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(54) **Title:** OXYGEN SCAVENGERS, COMPOSITIONS COMPRISING THE SCAVENGERS, AND ARTICLES MADE FROM THE COMPOSITIONS

(57) **Abstract:** The present disclosure relates to oxygen scavenging molecules, compositions comprising the molecules, and articles made from the compositions.

**OXYGEN SCAVENGERS, COMPOSITIONS COMPRISING THE SCAVENGERS,
AND ARTICLES MADE FROM THE COMPOSITIONS**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to United States Provisional Patent application no. 61/261,158, filed November 13, 2009, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] It is known in the art to include an oxygen scavenger in the packaging structure for the protection of oxygen sensitive materials. Such scavengers are believed to react with oxygen that is trapped in the package or that permeates from outside of the package, thus extending to life of package contents. These packages include films, bottles, containers, and the like. Food, beverages (such as beer and fruit juices), cosmetics, medicines, and the like are particularly sensitive to oxygen exposure and require high barrier properties to oxygen to preserve the freshness of the package contents and avoid changes in flavor, texture and color.

[0003] Use of certain polyamides in combination with a transition metal is known to be useful as the oxygen scavenging material. One particularly useful polyamide is MXD6 which contains meta-xylene residues in the polymer chain. See, for example, U.S. Pat. Nos. 5,639,815; 5,049,624; and 5,021,515.

[0004] Other oxygen scavengers include potassium sulfite (U.S. Pat. No. 4,536,409), unsaturated hydrocarbons (U.S. Pat. No. 5,211,875), and ascorbic acid derivatives (U.S. Pat. No. 5,075,362).

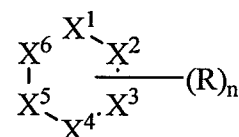
[0005] In barrier layers of packaging walls that are made from blends of oxygen scavenging materials with base polymer resins such as PET, haze can result due to such factors as the immiscibility of the scavenging materials with the base polymer resins and the inability to create by mechanical blending means disperse-phase domains that are so small as not to interfere with the passage of light therethrough; and the adverse influence of the scavenging material on the crystallization behavior of PET base resin. One approach to minimizing such haze is careful selection of base resin to improve dispersibility of the scavenger material and, thus, reduce, but not substantially eliminate, haze; and to minimize

the adverse crystallization effect. This approach may undesirably narrowly restrict the choice of base polymer resin. Another approach is to use compositions that serve as compatibilizers to reduce haze. These approaches add cost to the layer and the compatibilizer adds an additional material that must be evaluated for its suitability for contact with food. Thus, there is a need in the art for improved materials which provide high oxygen scavenging capability and are substantially transparent.

SUMMARY

[0006] The melt blended polymer compositions disclosed herein comprise:

- a) a thermoplastic polymer; and
- b) a transition metal in a positive oxidation state, the metal present in an amount of from about 10 ppm to about 400 ppm
- c) a compound having the formula:



wherein X^1 , X^2 , X^3 , X^4 , X^5 , and X^6 are each independently:

- i) $=\text{CR}^1-$;
- ii) $=\text{N}-$;
- iii) $-\text{O}-$; or
- iv) $-\text{S}-$;

or when an R group is present, R^1 is equal to R;

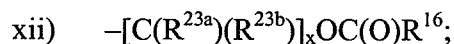
each R^1 is independently chosen from:

- i) hydrogen;
- ii) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
- iii) C_2 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkenyl;
- iv) C_2 - C_{12} substituted or unsubstituted linear or branched alkynyl;
- v) C_6 or C_{10} substituted or unsubstituted aryl;
- vi) C_1 - C_9 substituted or unsubstituted heterocyclic;
- vii) C_1 - C_{11} substituted or unsubstituted heteroaryl;
- viii) halogen;
- ix) $-\text{[C}(\text{R}^{23a})(\text{R}^{23b})\text{]}_x\text{OR}^{10}$;

R^{10} is chosen from:

- a) -H;
- b) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- c) C₆ or C₁₀ substituted or unsubstituted aryl or alkylenearyl;
- d) C₁-C₉ substituted or unsubstituted heterocyclic;
- e) C₁-C₁₁ substituted or unsubstituted heteroaryl;
- x) $-[C(R^{23a})(R^{23b})]_x N(R^{11a})(R^{11b})$;
 R^{11a} and R^{11b} are each independently chosen from:
- a) -H;
- b) -OR¹²;
- R¹² is hydrogen or C₁-C₄ linear alkyl;
- c) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- d) C₆ or C₁₀ substituted or unsubstituted aryl;
- e) C₁-C₉ substituted or unsubstituted heterocyclic;
- f) C₁-C₁₁ substituted or unsubstituted heteroaryl; or
- g) R^{11a} and R^{11b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xi) $-[C(R^{23a})(R^{23b})]_x C(O)R^{13}$;
 R¹³ is:
- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) -OR¹⁴;
- R¹⁴ is hydrogen, substituted or unsubstituted C₁-C₄ linear alkyl, C₆ or C₁₀ substituted or unsubstituted aryl, C₁-C₉ substituted or unsubstituted heterocyclic, C₁-C₁₁ substituted or unsubstituted heteroaryl;
- c) $-N(R^{15a})(R^{15b})$;
 R^{15a} and R^{15b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{15a} and R^{15b} can be taken

together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;

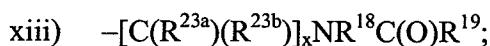


R¹⁶ is:

a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;



R^{17a} and R^{17b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{17a} and R^{17b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;



R¹⁸ is:

a) -H; or

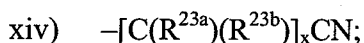
b) C₁-C₄ substituted or unsubstituted linear, branched, or cyclic alkyl;

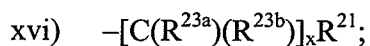
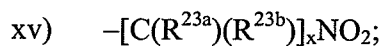
R¹⁹ is:

a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;

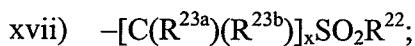


R^{20a} and R^{20b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{20a} and R^{20b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;





R^{21} is C_1 - C_{10} linear, branched, or cyclic alkyl substituted by from 1 to 21 halogen atoms chosen from $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, or $-\text{I}$;

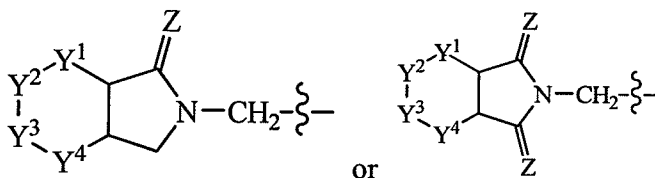


R^{22} is hydrogen, hydroxyl, substituted or unsubstituted C_1 - C_4 linear or branched alkyl; substituted or unsubstituted C_6 , C_{10} , or C_{14} aryl; C_7 - C_{15} alkylenearyl; C_1 - C_9 substituted or unsubstituted heterocyclic; or C_1 - C_{11} substituted or unsubstituted heteroaryl; or

xviii) R^1 units on two adjacent carbons can be taken together to form a substituted or unsubstituted 5, 6, or 7 member fused ring comprising one or more heteroatoms chosen from nitrogen, oxygen, or sulfur, and wherein the fused ring can be substituted by C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or when one of the ring atoms is a carbon, the atom can be substituted with carbonyl having the formula $=\text{O}$, or imide having the formula $=\text{NH}$;

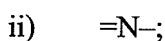
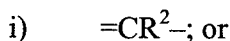
R^{23a} and R^{23b} are each independently hydrogen or C_1 - C_4 alkyl; and the index x is an integer from 0 to 5;

R is has the formula:



each Z is independently O , NH , or S ;

Y^1 , Y^2 , Y^3 , and Y^4 are each independently:



each R^2 is independently chosen from:

- i) hydrogen;
- ii) substituted or unsubstituted C_1 - C_{10} linear, branched, or cyclic alkyl;
- iii) substituted or unsubstituted C_2 - C_{10} linear, branched, or cyclic alkenyl;
- iv) substituted or unsubstituted C_2 - C_{10} linear or branched alkynyl;
- v) substituted or unsubstituted C_6 or C_{10} aryl;

- vi) substituted or unsubstituted C₁-C₉ heterocyclic;
- vii) substituted or unsubstituted C₁-C₉ heteroaryl; or

two R² units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or unsubstituted heteroaryl ring having from 2 to 20 carbon atoms and from 1 to 7 heteroatoms; and n is an integer from 0 to 6

[0007] Also disclosed herein are methods of making the disclosed compositions.

[0008] Also disclosed herein are methods of preparing articles from the disclosed compositions.

[0009] Additional advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or can be learned by practice of the invention. The advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a plot showing oxygen scavenging ability of a disclosed composition.

[0011] Figure 2 is a plot showing oxygen scavenging ability of a disclosed composition.

DETAILED DESCRIPTION

[0012] In this specification and in the claims that follow, reference will be made to a number of terms that shall be defined to have the following meanings:

[0013] Throughout this specification, unless the context requires otherwise, the word "comprise," or variations such as "comprises" or "comprising," will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

[0014] It must be noted that, as used in the specification and the appended claims, the singular forms "a," "an" and "the" include plural referents unless the context clearly dictates

otherwise. Thus, for example, reference to “a carrier” includes mixtures of two or more such carriers, and the like.

[0015] “Optional” or “optionally” means that the subsequently described event or circumstance can or cannot occur, and that the description includes instances where the event or circumstance occurs and instances where it does not.

[0016] Ranges may be expressed herein as from “about” one particular value, and/or to “about” another particular value. When such a range is expressed, another aspect includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent “about,” it will be understood that the particular value forms another aspect. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint.

[0017] A weight percent of a component, unless specifically stated to the contrary, is based on the total weight of the formulation or composition in which the component is included.

[0018] As used herein, “master batch” refers to a mixture of base polymer, oxidizable organic component, and transition metal that will be diluted, typically with at least additional base polymer, prior to forming an article. As such, the concentrations of oxidizable organic component and transition metal are higher than in the formed article.

[0019] “Admixture” or “blend” is generally used herein means a physical combination of two or more different components.

[0020] The terms “electron-withdrawing” or “electron-donating” refer to the ability of a substituent to withdraw or donate electrons relative to that of hydrogen if hydrogen occupied the same position in the molecule. These terms are well-understood by one skilled in the art and are discussed, for example, in *Advanced Organic Chemistry* by J. March, 1985, pp. 16-18.

[0021] As used herein, the description of one or more method steps does not preclude the presence of additional method steps before or after the combined recited steps. Additional steps can also be intervening steps to those described. In addition, it is understood that the lettering of process steps or ingredients is a convenient means for

identifying discrete activities or ingredients and the recited lettering can be arranged in any sequence.

[0022] Where a range of numbers is presented in the application, it is understood that the range includes all integers and fractions thereof between the stated range limits. A range of numbers expressly includes numbers less than the stated endpoints and those in-between the stated range. A range of from 1-3, for example, includes the integers one, two, and three as well as any fractions that reside between these integers.

[0023] The following chemical hierarchy is used throughout the specification to describe and enable the scope of the present disclosure and to particularly point out and distinctly claim the units which comprise the compounds of the present disclosure, however, unless otherwise specifically defined, the terms used herein are the same as those of the artisan of ordinary skill. The term “hydrocarbyl” stands for any carbon atom-based unit (organic molecule), said units optionally containing one or more organic functional group, including inorganic atom comprising salts, *inter alia*, carboxylate salts, quaternary ammonium salts. Within the broad meaning of the term “hydrocarbyl” are the classes “acyclic hydrocarbyl” and “cyclic hydrocarbyl” which terms are used to divide hydrocarbyl units into cyclic and non-cyclic classes.

[0024] As it relates to the following definitions, “cyclic hydrocarbyl” units can comprise only carbon atoms in the ring (carbocyclic and aryl rings) or can comprise one or more heteroatoms in the ring (heterocyclic and heteroaryl). For “carbocyclic” rings the lowest number of carbon atoms in a ring are 3 carbon atoms; cyclopropyl. For “aryl” rings the lowest number of carbon atoms in a ring are 6 carbon atoms; phenyl. For “heterocyclic” rings the lowest number of carbon atoms in a ring is 1 carbon atom; diazirinyl. Ethylene oxide comprises 2 carbon atoms and is a C₂ heterocycle. For “heteroaryl” rings the lowest number of carbon atoms in a ring is 1 carbon atom; 1,2,3,4-tetrazolyl. The following is a non-limiting description of the terms “acyclic hydrocarbyl” and “cyclic hydrocarbyl” as used herein.

[0025] A. Substituted and unsubstituted acyclic hydrocarbyl:

For the purposes of the present disclosure the term “substituted and unsubstituted acyclic hydrocarbyl” encompasses 3 categories of units:

- 1) linear or branched alkyl, non-limiting examples of which include, methyl (C₁), ethyl (C₂), n-propyl (C₃), *iso*-propyl (C₃), n-butyl (C₄), *sec*-butyl (C₄), *iso*-butyl (C₄), *tert*-butyl (C₄), and the like; substituted linear or branched alkyl, non-limiting examples of which includes, hydroxymethyl (C₁), chloromethyl (C₁), trifluoromethyl (C₁), aminomethyl (C₁), 1-chloroethyl (C₂), 2-hydroxyethyl (C₂), 1,2-difluoroethyl (C₂), 3-carboxypropyl (C₃), and the like.
- 2) linear or branched alkenyl, non-limiting examples of which include, ethenyl (C₂), 3-propenyl (C₃), 1-propenyl (*also* 2-methylethenyl) (C₃), isopropenyl (*also* 2-methylethen-2-yl) (C₃), buten-4-yl (C₄), and the like; substituted linear or branched alkenyl, non-limiting examples of which include, 2-chloroethenyl (*also* 2-chlorovinyl) (C₂), 4-hydroxybuten-1-yl (C₄), 7-hydroxy-7-methyloct-4-en-2-yl (C₉), 7-hydroxy-7-methyloct-3,5-dien-2-yl (C₉), and the like.
- 3) linear or branched alkynyl, non-limiting examples of which include, ethynyl (C₂), prop-2-ynyl (*also* propargyl) (C₃), propyn-1-yl (C₃), and 2-methyl-hex-4-yn-1-yl (C₇); substituted linear or branched alkynyl, non-limiting examples of which include, 5-hydroxy-5-methylhex-3-ynyl (C₇), 6-hydroxy-6-methylhept-3-yn-2-yl (C₈), 5-hydroxy-5-ethylhept-3-ynyl (C₉), and the like.

[0026] B. Substituted and unsubstituted cyclic hydrocarbyl:

For the purposes of the present disclosure the term “substituted and unsubstituted cyclic hydrocarbyl” encompasses 5 categories of units:

- 1) The term “carbocyclic” is defined herein as “encompassing rings comprising from 3 to 20 carbon atoms, wherein the atoms which comprise said rings are limited to carbon atoms, and further each ring can be independently substituted with one or more moieties capable of replacing one or more hydrogen atoms.” The following are non-limiting examples of “substituted and unsubstituted carbocyclic rings” which encompass the following categories of units:
 - i) carbocyclic rings having a single substituted or unsubstituted hydrocarbon ring, non-limiting examples of which include, cyclopropyl (C₃), 2-methyl-cyclopropyl (C₃), cyclopropenyl (C₃), cyclobutyl (C₄), 2,3-dihydroxycyclobutyl (C₄), cyclobutenyl (C₄), cyclopentyl (C₅), cyclopentenyl (C₅), cyclopentadienyl (C₅), cyclohexyl (C₆), cyclohexenyl (C₆), cycloheptyl (C₇), cyclooctanyl (C₈), 2,5-dimethylcyclopentyl (C₅), 3,5-dichlorocyclohexyl (C₆), 4-hydroxycyclohexyl (C₆), and 3,3,5-trimethylcyclohex-1-yl (C₆).

- ii) carbocyclic rings having two or more substituted or unsubstituted fused hydrocarbon rings, non-limiting examples of which include, octahydropentalenyl (C₈), octahydro-1*H*-indenyl (C₉), 3*a*,4,5,6,7,7*a*-hexahydro-3*H*-inden-4-yl (C₉), decalinyl (C₁₀), decahydroazulenyl (C₁₀).
 - iii) carbocyclic rings which are substituted or unsubstituted bicyclic hydrocarbon rings, non-limiting examples of which include, bicyclo-[2.1.1]hexanyl, bicyclo[2.2.1]heptanyl, bicyclo[3.1.1]heptanyl, 1,3-dimethyl[2.2.1]heptan-2-yl, bicyclo[2.2.2]octanyl, and bicyclo[3.3.3]undecanyl.
- 2) The term “aryl” is defined herein as “units encompassing at least one phenyl or naphthyl ring and wherein there are no heteroaryl or heterocyclic rings fused to the phenyl or naphthyl ring and further each ring can be independently substituted with one or more moieties capable of replacing one or more hydrogen atoms.” The following are non-limiting examples of “substituted and unsubstituted aryl rings” which encompass the following categories of units:
- i) C₆ or C₁₀ substituted or unsubstituted aryl rings; phenyl and naphthyl rings whether substituted or unsubstituted, non-limiting examples of which include, phenyl (C₆), naphthylen-1-yl (C₁₀), naphthylen-2-yl (C₁₀), 4-fluorophenyl (C₆), 2-hydroxyphenyl (C₆), 3-methylphenyl (C₆), 2-amino-4-fluorophenyl (C₆), 2-(*N,N*-diethylamino)phenyl (C₆), 2-cyanophenyl (C₆), 2,6-di-*tert*-butylphenyl (C₆), 3-methoxyphenyl (C₆), 8-hydroxynaphthylen-2-yl (C₁₀), 4,5-dimethoxynaphthylen-1-yl (C₁₀), and 6-cyano-naphthylen-1-yl (C₁₀).
 - ii) C₆ or C₁₀ aryl rings fused with 1 or 2 saturated rings non-limiting examples of which include, bicyclo[4.2.0]octa-1,3,5-trienyl (C₈), and indanyl (C₉).
- 3) The terms “heterocyclic” and/or “heterocycle” are defined herein as “units comprising one or more rings having from 3 to 20 atoms wherein at least one atom in at least one ring is a heteroatom chosen from nitrogen (N), oxygen (O), or sulfur (S), or mixtures of N, O, and S, and wherein further the ring which comprises the heteroatom is also not an aromatic ring.” The following are non-limiting examples of “substituted and unsubstituted heterocyclic rings” which encompass the following categories of units:
- i) heterocyclic units having a single ring containing one or more heteroatoms, non-limiting examples of which include, diazirinyl (C₁), aziridinyl (C₂), urazolyl (C₂), azetidiny (C₃), pyrazolidinyl (C₃), imidazolidinyl (C₃), oxazolidinyl (C₃), isoxazoliny (C₃), thiazolidinyl (C₃), isothiazoliny (C₃), oxathiazolidinonyl (C₃),

oxazolidinonyl (C₃), hydantoinyl (C₃), tetrahydrofuranyl (C₄), pyrrolidinyl (C₄), morpholinyl (C₄), piperazinyl (C₄), piperidinyl (C₄), dihydropyranyl (C₅), tetrahydropyranyl (C₅), piperidin-2-onyl (valerolactam) (C₅), 2,3,4,5-tetrahydro-1*H*-azepinyl (C₆), 2,3-dihydro-1*H*-indole (C₈), and 1,2,3,4-tetrahydro-quinoline (C₉).

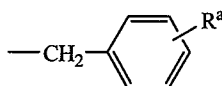
ii) heterocyclic units having 2 or more rings one of which is a heterocyclic ring, non-limiting examples of which include hexahydro-1*H*-pyrroliziny (C₇), 3a,4,5,6,7,7a-hexahydro-1*H*-benzo[d]imidazolyl (C₇), 3a,4,5,6,7,7a-hexahydro-1*H*-indolyl (C₈), 1,2,3,4-tetrahydroquinolinyl (C₉), and decahydro-1*H*-cycloocta[b]pyrrolyl (C₁₀).

- 4) The term “heteroaryl” is defined herein as “encompassing one or more rings comprising from 5 to 20 atoms wherein at least one atom in at least one ring is a heteroatom chosen from nitrogen (N), oxygen (O), or sulfur (S), or mixtures of N, O, and S, and wherein further at least one of the rings which comprises a heteroatom is an aromatic ring.” The following are non-limiting examples of “substituted and unsubstituted heterocyclic rings” which encompass the following categories of units:

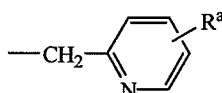
i) heteroaryl rings containing a single ring, non-limiting examples of which include, 1,2,3,4-tetrazolyl (C₁), [1,2,3]triazolyl (C₂), [1,2,4]triazolyl (C₂), triazinyl (C₃), thiazolyl (C₃), 1*H*-imidazolyl (C₃), oxazolyl (C₃), isoxazolyl (C₃), isothiazolyl (C₃), furanyl (C₄), thiophenyl (C₄), pyrimidinyl (C₄), 2-phenylpyrimidinyl (C₄), pyridinyl (C₅), 3-methylpyridinyl (C₅), and 4-dimethylaminopyridinyl (C₅).

ii) heteroaryl rings containing 2 or more fused rings one of which is a heteroaryl ring, non-limiting examples of which include: 7*H*-purinyl (C₅), 9*H*-purinyl (C₅), 6-amino-9*H*-purinyl (C₅), 5*H*-pyrrolo[3,2-*d*]pyrimidinyl (C₆), 7*H*-pyrrolo[2,3-*d*]pyrimidinyl (C₆), pyrido[2,3-*d*]pyrimidinyl (C₇), 2-phenylbenzo[d]thiazolyl (C₇), 1*H*-indolyl (C₈), 4,5,6,7-tetrahydro-1-*H*-indolyl (C₈), quinoxalinyl (C₈), 5-methylquinoxalinyl (C₈), quinazolinyl (C₈), quinolinyl (C₉), 8-hydroxy-quinolinyl (C₉), and isoquinolinyl (C₉).

- 5) C₁-C₆ tethered cyclic hydrocarbyl units (whether carbocyclic units, C₆ or C₁₀ aryl units, heterocyclic units, or heteroaryl units) which connected to another moiety, unit, or core of the molecule by way of a C₁-C₆ alkylene unit. Non-limiting examples of tethered cyclic hydrocarbyl units include benzyl C₁-(C₆) having the formula:



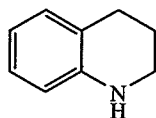
wherein R^a is optionally one or more independently chosen substitutions for hydrogen. Further examples include other aryl units, *inter alia*, (2-hydroxyphenyl)hexyl C₆-(C₆); naphthalen-2-ylmethyl C₁-(C₁₀), 4-fluorobenzyl C₁-(C₆), 2-(3-hydroxy-phenyl)ethyl C₂-(C₆), as well as substituted and unsubstituted C₃-C₁₀ alkylencarbocyclic units, for example, cyclopropylmethyl C₁-(C₃), cyclopentylethyl C₂-(C₅), cyclohexylmethyl C₁-(C₆);. Included within this category are substituted and unsubstituted C₁-C₁₀ alkylene-heteroaryl units, for example a 2-picolyl C₁-(C₆) unit having the formula:



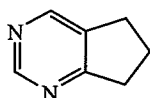
wherein R^a is the same as defined above. In addition, C₁-C₁₂ tethered cyclic hydrocarbyl units include C₁-C₁₀ alkyleneheterocyclic units and alkylene-heteroaryl units, non-limiting examples of which include, aziridinylmethyl C₁-(C₂) and oxazol-2-ylmethyl C₁-(C₃).

[0027] For the purposes of the present disclosure carbocyclic rings are from C₃ to C₂₀; aryl rings are C₆ or C₁₀; heterocyclic rings are from C₁ to C₉; and heteroaryl rings are from C₁ to C₉.

[0028] For the purposes of the present disclosure, and to provide consistency in defining the present disclosure, fused ring units, as well as spirocyclic rings, bicyclic rings and the like, which comprise a single heteroatom will be characterized and referred to herein as being encompassed by the cyclic family corresponding to the heteroatom containing ring, although the artisan can have alternative characterizations. For example, 1,2,3,4-tetrahydroquinoline having the formula:

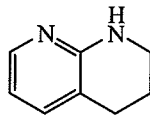


is, for the purposes of the present disclosure, considered a heterocyclic unit. 6,7-Dihydro-5H-cyclopentapyrimidine having the formula:



is, for the purposes of the present disclosure, considered a heteroaryl unit. When a fused ring unit contains heteroatoms in both a saturated ring (heterocyclic ring) and an aryl ring (heteroaryl ring), the aryl ring will predominate and determine the type of category to which

the ring is assigned herein for the purposes of describing the disclosure. For example, 1,2,3,4-tetrahydro-[1,8]naphthyridine having the formula:



is, for the purposes of the present disclosure, considered a heteroaryl unit.

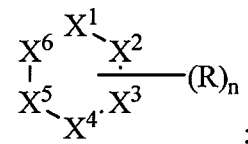
[0029] The term “substituted” is used throughout the specification. The term “substituted” is applied to the units described herein as “substituted unit or moiety is a hydrocarbyl unit or moiety, whether acyclic or cyclic, which has one or more hydrogen atoms replaced by a substituent or several substituents as defined herein below.” The units, when substituting for hydrogen atoms are capable of replacing one hydrogen atom, two hydrogen atoms, or three hydrogen atoms of a hydrocarbyl moiety at a time. In addition, these substituents can replace two hydrogen atoms on two adjacent carbons to form said substituent, new moiety, or unit. For example, a substituted unit that requires a single hydrogen atom replacement includes halogen, hydroxyl, and the like. A two hydrogen atom replacement includes carbonyl, oximino, and the like. A two hydrogen atom replacement from adjacent carbon atoms includes epoxy, and the like. Three hydrogen replacement includes cyano, and the like. The term substituted is used throughout the present specification to indicate that a hydrocarbyl moiety, *inter alia*, aromatic ring, alkyl chain; can have one or more of the hydrogen atoms replaced by a substituent. When a moiety is described as “substituted” any number of the hydrogen atoms can be replaced. For example, 4-hydroxyphenyl is a “substituted aromatic carbocyclic ring (aryl ring)”, (N,N-dimethyl-5-amino)octanyl is a “substituted C₈ linear alkyl unit, 3-guanidinopropyl is a “substituted C₃ linear alkyl unit,” and 2-carboxypyridinyl is a “substituted heteroaryl unit.”

Polymer Composition

[0030] Disclosed herein are polymer compositions comprising one or more oxygen scavengers. The oxygen scavengers can be added during the formation of the polymer composition or the oxygen scavengers can be formed in situ during the formulation of the composition, during the formation of an article of manufacture comprising the composition, or upon curing or other process step chosen by the formulator. The end product oxygen scavenger can be formed in situ by the degradation of a precursor or, alternatively, the oxygen scavenger can result from the break down of an oxygen scavenger in the course of the first scavenger successfully scavenging oxygen.

[0031] As such, disclosed herein are polymer compositions comprising:

- a) a thermoplastic polymer; and
- b) a compound having the formula:

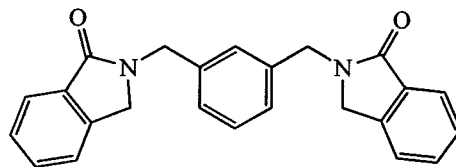


wherein the index n represents the number of R units attached to the core ring. The value of n is an integer from 0 to 6. Each X¹, X², X³, X⁴, X⁵, and X⁶ is independently chosen from:

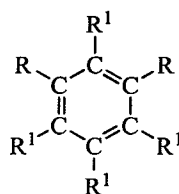
- i) =CR¹-;
- ii) =N-;
- iii) -O-; or
- iv) -S-;

or when one or more R groups are present on the ring, i.e., n is not equal to 0, then the X¹, X², X³, X⁴, X⁵, or X⁶ to which the R unit is attached will have the corresponding formula =CR-.

[0032] For example, a compound having the formula:

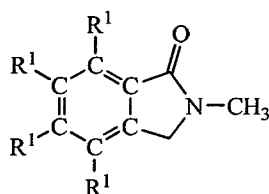


is represented by the formula:



wherein X¹, X³, X⁴, and X⁵ are =CR¹-; X⁶ and X² are =CR-; and the index n is equal to 2.

[0033] As further defined herein, two adjacent R¹ units can be taken together to form a fused ring system, for example, a ring system having the formula:



wherein R¹ can be hydrogen or any substitute for hydrogen as defined herein.

The following are non-limiting examples of units which can substitute for hydrogen when R¹ is not a hydrogen atom:

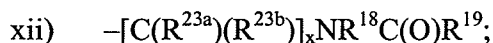
- i) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; for example, methyl (C₁), chloromethyl (C₁), trifluoromethyl (C₁), aminomethyl (C₁), ethyl (C₂), hydroxymethyl 1-chloroethyl (C₂), 2-hydroxyethyl (C₂), 1,2-difluoroethyl (C₂), n-propyl (C₃), *iso*-propyl (C₃), 3-carboxypropyl (C₃), cyclopropyl (C₃), 2-methylcyclopropyl (C₃), n-butyl (C₄), *sec*-butyl (C₄), *iso*-butyl (C₄), *tert*-butyl (C₄), cyclobutyl (C₄), 2,3-dihydroxycyclobutyl (C₄), pentyl (C₅), cyclopentyl (C₅), hexyl (C₆), and cyclohexyl (C₆), and the like;
- ii) C₂-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkenyl; for example, ethenyl (C₂), 2-chloroethenyl (*also* 2-chlorovinyl) (C₂), 3-propenyl (C₃), 1-propenyl (*also* 2-methylethenyl) (C₃), isopropenyl (*also* 2-methylethen-2-yl) (C₃), buten-4-yl (C₄), 4-hydroxybuten-1-yl (C₄), cyclobutenyl (C₄), cyclopentenyl (C₅), cyclopentadienyl (C₅), cyclohexenyl (C₆), 7-hydroxy-7-methyloct-4-en-2-yl (C₉), and 7-hydroxy-7-methyloct-3,5-dien-2-yl (C₉), and the like;
- iii) C₂-C₁₂ substituted or unsubstituted linear or branched alkynyl; for example, ethynyl (C₂), prop-2-ynyl (*also* propargyl) (C₃), propyn-1-yl (C₃), 2-methyl-hex-4-yn-1-yl (C₇); 5-hydroxy-5-methylhex-3-ynyl (C₇), 6-hydroxy-6-methylhept-3-yn-2-yl (C₈), 5-hydroxy-5-ethylhept-3-ynyl (C₉), and the like;
- iv) C₆ or C₁₀ substituted or unsubstituted aryl; for example, phenyl, 2-chlorophenyl, 3-hydroxyphenyl, 4-nitrophenyl, 2-fluoro-4-methylphenyl, 3,5-dinitrophenyl, 8-hydroxynaphth-1-yl, 6-sulfonylnaphth-2-yl, and the like;
- v) C₁-C₉ substituted or unsubstituted heterocyclic; for example, as defined further herein;
- vi) C₁-C₁₁ substituted or unsubstituted heteroaryl; for example, as defined further herein;
- vii) halogen; for example, fluoro, chloro, bromo, and iodo;
- viii) $-\text{[C(R}^{23\text{a}}\text{)(R}^{23\text{b}}\text{)]}_x\text{OR}^{10}$;

R¹⁰ is chosen from:

- a) -H;
- b) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- c) C₆ or C₁₀ substituted or unsubstituted aryl or alkylenearyl;
- d) C₁-C₉ substituted or unsubstituted heterocyclic;

- e) C₁-C₁₁ substituted or unsubstituted heteroaryl;
- ix) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{N(R}^{11a}\text{)(R}^{11b}\text{)}$;
 R^{11a} and R^{11b} are each independently chosen from:
- a) -H;
- b) -OR¹²;
 R¹² is hydrogen or C₁-C₄ linear alkyl;
- c) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- d) C₆ or C₁₀ substituted or unsubstituted aryl;
- e) C₇-C₂₂ substituted or unsubstituted alkylenearyl;
- f) C₁-C₉ substituted or unsubstituted heterocyclic;
- g) C₂-C₂₀ substituted or unsubstituted alkyleneheterocyclic;
- h) C₁-C₁₁ substituted or unsubstituted heteroaryl;
- i) C₂-C₂₀ substituted or unsubstituted alkyleneheteroaryl; or
- j) R^{11a} and R^{11b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- x) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{C(O)R}^{13}$;
 R¹³ is:
- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) -OR¹⁴;
 R¹⁴ is hydrogen, substituted or unsubstituted C₁-C₄ linear alkyl, C₆ or C₁₀ substituted or unsubstituted aryl, C₁-C₉ substituted or unsubstituted heterocyclic, C₁-C₁₁ substituted or unsubstituted heteroaryl;
- c) $-\text{N(R}^{15a}\text{)(R}^{15b}\text{)}$;
 R^{15a} and R^{15b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{15a} and R^{15b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xi) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{OC(O)R}^{16}$;
 R¹⁶ is:
- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) $-\text{N(R}^{17a}\text{)(R}^{17b}\text{)}$;

R^{17a} and R^{17b} are each independently hydrogen, C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or R^{17a} and R^{17b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;



R^{18} is:

a) $-H$; or

b) C_1 - C_4 substituted or unsubstituted linear, branched, or cyclic alkyl;

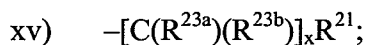
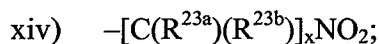
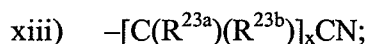
R^{19} is:

a) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;

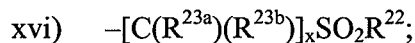
b) $-N(R^{20a})(R^{20b})$;

R^{20a} and R^{20b} are each independently hydrogen, C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or R^{20a} and R^{20b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;

c) R^{18} and R^{19} can be taken together to form a heterocyclic ring, or a fused ring system having from 5 to 20 atoms and from 1 to 4 heteroatoms chosen from oxygen, nitrogen and sulfur;



R^{21} is C_1 - C_{10} linear, branched, or cyclic alkyl substituted by from 1 to 21 halogen atoms chosen from $-F$, $-Cl$, $-Br$, or $-I$;

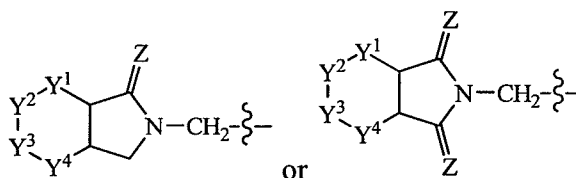


R^{22} is hydrogen, hydroxyl, substituted or unsubstituted C_1 - C_4 linear or branched alkyl; substituted or unsubstituted C_6 , C_{10} , or C_{14} aryl; C_7 - C_{15} alkylenearyl; C_1 - C_9 substituted or unsubstituted heterocyclic; or C_1 - C_{11} substituted or unsubstituted heteroaryl;

R^{23a} and R^{23b} are each independently hydrogen or C_1 - C_4 alkyl; and

the index x is an integer from 0 to 5.

R units have the formula:



wherein Z is O, NH, or S;

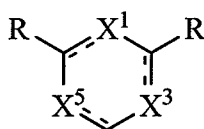
each Y¹, Y², Y³, and Y⁴ unit is independently chosen from:

- i) =CR²-; or
- ii) =N-.

each R² unit is independently chosen from:

- i) hydrogen;
 - ii) substituted or unsubstituted C₁-C₁₀ linear, branched, or cyclic alkyl;
 - iii) substituted or unsubstituted C₂-C₁₀ linear, branched, or cyclic alkenyl;
 - iv) substituted or unsubstituted C₂-C₁₀ linear or branched alkynyl;
 - v) substituted or unsubstituted C₆ or C₁₀ aryl;
 - vi) substituted or unsubstituted C₁-C₉ heterocyclic;
 - vii) substituted or unsubstituted C₁-C₉ heteroaryl; or
- two R² units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or unsubstituted heteroaryl ring having from form 2 to 20 carbon atoms and from 1 to 7 heteroatoms.

[0034] In one aspect the disclosed compounds having one or more heteroatoms in the core ring, the compounds having the formula:

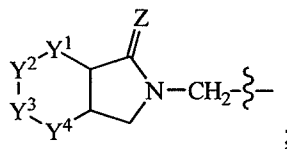


wherein X¹, X³, and X⁵ are each independently chosen from:

- i) =CR¹-;
- ii) =N-;
- iii) -O-; or
- iv) -S-;

and when X¹, X³, or X⁵ are equal to =CR¹- or =N- the dotted line --- represents a potential bond and when X¹, X³, or X⁵ are equal to -O- or -S-, the potential bond represented by the dotted line is absent.

R units of this aspect have the formula:



wherein each Z is independently O, NH, or S; and Y¹, Y², Y³, and Y⁴ are each independently:

- i) =CR²-; or
- ii) =N-.

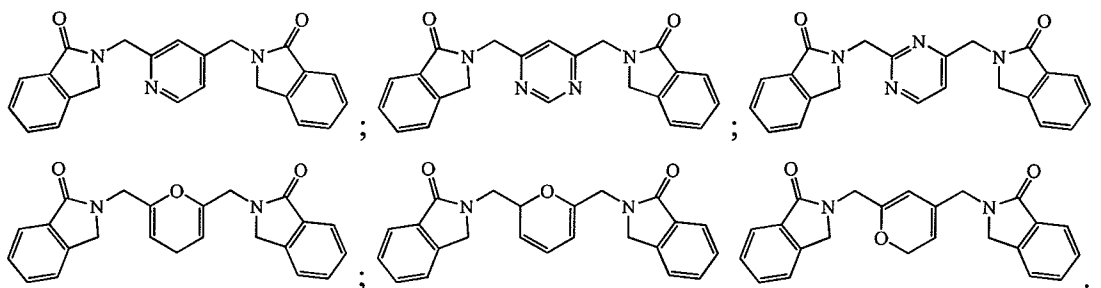
One iteration of this aspect relates to compounds wherein each R¹ is chosen from:

- i) -H;
- ii) -CH₃; or
- iii) -CHO.

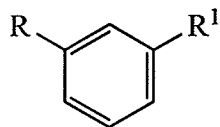
Each R² is independently chosen from:

- i) hydrogen;
- ii) substituted or unsubstituted C₁-C₁₀ linear, branched, or cyclic alkyl;
- iii) substituted or unsubstituted C₂-C₁₀ linear, branched, or cyclic alkenyl;
- iv) substituted or unsubstituted C₂-C₁₀ linear or branched alkynyl;
- v) substituted or unsubstituted C₆ or C₁₀ aryl;
- vi) substituted or unsubstituted C₁-C₉ heterocyclic;
- vii) substituted or unsubstituted C₁-C₉ heteroaryl; or
- viii) two R² units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or unsubstituted heteroaryl ring having from 2 to 20 carbon atoms and from 1 to 7 heteroatoms.

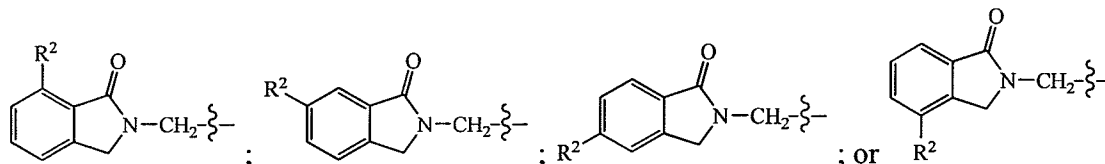
[0035] Non-limiting examples of this aspect include:



[0036] A further aspect relates to compound having the formula:



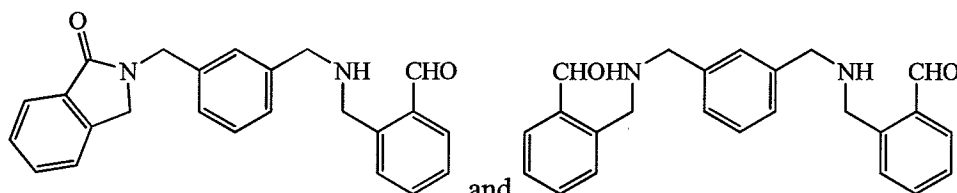
[0037] One embodiment of this aspect relates to compounds wherein R has the formula:



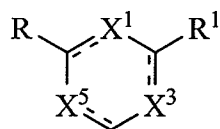
[0038] In one iteration of this embodiment, R^2 is chosen from groups having electron donating properties. Non-limiting examples of electron donating groups include hydroxy, lower alkoxy, lower alkyl, amino, lower alkylamino, di(lower alkyl)amino, aryloxy, mercapto, lower alkylthio, lower alkylmercapto, disulfide and the like, including combinations of these groups.

[0039] In another iteration of this embodiment, R^2 is chosen from groups having electron withdrawing properties. Non-limiting examples of electron withdrawing groups include fluoro, chloro, bromo, nitro, acyl, cyano, carboxyl, C_2 - C_8 alkenyl, C_2 - C_8 alkynyl, carboxaldehyde, carboxyamido, aryl, quaternary ammonium, trifluoro-methyl, alkoxy-carbonyl, aryloxy-carbonyl, aminocarbonyl, sulfonic, alkanesulfonyl, arylsulfonyl, perfluoroalkanesulfonyl, perfluoroarylsulfonyl, phosphoryl, tertiary amine cation and the like, including combinations of these groups.

[0040] In one embodiment, R^1 is $-[C(R^{23a})(R^{23b})]_xN(R^{11a})(R^{11b})$ as defined herein above. In one iteration, R^{11a} is hydrogen, R^{11b} is C_7 - C_{22} substituted or unsubstituted alkylenearyl, R^{23a} and R^{23b} are both hydrogen, and the index x is equal to 1, thereby providing R^1 units having the general formula $-CH_2NHR^{11b}$ wherein R^{11b} is a suitable substituted benzyl, for example, compounds having the formula.



[0041] In another aspect, the compounds have the formula:



wherein X¹, X³, and X⁵ are each independently chosen from:

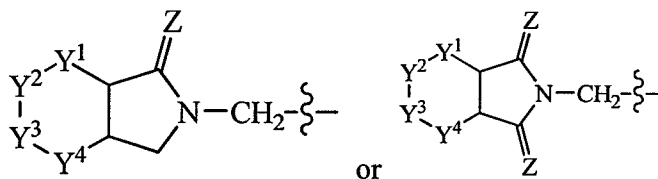
- i) =CR¹-;
- ii) =N-;
- iii) -O-; or
- iv) -S-,

and when X¹, X³, or X⁵ are equal to =CR¹- or =N- the dotted line --- represents a bond and when X¹, X³, or X⁵ are equal to -O- or -S-, the bond represented by the dotted line is absent.

For this aspect, when R¹ is present, R¹ can be

- i) -CH₃; or
- ii) -CHO.

R has the formula:



wherein each Z is independently O, NH, or S; and Y¹, Y², Y³, and Y⁴ are each independently:

- i) =CR²-; or
- ii) =N-.

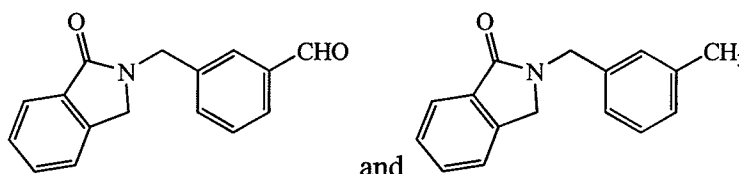
Each R² is independently chosen from:

- i) hydrogen;
- ii) substituted or unsubstituted C₁-C₁₀ linear, branched, or cyclic alkyl;
- iii) substituted or unsubstituted C₂-C₁₀ linear, branched, or cyclic alkenyl;
- iv) substituted or unsubstituted C₂-C₁₀ linear or branched alkynyl;
- v) substituted or unsubstituted C₆ or C₁₀ aryl;
- vi) substituted or unsubstituted C₁-C₉ heterocyclic;
- vii) substituted or unsubstituted C₁-C₉ heteroaryl; or
- viii) two R² units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or unsubstituted heteroaryl ring having from 2 to 20 carbon atoms and from 1 to 7 heteroatoms.

R¹ is chosen from:

- i) -CH₃; or
- ii) -CHO.

[0042] One iteration of this aspect includes the following non-limiting examples:



[0043] The oxygen scavengers described herein are present in an amount of about 1% to about 10% by weight based on the weight of the composition in some embodiments. In other embodiments, the oxygen scavenging compound is present in an amount of about 1% to about 5% by weight based on the weight of the composition. In still other embodiments, the compound is present in an amount of about 1% to about 3% by weight based on the weight of the composition. Also within the scope of the present disclosure are those embodiments where the oxygen scavengers described herein are present in an amount of about 0.1% to about 10% by weight based on the weight of the composition.

[0044] One embodiment disclosed herein further comprises from 30 to 150 ppm of one or more transition metals.

[0045] Other aspects of the disclosure relate to package walls comprising at least one layer, the layer comprising a composition, the composition comprising:

- a) a thermoplastic polymer;
- b) at least one compound of the disclosed oxygen scavengers; and
- c) at least one transition metal in a positive oxidation state, i.e., M^{+m}, wherein m

is an integer from 1 to 8, the metal being present in the composition in an amount of from about 10 to about 400 ppm; wherein further the oxygen scavenger is present in an amount of about 0.10 % to about 10% by weight of the composition.

[0046] Yet other aspects of the disclosure relate to package walls comprising a composition, the composition comprising:

- A) one or more outer layers; and
- B) one or more inner layers;

wherein at least one of the inner or at least one of the outer layers comprises a composition comprising:

- a) a thermoplastic polymer;
- b) at least one compound of the disclosed oxygen scavengers; and
- c) at least one transition metal in a positive oxidation state, the metal being present in the composition in an amount of from about 10 to about 400 ppm; wherein further the oxygen scavenger is present in an amount of about 0.10 % to about 10% by weight of the composition.

[0047] As it relates to this aspect, one embodiment relates to package walls wherein the first layer is disposed radially outward from the second layer.

[0048] Also disclosed herein are methods for packaging an oxygen sensitive material comprising:

- A) preparing a package having a wall comprising at least one layer, at least one of the layers comprising a composition, the composition comprising
 - a) a thermoplastic polymer;
 - b) at least one compound of the disclosed oxygen scavengers; and
 - c) at least one transition metal in a positive oxidation state, the metal being present in the composition in an amount of from about 10 to about 400 ppm; wherein further the oxygen scavenger is present in an amount of about 0.10 % to about 10% by weight of the composition;
- B) introducing the oxygen sensitive material into the package; and
- C) closing the package.

[0049] Still further disclosed herein are methods for producing a packaging material having a wall with oxygen barrier properties comprising:

- A) combining a thermoplastic polymer with at least one of the oxygen scavengers disclosed herein to form a composition, wherein the composition has at least one transition metal in a positive oxidation state, the metal being present in the composition in an amount of from about 10 to about 400 ppm;

wherein further the oxygen scavenger is present in an amount of about 0.10 % to about 10% by weight of the composition;

- B) forming the product of step (A) into a wall; and
- C) forming a container which comprises the wall.

[0050] Another aspect of the disclosure concerns processes for making an article comprising:

- A) forming a melt by combining in a melt processing zone:
 - a) a thermoplastic polymer;
 - b) at least one compound of the disclosed oxygen scavengers; and
 - c) at least one transition metal in a positive oxidation state, the metal being present in the composition in an amount of from about 10 to about 400 ppm; wherein further the oxygen scavenger is present in an amount of about 0.10 % to about 10% by weight of the composition; and
- B) forming an article from the melt.

[0051] In some embodiments, the article is a preform, a sheet, a bottle, a cup, or a jar.

[0052] The antioxidant/oxygen scavengers disclosed herein can be used in a broad range of organic products normally subject to gradual degradation in the presence of oxygen during use over an extended period. One embodiment disclosed herein relates to organic compositions protected by the present antioxidants that are of the type wherein the art recognizes the need for antioxidant protection and to which an antioxidant a known antioxidant is customarily added to obtain an extended service life. The oxidative degradation that this protects against is the slow gradual deterioration of the organic composition rather than, for example, combustion. In other words, the disclosed additives are not necessarily flame retarding additives nor flame suppressing.

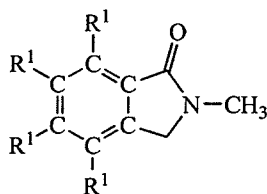
[0053] In some embodiments, the antioxidant/oxygen scavenger can be utilized at elevated temperatures. One such use would be during a melt processing operation.

ANTIOXIDANTS/OXYGEN SCAVENGERS

[0054] The disclosed oxygen scavengers can be prepared by the procedures outlined

below in the various schemes and as described in the Examples herein.

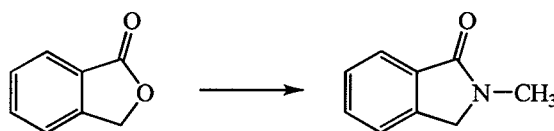
[0055] One category of oxygen scavenger relates to compounds having the formula:



wherein R¹ can be hydrogen or any substitute for hydrogen as defined herein above.

Scheme I and Example 1 provide a non-limiting example of the preparation of compounds according to this category.

Scheme I



Reagents and conditions: CH₃NH₂ (aq.); xylene; reflux.

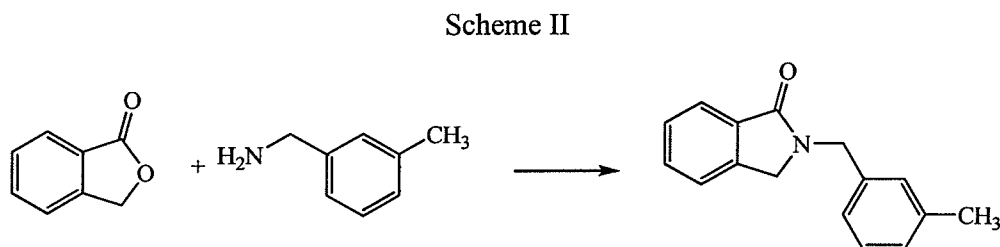
EXAMPLE 1 - Prophetic preparation of substituted and unsubstituted 2-methylisobenzofuran-1-one:

[0056] To a 500 mL 3-neck flask fitted with a Dean-Stark trap/condenser, magnetic stirring, and an addition funnel, isobenzofuran-1(3H)-one (13.4 g, 100 mmol) and xylene (250 mL) can be charged. With good stirring, a solution of methyl amine (100 mmol in xylene) can be slowly added. The course of the reaction can be followed by TLC. When the starting materials appear consumed, the flask can be heated and water collected until the theoretical amount is obtained. After a removal of the xylene under reduced pressure, the product can be obtained by crystallization or purification over silica.

EXAMPLE 2 - Preparation of n-metaxylylene-2,3-dihydro-1H-isobenzofuran-1-one:

[0057] Twenty-nine grams of phthalide (0.216 mol) and twenty five grams of 3-methylbenzyl amine (0.206 mol) are combined in a 1 L Parr reactor. The reactor is evacuated to 26" of vacuum. The vacuum is broken with nitrogen, and the reactor is pressurized to 10 psig with nitrogen. The reactor is heated to 165°C, and heat is maintained until the pressure of the reactor reaches 70 psig. The reactor is rapidly cooled. This yielded 51 grams of dark oil. The oil is placed in a sublimating vessel, and heated to 70°C with <25

mmHg vacuum, for approximately 6 hours. Unreacted phthalide sublimes overhead, and is discarded. The remaining oil is dissolved in heptane, and extracted with 2% HCl water. The heptane layer is treated with carbon, and the carbon is removed by centrifugation. The heptane is removed from the product layer by heating to 30°C under 25 mmHg vacuum. The results in a clear yellow oil, 25 grams ((~0.105 mol)) (51% yield). Boiling Point >200°C / 25 mm Hg. This reaction is schematically depicted in Scheme 2 below:



Reagents and conditions: xylene; reflux.

[0058] The resulting product from Example 2 was tested by HPLC and GC. Conditions for GC are as follows: 30 m DB -17, 0.32mm i.d. The initial temperature was 50°C, for 3 minutes with a temperature ramp of 10°C/min, followed by a final temperature of 250°C for 10 minutes. The methanol test solvent eluted at 1.0 minute. 3-methylbenzyl amine eluted at 3.3 minutes. Phthalide eluted at 15.5 minutes. The product eluted at 26.9 minutes.

[0059] HPLC conditions are as follows. HPLC was performed on a C18 column, 15 cm x 4.6 mm i.d. 5 micron. Detection was at 254 nm. The mobile phase elution profile is tabulated below.

Time	water	methanol	Flow
0.00	90	10	1.500 ml/min
8.00	20	80	1.500 ml/min
13.00	20	80	1.500 ml/min
17.00	90	10	1.500 ml/min
19.00	90	10	1.500 ml/min

EXAMPLE 3 – Hot melt preparation

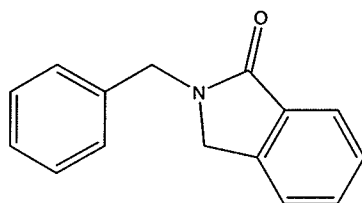
[0060] The n-metaxylylene-2,3-dihydro-1H-isoindol-1-one (DC-9-78) was prepared according to Example 2 having up to 90% purity. This liquid compound was physically

blended with hot, dry PET resin (Heatwave CF746 from Eastman Chemicals) and a PET based Cobalt Neodecanoate Masterbatch. The Heatwave CF746 PET resin was dried in Matsui dryer at 310°F for ~ 6 hrs with air dew point of -40°F. The final compositions were melt-blended in a BOY 22 S injection molder as follows: PET = 95.6% (w/w), compound n-metaxylylene-2,3-dihydro-1H-isoindol-1one = 1.4% (w/w) and PET based Cobalt Neodecanoate Masterbatch = 3% (w/w) (160 ppm Co). The BOY 22 S injection molder barrel temperatures during injection molding was ~ 270°C for both zones, the injection pressure was ~ 600 psi, nozzle heater and sprue heater temperatures were ~ 275°C. The mold was water cooled.

[0061] Plaques formed from the above composition were collected and tested for oxygen scavenging ability using Oxysense™. The plaques were ground to fine powder, placed in a sealed glass vial, with a photoluminescent window on the wall. The intensity of light reflected from the photoluminescent window is proportional to the oxygen content in the vial. The Oxysense™ data for the above composition and a control composition comprised of Constar International's DC-100 is shown in Figure 1. As seen from the data of Figure 1, the compound n-metaxylylene-2,3-dihydro-1H-isoindol-1one does scavenge oxygen when melt-blended with cobalt catalyst in a PET matrix.

Example 4 – Hot melt preparation

[0062] The compound 2-benzyl-1-isoindolinone (DCX-300-1) was prepared by reacting benzyl amine with phthalide (2-benzofuran-1(3H)-one). The chemical structure of 2-benzyl-1-isoindolinone is shown below:

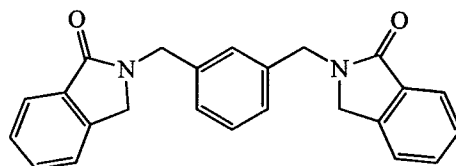


1.4 weight % of this compound (lot number LP 081710, prepared by Cymer LLC, Decatur, TN) was mixed with dried Eastlon CB-651S PET resin (lot number 0104896, manufactured by Far Eastern Textiles) and 80 ppm cobalt catalyst (added as a solid masterbatch of Cobalt Neodecanoate in PET). The PET resin was dried in a Piovan dryer at 170°C for 4 hours before being used for mixing. The mixture was fed into the BOY 22 S injection molding machine to mold plaques. The BOY 22 S injection molder barrel temperatures during injection molding was ~ 275°C for both heating zones, the injection pressure was ~ 700 psi,

nozzle heater and sprue heater temperatures were $\sim 280^{\circ}\text{C}$. The mold was water cooled.

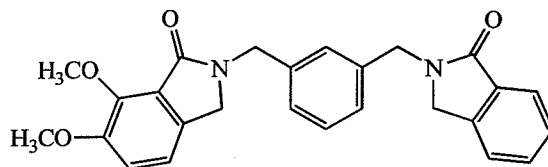
[0063] Plaques formed from the above composition were collected and tested for oxygen scavenging ability using OxysenseTM. The plaques were ground to fine powder, placed in a sealed glass vial, with a photoluminescent window on the wall. The intensity of light reflected from the photoluminescent window is proportional to the oxygen content in the vial. The OxysenseTM data for the above composition, a similar composition comprised of Constar International's DC-300 as the oxygen scavenger, and a control composition comprised of Constar International's DC-100 are shown in Figure 2. As seen from the data of Figure 2, the compound 2-benzyl-1-isoindolinone (DCX-300-1) does scavenge oxygen when melt-blended with cobalt catalyst in a PET matrix.

[0064] In addition to preparing the disclosed oxygen scavenger encompassed within this aspect, the formulator can purchase the compounds from one or more suppliers when available. The compounds can also be formed *in situ*. For example, the addition of 2,2'-[1,3-phenylenebis(methylene)]diisoindolin-1-one having the formula:

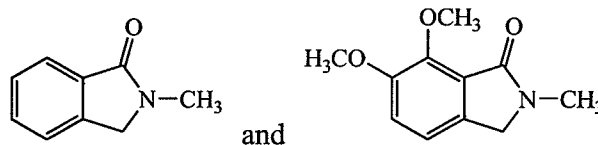


to the thermoplastic polymers disclosed herein will result in the formation of 2-methylisoindolin-1-one in the final melt composition.

[0065] For mixtures of lower molecular weight oxygen scavengers desired by the formulator, a compound such as 6,7-dimethoxy-2-{3-[(1-oxoisoindolin-2-yl)methyl]-benzylisoindolin-1-one having the formula:



can be added to the thermoplastic polymer wherein the resulting melt will comprise both 2-methylisoindolin-1-one and 6,7-dimethoxy-2-methylisoindolin-1-one having the respective formulae:



[0066] Oxygen scavengers such as 6,7-dimethoxy-2-{3-[(1-oxoisindolin-2-yl)methyl]-benzylisindolin-1-one and 6,7-dimethoxy-2-{3-[(1-oxoisindolin-2-yl)methyl]-benzylisindolin-1-one can be prepared by the procedures outlined and disclosed in U.S. Patent Application Publication 2008/0277622 A1, the entirety of which is incorporated herein by reference. Modifications to the procedures disclosed in U.S. Patent Application Publication 2008/0277622 A1 to afford the compounds disclosed herein are within the skill of the organic chemist.

Thermoplastic Polymers

[0067] Non-limiting examples of suitable thermoplastic polymers that can be used alone or with other polymers include both homopolymers and copolymers, of olefinically unsaturated monomers, for example, polyolefins such as polyethylene, polypropylene, polybutadiene, poly-halohydrocarbons such as polyvinyl chloride, polychloroprene, polyvinylidene chloride, polyfluoro olefins, natural and synthetic rubbers such as copolymers of olefinically unsaturated monomers including styrene-butadiene rubber (SBR rubber), ethylenepropylene copolymers, ethylene-propylenediene terpolymers such as the terpolymer of ethylene, propylene and cyclopentadiene or 1,4-cyclooctadiene, polybutadiene rubbers such as cis-polybutadiene rubber, poly-2-chloro-1,3-butadiene (neoprene) and poly-2-methyl-1,3-butadiene (isoprene rubber), acrylonitrile-butadiene-styrene (ABS) resins, ethylenevinyl acetate copolymers, butene-methylacrylate copolymers, nitrogen-containing polymers such as polyurethanes, nitrile rubber, and lauryl acrylate-vinyl-pyrrolidone copolymers.

Antioxidant Protection by the Disclosed Oxygen Scavengers

[0068] The disclosed oxygen scavengers can also protect other compounds and compositions that are susceptible to damage by oxygen. The following are non-limiting examples.

[0069] Petroleum oils such as solvent-refined, midcontinent lubricating oil and Gulfcoast lubricating oils are effectively stabilized. In hydrocarbon lubricating oils, both mineral and synthetic, the present additives are particularly effective when used in

combination with a zinc dihydrocarbyldithiophosphate, e.g. zinc dialkyldithiophosphate or zinc dialkaryldithiophosphate.

[0070] Synthetic ester lubricants such as those used in turbines and turbojet engines are given a high degree of stabilization. Typical synthetic ester lubricants include di-2-ethylhexyl sebacate, trimethylolpropane tripelargonate, C₅-C₉ aliphatic monocarboxylic esters of pentaerythritol, complex esters formed by condensing under esterifying conditions, mixtures of polyols, polycarboxylic acids, and aliphatic monocarboxylic acids and/or monohydric alkanols. An example of these complex esters is the condensation product formed from adipic acid, ethyleneglycol and a mixture of C₅-C₉ aliphatic monocarboxylic acids. Plasticizers such as dioctyl phthalate are effectively protected. Heavy petroleum fractions such as tar and asphalt can also be protected should the need arise.

[0071] Polyamides such as adipic acid-1,6-diaminohexane condensates and poly-6-aminohexanoic acid (nylon) are effectively stabilized. Polyalkylene oxides such as copolymers of phenol with ethylene oxide or propylene oxide are stabilized. Polyphenyl ethers such as poly-2,6-dimethylphenyl ether formed by polymerization of 2,6-dimethylphenol using a copper-pyridine catalyst are stabilized. Polycarbonate plastics and other polyformaldehydes are also protected.

[0072] Linear polyesters such as phthalic anhydride-glycol condensates are given a high degree of protection. Polyesters such as those derived from terephthalic acid and alkylene glycols are also given a high degree of protection. Other polyesters such as trimellitic acid-glycerol condensates are also protected. Polyacrylates such as polymethylacrylate and polymethylmethacrylate are effectively stabilized. Polyacrylonitriles and copolymers of acrylonitriles with other olefinically unsaturated monomers such as methylmeth-acrylates are also effectively stabilized.

[0073] The additives can be used to protect any of the many organic substrates to which an antioxidant is normally added. It can be used where economics permit to protect such substrates as asphalt, paper, fluorocarbons such as Teflon®, polyvinyl acetate, polyvinylidene chloride, coumarone-indene resins, polyvinyl ethers, polyvinylidene bromide, polyvinyl bromide, acrylonitrile, vinyl bromide copolymer, vinyl butyral resins, silicones such as dimethylsilicone lubricants, phosphate lubricants such as tricresylphosphate, and the like.

[0074] One embodiment disclosed herein is the incorporation of the disclosed oxygen scavenger into polyethylene terephthalate formulations which further include a transition metal catalyst. The oxygen scavenger works particularly well in the presence of the transition metal catalyst.

[0075] In combination with the composition components, compositions disclosed herein can include a transition metal salt, compound or complex, as an oxygen scavenger catalyst. The transition metal can be selected from the first, second, or third transition series of the Periodic Table. The metal can be Rh, Ru, or one of the elements in the series of Sc to Zn (i.e., Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, and Zn). Suitable anions for the salts include, but are not limited to, chloride, acetate, oleate, stearate, palmitate, 2-ethylhexanoate, neodecanoate, and naphthenate. Representative salts include cobalt (II) 2-ethylhexanoate, cobalt oleate, and cobalt (II) neodecanoate. The metal salt also can be an ionomer, in which case a polymeric counter ion can be employed.

[0076] The amounts of the components used in the oxygen scavenging formulations of the present disclosure can affect the use and effectiveness of this composition. Thus, the amounts of polymer, transition metal catalyst, antioxidant, polymeric diluents, additives, etc., can vary depending on the desired article and its end use. For example, one of the primary functions of the antioxidant or oxygen scavenging molecules described above is to react irreversibly with oxygen during the scavenging process, while a primary function of the transition metal catalyst is to facilitate this process. Thus, to a large extent, the amount of antioxidant (or oxygen scavenging molecules) present affects the oxygen scavenging capacity of the composition, i.e., the amount of oxygen that the composition can consume, while the amount of transition metal catalyst affects the rate at which oxygen is consumed as well as the induction period.

[0077] Methods of incorporating the additive into the substrate are well known. For example, if the substrate is liquid the additive can be merely mixed into the substrate. Frequently the organic substrate is in solution and the additive is added to the solution and the solvent removed. Solid organic substrates can be merely sprayed with a solution of the additive in a volatile solvent. For example, stabilized grain products result from spraying the grain with a toluene solution of the additive. In the case of rubbery polymers the additive can be added following the polymerization stage by mixing it with the final emulsion or solution polymerization mixture and then coagulating or removing solvent to

recover the stabilized polymer. It can also be added at the compounding stage by merely mixing the additive with the rubbery polymer in commercial mixing equipment such as a Banbury blender. In this manner, rubbery polymers such as styrene-butadiene rubber, cis-polybutadiene or isoprene polymers are blended with the antioxidant together with the other ingredients normally added such as carbon black, oil, sulfur, zinc oxide, stearic acid, vulcanization accelerators, and the like. Following mastication, the resultant mixture is fabricated and molded into a finished form and vulcanized.

[0078] The oxygen scavenger composition of the present disclosure can be incorporated in packaging articles having various forms. Suitable articles include, but are not limited to, flexible sheet films, flexible bags, pouches, semi-rigid and rigid containers such as bottles (e.g. PET bottles) or metal cans, or combinations thereof.

[0079] Typical flexible films and bags include those used to package various food items and can be made up of one or a multiplicity of layers to form the overall film or bag-like packaging material. The oxygen scavenger composition of the present disclosure can be used in one, some or all of the layers of such packaging material.

[0080] Typical rigid or semi-rigid articles include plastic, paper or cardboard containers, such as those utilized for juices, soft drinks, as well as thermoformed trays or cups normally having thickness in the range of from 100 to 1000 micrometers. The walls of such articles can comprise single or multiple layers of materials. The articles can also take the form of a bottle or metal can, or a crown, cap, crown or cap liner, plastisol or gasket. The oxygen scavenger composition of the present disclosure can be used as an integral layer or portion of, or as an external or internal coating or liner of, the formed semi-rigid or rigid packaging article. As a liner, the oxygen scavenger composition can be extruded as a film along with the rigid article itself, in e.g. a coextrusion, extrusion coating, or extrusion lamination process, so as to form the liner in situ during article production; or alternatively can be adhered by heat and/or pressure, by adhesive, or by any other suitable method to an outer surface of the article after the article has been produced.

[0081] Although it can be preferable from the standpoint of packaging convenience and/or scavenging effectiveness to employ the present disclosure as an integral or discrete part of the packaging wall, the disclosure can also be used as a non-integral component of a packaging article such as, for example, a bottle cap liner, adhesive or non-adhesive sheet insert, sealant, sachet, fibrous mat insert or the like.

[0082] Besides articles applicable for packaging food and beverage, articles for packaging other oxygen-sensitive products can also benefit from the present disclosure. Such products would include pharmaceuticals, oxygen sensitive medical products, corrodible metals or products, electronic devices and the like.

[0083] In some embodiments of the disclosure, the base polymer in the composition is a polyester. In certain embodiments, the polyester polymers of the disclosure are thermoplastic and, thus, the form of the compositions are not limited and can include a composition in the melt phase polymerization, as an amorphous pellet, as a solid stated polymer, as a semi-crystalline particle, as a composition of matter in a melt processing zone, as a bottle preform, or in the form of a stretch blow molded bottle or other articles. In certain preferred embodiments, the polyester is polyethylene terephthalate (PET).

[0084] Examples of suitable polyester polymers include polyethylene terephthalate homopolymers and copolymers modified with one or more polycarboxylic acid modifiers in a cumulative amount of less than about 15 mole %, or about 10 mole % or less, or about 8 mole % or less, or one or more hydroxyl compound modifiers in an amount of less than about 60 mol %, or less than about 50 mole %, or less than about 40 mole %, or less than about 15 mole %, or about 10 mole % or less, or about 8 mole % or less (collectively referred to for brevity as "PET") and polyethylene naphthalate homopolymers and copolymers modified with a cumulative amount of with less than about 15 mole %, or about 10 mole % or less, or about 8 mole % or less, of one or more polycarboxylic acid modifiers or modified less than about 60 mol %, or less than about 50 mole %, or less than about 40 mole %, or less than about 15 mole %, or about 10 mole % or less, or about 8 mole % or less of one or more hydroxyl compound modifiers (collectively referred to herein as "PEN"), and blends of PET and PEN. A modifier polycarboxylic acid compound or hydroxyl compound is a compound other than the compound contained in an amount of at least about 85 mole %. The preferred polyester polymer is polyalkylene terephthalate, and most preferred is PET.

[0085] In some embodiments, the polyester polymer contains at least about 90 mole % ethylene terephthalate repeat units, and in other embodiments, at least about 92 mole %, and in yet other embodiments, or at least about 94 mole %, based on the moles of all repeat units in the polyester polymers.

[0086] In addition to a diacid component of terephthalic acid, derivates of terephthalic

acid, naphthalene-2,6-dicarboxylic acid, derivatives of naphthalene-2,6-dicarboxylic acid, or mixtures thereof, the polycarboxylic acid component(s) of the present polyester can include one or more additional modifier polycarboxylic acids. Such additional modifier polycarboxylic acids include aromatic dicarboxylic acids preferably having about 8 to about 14 carbon atoms, aliphatic dicarboxylic acids preferably having about 4 to about 12 carbon atoms, or cycloaliphatic dicarboxylic acids preferably having about 8 to about 12 carbon atoms. Examples of modifier dicarboxylic acids useful as an acid component(s) are phthalic acid, isophthalic acid, naphthalene-2,6-dicarboxylic acid, cyclohexanedicarboxylic acid, cyclohexanediacetic acid, diphenyl-4,4'-dicarboxylic acid, succinic acid, glutaric acid, adipic acid, azelaic acid, sebacic acid, and the like, with isophthalic acid, naphthalene-2,6-dicarboxylic acid, and cyclohexanedicarboxylic acid being most preferable. It should be understood that use of the corresponding acid anhydrides, esters, and acid chlorides of these acids is included in the term "polycarboxylic acid." It is also possible for trifunctional and higher order polycarboxylic acids to modify the polyester.

[0087] The hydroxyl component is made from compounds containing 2 or more hydroxyl groups capable of reacting with a carboxylic acid group. In some preferred embodiments, preferred hydroxyl compounds contain 2 or 3 hydroxyl groups. Certain preferred embodiments, have 2 hydroxyl groups. These hydroxyl compounds include C₂-C₄ alkane diols, such as ethylene glycol, propane diol, and butane diol, among which ethylene glycol is most preferred for container applications. In addition to these diols, other modifier hydroxyl compound component(s) can include diols such as cycloaliphatic diols preferably having 6 to 20 carbon atoms and/or aliphatic diols preferably having about 3 to about 20 carbon atoms. Examples of such diols include diethylene glycol; triethylene glycol; 1,4-cyclohexanedimethanol; propane-1,3-diol and butane-1,4-diol (which are considered modifier diols if ethylene glycol residues are present in the polymer in an amount of at least 85 mole % based on the moles of all hydroxyl compound residues); pentane-1,5-diol; hexane-1,6-diol; 3-methylpentanediol-(2,4); neopentyl glycol; 2-methylpentanediol-(1,4); 2,2,4-trimethylpentane-diol-(1,3); 2,5-ethylhexanediol-(1,3); 2,2-diethyl propane-diol-(1,3); hexanediol-(1,3); 1,4-di-(hydroxyethoxy)-benzene; 2,2-bis-(4-hydroxycyclohexyl)-propane; 2,4-dihydroxy-1,1,3,3-tetramethyl-cyclobutane; 2,2-bis-(3-hydroxyethoxyphenyl)-propane; and 2,2-bis-(4-hydroxypropoxyphenyl)-propane. Typically, polyesters such as polyethylene terephthalate are made by reacting a glycol with a dicarboxylic acid as the free acid or its dimethyl ester to produce an ester monomer and/or oligomers, which are then polycondensed to produce the polyester.

[0088] In some preferred embodiments, modifiers include isophthalic acid, naphthalenic dicarboxylic acid, trimellitic anhydride, pyromellitic dianhydride, 1,4-cyclohexane dimethanol, and diethylene glycol. The amount of the polyester polymer in the formulated polyester polymer composition ranges from greater than about 50.0 wt. %, or from about 80.0 wt. %, or from about 90.0 wt. %, or from about 95.0 wt. %, or from about 96.0 wt. %, or from about 97 wt. %, and up to about 99.90 wt. %, based on the combined weight of all polyester polymers and all polyamide polymers. The formulated polyester polymer compositions can also include blends of formulated polyester polymer compositions with other thermoplastic polymers such as polycarbonate. In some preferred compositions, the polyester comprises a majority of the composition of the disclosures, and in some embodiments the polyester is present in an amount of at least about 80 wt. %, or at least about 90 wt. %, based on the weight of the composition (excluding fillers, inorganic compounds or particles, fibers, impact modifiers, or other polymers serve as impact modifiers or which form a discontinuous phase such as can be found in cold storage food trays).

[0089] The polyester compositions can be prepared by polymerization procedures known in the art sufficient to effect esterification and polycondensation. Polyester melt phase manufacturing processes include direct condensation of a dicarboxylic acid with the diol, optionally in the presence of esterification catalysts, in the esterification zone, followed by polycondensation in the prepolymer and finishing zones in the presence of a polycondensation catalyst; or ester exchange usually in the presence of a transesterification catalyst in the ester exchange zone, followed by prepolymerization and finishing in the presence of a polycondensation catalyst, and each can optionally be solid stated according to known methods.

[0090] The transition metal used in the instant compositions is a metal in the positive oxidation state. It should be noted that it is contemplated that one or more such metals can be used. In some embodiments, cobalt is added in +2 or +3 oxidation state. In some embodiments, it is preferred to use cobalt in the +2 oxidation state. In certain embodiments, copper in the +2 oxidation state is utilized. In some embodiments, rhodium in the +2 oxidation state is used. In certain embodiments, zinc can also be added to the composition. Preferred zinc compounds include those in a positive oxidation state.

[0091] Suitable counter-ions to the transition metal cations include carboxylates, such as

neodecanoates, octanoates, acetates, lactates, naphthalates, malates, stearates, acetylacetonates, linoleates, oleates, palmitates, 2-ethylhexanoates, or ethylene glycolates; or as their oxides, borates, carbonates, chlorides, dioxides, hydroxides, nitrates, phosphates, sulfates, or silicates among others.

[0092] In some embodiments, levels of at least about 10 ppm, or at least about 50 ppm, or at least about 100 ppm of metal can achieve suitable oxygen scavenging levels. The exact amount of transition metal used in an application can be determined by trials that are well within the skill level of one skilled in the art. In some embodiments involving wall applications (as opposed to master batch applications where more catalyst is used), it is preferred to keep the level of metal below about 300 ppm and, in other embodiments, preferably below about 250 ppm.

[0093] The transition metal or metals can be added neat or in a carrier (such as a liquid or wax) to an extruder or other device for making the article, or the metal can be present in a concentrate or carrier with the oxidizable organic component, in a concentrate or carrier with a base polymer, or in a concentrate or carrier with a base polymer/oxidizable organic component blend. Alternatively, at least a portion of the transition metal can be added as a polymerization catalyst to the melt phase reaction for making the base polymer (a polyester polymer in some embodiments) and be present as residual metals when the polymer is fed to the melting zone (e.g. the extrusion or injection molding zone) for making the article such as a preform or sheet. It is desirable that the addition of the transition metal does not substantially increase the intrinsic viscosity (I.V) of the melt in the melt processing zone. Thus, transition metal or metals can be added in two or more stages, such as once during the melt phase for the production of the polyester polymer and again once more to the melting zone for making the article.

[0094] The composition can also include other components such as colorants, pigments, fillers, crystallization aids, impact modifiers, surface lubricants, denesting agents, stabilizers, ultraviolet light absorbing agents, metal deactivators, nucleating agents such as polyethylene and polypropylene, phosphate stabilizers and dyestuffs. Other additional components are well known to those skilled in the art and can be added to the existing composition so long as they do not negatively impact the performance of the compositions. Typically, the total quantity of such components will be less than about 10% by weight relative to the whole composition. In some embodiments, the amount of these optional

components is less than about 5%, by weight relative to the total composition.

[0095] A common additive used in the manufacture of polyester polymer compositions used to make stretch blow molded bottles is a reheat additive because the preforms made from the composition must be reheated prior to entering the mold for stretch blowing into a bottle. Any of the conventional reheat additives can be used, such additives include various forms of black particles, e.g. carbon black, activated carbon, black iron oxide, glassy carbon, and silicon carbide; the gray particles such as antimony, and other reheat additives such as silicas, red iron oxide, and so forth.

[0096] Other typical additives, depending on the application, are impact modifiers. Examples of typical commercially available impact modifiers well-known in the art and useful in this disclosure include ethylene/acrylate/glycidyl terpolymers and ethylene/acrylate copolymers in which the acrylate is a methyl or ethyl acrylate or methyl or ethyl methacrylate or the corresponding butyl acrylates, styrene based block copolymers, and various acrylic core/shell type impact modifiers. The impact modifiers can be used in conventional amounts from about 0.1 to about 25 weight percent of the overall composition and, in some embodiments, preferably in amounts from about 0.1 to about 10 weight percent of the composition.

[0097] In many applications, not only are the packaging contents sensitive to the ingress of oxygen, but the contents can also be affected by UV light. Fruit juices and pharmaceuticals are two examples of such contents. Accordingly, in some embodiments, it is desirable to incorporate into the polyester composition any one of the known UV absorbing compounds in amounts effective to protect the packaged contents.

[0098] The instant compositions can be made by mixing a base polymer (PET, for example) with the oxidizable organic component and the transition metal composition. Such compositions can be made by any method known to those skilled in the art. In certain embodiments, some or part of the transition metal can exist in the base polymer prior to mixing. This residual metal, for example, can exist from the manufacturing process of the base polymer. In some embodiments, the base polymer, the oxidizable organic component and the transition metal are mixed by tumbling in a hopper. Other optional ingredients can be added during this mixing process or added to the mixture after the aforementioned mixing or to an individual component prior to the aforementioned mixing step.

[0099] The instant composition can also be made by adding each ingredient separately and mixing the ingredients prior melt processing the composition to form an article. In some embodiments, the mixing can be just prior to the melt process zone. In other embodiments, one or more ingredients can be premixed in a separate step prior to bringing all of the ingredients together.

[00100] In some embodiments, the disclosure concerns use of the compositions described herein as a component of a wall that is used in a package for oxygen sensitive materials. The necessary scavenging capacity of a package will generally have to be greater for walls that have a greater permeance in the absence of scavenging additives. Accordingly, a good effect is harder to achieve with inherently higher permeance materials are used.

[00101] The wall can be a rigid one, a flexible sheet, or a clinging film. It can be homogenous or a laminate or coated with other polymers. If it is laminated or coated, then the scavenging property can reside in a layer of the wall the permeance of which is relatively high in the absence of scavenging and which alone would not perform very satisfactorily but which performs satisfactorily in combination with one or more other layers which have a relatively low permeance but negligible or insufficient oxygen-scavenging properties. A single such layer could be used on the outside of the package since this is the side from which oxygen primarily comes when the package is filled and sealed. However, such a layer to either side of the scavenging layer would reduce consumption of scavenging capacity prior to filling and sealing.

[00102] When the instant compositions are used in a wall or as a layer of a wall, the permeability of the composition for oxygen is advantageously not more than about 3.0, or about 1.7, or about 0.7, or about 0.2, or about 0.03 $\text{cm}^3 \text{ mm}/(\text{m}^2 \text{ atm day})$. The permeability of the composition provided by the present disclosure is advantageously not more than about three-quarters of that in the absence of oxygen-scavenging properties. In some embodiments, the permeability is not more than about one half, one-tenth in certain embodiments, one twenty-fifth in other embodiments, and not more than one-hundredth in yet other embodiments of that in the absence of oxygen-scavenging properties. The permeability in the absence of oxygen-scavenging properties is advantageously not more than about 17 $\text{cm}^3 \text{ mm}/(\text{m}^2 \text{ atm day})$, or about 10, and or about 6. A particularly good effect can be achieved for such permeabilities in the range from about 0.5, or about 1.0, to 10, or

about 6.0, cm³ mm/(m² atm day). Measurements of oxygen permeation can be made by methods described, for example, in U.S. Pat. No. 5,639,815, the contents of which are incorporated herein in its entirety.

[00103] In another aspect, the instant composition can be used as a master batch for blending with a polymer or a polymer containing component. In such compositions, the concentration of the oxidizable organic component and the transition metal will be higher to allow for the final blended product to have suitable amounts of these components. The master batch can also contain an amount of the polymer to which the master batch is to be blended with. In other embodiments, the master batch can contain a polymer that is compatible with the polymer that the master batch is to be blended with.

[00104] In yet another aspect, the compositions of the instant disclosure can be used for forming a layer of a wall which primarily provides oxygen-scavenging (another layer including polymer providing gas barrier without significant scavenging), or as a head-space scavenger (completely enclosed, together with the package contents, by a package wall). Such techniques are well known to those skilled in the art. Persons familiar with oxygen scavenging technology and products will understand how to implement the structures disclosed in this paragraph.

[00105] The time period for which the permeability is maintained can be extended by storing the articles in sealed containers or under an inert atmosphere such as nitrogen prior to use with oxygen sensitive materials.

[00106] In another aspect, the disclosure provides a package, whether rigid, semi-rigid, collapsible, lidded, or flexible or a combination of these, comprising a wall as formed from the compositions described herein. Such packages can be formed by methods well known to those skilled in the art.

[00107] Among the techniques that can be used to make articles are moulding generally, injection moulding, stretch blow moulding, extrusion, thermoforming, extrusion blow moulding, and (specifically for multilayer structures) co-extrusion and lamination using adhesive tie layers. Orientation, e.g. by stretch blow moulding, of the polymer is especially attractive with phthalate polyesters because of the known mechanical advantages that result.

[00108] The melt processing zone for making the article can be operated under

customary conditions effective for making the intended articles, such as preforms, bottles, trays, and other articles mentioned below. In one embodiment, such conditions are effective to process the melt without substantially increasing the I.V. of the melt and which are ineffective to promote transesterification reactions. In some preferred embodiments, suitable operating conditions effective to establish a physical blend of the polyester polymer, oxidizable organic component, and transition metal are temperatures in the melt processing zone within a range of about 250°C. to about 300°C at a total cycle time of less than about 6 minutes, and typically without the application of vacuum and under a positive pressure ranging from about 0 psig to about 900 psig. In some embodiments, the residence time of the melt on the screw can range from about 1 to about 4 minutes.

[00109] Specific articles include preforms, containers and films for packaging of food, beverages, cosmetics, pharmaceuticals, and personal care products where a high oxygen barrier is needed. Examples of beverage containers are bottles for holding water and carbonated soft drinks, and the disclosure is particularly useful in bottle applications containing juices, sport drinks, beer or any other beverage where oxygen detrimentally affects the flavor, fragrance, performance (prevent vitamin degradation), or color of the drink. The compositions of the instant disclosure are also particularly useful as a sheet for thermoforming into rigid packages and films for flexible structures. Rigid packages include food trays and lids. Examples of food tray applications include dual ovenable food trays, or cold storage food trays, both in the base container and in the lidding (whether a thermoformed lid or a film), where the freshness of the food contents can decay with the ingress of oxygen. The compositions of the instant disclosure also find use in the manufacture of cosmetic containers and containers for pharmaceuticals or medical devices.

[00110] The package walls of the instant disclosure can be a single layer or a multilayer constructions. In some embodiments using multilayer walls, the outer and inner layers can be structural layers with one or more protective layers containing the oxygen scavenging material positioned there between. In some embodiments, the outer and inner layers comprise and polyolefin or a polyester. In certain embodiments, a single layer design is preferred. Such a layer can have advantages in simplicity of manufacture and cost.

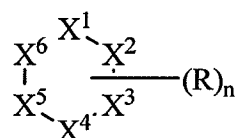
[00111] Unless otherwise indicated, the disclosure is not limited to specific molecular structures, substituents, synthetic methods, reaction conditions, or the like, as such can vary. It is also to be understood that the terminology used herein is for the purpose of describing

particular embodiments only and is not intended to be limiting.

CLAIMS

What is claimed is:

1. A melt-blended polymer composition comprising:
- a thermoplastic polymer; and
 - a transition metal in a positive oxidation state, the metal present in an amount of from about 10 ppm to about 400 ppm
 - a compound having the formula:



wherein X^1 , X^2 , X^3 , X^4 , X^5 , and X^6 are each independently:

- $=\text{CR}^1-$;
 - $=\text{N}-$;
 - $-\text{O}-$; or
 - $-\text{S}-$;
- or when an R group is present, R^1 is equal to R;
- each R^1 is independently chosen from:
- hydrogen;
 - C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
 - C_2 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkenyl;
 - C_2 - C_{12} substituted or unsubstituted linear or branched alkynyl;
 - C_6 or C_{10} substituted or unsubstituted aryl;
 - C_1 - C_9 substituted or unsubstituted heterocyclic;
 - C_1 - C_{11} substituted or unsubstituted heteroaryl;
 - halogen;
 - $-\text{[C}(\text{R}^{23a})(\text{R}^{23b})\text{]}_x\text{OR}^{10}$;

R^{10} is chosen from:

- $-\text{H}$;
- C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
- C_6 or C_{10} substituted or unsubstituted aryl or alkylenearyl;
- C_1 - C_9 substituted or unsubstituted heterocyclic;

- e) C₁-C₁₁ substituted or unsubstituted heteroaryl;
- x) $-\text{[C(R}^{23\text{a}}\text{)(R}^{23\text{b}}\text{)]}_x\text{N(R}^{11\text{a}}\text{)(R}^{11\text{b}}\text{)}$;
 R^{11a} and R^{11b} are each independently chosen from:
- a) -H;
- b) -OR¹²;
- R¹² is hydrogen or C₁-C₄ linear alkyl;
- c) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- d) C₆ or C₁₀ substituted or unsubstituted aryl;
- e) C₁-C₉ substituted or unsubstituted heterocyclic;
- f) C₁-C₁₁ substituted or unsubstituted heteroaryl; or
- g) R^{11a} and R^{11b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xi) $-\text{[C(R}^{23\text{a}}\text{)(R}^{23\text{b}}\text{)]}_x\text{C(O)R}^{13}$;
 R¹³ is:
- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) -OR¹⁴;
- R¹⁴ is hydrogen, substituted or unsubstituted C₁-C₄ linear alkyl, C₆ or C₁₀ substituted or unsubstituted aryl, C₁-C₉ substituted or unsubstituted heterocyclic, C₁-C₁₁ substituted or unsubstituted heteroaryl;
- c) $-\text{N(R}^{15\text{a}}\text{)(R}^{15\text{b}}\text{)}$;
 R^{15a} and R^{15b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{15a} and R^{15b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xii) $-\text{[C(R}^{23\text{a}}\text{)(R}^{23\text{b}}\text{)]}_x\text{OC(O)R}^{16}$;
 R¹⁶ is:

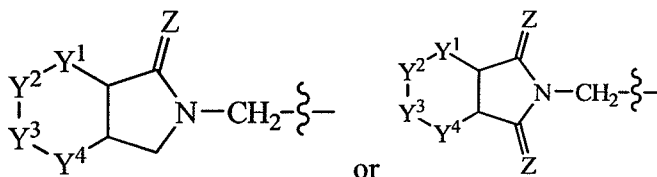
- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) -N(R^{17a})(R^{17b});
R^{17a} and R^{17b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{17a} and R^{17b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xiii) -[C(R^{23a})(R^{23b})]_xNR¹⁸C(O)R¹⁹;
R¹⁸ is:
- a) -H; or
- b) C₁-C₄ substituted or unsubstituted linear, branched, or cyclic alkyl;
- R¹⁹ is:
- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) -N(R^{20a})(R^{20b});
R^{20a} and R^{20b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{20a} and R^{20b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xiv) -[C(R^{23a})(R^{23b})]_xCN;
- xv) -[C(R^{23a})(R^{23b})]_xNO₂;
- xvi) -[C(R^{23a})(R^{23b})]_xR²¹;
R²¹ is C₁-C₁₀ linear, branched, or cyclic alkyl substituted by from 1 to 21 halogen atoms chosen from -F, -Cl, -Br, or -I;
- xvii) -[C(R^{23a})(R^{23b})]_xSO₂R²²;

R^{22} is hydrogen, hydroxyl, substituted or unsubstituted C_1 - C_4 linear or branched alkyl; substituted or unsubstituted C_6 , C_{10} , or C_{14} aryl; C_7 - C_{15} alkylenearyl; C_1 - C_9 substituted or unsubstituted heterocyclic; or C_1 - C_{11} substituted or unsubstituted heteroaryl; or

xviii) R^1 units on two adjacent carbons can be taken together to form a substituted or unsubstituted 5, 6, or 7 member fused ring comprising one or more heteroatoms chosen from nitrogen, oxygen, or sulfur, and wherein the fused ring can be substituted by C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or when one of the ring atoms is a carbon, the atom can be substituted with carbonyl having the formula $=O$, or imide having the formula $=NH$;

R^{23a} and R^{23b} are each independently hydrogen or C_1 - C_4 alkyl; and the index x is an integer from 0 to 5;

R is has the formula:



each Z is independently O, NH, or S;

Y^1 , Y^2 , Y^3 , and Y^4 are each independently:

i) $=CR^2-$; or

ii) $=N-$;

each R^2 is independently chosen from:

- viii) hydrogen;
- ix) substituted or unsubstituted C_1 - C_{10} linear, branched, or cyclic alkyl;
- x) substituted or unsubstituted C_2 - C_{10} linear, branched, or cyclic alkenyl;
- xi) substituted or unsubstituted C_2 - C_{10} linear or branched alkynyl;
- xii) substituted or unsubstituted C_6 or C_{10} aryl;
- xiii) substituted or unsubstituted C_1 - C_9 heterocyclic;
- xiv) substituted or unsubstituted C_1 - C_9 heteroaryl; or

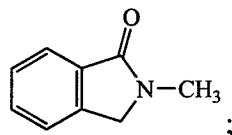
two R^2 units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or

unsubstituted heteroaryl ring having from form 2 to 20 carbon atoms
and from 1 to 7 heteroatoms; and

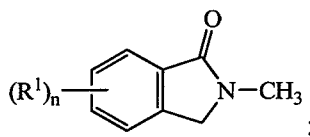
n is an integer from 0 to 6.

2. The polymer composition according to Claim 1, wherein the compound has the formula chosen from:

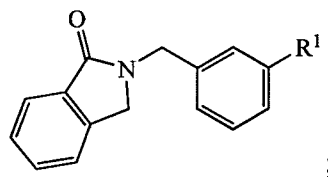
i)



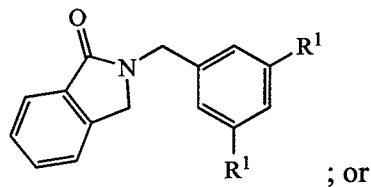
ii)



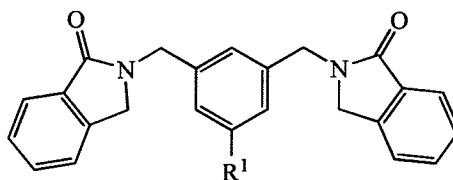
iii)



iv)



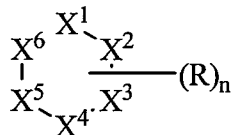
v)



wherein R¹ is chosen from:

- i) -CH₃;
ii) -CHO; or
ii) a combination thereof; and
the index n is equal to 1 or 2.

3. The polymer composition according to either Claim 1 or 2, further comprising a transition metal in the positive oxidation state.
4. The polymer composition according to Claim 3, comprising from about 10 ppm to about 400 ppm of a transition metal.
5. The polymer composition according to Claim 3, comprising from about 30 ppm to about 150 ppm of a transition metal.
6. The polymer composition according to any of Claims 1 to 5, wherein the thermoplastic polymer is a polyester homopolymer or polyester copolymer.
7. The polymer composition according to any of Claims 1 to 5, wherein the thermoplastic polymer comprises polyethylene terephthalate or a copolymer thereof.
8. The polymer composition according to any of Claims 1 to 7, wherein the compound comprises from about 1% to about 10% by weight of the composition.
9. The polymer composition according to any of Claims 1 to 7, wherein the compound comprises from about 1% to about 5% by weight of the composition.
10. The polymer composition according to any of Claims 1 to 7, wherein the compound comprises from about 1% to about 3% by weight of the composition.
11. The polymer composition according to any of Claims 1 to 10, further comprising a colorant.
12. An oxygen scavenger having the formula:



wherein X¹, X², X³, X⁴, X⁵, and X⁶ are each independently:

- i) =CR¹-;
- ii) =N-;

iii) $-O-$; or

iv) $-S-$;

each R^1 is independently chosen from:

i) hydrogen;

ii) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;

iii) C_2 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkenyl;

iv) C_2 - C_{12} substituted or unsubstituted linear or branched alkynyl;

v) C_6 or C_{10} substituted or unsubstituted aryl;

vi) C_1 - C_9 substituted or unsubstituted heterocyclic;

vii) C_1 - C_{11} substituted or unsubstituted heteroaryl;

viii) halogen;

ix) $-[C(R^{23a})(R^{23b})]_xOR^{10}$;

R^{10} is chosen from:

a) $-H$;

b) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;

c) C_6 or C_{10} substituted or unsubstituted aryl or alkylenearyl;

d) C_1 - C_9 substituted or unsubstituted heterocyclic;

e) C_1 - C_{11} substituted or unsubstituted heteroaryl;

x) $-[C(R^{23a})(R^{23b})]_xN(R^{11a})(R^{11b})$;

R^{11a} and R^{11b} are each independently chosen from:

a) $-H$;

b) $-OR^{12}$;

R^{12} is hydrogen or C_1 - C_4 linear alkyl;

c) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;

d) C_6 or C_{10} substituted or unsubstituted aryl;

e) C_1 - C_9 substituted or unsubstituted heterocyclic;

f) C_1 - C_{11} substituted or unsubstituted heteroaryl; or

g) R^{11a} and R^{11b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;

xi) $-[C(R^{23a})(R^{23b})]_xC(O)R^{13}$;

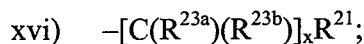
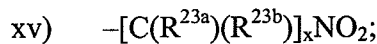
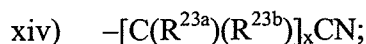
R^{13} is:

a) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;

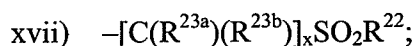
b) $-OR^{14}$;

- R^{14} is hydrogen, substituted or unsubstituted C_1 - C_4 linear alkyl, C_6 or C_{10} substituted or unsubstituted aryl, C_1 - C_9 substituted or unsubstituted heterocyclic, C_1 - C_{11} substituted or unsubstituted heteroaryl;
- c) $-N(R^{15a})(R^{15b})$;
 R^{15a} and R^{15b} are each independently hydrogen, C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or R^{15a} and R^{15b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xii) $-[C(R^{23a})(R^{23b})]_x OC(O)R^{16}$;
 R^{16} is:
 a) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
 b) $-N(R^{17a})(R^{17b})$;
 R^{17a} and R^{17b} are each independently hydrogen, C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or R^{17a} and R^{17b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xiii) $-[C(R^{23a})(R^{23b})]_x NR^{18}C(O)R^{19}$;
 R^{18} is:
 a) $-H$; or
 b) C_1 - C_4 substituted or unsubstituted linear, branched, or cyclic alkyl;
 R^{19} is:
 a) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
 b) $-N(R^{20a})(R^{20b})$;
 R^{20a} and R^{20b} are each independently hydrogen, C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or R^{20a} and R^{20b} can be

taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;



R^{21} is $\text{C}_1\text{-C}_{10}$ linear, branched, or cyclic alkyl substituted by from 1 to 21 halogen atoms chosen from $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, or $-\text{I}$;

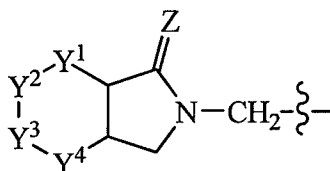


R^{22} is hydrogen, hydroxyl, substituted or unsubstituted $\text{C}_1\text{-C}_4$ linear or branched alkyl; substituted or unsubstituted C_6 , C_{10} , or C_{14} aryl; $\text{C}_7\text{-C}_{15}$ alkylenearyl; $\text{C}_1\text{-C}_9$ substituted or unsubstituted heterocyclic; or $\text{C}_1\text{-C}_{11}$ substituted or unsubstituted heteroaryl; or

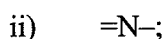
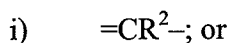
xviii) R^1 units on two adjacent carbons can be taken together to form a substituted or unsubstituted 5, 6, or 7 member fused ring comprising one or more heteroatoms chosen from nitrogen, oxygen, or sulfur, and wherein the fused ring can be substituted by $\text{C}_1\text{-C}_{12}$ substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; $\text{C}_1\text{-C}_9$ substituted or unsubstituted heterocyclic; $\text{C}_1\text{-C}_{11}$ substituted or unsubstituted heteroaryl; or when one of the ring atoms is a carbon, the atom can be substituted with carbonyl having the formula $=\text{O}$, or imide having the formula $=\text{NH}$;

R^{23a} and R^{23b} are each independently hydrogen or $\text{C}_1\text{-C}_4$ alkyl; and the index x is an integer from 0 to 5;

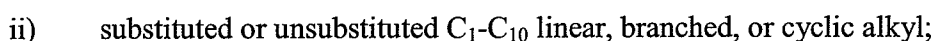
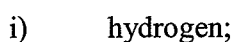
R is has the formula:



Y^1 , Y^2 , Y^3 , and Y^4 are each independently:

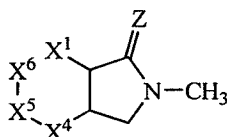


each R^2 is independently chosen from:



- iii) substituted or unsubstituted C₂-C₁₀ linear, branched, or cyclic alkenyl;
 - iv) substituted or unsubstituted C₂-C₁₀ linear or branched alkynyl;
 - v) substituted or unsubstituted C₆ or C₁₀ aryl;
 - vi) substituted or unsubstituted C₁-C₉ heterocyclic;
 - vii) substituted or unsubstituted C₁-C₉ heteroaryl; or
- two R² units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or unsubstituted heteroaryl ring having from 2 to 20 carbon atoms and from 1 to 7 heteroatoms; and n is an integer from 1 to 5.

13. The oxygen scavenger according to Claim 12, wherein the index n is equal to 0.
14. The oxygen scavenger according to either Claim 12 or 13, wherein two R¹ units on adjacent carbons are taken together to form a compound having the formula:



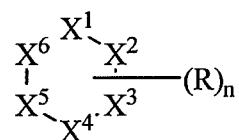
X¹, X⁴, X⁵, and X⁶ are each =CR¹- or -N-;

each R¹ is independently chosen from:

- i) hydrogen; or
- ii) methyl; and

Z is O or NH.

15. The oxygen scavenger according to any one of Claims 12 to 14, wherein each of X¹, X⁴, X⁵, and X⁶ are =CH-, and Z is O.
16. A method for making an oxygen scavenging polymer composition comprising the step of combining:
- a) a thermoplastic polymer;
 - b) a transition metal in a positive oxidation state, the metal present in the composition in an amount of from about 10 ppm to about 400 ppm; and
 - c) a compound having the formula:



wherein X^1 , X^2 , X^3 , X^4 , X^5 , and X^6 are each independently:

- i) $=CR^1-$;
- ii) $=N-$;
- iii) $-O-$; or
- iv) $-S-$;

or when an R group is present, R^1 is equal to R;

each R^1 is independently chosen from:

- i) hydrogen;
- ii) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
- iii) C_2 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkenyl;
- iv) C_2 - C_{12} substituted or unsubstituted linear or branched alkynyl;
- v) C_6 or C_{10} substituted or unsubstituted aryl;
- vi) C_1 - C_9 substituted or unsubstituted heterocyclic;
- vii) C_1 - C_{11} substituted or unsubstituted heteroaryl;
- viii) halogen;
- ix) $-[C(R^{23a})(R^{23b})]_xOR^{10}$;

R^{10} is chosen from:

- a) $-H$;
- b) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
- c) C_6 or C_{10} substituted or unsubstituted aryl or alkylenearyl;
- d) C_1 - C_9 substituted or unsubstituted heterocyclic;
- e) C_1 - C_{11} substituted or unsubstituted heteroaryl;
- x) $-[C(R^{23a})(R^{23b})]_xN(R^{11a})(R^{11b})$;

R^{11a} and R^{11b} are each independently chosen from:

- a) $-H$;
- b) $-OR^{12}$;

R^{12} is hydrogen or C_1 - C_4 linear alkyl;

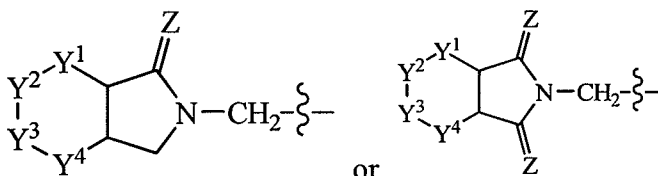
- c) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
- d) C_6 or C_{10} substituted or unsubstituted aryl;
- e) C_1 - C_9 substituted or unsubstituted heterocyclic;
- f) C_1 - C_{11} substituted or unsubstituted heteroaryl; or

- g) R^{11a} and R^{11b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xi) $-[C(R^{23a})(R^{23b})]_x C(O)R^{13}$;
 R^{13} is:
- a) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) $-OR^{14}$;
 R^{14} is hydrogen, substituted or unsubstituted C_1 - C_4 linear alkyl, C_6 or C_{10} substituted or unsubstituted aryl, C_1 - C_9 substituted or unsubstituted heterocyclic, C_1 - C_{11} substituted or unsubstituted heteroaryl;
- c) $-N(R^{15a})(R^{15b})$;
 R^{15a} and R^{15b} are each independently hydrogen, C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or R^{15a} and R^{15b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xii) $-[C(R^{23a})(R^{23b})]_x OC(O)R^{16}$;
 R^{16} is:
- a) C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) $-N(R^{17a})(R^{17b})$;
 R^{17a} and R^{17b} are each independently hydrogen, C_1 - C_{12} substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; C_1 - C_9 substituted or unsubstituted heterocyclic; C_1 - C_{11} substituted or unsubstituted heteroaryl; or R^{17a} and R^{17b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;

- xiii) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{NR}^{18}\text{C(O)R}^{19}$;
 R^{18} is:
 a) $-\text{H}$; or
 b) $\text{C}_1\text{-C}_4$ substituted or unsubstituted linear, branched, or cyclic alkyl;
 R^{19} is:
 a) $\text{C}_1\text{-C}_{12}$ substituted or unsubstituted linear, branched, or cyclic alkyl;
 b) $-\text{N(R}^{20a}\text{)(R}^{20b}\text{)}$;
 R^{20a} and R^{20b} are each independently hydrogen, $\text{C}_1\text{-C}_{12}$ substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; $\text{C}_1\text{-C}_9$ substituted or unsubstituted heterocyclic; $\text{C}_1\text{-C}_{11}$ substituted or unsubstituted heteroaryl; or R^{20a} and R^{20b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xiv) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{CN}$;
- xv) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{NO}_2$;
- xvi) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{R}^{21}$;
 R^{21} is $\text{C}_1\text{-C}_{10}$ linear, branched, or cyclic alkyl substituted by from 1 to 21 halogen atoms chosen from $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, or $-\text{I}$;
- xvii) $-\text{[C(R}^{23a}\text{)(R}^{23b}\text{)]}_x\text{SO}_2\text{R}^{22}$;
 R^{22} is hydrogen, hydroxyl, substituted or unsubstituted $\text{C}_1\text{-C}_4$ linear or branched alkyl; substituted or unsubstituted C_6 , C_{10} , or C_{14} aryl; $\text{C}_7\text{-C}_{15}$ alkylenearyl; $\text{C}_1\text{-C}_9$ substituted or unsubstituted heterocyclic; or $\text{C}_1\text{-C}_{11}$ substituted or unsubstituted heteroaryl; or
- xviii) R^1 units on two adjacent carbons can be taken together to form a substituted or unsubstituted 5, 6, or 7 member fused ring comprising one or more heteroatoms chosen from nitrogen, oxygen, or sulfur, and wherein the fused ring can be substituted by $\text{C}_1\text{-C}_{12}$ substituted or unsubstituted linear, branched, or cyclic alkyl; C_6 or C_{10} substituted or unsubstituted aryl; $\text{C}_1\text{-C}_9$ substituted or unsubstituted heterocyclic; $\text{C}_1\text{-C}_{11}$ substituted or unsubstituted heteroaryl; or when one of the

ring atoms is a carbon, the atom can be substituted with carbonyl having the formula =O, or imide having the formula =NH; R^{23a} and R^{23b} are each independently hydrogen or C_1 - C_4 alkyl; and the index x is an integer from 0 to 5;

R is has the formula:



each Z is independently O, NH, or S;

Y^1 , Y^2 , Y^3 , and Y^4 are each independently:

i) =CR²-; or

ii) =N-;

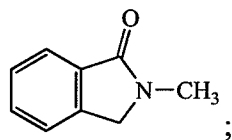
each R² is independently chosen from:

- xv) hydrogen;
- xvi) substituted or unsubstituted C_1 - C_{10} linear, branched, or cyclic alkyl;
- xvii) substituted or unsubstituted C_2 - C_{10} linear, branched, or cyclic alkenyl;
- xviii) substituted or unsubstituted C_2 - C_{10} linear or branched alkynyl;
- xix) substituted or unsubstituted C_6 or C_{10} aryl;
- xx) substituted or unsubstituted C_1 - C_9 heterocyclic;
- xxi) substituted or unsubstituted C_1 - C_9 heteroaryl; or

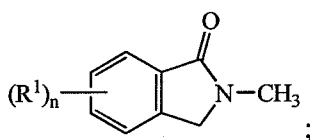
two R² units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or unsubstituted heteroaryl ring having from form 2 to 20 carbon atoms and from 1 to 7 heteroatoms; and n is an integer from 0 to 6.

17. The method of claim 16, wherein the compound has the formula chosen from:

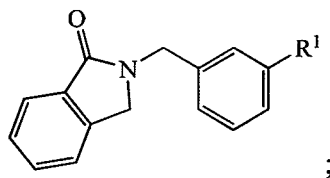
i)



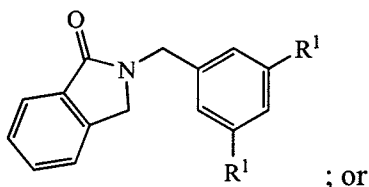
ii)



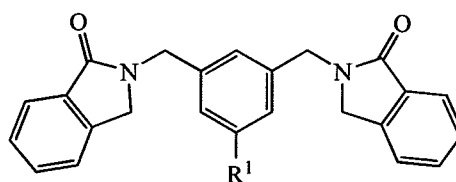
iii)



iv)



v)

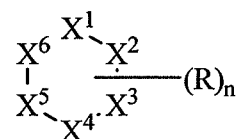


wherein R¹ is chosen from:

- i) -CH₃;
 - ii) -CHO; or
 - ii) a combination thereof; and
- the index n is equal to 1 or 2.

18. A method of preparing an article comprising the step of providing a polymer composition, the composition comprising:

- a) a thermoplastic polymer;
- b) a transition metal in a positive oxidation state, the metal present in the composition in an amount of from about 10 ppm to about 400 ppm; and
- c) a compound having the formula:



wherein X¹, X², X³, X⁴, X⁵, and X⁶ are each independently:

- i) =CR¹-;
- ii) =N-;
- iii) -O-; or
- iv) -S-;

or when an R group is present, R¹ is equal to R;

each R¹ is independently chosen from:

- i) hydrogen;
- ii) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- iii) C₂-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkenyl;
- iv) C₂-C₁₂ substituted or unsubstituted linear or branched alkynyl;
- v) C₆ or C₁₀ substituted or unsubstituted aryl;
- vi) C₁-C₉ substituted or unsubstituted heterocyclic;
- vii) C₁-C₁₁ substituted or unsubstituted heteroaryl;
- viii) halogen;
- ix) $-\text{[C(R}^{23\text{a}}\text{)(R}^{23\text{b}}\text{)]}_x\text{OR}^{10}$;

R¹⁰ is chosen from:

- a) -H;
- b) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- c) C₆ or C₁₀ substituted or unsubstituted aryl or alkylenearyl;
- d) C₁-C₉ substituted or unsubstituted heterocyclic;
- e) C₁-C₁₁ substituted or unsubstituted heteroaryl;
- x) $-\text{[C(R}^{23\text{a}}\text{)(R}^{23\text{b}}\text{)]}_x\text{N(R}^{11\text{a}}\text{)(R}^{11\text{b}}\text{)}$;

R^{11a} and R^{11b} are each independently chosen from:

- a) -H;
 - b) -OR¹²;
- R¹² is hydrogen or C₁-C₄ linear alkyl;
- c) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
 - d) C₆ or C₁₀ substituted or unsubstituted aryl;
 - e) C₁-C₉ substituted or unsubstituted heterocyclic;
 - f) C₁-C₁₁ substituted or unsubstituted heteroaryl; or
 - g) R^{11a} and R^{11b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
 - xi) $-\text{[C(R}^{23\text{a}}\text{)(R}^{23\text{b}}\text{)]}_x\text{C(O)R}^{13}$;

R¹³ is:

- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) -OR¹⁴;
R¹⁴ is hydrogen, substituted or unsubstituted C₁-C₄ linear alkyl, C₆ or C₁₀ substituted or unsubstituted aryl, C₁-C₉ substituted or unsubstituted heterocyclic, C₁-C₁₁ substituted or unsubstituted heteroaryl;
- c) -N(R^{15a})(R^{15b});
R^{15a} and R^{15b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{15a} and R^{15b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xii) -[C(R^{23a})(R^{23b})_xOC(O)R¹⁶];
R¹⁶ is:
- a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;
- b) -N(R^{17a})(R^{17b});
R^{17a} and R^{17b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{17a} and R^{17b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;
- xiii) -[C(R^{23a})(R^{23b})_xNR¹⁸C(O)R¹⁹];
R¹⁸ is:
- a) -H; or
- b) C₁-C₄ substituted or unsubstituted linear, branched, or cyclic alkyl;

R¹⁹ is:

a) C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl;

b) -N(R^{20a})(R^{20b});

R^{20a} and R^{20b} are each independently hydrogen, C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or R^{20a} and R^{20b} can be taken together to form a substituted or unsubstituted ring having from 3 to 10 carbon atoms and from 0 to 3 heteroatoms chosen from oxygen, nitrogen, and sulfur;

xiv) -[C(R^{23a})(R^{23b})_xCN];

xv) -[C(R^{23a})(R^{23b})_xNO₂];

xvi) -[C(R^{23a})(R^{23b})_xR²¹];

R²¹ is C₁-C₁₀ linear, branched, or cyclic alkyl substituted by from 1 to 21 halogen atoms chosen from -F, -Cl, -Br, or -I;

xvii) -[C(R^{23a})(R^{23b})_xSO₂R²²];

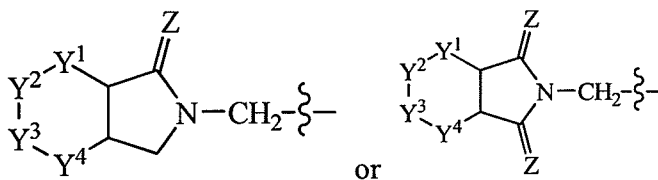
R²² is hydrogen, hydroxyl, substituted or unsubstituted C₁-C₄ linear or branched alkyl; substituted or unsubstituted C₆, C₁₀, or C₁₄ aryl; C₇-C₁₅ alkylenearyl; C₁-C₉ substituted or unsubstituted heterocyclic; or C₁-C₁₁ substituted or unsubstituted heteroaryl; or

xviii) R¹ units on two adjacent carbons can be taken together to form a substituted or unsubstituted 5, 6, or 7 member fused ring comprising one or more heteroatoms chosen from nitrogen, oxygen, or sulfur, and wherein the fused ring can be substituted by C₁-C₁₂ substituted or unsubstituted linear, branched, or cyclic alkyl; C₆ or C₁₀ substituted or unsubstituted aryl; C₁-C₉ substituted or unsubstituted heterocyclic; C₁-C₁₁ substituted or unsubstituted heteroaryl; or when one of the ring atoms is a carbon, the atom can be substituted with carbonyl having the formula =O, or imide having the formula =NH;

R^{23a} and R^{23b} are each independently hydrogen or C₁-C₄ alkyl; and

the index x is an integer from 0 to 5;

R is has the formula:



each Z is independently O, NH, or S;

Y^1 , Y^2 , Y^3 , and Y^4 are each independently:

i) $=CR^2-$; or

ii) $=N-$;

each R^2 is independently chosen from:

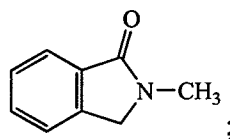
- xxii) hydrogen;
- xxiii) substituted or unsubstituted C_1 - C_{10} linear, branched, or cyclic alkyl;
- xxiv) substituted or unsubstituted C_2 - C_{10} linear, branched, or cyclic alkenyl;
- xxv) substituted or unsubstituted C_2 - C_{10} linear or branched alkynyl;
- xxvi) substituted or unsubstituted C_6 or C_{10} aryl;
- xxvii) substituted or unsubstituted C_1 - C_9 heterocyclic;
- xxviii) substituted or unsubstituted C_1 - C_9 heteroaryl; or

two R^2 units on adjacent carbon atoms can be taken together to form a substituted or unsubstituted heterocyclic or substituted or unsubstituted heteroaryl ring having from form 2 to 20 carbon atoms and from 1 to 7 heteroatoms; and n is an integer from 0 to 6, and

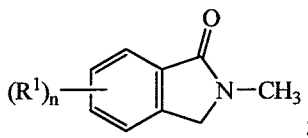
forming an article from the composition.

19. The method of claim 18, wherein the compound has the formula chosen from:

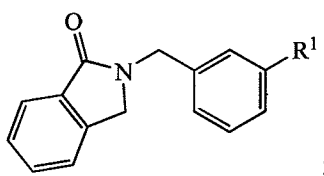
i)



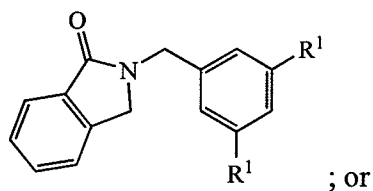
ii)



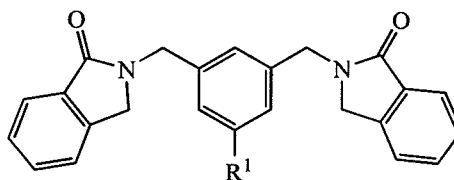
iii)



iv)



v)



wherein R¹ is chosen from:

- i) -CH₃;
- ii) -CHO; or
- ii) a combination thereof; and

the index n is equal to 1 or 2.

20. The method of claim 18 or 19, wherein the step of forming comprises injection moulding, stretch blow moulding, extrusion, thermoforming, or extrusion blow moulding.

21. The method of claim 18, 19, or 20, wherein the step of forming is sheet or film extrusion.

22. The method of claim 18, wherein the article is a bottle or a preform.

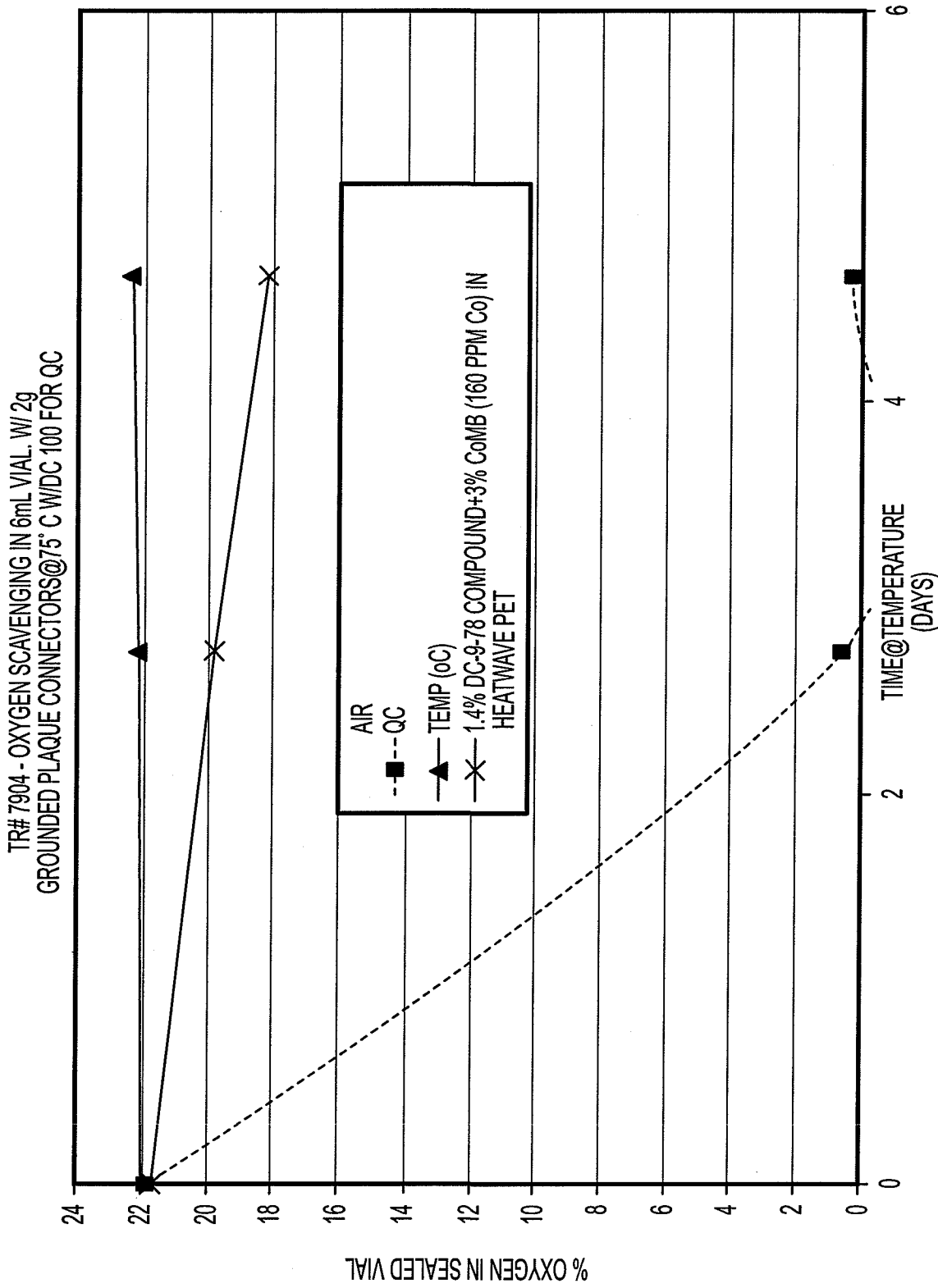


FIG. 1

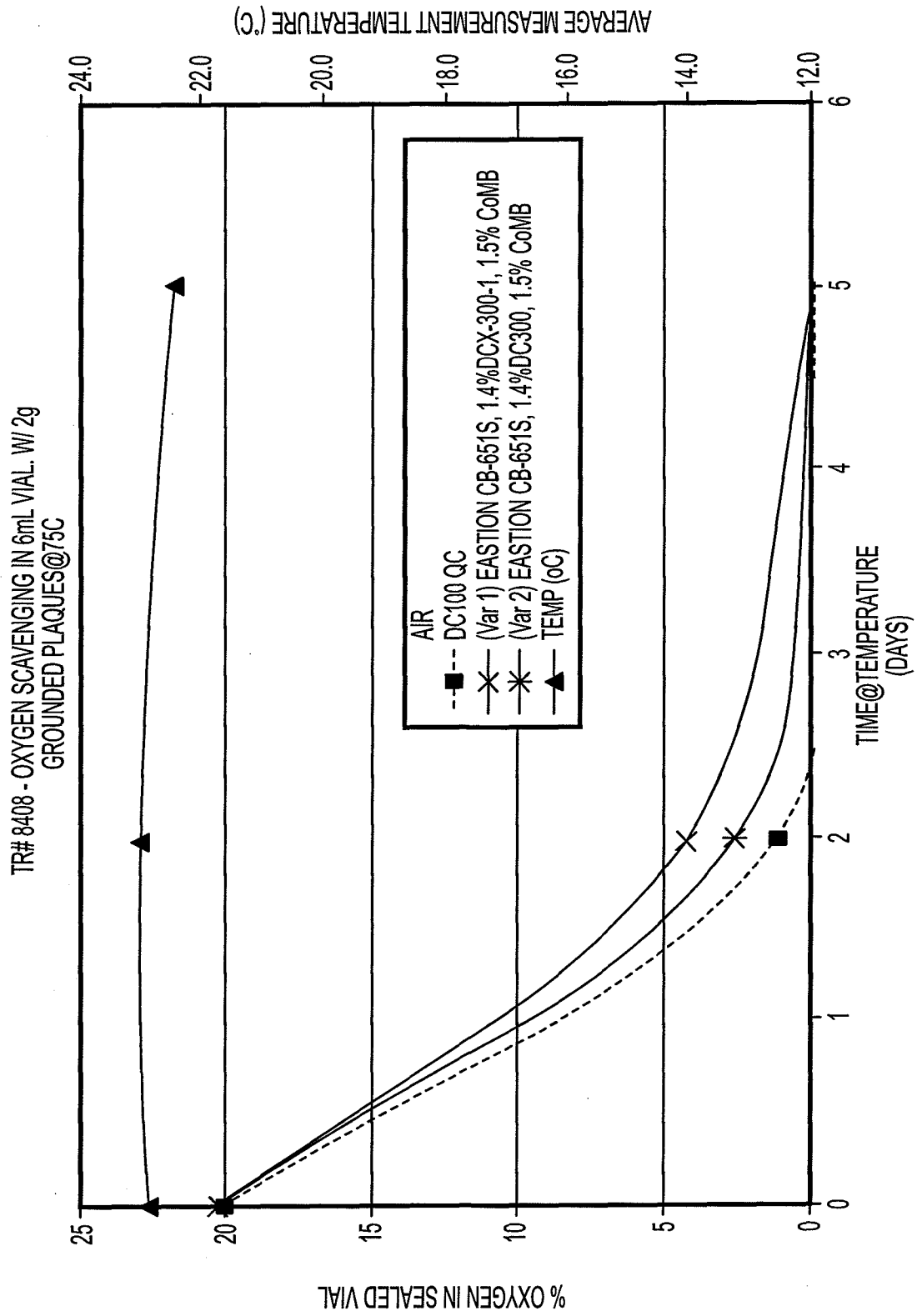


FIG. 2