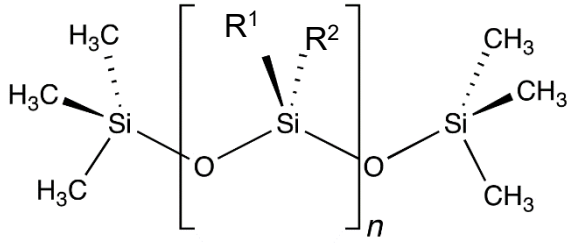
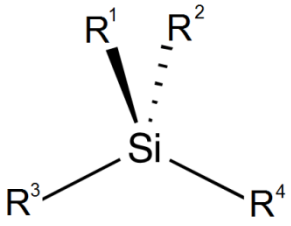
Claims

1. A lubricating oil composition comprising a base oil of lubricating viscosity, a calcium containing detergent, and a silicon containing additive, wherein: the calcium containing detergent provides the lubricating oil composition with a calcium content of at least 0.08 wt%, based on the weight of the lubricating oil composition; the lubricating oil composition has a calcium content of from 0.08 wt % to 0.25 wt %, based on the weight of the lubricating oil composition; the silicon containing additive provides the lubricating oil composition with a silicon content of ~~at least 12 ppm~~greater than 20 ppm by weight, based on the weight of the lubricating oil composition; and, the silicon containing additive is one or more selected from the list consisting of: (i) silazane compounds; (ii) siloxane compounds and organo modified siloxane compounds according to Formula 1,



Formula 1

wherein n is from 50 to 450 and R^1 and R^2 are independently C_1-C_{10} alkyl, or wherein n is from 50 to 450 and R^1 and R^2 are independently a polyether group, a C_{11}-C_{100} alkyl group, or a C_6-C_{14} aryl group; and, (iii) small molecule silicon compounds according to Formula 2,



Formula 2

wherein, each of R^1, R^2, R^3 and R^4 is, independently, a C_1-C_{10} hydrocarbyl group or a C_1-C_{10} heterocarbyl group.

~~2. A lubricating oil composition according to claim 1, wherein the lubricating oil composition has a silicon content of at least 15 ppm, by weight, based on the weight of the lubricating oil composition.~~

~~3. A lubricating oil composition according to claim 2, wherein the lubricating oil composition has a silicon content of greater than 20 ppm, by weight, based on the weight of the lubricating oil composition.~~

~~4. A lubricating oil composition according to claim 1, wherein the lubricating oil composition has a silicon content of from 12 to 2000 ppm, by weight, based on the weight of the lubricating oil composition.~~

~~5.~~2. A lubricating oil composition according to claim 4<u>1</u>, wherein the lubricating oil composition has a silicon content of from greater than 20 to 2000 ppm, by weight, based on the weight of the lubricating oil composition.

~~6.~~3. A lubricating oil composition as claimed in ~~any one of~~ claims ~~2 to 5~~, wherein the silicon content of the lubricating oil composition is provided entirely by the silicon containing additive.

~~7.~~4. A lubricating oil composition according to any one of the preceding claims, wherein the silicon-containing compound is a siloxane compound according to Formula 1, wherein n is from 50 to 450, and wherein R^1 and R^2 are methyl.

~~8.~~5. A lubricating oil composition according to any one of claims 1 to ~~6~~3, wherein the silicon-containing compound is an organo modified siloxane compound according to Formula 1, wherein n is from 50 to 450 and R^1 and R^2 are independently a polyether group.

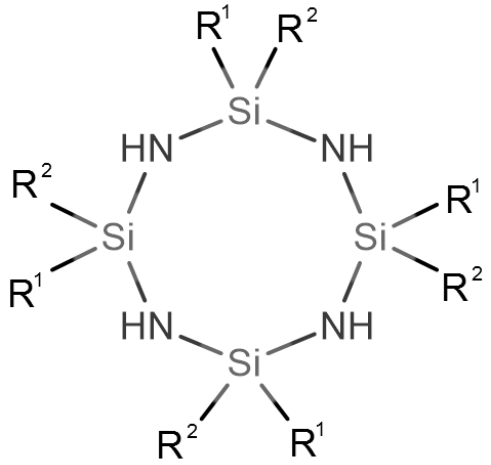
~~9.~~6. A lubricating oil composition according to any one of claims 1 to ~~6~~3, wherein the silicon-containing compound is the small molecule silicon compound according to Formula 2, having a molecular weight of no more than 600 g/mol.

~~10.~~7. A lubricating oil composition according to claim ~~9~~6, wherein the small molecule silicon compound has a molecular weight of no more than 300 g/mol.

~~11.~~8. A lubricating oil composition according to any one of claims 1 to ~~6~~3, ~~9~~ 6 and ~~10~~7, wherein the silicon-containing compound is the small molecule silicon compound according to Formula 2, wherein each of R^1, R^2, R^3 and R^4 is, independently, a C_1-C_{10} alkyl group or a C_1-C_{10} alkoxy group.

~~12.~~9. A the lubricating oil composition according to claim ~~11~~8, comprising one or more silicon-containing compounds selected from the list consisting of tetraethylsilane ($Si(C_2H_5)_4$), tetraethyl orthosilicate ($Si(OC_2H_5)_4$), triethoxymethylsilane ($CH_3Si(OC_2H_5)_3$) and tetrabutyl orthosilicate ($Si(OC_4H_9)_4$).

~~13.~~10. A lubricating oil composition according to any one of claims 1 to ~~6~~3, wherein the silicon-containing compound is a silazane compound according to Formula 3,



Formula 3

wherein, each of R^1 and R^2 is, independently, a C_1-C_3 hydrocarbyl group, such as a C_1-C_3 alkyl group.

~~14.~~11. A lubricating oil composition as claimed in any one of the preceding claims, wherein 100% of the calcium content of the lubricating oil composition is provided by the calcium containing detergent.

~~15.~~12. A method of reducing low-speed pre-ignition (LSPI) events in a direct-injection spark-ignition internal combustion engine comprising lubricating the crankcase of the engine with a lubricating oil composition as claimed in any one of the preceding claims.

~~16.~~13. A method according to claim ~~15~~12, wherein, in operation, the engine generates a brake mean effective pressure level, as defined herein, of greater than 1,500 kPa, optionally greater than 2,000 kPa, at engine speeds of from 1,000 to 2,500 rotations per minute (rpm), optionally from 1,000 to 2,000 rpm.