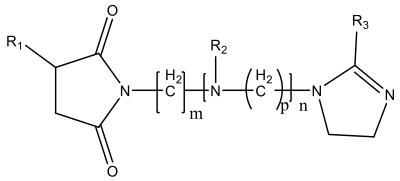
context for lubricants in turbine applications, commonly used rust preventative and demulsifier additives tend to negatively impact a more recently developed filterability characteristic that is now being required by more and more turbine operators.

[0005] The ability of a lubricating fluid to pass through fine filters, without plugging, is generally called filterability. ISO 13357-1 provides a demanding procedure for assessing the filterability of lubricating oils that have been heat-soaked in the presence of water. This so-called wet-filtration test typically involves two measurements or, as referred to in the test, two stages. This test is intended to estimate the behavior of the fluid when in service, such as when used in a turbine application. Stage I of wet-filterability is a comparison of the mean flow rate of a fluid through a test membrane relative to the initial flow rate. Stage II of wet filterability is a more severe evaluation and is based upon a ratio between the initial flow rate of lubricant through the test membrane and the rate at the end of the test. The stage II evaluation is more difficult to pass, and is believed to be sensitive to the presence of gels and fine particulate in the oil, which may be present in a lubricant or base oil slate when produced, or in other instances, gels and particulate could be formed as a lubricant ages, especially when exposed to humidity and elevated temperatures. As appreciated by those of skill, passing a wet-filterability stage II test is a challenge while still maintaining the other required characteristics of the fluid.

SUMMARY

[0005a] In a first aspect of the present disclosure, there is provided an additive package for a turbine lubricant to provide rust prevention and high filterability in the presence of water, the additive package comprising:

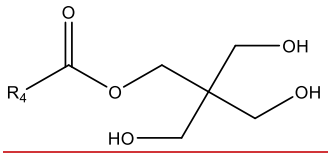
a rust-preventing mixture including an imidazoline derivative of an alkenyl succinic acid or anhydride having the structure of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons; combined with

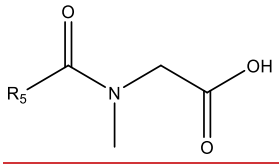
a partial ester of a polyhydric alcohol of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl group;

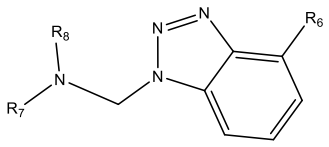
an acyl sarcosine compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a corrosion inhibiting additive of a substituted benzotriazole of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

wherein the additive package includes 3 to 7 weight percent of the imidazoline derivative of an alkenyl succinic acid or anhydride, 0.5 to 3 weight percent of the partial ester of a polyhydric alcohol, 0.5 to 3 weight percent of the acyl sarcosine compound, and 3 to 8 weight percent of the substituted benzotriazole;

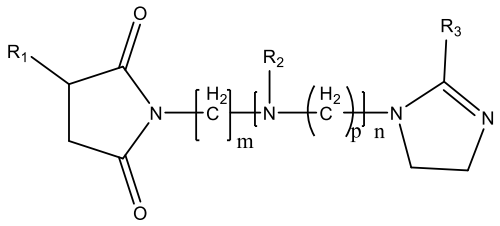
a weight ratio of imidazoline provided by the rust-preventing mixture to triazole provided by the corrosion inhibitor of 1:1 to 2:1 with no more than 10 weight percent of the one or more imidazoline derivatives in the additive package; and

when added to a turbine lubricant, the turbine lubricant with the additive package exhibits more than 70 percent stage II filterability according to ISO 13357-1.

[0005b] In another aspect of the present disclosure, there is provided a turbine lubricant to provide rust prevention and high filterability in the presence of water, the turbine lubricant comprising:

a base oil of lubricating viscosity selected from a Group I, Group II, or Group III oil, or blends thereof;

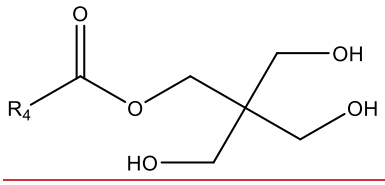
a first lubricant additive including a compound of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons, or a residue derived from a hydrocarbyl substituted dicarboxylic acid or anhydride thereof;

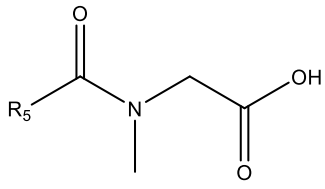
a second lubricant additive including a compound of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl chain;

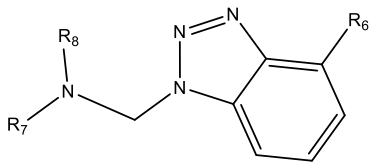
a third lubricant additive including a compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a fourth lubricant additive of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

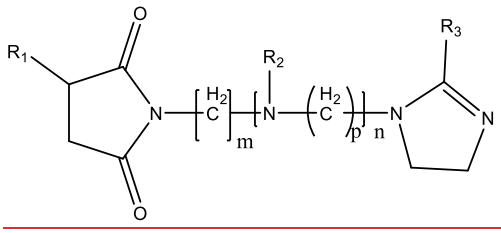
wherein the turbine lubricant has a weight ratio of imidazoline provided by the first lubricant additive to triazole provided by the fourth lubricant additive of 1:1 to 2:1 with no more than 0.1 weight percent of the first lubricant additive; and

wherein the turbine lubricant exhibits more than 70 percent stage II filterability according to ISO 13357-1.

[0005c] In a further aspect of the present disclosure, there is provided a turbine lubricant to provide rust prevention and high filterability in the presence of water, the turbine lubricant comprising:

a base oil of lubricating viscosity selected from a Group I, Group II, or Group III oil, or blends thereof;

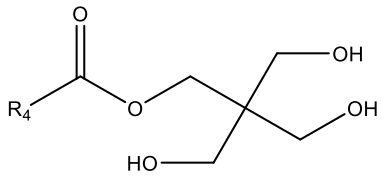
a first lubricant additive including a compound of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons, or a residue derived from a hydrocarbyl substituted dicarboxylic acid or anhydride thereof;

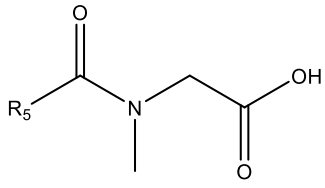
a second lubricant additive including a compound of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl chain;

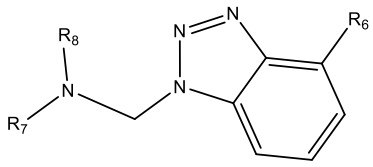
a third lubricant additive including a compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a fourth lubricant additive of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

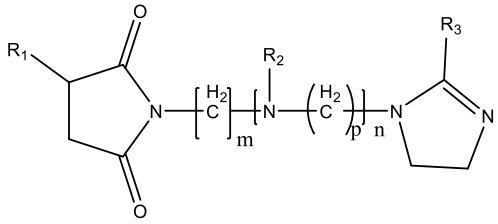
wherein the turbine lubricant has a weight ratio of imidazoline provided by the first lubricant additive to triazole provided by the fourth lubricant additive of 1:1 to 2:1 with no more than 0.1 weight percent of the first lubricant additive; and

, wherein the base oil includes a blend of Group I and Group II base oils and has a KV40 of 30 to 100 cSt.

[0005d] In yet another aspect of the present disclosure, there is provided a turbine lubricant to provide rust prevention and high filterability in the presence of water, the turbine lubricant comprising:

a base oil of lubricating viscosity selected from a Group I, Group II, or Group III oil, or blends thereof;

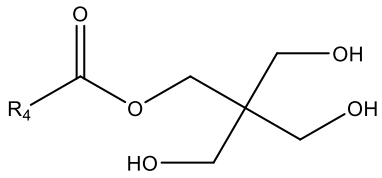
a first lubricant additive including a compound of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons, or a residue derived from a hydrocarbyl substituted dicarboxylic acid or anhydride thereof;

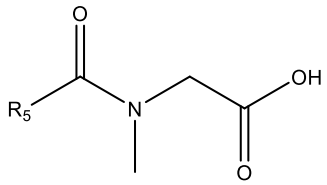
a second lubricant additive including a compound of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl chain;

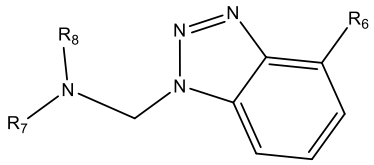
a third lubricant additive including a compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a fourth lubricant additive of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

wherein the turbine lubricant has a weight ratio of imidazoline provided by the first lubricant additive to triazole provided by the fourth lubricant additive of 1:1 to 2:1 with no more than 0.1 weight percent of the first lubricant additive; and

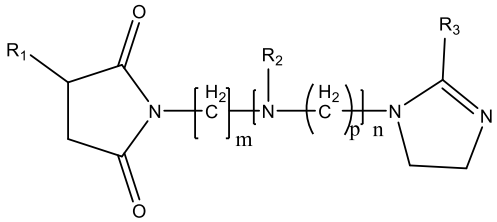
wherein the turbine lubricant exhibits more than 70 percent stage II filterability according to ISO 13357-1, a passing rust performance according to ASTM D665B, and less than 10 minutes to 37 ml of water separation according to ASTM D1401.

[0006] In one approach or ~~embodiment~~example, an additive package for a turbine lubricant to provide rust prevention and high filterability in the presence of water is described herein. In one ~~aspect~~example, the additive package includes a rust-preventing mixture including at least an imidazoline derivative of an alkenyl succinic acid or anhydride combined with additives selected from a partial ester of a polyhydric alcohol, an acyl sarcosine compound, and mixtures thereof, a corrosion inhibiting additive selected from at least a substituted benzotriazole. In some approaches or ~~embodiments~~examples, the additive package also includes a weight ratio of imidazoline provided by the rust-preventing mixture to triazole provided by the corrosion inhibitor of about 1:1 to about 2:1 with no more than 10 weight percent of the one or more imidazoline derivatives in the additive package.

[0007] The additive package of the preceding paragraph may be combined with one or more optional features in any combination. These optional features include: a copolymer additive

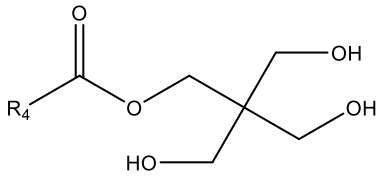
having one or more polypropylene oxide derived moieties and of one or more polyethylene oxide derived moieties and having a number average molecular weight of about 3200 g/mol to about 4300 g/mol; and/or wherein the additive package includes about 3 to about 7 weight percent of the imidazoline derivative of an alkenyl succinic acid or anhydride, about 0.5 to about 3 weight percent of the partial ester of a polyhydric alcohol, about 0.5 to about 3 weight percent of the acyl sarcosine compound, and about 3 to about 8 weight percent of the substituted benzotriazole; and/or wherein the additive package includes about 0.02 to about 1 weight percent of the copolymer additive; and /or wherein the imidazoline derivative is the reaction product of an alkenyl succinic acid or anhydride and an amino-substituted imidazoline; and/or wherein the partial ester of a polyhydric alcohol is the reaction product of pentaerythritol and a C13 to a C20 unsaturated fatty acid; and/or wherein the acyl sarcosine compound is selected from sarcosine fatty acids having a C12 to C20 acyl group; and/or wherein the acyl sarcosine compound is selected from lauroyl sarcosine, cocyl sarcosine, oleoyl sarcosine, stearoyl sarcosine, tall oil acyl sarcosine, and mixtures thereof; and/or; with no more than about 7 weight percent of the imidazoline derivative in the additive package; and/or wherein the rust-preventing mixture includes about 1.5 to about 2.5 times more of the imidazoline derivative relative to the partial ester of a polyhydric alcohol and the acyl sarcosine compound combined.

[0008] In another ~~aspect~~example ~~or embodiment~~, this present disclosure also provides a turbine lubricant to provide rust prevention and high filterability in the presence of water. In some approaches, the turbine lubricant includes a base oil of lubricating viscosity selected from a Group I, Group II, or Group III oil, or blends thereof; a first lubricant additive including a compound of Formula I



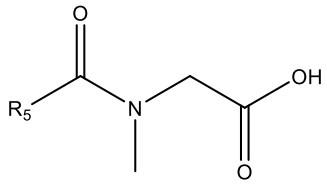
(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons, or a residue derived from a hydrocarbyl substituted dicarboxylic acid or anhydride thereof; a second lubricant additive including a compound of Formula II



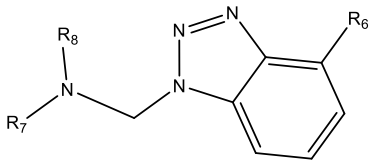
(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl chain; a third lubricant additive including a compound of Formula III,



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group; a fourth lubricant additive of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group. In other approaches or ~~embodiments~~examples, the turbine lubricant has a weight ratio of imidazoline provided by the first lubricant additive to triazole provided by the fourth lubricant additive of about 1:1 to about 2:1 with no more than 0.1 weight percent of the first lubricant additive.

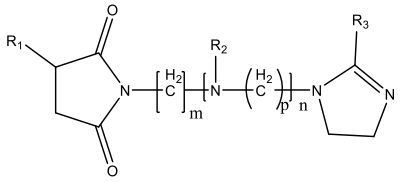
[0009] The turbine lubricant of the preceding paragraph may also be combined with one or more optional features in any combination. These optional features include: a copolymer having one or more polypropylene oxide derived moieties with a total molecular weight of less than about 3400 g/mol and about 5 to about 15 percent of one or more polyethylene oxide derived moieties; and/or wherein the turbine lubricant includes about 0.01 to about 0.05 weight percent of the first lubricant additive, about 0.005 to about 0.1 weight percent of the second lubricant additive (in other approaches, 0.01 to about 0.1 wt%), about 0.005 to about 0.1 weight percent of the third lubricant additive (in other approaches, about 0.01 to about 0.1 wt%), and about 0.01 to about 0.07 weight percent of the fourth lubricant additive; and/or wherein the turbine lubricant includes about 0.001 to about 0.01 weight percent of the copolymer; and/or; with no more than 0.05 weight percent of the first lubricant additive; and/or wherein the turbine lubricant includes

CLAIMS

WHAT IS CLAIMED IS

1. An additive package for a turbine lubricant to provide rust prevention and high filterability in the presence of water, the additive package comprising:

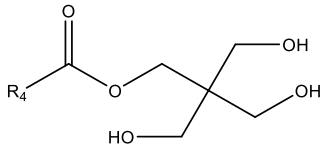
a rust-preventing mixture including an imidazoline derivative of an alkenyl succinic acid or anhydride having the structure of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons; combined with

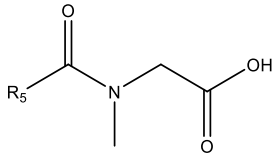
a partial ester of a polyhydric alcohol of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl group;

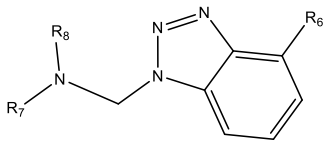
an acyl sarcosine compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a corrosion inhibiting additive of a substituted benzotriazole of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

wherein the additive package includes ~~about~~ 3 to ~~about~~ 7 weight percent of the imidazoline derivative of an alkenyl succinic acid or anhydride, ~~about~~ 0.5 to ~~about~~ 3 weight

percent of the partial ester of a polyhydric alcohol, ~~about~~ 0.5 to ~~about~~ 3 weight percent of the acyl sarcosine compound, and ~~about~~ 3 to ~~about~~ 8 weight percent of the substituted benzotriazole;

a weight ratio of imidazoline provided by the rust-preventing mixture to triazole provided by the corrosion inhibitor of ~~about~~ 1:1 to ~~about~~ 2:1 with no more than 10 weight percent of the one or more imidazoline derivatives in the additive package; and

when added to a turbine lubricant, the turbine lubricant with the additive package exhibits more than ~~about~~ 70 percent stage II filterability according to ISO 13357-1.

2. The additive package of claim 1, further including a copolymer additive having one or more polypropylene oxide derived moieties and of one or more polyethylene oxide derived moieties and having a number average molecular weight of ~~about~~ 3200 g/mol to ~~about~~ 4300 g/mol.

3. The additive package of claim 1, wherein the additive package includes ~~about~~ 0.02 to ~~about~~ 1 weight percent of the copolymer additive.

4. The additive package of claim 1, wherein the imidazoline derivative is the reaction product of an alkenyl succinic acid or anhydride and an amino-substituted imidazoline.

5. The additive package of claim 1, wherein the partial ester of a polyhydric alcohol is the reaction product of pentaerythritol and a C13 to a C20 unsaturated fatty acid.

6. The additive package of claim 1, wherein the acyl sarcosine compound is selected from sarcosine fatty acids having a C12 to C20 acyl group.

7. The additive package of claim 6, wherein the acyl sarcosine compound is selected from lauroyl sarcosine, cocyl sarcosine, oleoyl sarcosine, stearoyl sarcosine, tall oil acyl sarcosine, and mixtures thereof.

8. The additive package of claim 1, with no more than 7 weight percent of the imidazoline derivative in the additive package.

9. The additive package of claim 1, wherein the rust-preventing mixture includes ~~about~~ 1.5 to ~~about~~ 2.5 times more of the imidazoline derivative relative to the partial ester of a polyhydric alcohol and the acyl sarcosine compound combined.

10. The turbine lubricant of claim 15, further including a copolymer having one or more polypropylene oxide derived moieties with a total molecular weight of less than ~~about~~ 3400 g/mol and ~~about~~ 5 to ~~about~~ 15 percent of one or more polyethylene oxide derived moieties.

11. The turbine lubricant of claim 15, wherein the turbine lubricant includes ~~about~~ 0.01 to ~~about~~ 0.05 weight percent of the first lubricant additive, ~~about~~ 0.005 to ~~about~~ 0.1 weight percent of the second lubricant additive, ~~about~~ 0.005 to ~~about~~ 0.1 weight percent of the third lubricant additive, and ~~about~~ 0.01 to ~~about~~ 0.07 weight percent of the fourth lubricant additive.

12. The turbine lubricant of claim 11, wherein the turbine lubricant includes ~~about~~ 0.001 to ~~about~~ 0.01 weight percent of the copolymer.

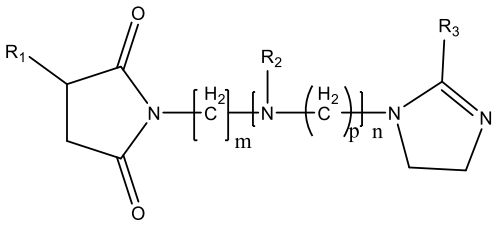
13. The turbine lubricant of claim 15, with no more than 0.05 weight percent of the first lubricant additive.

14. The turbine lubricant of claim 15, wherein the turbine lubricant includes ~~about~~ 1.5 to ~~about~~ 2.5 times more of the first lubricant additive relative to the second and third lubricant additives combined.

15. A turbine lubricant to provide rust prevention and high filterability in the presence of water, the turbine lubricant comprising:

a base oil of lubricating viscosity selected from a Group I, Group II, or Group III oil, or blends thereof;

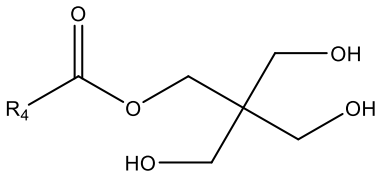
a first lubricant additive including a compound of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons, or a residue derived from a hydrocarbyl substituted dicarboxylic acid or anhydride thereof;

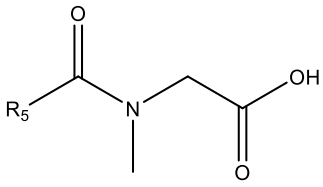
a second lubricant additive including a compound of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl chain;

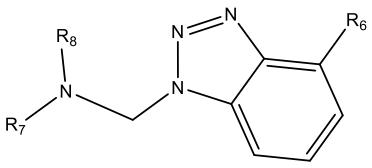
a third lubricant additive including a compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a fourth lubricant additive of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

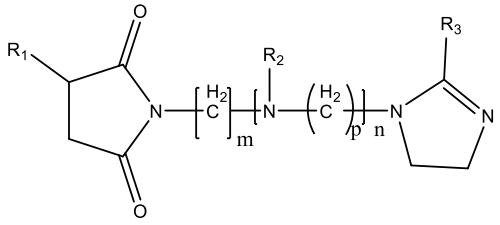
wherein the turbine lubricant has a weight ratio of imidazoline provided by the first lubricant additive to triazole provided by the fourth lubricant additive of ~~about~~ 1:1 to ~~about~~ 2:1 with no more than 0.1 weight percent of the first lubricant additive; and

wherein the turbine lubricant exhibits more than ~~about~~ 70 percent stage II filterability according to ISO 13357-1.

16. A turbine lubricant to provide rust prevention and high filterability in the presence of water, the turbine lubricant comprising:

a base oil of lubricating viscosity selected from a Group I, Group II, or Group III oil, or blends thereof;

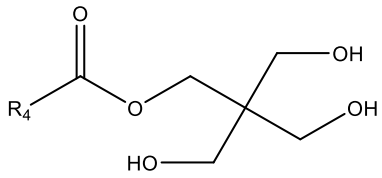
a first lubricant additive including a compound of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons, or a residue derived from a hydrocarbyl substituted dicarboxylic acid or anhydride thereof;

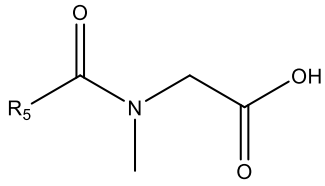
a second lubricant additive including a compound of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl chain;

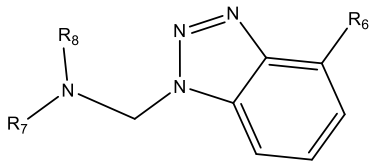
a third lubricant additive including a compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a fourth lubricant additive of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

wherein the turbine lubricant has a weight ratio of imidazoline provided by the first lubricant additive to triazole provided by the fourth lubricant additive of ~~about~~ 1:1 to ~~about~~ 2:1 with no more than 0.1 weight percent of the first lubricant additive; and

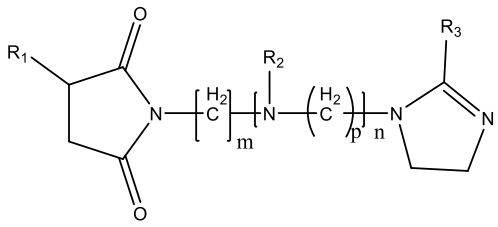
, wherein the base oil includes a blend of Group I and Group II base oils and has a KV40 of ~~about~~ 30 to ~~about~~ 100 cSt.

17. The turbine lubricant of claim 16, wherein the turbine lubricant includes ~~about~~ 0.12 to ~~about~~ 0.35 weight percent of the combined first, second, third, and fourth lubricant additives.

18. A turbine lubricant to provide rust prevention and high filterability in the presence of water, the turbine lubricant comprising:

a base oil of lubricating viscosity selected from a Group I, Group II, or Group III oil, or blends thereof;

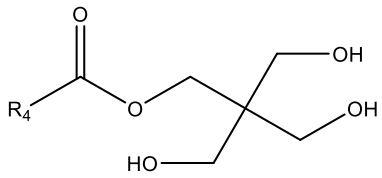
a first lubricant additive including a compound of Formula I



(Formula I)

wherein R1 and R3 are, independently, a hydrocarbyl group having 10 to 19 carbons, and R2 is hydrogen, a hydrocarbyl group having 10 to 20 carbons, or a residue derived from a hydrocarbyl substituted dicarboxylic acid or anhydride thereof;

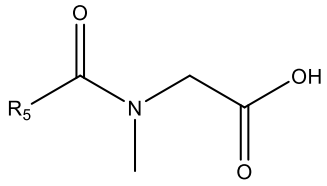
a second lubricant additive including a compound of Formula II



(Formula II)

wherein R4 is a C13 to C20 saturated or unsaturated hydrocarbyl chain;

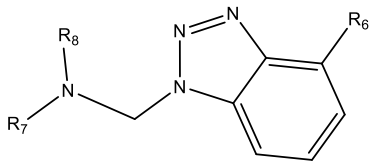
a third lubricant additive including a compound of Formula III



(Formula III)

wherein R5 is a saturated or unsaturated C12 to C20 hydrocarbyl group;

a fourth lubricant additive of Formula IV



(Formula IV)

wherein R6 is a C1 to C5 hydrocarbyl group and R7 and R8 are, independently, a C1 to C10 linear or branched hydrocarbyl group;

wherein the turbine lubricant has a weight ratio of imidazoline provided by the first lubricant additive to triazole provided by the fourth lubricant additive of ~~about~~ 1:1 to ~~about~~ 2:1 with no more than 0.1 weight percent of the first lubricant additive; and

wherein the turbine lubricant exhibits more than ~~about~~ 70 percent stage II filterability according to ISO 13357-1, a passing rust performance according to ASTM D665B, and less than ~~about~~ 10 minutes to 37 ml of water separation according to ASTM D1401.