What is claimed is:

1. A lubricant composition comprising:

a base oil of lubricating viscosity;

an ashless phosphorus-containing antiwear agent;

an alkaline earth metal detergent;

an ashless antioxidant; and

an ashless dispersant,

where the lubricant composition is substantially free of zinc.

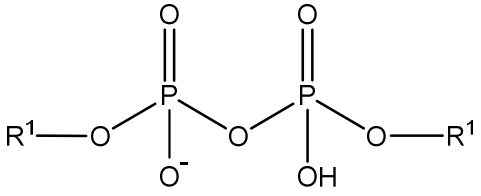
2. The lubricant composition of claim 1, wherein the oil of lubricating viscosity comprises 80 to 95 wt % or 80 to 90 wt % of the lubricant composition.

3. The lubricant composition of any of the preceding claims, wherein the ashless phosphorous-containing antiwear agent is an organo-phosphorous antiwear agent.

4. The lubricant composition of any of the preceding claims, wherein the ashless phosphorous-containing antiwear agent is selected from a phosphite, a (thio)phosphate, a (thio)phosphate amine salt, and combinations thereof.

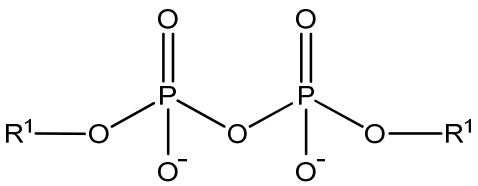
5. The lubricant composition of claim 4, wherein the (thio)phosphate amine salt is an alkyl phosphate amine salt and , wherein at least 30 mole percent of the phosphorous atoms in the alkyl phosphate amine salt are in an alkyl pyrophosphate salt structure.

6. The lubricant composition of claim 5, wherein the amine alkyl pyrophosphate salt comprises a species represented by formula (I) or (II):



$R^2{}_3NH^+$

or



$R^2{}_3NH^+$ $R^2{}_3NH^+$

(I) (II)

wherein each R^1 is independently a primary alkyl group of about 3 to about 12 carbon atoms and each R^2 is independently hydrogen or a hydrocarbyl group or an ester-containing group, and at least one R^2 group is a hydrocarbyl group or an ester-containing group; or wherein the –OH group is replaced by an $–OR^1$ group, or wherein one or more $–OR^1$ groups are replaced by –OH groups, or wherein an R^1 group is replaced by a phosphorus-containing group.

7. The lubricant composition of any one of the preceding claims, wherein the ashless phosphorus-containing antiwear agent is present in the lubricant composition in amount of from 0.1 to 1.5 wt % or 0.3 to 1.2 wt % or0.5 to 1.1 wt % or 0.6 to 0.9 wt %.

8. The lubricant composition of any one of the preceding claims, wherein the ashless phosphorus-containing antiwear agent is present in amount to deliver from 500 to 900 ppm phosphorous or 550 to 850 ppm or 600 to 825 ppm or 650 to 800 ppm or 700 to 800 ppm phosphorous to the lubricant composition.

9. The lubricant composition of any one of the preceding claims, wherein the alkaline earth metal detergent is selected from an alkaline earth metal sulfonate, phenate, and salicylate.

10. The lubricant composition of any one of the preceding claims, wherein the alkaline earth metal detergent is present in the lubricant composition in an amount of from 0.3 to 2.5 wt % or 0.6 to 1.8 wt %.

11. The lubricant composition of any one of the preceding claims, wherein the alkaline earth metal detergent comprises a mixture of alkaline earth metal detergents and the mixture is present in the lubricating composition in an amount of from 0.8 to 2.0 wt %, , wherein the mixture of alkaline earth metal detergents includes 0.4 to 0.8 wt% of a calcium sulfonate detergent and 0.6 to

1.1 wt % of a magnesium sulfonate detergent based on the total weight of the lubricant composition.

12. The lubricant composition of any one of the preceding claims, wherein the ashless antioxidant is selected from an arylamine, diarylamine, an alkylated arylamines, an alkylated diaryl amines, a phenols, a hindered phenols, a sulfurized olefins, and mixtures thereof.

13. The lubricant composition of any one of the preceding claims, wherein the antioxidant is present in the lubricant composition in an amount of from 0.1 to 2.1 wt % or 0.2 to 1.8 wt %.

14. The lubricant composition of any one of claims 12 or 13, wherein the antioxidant includes 0.8 to 1.3 wt % of an alkylated diarylamine and 0.1 to 0.5 wt % of a sulfurized olefin.

15. The lubricant composition of any one of the preceding claims, wherein the ashless dispersant is a polyisobutylene succinimide dispersant, wherein the polyisobutylene succinimide dispersant is optionally borated.

16. The lubricant composition any one of the preceding claims, wherein the ashless dispersant is present in the lubricant composition in an amount of from 1 to 6 wt %, or 2 to 5 wt %, or 2.5 to 4.5 wt %.

17. The lubricant composition of any one of claims 1 to 16, wherein the ashless dispersant includes 0.8 to 1.6 wt % of a boron free polyisobutylene succinimide dispersant and 1.8 to 3.1 wt % of a borated polyisobutylene dispersant.

18. The lubricant composition of any one of the preceding claims, wherein the ashless phosphorus-containing antiwear agent contains sulfur and the ratio of sulfur to phosphorous is 2 to 1 or less than 1.75 to 1.

19. A method for reducing low speed pre-ignition in an engine, comprising suppling to a spark-ignited direct injection internal combustion engine a lubricant composition of any one of the preceding claims.

20. Use of the lubricant composition in any one of claims 1 to 18 to reduce low speed pre-ignition in a spark-ignited direct injection internal combustion engine.