available under tradename NA-Lube® ADTC (King Industries), phosphorus-sulfur containing additive which is commercially available under tradename NA-Lube® AW-6330 (King Industries), sulfurized hydrocarbon which is commercially available under tradename Elco 213 (Elco Corporation), sulfurized hydrocarbon which is commercially available under tradename Elco 226 (Elco Corporation), sulfurized ester which is commercially available under tradename Elco 2556 (Elco Corporation), sulfurized ester which is commercially available under tradename Elco 2410SE (Elco Corporation), sulfurized ester which is commercially available under tradename Elco 2415C (Elco Corporation), sulfurized fatty acid which is commercially available under tradename Elco 2418 (Elco Corporation), sulfurized ester which is commercially available under tradename Elco 2426C (Elco Corporation), sulfurized ester which is commercially available under tradename Elco 2430C (Elco Corporation), sulfurized vegetable oil which is commercially available under tradename Elco 2451 (Elco Corporation), sulfurized vegetable oil which is commercially available under tradename Elco 2452 (Elco Corporation), sulfurized vegetable oil which is commercially available under tradename Elco 2452D (Elco Corporation), sulfurized ester which is commercially available under tradename Elco 2456 (Elco Corporation), sulfurized ester which is commercially available under tradename Elco 2456D (Elco Corporation), sulfurized isobutylene which is commercially available under tradename C-TEC 321 (Tianhe Chemicals) and sulfur-containing phenols which is commercially available under tradename Songnox® 1035 (Songwon).

[038] Certain compatible additives can contain both molybdenum and sulfur. Examples of these include molybdenum dithiocarbamate (DTC) and molybdenum dithiophosphate (DTP).

Lubricating Oil Compositions

[039] The antioxidant compositions of present disclosure may be used in lubricating oil to impart oxidation stability to the lubricating oil. When employed in this manner, the mixture of alkylated diphenylamines are usually present in the lubricating oil composition in concentrations ranging from 0.05 wt % to 10 wt %

available from Vanderbilt Chemicals, LLC (Norwalk, CT) under the tradename Molyvan® 855. The concentration of C is 0.24 wt %. The molybdenum concentration is 200 ppm.

[059] Example 5 is the PDSC results that show the degree of synergy between compositions A and C. The concentration of A is 1 wt %. The concentration of B is 0.24 wt %.

[060] Example 6 is the PDSC results that show the degree of oxidation stability of composition D which is an ashless alkyl dithiocarbamate, commercially available from Vanderbilt Chemicals, LLC (Norwalk, CT) under the tradename Vanlube® 7723. The concentration of D is 0.37 wt %. The sulfur concentration is 2000 ppm.

[061] Example 7 is the PDSC results that show the degree of synergy between compositions A and D. The concentration of A is 1 wt %. The concentration of B is 0.37 wt %.

[062] Example 8 is the PDSC results that show the degree of oxidation stability of composition E which is a reaction product butyl-cyclohex-3-enecarboxylate, sulfur, and triphenyl phosphite. This reaction is described in US 3,498,915, which is hereby incorporated by reference. The concentration of E is 0.67 wt %. The sulfur concentration is 2000 ppm.

[063] Example 9 is the PDSC results that show the degree of synergy between compositions A and E. The concentration of A is 1 wt %. The concentration of E is 0.67 wt %.

[064] Example 10 is the PDSC results that show the degree of oxidation stability of composition F. Composition F is a sulfur-containing phenolic antioxidant, commercially available from Songwon (Friendswood, TX) under the tradename Songnox® 1035. The concentration of F is 1.22 wt %.

[065] Example 11 is the PDSC results that show the level of synergy between compositions A and F. The concentration of A is 1 wt %. The concentration of F is 1.22 wt %.

[066] Example 12 is the PDSC results that show the degree of oxidation stability of composition G. Composition G is a non-sulfur containing methylenebisphenol

CLAIMS

1. A lubricating oil composition comprising:

a major amount of a base oil; and

a minor amount of an antioxidant composition comprising:

a mixture of alkylated diphenylamines having a weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranging from 0.6 to 4; and

a molybdenum or sulfur additive that provides synergistic enhancement of oxidation stability in combination with the mixture of alkylated diphenylamines.

2. The lubricating oil composition of claim 1, wherein the mixture of alkylated diphenylamines is present in a concentration ranging from 0.01 wt % to 5 wt % of the lubricating oil composition.

3. The lubricating oil composition of claim 1, wherein the molybdenum or sulfur additive is present in a concentration ranging from 0.01 wt % to 5 wt % of the lubricating oil composition.

4. The lubricating oil composition of claim 1, wherein the mixture of alkylated diphenylamine is primarily a mixture product of diphenylamine alkylated with propylene tetramer.

5. The lubricating oil composition of claim 1, wherein the additive is a molybdenum succinimide, molybdenum amino alcohol, molybdenum dithiocarbamate, sulfurized olefin ester, sulfurized isobutylene, methylene bisdithiocarbamate, molybdenum dialkyldithiocarbamate, molybdenum ester/amide, molybdenum dithiophosphate, molybdenum amine-complex, methylene bis(dibutyldithiocarbamate), sulfurized hydrocarbon, sulfurized ester, sulfurized fatty

acid, sulfurized vegetable oil, sulfurized isobutylene, sulfur-containing phenol, or thioester bis-hydrocinnamic ester.

6. The lubricating oil composition of claim 1, wherein the weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranges from 0.8 to 3.

7. The lubricating oil composition of claim 1, wherein the weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranges from 0.9 to 1.1.

8. The lubricating oil of claim 1, further comprising:

an antioxidant, an ashless dispersant, an anti-wear agent, a detergent, a rust inhibitor, a dehazing agent, a demulsifying agent, a friction modifier, a metal deactivating agent, a pour point depressant, a viscosity modifier, an antifoaming agent, a co-solvent, a package compatibilizer, a corrosion-inhibitor, a dye, or an extreme pressure agent.

9. An oxidation stabilizing composition comprising:

a mixture of alkylated diphenylamines having a weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranging from 0.6 to 4; and

a molybdenum or sulfur additive that provides synergistic enhancement of oxidation stability in combination with the mixture of alkylated diphenylamines.

10. The oxidation stabilizing composition of claim 9, further comprising:

a lubricating oil, a mineral oil, a hydraulic fluid, a metal working fluid, or a gear oil.

11. The oxidation stabilizing composition of claim 9, wherein the additive is a organomolybdenum compound, sulfur-containing organomolybdenum compound, sulfur-free organomolybdenum compound, or a sulfur-containing organic compound.

12. The oxidation stabilizing composition of claim 9, wherein the additive is a molybdenum succinimide, molybdenum amino alcohol, molybdenum dithiocarbamate, molybdenum dialkyldithiocarbamate, molybdenum ester/amide, molybdenum dithiophosphate, molybdenum amine-complex, sulfurized olefin ester, sulfurized isobutylene, methylene bisdithiocarbamate, methylene bis(dibutyldithiocarbamate), sulfurized hydrocarbon, sulfurized ester, sulfurized fatty acid, sulfurized vegetable oil, sulfurized isobutylene, or thioester bis hydrocinnamic ester.

13. The oxidation stabilizing composition of claim 9, wherein the mixture of alkylated diphenylamine is primarily a mixture product of diphenylamine alkylated with propylene tetramer.

14. The oxidation stabilizing composition of claim 9, wherein the weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranges from 0.8 to 3.

15. The oxidation stabilizing composition of claim 9, wherein the weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranges from 0.9 to 1.1.

16. The oxidation stabilizing composition of claim 9, further comprising:

an antioxidant, an ashless dispersant, an anti-wear agent, a detergent, a rust inhibitor, a dehazing agent, a demulsifying agent, a friction modifier, a metal deactivating agent, a pour point depressant, a viscosity modifier, an antifoaming agent, a co-solvent, a package compatibilizer, a corrosion-inhibitor, a dye, or an extreme pressure agent.

17. A method of improving oxidation stability of a lubricating oil, the method comprising:

supplying to the engine a lubricating oil composition comprising:

a major amount of a base oil;

a mixture of alkylated diphenylamines having a weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranging from 0.6 to 4; and

a molybdenum or sulfur additive that provides synergistic enhancement of oxidation stability in combination with the mixture of alkylated diphenylamines.

18. The method of claim 17, wherein the lubricating oil composition further comprises:

an antioxidant, an ashless dispersant, an anti-wear agent, a detergent, a rust inhibitor, a dehazing agent, a demulsifying agent, a friction modifier, a metal deactivating agent, a pour point depressant, a viscosity modifier, an antifoaming agent, a co-solvent, a package compatibilizer, a corrosion-inhibitor, a dye, or an extreme pressure agent.

19. The method of claim 17, wherein the mixture of alkylated diphenylamines is primarily a mixture product of diphenylamine alkylated with propylene tetramer.

20. The method of claim 17, wherein the additive is molybdenum succinimide, molybdenum amino alcohol, molybdenum dithiocarbamate, sulfurized olefin ester, sulfurized isobutylene, methylene bisdithiocarbamate, molybdenum dialkyldithiocarbamate, molybdenum ester/amide, molybdenum dithiophosphate, molybdenum amine-complex, methylene bis(dibutyldithiocarbamate), sulfurized hydrocarbon, sulfurized ester, sulfurized fatty acid, sulfurized vegetable oil, sulfurized isobutylene, or thioester bis hydrocinnamic ester.

21. A lubricating oil composition comprising:

a major amount of a base oil; and

a minor amount of an antioxidant comprising a mixture of alkylated diphenylamines having a weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranging from 0.6 to 4, wherein the alkylated diphenylamines is a product of an alkylation of diphenylamine and propylene tetramer.

22. The lubricating oil composition of claim 21, wherein the mixture of alkylated diphenylamines is present in a concentration ranging from 0.01 wt % to 5 wt % of the lubricating oil composition.

23. The lubricating oil of claim 21, further comprising:

an antioxidant, an ashless dispersant, an anti-wear agent, a detergent, a rust inhibitor, a dehazing agent, a demulsifying agent, a friction modifier, a metal deactivating agent, a pour point depressant, a viscosity modifier, an antifoaming agent, a co-solvent, a package compatibilizer, a corrosion-inhibitor, a dye, or an extreme pressure agent.

24. The lubricating oil of claim 21, wherein the weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranges from 0.8 to 3.

25. The lubricating oil of claim 21, wherein the weight ratio of mono-alkylated diphenylamine to di-alkylated diphenylamine ranges from 0.9 to 1.1.