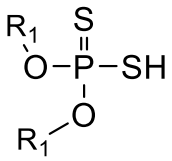
an organometallic phosphorus-providing antiwear additive or salt thereof made by a process comprising the steps of (a) reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product; (b) distilling the reaction product and recovering a condensate; and (c) neutralizing the condensate with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof; wherein

the reaction product comprises diesters of dithiophosphoric acids having the structure of Formula 1 below; and

the condensate includes diesters of dithiophosphoric acids having the structure of Formula 1 below and having a content of phosphorus polysulfides derived from the reaction product of less than 1 wt%



Formula 1

wherein R_1 is a residue derived from the organic hydroxy compound.

[0004] In another approach or example, the lubricating composition of the previous paragraph may include optional features or examples in any combination. These optional features or examples may include one or more of the following: wherein the distillation occurs at one or more of a temperature of at least about 50°C, a pressure of at least about 0.1 torr, or combinations thereof; and/or wherein the condensate is recovered at a temperature of about 10°C or less; and/or wherein the distillation occurs in a falling-film evaporator, a wiped-film evaporator, a thin-film evaporator, a short-path evaporator, or combinations thereof; and/or

[0005a] In one aspect, the present disclosure refers to a method of preparing an organometallic phosphorus-providing antiwear additive, the method comprising:

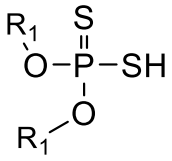
reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product;

distilling the reaction product and recovering a condensate therefrom; and

neutralizing the condensate with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof; wherein

the reaction product comprises diesters of dithiophosphoric acids having the structure of Formula 1 below; and

the condensate is diesters of dithiophosphoric acids having the structure of Formula 1 below and having a content of phosphorus polysulfides derived from the reaction product of less than 1 wt%



Formula 1

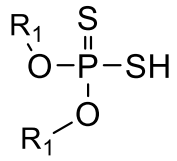
wherein R_1 is a residue derived from the organic hydroxy compound.

[0006] In other approaches or examples, the method of the previous paragraph may

(c) neutralizing the condensate with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof. In other approaches or examples, the additive may include any optional feature or example as further described in the lubricant or the method of this Summary. In one aspect, the present disclosure refers to an organometallic phosphorus-providing antiwear additive or salt thereof made by a process comprising the steps of (a) reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product; (b) distilling the reaction product and recovering a condensate; and (c) neutralizing the condensate with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof; wherein

the reaction product comprises diesters of dithiophosphoric acids having the structure of Formula 1 below; and

the condensate is diesters of dithiophosphoric acids having the structure of Formula 1 below and having a content of phosphorus polysulfides derived from the reaction product of less than 1 wt%



Formula 1

wherein R_1 is a residue derived from the organic hydroxy compound.

[0008] In yet other approaches or examples, the use of evaporation or distillation to recover a condensate from the reaction product of an organic hydroxy compound reacted with phosphorus pentasulfide is described herein and wherein the condensate is neutralized with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof. The use herein may include any further example as described in this Summary

CLAIMS

WHAT IS CLAIMED IS

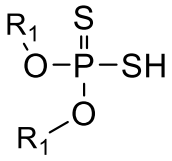
1. A lubricating composition comprising:

a majority of one or more base oils of lubricating viscosity;

an organometallic phosphorus-providing antiwear additive or salt thereof made by a process comprising the steps of (a) reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product; (b) distilling the reaction product and recovering a condensate; and (c) neutralizing the condensate with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof; wherein

the reaction product comprises diesters of dithiophosphoric acids having the structure of Formula 1 below; and

the condensate includes diesters of dithiophosphoric acids having the structure of Formula 1 below and having a content of phosphorus polysulfides derived from the reaction product of less than 1 wt%



Formula 1

wherein R_1 is a residue derived from the organic hydroxy compound.

2. The lubricating composition of claim 1, wherein the distillation occurs at one or more of a temperature of at least 50°C, a pressure of at least 0.1 torr, or combinations thereof; and/or wherein the condensate is recovered at a temperature of 10°C or less.

3. The lubricating composition of claim 1, wherein the distillation occurs in a falling-film evaporator, a wiped-film evaporator, a thin-film evaporator, a short-path evaporator, or combinations thereof.

4. The lubricating composition of claim 1, wherein the condensate includes a dialkyl dithiophosphoric acid.

5. The lubricating composition of claim 4, wherein the dialkyl dithiophosphoric acid is dipropyl dithiophosphoric acid, diisopropyl dithiophosphoric acid, dibutyl dithiophosphoric acid, diisobutyl dithiophosphoric acid, or combinations thereof.

6. The lubricating composition of claim 1, wherein the basic or neutral metal compound is a metal oxide, a metal hydroxide, or a metal carbonate of aluminum, lead, tin, molybdenum, manganese, nickel, copper, titanium, zirconium, zinc, or combinations thereof.

7. The lubricating composition of claim 6, wherein the basic or neutral metal compound is a molar excess of zinc oxide.

8. The lubricating composition of claim 1, wherein the organic hydroxy compound is a C1 to C6 linear or branched alcohol, a hydroxyl aryl compound, or mixtures thereof.

9. The lubricating composition of claim 8, wherein the organic hydroxy compound is methyl alcohol, ethyl alcohol, propyl alcohol, isopropyl alcohol, butyl alcohol, isobutyl alcohol, tert-butyl alcohol, sec-butyl alcohol, phenol, naphthol, an amyl alcohol, hexyl alcohol, iso-hexyl alcohol, octyl alcohol, decyl alcohol, dodecyl alcohol, octadecyl alcohol, 2-ethylhexyl alcohol, 4-methyl-2-pentyl alcohol, phenyl alcohol, butylphenyl alcohol, cyclohexyl alcohol, methylcyclopentyl alcohol, propenyl alcohol, butenyl alcohol, or combinations thereof.

10. The lubricating composition of claim 1, wherein the organic hydroxy compound is ethylhexyl alcohol, the reaction product comprises di-ethylhexyl dithiophosphoric acid and one or more phosphorus polysulfides, the condensate includes the di-ethylhexyl dithiophosphoric acid and is substantially free of the one or more phosphorus polysulfides, and the condensate is further reacted with zinc oxide to form the organometallic phosphorus-providing antiwear additive.

11. The lubricating composition of claim 1, wherein the lubricating composition includes 0.1 to 5 weight percent of the organometallic phosphorus-providing antiwear additive.

12. The lubricating composition of claim 1, wherein the organic hydroxy compound is provided in a molar ratio relative to the phosphorus pentasulfide of 4:1 to 10:1.

13. The lubricating composition of claim 12, wherein the basic or neutral metal compound is provided in a molar ratio relative to the organic hydroxy compound of 0.01:1 to 0.5:1.

14. A method of preparing an organometallic phosphorus-providing antiwear additive, the method comprising:

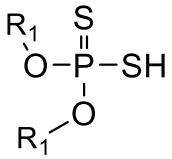
reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product;

distilling the reaction product and recovering a condensate therefrom; and

neutralizing the condensate with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof; wherein

the reaction product comprises diesters of dithiophosphoric acids having the structure of Formula 1 below; and

the condensate is diesters of dithiophosphoric acids having the structure of Formula 1 below and having a content of phosphorus polysulfides derived from the reaction product of less than 1 wt%



Formula 1

wherein R_1 is a residue derived from the organic hydroxy compound.

15. The method of claim 14, wherein the distillation occurs at a temperature of at least 80°C and a pressure of at least 0.4 torr.

16. The method of claim 15, wherein the condensate is recovered at a temperature of 10°C or less.

17. The method of claim 14, wherein the distillation occurs in a falling-film evaporator, a wiped-film evaporator, a thin-film evaporator, a short-path evaporator, or combinations thereof.

18. The method of claim 14, wherein the condensate includes a dialkyl dithiophosphorus acid.

19. The method of claim 18, wherein the dialkyl dithiophosphoric acid is dipropyl dithiophosphoric acid, diisopropyl dithiophosphoric acid, dibutyl dithiophosphoric acid, diisobutyl dithiophosphoric acid, or combinations thereof.

20. The method of claim 14, wherein the basic or neutral metal compound is a metal oxide, a metal hydroxide, or a metal carbonate of aluminum, lead, tin, molybdenum, manganese, nickel, copper, titanium, zirconium, zinc, or combinations thereof.

21. The method of claim 20, wherein the basic or neutral metal compound is a molar excess of zinc oxide.

22. The method of claim 14, wherein the organic hydroxy compound is a C1 to C6 linear or branched alcohol, a hydroxy aryl compound, or mixtures thereof.

23. The method of claim 22, wherein the organic hydroxy compound is methyl alcohol, ethyl alcohol, propyl alcohol, isopropyl alcohol, butyl alcohol, isobutyl alcohol, tert-butyl alcohol, sec-butyl alcohol, phenol, naphthol, an amyl alcohol, hexyl alcohol, iso-hexyl alcohol, octyl alcohol, decyl alcohol, dodecyl alcohol, octadecyl alcohol, 2-ethylhexyl alcohol, 4-

methyl-2-pentyl alcohol, phenyl alcohol, butylphenyl alcohol, cyclohexyl alcohol, methylcyclopentyl alcohol, propenyl alcohol, butenyl alcohol, or combinations thereof.

24. The method of claim 14, wherein the organic hydroxy compound is isopropyl alcohol, the reaction product comprises diisopropyl dithiophosphoric acid and one or more phosphorus polysulfides, the condensate includes the diisopropyl dithiophosphoric acid and is substantially free of the one or more phosphorus polysulfides, and the condensate is neutralized with a molar excess of zinc oxide.

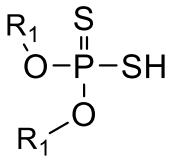
25. The method of claim 14, wherein the organic hydroxy compound is provided in a molar ratio relative to the phosphorus pentasulfide of 4:1 to 10:1.

26. The method of claim 25, wherein the basic or neutral metal compound is provided in a molar ratio relative to the organic hydroxy compound of 0.01:1 to 0.5:1.

27. An organometallic phosphorus-providing antiwear additive or salt thereof made by a process comprising the steps of (a) reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product; (b) distilling the reaction product and recovering a condensate; and (c) neutralizing the condensate with a basic or neutral metal compound including one or more of a metal oxide, a metal hydroxide, or a metal carbonate to form the organometallic phosphorus-providing antiwear additive or salt thereof; wherein

the reaction product comprises diesters of dithiophosphoric acids having the structure of Formula 1 below; and

the condensate is diesters of dithiophosphoric acids having the structure of Formula 1 below and having a content of phosphorus polysulfides derived from the reaction product of less than 1 wt%



Formula 1

wherein R_1 is a residue derived from the organic hydroxy compound.