.S. Patent No. 4,234,435).

Polyalkylene succinic anhydrides also can be produced thermally also from high methylvinylidene polybutene as disclosed in U.S. Patent No. 4,152,499. This process is further discussed in U.S. Patent No. 5,241,003 for the case where the succinic ratio is less than 1.3 and in EP 0 355 895 for the case where the succinic ratio is greater than 1.3. European Applications EP 0 602 863 and EP 0 587 381, and U.S. Patent No. 5,523,417 disclose a procedure for washing out the polymaleic anhydride resin from polyalkylene succinic anhydride prepared from high methylvinylidene polybutene. A polyalkylene succinic anhydride with a succinic ratio of 1.0 is disclosed. One advantage of polyalkylene succinic anhydride from high methylvinylidene polybutene is that it can be prepared essentially free of chlorine.

U.S. Patent No. 4,234,435 teaches a preferred polyalkene-derived substituent group with a M_n in the range of 1500-3200. For polybutenes, an especially preferred M_n range is 1700-2400. This patent also teaches that the succinimides must have a succinic ratio of at least 1.3. That is, there should be at least 1.3 succinic groups per equivalent weight of polyalkene-derived substituent group. Most preferably, the succinic ratio should be from 1.5 to 2.5.

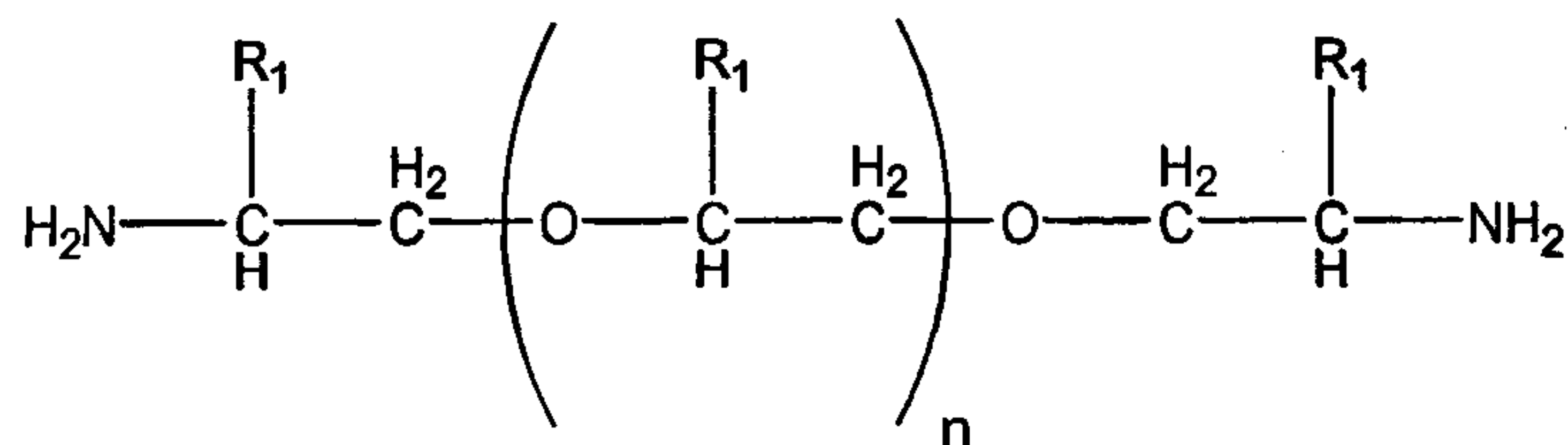
Other suitable alkenyl succinic anhydrides includes those described in U.S. Patent No. 6,030,930. Typical alkenes used in the preparation are ethylene and 1-butene copolymers.

(B) The Ether Compounds

In one embodiment of the present invention, the copolymer is further reacted with an ether compound capable of linking two succinimide groups. Suitable ether compounds include, but are not limited to, the following:

Polyether Polyamines

Examples of suitable polyetheramines include compounds having the following structure:

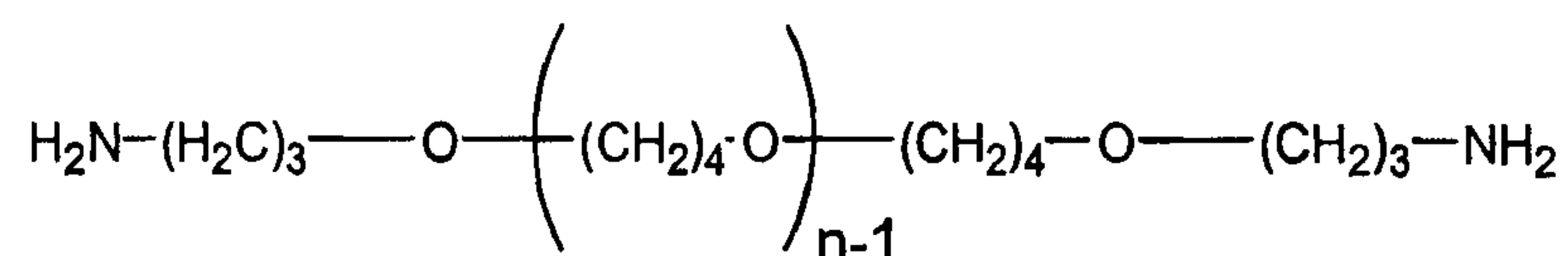


wherein R_1 is independently hydrogen or a hydrocarbyl group having 1 to 4 carbons, and n is the degree of polymerization. Generally the polyether polyamines suitable for use in the present invention will contain at least about one ether unit, preferably from about 5 to about 100, more preferably from about 10 to 50, and even more preferably from about 15 to about 25 ether units.

The polyether polyamines can be based on polymers derived from C₂-C₆ epoxides such as ethylene oxide, propylene oxide, and butylene oxide. Examples of polyether polyamines are sold under the Jeffamine® brand and are commercially available from Hunstman Corporation located in Houston, Texas.

5

Other examples of suitable polyetheramines include polyoxytetramethylene polyamine compounds having the following structure:



10

wherein n is the degree of polymerization (i.e., number of monomer ether units).

Polyether Amine Derivatives

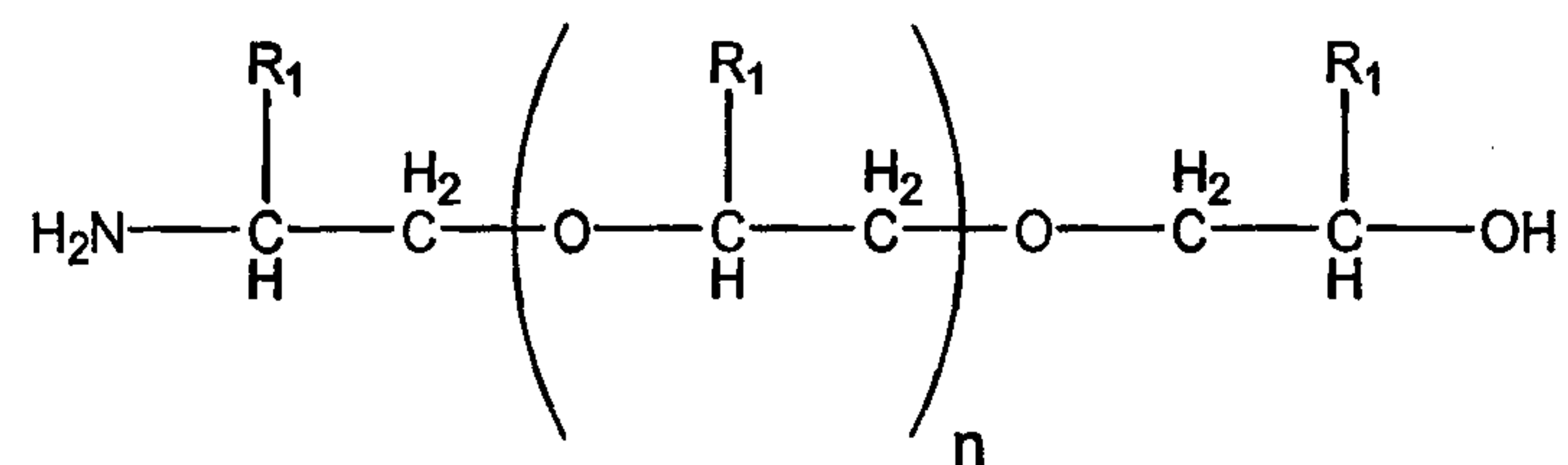
15 Furthermore, the copolymer reactant may be reacted with a polyether amino alcohol or amino thiol.

Polyether Amino Alcohol

20 Typically, amino alcohols may be formed when the alcohol end groups of a compound are not completely converted to amines during reactions, such as reductive amination. Also, one may initiate a polymer chain (i.e., grow propylene or ethylene oxide) from an amino group and therefore have an amino on one end of the polymer chain (i.e., initiator) and an alcohol terminus, or an amine internally in the molecule

25 with alcohol termini.

Examples of suitable polyetheramino alcohols include compounds having the following structure:

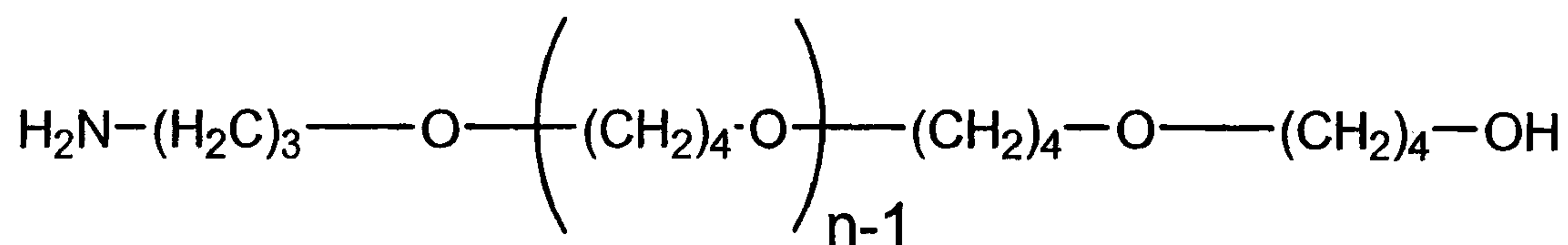


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wherein R_1 is independently a hydrogen or hydrocarbyl group, having 1 to 4 carbons, and n is the degree of polymerization. Generally, the polyether amino alcohols, suitable for use in the present invention will contain at least about one ether unit, preferably from about 5 to about 100, more preferably from about 10 to about 50, and even more preferably from about 15 to about 25 ether units.

10

Other examples of suitable polyetheramino alcohols include polyoxytetramethyleneamino alcohol compounds having the following structure:



15

wherein n is the degree of polymerization.

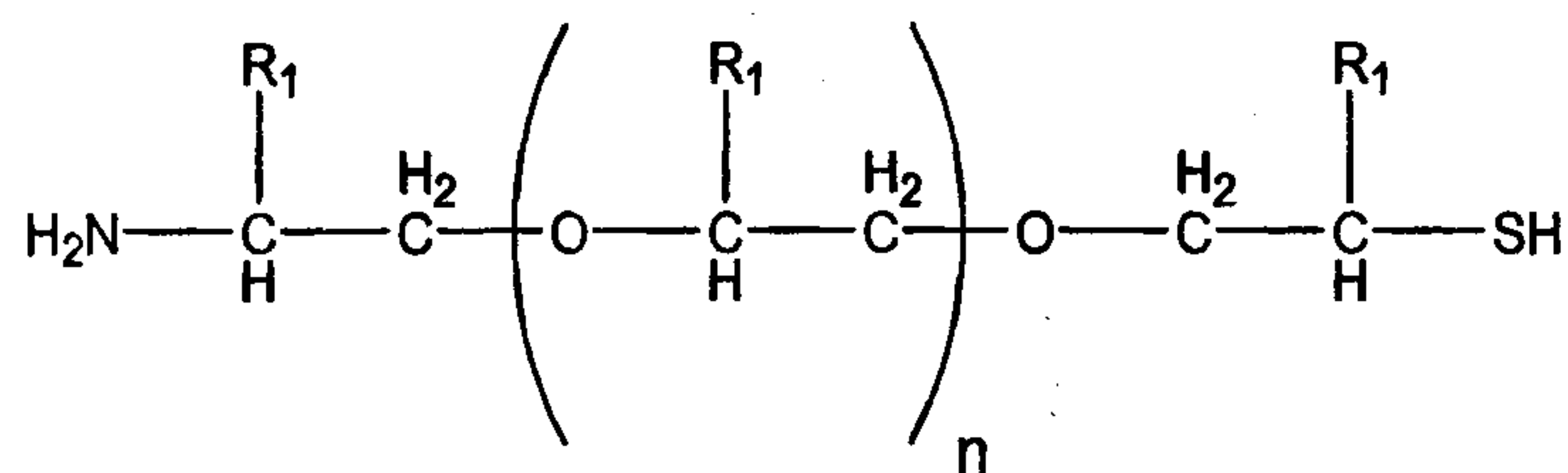
Polyether Amino Thiol

20

Typically, amino thiols may be formed when the thiol end groups of a compound are not completely converted to amines. Also, one may initiate a polymer chain (e.g., grow propylene or ethylene oxide) from an amino group and therefore have an amino on one end (i.e., an initiator) and a thiol terminus.

25

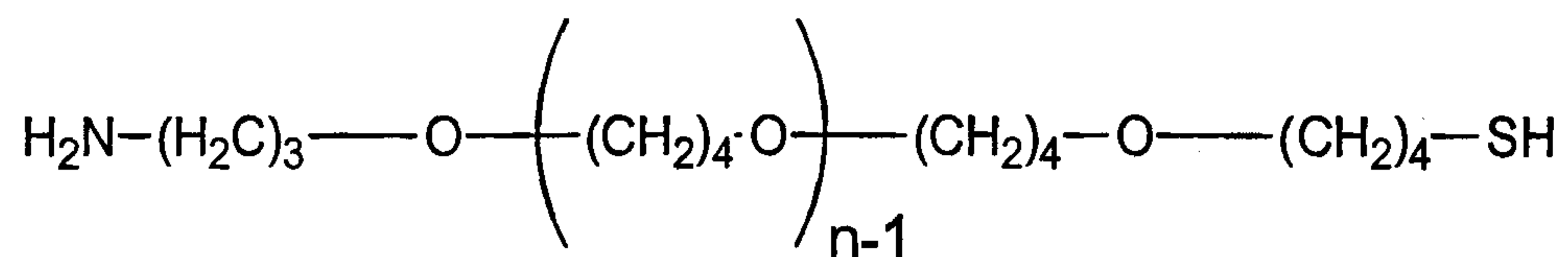
Examples of suitable polyetheramino thiols include compounds having the following structure:



5

wherein R_1 is independently a hydrogen or hydrocarbyl group, having 1 to 4 carbons and n is the degree of polymerization.

Other examples of suitable polyetheramino thiols include
10 polyoxytetramethyleneamino thiol having the following structure:



wherein n is the degree of polymerization.

15

Generally, the polyetheramino thiols suitable for use in the present invention will contain at least about one ether unit, preferably from about 5 to about 100, more preferably from about 10 to about 50, and even more preferably from about 15 to about 25 ether units.

20

Ether Polyamines

Ether Diamines

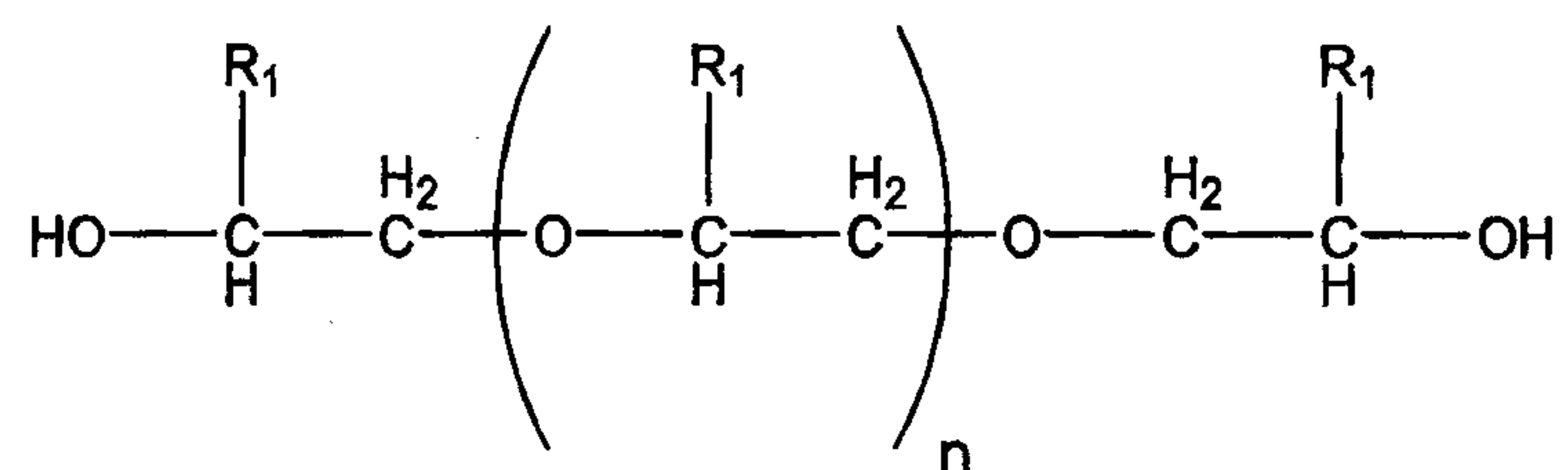
25 In yet another embodiment of the present invention, the copolymer may be reacted with ether diamines. Suitable diamines are reacted with the copolymer, such as decyloxypropyl-1,3-diaminopropane, isodecyloxypropyl-1,3-diaminopropane,

isododecyloxypropyl-1,3-diaminopropane,
 dodecyl/tetradecyloxypropyl-1,3-diaminopropane,
 isotridecyloxypropyl-1,3-diaminopropane, tetradecyloxypropyl-1,3-diaminopropane.

5 Polyether Polyols

In yet another embodiment of the present invention, the copolymer may be reacted with a polyether containing at least two hydroxyl end groups to form an ester. The polyether polyols have the following structure:

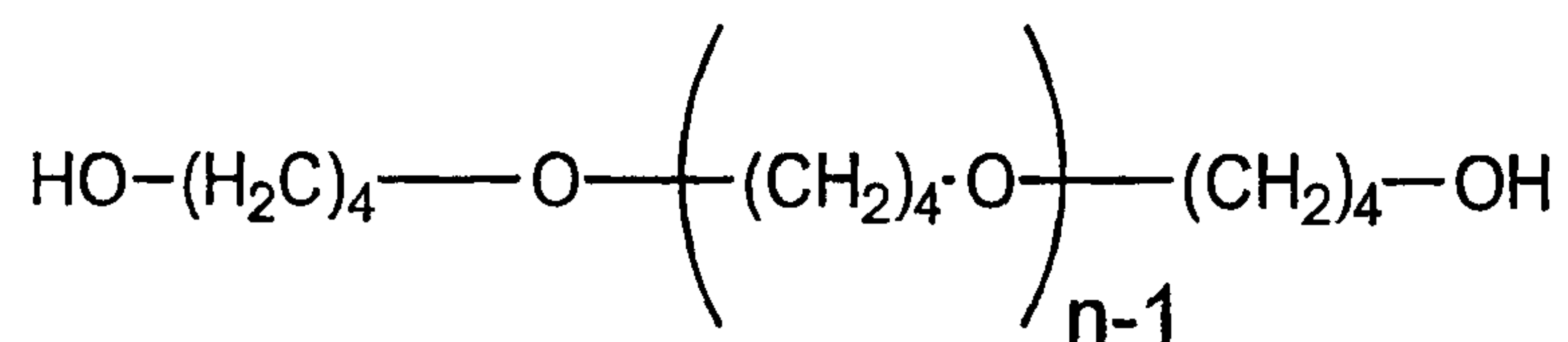
10



wherein R_1 is independently a hydrogen or hydrocarbyl group, having 1 to 4 carbons, and n is the degree of polymerization.

15

Other examples of suitable polyether polyols include polyoxytetramethylene polyol compounds, such as those referred to as Terathane® which may be purchased from DuPont Corporation, Wilmington, Delaware, having the following structure:



20

wherein n is the degree of polymerization.

Suitable polyether polyols include, but are not limited to, the following:

25 polyoxyethylene glycol, polyoxypropylene glycol, polyoxybutylene glycol, and polyoxytetramethylene glycol.

The molecular weight of the presently employed polyether polyol will generally range from about 150 to about 5000, preferably from about 500 to about 2000.

5 Generally, the polyether compounds suitable for use in the present invention will contain at least one ether unit preferably from about 5 to about 100, more preferably from about 10 to about 50, and even more preferred from about 15 to about 25 ether units.

10 Generally, the polyether compounds suitable for use in the present invention may be derived from only one ether type or a mixture of ether types, such as poly(oxyethylene-co-oxypropylene) diamine. The mixture of ether units may be block, random, or alternating copolymers. The presently employed ether compounds are capable of reacting with at least two carboxylic acid groups or anhydride derivatives thereof.

15 Generally, the copolymer may be reacted with a mixture of polyether polyamines, polyether amino alcohols, polyether amino thiols, polyether polyols, or ether diamines to form a mixture of imides, amides and esters.

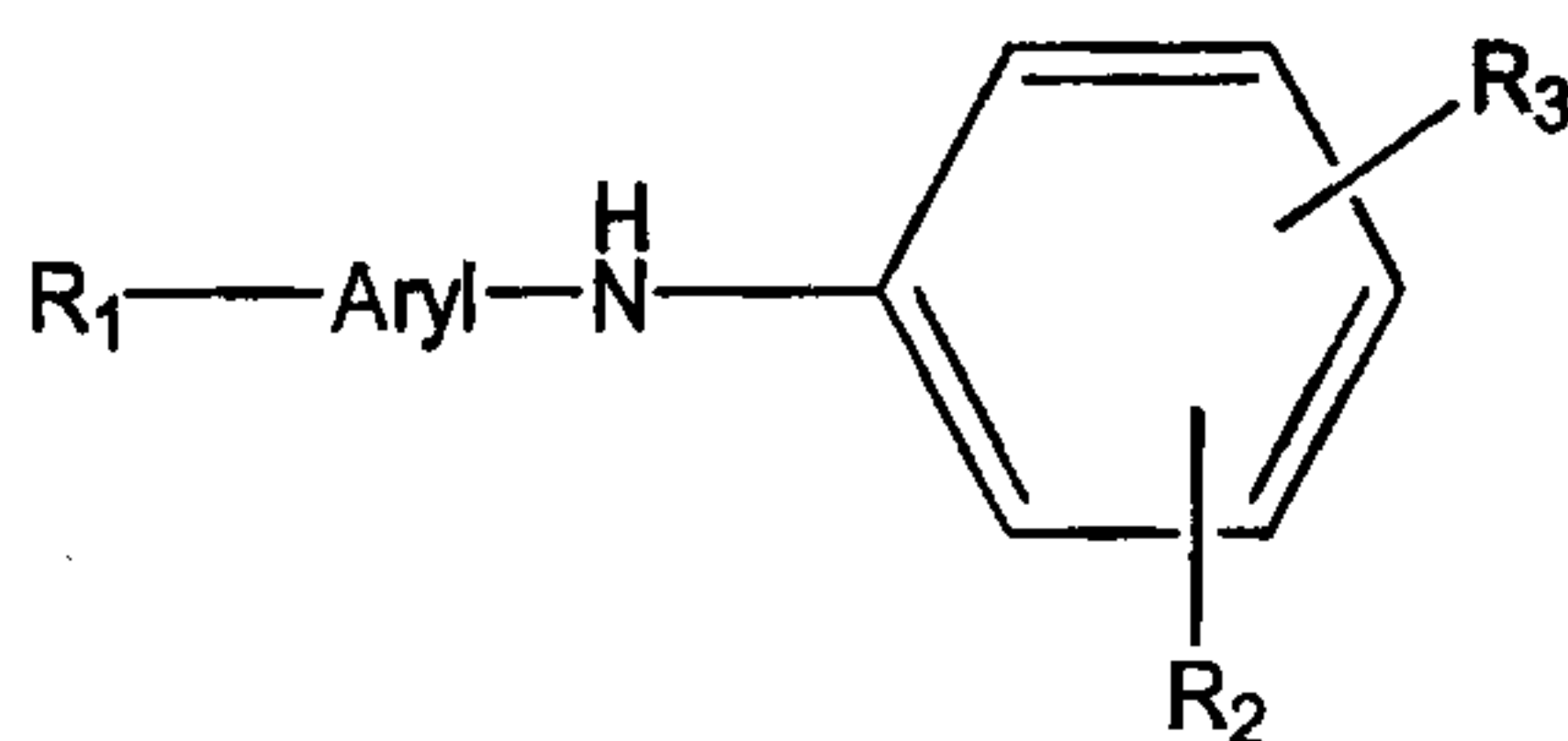
20 (C) Amino Aromatic Reactant

In addition to the ether compound (i.e., polyether polyamine, polyether polyamine derivative, polyether polyol, ether diamines and ether triamine) above, the copolymer is also reacted with at least one amino aromatic selected from the group consisting of

25 (a) N-arylphenylenediamine, (b) aminocarbazole, (c) amino-indazolinone, (d) aminomercaptotriazole, (e) aminoperimidine; and (f) aryloxyphenylene amine.

Preferred amino aromatic compounds are described as follows:

(a) an N-arylphenylenediamine represented by the formula:



5

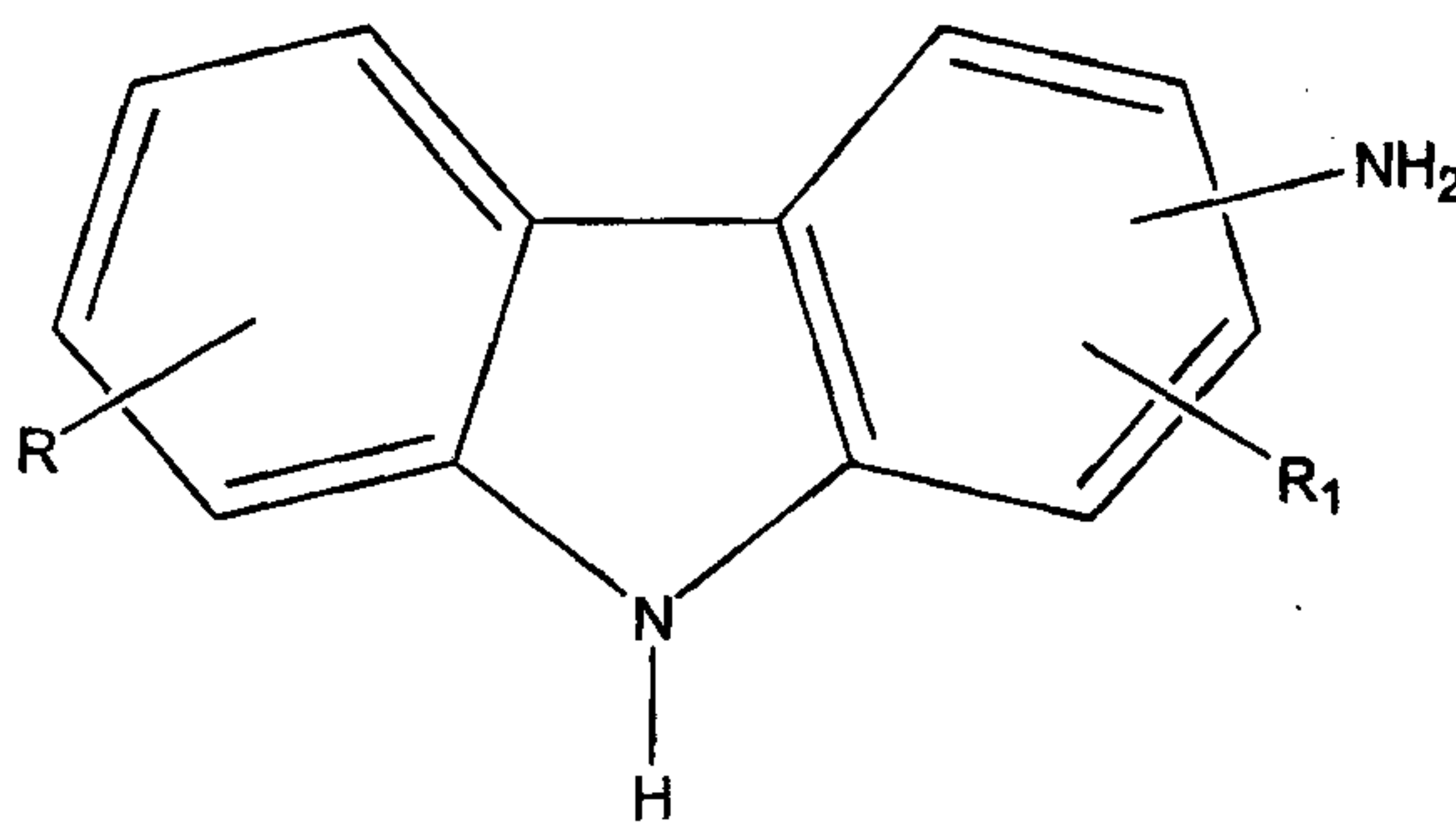
in which R_1 is H, --NHaryl, -NHalkaryl, or a branched or straight chain radical having from 4 to 24 carbon atoms that can be alkyl, alkenyl, alkoxyl, aralkyl or alkaryl; R_2 is --NH₂, --(NH(CH₂))_n--m NH₂, --NHalkyl, --NHaralkyl, --CH₂ --aryl--NH₂, in which n and m each have a value from 1 to 10; and R_3 is hydrogen, alkyl, alkenyl, alkoxyl, aralkyl, or alkaryl, having from 4 to 24 carbon atoms. Particularly preferred N-arylphenylenediamines are N-phenylphenylenediamines (NPPDA), for example, N-phenyl-1,4-phenylenediamine, N-phenyl-1,3-phenylenediamine, and N-phenyl-1,2-phenylenediamine and N-naphthyl-1, 4-phenylenediamine. Other polyamines of NPPDA may also be included, such as N-aminopropyl-N'-phenylphenylenediamine.

10

15

(b) aminocarbazole represented by the formula:

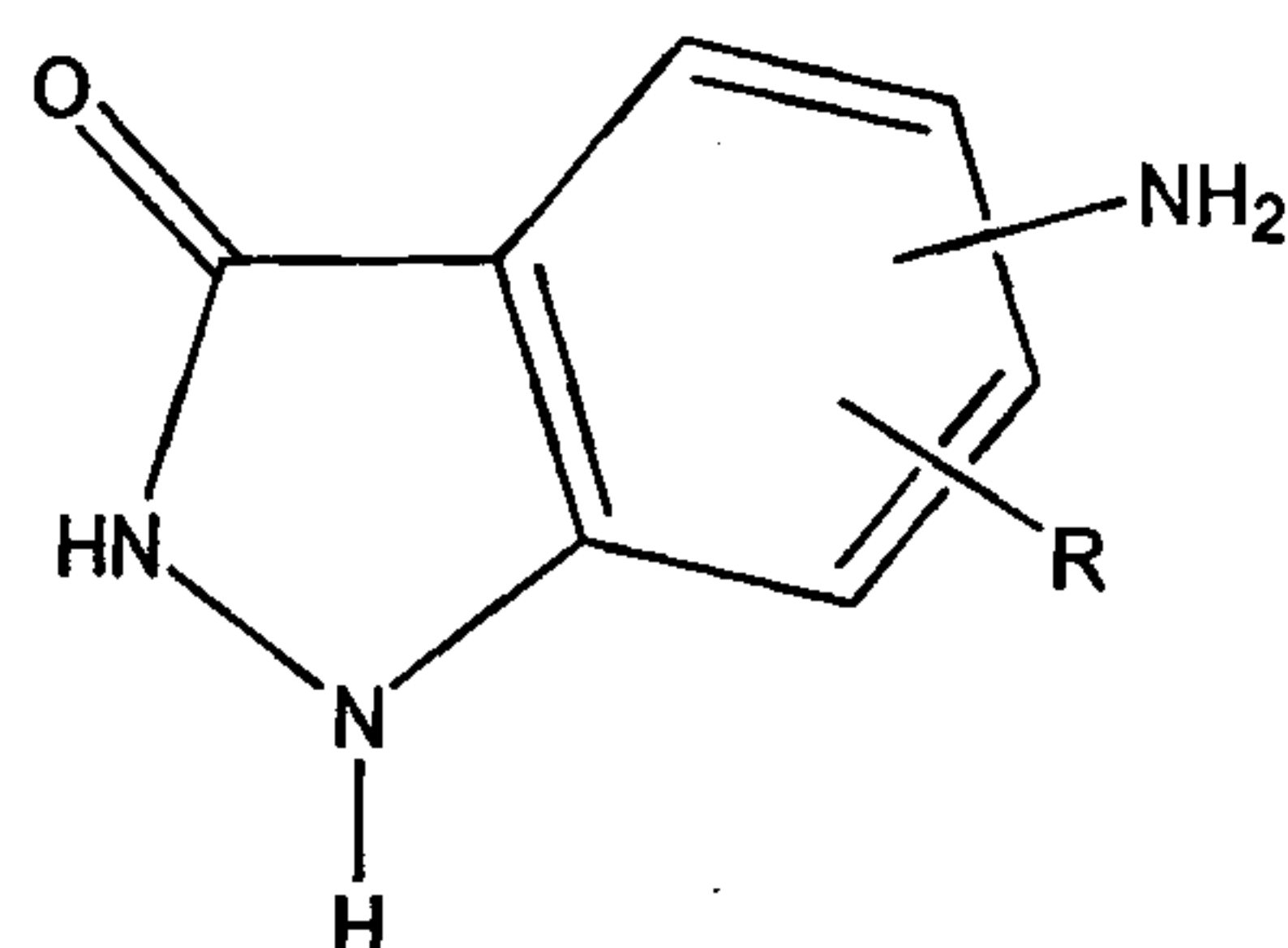
20



in which R and R^1 each independently represent hydrogen or an alkyl or alkenyl radical having from 1 to 14 carbon atoms,

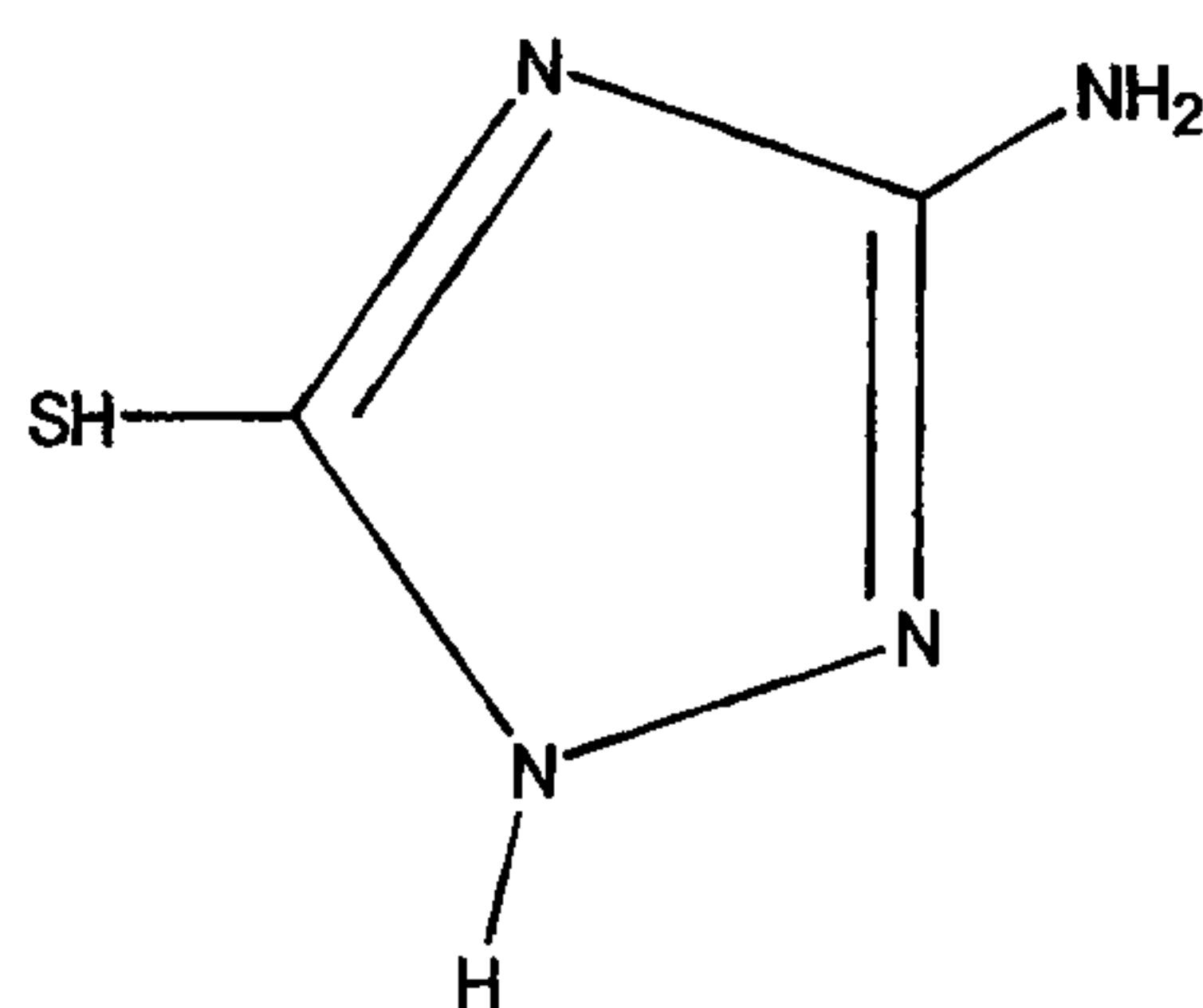
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- (c) an amino-indazolinone represented by the formula:



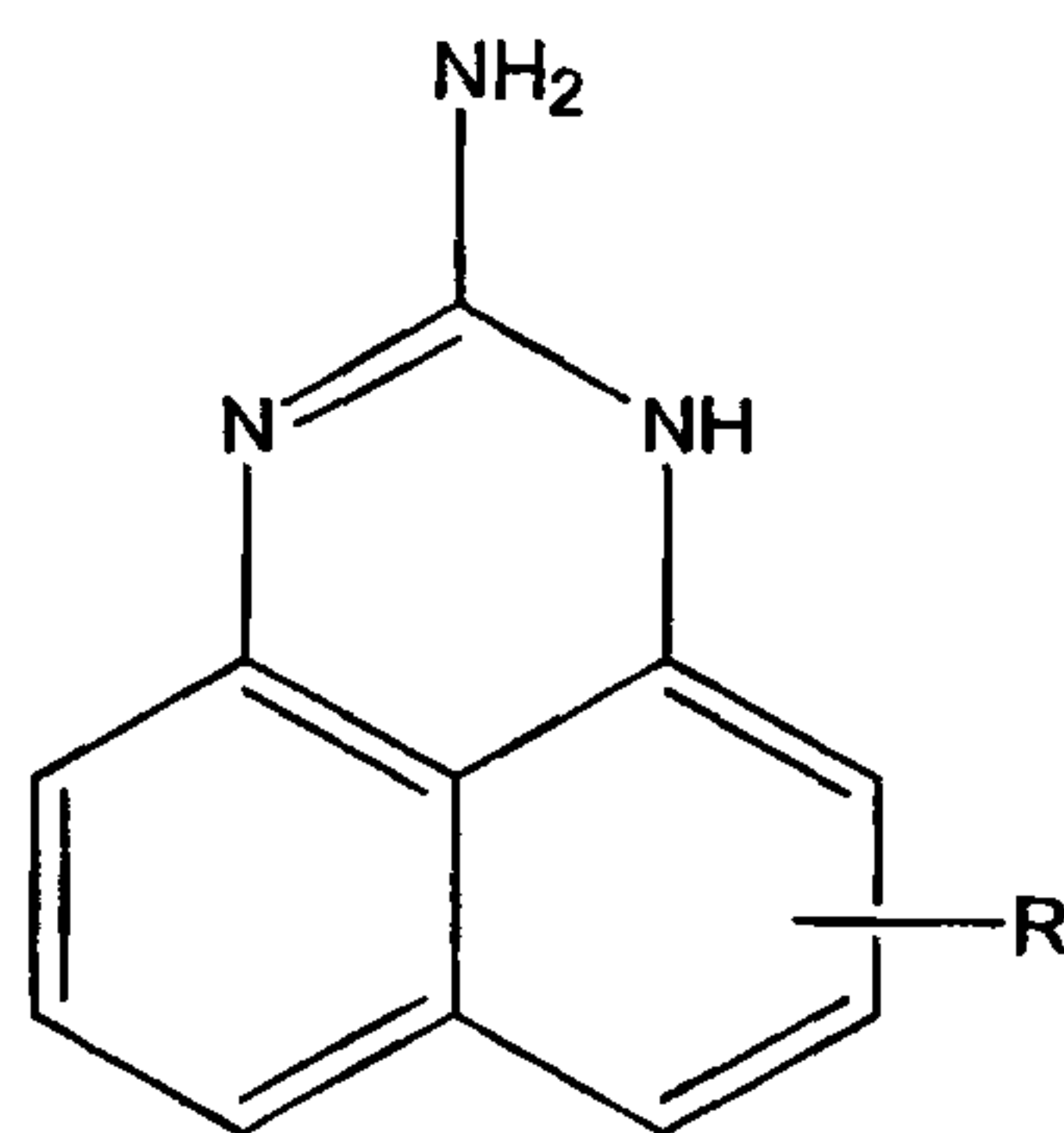
- 5 in which R is hydrogen or an alkyl radical having from 1 to 14 carbon atoms;
and

- (d) an aminomercaptotriazole represented by the formula:



10

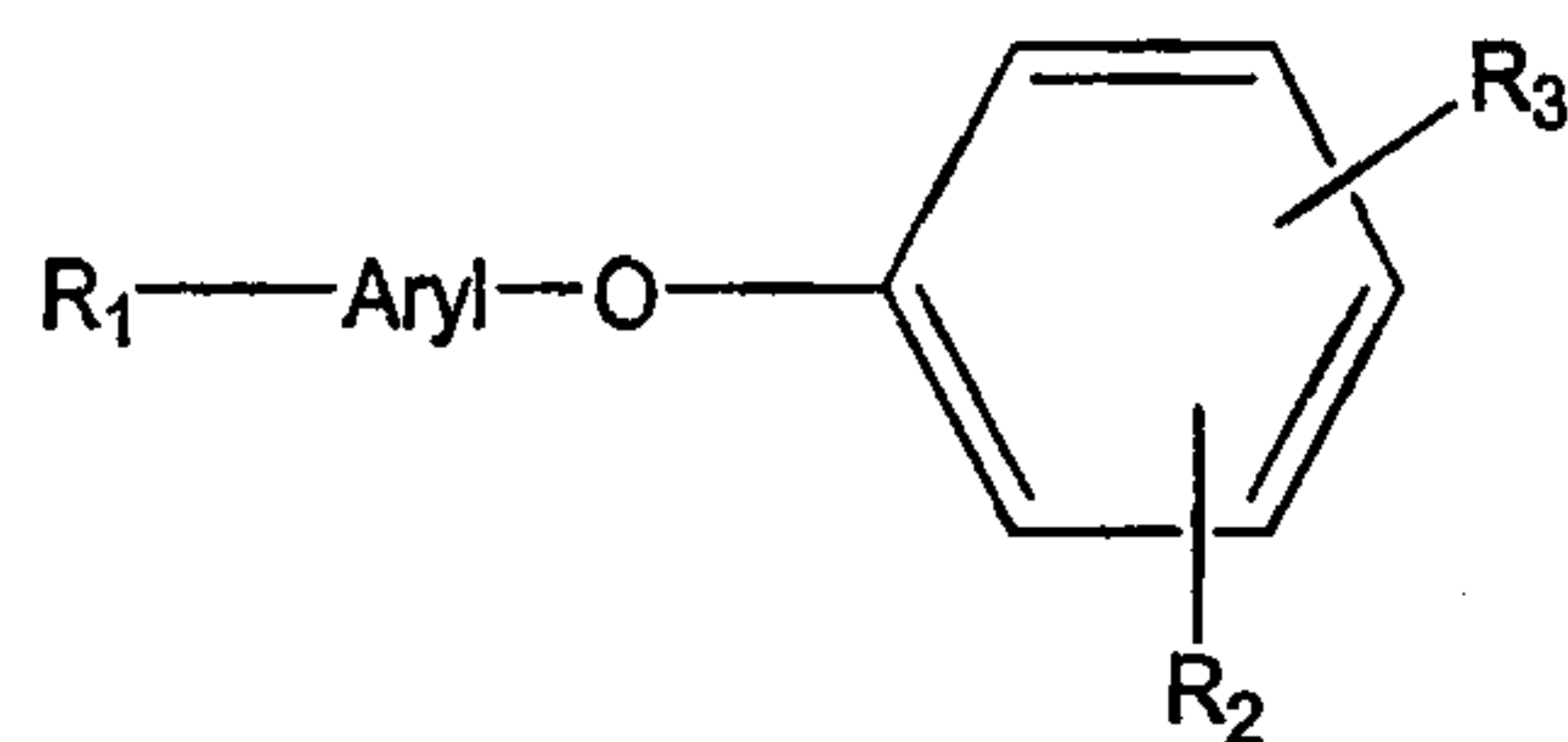
- (e) an aminoperimidine represented by the formula:



15

- in which R represents hydrogen or an alkyl radical having from 1 to 14 carbon atoms; and

(f) an aryloxyphenyleneamine represented by the formula:



- 5 in which R_1 is H, $--NH_{aryl}$, $--NH_{alkaryl}$, or branched or straight chain radical having from 4 to 24 carbon atoms that can be alkyl, alkenyl, alkoxyl, aralkyl or alkaryl; R_2 is $--NH_2$, $--(NH(CH_2)--_n)--_m NH_2$, $--NH_{alkyl}$, or $--NH_{aralkyl}$, in which n and m each have a value from 1 to 10; and R_3 is hydrogen, alkyl, alkenyl, alkoxyl, aralkyl, or alkaryl, having from 4 to 24 carbon atoms. A
10 particularly preferred aryloxyphenyleneamine is 4-phenoxyaniline.

Method of Making the Oil-Soluble Lubricating Oil Additive (Component I)

The oil-soluble lubricating oil additive (Component I) is prepared by a process
15 comprising charging the reactant copolymer (e.g., at least one of copolymers (i), (ii) and (iii) as described herein) in a reactor, optionally under a nitrogen purge, and heating at a temperature of from about 80°C to about 170°C. Optionally, a diluent oil may be charged optionally under a nitrogen purge in the same reactor. Both an amino aromatic amine and an ether polyamine, polyetheramine, polyetheramine derivative
20 and/or polyether polyol are charged, optionally under a nitrogen purge, to the reactor. This mixture is heated under a nitrogen purge to a temperature in range from about 130°C to about 200°C. Optionally, a vacuum is applied to the mixture for about 0.5 to about 2.0 hours to remove excess water.

25 The oil-soluble lubricating oil additive can also be made using a process comprising simultaneously charging all the reactants (reactant copolymer (i), (ii), or (iii); the amino aromatic amine; and the ether compound which consists of at least one of a polyether polyamine, polyether amino alcohol, polyetheramino thiol, ether polyamine and polyether polyol) at the desired ratios into the reactor, thereby producing the
30 polysuccinimide lubricating oil additive composition. One or more of the reactants

can be charged at an elevated temperature to facilitate mixing and reaction. A static mixer can be used to facilitate mixing of the reactants as they are being charged to the reactor. The reaction is carried out for about 0.5 to 2 hours at a temperature from about 130°C to 200°C. Optionally a vacuum is applied to the reaction mixture during
5 the reaction period.

Preferably, the ratio of polyetheramine, polyetheramine derivative and/or polyetherpolyol to monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester or C₄-C₂₈ dicarboxylic acid, anhydride or ester is 0.45 to 0.05; more preferred,
10 the ratio is 0.40 to 0.1; even more preferred, the ratio is 0.35 to 0.20; most preferred, the ratio is 0.33.

Preferably, the ratio of amino aromatic compound to monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or
15 ester is 0.95 to 0.10; more preferred, the ratio is 0.40 to 0.20; even more preferred, the ratio is 0.35 to 0.25; most preferred, the ratio is 0.33.

In one embodiment, the non-free radical catalyzed reaction product of compound (i)(a) and compound (i)(b) or (i)(c), which is contacted with either copolymer (i) or
20 copolymer (ii) or both, may be contacted in the presence of component (C) (i.e., the aromatic amine) prior to the addition of component (B) (i.e., the ether compound).

II. The Ashless Dispersant Additive

25 Component II of the oil-soluble lubricating oil additive composition employed in the present invention comprises at least an ashless dispersant. A dispersant is an additive for a lubricating composition whose primary function is to hold solid and liquid contaminants in suspension, thereby passivating and reducing engine deposits at the same time as reducing sludge depositions. Thus, for example, a dispersant maintains
30 in suspension oil-insoluble substances that result from oxidation during use of the lubricating oil, thus preventing sludge flocculation and precipitation or deposition on metal parts of the engine.

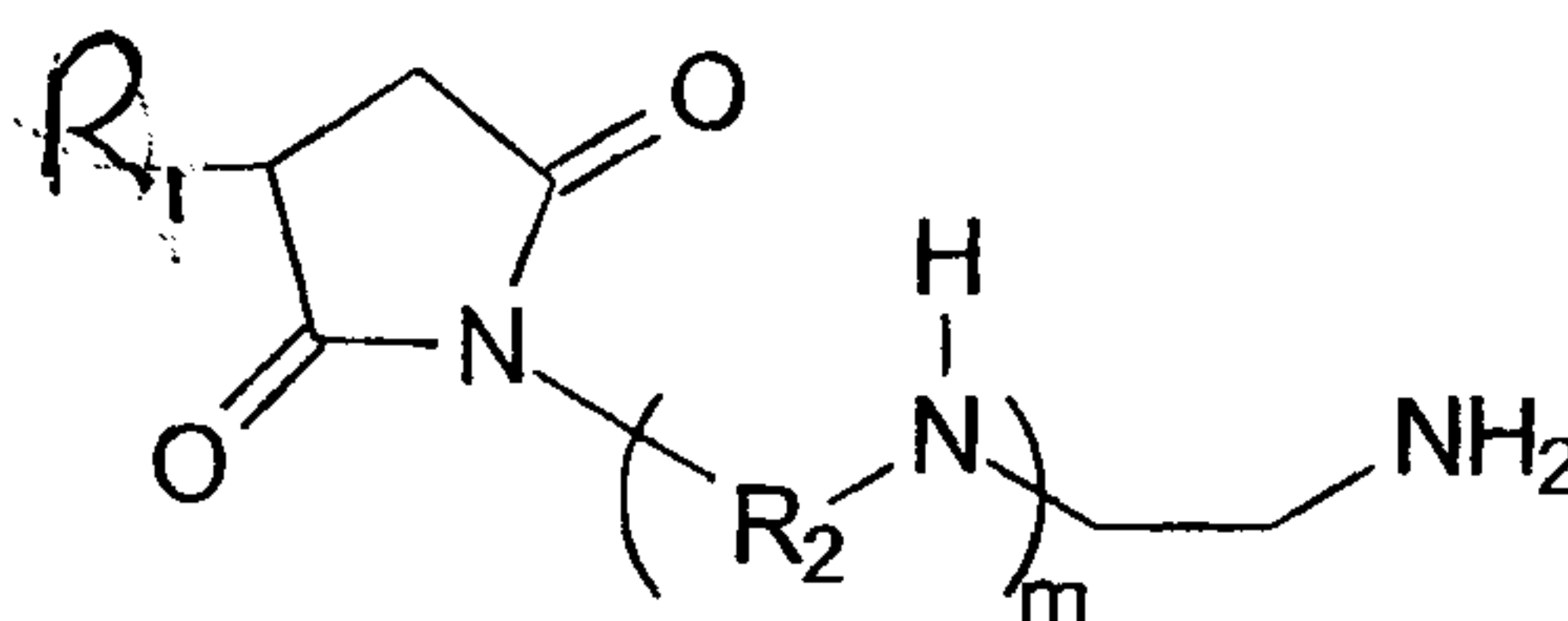
A noteworthy class of dispersants are "ashless," meaning a non-metallic organic material that forms substantially no ash on combustion, in contrast to metal-containing, hence ash-forming, materials. Ashless dispersants comprise a long chain hydrocarbon with a polar head, the polarity being derived from inclusion of, e.g., an oxygen, phosphorus or nitrogen atom. The hydrocarbon is an oleophilic group that confers oil-solubility, having for example 40 to 500 carbon atoms. Thus, ashless dispersants may comprise an oil-soluble polymeric hydrocarbon backbone having functional groups that are capable of associating with particles to be dispersed. Examples of ashless dispersants include Mannich dispersants; polymeric dispersants; carboxylic dispersants; amine dispersants, high molecular weight (C_n wherein $n > 12$) esters and the like; esterified maleic anhydride styrene copolymers; maleated ethylene diene monomer copolymers; surfactants; emulsifiers; functionalized derivatives of each component listed herein and the like; and combinations and mixtures thereof.

In one embodiment of the present invention, at least one ashless dispersant additive is combined with the oil-soluble lubricating oil additive in a major amount of an oil of lubricating viscosity.

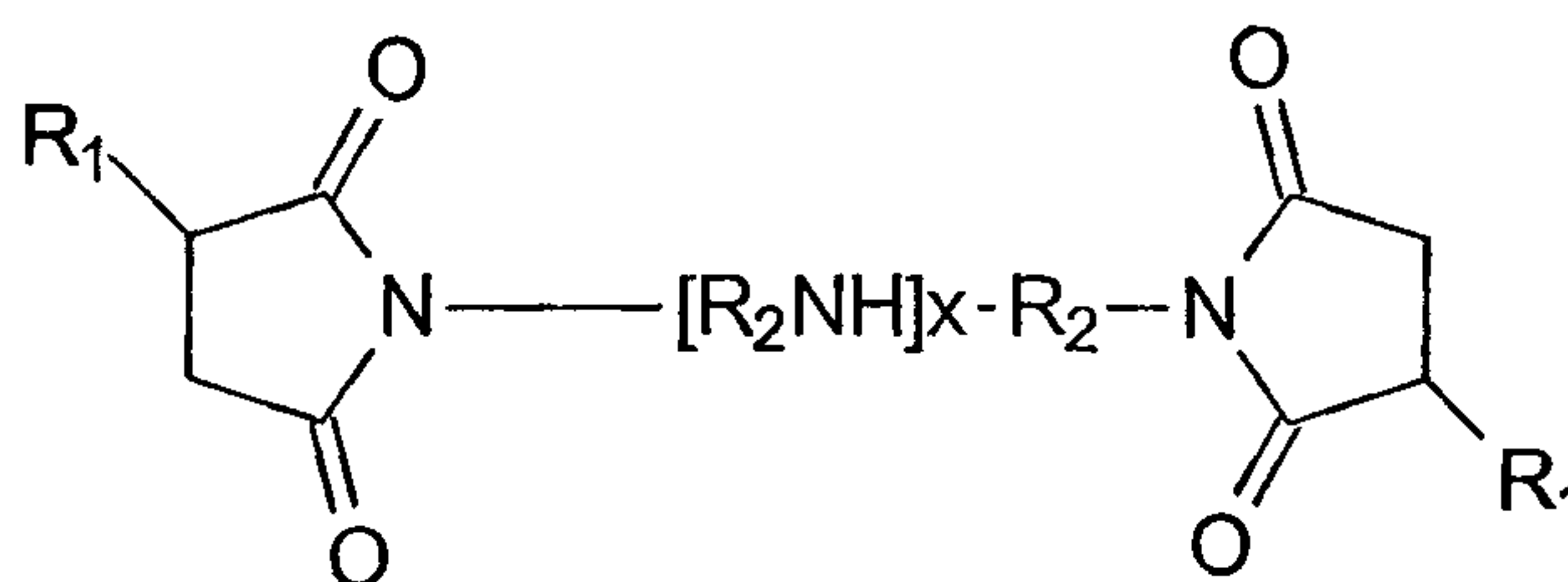
Furthermore, the dispersant may include but is not limited to ashless type dispersants such as polyisobutenyl succinimide and the like. Polyisobutenyl succinimide ashless dispersants are commercially-available products which are typically made by reacting together polyisobutylene having a number average molecular weight (" M_n ") of about 300 to 10,000 with maleic anhydride ("PIBSA") and then reacting the product so obtained with a polyamine typically containing 1 to 10 ethylene diamine groups per molecule.

Ashless type dispersants are characterized by a polar group attached to a relatively high molecular weight hydrocarbon chain. Typical ashless dispersants include N-substituted long chain alkenyl succinimides, having a variety of chemical structures including typically:

5



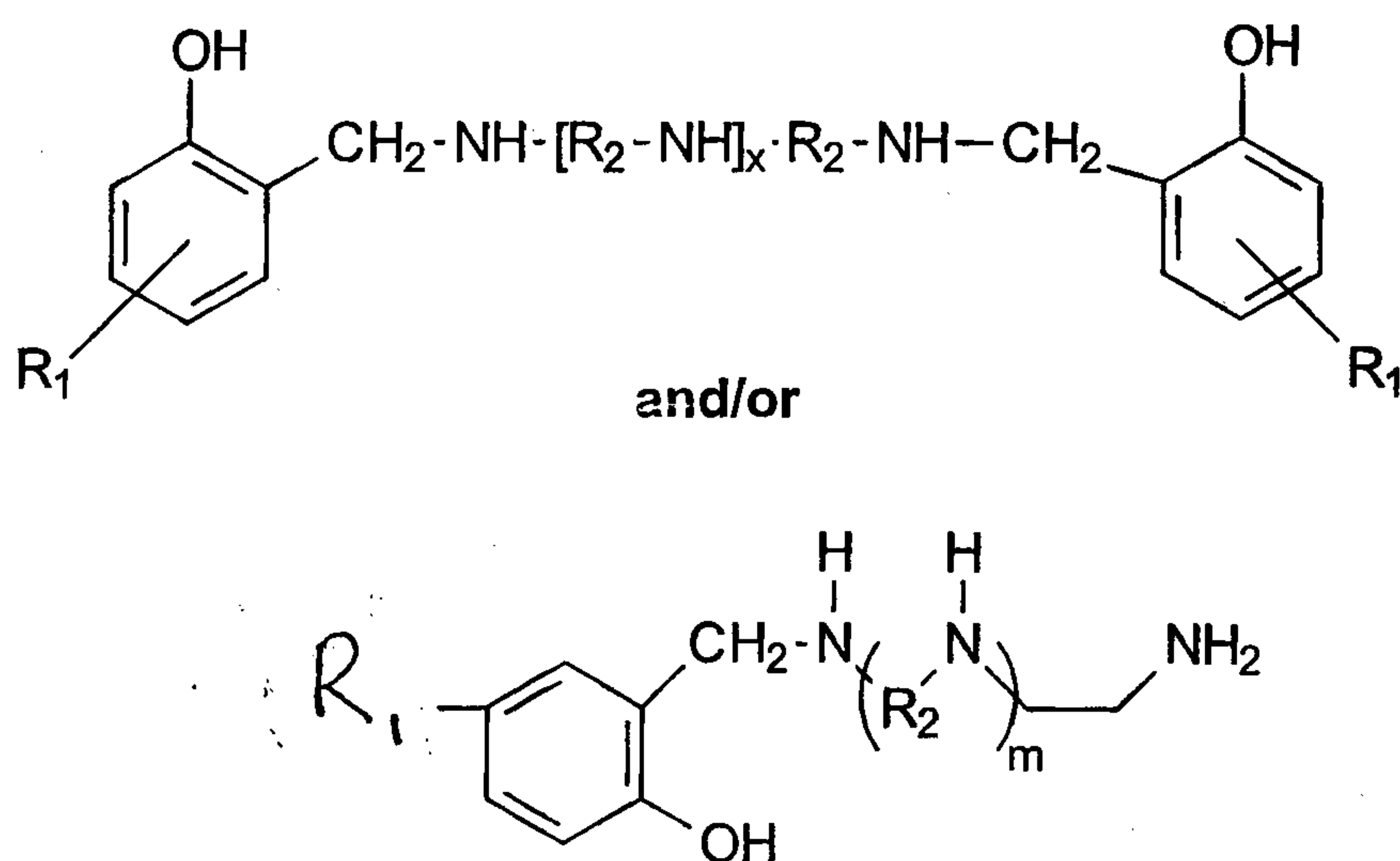
and/or



where each R^1 is independently an alkyl group, frequently a polyisobutyl group with a molecular weight of 500-5000, and R_2 are alkylene groups, commonly ethylenyl (C_2H_4) groups. Succinimide dispersants are more fully described in U.S. Patent No. 4,234,435.

10

Another class of ashless dispersants includes but is not limited to high molecular weight esters, Mannich dispersants and the like. The Mannich dispersants are the reaction products of alkyl phenols in which the alkyl group contains at least about 30 carbon atoms with aldehydes (especially formaldehyde) and amines (especially polyalkylene polyamines). Mannich bases having the following general structure (including a variety of different isomers and the like) are especially interesting.



wherein R_1 and R_2 are as described above.

Another class of dispersants is carboxylic dispersants. Examples of these "carboxylic dispersants" are described in U.S. Patent No. 3,219,666.

Amine dispersants are reaction products of relatively high molecular weight aliphatic halides and amines, preferably polyalkylene polyamines. Examples thereof are described, in U.S. Patent No. 3,565,804.

Polymeric dispersants are interpolymers of oil-solubilizing monomers such as decyl methacrylate, vinyl decyl ether and high molecular weight olefins with monomers containing polar substituents, e.g., aminoalkyl acrylates or acrylamides and poly-(oxyethylene)-substituted acrylates. Examples of polymer dispersants thereof are disclosed in the following U.S. Patent Nos. 3,329,658 and 3,702,300.

Dispersants can also be post-treated by reaction with any of a variety of agents. Among these are urea, thiourea, dimercaptothiadiazoles, carbon disulfide, aldehydes, ketones, carboxylic acids, hydrocarbon-substituted succinic anhydrides, nitriles, epoxides, boron compounds, and phosphorus compounds.

In one embodiment of the present invention, the at least one ashless dispersant is a post-treated polymer. The post-treatment step is either a cyclic carbonate post-treatment step or a post-treatment step that utilizes boric acid or similar boron compounds, such as boron oxides, boron halides and esters of boric acid to form borated dispersants. Preferably the at least one ashless dispersant is either a borated dispersant or an ethylene carbonate treated (EC treated) dispersant. More preferred, the borated dispersant is a borated bissuccinimide and the ethylene carbonate treated dispersant is an ethylene carbonate treated bissuccinimide. Preferably, the at least one ashless dispersant is a mixture of the borated dispersant and the ethylene carbonate dispersant. More preferred, the mixture of the borated dispersant and the ethylene carbonate treated dispersant is a mixture of a borated bissuccinimide and an ethylene carbonate treated bissuccinimide.

The EC treated dispersant is a polybutene succinimide derived from polybutenes having a molecular weight of at least 1800, preferably from 2000 to 2400. The EC-treated succinimide of this invention is described in U.S. Patent No. 5,334,321.

The borated dispersant is a polybutene succinimide derived from polybutenes having a molecular weight of at least 1800, preferably from 2000 to 2400. The borated succinimide of this invention is made as described in U.S. Patent No. 4,652,387 and U.S. Patent No. 6,906,011.

Preferably from about 0.1 wt% to about 5.0 wt% of the total amount of the ashless dispersant(s) is employed in the present invention. Preferably the ashless dispersant is a borated dispersant or an EC-treated dispersant or mixtures thereof. Preferably, from about 0.1 wt% to about 5.0 wt% of a borated dispersant is combined with the

- oil-soluble lubricating oil additive; more preferred, from about 1.0 wt% to about 5.0 wt% of the borated dispersant; and most preferred, from about 1.0 wt% to about 4.0 wt% of the borated dispersant. Preferably, from about 0.1 wt% to about 5.0 wt% of an ethylene carbonate treated dispersant is combined with the oil-soluble lubricating oil additive; more preferred from about 1.0 wt% to about 4.0 wt% of the ethylene carbonate treated dispersant is combined with the oil-soluble lubricating oil additive; and most preferred from about 2.0 wt% to about 3.0 wt% of the ethylene carbonate treated dispersant is combined with the oil-soluble lubricating oil additive.
- 10 In one embodiment of the present invention, the two ashless dispersants (i.e., borated dispersant and the ethylene carbonate treated dispersant) may be combined with the oil-soluble lubricating oil additive in the same vessel in which the oil-soluble lubricating oil additive was produced.
- 15 Additionally, other additives well known in lubricating oil compositions may be added to the lubricating oil additive composition the present invention to complete a finished oil.

Other Additives

20

The following additive components are examples of some of the components that can be favorably employed in the present invention. These examples of additives are provided to illustrate the present invention, but they are not intended to limit it:

1. Metal Detergents

25

30

Sulfurized or unsulfurized alkyl or alkenyl phenates, alkyl or alkenyl aromatic sulfonates, borated sulfonates, sulfurized or unsulfurized metal salts of multi-hydroxy alkyl or alkenyl aromatic compounds, alkyl or alkenyl hydroxy aromatic sulfonates, sulfurized or unsulfurized alkyl or alkenyl naphthenates, metal salts of alkanolic acids, metal salts of an alkyl or alkenyl multiacid, and chemical and physical mixtures thereof.

2. Anti-Oxidants

Anti-oxidants reduce the tendency of mineral oils to deteriorate in service
 which deterioration is evidenced by the products of oxidation such as sludge
 and varnish-like deposits on the metal surfaces and by an increase in viscosity.
 Examples of anti-oxidants useful in the present invention include, but are not
 limited to, phenol type (phenolic) oxidation inhibitors, such as
 4,4'-methylene-bis(2,6-di-tert-butylphenol), 4,4'-bis(2,6-di-tert-butylphenol),
 4,4'-bis(2-methyl-6-tert-butylphenol),
 2,2'-methylene-bis(4-methyl-6-tert-butylphenol),
 4,4'-butylidene-bis(3-methyl-6-tert-butylphenol),
 4,4'-isopropylidene-bis(2,6-di-tert-butylphenol),
 2,2'-methylene-bis(4-methyl-6-nonylphenol),
 2,2'-isobutylidene-bis(4,6-dimethylphenol),
 2,2'-5-methylene-bis(4-methyl-6-cyclohexylphenol),
 2,6-di-tert-butyl-4-methylphenol, 2,6-di-tert-butyl-4-ethylphenol,
 2,4-dimethyl-6-tert-butylphenol, 2,6-di-tert-l-dimethylamino-p-cresol,
 2,6-di-tert-4-(N,N'-dimethylaminomethylphenol),
 4,4'-thiobis(2-methyl-6-tert-butylphenol),
 2,2'-thiobis(4-methyl-6-tert-butylphenol),
 bis(3-methyl-4-hydroxy-5-tert-10-butylbenzyl)-sulfide, and
 bis(3,5-di-tert-butyl-4-hydroxybenzyl). Diphenylamine-type oxidation
 inhibitors include, but are not limited to, alkylated diphenylamine,
 phenyl-alpha-naphthylamine, and alkylated-alpha-naphthylamine. Other types
 of oxidation inhibitors include metal dithiocarbamate (e.g., zinc
 dithiocarbamate), and 15-methylenebis(dibutyldithiocarbamate).

3. Anti-Wear Agents

As their name implies, these agents reduce wear of moving metallic parts. Examples of such agents include, but are not limited to, phosphates and thiophosphates and salts thereof, carbamates, esters, and molybdenum complexes.

4. Rust Inhibitors (Anti-Rust Agents)

- a) Nonionic polyoxyethylene surface active agents: polyoxyethylene lauryl ether, polyoxyethylene higher alcohol ether, polyoxyethylene nonyl phenyl ether, polyoxyethylene octyl phenyl ether, polyoxyethylene octyl stearyl ether, polyoxyethylene oleyl ether, polyoxyethylene sorbitol monostearate, polyoxyethylene sorbitol mono-oleate, and polyethylene glycol mono-oleate.
- b) Other compounds: stearic acid and other fatty acids, dicarboxylic acids, metal soaps, fatty acid amine salts, metal salts of heavy sulfonic acid, partial carboxylic acid ester of polyhydric alcohol, and phosphoric ester.

5. Demulsifiers

Addition product of alkylphenol and ethylene oxide, polyoxyethylene alkyl ether, and polyoxyethylene sorbitan ester.

6. Extreme Pressure Anti-Wear Agents (EP/AW Agents)

Sulfurized olefins, zinc dialky-1-dithiophosphate (primary alkyl, secondary alkyl, and aryl type), diphenyl sulfide, methyl trichlorostearate, chlorinated

naphthalene, fluoroalkylpolysiloxane, lead naphthenate, neutralized or partially neutralized phosphates, dithiophosphates, and sulfur-free phosphates.

7. Friction Modifiers

5

Fatty alcohol, fatty acid (stearic acid, isostearic acid, oleic acid and other fatty acids or salts thereof), amine, borated ester, other esters, phosphates, other phosphites besides tri- and di-hydrocarbyl phosphites, and phosphonates.

10 8. Multifunctional Additives

15

Sulfurized oxymolybdenum dithiocarbamate, sulfurized oxymolybdenum organo phosphorodithioate, oxymolybdenum monoglyceride, oxymolybdenum diethylate amide, amine-molybdenum complex compound, and sulfur-containing molybdenum complex compound.

9. Viscosity Index Improvers

20

Polymethacrylate type polymers, ethylene-propylene copolymers, styrene-isoprene copolymers, hydrated styrene-isoprene copolymers, polyisobutylene, and dispersant type viscosity index improvers.

10. Pour Point Depressants

25

Polymethyl methacrylate.

11. Foam Inhibitors

Alkyl methacrylate polymers and dimethyl silicone polymers.

12. Metal Deactivators

Disalicylidene propylenediamine, triazole derivatives,
5 mercaptobenzothiazoles, thiadiazole derivatives, and mercaptobenzimidazoles.

13. Dispersants

Alkenyl succinimides, alkenyl succinimides modified with other organic
compounds, alkenyl succinimides modified by post-treatment with ethylene
10 carbonate or boric acid, esters of polyalcohols and polyisobutenyl succinic
anhydride, phenate-salicylates and their post-treated analogs, alkali metal or
mixed alkali metal, alkaline earth metal borates, dispersions of hydrated alkali
metal borates, dispersions of alkaline-earth metal borates, polyamide ashless
dispersants and the like or mixtures of such dispersants.

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Lubricating Oil Composition

The lubricating oil additive composition described above is generally added to a base
oil that is sufficient to lubricate moving parts, for example internal combustion
20 engines, gears, and transmissions. Typically, the lubricating oil composition of the
present invention comprises a major amount of oil of lubricating viscosity and a
minor amount of the lubricating oil additive composition.

In one embodiment of the present invention, the polysuccinimide lubricating oil
25 additive composition may be added to a major amount of an oil of lubricating
viscosity thereby producing a lubricating oil composition. At least one of the ashless
dispersants may then be added to the resulting lubricating oil composition. In the
alternative, the combination of the oil-soluble lubricating oil additive and the at least
one ashless dispersant is added to a major amount of an oil of lubricating viscosity.

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The base oil employed may be any of a wide variety of oils of lubricating viscosity. The base oil of lubricating viscosity used in such compositions may be mineral oils or synthetic oils. A base oil having a viscosity of at least 2.5 cSt at 40°C and a pour point below 20°C, preferably at or below 0°C, is desirable. The base oils may be derived
5 from synthetic or natural sources. Mineral oils for use as the base oil in this invention include, for example, paraffinic, naphthenic and other oils that are ordinarily used in lubricating oil compositions. Synthetic oils include, for example, both hydrocarbon synthetic oils and synthetic esters and mixtures thereof having the desired viscosity. Hydrocarbon synthetic oils may include, for example, oils prepared from the
10 polymerization of ethylene, polyalphaolefin or PAO oils, or oils prepared from hydrocarbon synthesis procedures using carbon monoxide and hydrogen gases such as in a Fisher-Tropsch process. Useful synthetic hydrocarbon oils include liquid polymers of alpha olefins having the proper viscosity. Especially useful are the hydrogenated liquid oligomers of C₆ to C₁₂ alpha olefins such as 1-decene trimer.
15 Likewise, alkyl benzenes of proper viscosity, such as didodecyl benzene, can be used. Useful synthetic esters include the esters of monocarboxylic acids and polycarboxylic acids, as well as mono-hydroxy alkanols and polyols. Typical examples are didodecyl adipate, pentaerythritol tetracaprate, di-2-ethylhexyl adipate, dilaurylsebacate, and the like. Complex esters prepared from mixtures of mono and dicarboxylic acids and
20 mono and dihydroxy alkanols can also be used. Blends of mineral oils with synthetic oils are also useful.

Thus, the base oil can be a refined paraffin type base oil, a refined naphthenic base oil, or a synthetic hydrocarbon or non-hydrocarbon oil of lubricating viscosity. The
25 base oil can also be a mixture of mineral and synthetic oils.

Method of Use of the Present Invention

The lubricating oil additive composition of the present invention is added to a major
30 amount of an oil of lubricating viscosity thereby producing a lubricating oil composition. The lubricating oil composition contacts the engine, improving dispersancy, more specifically improving soot dispersancy. Accordingly, the present invention is also directed to a method of improving dispersancy, and more specifically

soot dispersancy, in an internal combustion engine which comprises operating the engine with the lubricating oil composition of the invention.

The following examples are presented to illustrate specific embodiments of this invention and are not to be construed in any way as limiting the scope of the invention.

EXAMPLES

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Example 1

Preparation of Terpolymer PIBSA

2513 grams of high methylvinylidene polyisobutylene having a number average molecular weight (M_n) of about 2300 and a methylvinylidene content of about 78% (which is available from BASF as Glissopal® 2300) was charged to a 4-L reactor equipped with agitator, temperature controller and overhead condenser and receiver. 27.3 grams 1-hexadecene was also charged to the reactor, and the agitated mixture was heated to 150°C. Traces of moisture were removed by sparging 250 scm/min nitrogen through the mixture for about an hour. After drying, the nitrogen was fed to the reactor head space at a rate of 30 scm/min. 178.8 grams maleic anhydride and 16.4 grams dicumyl peroxide in a 50% solution with toluene were fed simultaneously to the reactor over 2 hours. After the maleic anhydride and dicumyl peroxide charging were finished, the temperature of the reactor was maintained at 150°C for another 1.5 hours. The reactor was heated to 190°C. During the heating of the reactor, the pressure was gradually lowered to 20 mm Hg when the temperature of the reactor reached 180°C. The temperature was held at 190°C and the pressure was held at 20 mm Hg for 1 hour during which 15 grams of condensate was collected. The product was cooled and a yield of 2693 grams of copolymer (i) was obtained.

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Example 2 - XC1573

Preparation of Oil Soluble Lubricating Oil Additive

3700 grams of terpolymer PIBSA prepared according to Example 1 were charged to a reactor under a nitrogen purge and heated to a temperature of 140°C. The charged

polymer was put under a vacuum for 45-60 minutes. In the same reactor, 778.7 grams of diluent oil were charged. In the same reactor, 62.8 grams of N-phenylphenylenediamine (N-PPDA) were charged under a nitrogen purge. 568.0 grams of polyethyleneoxide diamine (PEO DA, having an approximate number average molecular weight of 1000) were slowly charged to the same reactor under a nitrogen purge. The reactor was heated to 150°C under a nitrogen purge. The reactor was put under a vacuum for 1.5 hours to remove excess water. The charge mole ratio of N-PPDA to anhydride was 0.20. The charge mole ratio of PEO DA to anhydride was 0.33.

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Example 3 - XC1588

Preparation of Oil Soluble Lubricating Oil Additive

4017 grams of terpolymer PIBSA prepared according to Example 1 were charged to a reactor under a nitrogen purge and heated to a temperature of 140°C. The charged polymer was put under a vacuum for 45-60 minutes. In the same reactor, 1034.8 grams of diluent oil were charged. In the same reactor, 78.4 grams of N-phenylphenylenediamine (N-PPDA) were charged under a nitrogen purge. 829.0 grams of polyethyleneoxide diamine (PEO DA, having an approximate number average molecular weight of 1000) were slowly charged to the same reactor under a nitrogen purge. The reactor was heated to 150°C under a nitrogen purge. The reactor was put under a vacuum for 1.5 hours to remove excess water. The charge mole ratio of N-PPDA to anhydride was 0.23. The charge mole ratio of PEO DA to anhydride to was 0.38.

25

Sample 1

Preparation of Lubricating Oil Composition

In a stainless steel vessel, 1.5 wt% of the lubricating oil additive prepared in **Example 2** was combined with 2.0 wt% of borated bissuccinimide (prepared by 1) reacting 1300 g/mol polyisobutene (PIB) with maleic anhydride to form polyisobutenyl succinic anhydride (PIBSA); 2) reacting PIBSA with a polyamine such as tetraethylene pentamine (TEPA) or heavy polyamine (HPA) to form a

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bissuccinimide and 3) reacting boric acid with the bissuccinimide). To the same vessel 1.0 wt% of ethylene carbonate treated bissuccinimide was also added. The ethylene carbonate treated bissuccinimide was prepared by 1) reacting 2300 g/mol PIB with maleic anhydride to form PIBSA; 2) reacting PIBSA with a polyamine such as tetraethylene pentamine (TEPA) or heavy polyamine (HPA) to form a bissuccinimide and 3) reacting ethylene carbonate with the bissuccinimide. In the same vessel, 0.20 wt% corrosion inhibitor, 0.20 wt% molybdenum complex, 2.20 wt% phenate, 0.59 wt% sulfonate, 0.50 wt% antioxidant, 0.50 wt% antioxidant, 1.66 wt% zinc dithiophosphate, 0.02 wt% foam inhibitor, 7.6 wt% viscosity index improver. In the same vessel, the blended additive package was added to a mixture of basestocks which consists of 67 wt% Group 2 base oil and 33 wt% Group 1 base oil to provide the lubricating oil composition of the present invention.

In **Samples 2-7**, the concentrations of the EC-Treated Bissuccinimide, the Borated Bissuccinimide, and/or **Example 2** were varied while keeping constant the values of the other additives in **Sample 1**. The results of **Samples 1-7** are detailed in Table 1.

In **Samples 8-12**, the concentrations of the EC-Treated Bissuccinimide, the Borated Bissuccinimide, and/or **Example 3** were varied. **Example 2** was omitted from **Samples 8-12** and all other additive concentrations were identical to **Sample 1**. The results of **Samples 8-12** are detailed in Table 1.

In **Comparative Samples A-E**, examples 2 and 3 were omitted from the formulations and the concentrations of the EC-Treated Bissuccinimide and/or the Borated Bissuccinimide were varied, while keeping constant the values of the other additives in **Sample 1**. The results of **Comparative Samples A-E** are detailed in Table 1.

Table 1

Sample	Ex. 2 (wt%)	Ex. 3 (wt%)	EC-BS (wt%)	B-BS (wt%)	CI (wt%)	MC (wt%)	Phenate (wt%)	Sulfonate (wt%)	AO (wt%)	ZDDP (wt%)	FI (wt%)	VII (wt%)	STBT Results
1	0.75	0	0.52	1.14	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	44.2
2	0.75	0	0.52	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	41.0
3	0.75	0	1.04	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	42.4
4	0.75	0	1.56	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	40.8
5	1.5	0	0.52	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	42.4
6	1.5	0	1.04	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	45.5
7	1.5	0	1.56	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	42.6
8	0	0.75	0.52	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	42.2
9	0	0.75	1.04	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	41.2
10	0	2.5	0.52	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	42.4
11	0	1.5	0.52	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	43.2
12	0	1.5	1.04	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	43.1
A	0	0	0.52	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	55.3
B	0	0	1.04	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	46.8
C	0	0	1.56	0.57	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	43.7
D	0	0	0.52	1.14	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	52.6
E	0	0	1.04	1.14	0.20	0.20	2.20	0.59	0.50	1.66	0.02	7.6	47.0

EC-BS: Ethylene Carbonate Bissuccinimide

B-BS: Borated Bissuccinimide

5 CI: Corrosion Inhibitor

MC: Molybdenum Complex

AO: Antioxidant

ZDDP: Zinc Dialkylthiophosphate

FI: Foam Inhibitor

10 VII: Viscosity Index Improver

STBT: Soot Thickening Bench Test (depicts percent viscosity increase)

Example 4 - XC1571

Preparation of Oil Soluble Lubricating Oil Additive

3700 grams of terpolymer PIBSA prepared according to Example 1 were charged to a
5 reactor under a nitrogen purge and heated to a temperature of 140°C. The charged
polymer was put under a vacuum for 45-60 minutes. In the same reactor,
778.7 grams of diluent oil were charged. In the same reactor, 62.8 grams of
N-phenylphenylenediamine (N-PPDA) were charged under a nitrogen purge.
568.0 grams of polyethyleneoxide diamine (PEO DA, having an approximate number
10 average molecular weight of 1000) were slowly charged to the same reactor under a
nitrogen purge. The reactor was heated to 150°C under a nitrogen purge. The reactor
was put under a vacuum for 1.5 hours to remove excess water. The charge mole ratio
of N-PPDA to anhydride was 0.20. The charge mole ratio of PEO DA to anhydride
was 0.33.

15

Sample 13

Preparation of Lubricating Oil Composition

In a stainless steel vessel, 5.0 wt% of the lubricating oil additive prepared in
20 Example 4 was top treated to a fully formulated oil. The fully formulated oil
comprised 0.20 wt% corrosion inhibitor, 0.20 wt% molybdenum complex,
0.20 wt% friction modifier, 2.95 wt% phenate-based detergent,
0.59 wt% sulfonate-based detergent, 0.27 wt% high overbased calcium sulfonate,
0.40 wt% antioxidant 1.89 wt% zinc dithiophosphate, 0.02 wt% foam inhibitor,
25 0.20 wt% pour point depressant, and 6.6 wt% viscosity index improver. In the same
vessel, the blended additive package was added to a mixture of basestocks which
consists of 67 wt% Group 2 base oil, and 33.0 wt% Group 1 base oil to provide the
lubricating oil composition of the present invention. The formulation and result of
Sample 13 are listed in Table 2.

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In Samples 14-15, the concentration of the EC-Treated Bissuccinimide was varied
while keeping constant the values of the other additives in Sample 13, except

Example 4 was charged at 3.0 wt%. The formulations and results of **Samples 14-15** are listed in Table 2.

In Comparative Samples F-J, the concentration of the EC-Treated Bissuccinimide was
5 varied while keeping constant the values of the other additives in Sample 13, except **Example 4** was omitted from the formulations. The formulations and results of Comparative Samples F-J are listed in Table 2.

Table 2

Sample	Ex. 4 (wt%)	EC- BS (wt%)	CI (wt%)	MC (wt%)	FM (wt%)	PPD (wt%)	Phenate (wt%)	Sulfonate (wt%)	HOB (wt%)	AO (wt%)	ZDDP (wt%)	FI (wt%)	VII (wt%)	STBT Results
13	2.5	0.52	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	105.3
14	1.5	1.04	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	101.8
15	1.5	1.56	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	97.2
F	0	0.0	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	TVTM
G	0	0.52	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	TVTM
H	0	1.04	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	TVTM
I	0	1.56	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	TVTM
J	0	2.08	0.20	0.20	0.20	0.20	2.95	0.59	0.27	0.4	1.89	0.02	6.6	TVTM

EC-BS:

CI:

5 MC:

FM:

PPD:

HOB:

AO:

10 ZDDP:

FI:

VII:

STBT:

TVTM:

Ethylene Carbonate Bissuccinimide

Corrosion Inhibitor

Molybdenum Complex

Friction Modifier

Pour Point Depressant

HOB Calcium Sulfonate

Antioxidant

Zinc Dialkylthiophosphate

Foam Inhibitor

Viscosity Index Improver

Soot Thickening Bench Test (depicts percent viscosity increase)

Too Viscous To Measure (> 200 % viscosity increase)

Percent Viscosity Increase - Results

Samples 1-15, which exemplify the lubricating oil additive composition of the present invention, were evaluated for percent viscosity increase using a soot thickening bench test, which measures the ability of the formulation to disperse and control viscosity increase resulting from the addition of carbon black, a soot surrogate. Using the soot thickening bench test, the viscosity of a fresh oil is measured in centistokes. The fresh oil is then treated with 4 wt% Vulcan™ XC72R carbon black, supplied by Cabot Chemical Co., to form a mixture containing approximately 4 grams Vulcan™ XC72R carbon black and 96 grams fresh oil (test oil). The test oil, which contains carbon black, is allowed to soak, non-agitated, under ambient conditions for 16 hours. The test oil is then homogenized using a high speed tissue homogenizer for 60 seconds to thoroughly mix the carbon black with the fresh oil. The resulting test oil containing carbon black is then degassed at 100°C for 30 minutes. The viscosity of the oil containing carbon black is measured according to methods that are well known in the art. The percent viscosity increase is calculated according to the following formula:

$$\% \text{ viscosity increase} = [(\text{vis}_{\text{cbo}} - \text{vis}_{\text{fo}}) / (\text{vis}_{\text{fo}}) \times 100]$$

where:

vis_{cbo} : viscosity of carbon black in oil

vis_{fo} : viscosity of fresh oil

Using the soot thickening bench test, the percent viscosity increase calculated for the additive composition of Samples 1-15 in a formulated oil was compared to a formulated oil that does not contain a lubricating oil additive composition of the present invention (see Samples A-J).

The results of the soot thickening bench test for the Samples of the present invention and the Comparative Samples are summarized in Tables 1 and 2.

The results of the soot thickening bench test indicate that the percent viscosity increase using the lubricating oil additive composition of the present invention in

conjunction with at least one post treated bissuccinimide was lower than the percent viscosity increase of a lubricant formulation that does not contain the lubricating oil additive composition of the present invention. The percent viscosity increase was especially high when only one post treated bissuccinimide was used without the
5 lubricating oil additive of the present invention. As shown in Table 2, those fully formulated oils that were top-treated with only the post treated bissuccinimide (i.e., ethylene carbonate treated bissuccinimide) were too viscous to measure in the bench test. These test results illustrate that the lubricating oil additive composition of the present invention has good dispersant properties.

10

It is understood that although modifications and variations of the invention can be made without departing from the scope thereof, only such limitations should be imposed as are indicated in the appended claims.

WHAT IS CLAIMED IS:

1. A lubricating oil additive composition comprising:
 - 5 I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting
 - (A) at least one of the following copolymers:
 - 10 (i) a copolymer obtained by free radical copolymerization of components comprising:
 - (a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or
 15 C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;
 - (b) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to
 20 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and
 - (c) at least one monoolefin compound which is
 25 copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:
 - 30 (1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy substituted or is unsubstituted, and containing 1 to 40 carbon atoms;

- 5 (2) an alkyl amine and an N-alkylamide of a monoethylenically unsaturated mono- or dicarboxylic acid of 3 to 10 carbon atoms where the alkyl substituent contains 1 to 40 carbon atoms;
- 10 (3) an N-vinylcarboxamide of carboxylic acids of 1 to 8 carbon atoms;
- 10 (4) an N-vinyl substituted nitrogen-containing heterocyclic compound; and
- 15 (5) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof, provided that
- 20 the olefin employed is not the same as the olefin employed in (i)(b);
- 25 (ii) a copolymer obtained by reacting compound (i)(a) and compound(i)(b) in the presence of a free radical initiator; or
- 30 (iii) a copolymer obtained by (a) reacting compound (i)(a) with compound (i)(b) or (i)(c) in a non-free radical catalyzed reaction in the presence of copolymer (i) or copolymer (ii) or both; or by (b) contacting copolymer (i) or copolymer (ii) or both with the non-free radical catalyzed reaction product of compound (i)(a) and compound (i)(b) or (i)(c);

with

5 (B) at least one ether compound selected from the group consisting of an ether polyamine, a polyether polyamine, a polyether amino alcohol, a polyether amino thiol, and a polyether polyol; and

(C) at least one aromatic amine and

10 II. at least two ashless dispersants other than the lubricating oil additive of I.

2. The lubricating oil additive composition of Claim 1, wherein in copolymer (iii)(b), said copolymer (i) or copolymer (ii) or both are contacted with the
15 non-free radical catalyzed reaction product of compound (i)(a) and compound (i)(b) or (i)(c) in the presence of component (C).

3. The lubricating oil additive composition of Claim 1, wherein the ether compound (B) is a polyether polyamine.
20

4. The lubricating oil additive composition of Claim 3, wherein the polyether polyamine is a polyoxyalkylene diamine wherein each alkylene unit individually contains from 2 to 5 carbon atoms.

25 5. The lubricating oil additive composition of Claim 4 wherein the oxyalkylene moiety is oxyethylene or oxypropylene, or mixtures thereof.

6. The lubricating oil additive composition of Claim 5 wherein the polyether polyamine is polyoxyethylene diamine.
30

7. The lubricating oil additive composition of Claim 1 wherein the copolymer is copolymer (i).

8. The lubricating oil additive composition of Claim 1 wherein the copolymer is copolymer (ii).
9. The lubricating oil additive composition of Claim 8 wherein copolymer (ii) is
5 polyPIBSA, obtained by the free radical catalyzed reaction of maleic anhydride and polyisobutylene.
10. The lubricating oil additive composition of Claim 1 wherein the copolymer is copolymer (iii).
- 10 11. The lubricating oil additive composition of Claim 1 wherein the aromatic amine is selected from a group consisting of N-arylphenylenediamine, aminocarbazole, amino-indazolinone, aminomercaptotriazole, aminoperimidine, and aryloxyphenyleneamine.
- 15 12. The lubricating oil additive composition of Claim 11 wherein the aromatic amine is N-arylphenylenediamine.
13. The lubricating oil additive composition of Claim 12 wherein the
20 N-arylphenylenediamine is N-phenylphenylenediamine.
14. The lubricating oil additive composition of Claim 1 wherein compound (i)(b) of copolymer (i) is polyisobutene having a number average molecular weight (M_n) of about 2300.
- 25 15. The lubricating oil additive composition of Claim 1 wherein (i)(a) is a dicarboxylic acid, anhydride or ester thereof.
16. The lubricating oil additive composition of Claim 15 wherein wherein (i)(a) is
30 maleic anhydride or ester thereof.
17. The lubricating oil additive composition of Claim 1 wherein the monoolefin of (i)(c) is a 1-olefin.

18. The lubricating oil additive composition according to Claim 1 wherein the at least two ashless dispersants comprise a borated dispersant.
19. The lubricating oil additive composition according to Claim 1 wherein the at least two ashless dispersants comprise an ethylene carbonate treated dispersant.
20. The lubricating oil additive composition according to Claim 18 wherein the borated dispersant is a borated bissuccinimide.
21. The lubricating oil additive composition according to Claim 19 wherein the ethylene carbonate treated dispersant is an ethylene carbonate treated bissuccinimide.
22. The lubricating oil additive composition according to Claim 1 wherein the at least two ashless dispersants is a mixture of a borated dispersant and an ethylene carbonate treated dispersant.
23. The lubricating oil additive composition according to Claim 22 wherein the mixture of the borated dispersant and the ethylene carbonate treated dispersant is a mixture of a borated bissuccinimide and an ethylene carbonate treated bissuccinimide.
24. A lubricating oil composition comprising a major amount of an oil of lubricating viscosity and a minor amount of a lubricating oil additive composition comprising:
- I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting
- (A) at least one of the following copolymers:

- (i) a copolymer obtained by free radical copolymerization of components comprising:
- 5 (a) at least one monoethylenically unsaturated C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;
 - 10 (b) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and
 - 15 (c) at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:
 - 20 (1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy substituted or is unsubstituted, and containing 1 to 40 carbon atoms;
 - 25 (2) an alkyl amine and an N-alkylamide of a monoethylenically unsaturated mono- or dicarboxylic acid of 3 to 10 carbon atoms where the alkyl substituent
 - 30 (3) an N-vinylcarboxamide of carboxylic acids of 1 to 8 carbon atoms;

- 5 (4) an N-vinyl substituted nitrogen-
containing heterocyclic compound; and
- 10 (5) at least one 1-olefin comprising 2 to
40 carbon atoms or at least one
polyolefin comprising 4 to 360 carbon
atoms and having a terminal
copolymerizable group in the form of a
vinyl, vinylidene or alkyl vinylidene
group or mixtures thereof, provided that
the olefin employed is not the same as
the olefin employed in (i)(b);
- 15 (ii) a copolymer obtained by reacting compound (i)(a) and
compound(i)(b) in the presence of a free radical
initiator; or
- 20 (iii) a copolymer obtained by (a) reacting compound (i)(a)
with compound (i)(b) or (i)(c) in a non-free radical
catalyzed reaction in the presence of copolymer (i) or
copolymer (ii) or both; or by (b) contacting copolymer
(i) or copolymer (ii) or both with the non-free radical
catalyzed reaction product of compound (i)(a) and
compound (i)(b) or (i)(c);
- 25 with
- 30 (B) at least one ether compound selected from the group consisting
of an ether polyamine, a polyether polyamine, a polyether
amino alcohol, a polyether amino thiol, and a polyether polyol;
and
- (C) at least one aromatic amine and

II. at least two ashless dispersants other than the lubricating oil additive of I.

25. The lubricating oil composition according to Claim 24 wherein the at least two ashless dispersants comprise a borated dispersant.
26. The lubricating oil composition according to Claim 24 wherein the at least two ashless dispersants comprise an ethylene carbonate treated dispersant.
27. The lubricating oil composition according to Claim 25 wherein the borated dispersant is a borated bissuccinimide.
28. The lubricating oil composition according to Claim 26 wherein the ethylene carbonate treated dispersant is an ethylene carbonate treated bissuccinimide.
29. The lubricating oil composition according to Claim 24 wherein the at least two ashless dispersants is a mixture of a borated dispersant and an ethylene carbonate treated dispersant.
30. The lubricating oil composition according to Claim 29 wherein the mixture of the borated dispersant and the ethylene carbonate treated dispersant is a mixture of a borated bissuccinimide and an ethylene carbonate treated bissuccinimide.
31. The lubricating oil composition according to Claim 30 comprising from about 0.1 wt% to about 5.0 wt% borated bissuccinimide and from about 0.1 wt% to about 5.0 wt% ethylene carbonate treated bissuccinimide.
32. The lubricating oil composition according to Claim 31 comprising from about 1.0 wt% to about 5.0 wt% of the borated bissuccinimide and from about 1.0 wt% to about 4.0 wt% of the ethylene carbonate treated bissuccinimide.

33. The lubricating oil composition according to Claim 32 comprising from about 1.0 wt% to about 4.0 wt% borated bissuccinimide and from about 2.0 wt% to about 3.0 wt% ethylene carbonate treated bissuccinimide.
- 5 34. The lubricating oil composition according to Claim 24 further comprises at least one overbased detergent.
35. The lubricating oil composition according to Claim 24 further comprises at least one anti-wear additive.
- 10 36. The lubricating oil composition according to Claim 24 further comprises at least one anti-oxidant additive.
37. A method of making a lubricating oil additive composition comprising mixing
- 15 I. an oil-soluble lubricating oil additive prepared by the process which comprises reacting
- (A) at least one of the following copolymers:
- 20 (i) a copolymer obtained by free radical copolymerization of components comprising:
- (a) at least one monoethylenically unsaturated
- 25 C₃-C₂₈ monocarboxylic acid or ester thereof, or C₄-C₂₈ dicarboxylic acid, anhydride or ester thereof;
- (b) at least one 1-olefin comprising 2 to 40 carbon
- 30 atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene group or mixtures thereof; and

- 5
- (c) at least one monoolefin compound which is copolymerizable with the monomers of (a) and (b) and is selected from the group consisting of:
- 10
- (1) an alkyl vinyl ether and an allyl alkyl ether where the alkyl group is hydroxyl, amino, dialkylamino or alkoxy substituted or is unsubstituted, and containing 1 to 40 carbon atoms;
- 15
- (2) an alkyl amine and an N-alkylamide of a monoethylenically unsaturated mono- or dicarboxylic acid of 3 to 10 carbon atoms where the alkyl substituent contains 1 to 40 carbon atoms;
- 20
- (3) an N-vinylcarboxamide of carboxylic acids of 1 to 8 carbon atoms;
- (4) an N-vinyl substituted nitrogen-containing heterocyclic compound; and
- 25
- (5) at least one 1-olefin comprising 2 to 40 carbon atoms or at least one polyolefin comprising 4 to 360 carbon atoms and having a terminal copolymerizable group in the form of a vinyl, vinylidene or alkyl vinylidene
- 30
- group or mixtures thereof, provided that the olefin employed is not the same as the olefin employed in (i)(b);

- (ii) a copolymer obtained by reacting compound (i)(a) and compound (i)(b) in the presence of a free radical initiator; or
- 5 (iii) a copolymer obtained by (a) reacting compound (i)(a) with compound (i)(b) or (i)(c) in a non-free radical catalyzed reaction in the presence of copolymer (i) or copolymer (ii) or both; or by (b) contacting copolymer (i) or copolymer (ii) or both with the non-free radical
- 10 catalyzed reaction product of compound (i)(a) and compound (i)(b) or (i)(c);
- with
- (B) at least one ether compound selected from the group consisting
- 15 of an ether polyamine, a polyether polyamine, a polyether amino alcohol, a polyether amino thiol, and a polyether polyol; and
- (C) at least one aromatic amine and
- 20
- II. at least two ashless dispersants other than the lubricating oil additive of I.
38. The method of making the lubricating oil additive composition according to
- 25 Claim 37 wherein the at least two ashless dispersants comprise a borated dispersant.
39. The method of making the lubricating oil additive composition according to
- 30 Claim 37 wherein the at least two ashless dispersants comprise an ethylene carbonate treated dispersant.
40. The method of making the lubricating oil additive composition according to Claim 38 wherein the borated dispersant is a borated bissuccinimide.

41. The method of making the lubricating oil additive composition according to Claim 39 wherein the ethylene carbonate treated dispersant is an ethylene carbonate treated bissuccinimide.
- 5 42. The method of making the lubricating oil additive composition according to Claim 37 wherein the at least two ashless dispersants is a mixture of a borated dispersant and an ethylene carbonate treated dispersant.
- 10 43. A method of making a lubricating oil composition comprising mixing the lubricating oil additive composition of Claim 1 with a major amount of an oil of lubricating viscosity.
- 15 44. A method of improving soot dispersancy in an internal combustion engine which comprises operating the engine with a lubricating oil composition comprising a major amount of oil of lubricating viscosity and an effective amount of the lubricating oil additive composition of Claim 1.