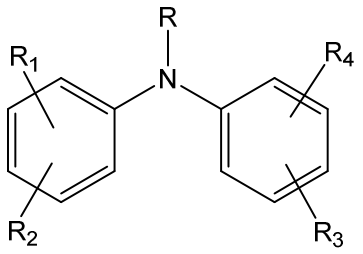


I

wherein R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl; and R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl. In certain examples, the number average molecular weight (Mn) of the antioxidant polymer (e.g., oligomer) composition is at least about 350 g/mol or from about 350 g/mol to about 5000 g/mol.

[0005a] In an aspect, there is provided an antioxidant polymer composition comprising repeat units of diphenylamine monomers of formula I



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wherein

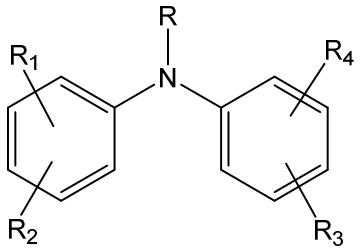
R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl and

R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl and

wherein

the number average molecular weight (Mn) of the polymer is from 400 g/mol to 1500 g/mol, determined by gel permeation chromatography (GPC).

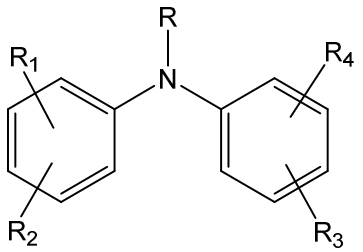
[0006] Also disclosed in certain examples is an antioxidant polymer (e.g., oligomer) composition comprising repeat units of diphenylamine monomers of formula I, wherein the composition comprises ≤ about 99 wt%, ≤ about 90 wt%, ≤ about 80 wt%, ≤ about 70 wt%, ≤ about 65 wt%, ≤ about 60 wt%, ≤ about 55 wt%, ≤ about 50 wt%, ≤ about 45 wt%, ≤ about 40 wt%, ≤ about 35 wt%, ≤ about 30 wt%, ≤ about 25 wt%, ≤ about 20



I

wherein R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl; and R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl.; to dehydrocondensation conditions. Also disclosed are products prepared by the processes disclosed herein.

[0007a] In another aspect, there is provided a process for preparing the antioxidant polymer composition as defined above, the process comprising subjecting one or more diphenylamine monomers of formula



I

wherein

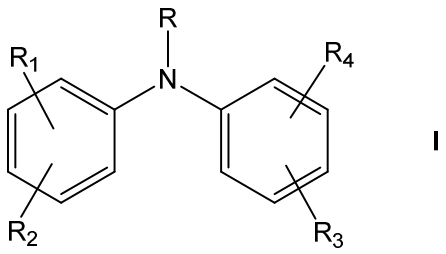
R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl and

R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl;

to dehydrocondensation conditions,

wherein the antioxidant polymer composition has a number average molecular weight (Mn) of from 400 g/mol to 1500 g/mol determined by gel permeation chromatography (GPC) technique.

[0007b] In another aspect, there is provided an antioxidant polymer composition comprising repeat units of diphenylamine monomers of formula I



I

wherein

R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl and

R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl and

wherein the polymer comprises ≤ about 70 wt%, ≤ about 65 wt%, ≤ about 60 wt%, ≤ about 55 wt%, ≤ about 50 wt%, ≤ about 45 wt%, ≤ about 40 wt%, ≤ about 35 wt%, ≤ about 30 wt%, ≤ about 25 wt%, ≤ about 20 wt%, ≤ about 15 wt%, ≤ about 10 wt% or ≤ about 5 wt% residual monomers of formula I, based on the weight of the composition,

wherein the antioxidant polymer composition has a number average molecular weight (Mn) of from 400 g/mol to 1500 g/mol determined by gel permeation chromatography (GPC) technique.

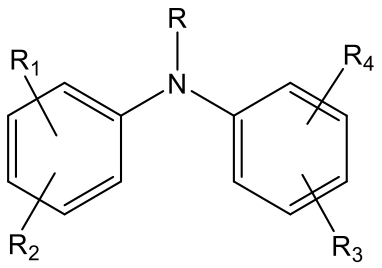
[0007c] In another aspect, there is provided a liquid blend comprising the antioxidant polymer composition as defined above and one to three components selected from the group consisting of solvents, base oils, further antioxidants, metal passivators, rust inhibitors, corrosion inhibitors, viscosity index improvers, extreme pressure agents, pour point depressants, dispersants, detergents, antifoams, color stabilizers, demulsifiers, friction modifiers and antiwear additives.

[0007d] In another aspect, there is provided a liquid concentrate comprising the antioxidant polymer composition as defined above and a solvent and/or a base oil, wherein the concentrate comprises from about 50 wt% to about 95 wt%, based on the total weight of the concentrate, of the antioxidant polymer composition.

[0007e] In another aspect, there is provided a method of preparing a liquid blend, the method comprising mixing an antioxidant polymer composition as defined above with one to three components selected from the group consisting of solvents, base oils, further antioxidants, metal passivators, rust inhibitors, corrosion inhibitors, viscosity index improvers, extreme pressure agents, pour point depressants, dispersants, detergents, antifoams, color stabilizers, demulsifiers, friction modifiers and antiwear additives.

Claims

1. An antioxidant polymer composition comprising repeat units of diphenylamine monomers of formula I



I

wherein
R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl and
R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl and
wherein
the number average molecular weight (Mn) of the polymer is from 400 g/mol to 1500 g/mol, determined by gel permeation chromatography (GPC).

2. The composition according to claim 1, wherein the Mn is from 490 g/mol to 1500 g/mol.

3. The composition according to claim 1 or 2, wherein
R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_4-C_{10} alkyl.

4. The composition according to any of the preceding claims, wherein
R_1, R_2, R_3 and R_4 are each independently H, tert-butyl or tert-octyl.

5. The composition according to any of the preceding claims, further comprising one or more monomers selected from the group consisting of other diphenylamines, phenothiazines, phenoxazines, aminodiphenylamines, methylenedianiline, toluenediamine, aminophenols, alkylphenols, thiophenols, phenylenediamines, quinolines, phenyl pyridinediamines, pyridinepyrimidinediamines and phenylpyrimidinediamines.

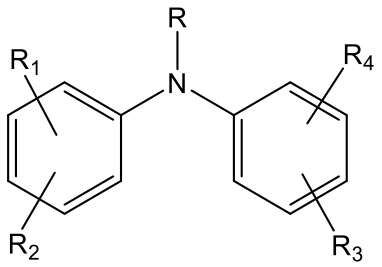
6. The composition according to any of the preceding claims, comprising from 50 mol% to 80 mol% diphenylamine monomers, based on the total weight of the composition.

7. The composition according to any of the preceding claims, comprising ≤ 70 wt%, ≤ 65 wt%, ≤ 60 wt%, ≤ 55 wt%, ≤ 50 wt%, ≤ 45 wt%, ≤ 40 wt%, ≤ 35 wt%, ≤ 30 wt%, ≤ 25 wt%, ≤ 20 wt%, ≤ 15 wt%, ≤ 10 wt% or ≤ 5 wt% residual monomers of formula I, based on the total weight of the composition.

8. The composition according to any of the preceding claims, comprising residual monomer, wherein from 90 wt% to 100 wt% of the residual monomer is of formula I wherein R_1 and R_4 are independently C_4-C_{18} alkyl, C_4-C_{18} alkenyl or C_7-C_{21} aralkyl, based on the total weight of residual monomer.

9. The composition according to any of the preceding claims, having a kinematic viscosity at 100 °C of from 20 cSt to 600 cSt based on ASTM D445.

10. A process for preparing the antioxidant polymer composition according to any of the preceding claims, the process comprising subjecting one or more diphenylamine monomers of formula



I

wherein

R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl and

R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl;

to dehydrocondensation conditions,

wherein the antioxidant polymer composition has a number average molecular weight (Mn) of from 400 g/mol to 1500 g/mol determined by gel permeation chromatography (GPC) technique.

11. The process according to claim 10, wherein the dehydrocondensation conditions comprise reaction with a free radical precursor.

12. The process according to claim 10 or 11, wherein the dehydrocondensation conditions comprise reaction with an organic peroxide.

13. The process according to claims 10 to 12, wherein the dehydrocondensation conditions comprise reaction temperatures of from 40°C to 250°C.

14. The process according to claims 10 to 13, wherein the dehydrocondensation conditions comprise a time period of from 0.3 hours to 12 hours.

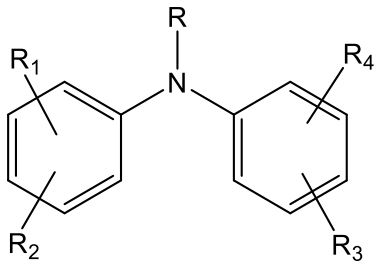
15. The process according to claims 10 to 14, wherein the dehydrocondensation conditions are neat.

16. The process according to claims 10 to 14, wherein the dehydrocondensation conditions comprise presence of a solvent.

17. The process according to claim 16, wherein the solvent is an organic solvent.

18. The process according to claims 10 to 17, comprising purifying a product obtained from the dehydrocondensation conditions.

19. An antioxidant polymer composition comprising repeat units of diphenylamine monomers of formula I



I

wherein

R is H, C_1-C_{18} alkyl, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl, -C(O)C_1-C_{18} alkyl, -C(O)aryl and

R_1, R_2, R_3 and R_4 are each independently H or a linear or branched C_1-C_{18} alkyl, C_1-C_{18} alkoxy, C_1-C_{18} alkylamino, C_1-C_{18} dialkylamino, C_1-C_{18} alkylthio, C_2-C_{18} alkenyl, C_2-C_{18} alkynyl or C_7-C_{21} aralkyl and

wherein the polymer comprises ≤ 70 wt%, ≤ 65 wt%, ≤ 60 wt%, ≤ 55 wt%, ≤ 50 wt%, ≤ 45 wt%, ≤ 40 wt%, ≤ 35 wt%, ≤ 30 wt%, ≤ 25 wt%, ≤ 20 wt%, ≤ 15 wt%, ≤ 10 wt% or ≤ 5 wt% residual monomers of formula I, based on the weight of the composition, and

wherein the antioxidant polymer composition has a number average molecular weight (Mn) of from 400 g/mol to 1500 g/mol determined by gel permeation chromatography (GPC).

20. The composition according to claim 19 comprising residual monomer, wherein from 90 wt% to 100 wt% of the residual monomer is of formula I wherein R_1 and R_4 are independently C_4-C_{18} alkyl, C_4-C_{18} alkenyl or C_7-C_{21} aralkyl, based on the total weight of residual monomer.

21. A liquid blend comprising the antioxidant polymer composition according to any of claims 1-9 and 19-20 and one to three components selected from the group consisting of solvents, base oils, further antioxidants, metal passivators, rust inhibitors, corrosion inhibitors, viscosity index improvers, extreme pressure agents, pour point depressants, dispersants, detergents, antifoams, color stabilizers, demulsifiers, friction modifiers and antiwear additives.

22. The liquid blend according to claim 21, wherein the one to three components are selected from the group consisting of further antioxidants.

23. The liquid blend according to claim 22, wherein the one to three components are selected from the group consisting of aminic and phenolic antioxidants.

24. The liquid blend according to claim 23, wherein the antioxidants are selected from the group consisting of N,N-di-(p-tert-butylphenyl)amine, N,N-di-(p-tert-octylphenyl)amine, N-(p-tert-butylphenyl)-N-phenylamine, N-(p-tert-octylphenyl)-N-phenylamine and N-(p-tert-butylphenyl)-N-(p-tert-octylphenyl)amine, bis-nonylphenyldiphenylamine, N-(tert-C_1-C_{20}alkylphenyl)-1-naphthylamine and 3,5-di-tert-butyl-4-hydroxyhydrocinnamic acid octyl ester.

25. The liquid blend according to claim 21, wherein the blend comprises a solvent selected from the group consisting of naphtha, benzene, toluene, xylene and glymes.

26. A liquid concentrate comprising the antioxidant polymer composition according to any of claims 1-9 and 19-20 and a solvent and/or a base oil, wherein the concentrate comprises from 50 wt% to 95 wt%, based on the total weight of the concentrate, of the antioxidant polymer composition.

27. A method of preparing a liquid blend, the method comprising mixing an antioxidant polymer composition according to any of claims 1-9 and 19-20 with one to three components selected from the group consisting of solvents, base oils, further antioxidants, metal passivators, rust inhibitors, corrosion inhibitors, viscosity index improvers, extreme pressure agents, pour point depressants, dispersants, detergents, antifoams, color stabilizers, demulsifiers, friction modifiers and antiwear additives.