



- (51) **International Patent Classification:**
C10M 169/04 (2006.01)
- (21) **International Application Number:**
PCT/US2014/029022
- (22) **International Filing Date:**
14 March 2014 (14.03.2014)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/794,912 15 March 2013 (15.03.2013) US
- (71) **Applicant:** TRANE INTERNATIONAL INC. [US/US];
One Centennial Avenue, Piscataway, New Jersey 08855
(US).
- (72) **Inventors:** KUJAK, Stephen Anthony; W7543 County
Road ZB, Onalaska, Wisconsin 54650 (US). MAJURIN,
Julie Ann; N2292 Willow Way E, La Crosse, Wisconsin
54601 (US). STEINKE, Daryl Dean; 248 North Main,
Stoddard, Wisconsin 54658 (US).
- (74) **Agent:** SCHUMANN, Michael D.; Hamre, Schumann,
Mueller & Larson, P.C., P.O. Box 2902, Minneapolis,
Minnesota 55402 (US).
- (81) **Designated States** (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.

- (84) **Designated States** (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments (Rule 48.2(h))*

(54) **Title:** LUBRICANT DEFOAMING ADDITIVES AND COMPOSITIONS

(57) **Abstract:** Defoaming compounds that can be included in a HVAC system are provided. In some embodiments, the refrigerant compositions and/or additives may include one or more defoaming compounds that have one or more of the following properties: helping reduce a surface tension of the lubricant and/or refrigerant; having a different surface tension than the lubricant and/or refrigerant; being substantially non-dissolvable with the refrigerant and/or lubricant; and/or having less dense than the refrigerant and/or lubricant so that the compounds may stay on the surface of the refrigerant and/or lubricant. In some embodiments, the defoaming compounds may be selected from mineral oil, silicone based oil, fatty alcohols, fatty acids, alkyl amines, treated silica, aluminum oxide, polyacrylates, acrylate esters polypropylene, alkyl sulfates, alkyl ethoxylate sulfates, alkyl aryl sulfonates, phosphate esters, quaternary ammonium compounds, fatty amine salts, fatty acid amides, alkyl phenol ethoxylates, ethoxylate -propoxylate polymers and fatty alcohol ethoxylates.



LUBRICANT DEFOAMING ADDITIVES AND COMPOSITIONS

Field

The disclosure herein relates to heating, ventilation, and air-conditioning (“HVAC”) systems, and more particularly to a defoaming compound that may help reduce foaming of lubricants, such as mineral oil, polyolester (POE), alkyl benzene (AB), polyalkylene glycol (PAG), polyalphaolefin (PAO), polyvinyl ether (PVE), or the combination thereof, used in the HVAC system during operation. The defoaming compound may be added to refrigerant and/or a lubricant of the HVAC system to form a refrigerant/lubricant composition, or may be included in another refrigerant/lubricant additive that can be added to the refrigerant and/or lubricant of the HVAC system to form a refrigerant/lubricant composition.

Background

A HVAC system, such as a chiller, generally includes a compressor, a condenser, an evaporator and an expansion device forming a refrigeration circuit that may be used for cooling/heating applications. In a cooling cycle of the HVAC system, the compressor can compress refrigerant vapor, and the compressed refrigerant vapor may be directed into the condenser to condense into liquid refrigerant. The liquid refrigerant can then be expanded by the expansion device and directed into the evaporator.

Components of the HVAC system, such as the compressor, may include moving parts, and may require lubrication during operation. Lubricants, such as oil, are commonly used in the HVAC system to lubricate the moving parts. The lubricant can be added to the refrigerant and circulated along with the refrigerant in the refrigeration circuit.

Summary

Embodiments are described to provide defoaming compounds that can be included in refrigerant/lubricant compositions and/or additives to help prevent/reduce lubricant foaming. In some embodiments, the refrigerant compositions and/or additives may include one or more

defoaming compounds that may have one or more of the following properties: helping reduce a surface tension of the lubricant and/or refrigerant; having a different surface tension than the lubricant and/or refrigerant; being substantially non-dissolvable with the refrigerant and/or lubricant; and/or having less density than the refrigerant and/or lubricant so that the defoaming compound(s) may stay on the surface of the refrigerant and/or lubricant.

In some embodiments, the defoaming compound(s) may be selected from nonpolar oils, such as mineral oil, silicone based oil, polar oils such as fatty alcohols, fatty acids, alky amines, hydrophobic solids such as treated silica, aluminum oxide, polypropylene, surfactants such as alkyl sulfates, alkyl ethoxylate sulfates, alkyl aryl sulfonates, phosphate esters, quaternary ammonium compounds, fatty amine salts, fatty acid amides, alkyl phenol ethoxylates, ethoxylate-propoxylate polymers, acrylate esters, fatty alcohol ethoxylates and combinations thereof.

In some embodiments, a refrigerant/lubricant composition may include the defoaming compound from 0.0001% or about 0.0001% to 1% or about 1% by weight of the refrigerant/lubricant composition.

In some embodiments, the refrigerant composition may generally include hydrochlorofluorocarbon (HCFC), hydrofluorocarbon (HFC), unsaturated HFC's such as hydrochlorofluoroolefin (HCFO), hydrofluoroolefin (HFO) and/or other suitable refrigerants. In some embodiments, the refrigerant composition may include a refrigerant selected from a group including: 1-chloro-3,3,3 trifluoropropene (E), 1-chloro-3,3,3 trifluoropropene (Z), 2-chloro-3,3,3 trifluoropropene, 1,1,dichloro-3,3,3 trifluoropropene, 1,2 dichloro-3,3,3 trifluoropropene (E), 1,2 dichloro-3,3,3 trifluoropropene (Z), 1,3,3,3 tetrafluoropropene (E), 1,3,3,3 tetrafluoropropene (Z), 2,3,3,3 tetrafluoropropene, 1,1,2 trichloro-3,3,3 trifluoropropene, 1,2 dichloroethylene (E), 1,2 dichloroethylene (Z), 1,1 dichloroethylene, 1,1,1,4,4,4 hexafluorobutene (Z), 1,1,1,4,4,4 hexafluorobutene (E), 1,1,3,3 tetrafluoropropane, 1,1,1,2,3 pentafluoropropane, 1,1,2,3,3 pentafluoropropane, 1,1,1,3,3 pentafluoropropane, 1,1,1,2,2 pentafluoropropane, 1,1,1,2,2,3 hexafluoropropane, 1,1,1,2,3,3 hexafluoropropane, 1,1,1,3,3,3 hexafluoropropane, isopentane, pentane, cyclopentane, 1,1 difluoroethene, 1,2-difluoroethane,

difluoromethane, 1,1,1,2 tetrafluoroethane, R1234ze (E), 1, 1 difluoroethane, 1,2 difluoroethene (E), 1,2 difluoroethene (Z) or combinations thereof.

In some embodiments, the lubricant composition for a HVAC system may include 0.00025% or about 0.00025% to 0.0075% or about 0.0075% of silicone oil. In some

5 embodiments, the lubricant composition may include 0.00025% or about 0.00025% to 0.1% or about 0.1% of polyacrylates or acrylate esters.

In some embodiments, the refrigerant/lubricant composition as disclosed herein can be used in production of a HVAC system to reduce foaming of a lubricant or when the HVAC system is in operation. In some embodiments, the refrigerant/lubricant additive as disclosed
10 herein can be added to a HVAC system already in service to reduce foaming of the lubricant when the HVAC system is in operation.

Other features and aspects of the fluid management approaches will become apparent by consideration of the following detailed description.

15

Detailed Description

A HVAC system, such as a chiller system, may commonly include components with moving parts, such as rollers and balls of bearings of a compressor (such as a centrifugal compressor, a screw compressor and/or a scroll compressor). The moving parts generally require proper lubrication. The lubrication is commonly provided by a lubricant(s), such as a
20 mineral oil, POE, AB, PAG, PAO and/or PVE based lubricant(s). The lubricant(s) can be added to the refrigerant and circulated along with the refrigerant in the HVAC system.

Using a lubricant(s) with the refrigerant can present some challenges. Refrigerant, such as hydrochlorofluorocarbons (HCFC), hydrofluorocarbons (HFC), unsaturated HFC's such as hydrochlorofluoroolefin (HCFO) and/or hydrofluoroolefin (HFO), can dissolve in the lubricant.
25 In certain operation conditions, such as when the condenser temperature is relatively high (e.g. about 120°F), or when the HVAC system starts when the components of the HVAC system is still at a relatively high temperature, the refrigerant dissolved in the lubricant can be suddenly released from the lubricant, causing lubricant foaming. The foaming of the lubricant can cause

some operational or reliability issues. For example, foaming of the lubricant can cause the bearing lubricant delivery pump to malfunction and stop or slow the lubricant flow, which may cause component wear.

In another example, the lubricant foaming can lead to loss of lubricant from the lubricant sump to the other chiller system components and result in loss of lubricant flow as well to the bearing system. In addition, loss of lubricant to the other chiller components may require a significant amount of down time to recover the lost lubricant back to the lubricant delivery system. Refrigerant/lubricant compositions and/or additives are disclosed herein that can help prevent/reduce the foaming of the lubricant.

Embodiments are described herein to provide defoaming compounds that can be included in a refrigerant/lubricant composition and/or in an additive for a refrigerant/lubricant mixture to help prevent/reduce lubricant foaming. It is noted that the term “refrigerant composition” and the term “refrigerant/lubricant composition” are used interchangeably, and are generally referred to as a working fluid circulating in the HVAC system. The refrigerant composition may generally include refrigerant, a lubricant and/or other additive(s). The term “lubricant composition” generally means a composition that includes a lubricant and/or an additive(s), but does not include refrigerant.

In some embodiments, the refrigerant compositions and/or the additive may include one or more defoaming compounds that have one or more of the following properties: helping reduce a surface tension of the lubricant and/or refrigerant mixtures by, for example, 10% or about 10% to 80% or about 80%, more preferably 30% or about 30% to 60% or about 60% when the HVAC system is in operation; having a different surface tension than the lubricant and/or refrigerant mixtures in a range of, for example, 1 or about 1 to 60 or about 60 millinewtons per meter, more preferably 5 or about 5 to 40 or about 40 millinewton difference; being substantially non-dissolvable with the refrigerant and/or lubricant; and/or having less density than the refrigerant and/or lubricant so that the compounds may stay on the surface of the refrigerant and/or lubricant, for example, in an oil sump.

In some embodiments, the defoaming compounds may include non-polar oil, such as

mineral oil and/or silicone based oil. In some embodiments, the defoaming compounds may include a polar oil, such as fatty alcohols, fatty acids and/or alkyl amines. In some embodiments, defoaming compounds may include hydrophobic solids, such as treated silica, aluminum oxide, and/or polypropylene. In some embodiments, the defoaming compounds may include

5 surfactants, such as polyacrylates or acrylate esters, alkyl sulfates, alkyl ethoxylate sulfates, alkyl aryl sulfonates, phosphate esters, quaternary ammonium compounds, fatty amine salts, fatty acid amides, alkyl phenol ethoxylates, ethoxylate-propoxylate polymers, and/or fatty alcohol ethoxylates.

In some embodiments, the lubricant composition may include 0.00025% or about

10 0.00025% to 0.1% or about 0.1% of polyacrylates or acrylate esters.

In some embodiments, the refrigerant compositions may be made by adding one or more of the defoaming compounds to the refrigerant or the refrigerant/lubricant mixture. In some embodiments, the refrigerant composition may be made by adding the defoaming compound(s) into the lubricant to form a lubricant composition, and then mixing the lubricant composition

15 with the refrigerant. In some embodiments, the additive may be premade by putting one or more of the defoaming compounds together. The premade additive can be added to the refrigerant and/or lubricant to form the refrigerant/lubricant composition(s) or lubricant composition(s). In some embodiments, the premade additive may be added to the HVAC system directly, for example, when retrofitting a HVAC system.

In some embodiments, the defoaming compounds may be added to the refrigerant in amounts of from 0.0001% or about 0.0001% to 1% or about 1% by weight of the final refrigerant composition with a preferred range of 0.0001% or about 0.0001% to 0.1% or about 0.1%. In some embodiments, the defoaming compounds may be added to the lubricant in amounts of from 0.0001% or about 0.0001% to 1% or about 1% by weight of the final lubricant composition with

25 a preferred range of 0.0001% or about 0.0001% to 0.1% or about 0.1%.

In some embodiments, the defoaming compounds may be added to the refrigerant/lubricant mixture from 0.0001% or about 0.0001% to 1% or about 1% by weight of the final refrigerant/lubricant composition with a preferred range of 0.0001% or about 0.0001%

to 0.1% or about 0.1% . In some embodiments, the additive may include one or more of defoaming compounds and may be added to the lubricant, the refrigerant or the refrigerant/lubricant mixture so that the final concentration of the defoaming compounds collectively may be from 0.0001% or about 0.0001% to 1% about 1% by weight of the final compositions with a preferred range of 0.0001% or about 0.0001% to 0.1% or about 0.1%.

In some embodiments, preferred refrigerant(s) that may be used with the defoaming compounds may be relatively environmental-friendly. In some embodiments, the preferred refrigerant to be used with the defoaming compounds may include one or blends of: 1-chloro-3,3,3 trifluoropropene (E), 1-chloro-3,3,3 trifluoropropene (Z), 2-chloro-3,3,3 trifluoropropene, 1,1,dichloro-3,3,3 trifluoropropene, 1,2 dichloro-3,3,3 trifluoropropene (E), 1,2 dichloro-3,3,3 trifluoropropene (Z), 1,3,3,3 tetrafluoropropene (E), 1,3,3,3 tetrafluoropropene (Z), 2,3,3,3, tetrafluoropropene, 1,1,2 trichloro-3,3,3 trifluoropropene, 1,2 dichloroethylene (E), 1,2 dichloroethylene (Z), 1,1 dichloroethylene, 1,1,1,4,4,4 hexafluorobutene (Z), 1,1,1,4,4,4 hexafluorobutene (E), 1,1,3,3 tetrafluoropropane, 1,1,1,2,3 pentafluoropropane, 1,1,2,3,3 pentafluoropropane, 1,1,1,3,3 pentafluoropropane, 1,1,1,2,2 pentafluoropropane, 1,1,1,2,2,3 hexafluoropropane, 1,1,1,2,3,3 hexafluoropropane, 1,1,1,3,3,3 hexafluoropropane, isopentane, pentane, cyclopentane, 1,1 difluoroethene, 1,2-difluoroethane, difluoromethane, 1,1,1,2 tetrafluoroethane, R1234ze (E), 1, 1 difluoroethane, 1,2 difluoroethene (E), 1,2 difluorethene (Z), or combinations thereof.

In one preferred embodiment, silicone oil may be added to a lubricant to 0.00025% or about 0.00025% to 0.005% or about 0.005% of the weight of the final lubricant composition. In one embodiment, may be added to a lubricant to 0.00025% or about 0.00025% to 0.0075% or about 0.0075% by the weight of the final lubricant composition. The final lubricant composition may be mixed with a refrigerant in a HVAC system. In some embodiments, the final lubricant composition may be mixed with the refrigerant at or about 1:2 ratio to at or about 1:100 ratio by weight.

The refrigerant/lubricant additive mixture (or composition) as disclosed herein can be added directly to the lubricant during a manufacturing process of the HVAC system, or during

startup and/or service of the HVAC system. In some embodiments, the refrigerant/lubricant additive mixture (or composition) as disclosed herein can be added to a HVAC system already in service to reduce foaming. In some embodiments, the refrigerant/lubricant additive mixture (or composition) can be added to the refrigerant of the HVAC system. In some embodiments, the refrigerant/lubricant additive mixture (or composition) can be applied to the parts, such as the bearing, directly by, for example, spraying or dipping type application during the manufacturing process or during servicing of the HVAC system.

In some embodiments, the refrigerant/lubricant composition and/or the refrigerant/lubricant additive can be used with a chiller system with different types of compressors, such as a centrifugal compressor, a screw compressor, reciprocating compressor, rotary vane compressor or a scroll compressor.

It is to be appreciated that the defoaming compounds as disclosed herein may be used with lubricants to reduce lubricant foaming in other applications, such as, air compressors, and vacuum pumps.

Experimental Results #1

About 0.005% of silicone oil was added to a lubricant for a HVAC system. Foaming of the lubricant was conducted by bubbling the lubricant with nitrogen gas through a fine glass frit. The foaming of the lubricant with the silicone oil resulted in only about 10% of the foaming of the lubricant without the silicone oil.

Experimental Results #2

About 0.05% of polyacrylate or acrylate ester oil was added to a lubricant for a HVAC system. Foaming of the lubricant was conducted by bubbling the lubricant with nitrogen gas through a fine glass frit. The foaming of the lubricant with the polyacrylate or acrylate ester oil resulted in about 10% of the foaming of the lubricant without the additive.

Aspects

Any of aspects 1-8 can be combined with any of aspects 9-19. Any of aspects 9 can be combined with any of aspects 10-19. Aspect 10 can be combined with any of aspects 11-19. Aspect 11 can be combined with any of aspects 12-19. Aspect 12 can be combined with any of aspects 13-19. Any of aspects 13-14 can be combined with any of aspects 15-19. Any of aspects 15-17 can be combined with any of aspects 18-19.

Aspect 1. A defoaming compound for a refrigerant/lubricant mixture in a HVAC system, comprising at least one compound that includes one or more properties of:

- reducing a surface tension of the refrigerant/lubricant mixture by 10% to 80%;
- having a different surface tension than the refrigerant/lubricant mixture in a range of 1 to 60 millinewtons per meter;
- being substantially non-dissolvable with the refrigerant/lubricant mixture; and
- having less density than the refrigerant/lubricant mixture.

Aspect 2. The defoaming compound of aspect 1, wherein the property of reducing the surface tension of the refrigerant/lubricant mixture is in a range of 30% to 60%.

Aspect 3. The defoaming compound of aspects 1-2, wherein the property of having the different surface tension than the refrigerant/mixture is in a range of 5 to 40 millinewtons per meter.

Aspect 4. The defoaming compound of aspects 1-3, comprising a compound selected from a group comprising: a non-polar oil, a polar oil, hydrophobic solids, surfactants, or a combination thereof.

Aspect 5. The defoaming compound of aspect 4, wherein the non-polar oil is selected from a group comprising:

- mineral oil, silicone based oil, or a combination thereof.

Aspect 6. The defoaming compound of aspects 4-5, wherein the polar oil is selected from a group comprising: fatty alcohols, fatty acids, alky amines, or a combination thereof.

- 5 Aspect 7. The defoaming compound of aspects 4-6, wherein the hydrophobic solids are selected from a group comprising: treated silica, aluminum oxide, polyacrylates, acrylate esters polypropylene, or a combination thereof.

- 10 Aspect 8. The defoaming compound of aspects 4-7, wherein the surfactants is selected from a group comprising: alkyl sulfates, alkyl ethoxylate sulfates, alkyl aryl sulfonates, phosphate esters, quaternary ammonium compounds, fatty amine salts, fatty acid amides, alkyl phenol ethoxylates, ethoxylate-propoxylate polymers, fatty alcohol ethoxylates or a combination thereof.

- 15 Aspect 9. A refrigerant composition comprising the defoaming compound of aspects 1-8, wherein the defoaming compound is from about 0.0001% to about 1% by weight of the refrigerant composition.

- Aspect 10. The refrigerant composition of aspect 9, wherein the defoaming compound is from about 0.0001% to 0.1%

- 20 Aspect 11. The defoaming compound of aspects 1-8, wherein a refrigerant for the refrigerant/lubricant mixture is selected from a group comprising: 1-chloro-3,3,3 trifluoropropene (E), 1-chloro-3,3,3 trifluoropropene (Z), 2-chloro-3,3,3 trifluoropropene, 1,1,dichloro-3,3,3 trifluoropropene, 1,2 dichloro-3,3,3 trifluoropropene (E), 1,2 dichloro-3,3,3 trifluoropropene (Z), 1,3,3,3 tetrafluoropropene (E), 1,3,3,3 tetrafluoropropene (Z), 2,3,3,3, tetrafluoropropene, 1,1,2 trichloro-3,3,3 trifluoropropene, 1,2 dichloroethylene (E), 1,2 dichloroethylene (Z), 1,1 dichloroethylene, 1,1,1,4,4,4 hexafluorobutene (Z), 1,1,1,4,4,4 hexafluorobutene (E), 1,1,3,3 tetrafluoropropane, 1,1,1,2,3 pentafluoropropane, 1,1,2,3,3

pentafluoropropane, 1,1,1,3,3 pentafluoropropane, 1,1,1,2,2 pentafluoropropane, 1,1,1,2,2,3 hexafluoropropane, 1,1,1,2,3,3 hexafluoropropane, 1,1,1,3,3,3 hexafluoropropane, isopentane, pentane, cyclopentane, 1,1 difluoroethene, 1,2-difluoroethane, difluoromethane, 1,1,1,2 tetrafluoroethane, R1234ze (E), 1, 1 difluoroethane, 1,2 difluoroethene (E), 1,2 difluorethene (Z).

5

Aspect 12. An additive for a HVAC system comprising the defoaming compound of aspect 1.

Aspect 13. A refrigerant composition comprising the additive of aspect 12, wherein the additive is from about 0.0001% to about 1% by weight of the refrigerant composition.

10

Aspect 14. The refrigerant composition of aspect 13, wherein the additive is from about 0.0001% to 0.1%.

Aspect 15. A lubricant composition for a HVAC system, comprising about 0.00025% to 0.0075% of silicone oil.

15

Aspect 16. The lubricant composition of aspect 15, wherein the silicon oil is about 0.00025% to 0.005%.

Aspect 17. The lubricant composition of aspects 15-16, wherein the silicon oil is 0.005%.

20

Aspect 18. A lubricant composition for a HVAC system, comprising 0.00025% to 0.1% of polyacrylates, acrylate esters or a combination thereof.

Aspect 19. The lubricant composition of aspect 18, wherein the polyacrylates, acrylate esters or a combination thereof is about 0.05%.

25

With regard to the foregoing description, it is to be understood that changes may be made

in detail, without departing from the scope of the present invention. It is intended that the specification and depicted embodiments are to be considered exemplary only, with a true scope and spirit of the invention being indicated by the broad meaning of the claims.

Claims

What claimed is:

Claim 1. A defoaming compound for a refrigerant/lubricant mixture in a HVAC system, comprising at least one compound that includes one or more properties of:

- 5 reducing a surface tension of the refrigerant/lubricant mixture by 10% to 80%;
- having a different surface tension than the refrigerant/lubricant mixture in a range of 1 to 60 millinewtons per meter;
- being substantially non-dissolvable with the refrigerant/lubricant mixture; and
- having less density than the refrigerant/lubricant mixture.

10

Claim 2. The defoaming compound of claim 1, wherein the property of reducing the surface tension of the refrigerant/lubricant mixture is in a range of 30% to 60%.

- 15 Claim 3. The defoaming compound of claim 1, wherein the property of having the different surface tension than the refrigerant/mixture is in a range of 5 to 40 millinewtons per meter.

Claim 4. The defoaming compound of claim 1, comprising a compound selected from a group comprising: a non-polar oil, a polar oil, hydrophobic solids, surfactants, or a combination thereof.

20

Claim 5. The defoaming compound of claim 4, wherein the non-polar oil is selected from a group comprising:

mineral oil, silicone based oil, or a combination thereof.

- 25 Claim 6. The defoaming compound of claim 4, wherein the polar oil is selected from a group comprising: fatty alcohols, fatty acids, alky amines, or a combination thereof.

Claim 7. The defoaming compound of claim 4, wherein the hydrophobic solids are selected from a group comprising: treated silica, aluminum oxide, polyacrylates, acrylate esters polypropylene, or a combination thereof.

5 Claim 8. The defoaming compound of claim 4, wherein the surfactants is selected from a group comprising: alkyl sulfates, alkyl ethoxylate sulfates, alkyl aryl sulfonates, phosphate esters, quaternary ammonium compounds, fatty amine salts, fatty acid amides, alkyl phenol ethoxylates, ethoxylate-propoxylate polymers, fatty alcohol ethoxylates or a combination thereof.

10 Claim 9. A refrigerant composition comprising the defoaming compound of claim 1, wherein the defoaming compound is from about 0.0001% to about 1% by weight of the refrigerant composition.

Claim 10. The refrigerant composition of claim 9, wherein the defoaming compound is from
15 about 0.0001% to 0.1%

Claim 11. The defoaming compound of claim 1, wherein a refrigerant for the refrigerant/lubricant mixture is selected from a group comprising: 1-chloro-3,3,3 trifluoropropene (E), 1-chloro-3,3,3 trifluoropropene (Z), 2-chloro-3,3,3 trifluoropropene, 20 1,1,dichloro-3,3,3 trifluoropropene, 1,2 dichloro-3,3,3 trifluoropropene (E), 1,2 dichloro-3,3,3 trifluoropropene (Z), 1,3,3,3 tetrafluoropropene (E), 1,3,3,3 tetrafluoropropene (Z), 2,3,3,3, tetrafluoropropene, 1,1,2 trichloro-3,3,3 trifluoropropene, 1,2 dichloroethylene (E), 1,2 dichloroethylene (Z), 1,1 dichloroethylene, 1,1,1,4,4,4 hexafluorobutene (Z), 1,1,1,4,4,4 hexafluorobutene (E), 1,1,3,3 tetrafluoropropane, 1,1,1,2,3 pentafluoropropane, 1,1,2,3,3 25 pentafluoropropane, 1,1,1,3,3 pentafluoropropane, 1,1,1,2,2 pentafluoropropane, 1,1,1,2,2,3 hexafluoropropane, 1,1,1,2,3,3 hexafluoropropane, 1,1,1,3,3,3 hexafluoropropane, isopentane, pentane, cyclopentane, 1,1 difluoroethene, 1,2-difluoroethane, difluoromethane, 1,1,1,2 tetrafluoroethane, R1234ze (E), 1, 1 difluoroethane, 1,2 difluoroethene (E), 1,2 difluorethene (Z).

Claim 12. An additive for a HVAC system comprising the defoaming compound of claim 1.

Claim 13. A refrigerant composition comprising the additive of claim 12, wherein the additive is
5 from about 0.0001% to about 1% by weight of the refrigerant composition.

Claim 14. The refrigerant composition of claim 13, wherein the additive is from about 0.0001%
to 0.1%.

10 Claim 15. A lubricant composition for a HVAC system, comprising about 0.00025% to
0.0075% of silicone oil.

Claim 16. The lubricant composition of claim 15, wherein the silicon oil is about 0.00025% to
0.005%.

15

Claim 17. The lubricant composition of claim 15, wherein the silicon oil is 0.005%.

Claim 18. A lubricant composition for a HVAC system, comprising 0.00025% to 0.1% of
polyacrylates, acrylate esters or a combination thereof.

20

Claim 19. The lubricant composition of claim 18, wherein the polyacrylates, acrylate esters or a
combination thereof is about 0.05%.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/029022**A. CLASSIFICATION OF SUBJECT MATTER****C10M 169/04(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10M 169/04; C10M 155/02; C10M 149/20; C09K 5/04; B01D 19/04; C08G 77/46; C10M 1/16; C10M 169/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords:refrigerant, lubricant, defoam, antifoam, silicon oil, polyacrylate, surface tension

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-209778 A (NIPPON MITSUBISHI OIL CORPORATION et al.) 3 August 1999 See abstract; claim 1; paragraphs [0002], [0003], [0007], [0010].	1-5, 7, 9-10, 12-19
Y		6, 8, 11
Y	US 2010-0084597 A1 (SCHWAB, P. et al.) 8 April 2010 See abstract; claims 1-13; paragraphs [0153]-[0156].	6, 8
A		1-5, 7, 9-19
Y	US 2010-0252772 A1 (KANEKO, M.) 7 October 2010 See abstract; claims 1-12; paragraphs [0057], [0071].	11
A		1-10, 12-19
A	US 5766513 A (PILLON, L. Z. et al.) 16 June 1998 See abstract; claims 1-4.	1-19
A	US 4504403 A (TSUNEMI, M. et al.) 12 March 1985 See abstract; claim 1.	1-19



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

18 August 2014 (18.08.2014)

Date of mailing of the international search report

19 August 2014 (19.08.2014)

Name and mailing address of the ISA/KR

International Application Division
Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea

Facsimile No. +82-42-472-7140

Authorized officer

LEE, Dong Wook

Telephone No. +82-42-481-8163



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/029022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 11-209778A	03/08/1999	None	
US 2010-0084597 A1	08/04/2010	CA 2652320 A1 CN 101502728 A EP 2087931 A2 EP 2087931 A3 JP 2009-185286 A US 8362095 B2	05/08/2009 12/08/2009 12/08/2009 31/08/2011 20/08/2009 29/01/2013
US 2010-0252772 A1	07/10/2010	CN 101248163 A CN 101248163 B CN 101248163 C0 EP 1921127 A1 EP 1921127 A4 JP 05-400298 B2 KR 10-1317074 B1 KR 10-2008-0045164 A TW I414594 B US 2009-0072187 A1 US 2011-0136712 A1 US 7824567 B2 US 8349206 B2 WO 2007-026647 A1	20/08/2008 06/02/2013 20/08/2008 14/05/2008 09/01/2013 29/01/2014 11/10/2013 22/05/2008 11/11/2013 19/03/2009 09/06/2011 02/11/2010 08/01/2013 08/03/2007
US 05766513 A	16/06/1998	None	
US 04504403 A	12/03/1985	JP 57-177096 A	30/10/1982