## SUMMARY

**[005]** In one approach or example, an electric driveline fluid suitable for electric or hybrid-electric vehicles is described herein. In an example of this approach, the electric driveline fluid includes one or more base oils of lubricating viscosity; a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of about 2,000 or greater, wherein the succinimide dispersant has up 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 150 to about 270 ppm of dispersant phosphorus (P) to the electric driveline fluid; a sulfur-providing additive including a thiadiazole or derivative thereof, wherein the thiadiazole or derivative thereof provides at least about 1000 ppm of thiadiazole sulfur (S) to the electric driveline fluid; wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is at least about 1300 ppm and wherein a weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is at least about 0.1; a detergent system providing one or more calcium-containing detergents, and wherein the one or more calcium-containing detergents provide no more than about 200 ppm of calcium; no more than about 0.4 weight percent of a friction modifier; and wherein the electric driveline fluid has a kV100 viscosity of about 3.2 cSt or more, about 150 to about 270 ppm of total phosphorus, and an electrical conductivity of about 130 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric driveline fluid and measured at 20 Hz and at 170°C.

**[005a]** In one aspect, the present disclosure refers to an electric driveline 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 up 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 150 to 270 ppm of dispersant phosphorus (P) to the electric driveline fluid;

a sulfur-providing additive including a thiadiazole, wherein the thiadiazole provides at least 1000 ppm of thiadiazole sulfur (S) to the electric driveline fluid;

wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is at least 1300 ppm and wherein a weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is at least 0.1;

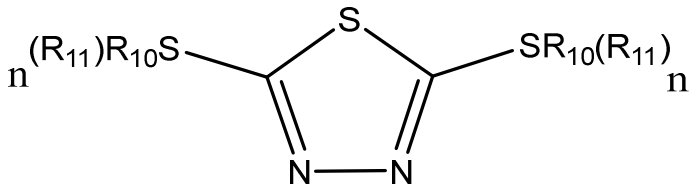
a detergent system providing one or more calcium-containing detergents, and wherein the one or more calcium-containing detergents provide no more than 200 ppm of calcium;

no more than 0.4 weight percent of friction modifier; and

wherein the electric driveline fluid has a kV100 viscosity of 3.2 cSt or more, 150 to 270 ppm of total phosphorus, and an electrical conductivity of 130 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric driveline fluid and measured at 20 Hz and at 170° C.

**[006]** In other approaches or examples, the electric driveline fluid of the previous paragraph may include one or more optional features or examples in any combination. These optional features or examples may include one or more of the following: wherein the friction modifier is an alkyl imide, an alkyl amine, a hydrocarbyl imidazole, derivatives thereof, or combinations thereof; and/or wherein the friction modifier comprises 0 to about 0.4 weight percent of one or more of a linear or branched C16 to C18 substituted succinic acid or anhydride reacted with an amine, polyamine, or ammonia (preferably, reacted with ammonia), 0 to about 0.08 weight percent of ethoxylated alkyl amine (preferably, ethoxylated tallow amine); and/or wherein the friction modifier is 0 to about 0.1 weight percent of a linear or branched C16 to C18 substituted succinic acid or anhydride reacted with an amine, polyamine, or ammonia (preferably reacted with ammonia); and/or wherein the number average molecular weight of the

polyisobutylene is about 2,000 to about 2,400; and/or wherein the electric motor lubricating fluid includes about 2 to about 8 weight percent of the succinimide dispersant (preferably, about 4 to about 8 weight percent); and/or wherein the electric driveline fluid has a change in viscosity of less than about 0.5 cSt after the electric driveline fluid has been aged according to CEC L-48-A; and/or wherein the electric driveline fluid achieves a failure load stage of at least about 8 in the FZG A10/16.6R/120 scuffing test of CEC L-84-02; and/or wherein the thiadiazole or derivative thereof provides about 1500 ppm or less of sulfur; and/or wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is about 1300 ppm to about 1400 ppm; and/or wherein the weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is about 0.1 to about 0.3; and/or wherein about 90 to about 100 percent of the total phosphorus is provided by the succinimide dispersant; and/or wherein the amount of provided phosphorus is about 1 ppm of phosphorus per each 8 to 13 number average molecular weight units of the polyisobutylene moiety of the succinimide dispersant; and/or wherein the thiadiazole or derivative thereof includes one or more compounds having a structure of Formula I:




(Formula III)

wherein each $R_{10}$ of Formula III is, independently, hydrogen or sulfur; each $R_{11}$ of Formula III 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.

**[007]** In another approach or example, a method for lubricating a driveline component including an electric motor is described herein. In examples, the method includes lubricating the driveline component with an electric driveline fluid and, in some examples, the electric driveline fluid contacts portions of the electric motor. In other examples, the electric driveline fluid includes (i) one or more base oils of lubricating viscosity; (ii) a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of about 2,000 or greater, wherein the succinimide dispersant has up 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 150 to about 270

ppm of dispersant phosphorus (P) to the electric driveline fluid; (iii) a sulfur-providing additive including a thiadiazole or derivative thereof providing at least about 1000 ppm of thiadiazole sulfur (S) to the electric driveline fluid (preferably about 1000 to about 1400 ppm), wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is at least about 1300 ppm (preferably about 1300 to about 1400) and wherein a weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is at least about 0.1 (preferably about 0.1 to about 0.3); (iv) a detergent system providing one or more calcium-containing detergents, wherein the one or more calcium-containing detergents provide no more than about 200 ppm of calcium; and (v) no more than about 0.4 weight percent of a friction modifier; and wherein the electric driveline fluid has a kV100 viscosity of about 3.2 cSt or more, about 150 to about 270 ppm of total phosphorus, and an electrical conductivity of about 130 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric driveline fluid and measured at 20 Hz and at 170°C.

**[007a]** In one aspect, the present disclosure refers to method for lubricating a driveline component including an electric motor, the method comprising:

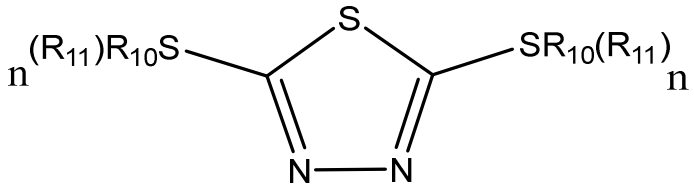
lubricating the driveline component with an electric driveline fluid;

the electric driveline fluid includes (i) one or more base oils of lubricating viscosity; (ii) a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has up 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 150 to 270 ppm of dispersant phosphorus (P) to the electric driveline fluid; (iii) a sulfur-providing additive including a thiadiazole providing at least 1000 ppm of thiadiazole sulfur (S) to the electric driveline fluid, wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is at least 1300 ppm and wherein a weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is at least 0.1; (iv) a detergent system providing one or more calcium-containing detergents, wherein the one or more calcium-containing detergents provide no more than 200 ppm of calcium; and (v) no more than 0.4 weight percent of a friction modifier; and

wherein the electric driveline fluid has a kV100 viscosity of 3.2 cSt or more, 150 to 270 ppm of total phosphorus, and an electrical conductivity of 130 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric driveline fluid and measured at 20 Hz and at 170°C.

**[008]** In yet further approaches or examples, the method for lubricating a driveline component including an electric motor as described in the previous paragraph may include one or more optional method steps, features, or examples in any combination. These optional method steps, features, or examples may include one or more of the following: wherein the friction modifier is an alkyl imide, an alkyl amine, a hydrocarbyl imidazole, derivatives thereof, or combinations thereof; and/or wherein the friction modifier is 0 to about 0.08 weight percent of an ethoxylated alkyl amine (preferably, ethoxylated tallow amine); and/or wherein wherein the organic friction modifier is 0 to about 0.4 weight percent of a linear or branched C16 to C18 substituted succinic acid or anhydride reacted with an amine, polyamine, or ammonia (preferably, reacted with ammonia); and/or wherein wherein the number average molecular weight of the polyisobutylene is about 2,000 to about 2,400; and/or wherein the electric driveline fluid includes about 2 to about 8 weight percent of the succinimide dispersant (preferably, about 4 to about 8 weight percent); and/or wherein the electric driveline fluid has a change in viscosity of less than about 0.5 cST after the electric driveline fluid has been aged according to CEC L-48-A; and/or wherein wherein the electric driveline fluid achieves a failure load stage of at least about 8 in the FZG A10/16.6R/120 scuffing test of CEC L-84-02; and/or wherein wherein about 90 to about 100 percent of the total phosphorus is provided by the succinimide dispersant; 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.

**[009]** In yet other approaches or examples, the use of an electric driveline fluid is described herein to achieve one or more of (i) an electrical conductivity of about 130 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric driveline fluid and measured at 20 Hz and at 170°C; (ii) a change in viscosity of less than about 0.5 cST after the electric driveline fluid has been aged according to CEC L-48-A; and/or (iii) a failure load stage of at least about 8 in the FZG A10/16.6R/120 scuffing test of CEC L-84-02. In such examples, the electric driveline fluid includes any example as described in this Summary and at least includes (i) one or more base oils of lubricating viscosity; (ii) a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of about 2,000 or greater, wherein the succinimide dispersant has up 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 150 to about 270 ppm of dispersant phosphorus (P) to the electric driveline fluid; (iii) a sulfur-providing additive including a thiadiazole or derivative thereof providing at least about 1000 ppm of thiadiazole sulfur (S) to the electric driveline fluid (preferably about 1000 to about 1400 ppm), wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is at least about 1300 ppm (preferably about 1300 to about 1400) and wherein a weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is at least about 0.1 (preferably about 0.1 to about 0.3); (iv) a detergent system providing one or more calcium-containing detergents, wherein the one or more calcium-containing detergents provide no more than about 200 ppm of calcium; and (v) no more

than about 0.4 weight percent of a friction modifier; and wherein the electric driveline fluid has a kV100 viscosity of about 3.2 cSt or more, about 150 to about 270 ppm of total phosphorus.

**[010]** Other examples of the present disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the disclosure disclosed herein.

**[011]** The following definitions of terms are provided in order to clarify the meanings of certain terms as used herein.

**[012]** The terms “lubricating oil,” “lubricant composition,” “lubricating composition,” “lubricant” and “lubricating and cooling fluid” refer to a finished lubrication product comprising a major amount of a base oil plus a minor amount of an additive composition.

**[013]** As used herein, the terms “additive package,” “additive concentrate,” and “additive composition,” refer the portion of the lubricating oil composition excluding the major amount of base oil.

**[014]** As used herein, the term "hydrocarbyl substituent" or "hydrocarbyl group" is used in its ordinary sense, which is well-known to those skilled in the art. Specifically, it refers to a group having a carbon atom directly attached to the remainder of the molecule and having a predominantly hydrocarbon character. Each hydrocarbyl group is independently selected from hydrocarbon substituents, and substituted hydrocarbon substituents containing one or more of halo groups, hydroxyl groups, alkoxy groups, mercapto groups, nitro groups, nitroso groups, amino groups, pyridyl groups, furyl groups, imidazolyl groups, oxygen and nitrogen, and wherein no more than two non-hydrocarbon substituents are present for every ten carbon atoms in the hydrocarbyl group.

**[015]** As used herein, the term "percent by weight" or “wt%”, unless expressly stated otherwise, means the percentage the recited component represents to the weight of the entire composition.

**[016]** The terms "soluble," "oil-soluble," or "dispersible" used herein may, but does not necessarily, indicate that the compounds or additives are soluble, dissolvable, miscible, or capable of being suspended in the oil in all proportions. The foregoing terms do mean, however, that they are, for instance, soluble, suspendable, dissolvable, or stably dispersible in oil to an extent sufficient to exert their intended effect in the environment in which the oil is employed. Moreover, the additional incorporation of other additives may also permit incorporation of higher levels of a particular additive, if desired.

**[017]** The term "alkyl" as employed herein refers to straight, branched, cyclic, and/or substituted saturated chain moieties from about 1 to about 200 carbon atoms.

**[018]** The term "alkenyl" as employed herein refers to straight, branched, cyclic, and/or substituted unsaturated chain moieties from about 3 to about 30 carbon atoms.

**[019]** The term “aryl” as employed herein refers to single and multi-ring aromatic compounds that may include alkyl, alkenyl, alkylaryl, amino, hydroxyl, alkoxy, halo substituents, and/or heteroatoms including, but not limited to, nitrogen, and oxygen.

**[020]** As used herein, the “average number molecular weight” or “Mn” is determined by gel permeation chromatography (GPC) using commercially available polystyrene standards (with a Mn of about 180 to about 18,000 as the calibration reference).

**[021]** It is to be understood that throughout the present disclosure, the terms "comprises," "includes," “contains,” etc. are considered open-ended and include any element, step, or ingredient not explicitly listed. The phrase "consists essentially of" is meant to include any expressly listed element, step, or ingredient and any additional elements, steps, or ingredients that do not materially affect the basic and novel aspects of the disclosure. The present disclosure also contemplates that any composition described using the terms, "comprises," "includes," “contains,” is also to be interpreted as including a disclosure of the same composition "consisting essentially of" or “consisting of” the specifically listed components thereof.

## DETAILED DESCRIPTION

**[022]** According to exemplary embodiments, a lower viscosity driveline lubricant suitable for electric or hybrid-electric vehicles is described herein with select elemental relationships that surprisingly achieve passing performance in the demanding FZG scuffing tests, such as the A10/16.6R/90 test of CEC L-84-02 and, at the same time, achieving good electrical conductivity and maintaining oxidative stability. What is surprising about the lubricating fluids herein, however, is that the combination of certain additives, including a succinimide dispersant derived from a polyisobutylene having a number average molecular number of greater than 2000, were found helpful to achieve passing wear, conductivity, and oxidation performance when such dispersant was used in combination with select phosphorus, sulfur, and calcium elemental relationships. In some embodiments, it was also discovered that certain friction modifiers need to be limited in the compositions.

## CLAIMS

WHAT IS CLAIMED IS:

1. An electric driveline 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 up 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 150 to 270 ppm of dispersant phosphorus (P) to the electric driveline fluid;

a sulfur-providing additive including a thiadiazole, wherein the thiadiazole provides at least 1000 ppm of thiadiazole sulfur (S) to the electric driveline fluid;

wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is at least 1300 ppm and wherein a weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is at least 0.1;

a detergent system providing one or more calcium-containing detergents, and wherein the one or more calcium-containing detergents provide no more than 200 ppm of calcium;

no more than 0.4 weight percent of friction modifier; and

wherein the electric driveline fluid has a kV100 viscosity of 3.2 cSt or more, 150 to 270 ppm of total phosphorus, and an electrical conductivity of 130 nS/M or less as measured by a modified conductivity test pursuant to ASTM D2624-15 using the electric driveline fluid and measured at 20 Hz and at 170° C.

2. The electric driveline fluid of claim 1, wherein the friction modifier is an alkyl imide, an alkyl amine, a hydrocarbyl imidazole, or combinations thereof.

3. The electric driveline fluid of claim 1, wherein the friction modifier is 0 to 0.08 weight percent of an ethoxylated alkyl amine.

4. The electric driveline fluid of claim 1, wherein the friction modifier is 0 to 0.4 weight percent of a linear or branched C16 to C18 substituted succinic acid or anhydride reacted with an amine, polyamine, or ammonia.

5. The electric driveline fluid of claim 1, wherein the number average molecular weight of the polyisobutylene is 2,000 to 2,400.

6. The electric driveline fluid of claim 5, wherein the electric driveline fluid includes 2 to 8 weight percent of the succinimide dispersant.

7. The electric driveline fluid of claim 1, wherein the electric driveline fluid has a change in viscosity of less than 0.5 cSt after the electric driveline fluid has been aged according to CEC L-48-A.

8. The electric driveline fluid of claim 1, wherein the electric driveline fluid achieves a failure load stage of at least 8 in the FZG A10/16.6R/120 scuffing test of CEC L-84-02.

9. The electric driveline fluid of claim 1, wherein the thiadiazole provides 1500 ppm or less of sulfur.

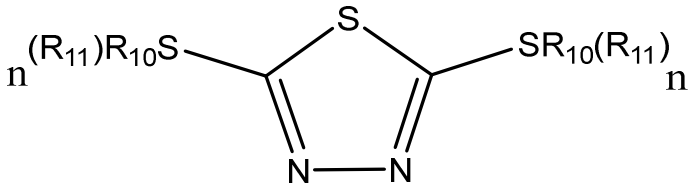
10. The electric driveline fluid of claim 1, wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is 1300 ppm to 1400 ppm.

11. The electric driveline fluid of claim 1, wherein the weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is 0.1 to 0.3.

12. The electric driveline fluid of claim 1, wherein 90 to 100 percent of the total phosphorus is provided by the succinimide dispersant.

13. The electric driveline fluid of claim 12, wherein the amount of provided phosphorus is 1 ppm of phosphorus per each 8 to 13 number average molecular weight units of the polyisobutylene moiety of the succinimide dispersant.

14. The electric driveline fluid of claim 1, wherein the thiadiazole includes one or more compounds having a structure of Formula I:




(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.

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

lubricating the driveline component with an electric driveline fluid;

the electric driveline fluid includes (i) one or more base oils of lubricating viscosity; (ii) a succinimide dispersant derived from a polyisobutylene having a number average molecular weight of 2,000 or greater, wherein the succinimide dispersant has up 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 150 to 270 ppm of dispersant phosphorus (P) to the electric driveline fluid; (iii) a sulfur-providing additive including a thiadiazole providing at least 1000 ppm of thiadiazole sulfur (S) to the electric driveline fluid, wherein the combined dispersant phosphorus and thiadiazole sulfur (P + S) is at least 1300 ppm and wherein a weight ratio of the dispersant phosphorus to the thiadiazole sulfur (P/S) is at least 0.1; (iv) a detergent system providing one or more calcium-containing detergents, wherein the one or more calcium-containing detergents provide no more than 200 ppm of calcium; and (v) no more than 0.4 weight percent of a friction modifier; and

wherein the electric driveline fluid has a kV100 viscosity of 3.2 cSt or more, 150 to 270 ppm of total phosphorus, and an electrical conductivity of 130 nS/M or less as measured by a

modified conductivity test pursuant to ASTM D2624-15 using the electric driveline fluid and measured at 20 Hz and at 170°C.

16. The method for lubricating a driveline component including an electric motor of claim 15, wherein the friction modifier is an alkyl imide, an alkyl amine, a hydrocarbyl imidazole, or combinations thereof.

17. The method for lubricating a driveline component including an electric motor of claim 15, wherein the friction modifier is 0 to 0.08 weight percent of an ethoxylated alkyl amine.

18. The method for lubricating a driveline component including an electric motor of claim 15, wherein the friction modifier is 0 to 0.4 weight percent of a linear or branched C16 to C18 substituted succinic acid or anhydride reacted with an amine, polyamine, or ammonia.

19. The method for lubricating a driveline component including an electric motor of claim 15, wherein the number average molecular weight of the polyisobutylene is 2,000 to 2,400.

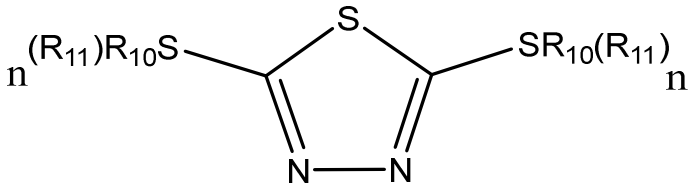
20. The method for lubricating a driveline component including an electric motor of claim 19, wherein the electric driveline fluid includes 2 to 8 weight percent of the succinimide dispersant.

21. The method for lubricating a driveline component including an electric motor of claim 15, wherein the electric driveline fluid has a change in viscosity after aging of less than 0.5 cSt after the electric driveline fluid has been aged according to CEC L-48-A.

22. The method for lubricating a driveline component including an electric motor of claim 15, wherein the electric driveline fluid achieves a failure load stage of at least 8 in the FZG A10/16.6R/120 scuffing test of CEC L-84-02.

23. The method for lubricating a driveline component including an electric motor of claim 15, wherein 90 to 100 percent of the total phosphorus is provided by the succinimide dispersant.

24. The method for lubricating a driveline component including an electric motor of claim 15, 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.