

(Formula III)

wherein each R_{10} is, independently, hydrogen or sulfur; each R_{11} is, independently, an alkyl group; n is an integer of 0 or 1 and if R_{10} is hydrogen then the integer n of the adjacent R_{11} moiety is 0 and if R_{10} is sulfur then the n of the adjacent R_{11} moiety is 1; and wherein at least one R_{10} is sulfur; and/or further including one or more metal-containing detergent additives providing no more than about 50 ppm of calcium to the electric motor lubricating fluid.

[005a] In another aspect of the present disclosure, there is provided an electric motor lubricating fluid suitable for electric or hybrid-electric vehicles, the electric motor lubricating fluid comprising:

one or more base oils of lubricating viscosity;

2 to 4 weight percent of a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of 2,000 to 2,300, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating fluid;

an amine salt of a phosphoric acid ester providing 40 to 70 ppm of phosphorus to the electric motor lubricating fluid;

an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 40 to 70 ppm of phosphorus to the electric motor lubricating fluid;

a sulfur-providing additive including a thiadiazole providing up to 950 ppm of sulfur to the electric motor lubricating fluid; and

wherein the electric motor lubricating fluid has a kV100°C of 4.5 cSt or less and, 150 to 250 ppm of total phosphorus.

[006] As described herein, the present disclosure provides for an additive concentrate suitable for an electric motor lubricating fluid. In approaches, the additive concentrate includes a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of about 2,000 or greater, wherein the succinimide dispersant has about 0.5 to about 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant is present in an amount to deliver about 1400 to about 2450 ppm

R_{10} is sulfur; and/or further including one or more metal-containing detergent additives providing no more than about 950 ppm of calcium to the additive concentrate.

[007a] In another aspect of the present disclosure, there is provided an additive concentrate suitable for an electric motor lubricating fluid, the additive concentrate comprising:

40 to 70 weight percent of a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating fluid;

an amine salt of a phosphoric acid ester providing 1000 to 1500 ppm of phosphorus to the additive concentrate;

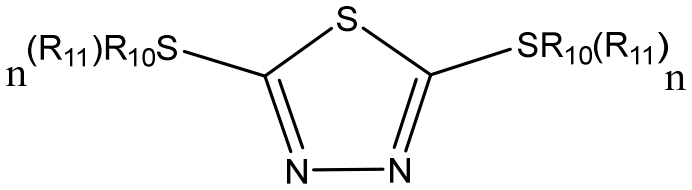
an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 800 ppm to 1300 ppm of phosphorus to the additive concentrate;

a sulfur-providing additive including a thiadiazole providing sulfur, but no more than 18,000 ppm of sulfur to the additive concentrate; and

wherein the additive concentrate has a kV100°C of 15 cSt to 80 cSt.

[008] As described herein is a method for lubricating a driveline component including an electric motor. In approaches, the method includes lubricating the driveline component with an electric motor lubricating composition and wherein the electric motor lubricating composition contacts portions of the electric motor; and wherein the electric motor lubricating composition includes (i) one or more base oils of lubricating viscosity; (ii) a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of about 2,000 or greater, wherein the succinimide dispersant has about 0.5 to about 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers about 70 to about 140 ppm phosphorus and about 150 to about 300 ppm nitrogen to the electric motor lubricating fluid; (iii) an amine salt of a phosphoric acid ester providing about 40 to about 70 ppm of phosphorus to the electric motor lubricating fluid; (iv) an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing about 40 to about 70 ppm of phosphorus to the electric motor lubricating fluid; and (v) a sulfur-providing additive including a thiadiazole or derivative thereof providing sulfur, but no more than about 950 ppm of sulfur to the electric motor lubricating fluid; and wherein the

phosphinothioyl]thio]-2-methyl-propanoic acid; and/or wherein the thiadiazole or derivative thereof includes one or more compounds having a structure of Formula III:



(Formula III)

wherein each R_{10} is, independently, hydrogen or sulfur; each R_{11} is, independently, an alkyl group; n is an integer of 0 or 1 and if R_{10} is hydrogen then the integer n of the adjacent R_{11} moiety is 0 and if R_{10} is sulfur then the n of the adjacent R_{11} moiety is 1; and wherein at least one R_{10} is sulfur; and/or wherein the electric motor lubricating composition further includes one or more metal-containing detergent additives providing no more than about 50 ppm of calcium to the electric motor lubricating composition.

[009a] In another aspect of the present disclosure, there is provided a method for lubricating a driveline component including an electric motor, the method comprising:

lubricating the driveline component with an electric motor lubricating composition and wherein the electric motor lubricating composition contacts portions of the electric motor;

the electric motor lubricating composition including (i) one or more base oils of lubricating viscosity; (ii) 2 to 4 weight percent of a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating composition; (iii) an amine salt of a phosphoric acid ester providing 40 to 70 ppm of phosphorus to the electric motor lubricating composition; (iv) an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 40 to 70 ppm of phosphorus to the electric motor lubricating composition; and (v) a sulfur-providing additive including a thiadiazole providing sulfur, but no more than 950 ppm of sulfur to the electric motor lubricating composition; and

wherein the electric motor lubricating composition has a kV100°C of 3.5 cSt or less, 150 to 200 ppm of total phosphorus, and an electrical conductivity of 37 nS/M or less, as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric motor lubricating composition and measured at 20 Hz and at 100°C.

CLAIMS

WHAT IS CLAIMED IS:

1. An electric motor lubricating fluid suitable for electric or hybrid-electric vehicles, the electric motor lubricating fluid comprising:

one or more base oils of lubricating viscosity;

a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating fluid;

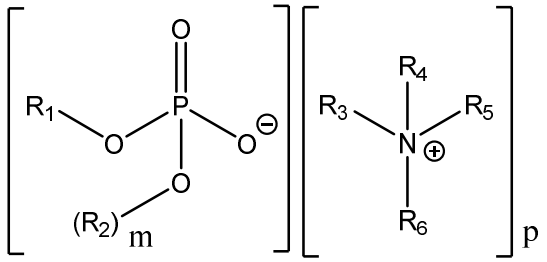
an amine salt of a phosphoric acid ester providing 40 to 70 ppm of phosphorus to the electric motor lubricating fluid;

an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 40 to 70 ppm of phosphorus to the electric motor lubricating fluid;

a sulfur-providing additive including a thiadiazole providing up to 950 ppm of sulfur to the electric motor lubricating fluid; and

wherein the electric motor lubricating fluid has a kV100°C of 4.5 cSt or less and, 150 to 250 ppm of total phosphorus.

2. The electric motor lubricating fluid of claim 1, wherein the amine salt of a phosphoric acid ester has the structure of Formula I or a solvate or hydrate thereof:



(Formula I)

wherein

R_1 and R_2 are, independently, hydrogen or a linear, branched, or cyclic hydrocarbyl group;

m is an integer from 0 to 1, p is an integer from 1 to 2, and m + p equals 2;

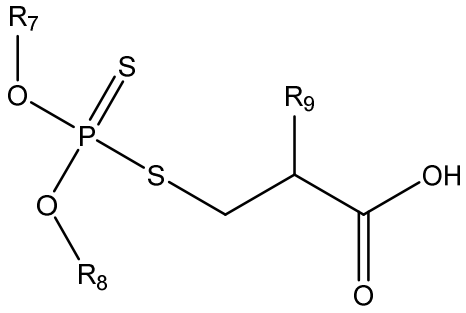
R_3, R_4, R_5, and R_6 are, independently, hydrogen or a hydrocarbyl group and at least one of R_3 to R_6 is a hydrocarbyl group, and preferably wherein R_1 and R_2 are, independently, a C_3 to C_{10} alkyl group and wherein at least one of R_3, R_4, R_5 and R_6 is a C_{10} to C_{20} alkyl group.

3. The electric motor lubricating fluid of claim 1, wherein the number average molecular weight of the high molecular weight polyisobutylene is 2,000 to 2,300; and/or wherein the electric motor lubricating fluid includes 2 to 4 weight percent of the succinimide dispersant.

4. The electric motor lubricating fluid of claim 1, wherein the succinimide dispersant, the amine salt of a phosphoric acid ester, the ashless dialkyl dithiophosphate, and the thiadiazole is provided in an additive concentrate and wherein the additive concentrate has a kV100°C of 15 to 80 cSt; and/or wherein a ratio of the kV100°C of the additive concentrate to the kV100°C of the electric motor lubricating fluid is 5:1 to 30:1.

5. The electric motor lubricating fluid of claim 1, wherein the electric motor lubricating fluid has a change in viscosity of less than 0.09 cSt after the electric motor lubricating fluid has been aged according to CEC L-48-A; and/or wherein the electric motor lubricating fluid achieves a failure load stage of at least 8 in the FZG A10/16.6R/90 scuffing test of CEC L-84-02; and/or wherein the electric motor lubricating fluid has an electrical conductivity of 60 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric motor lubricating fluid and measured at 20 Hz and at 100°C.

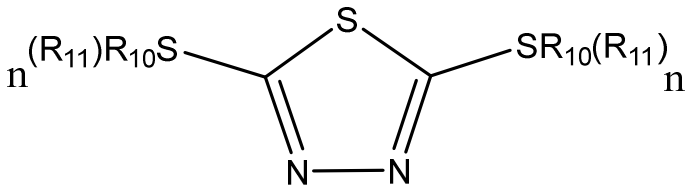
6. The electric motor lubricating fluid of claim 1, wherein the oil-soluble phosphorus antiwear additive including the ashless dialkyl dithiophosphate is made by a process comprising the steps of (a) reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product and further reacting the reaction product with an unsaturated carboxylic acid to form the oil-soluble phosphorus antiwear additive including the ashless dialkyl dithiophosphate; and/or wherein the ashless dialkyl dithiophosphate includes a compound of Formula II, or a salt thereof:



(Formula II)

wherein R_7 and R_8 are, independently, a C_3 to C_8 linear or branched alkyl group, and R_9 is -H or -CH_3, and preferably wherein the ashless dialkyl dithiophosphoate is 3-[[bis(2-methylpropoxy) phosphinothioyl]thio]-2-methyl-propanoic acid.

7. The electric motor lubricating fluid of claim 1, wherein the thiadiazole includes one or more compounds having a structure of Formula III:



(Formula III)

wherein

each R_{10} is, independently, hydrogen or sulfur;

each R_{11} is, independently, an alkyl group;

n is an integer of 0 or 1 and if R_{10} is hydrogen then the integer n of the adjacent R_{11} moiety is 0 and if R_{10} is sulfur then the n of the adjacent R_{11} moiety is 1; and

wherein at least one R_{10} is sulfur.

8. The electric motor lubricating fluid of claim 1, further including one or more metal-containing detergent additives providing no more than 50 ppm of calcium to the electric motor lubricating fluid.

9. An additive concentrate suitable for an electric motor lubricating fluid, the additive concentrate comprising:

a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has 0.5

to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant is present in an amount to deliver 1400 to 2450 ppm phosphorus and 3000 to 5400 ppm nitrogen to the dispersant additive concentrate;

an amine salt of a phosphoric acid ester providing 1000 to 1500 ppm of phosphorus to the additive concentrate;

an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 800 ppm to 1300 ppm of phosphorus to the additive concentrate;

a sulfur-providing additive including a thiadiazole providing sulfur, but no more than 18,000 ppm of sulfur to the additive concentrate; and

wherein the additive concentrate has a kV100°C of 15 cSt to 80 cSt.

10. The additive concentrate of claim 9, wherein the number average molecular weight of the high molecular weight polyisobutylene is 2,000 to 2,300; and/or wherein the succinimide dispersant comprises 40 to 70 weight percent of the additive concentrate; and/or further including one or more metal-containing detergent additives providing no more than 950 ppm of calcium to the additive concentrate.

11. A method for lubricating a driveline component including an electric motor, the method comprising:

lubricating the driveline component with an electric motor lubricating composition and wherein the electric motor lubricating composition contacts portions of the electric motor;

the electric motor lubricating composition including (i) one or more base oils of lubricating viscosity; (ii) a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating composition; (iii) an amine salt of a phosphoric acid ester providing 40 to 70 ppm of phosphorus to the electric motor lubricating composition; (iv) an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 40 to 70 ppm of phosphorus to the

electric motor lubricating composition; and (v) a sulfur-providing additive including a thiadiazole providing sulfur, but no more than 950 ppm of sulfur to the electric motor lubricating composition; and

wherein the electric motor lubricating composition has a kV100°C of 3.5 cSt or less, 150 to 200 ppm of total phosphorus, and an electrical conductivity of 37 nS/M or less, as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric motor lubricating composition and measured at 20 Hz and at 100°C.

12. The method for lubricating a driveline component including an electric motor of claim 11, wherein the number average molecular weight of the high molecular weight polyisobutylene is 2,000 to 2,300; and/or wherein the electric motor lubricating composition includes 2 to 4 weight percent of the succinimide dispersant.

13. The method for lubricating a driveline component including an electric motor of claim 11, wherein the succinimide dispersant, the amine salt of a phosphoric acid ester; the oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate; and the sulfur-providing additive including a thiadiazole is provided in an additive concentrate having a kV100°C of 15 to 80 cSt; and/or wherein the electric motor lubricating composition further includes one or more metal-containing detergent additives providing no more than 50 ppm of calcium to the electric motor lubricating composition.

14. The method for lubricating a driveline component including an electric motor of claim 13, wherein a ratio of the kV100°C of the additive concentrate to the kV100°C of the electric motor lubricating composition is 5:1 to 30:1.

15. The method for lubricating a driveline component including an electric motor of claim 11, wherein the electric motor lubricating composition has a change in viscosity of less than 0.09 cSt after the electric motor lubricating composition has been aged according to CEC L-48-A; and/or wherein the electric motor lubricating composition achieves a failure load stage of at least 8 in the FZG A10/16.6R/90 scuffing test of CEC L-84-02.

16. An electric motor lubricating fluid suitable for electric or hybrid-electric vehicles, the electric motor lubricating fluid comprising:

one or more base oils of lubricating viscosity;

2 to 4 weight percent of a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of 2,000 to 2,300, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating fluid;

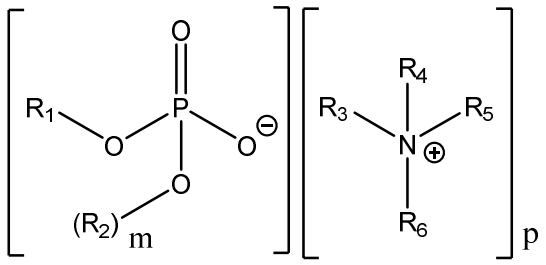
an amine salt of a phosphoric acid ester providing 40 to 70 ppm of phosphorus to the electric motor lubricating fluid;

an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 40 to 70 ppm of phosphorus to the electric motor lubricating fluid;

a sulfur-providing additive including a thiadiazole providing up to 950 ppm of sulfur to the electric motor lubricating fluid; and

wherein the electric motor lubricating fluid has a kV100°C of 4.5 cSt or less and, 150 to 250 ppm of total phosphorus.

17. The electric motor lubricating fluid of claim 16, wherein the amine salt of a phosphoric acid ester has the structure of Formula I or a solvate or hydrate thereof:



(Formula I)

wherein

R_1 and R_2 are, independently, hydrogen or a linear, branched, or cyclic hydrocarbyl group;

m is an integer from 0 to 1, p is an integer from 1 to 2, and m + p equals 2;

R_3, R_4, R_5, and R_6 are, independently, hydrogen or a hydrocarbyl group and at least one of R_3 to R_6 is a hydrocarbyl group.

18. The electric motor lubricating fluid of claim 17, wherein R_1 and R_2 are, independently, a C_3 to C_{10} alkyl group and wherein at least one of R_3, R_4, R_5 and R_6 is a C_{10} to C_{20} alkyl group.

19. The electric motor lubricating fluid of claim 16, wherein the succinimide dispersant, the amine salt of a phosphoric acid ester, the ashless dialkyl dithiophosphate, and the thiadiazole is provided in an additive concentrate and wherein the additive concentrate has a kV100°C of 15 to 80 cSt.

20. The electric motor lubricating fluid of claim 19, wherein a ratio of the kV100°C of the additive concentrate to the kV100°C of the electric motor lubricating fluid is 5:1 to 30:1.

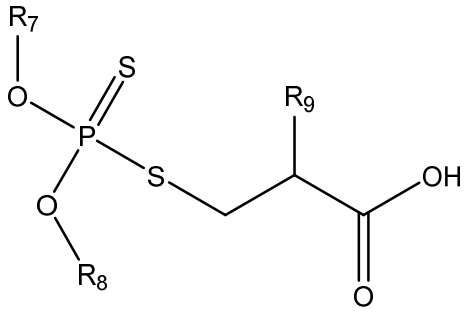
21. The electric motor lubricating fluid of claim 16, wherein the electric motor lubricating fluid has a change in viscosity of less than 0.09 cSt after the electric motor lubricating fluid has been aged according to CEC L-48-A.

22. The electric motor lubricating fluid of claim 16, wherein the electric motor lubricating fluid achieves a failure load stage of at least 8 in the FZG A10/16.6R/90 scuffing test of CEC L-84-02.

23. The electric motor lubricating fluid of claim 16, wherein the electric motor lubricating fluid has an electrical conductivity of 60 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric motor lubricating fluid and measured at 20 Hz and at 100°C.

24. The electric motor lubricating fluid of claim 16, wherein the oil-soluble phosphorus antiwear additive including the ashless dialkyl dithiophosphate is made by a process comprising the steps of (a) reacting an organic hydroxy compound with phosphorus pentasulfide to form a reaction product and further reacting the reaction product with an unsaturated carboxylic acid to form the oil-soluble phosphorus antiwear additive including the ashless diaalkyl dithiophosphate.

25. The electric motor lubricating fluid of claim 16, wherein the ashless dialkyl dithiophosphate includes a compound of Formula II, or a salt thereof:

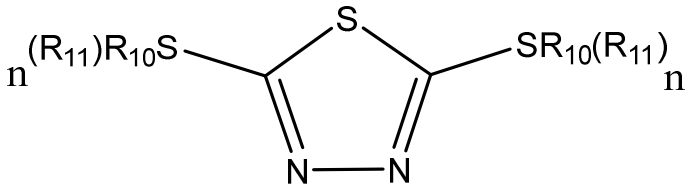


(Formula II)

wherein R_7 and R_8 are, independently, a C_3 to C_8 linear or branched alkyl group, and R_9 is -H or -CH_3.

26. The electric motor lubricating fluid of claim 25, wherein the ashless dialkyl dithiophosphoate is 3-[[bis(2-methylpropoxy) phosphinothioyl]thio]-2-methyl-propanoic acid.

27. The electric motor lubricating fluid of claim 16, wherein the thiadiazole includes one or more compounds having a structure of Formula III:



(Formula III)

wherein

each R_{10} is, independently, hydrogen or sulfur;

each R_{11} is, independently, an alkyl group;

n is an integer of 0 or 1 and if R_{10} is hydrogen then the integer n of the adjacent R_{11} moiety is 0 and if R_{10} is sulfur then the n of the adjacent R_{11} moiety is 1; and

wherein at least one R_{10} is sulfur.

28. The electric motor lubricating fluid of claim 16, further including one or more metal-containing detergent additives providing no more than 50 ppm of calcium to the electric motor lubricating fluid.

29. An additive concentrate suitable for an electric motor lubricating fluid, the additive concentrate comprising:

40 to 70 weight percent of a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating fluid;

an amine salt of a phosphoric acid ester providing 1000 to 1500 ppm of phosphorus to the additive concentrate;

an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 800 ppm to 1300 ppm of phosphorus to the additive concentrate;

a sulfur-providing additive including a thiadiazole providing sulfur, but no more than 18,000 ppm of sulfur to the additive concentrate; and

wherein the additive concentrate has a kV100°C of 15 cSt to 80 cSt.

30. The additive concentrate of claim 29, wherein the number average molecular weight of the high molecular weight polyisobutylene is 2,000 to 2,300.

31. The additive concentrate of claim 29, further including one or more metal-containing detergent additives providing no more than 950 ppm of calcium to the additive concentrate.

32. A method for lubricating a driveline component including an electric motor, the method comprising:

lubricating the driveline component with an electric motor lubricating composition and wherein the electric motor lubricating composition contacts portions of the electric motor;

the electric motor lubricating composition including (i) one or more base oils of lubricating viscosity; (ii) 2 to 4 weight percent of a succinimide dispersant derived from a high molecular weight polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has 0.5 to 1 weight percent nitrogen and is post treated with a phosphorus containing compound and a boron containing compound, and wherein the

succinimide dispersant delivers 70 to 140 ppm phosphorus and 150 to 300 ppm nitrogen to the electric motor lubricating composition; (iii) an amine salt of a phosphoric acid ester providing 40 to 70 ppm of phosphorus to the electric motor lubricating composition; (iv) an oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate providing 40 to 70 ppm of phosphorus to the electric motor lubricating composition; and (v) a sulfur-providing additive including a thiadiazole providing sulfur, but no more than 950 ppm of sulfur to the electric motor lubricating composition; and

wherein the electric motor lubricating composition has a kV100°C of 3.5 cSt or less, 150 to 200 ppm of total phosphorus, and an electrical conductivity of 37 nS/M or less, as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric motor lubricating composition and measured at 20 Hz and at 100°C.

33. The method for lubricating a driveline component including an electric motor of claim 32, wherein the number average molecular weight of the high molecular weight polyisobutylene is 2,000 to 2,300.

34. The method for lubricating a driveline component including an electric motor of claim 32, wherein the succinimide dispersant, the amine salt of a phosphoric acid ester; the oil-soluble phosphorus antiwear additive including an ashless dialkyl dithiophosphate; and the sulfur-providing additive including a thiadiazole is provided in an additive concentrate having a kV100°C of 15 to 80 cSt.

35. The method for lubricating a driveline component including an electric motor of claim 34, wherein a ratio of the kV100°C of the additive concentrate to the kV100°C of the electric motor lubricating composition is 5:1 to 30:1.

36. The method for lubricating a driveline component including an electric motor of claim 32, wherein the electric motor lubricating composition has a change in viscosity of less than 0.09 cSt after the electric motor lubricating composition has been aged according to CEC L-48-A.

37. The method for lubricating a driveline component including an electric motor of claim 32, wherein the electric motor lubricating composition achieves a failure load stage of at least 8 in the FZG A10/16.6R/90 scuffing test of CEC L-84-02.

38. The method for lubricating a driveline component including an electric motor of claim 32, wherein the electric motor lubricating composition further includes one or more metal-containing detergent additives providing no more than 50 ppm of calcium to the electric motor lubricating composition.