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LUBRICANT COMPOSITIONS AND METHODS OF DRY LUBRICATING SURFACE USING THE SAME

Abstract

A lubricant composition comprises vegetable oil; nonionic surfactant; water in an amount of from about 0% to about 15% by weight based on total weight of the composition; optionally biocide; and optionally chelating agent, wherein the weight ratio of vegetable oil to nonionic surfactant is in a range of from about 1:1 to about 9:1. Also disclosed is a lubricant composition that comprises about 40% to about 90% by weight of vegetable oil; from about 10% to about 40% by weight of nonionic surfactant; from about 0% to about 15% by weight of based on total weight of the composition; optionally biocide; and optionally chelating agent. The disclosed lubricant compositions may further comprise the ester of fatty alcohol. Furthermore, a method of dry lubricating surface using the lubricant composition is disclosed.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Indian Provisional Application No. 202211024001, filed on Apr. 23, 2022.

TECHNICAL FIELD

[0002] This disclosure relates to the lubricant compositions and the methods of dry lubricating surfaces, particularly during conveyor transport of containers.

BACKGROUND OF THE DISCLOSURE

[0003] During commercial container filling or packaging operations, containers are moved from one place to another by the conveyor belt of a conveyor system at a high speed. This results in a friction between the container-contacting surface of conveyor belt and the surface of container that is in contact with the conveyor belt. Lubricant must be applied to the conveyor belt to reduce friction between the surfaces and to ensure the good gliding contact.

[0004] Conventionally, wet lubrication process is used to address the friction problem. Fatty acid-based or fatty amine-based lubricant compositions are commonly used for the wet lubrication process. The lubricant composition is diluted with water at, e.g., a dilution ratio of from about 1:100 to about 1:1000, to form an aqueous wet lubricant solution prior to its use for the wet lubrication process. Copious amounts of such aqueous wet lubricant solution must be applied to the conveyor belt continuously to ensure the proper high speed conveyor operation. During the wet lubrication process, large amounts of aqueous wet lubricant solution flow off the conveyor belt, resulting in a slippery floor surface that may constitute a hazard to operators working in the immediate environment. Furthermore, this leads to a waste of chemical and large amounts of water that must be disposed of or recycled. Therefore, the wet lubrication process consumes extensive operation and energy costs.

[0005] Dry lubrication process has been used to address the aforementioned drawback of the wet lubrication process. Silicon-based compositions are commonly used as the dry lubricant compositions for the dry lubrication process. Dry lubricant composition typically contains less than 50% by weight of water, and it is applied to the surfaces of conveyor belt and/or containers without dilution. Hence, the dry lubrication process employs significantly lower amount of water and consumes reduced operation and energy costs, compared to the wet lubrication process.

[0006] There is still a need for the lubricant compositions and the methods of dry lubrication that provide excellent lubricity and minimal blackness problem as the conventional methods of wet lubrication, and yet still consume low levels of water, energy and operation cost as the conventional methods of dry lubrication.

SUMMARY

[0007] In the first aspect, a lubricant composition is disclosed that comprises vegetable oil; nonionic surfactant; from about 0% to about 15% by weight of water based on total weight of the composition; optionally biocide; and optionally chelating agent, wherein a weight ratio of the vegetable oil to the nonionic surfactant is in a range of from about 1:1 to about 9:1. In some embodiments, the lubricant composition comprises from about 0% to about 10% by weight of water, preferably from about 0% to about 5% by weight of water, based on total weight of the composition. In some embodiments, the lubricant composition is substantially free of water. In some embodiments, the amount of vegetable oil is from about 40% to about 90% by weight, preferably from about 40% to about 80% by weight, based on total weight of the composition. In some embodiments, the amount of nonionic surfactant is from about 10% to about 40% by weight based on total weight of the composition. The lubricant composition may further comprise ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms. In some embodiments, the weight ratio of vegetable oil to ester of fatty alcohol is in a range of from about 1:1 to about 20:1. In some embodiments, the ester of fatty alcohol is present in an amount of from about 4% to about 40% by weight based on total weight of the composition. In some embodiments, the lubricant composition is substantially free of silicon-based compound, mineral oil, fatty acid, fatty amine, or any combination thereof.

[0008] In the second aspect, a lubricant composition is disclosed that comprises vegetable oil in an amount of from about 40% to about 90% by weight; nonionic surfactant in an amount of from about 10% to about 40% by weight; water in an amount of from about 0% to about 15% by weight based on total weight of the composition; optionally biocide; and optionally chelating agent. In some embodiments, the lubricant composition comprises from about 0% to about 10% by weight of water, preferably from about 0% to about 5% by weight of water, based on total weight of the composition. In some embodiments, the lubricant composition is substantially free of water. In some embodiments, the vegetable oil is present in an amount of from about 40% to about 80% by weight, based on total weight of the composition. In some embodiments, the weight ratio of vegetable oil to nonionic surfactant is in a range of from about 1:1 to about 9:1. The lubricant composition may further comprise ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms. In some embodiments, the ester of fatty alcohol is present in an amount of from about 4% to about 40% by weight based on total weight of the composition. In some embodiments, the weight ratio of vegetable oil to ester of fatty alcohol is in a range of from about 1:1 to about 20:1. In some embodiments, the lubricant composition is substantially free of silicon-based compound, mineral oil, fatty acid, fatty amine, or any combination thereof.

[0009] In the third aspect, a method of lubricating surface is disclosed that comprises (i) applying the lubricant composition of the first or second aspect discontinuously to the surface without diluting the lubricant composition prior to the application, wherein the lubricant composition provides an initial coefficient of friction of from about 0.07 to about 0.17 on the surface; (ii) applying water intermittently to the surface, wherein the water facilitates removal of blackness from the surface; (iii) monitoring a coefficient of friction on the surface and re-applying the lubricant composition discontinuously to the surface when the monitored coefficient of friction on the surface increases to about 0.17; and (iv) continuing to apply water intermittently to the surface to facilitate the removal of blackness from the surface. In some embodiments, the initial coefficient of friction is in a range of from about 0.07 to about 0.15, and the lubricant composition is re-applied discontinuously to the surface when the monitored coefficient of friction on the surface increases to about 0.15. In some embodiments, the water is applied to the surface intermittently at every one hour after the application of lubricant composition. In some embodiments, applying the water intermittently to the surface is performed using a non-energized spray nozzle, an energized spray nozzle, a metered diaphragm pump, a brush applicator, or any combination thereof. In some embodiments, water is applied when the blackness is visually observed on the surface. In some embodiments, water is applied at a minimum of one hour after the application of lubricant composition. In some embodiments, water is applied at every one hour after the application of lubricant composition.

[0010] In the fourth aspect, a method of lubricating surface is disclosed that comprises applying the lubricant composition of the first or second aspect discontinuously to the conveyor belt without diluting the lubricant composition prior to the application. The method further comprises re-applying said lubricant composition discontinuously to the surface when the coefficient of friction on the surface increases to a selected value. In some embodiments, the lubricant composition is re-applied discontinuously to the surface when the coefficient of friction on the surface increases to about 0.17. In some embodiments of this fourth aspect, no intermittently application of water to the surface is required.

[0011] For the third and fourth aspects of the present disclosure, the surface comprises a container-contacting surface of conveyor belt, a container surface in contact with the conveyor belt, or both. In some embodiments, the container-contacting surface of conveyor belt comprises stainless steel. In some embodiments, the container surface in contact with the conveyor belt comprises glass. In some embodiments, the container-contacting surface of conveyor belt comprises stainless steel, and the container surface in contact with the conveyor belt comprises glass. Application of the lubricant composition can be carried out using any suitable technique including, but are not limited to, spraying, wiping, brushing, drip coating, roll coating, and other methods for application of a thin film. In some embodiments, applying the lubricant composition discontinuously to the surface is performed using a non-energized spray nozzle; an energized spray nozzle such as, but not limited to, a high pressure spray nozzle, a compressed air, a sonication applicator to deliver the lubricant on the top, between, and/or below the conveyor belt; a controlled dosing applicator that allows the application of lubricant composition to the surface at an accurate and low dosage level according to the pre-set rate of application; a metered diaphragm pump; a peristaltic pump; a valveless rotating reciprocating piston metering pump; a brush applicator; or any combination thereof. For the application using a controlled dosing applicator that allows the application of lubricant composition to the surface at an accurate and low dosage level according to the pre-set rate of application, in some embodiments the low dosage level is in a range of from about 0.1 ml/min to about 10 ml/minute.

[0012] Other aspects of the disclosure will become apparent by consideration of the detailed description.

Description

BRIEF DESCRIPTION OF THE DRAWING

[0013] FIG. **1** is a graph showing the comparative levels of blackness for the tested lubricant compositions at different time periods after an application to the conveyor belt.

DETAILED DESCRIPTION

[0014] The present disclosure generally relates to the lubricant compositions and the methods of dry lubricating surfaces that offer a reduced friction between the surfaces to ensure the good gliding contact, and provide an improved efficacy in removing the blackness that is one of the major drawbacks for the conventional methods of dry lubrication.

[0015] The singular forms “a”, “an”, and “the” include plural references unless the context dearly dictates otherwise.

[0016] The terms “comprise(s),” “comprising,” “include(s),” “including,” “having,” “has,” “contain(s),” “containing,” “characterized by,” and variants thereof are open-ended transitional phrases that are meant to encompass the items listed thereafter and equivalents thereof, as well as additional items. Where the term “comprising” is used, the present disclosure also contemplates other embodiments “comprising”, “consisting of”, or “consisting essentially of” elements presented herein, whether explicitly set forth or not.

[0017] The terms “consist(s) of”, “consisting of,” and variants thereof are dose-ended transitional phrases, terms, or words that are meant to encompass the items listed thereafter and equivalents thereof, and to exclude additional items except for impurities ordinarily associated therewith.

[0018] The terms “consist(s) essentially of”, “consisting essentially of,” and variants thereof are meant to encompass the items listed thereafter and equivalents thereof, as well as additional items that do not materially affect the basic and novel characteristics.

[0019] The term “about” used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (for example, it includes at least the degree of error associated with the measurement of the particular quantity). The term “about” also refers to plus or minus 10% of the indicated number. For examples, “about 10%” indicates a range from 9% to 11%, and “about 8” indicates a range from 7.2 to 8.8.

[0020] Any numerical range recited herein includes all values from the lower value to the upper value. For example, if a concentration range is stated as 1% to 50%, it is intended that values such as 2% to 40%, 10% to 30%, or 1% to 3%, etc., are expressly enumerated in this specification. These are only examples of what is specifically intended, and all possible combinations of numerical values between and including the lowest value and the highest value enumerated are to be considered to be expressly stated in this application.

[0021] The term “substantially free”, as used herein, means that a lubricant composition does not contain such particular compound, or such particular compound has not been added intentionally to the lubricant composition. Should such particular compound be present through contamination, the amount of such particular compound shall be less than 0.5% by weight, preferably less than 0.1% by weight.

[0022] The term “weight percent,” “wt %,” “percent by weight,” “% by weight,” and variations thereof, as used herein, refer to the concentration of a component as the weight of that component divided by the total weight of the composition and multiplied by 100. Unless indicated otherwise, all concentrations are expressed as weight percentage concentrations.

[0023] The term “effective amount” refers to an amount that would achieve a desired effect or result. For example, an effective amount of a lubricant composition refers to the amount of such composition to achieve a desired level of lubricity, which can be determined based on the coefficient of friction (COF) value.

[0024] The term “coefficient of friction” or “COF” is a dimensionless number that is defined as a ratio between (i) the frictional force resisting the motion of two surfaces that are in contact and (ii) the normal force pressing the two surfaces together.

[0025] The term “conveyor belt” as used herein refers to a moving surface of a conveyor system that is used for transporting objects from one place to another. Examples of common materials for the construction of conveyor belt include stainless steel or other metals, rubber, plastic, leather, and/or fabric.

[0026] The term “wet lubricant” or “wet lubricant composition” as used herein refers to a lubricant composition that must be diluted with water to form an aqueous dilute lubricant solution prior to an application to surface. The dilution ratio is generally in a range of from about 100 part water per one part wet lubricant to about 500 part water per one part dry lubricant, depending on the friction requirement and the water type. Thus, copious amounts of the aqueous dilute solution of wet lubricant is applied to the surface to be lubricated, e.g., the surface of conveyor belt. The method of wet lubrication uses large amounts of water that must be disposed of or recycled, which results in high operation and energy costs. Furthermore, the aqueous dilute solution of wet lubricant could flow off the conveyor track surface treated therewith, causing a slippery floor surface that may constitute a hazard to the operators working in the immediate environment, and collecting on floors and other surfaces that requires cleaning. Moreover, variations in the water can have negative side effects on the aqueous dilute solution of wet lubricant. For example, the presence or absence of dissolved minerals and alkalinity in the water can cause an unacceptably high coefficient of friction.

[0027] The term "dry lubricant" or "dry lubricant composition" refers to a lubricant composition that is used without dilution with water prior to an application to surface. The method of dry lubrication does not require copious amount of water; therefore; it is much more economical to operate than the method of wet lubrication. The method of dry lubrication typically requires approximately 1.5 to 20 milliliters of the dry lubricant per hour to be applied to the surface such as conveyor belt; whereas, the method of wet lubrication requires approximately 10 to 30 liters of an aqueous dilute solution of wet lubricant per hour to be applied.

[0028] The term "energized nozzle" refers to a nozzle wherein the stream of lubricant composition is broken into a spray of fine droplets by the use of energy. Examples of energized nozzles may include, but are not limited to, high pressures, compressed air, or sonication.

[0029] However, the method of dry lubrication has drawback of a so-called "blackness" problem. The term "blackness" as used herein refers to the residue comprising chromium, iron, silica, soil, dirt or any mixture thereof, that is commonly observed, during the method of dry lubrication, on the surfaces of the containers that have been transported on the conveyor belt and/or the surfaces of the conveyor belt.

[0030] The blackness may be caused by several sources: the dirt attached to the surfaces of containers, especially in case of the used containers; the dirt attached to the surfaces of conveyor belt; the wear of containers that have been transported on the conveyor belt, or any combination thereof. A further source of dirt on the conveyor belt may be fractions of liquid contents (e.g., alcoholic beverages, non-alcoholic beverages) that have not been filled into the container during the filling/refilling process, but rather have flown down on the outer surface of the container and then onto the conveyor belt. The problem of blackness is particularly predominant when the method of dry lubrication is utilized during conveying the glass containers on the stainless steel conveyor belts.

[0031] The blackness problem is not observed during the method of wet lubrication. As discussed above, the aqueous dilute solution of wet lubricant flows off the conveyor track surface during the method of wet lubrication. Therefore, most of the blackness developed during the conveyor process is carried away from the surfaces of conveyor belt and/or the surfaces of containers by the flowing off of aqueous dilute solution of wet lubricant.

[0032] Once blackness is formed during the method of dry lubrication, it is very difficult to remove from the conveyor belt. The entire conveyor system must be stopped from time to time, so that the conveyor belt can be properly cleaned with a conventional aqueous cleaner (e.g., an aqueous alkaline cleaning solution) to remove the blackness from the conveyor belt. The aqueous cleaner also removes the dry lubricant composition from the conveyor belt. Therefore, after stopping the conveyor operation to clean the conveyor belt, additional time and labor are needed to reapply the dry lubricant composition to the conveyor belt and ensure the trouble-free transport of containers on the conveyor belt.

[0033] The presently disclosed lubricant compositions and the methods of dry lubrication are cost effective due to the reduced amount of required water, afford an excellent lubricity between the surfaces during the transport of containers on the conveyor belt, and also provide an improved efficacy in removing the blackness that is one of the major drawbacks for the conventional methods of dry lubrication.

Dry Lubricant Compositions

[0034] The disclosed lubricant composition of the first aspect comprises: [0035] vegetable oil; [0036] nonionic surfactant; [0037] water in an amount of from about 0% to about 15% by weight based on total weight of the composition, [0038] optionally a biocide; and [0039] optionally a chelating agent; and [0040] wherein a weight ratio of the vegetable oil to the nonionic surfactant is in a range of from about 1:1 to about 9:1.

[0041] In some embodiments, the lubricant composition comprises the water in an amount of less than about 10%, about 7.5%, about 5%, about 3% or about 1% by weight based on total weight of the composition. In some embodiments, the water is present in an amount of from about 0% to about 10% by weight of water, preferably from about 0% to about 5% by weight of water, based on total weight of the composition. In some embodiments, the lubricant composition is substantially free of water.

[0042] In some embodiments, the lubricant composition comprises the vegetable oil in an amount of at least about 40%, about 45%, about 50%, about 55% or about 60% by weight based on total weight of the composition; and/or no more than about 65%, about 70%, about 75%, about 80%, about 85% or about 90% by weight based on total weight of the composition. In some embodiments, the vegetable oil is present in an amount of from about 40% to about 90% by weight, preferably from about 40% to about 80% by weight, based on total weight of the composition.

[0043] In some embodiments, the lubricant composition comprises the nonionic surfactant in an amount of at least about 10%, about 15%, about 20% or about 25% by weight based on total weight of the composition; and/or no more than about 25%, about 30%, about 35% or about 40% by weight based on total weight of the composition. In some embodiments, the nonionic surfactant is present in an amount of from about 10% to about 40% by weight based on total weight of the composition.

[0044] In some embodiments, the vegetable oil is present in an amount of from about 40% to about 90% by weight, preferably from about 40% to about 80% by weight, based on total weight of the composition; and the nonionic surfactant is present in an amount of from about 10% to about 40% by weight based on total weight of the composition.

[0045] In some embodiments, a weight ratio of the vegetable oil to the nonionic surfactant is in a range of at least about 1:1, about 1.5:1, about 2:1, about 2.5:1, about 3:1, about 3.5:1, about 4:1, about 4.5:1, about 5:1; and/or no more than about 5:1, about 5.5:1, about 6:1, about 6.5:1, about 7:1, about 7.5:1, about 8:1, about 8.5:1 or about 9:1. In some embodiments, a weight ratio of the vegetable oil to the nonionic surfactant is in a range of from about 1:1 to about 9:1.

[0046] In some embodiments, the lubricant composition further comprises ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms. The ester of fatty alcohol may be a blend of at least two esters of fatty alcohols.

[0047] In some embodiments, a weight ratio of the vegetable oil to the ester of fatty alcohol is in a range of at least about 1:1; about 2:1, about 4:1, about 6:1, about 8:1, about 10:1 or about 12:1; and/or no more than about 10:1, about 12:1, about 14:1, about 16:1, about 18:1 or about 20:1. In some embodiments, a weight ratio of the vegetable oil to the ester of fatty alcohol is in a range of from about 1:1 to about 20:1.

[0048] In some embodiments, the ester of fatty alcohol is present in an amount of at least about 4%, about 6%, about 8, about 10%, about 12.5%, about 15%, about 17.5%, about 20%, about 22.5% or about 25% by weight based on total weight of the composition; and/or no more than about 25%, about 27.5%, about 30%, about 32.5%, about 35%, about 37.5% or about 40% by weight based on total weight of the composition. In some embodiments, the lubricant composition comprises the ester of fatty alcohol in an amount of from about 4% to about 40% by weight based on total weight of the composition.

[0049] In some embodiments, the lubricant composition comprises: [0050] vegetable oil; [0051] nonionic surfactant; [0052] ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms; [0053] water in an amount of from about 0% to about 15%, preferably from about 0% to about 5% by weight of water, based on total weight of the composition, optionally a biocide; and [0054] optionally a chelating agent; [0055] wherein a weight ratio of the vegetable oil to the nonionic surfactant is in a range of from about 1:1 to about 9:1, and [0056] wherein a weight ratio of the vegetable oil to the ester of fatty alcohol is in a range of from about 1:1 to about 20:1.

[0057] In some embodiments, the lubricant composition is substantially free of silicon-based compound, mineral oil, fatty acid, fatty amine, or any combination thereof.
[0058] The disclosed lubricant composition of the second aspect comprises: [0059] vegetable oil in an amount of from about 40% to about 90% by weight, preferably from about 40% to about 80% by weight; [0060] nonionic surfactant in an amount of from about 10% to about 40% by weight; [0061] water in an amount of from about 0% to about 15% by weight, preferably from about 0% to about 5% by weight of water, based on total weight of the composition; [0062] optionally a biocide; and [0063] optionally a chelating agent.
[0064] In some embodiments, the lubricant composition comprises the water in an amount of less than about 10%, about 7.5%, about 5%, about 3% or about 1% by weight based on total weight of the composition. In some embodiments, the water is present in an amount of from about 0% to about 10% by weight of water, preferably from about 0% to about 5% by weight of water, based on total weight of the composition. In some embodiments, the lubricant composition is substantially free of water.
[0065] In some embodiments, the lubricant composition comprises the vegetable oil in an amount of at least about 40%, about 45%, about 50%, about 55% or about 60% by weight based on total weight of the composition; and/or no more than about 65%, about 70%, about 75%, about 80%, about 85% or about 90% by weight based on total weight of the composition. In some embodiments, the vegetable oil is present in an amount of from about 40% to about 80% by weight based on total weight of the composition
[0066] In some embodiments, the lubricant composition comprises the nonionic surfactant in an amount of at least about 10%, about 15%, about 20% or about 25% by weight based on total weight of the composition; and/or no more than about 25%, about 30%, about 35% or about 40% by weight based on total weight of the composition. In some embodiments, the lubricant composition comprises the nonionic surfactant in an amount of from about 10% to about 40% by weight based on total weight of the composition.
[0067] In some embodiments, the vegetable oil is present in an amount of from about 40% to about 80% by weight, and the nonionic surfactant is present in an amount of from about 10% to about 40% by weight based on total weight of the composition.
[0068] In some embodiments, a weight ratio of the vegetable oil to the nonionic surfactant is in a range of at least about 1:1, about 1.5:1, about 2:1, about 2.5:1, about 3:1, about 3.5:1, about 4:1, about 4.5:1, about 5:1; and/or no more than about 5:1, about 5.5:1, about 6:1, about 6.5:1, about 7:1, about 7.5:1, about 8:1, about 8.5:1 or about 9:1. In some embodiments, a weight ratio of the vegetable oil to the nonionic surfactant is in a range of from about 1:1 to about 9:1.
[0069] In some embodiments, the lubricant composition further comprises ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms. The ester of fatty alcohol may be a blend of at least two esters of fatty alcohols.
[0070] In some embodiments, the ester of fatty alcohol is present in an amount of at least about 4%, about 6%, about 8, about 10%, about 12.5%, about 15%, about 17.5%, about 20%, about 22.5% or about 25% by weight based on total weight of the composition; and/or no more than about 25%, about 27.5%, about 30%, about 32.5%, about 35%, about 37.5% or about 40% by weight based on total weight of the composition. In some embodiments, the lubricant composition comprises the ester of fatty alcohol in an amount of from about 4% to about 40% by weight based on total weight of the composition.
[0071] In some embodiments, a weight ratio of the vegetable oil to the ester of fatty alcohol is in a range of at least about 1:1; about 2:1, about 4:1, about 6:1, about 8:1, about 10:1 or about 12:1; and/or no more than about 10:1, about 12:1, about 14:1, about 16:1, about 18:1 or about 20:1. In some embodiments, a weight ratio of the vegetable oil to the ester of fatty alcohol is in a range of from about 1:1 to about 20:1.
[0072] In some embodiments, the lubricant composition comprises: [0073] vegetable oil in an

amount of from about 40% to about 90% by weight, preferably from about 40% to about 80% by weight; [0074] nonionic surfactant in an amount of from about 10% to about 40% by weight; [0075] ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms; [0076] water in an amount of from about 0% to about 15% by weight, preferably from about 0% to about 5% by weight of water, based on total weight of the composition; [0077] optionally a biocide; and [0078] optionally a chelating agent; [0079] In some embodiments, the dry lubricant composition is substantially free of silicon-based compound, mineral oil, fatty acid, fatty amine, or any combination thereof.

Vegetable Oil

[0080] The term ‘vegetable oil’ as used herein refers to an oil extracted from plant source, an oil extracted from plant source that has been processed (“processed vegetable oil”), or any combination thereof. Non-limiting examples of the processed vegetable oil include polymerized vegetable oil, heat treated vegetable oil, boiled vegetable oil, double boiled vegetable oil, blown vegetable oil, fully oxidized vegetable oil, partially oxidized vegetable oil, waste vegetable oil, recycled vegetable oil, or any mixture thereof.

[0081] One skilled in the art recognizes that vegetable oil, as well as processed vegetable oil, is a triglyceride of fatty acids, wherein the fatty acid is saturated fatty acid, unsaturated fatty acid, or a combination thereof.

[0082] The vegetable oil is extracted from plant sources such as seed, fruit, leave or any other parts of plant. Non-limiting examples of such vegetable oils include sunflower oil, rapeseed oil, soybean oil, grape seed oil, cocoa butter oil, almond oil, avocado oil, Brazil nut oil, cashew oil, cashew nut shell oil, neem oil, linseed oil, double boiled linseed oil, chia seed oil, coconut oil, corn oil, cottonseed oil, flaxseed oil, hemp seed oil, vigna mungo oil, mustard oil, olive oil, palm oil, lesquerella oil, canola oil, peanut oil, pecan oil, perilla oil, rice bran oil, safflower oil, sesame oil, walnut oil, meadowfoam oil, castor oil, or the like. In some embodiments, the oil extracted from plant source comprises sunflower oil, rapeseed oil, soybean oil, grape seed oil, cocoa butter oil, or any mixture thereof.

[0083] In some embodiments, the vegetable oil comprises a blend of the oil extracted from the plant source and at least one of the processed vegetable oil selected from polymerized vegetable oil, heat treated vegetable oil, boiled vegetable oil, double boiled vegetable oil, blown vegetable oil, fully oxidized vegetable oil, partially oxidized vegetable oil, waste vegetable oil, recycled vegetable oil, or any mixture thereof.

[0084] In some embodiments, the vegetable oil comprises the oil extracted from the plant source in an amount of at least about 50%, about 55%, about 60%, about 65%, about 70% or about 75% by weight based on total weight of the vegetable oil; and/or no more than about 80%, about 85%, about 90%, about 95% or 100% by weight based on total weight of the vegetable oil. In some embodiments, the vegetable oil comprises from about 60% to about 100% by weight of the oil extracted from the plant source, based on total weight of the vegetable oil.

Nonionic Surfactant

[0085] Nonionic surfactants suitable for the present disclosure include, but are not limited to: fatty alcohol surfactant such as cetyl alcohol, oleyl alcohol; fatty alcohol alkoxylate surfactant such as fatty alcohol ethoxylate, fatty alcohol propoxylate, fatty alcohol ethoxylate/propoxylate; fatty alcohol alkoxylate carboxylate such as fatty alcohol ethoxylate carboxylate, fatty alcohol propoxylate carboxylate, fatty alcohol ethoxylate/propoxylate carboxylate; sorbitan ester surfactant; sorbitan ethoxylated ester surfactant; or any combination thereof. Non-limiting examples of fatty alcohol ethoxylate surfactant include castor oil ethoxylate surfactant, ethoxylated esters of oleic acid, or the like.

[0086] In some embodiments, the nonionic surfactant comprises fatty alcohol alkoxylate having the following chemical structure

R—O—(CH(Y)—CH.sub.2—O).sub.n—(CH.sub.2).sub.m—COOH, [0087] wherein: [0088] R is an alkyl group containing 6 to 24 carbon atoms, [0089] Y is H or CH.sub.3, [0090] n is a number ranging from about 3 to about 50, and [0091] m is a number ranging from about 0 to about 3.

[0092] In some embodiments, the nonionic surfactant comprises fatty alcohol ethoxylate that includes C6-24 alkyl group and from about 3 to about 50 ethylene oxide repeating units.

[0093] In some embodiments, the nonionic surfactant comprises fatty alcohol ethoxylate that includes from C12-24 alkyl group (i.e., R is an alkyl group containing 12 to 24 carbon atoms) and from about 3 to about 14 ethylene oxide repeating units (i.e., n is from 3 to about 14). In some embodiments, the nonionic surfactant comprises fatty alcohol ethoxylate that includes from C12-14 alkyl group and 9 ethylene oxide repeating units.

[0094] Non-limiting examples of the fatty alcohol ethoxylate surfactants include lauryl alcohol ethoxylate surfactant, C9-C11 alcohol ethoxylate surfactant, C12-C13 alcohols ethoxylate surfactant, C12-14 alcohol ethoxylate surfactant, C12-15 alcohol ethoxylate surfactant, C14-C15 alcohol ethoxylate surfactant, or the like.

[0095] Sorbitan ester surfactant may include, but are not limited to, sorbitan monoester, sorbitan diester, sorbitan triester, or any combination thereof. Non-limiting examples of the sorbitan ester surfactants include sorbitan monooleate, sorbitan monolaurate, sorbitan monostearate, sorbitan monopalmitate, sorbitan tristearate, sorbitan trioleate, sorbitan sesquioleate, or a combination thereof.

[0096] Sorbitan ethoxylated ester surfactant may include, but are not limited to, sorbitan ethoxylated monoester, sorbitan ethoxylated diester, sorbitan ethoxylated triester, or any combination thereof. In some embodiments, sorbitan ethoxylated ester surfactant includes ethoxylated sorbitan mono-, di-, and/or tri-esters with linear or branched long chain fatty acids. Non-limiting examples of the sorbitan ethoxylated ester surfactants include polyoxyethylene sorbitan trioleate, ethoxylated sorbitan monolaurate, polyoxyethylene (20) sorbitan monolaurate, polyoxyethylene (20) sorbitan monopalmitate, polyoxyethylene (20) sorbitan monostearate, polyoxyethylene (20) sorbitan monooleate, or any mixture thereof.

Ester of Fatty Alcohol

[0097] The ester of fatty alcohol for the present disclosure is the ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms.

[0098] In some embodiments, the ester of fatty alcohol is a blend of at least two esters of the fatty alcohols.

[0099] In some embodiments, the ester of fatty alcohol comprises monoester of fatty alcohol.

[0100] In some embodiments, the ester of fatty alcohol has the following chemical structure: ##STR00001## [0101] wherein: [0102] R.sub.1 includes from about 3 to about 15 carbon atoms, preferable from about 5 to about 9 carbon atoms, most preferably from about 7 to about 9 carbon atoms; and [0103] R.sub.2 includes from about 4 to about 28 carbon atoms, preferable from about 8 to about 20 carbon atoms, most preferably from about 12 to about 18 carbon atoms.

[0104] In certain embodiments, R.sub.1 is an alkyl chain comprising from about 7 to about 9 carbon atoms, and R.sub.2 is an alkyl chain comprising from about 12 to about 18 carbon atoms.

[0105] Examples of the suitable esters of fatty alcohols include, but are not limited to, salicylate ester of fatty alcohol, caproate ester of fatty alcohol, caprylate ester of fatty alcohol, caprate ester of fatty alcohol, or any mixture thereof.

[0106] In some embodiments, the ester of fatty alcohol comprises tridecyl salicylate, dodecyl salicylate, decyl salicylate, octyl salicylate, 2-ethylhexyl salicylate, lauryl caproate, myristyl caproate, oleyl caproate, linoleyl caproate, linolenyl caproate, palmityl caproate, palmitoleyl caproate, stearyl caproate, lauryl caprylate, myristyl caprylate, oleyl caprylate, linoleyl caprylate, linolenyl caprylate, palmityl caprylate, palmitoleyl caprylate, stearyl caprylate, lauryl caprate, myristyl caprate, oleyl caprate, linoleyl caprate, linolenyl caprate, palmityl caprate, palmitoleyl caprate, stearyl caprate, or any mixture thereof.

Biocide

[0107] When desired, the disclosed dry lubricant composition may comprise biocide as an optional ingredient. As used herein, the term “biocide” also encompass any antimicrobial agent. Suitable biocides include, but are not limited to, quaternary ammonium salt, chlorobenzene, isothiazolinone, alcohol, amine, organic acid, aldehyde, phenol-based biocide, benzotriazole, 2,2-dibromo-2-cyanoacetamide, 3,5-dimethyl-1,3,5-thiadiazinane-2-thione, or any combination thereof.

[0108] Examples of quaternary ammonium salts include, but are not limited to, alkyl benzalkonium chloride, alkyl dimethylbenzylammonium chloride, dialkyl dimethyl ammonium chloride, alkyl dimethyl ethylbenzylammonium chloride, or any combination thereof.

[0109] Examples of chlorobenzene biocides include, but are not limited to, chlorhexidine, triclosan, chloroxylenol, dichlorohydroxydiphenylether, or any combination thereof.

[0110] Examples of isothiazolinone biocides include, but are not limited to, 2-methyl-4-isothiazolin-3-one; 5-chloro-2-methyl-4-isothiazolin-3-one; 1,2-benzisothiazolin-3-one, or any combination thereof.

[0111] Examples of alcohol biocides include, but are not limited to, phenoxyethanol; benzyl alcohol, 1,2-hexanediol, bronopol, ethylhexylglycerin, butylated hydroxytoluene, paraben, butylated hydroxy anisole, or any combination thereof.

[0112] Examples of amine biocides include, but are not limited to, (N-(3-aminopropyl)-N-dodecylprododecylpropane-1,3-diamine; sodium hydroxymethylglycinate; imidazolidinyl urea; or any combination thereof.

[0113] Examples of organic acid biocides include, but are not limited to, salicylic acid, benzoic acid, propionic acid, lactic acid, capric acid, caprylic acid, undecylinic acid, glycolic acid, pellargonic acid, formic acid, sorbic acid, malic acid, ascorbic acid, furoic acid, polygluamic acid, boric acid, or any combination thereof.

[0114] Examples of aldehyde biocides include, but are not limited to, succinaldehyde, glutaraldehyde, or any combination thereof.

[0115] Examples of phenol-based biocides include, but are not limited to, butylated hydroxytoluene, butylated hydroxy anisole, paraben, derivatives of paraben, or any combination thereof.

Chelating Agent

[0116] When desired, the disclosed dry lubricant composition may comprise chelating agent as an optional ingredient. Examples of suitable chelating agents include, but are not limited to, glutamic acid diacetic acid, methylglycinediacetic acid (MGDA), ethylenediaminetetraacetic acid (EDTA), phosphonobutane tricarboxylic acid (PBTC), ethylene glycol-bis(O-aminoethyl ether)-N,N,N′,N′-tetraacetic acid, nitrilotriacetic acid, diethylenetriamine pentaacetic acid, iminodisuccinic acid, hydroxyethyl ethylenediaminetetraacetic acid, ethylenediamine-N,N′-disuccinic acid, 1,3-propylenediaminetetraacetic acid, ethanoldiglycinic acid, hydroxyethane diphosphonic acid (HEDP), amino trimethylene phosphonic acid (ATMP), diethylene triamine penta methylene phosphonic acid, acetic acid, citric acid, oxalic acid, phosphoric acid, polymer of phosphoric acid, gluconic acid, aspartic acid, glucoheptonic acid, tartaric acid, succinic acid, triethanol amine, hexametaphosphate (HEMP), ion exchanger, polyacrylates, polysaccharides, bentonite, clay, sorbitol, alkylpolyglucoside, or any salt thereof.

[0117] In some embodiments, the chelating agent includes, but are not limited to, methylglycine diacetic acid (MGDA) or salt thereof, ethylene diamine tetraacetic acid (EDTA) or salts thereof, iminodisuccinic acid sodium salt, trans-1,2-diaminocydohexane tetracetic acid monohydrate, diethylene triamine pentacetic acid, sodium salt of nitrilotriacetic acid (NTA), pentasodium salt of N-hydroxyethylene diamine triacetic acid, trisodium salt of N,N-di(β-hydroxyethyl)glycine, sodium salt of sodium glucoheptonate, or any combination thereof.

[0118] In some embodiments, the chelating agent in the disclosed dry lubricant composition also functions as a biocide.

Other Optional Ingredients

[0119] When desired, the disclosed dry lubricant composition may comprise additional ingredients to further enhance processing and/or performance performances. Such additional ingredients may include, but not limited to, anionic surfactant, cationic surfactant, organic solvent, corrosion inhibitor, preservative, anti-rust agent, anti-foaming agent, defoamer, anti-wear agent, viscosity modifier, stress-cracking inhibiting agent, anti-freezing agent, stabilizing agent, antioxidant, pH adjusting agent, hydrotrope, or any combination thereof. The optional ingredients are chosen in a way that they are compatible with the other chemical components in the composition, for example, in respect of their miscibilities and stabilities. The amounts and types of such additional ingredients will be apparent to those skilled in the art.

[0120] Suitable anionic surfactants may include phosphate ester surfactant such as monoester phosphate, diester phosphate, or a mixture thereof; carboxylate surfactant; sulfate surfactant; sulfonate surfactant; succinate surfactant such as monoalkyl succinate; sulfosuccinate surfactant such as alkyl sulfosuccinate; maleate surfactant such as monoalkyl maleate; taurate surfactant such as alkyl taurate, acyl taurate; sulfoacetate surfactant; isethionate surfactant such as acyl isethionate; or any combination thereof.

[0121] The phosphate ester surfactant includes monoester, diester, or any combination thereof. The phosphate ester may comprise an alkyl and group containing from about 10 to 20 carbon atoms, preferably from about 12 to about 18 carbon atoms. Furthermore, the phosphate ester may comprise ethylene oxide (EO) and/or propylene oxide (PO) repeating units.

[0122] In some embodiments, the phosphate ester comprises at least one alkyl group having from about 10 to 20 carbon atoms (preferably from about 12 to 18 carbon atoms), as well as from about 2 to about 10 (preferably from about 3 to about 6) ethylene oxide (EO) and/or propylene oxide (PO) repeating units. In some embodiments, the phosphate ester comprises an alkyl group having from about 12 to 18 carbon atoms, and from about 3 to about 6 ethylene oxide (EO) repeating units.

[0123] Non-limiting examples of phosphate esters include oleyl-3EO-phosphate ester, C16-18 alkyl-O-5EO-phosphate ester (monoester and/or diester), C12-14 alkyl-O-4EO-phosphate ester (monoester and/or diester), C13-15 alkyl-O-7EO-phosphate ester (monoester and/or diester, oleyl-O-4EO-phosphate ester (mixture of monoester and diester), C17 alkyl-O-6EO-phosphate ester (monoester and/or diester), or any combination thereof. As used herein, for example, “3EO” means 3 ethylene oxide repeating units.

[0124] In addition, the phosphate ester may be in any forms of salts including, but not limiting to, amine salt, alkaline metal salt, alkaline metal earth salt, or any combination thereof. In some embodiments, the ammonium salt of phosphate ester includes C8-20 alkyl ammonium salts (preferably C10-18 alkyl ammonium salts) of monoester, diester, or a mixture thereof. Non-limiting examples of such ammonium salts of phosphate esters include C11-14 alkyl ammonium salts of monohexyl phosphate, C11-14 alkyl ammonium salts of dihexyl phosphate, or a mixture thereof.

[0125] Non-limiting examples of suitable carboxylate surfactants include alkyl carboxylate such as salts of C8-18 carboxylic acid; alkyl ether carboxylate (aka alkoxylated carboxylate) such as C16-18 alkyl ether carboxylate; or a combination thereof. In some embodiments, the carboxylate surfactant comprises an alkyl group having from about 4 to 18 carbon atoms, along with from about 3 to about 10 ethylene oxide (EO) and/or propylene oxide (PO) groups. Non-limiting example of such carboxylate surfactants include C12 alkyl-4EO-carboxylate, C16-18 alkyl-2EO-carboxylate, C16-18 alkyl-5EO-carboxylate, C16-18 alkyl-5EO-carboxylate, C4-8 alkyl-8EO-carboxylate, or any mixture thereof.

[0126] Non-limiting examples of sulfate surfactants include alkyl sulfate such as C12-18 alkyl sulfate; alkyl aryl sulfate; alkyl ether sulfate such as C12-14 alkyl ether sulfate; alkyl aryl ether sulfate; or any combination thereof.

[0127] Non-limiting examples of sulfonate surfactants include alkyl aryl sulfonate such as dodecylbenzene sulfonate; alpha-olefin sulfonate; alkyl glyceryl sulfonate; or any combination thereof.

[0128] Suitable organic solvents for the present disclosure are the water-miscible solvents such as, but not limited to, C1-C6 alcohol, glycol ether, or the like. Preferably C1-C6 alcohols are methanol, ethanol, isopropanol, or a mixture thereof. Example of preferably glycol ether is dipropylene glycolmethyl ether.

Methods of Dry Lubrication

[0129] The disclosed method of lubricating surface of the third aspect comprises applying the lubricant composition of the first or second aspect discontinuously to the conveyor belt without diluting the lubricant composition prior to the application. In the third aspect, the method of lubricating surface comprises: [0130] applying the disclosed lubricant composition of the first or second aspect discontinuously to the surface without diluting the dry lubricant composition prior to the application; [0131] applying water intermittently to the surface, wherein the water facilitates removal of blackness from the surface; [0132] monitoring a coefficient of friction on the surface and re-applying the lubricant composition discontinuously to the surface when the monitored coefficient of friction on the surface increases to about 0.17; and [0133] continuing to apply water intermittently to the surface to facilitate the removal of blackness from the surface.

[0134] Upon applying the disclosed dry lubricant composition discontinuously to the surface, the lubricant composition provides an excellent lubricity between the surfaces as indicated by the coefficient of friction (COF) in a range of from about 0.07 to about 0.17, and remains dry on the surfaces until water is intermittently applied the surface. The disclosed lubricant composition reduces the friction between the surfaces and ensures the good gliding contact to permit a proper high speed conveyor operation.

[0135] In some embodiments, the initial coefficient of friction in a range of from about 0.07 to about 0.15, and the lubricant composition is re-applied discontinuously to the surface when the monitored coefficient of friction on the surface increases to about 0.15.

[0136] As the conveyor operation proceeds, blackness starts to develop and accumulate on the surface, causing the cleanliness and aesthetic concerns for the processing/packaging operation. Furthermore, the blackness can transfer to the surface of containers that have been transported on the conveyor belt, thus jeopardizing the aesthetic appearance of the containers and devaluing the product contained therein. For the conventional method of dry lubrication, the conveyor operation must be stopped for a proper cleaning to ensure the sufficient removal of blackness from the surfaces before any further conveyor operation could proceed.

[0137] In the method of the third aspect, at a certain time period after the application of dry lubricant and the operation of conveyor system, water is applied intermittently to the surface for the removal of blackness from the surface. Water may be intermittently applied to the surface (e.g., conveyor belt) using any known applicators including, but not limited to, a non-energized spray nozzle; an energized spray nozzle such as, but not limited to, a high pressure spray nozzle, a compressed air, a sonication applicator to deliver the lubricant on the top, between, and/or below the conveyor belt; a metered diaphragm pump; a peristaltic pump; a valveless rotating reciprocating piston metering pump; a brush applicator; or any combination thereof. In some embodiments, water is applied when the blackness is visually observed on the surface. In some embodiments, water is applied at a minimum of one hour after the application of lubricant composition. In some embodiments, water is applied at every one hour after the application of lubricant composition.

[0138] Without limiting to any theory, it is believed that upon applying water intermittently to the surface (e.g., the surface of conveyor belt), the disclosed lubricant composition on the surface forms a lubricant emulsion on the surface. The lubricant emulsion emulsifies the blackness on the surface, and the resulting emulsified blackness can be rinsed away from the surface with the intermittently applied water. Hence, at least a portion of the lubricant composition on the surface functions as an emulsifier for blackness and is removed from the surface along with blackness. As a result, the amount of lubricant composition on the surface of conveyor belt continues to decrease as the conveyor operation proceeds. At a certain time period of the conveyor operation, the amount of lubricant composition on the surface decreases to a level that is too low to provide sufficient lubricity between the surfaces (e.g., the surfaces of conveyor belt and the surfaces of containers thereon). This is indicated by an increase in the COF value between the surfaces, as the conveyor operation proceeds and the water is intermittently applied to the surface. Accordingly, the lubricant composition must be re-applied to the surface (e.g., surface of conveyor belt), so that sufficient lubricity between the surfaces is achieved to ensure the good gliding contact.

[0139] In the disclosed method, the COF value between the surfaces is monitored during the conveyor operation. Generally, the COF value should be in a range of from about 0.07 to about 0.17 for the method of dry lubrication to ensure the proper conveyor operation. If the COF value is lower than 0.07, the containers may fall off the conveyor belt due to insufficient friction between the container-contacting surface of the conveyor belt and the conveyor-contacting surface of the container. If the COF value is higher than 0.17, the friction between the container-contacting surface of the conveyor belt and the conveyor-contacting surface of the containers may be too high to provide a good gliding contact between surfaces. The disclosed method of dry lubrication provides excellent lubricity. For example, the disclosed method of dry lubricant provides the COF value in the range of from about 0.07 to about 0.17, even at six hours after the application of the disclosed lubricant composition to the conveyor belt. See TABLE 2, TABLE 6.

[0140] As the conveyor operation proceeds and the blackness is removed with the intermittent application of water, the COF value increases. Once the COF value increases to more than about 0.17, the lubricant composition is re-applied to the surface discontinuously, so that the COF value is reduced to a level of no more than 0.17 and a proper lubricity between the surfaces is maintained.

[0141] Compared to the conventional method of dry lubrication, the disclosed method of dry lubrication exhibits a high efficacy in removing blackness without the need to cease the conveyor operation to ensure the sufficient removal of blackness from the surfaces with aggressive cleaning chemicals (e.g., a strong alkaline detergent composition containing surfactant), high pressure, and/or mechanical abrasion.

[0142] Furthermore, the level of blackness problem encountered in the disclosed method of dry lubrication may be as low as the level encountered in the conventional wet lubrication process, which is typically minimal or negligible. See FIG. **1**, TABLE 3, TABLE 4, TABLE 7.

[0143] Thus, the disclosed method of dry lubrication provides excellent lubricity and minimal blackness problem as the conventional methods of wet lubrication, and yet still consume low levels of water, energy and operation cost as the conventional methods of dry lubrication.

[0144] The disclosed method of lubricating surface of the fourth aspect comprises applying the lubricant composition of the first or second aspect discontinuously to the conveyor belt without diluting the lubricant composition prior to the application. The method further comprises re-applying said lubricant composition discontinuously to the surface when the coefficient of friction on the surface increases to a selected value. In some embodiments, the lubricant composition is re-applied discontinuously to the surface when the coefficient of friction on the surface increases to about 0.17. In some embodiments, the lubricant composition is re-applied discontinuously to the surface when the coefficient of friction on the surface increases to about 0.15.

[0145] Upon applying the disclosed dry lubricant composition discontinuously to the surface, the lubricant composition provides an excellent lubricity between the surfaces and ensures the good gliding contact to permit a proper high speed conveyor operation. See TABLE 9. As the conveyor operation proceeds, the COF values increases. Once the COF value increases to a selected value (e.g., about 0.17, or about 0.15), the lubricant composition is re-applied to the surface discontinuously, so that the COF value is reduced to a level below the selected value (e.g., more than 0.17, or more than about 0.15) and a proper lubricity between the surfaces is maintained.

[0146] In some embodiments of the fourth aspect, the method does not include intermittently application of water to the surface. Compared to the method of the third aspect, this particular embodiments for the method of the fourth aspect does not require the intermittently application of water to the surface, in order to facilitate the removal of blackness. See TABLE 9. Without limiting to any theory, it is believed that water on the surface (a container surface that is in contact with the conveyor belt, a surface of the conveyor belt that is in contact with the container, or both) is sufficient to facilitate the removal of blackness without the need for intermittently application of water to the surface. Following are non-limiting examples of the water on the surface: [0147] during the container filling operation, the containers may be filled with the selected content (e.g., carbonated beverage) at a temperature of from about 2° C. to about 17° C., thus resulting in a formation of condensate water on the outer surface of the filled containers. Hence, the containers have the condensate water on the outer surface after the containers leave the filling station; [0148] during the container filling operation, the containers may be inadvertently over-filled or even broken. An application of spray water is used to clean the content over-fills or spills, thus resulting in water on the conveyor surface as well as the outer surface of the nearby containers; [0149] during the transportation of the containers on the conveyor, some of the containers may be inadvertently broken. An application of spray water is used to clean the content spills, resulting in water on the conveyor surface as well as the outer surface of the nearby containers; [0150] water on the surface is the water that is carried over on the surface from other prior processing step (e.g., the container pre-wash step, the container wash step, and/or the container rinse step of the processing operation); etc.

[0151] With the presence of water on the surface, the disclosed lubricant composition forms a lubricant emulsion on the surface. The lubricant emulsion then emulsifies and effectively removes the blackness from the surface. The disclosed method substantially reduces the amount of required water: the disclosed lubricant is applied without the need for the dilution with water before an application to the surface, and the blackness is effectively removed from the surface without the intermittently application of water to the surface.

[0152] In some embodiments that the method does not include intermittently application of water to the surface, the reduction in water consumption could be 85% or more compared to the conventional method of lubricant using wet lubricant.

[0153] Furthermore, a desirable antimicrobial performance can be achieved when the disclosed dry lubricant include a biocide. See TABLE 7.

[0154] For the disclosed methods of lubricating surface (the third aspect and/or the fourth aspect), the surface comprises a container-contacting surface of conveyor belt, a container surface in contact with the conveyor belt, or both.

[0155] The disclosed methods of lubricating surface (the third aspect and/or the fourth aspect) may be employed for any conventional conveyor belt systems known to a person skilled in the art, such as the chain system, the track system or the like. The conveyor belt may be partially or completely made of any material known in the art including, but not limited to, stainless steel, rubber, plastic, polyacetal, polyamide or the like. These conveyor belts are widely used in the food and/or beverage industry, e.g., for the cleaning, filling, or refilling of containers such as bottles.

[0156] The containers may be partially or completely made of any known materials including, but not limited to, glass, metal, aluminum, plastic, paper, paperboard, or the like. Suitable plastic containers may be composed of polyethylene terephthalate, polycarbonate, or polyvinylchloride, silica-coated polyethylene terephthalate, etc. Furthermore, the containers may be in a variety of sizes and shapes (e.g., bottles, jars, jugs, tubes, cartons, keg, small drums, barrel keg, rigid liquid packaging, brick liquid cartons, shaped liquid carton, gable top carton, pouch, etc). In some embodiments, the container may be the “Affordable Small Sparkling Package” (ASSP).

[0157] In some embodiments, the container-contacting surface of conveyor belt comprises stainless steel. In some embodiments, the container surface in contact with the conveyor belt comprises glass. In some embodiments, the container-contacting surface of conveyor belt comprises stainless steel, and the container surface in contact with the conveyor belt comprises glass.

[0158] The disclosed methods of dry lubrication may be employed during the transportation of containers on conveyor belt, whereby the conveyor belt is integrated into different operation units. Non-limiting examples of such operation units include those for bottle washing, sorting, filling, capping, labelling, or packaging steps.

[0159] The disclosed lubricant composition may be applied to the surface (e.g., conveyor belt) using any known applicators including, but not limited to, spraying, wiping, brushing, drip coating, roll coating, and other methods for application of a thin film. In some embodiments, applying the lubricant composition discontinuously to the surface is performed using a non-energized spray nozzle; an energized spray nozzle (e.g., a high pressure spray nozzle, a compressed air, a sonication applicator to deliver the lubricant on the top, between, and/or below the conveyor belt); a controlled dosing applicator that allows the application of lubricant composition to the surface at an accurate and low dosage level according to the pre-set rate of application; a metered diaphragm pump; a peristaltic pump; a valveless rotating reciprocating piston metering pump; a brush applicator; or any combination thereof. For the application using a controlled dosing applicator that allows the application of lubricant composition to the surface at an accurate and low dosage level according to the pre-set rate of application, in some embodiments the low dosage level is in a range of from about 0.1 ml/min to about 10 ml/minute.

[0160] The lubricant may reside or be deliberately applied so as to reside between the conveyor belt chain and conveyor belt chain support such as a wear strip. As a non-limiting example, a nozzle may be placed underneath the conveyor belt table top with a spray directed at the underside of the conveyor belt chain link, or a nozzle may be placed with a spray directed towards the wear strip at a location where it is accessible through or underneath the conveyor belt chain.

[0161] In the disclosed methods of lubricating surface (the third aspect and/or the fourth aspect), the lubricity of the surfaces is monitored to determine whether and when the re-application of lubricant is required in order to maintain a proper lubricity between the surfaces. In some embodiments, a sensor based on the COF value between the surfaces is used to monitor the COF values and initiated to the re-application of lubricant when the COF value reaches a selected value. In some embodiments, a vibration sensor is used to monitor the vibration between the surfaces and initiated to the re-application of lubricant when the vibration reaches a selected value.

EXAMPLES

Example 1

[0162] A pilot, looped conveyor system with a stainless steel conveyor belt commercially available from Selvel Conveyors Private Ltd. (India) was used in the study. The conveyor system was installed with a brush applicator at a fixed position, and was cleaned prior to the study. Sunflower oil was used as the vegetable oil. A blend of salicylate ester and caprylate esters was used as the ester of fatty alcohol. Fatty alcohol ethoxylate such as the Brij™ surfactant commercially available from Croda Industrial Chemicals was used as the nonionic surfactant.

[0163] A white tissue paper was contacted with the top surface of conveyor belt (‘conveyor belt’) to take an imprint of blackness on the conveyor belt. The resulting imprinted white tissue paper (“imprinted paper”) was then measured for the reflectance value using Pantone CAPSURE spectrophotometer model number RM-200, which was commercially available from X-rite Corporation (USA). The reflectance value of the imprinted paper was recorded as the “R.sub.0” value, which was the reflectance value of the white tissue paper that was imprinted with the blackness on the conveyor belt when the tested lubricant was not yet applied to the conveyor belt.

[0164] About 36 grams of the tested lubricant composition was applied to the brush applicator. The conveyor system was turned on to operate at an ambient temperature. As the conveyor belt moved, the brush applicator distributed and spread the tested lubricant composition onto the conveyor belt. After at least three cycles of the chain movement on the looped conveyor system, eight glass bottles with a total weight of about 8 kilograms were placed on the conveyor belt.

[0165] TABLE 1 showed the tested lubricant compositions used in the study.

TABLE-US-00001 TABLE 1 Tested Lubricant Composition #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 Vegetable Oil 100% 95% 90% 70% 51% 60% 51% 76% 68% 41% Nonionic Surfactant — 5% 10% 30% 39% 20% 10% 17% 10% 21% Ester of — — — — 10% 20% 39% 4% 20% 38% Fatty Alcohol Water — — — — — — — — 3% 2% — Total 100% 100% 100% 100% 100% 100% 100% 100% 100% 100% Weight Ratio — 19:1 9:1 2.4:1 1.3:1 3.1:1 5.2:1 4.3:1 6.8:1 2.0:1 of Vegetable Oil:Nonionic Surfactant Weight Ratio — — — — 5.2:1 3.1:1 1.3:1 20:1 3.4:1 1.1:1 of Vegetable Oil:Ester of Fatty Alcohol

[0166] Sample #1 was vegetable oil. Samples #2 to #4 each was a mixture of vegetable oil and nonionic surfactant, but at different weight ratios of vegetable oil:nonionic surfactant. The weight ratios of vegetable oil:nonionic surfactant were 19:1, 9:1 and 7:3 for Samples #2, #3 and #4, respectively. Samples #5 to #10 each contained vegetable oil, nonionic surfactant, ester of fatty alcohol, and optional water. However, Samples #5 to #10 had different weight ratios of vegetable oil to nonionic surfactant and weight ratios of vegetable oil to ester of fatty alcohol as shown in TABLE 1.

[0167] As the conveyor operation proceeded, water was applied intermittently to the conveyor belt through a spray nozzle of the Spray Gun SG550 device commercially available from Power Action, Inc. (China). The intermittent application of water took place at every one hour after the application of tested lubricant composition.

[0168] Furthermore, the friction between the conveyer belt and glass bottles was measured and monitored on-line as the conveyor operation proceeded. The MecMesin Advanced Force Gauge (AFG) 500 device, which was a digital push pull commercially available from Mecmesin Ltd. (UK), was used for measuring and monitoring the coefficient of friction (COF) value.

[0169] TABLE 2 reported the COF values of each tested lubricant compositions at different time periods after the application of such lubricant composition to the conveyor belt.

[0170] As shown in TABLE 2, all of the tested lubricant compositions provided the COF values in the desirable range of from about 0.07 to about 0.17, even at six hours after the application of tested lubricant composition to the conveyor belt. Thus, all the tested lubricant compositions provided excellent lubricity between the surface of conveyor belt and the surface of glass bottles.

TABLE-US-00002 TABLE 2 Efficient of Friction (COF) Value Time After Application of the Tested Tested Lubricant Composition Lubricant #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 0 hour 0.10 0.07 0.08 0.08 0.08 0.09 0.09 0.08 0.08 0.08 1 hour 0.10 0.08 0.09 0.08 0.09 0.10 0.09 0.09 0.08 0.09 2 hours 0.10 0.09 0.10 0.09 0.09 0.09 0.10 0.10 0.08 0.09 3 hours 0.10 0.09 0.11 0.09 0.10 0.10 0.12 0.10 0.10 0.09 4 hours 0.10 0.10 0.11 0.10 0.11 0.10 0.12 0.11 0.10 0.11 5 hours 0.10 0.10 0.12 0.10 0.11 0.11 0.12 0.12 0.11 0.11 6 hours 0.10 0.11 0.13 0.11 0.11 0.11 0.13 0.12 0.11 0.10

[0171] As the operation of the conveyor system proceeded, blackness (i.e., the residue comprising chromium, iron, silica, soil, dirt or any mixture thereof) increasingly accumulated on the conveyor belt.

[0172] In the study, the tested lubricant composition was applied to the conveyor belt and the conveyor system was operated for one hour. At such one (1) hour time period, water was sprayed to the conveyor belt, and then the operation of conveyor system was stopped. A white tissue paper was contacted with the conveyor belt to take an imprint of blackness on the conveyor belt. The reflectance value of the imprinted paper was measured and recorded as the “R.sub.1” value. The conveyor system was started again and operated for one more hour, followed by an application of water spray to the conveyor belt. Then, the operation of conveyor system was stopped to take an imprint. The reflectance value of the imprinted paper was measured and recorded as the “R.sub.2” value. The conveyor system was started again and operated for one more hour, followed by an application of water spray to the conveyor belt. Then, the operation of conveyor system was stopped to take an imprint. The reflectance value of the imprinted paper was measured and recorded as the “R.sub.3” value. These steps continued every one hour until the reflectance values of the imprinted paper were obtained and recorded as the "R.sub.4", "R.sub.5" "R.sub.6" values, respectively.

[0173] TABLE 3 showed the reflectance values of the imprinted paper at different time periods. For comparison purpose, a convention wet lubricant was included in the study, wherein the wet lubricant was an aqueous lubricant solution comprising about 10% by weight of C8-18 fatty acids and about 82% by weight of water based on total weight of the lubricant solution.

TABLE-US-00003 TABLE 3 Reflectance Value of Imprinted Paper Time After Application of the Tested Tested Lubricant Composition Wet Lubricant #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 Lubricant 0 hour 43.07 50.77 50.70 49.50 50.37 50.87 50.50 50.57 49.80 49.27 49.17 (R.sub.0 Value) 1 hour 38.85 42.63 43.93 45.83 49.03 48.63 47.87 48.33 45.90 46.57 48.07 (R.sub.1 Value) 2 hours 37.22 43.50 45.80 47.77 49.83 48.03 49.03 48.7 48.23 48.27 48.73 (R.sub.2 Value) 3 hours 38.03 43.77 46.20 48.60 49.43 49.63 49.23 48.93 49.60 48.63 49.13 (R.sub.3 Value) 4 hours 38.05 45.03 46.77 47.20 48.70 48.97 48.97 50.03 49.80 48.93 48.57 (R.sub.4 Value) 5 hours 35.80 43.27 47.40 46.70 48.83 49.00 49.43 49.77 50.13 48.63 48.77 (R.sub.5 Value) 6 hours 36.32 44.47 47.90 46.93 48.80 49.97 49.57 49.90 50.80 49.10 50.03 (R.sub.6 Value)

[0174] The efficacy of the tested lubricant composition in removing blackness from the conveyor belt (i.e., the level of blackness on the conveyor belt) was evaluated based on the change in the reflectance values of the imprinted papers that was calculated using the following equation:

[00001]$\mathrm{ComparativeLevelofBlackness} = \%\mathrm{ReflectanceChange} = \frac{(R_0 - R_t)}{R_0} \times 100,$ [0175] wherein

[0176] R.sub.0 was the reflectance value of the white paper that was imprinted with the blackness on the conveyor belt when the tested lubricant composition was not yet applied to the conveyor belt (i.e., t=0 hour); and [0177] R.sub.t was the reflectance value of the white paper that was imprinted with the blackness on the conveyor belt after: the tested lubricant composition was applied to the conveyor belt, then the conveyor system was operated for a specific time period ("t"), and finally a spray of water was applied to the conveyor belt.

[0178] The lower % Reflectance Change value indicated the lower level of blackness on the surface of conveyor belt, and therefore the higher efficacy of the tested lubricant composition in removing blackness from the conveyor belt.

[0179] TABLE 4 showed the comparative levels of blackness (i.e., % Reflectance Change value of each tested lubricant composition) at different time periods after the application of tested lubricant composition to the conveyor belt. FIG. **1** showed the comparative levels of blackness for the tested lubricant compositions at different time periods after its application to the conveyor belt.

TABLE-US-00004 TABLE 4 Comparative Level of Blackness Time After Application of the Tested Tested Lubricant Composition Wet Lubricant #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 Lubricant 1 hour 9.80 16.03 13.35 7.41 2.65 4.40 5.21 4.43 7.83 5.48 1.76 2 hours 13.58 14.32 9.66 3.50 1.07 5.58 2.90 3.70 3.15 2.03 3.96 3 hours 11.70 13.79 8.88 1.82 1.86 2.43 2.51 3.24 0.40 1.30 2.64 4 hours 11.66 11.31 7.75 4.65 3.32 3.74 3.04 1.07 0.00 0.69 1.84 5 hours 16.88 14.77 6.51 5.66 3.05 3.68 2.11 1.58 −0.66 1.30 2.96 6 hours 15.67 12.41 5.52 5.19 3.12 1.78 1.85 1.32 −2.01 0.35 2.56

[0180] As shown in FIG. **1** and TABLE 4, the conventional wet lubricant provided a relatively low level of blackness (the % Reflectance Change value of only 2.56) even after six hours of the lubricant application. On the other hand, the Tested lubricant composition #1, which contained solely the vegetable oil, provided substantially high level of blackness (the % Reflectance Change value of 9.80 after one hour of the lubricant application). Furthermore, for Tested lubricant composition #1, the level of blackness continued to increase as the conveyor system was operated for a longer time period (e.g., the % Reflectance Change value increased to about 16 after six hours of the lubricant application). Thus, when Tested lubricant composition #1 was used as the lubricant, the blackness continued to develop and accumulated on the surface of conveyor belt as the operation of conveyor system proceeded.

[0181] Tested lubricant composition #2, which contained 95% by weight of vegetable oil and 5% by weight of nonionic surfactant, provided similarly high level of blackness as that of Tested lubricant composition #1. Tested lubricant composition #2 afforded the % Reflectance Change value of about 16 after one hour of the lubricant application and about 13 after six hours of the lubricant application.

[0182] Tested lubricant composition #3, which contained 90% by weight of vegetable oil and 10% by weight of nonionic surfactant, provided the % Reflectance Change value of about 13 after one hour of the lubricant application. However, the level of blackness significantly decreased as the operation of conveyor system proceeded. The % Reflectance Change value of only about 6 was observed after six hours, which was about a half of the % Reflectance Change value observed after one hour. This indicated that as the operation of conveyor system proceeded and the water was intermittently applied to the surface of conveyor belt, at least a portion of the blackness that was developed and accumulated on the conveyor belt, was removed. Thus, Tested lubricant composition #3 allowed for an improved removal of blackness from the conveyor belt.

[0183] Tested lubricant composition #4, which contained 70% by weight of vegetable oil and 30% by weight of nonionic surfactant, provided the % Reflectance Change value of about 7 after one hour of the lubricant application, and about 5 after six hours of the lubricant application. This indicated that Tested lubricant composition #4 allowed for an improved removal of blackness from the conveyor belt.

[0184] Tested lubricant compositions #5 to #10 contained vegetable oil, nonionic surfactant, the ester of fatty alcohol and optional water, but at different amounts of each chemical component, as well as different weight ratios of vegetable oil to nonionic surfactant and different weight ratios of vegetable oil to the ester of fatty alcohol.

[0185] As shown in FIG. **1** and TABLE 4, the Tested lubricant compositions #3 to #10 provided significantly low level of blackness compared to the Tested lubricant compositions #1 and #2. Furthermore, the level of blackness significantly decreased as the operation of conveyor system proceeded. This indicated that as the operation of conveyor system proceeded and the water was intermittently applied to the surface of conveyor belt, the removal of blackness from the conveyor belt continued to proceed. Thus, Tested lubricant compositions #3 to #10 provided a significant improvement in the blackness removal from the conveyor belt. More importantly, as the conveyor system was operated for a longer time period, the blackness level continued to decrease until the similar low level of blackness as the conventional wet lubricant was achieved. At the operation time of 6 hours after the lubricant application, the Tested lubricant compositions #6 to #10 led to even lower level of blackness compared to the conventional wet lubricant.

Example 2

[0186] TABLE 5 showed the lubricant compositions used in the study. Lubricant compositions #11 to #14 were tested for the lubricity performance and the efficacy for blackness removal using the same procedures as described in EXAMPLE 1.

TABLE-US-00005 TABLE 5 Tested Lubricant Composition #11 #12 #13 #14 Vegetable Oil 84.0% 68.2% 67.2% 78.2% Nonionic Surfactant 14.0% 19.5% 19.2% 15.0% Ester of Fatty Alcohol — 9.8% 9.6% — Biocide: N-(3-aminopropyl)-N- 2.0% — — — dodecylprododecylpropane-1,3-diamine N-alkyldimethylbenzylammonium chloride — 2.5% — — Salicylic acid — — 2.0% — Chelating Agent Acetic Acid — — 2.0% — Glutamic acid diacetic acid* — — — 2.9% Solvent — — — 3.9% Water — — — — Total 100% 100% 100% 100% Weight Ratio of 6.0:1 3.5:1 3.5:1 5.2:1 Vegetable Oil:Nonionic Surfactant Weight Ratio of — 6.9:1 7.0:1 — Vegetable Oil:Ester of Fatty Alcohol *Glutamic acid diacetic acid functioned as both biocide and chelating agent

[0187] TABLE 6 reported the COF values of each tested lubricant compositions at different time periods after the application of such lubricant composition to the conveyor belt.

TABLE-US-00006 TABLE 6 Efficient of Friction (COF) Value Time After Application of Tested Lubricant Composition the Tested Lubricant #11 #12 #13 #14 0 hour 0.082 0.089 0.071 0.090 1 hour 0.089 0.097 0.104 0.100 2 hours 0.09 0.098 0.114 0.098 3 hours 0.092 0.095 0.118 0.098 4 hours 0.098 0.099 0.120 0.102 5 hours 0.092 0.098 0.126 0.113 6 hours 0.100 0.103 0.128 0.109

[0188] As shown in TABLE 6, all of the tested lubricant compositions provided the COF values in the desirable range of from about 0.07 to about 0.17, even at six hours after the application of tested lubricant composition to the conveyor belt. Thus, all of the tested lubricant compositions provided excellent lubricity between the surface of conveyor belt and the surface of bottles.

[0189] TABLE 7 showed the reflectance values of the imprinted paper at different time periods. For comparison purpose, a convention wet lubricant was included in the study, wherein the wet lubricant was an aqueous lubricant solution comprising about 10% by weight of C8-18 fatty acids and about 82% by weight of water based on total weight of the lubricant solution.

TABLE-US-00007 TABLE 7 Reflectance Value of Imprinted Paper Time After Application of the Tested Lubricant Composition Wet Tested Lubricant #11 #12 #13 #14 Lubricant 0 hour 52.17 51.9 51.47 52.10 49.17 1 hour 47.30 47.53 48.47 47.70 48.07 2 hours 47.03 48.10 48.63 48.10 48.73 3 hours 47.50 46.87 47.80 48.20 49.13 4 hours 46.53 48.20 48.00 49.23 48.57 5 hours 47.53 47.77 48.77 49.73 48.77 6 hours 48.00 48.60 49.90 47.97 50.03

[0190] As shown in TABLE 7, each of the Tested lubricant compositions #13 to #19 provided no significant change in the Reflectance Value of Imprinted Paper. Thus, each of the Tested lubricant compositions #11 to #14 provided a significant improvement in the blackness removal from the conveyor belt.

[0191] TABLE 8 showed the antimicrobial efficacy of the tested lubricant compositions #11 to #14 against various microbials. The antimicrobial tests were performed using the Biocidal Products Regulation (BPR) standard EN13697 according to "*Performance Criteria—Overview of* (*EN*) *Standards, Test Conditions, and Pass Criteria*" (Appendix 4, BPR Efficacy Working Group Document, March 2017) available at European Chemical Agency (ECHA). The term "log reduction" is a mathematical term used to show the relative number of live microbials being reduced from a tested area. For example, "a log reduction of 5" or "a 5-log reduction" means lowering the number of microbials by 105; "a 4-log reduction" means lowering the number of microbials by 10.sup.4; "a 3-log reduction" means lowering the number of microbials by 10.sup.3; "a 2-log reduction" means lowering the number of microbials by 10.sup.2; and "a 1-log reduction" means lowering the number of microbials by 10.

TABLE-US-00008 TABLE 8 Antimicrobial Efficacy Tested Log Reduction Microbials #11 #12 #13 #14 *P. aerusginosa* >5 2.4 4.1 >5 *S. aureus* >6 ** <1 ** *E. hirae* 2.24 ** ** ** **Not tested

Example 3

[0192] The lubricity and the blackness removal efficacy of the disclosed dry lubricants were tested on the conveyor system having stainless steel conveyor belts. The container was a glass bottle containing 200 ml of carbonated beverage. The glass bottles were transported on the conveyor system at a high speed operation with a line speed of 600 bottles per minutes. A total of about 1.4 million glass bottles were tested on the conveyor system. A commercially available wet lubricant was also tested for the comparative purpose, wherein the wet lubricant was composed of fatty amine, cationic surfactant, and about 90% weight of water. The dry lubricant was applied to the surface of conveyor belt, without being dilution. Whereas, as required, the commercial wet lubricant was diluted with water to the concentration of 0.5% w/w before being applied to the surface of conveyor belt.

[0193] The lubricity between surfaces was determined based on the COF values. The efficacy of blackness removal was visually evaluated. The water consumption for the conveyor operation was determined based on the flow meter reading.

[0194] TABLE 9 showed the lubricity and the blackness removal efficacy of the dry lubricant in comparison to those of the commercial wet lubricant.

TABLE-US-00009 TABLE 9 Commerical Dry Lubricant Wet Lubricant Average COF value 0.13 0.12 Blackness deposit on the None None conveyor belt Blackness deposit on the Acceptable level Acceptable level base of bottle containers (Light marks) (Light marks) % Water Content in the 0%

99.5% (Commerical Lubricant upon application wet lubricant was to the surface diluted to 0.5% w/w)

[0195] As show in the table above, the examply dry lubricant of present disclosure provided similar levels of the lubricity performance and the blackness removal efficacy as the commercial wet lubricant. However, the examply dry lubricant of present disclosure allowed for the water saving of at least 85% compared to the commercial wet lubricant. In some working examples, the disclosed dry lubricant allowed for 100% water saving.

[0196] Various features and advantages of the invention are set forth in the following claims.

Claims

1. A lubricant composition, comprising: vegetable oil; nonionic surfactant; water in an amount of from about 0% to about 15% by weight based on total weight of the composition; optionally biocide; and optionally chelating agent; wherein a weight ratio of the vegetable oil to the nonionic surfactant is in a range of from about 1:1 to about 9:1.

2. The composition of claim 1, wherein the composition fulfills at least one of the following: (a) the vegetable oil is present in an amount of from about 40% to about 90% by weight, based on total weight of the composition, (b) the nonionic surfactant is present in an amount of from about 10% to about 40% by weight based on total weight of the composition.

3. The composition of claim 1, wherein the composition further comprises ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to about 28 carbon atoms.

4. The composition of claim 3, wherein a weight ratio of the vegetable oil to the ester of fatty alcohol is in a range of from about 1:1 to about 20:1.

5. The composition of claim 3, wherein the ester of fatty alcohol is present in an amount of from about 4% to about 40% by weight based on total weight of the composition.

6. A lubricant composition, comprising: vegetable oil in an amount of from about 40% to about 90% by weight; nonionic surfactant in an amount of from about 10% to about 40% by weight; water in an amount of from about 0% to about 15% by weight based on total weight of the composition; optionally biocide; and optionally chelating agent.

7. (canceled)

8. The composition of claim 6, wherein the composition further comprises ester of fatty alcohol, wherein the fatty alcohol includes from about 4 to 28 carbon atoms.

9. (canceled)

10. The composition of claim 8, wherein a weight ratio of the vegetable oil to the ester of fatty alcohol is in a range of from about 1:1 to about 20:1.

11. The composition of claim 3, wherein the ester of fatty alcohol fulfills at least one of the following: (a) the ester of fatty alcohol comprises monoester of fatty alcohol, (b) the ester of fatty alcohol is a blend of at least two esters of fatty alcohols.

12. The composition of claim 3, wherein the ester of fatty alcohol has the following chemical structure: ##STR00002## wherein: R.sub.1 includes from about 3 to about 15 carbon atoms, preferable from about 5 to about 9 carbon atoms, most preferably from about 7 to about 9 carbon atoms; and R.sub.2 includes from about 4 to about 28 carbon atoms, preferable from about 8 to about 20 carbon atoms, most preferably from about 12 to about 18 carbon atoms.

13. The composition of claim 3, wherein the ester of fatty alcohol comprises salicylate ester of fatty alcohol, caproate ester of fatty alcohol, caprylate ester of fatty alcohol, caprate ester of fatty alcohol, or any mixture thereof.

14. The composition of claim 3, wherein the ester of fatty alcohol comprises tridecyl salicylate, dodecyl salicylate, decyl salicylate, octyl salicylate, 2-ethylhexyl salicylate, lauryl caproate, myristyl caproate, oleyl caproate, linoleyl caproate, linolenyl caproate, palmityl caproate, palmitoleyl caproate, stearyl caproate, lauryl caprylate, myristyl caprylate, oleyl caprylate, linoleyl

caprylate, linolenyl caprylate, palmityl caprylate, palmitoleyl caprylate, stearyl caprylate, lauryl caprate, myristyl caprate, oleyl caprate, linoleyl caprate, linolenyl caprate, palmityl caprate, palmitoleyl caprate, stearyl caprate, or any mixture thereof.
15. (canceled)
16. The composition of claim 1, wherein the composition is substantially free of water.
17. (canceled)
18. The composition of claim 1, wherein vegetable oil comprises an oil extracted from a plant source, and wherein the oil extracted from plant source comprises sunflower oil, rapeseed oil, soybean oil, grape seed oil, cocoa butter oil, almond oil, avocado oil, Brazil nut oil, cashew oil, cashew nut shell oil, neem oil, linseed oil, double boiled linseed oil, chia seed oil, coconut oil, corn oil, cottonseed oil, flaxseed oil, hemp seed oil, vigna mungo oil, mustard oil, olive oil, palm oil, lesquerella oil, canola oil, peanut oil, pecan oil, perilla oil, rice bran oil, safflower oil, sesame oil, walnut oil, meadowfoam oil, castor oil, or any mixture thereof.
19. (canceled)
20. The composition of claim 1, wherein the nonionic surfactant comprises fatty alcohol surfactant, fatty alcohol ethoxylate surfactant, fatty alcohol propoxylate surfactant, fatty alcohol ethoxylated/propoxylate surfactant, castor oil ethoxylate surfactant, fatty alcohol ethoxylate carboxylate surfactant, fatty alcohol propoxylate carboxylate surfactant, fatty alcohol ethoxylated/propoxylate carboxylate surfactant, sorbitan ethoxylated ester surfactant, sorbitan ester surfactant, or any combination thereof.
21. The composition of claim 20, wherein the fatty alcohol ethoxylate surfactant is present and fulfills at least one of the following: (a) the fatty alcohol ethoxylate surfactant comprises C6-24 alcohol and from about 3 to about 50 moles of ethylene oxide, (b) the fatty alcohol ethoxylate surfactant comprises C12-14 alcohol and from about 3 to about 14 moles of ethylene oxide, (c) the fatty alcohol ethoxylate surfactant comprises lauryl alcohol ethoxylate surfactant, C9-C11 alcohol ethoxylate surfactant, C12-C13 alcohols ethoxylate surfactant, C12-14 alcohol ethoxylate surfactant, C12-15 alcohol ethoxylate surfactant, C14-C15 alcohol ethoxylate surfactant, or any mixture thereof.
22. The composition of claim 1, wherein the nonionic surfactant comprises fatty alcohol alkoxylate having the following chemical structure
R—O—(CH(Y)—CH.sub.2—O).sub.n—(CH.sub.2).sub.m—COOH, wherein: R is an alkyl group containing 6 to 24 carbon atoms, Y is H or CH.sub.3, n is a number ranging from about 3 to about 50, and m is a number ranging from about 0 to about 3.
23. (canceled)
24. (canceled)
25. (canceled)
26. The composition of claim 1, wherein the composition is substantially free of silicon-based compound, mineral oil, fatty acid, fatty amine, or any combination thereof.
27. A method of dry lubricating surface, comprising: applying the lubricant composition of claim 1 discontinuously to the surface without diluting the lubricant composition prior to the application; applying water intermittently to the surface, wherein the water facilitates removal of blackness from the surface; monitoring a coefficient of friction on the surface and re-applying the lubricant composition of any one of claims **1-26** discontinuously to the surface when the monitored coefficient of friction on the surface increases to about 0.17; and continuing to apply water intermittently to the surface to facilitate the removal of blackness from the surface.
28. (canceled)
29. (canceled)
30. (canceled)
31. A method of lubricating a conveyor belt, comprising: applying the dry lubricant composition of claim 1 discontinuously to the conveyor belt without diluting the dry lubricant composition prior to

the application.
32. (canceled)
33. (canceled)
34. (canceled)
35. (canceled)
36. (canceled)
37. (canceled)
38. (canceled)