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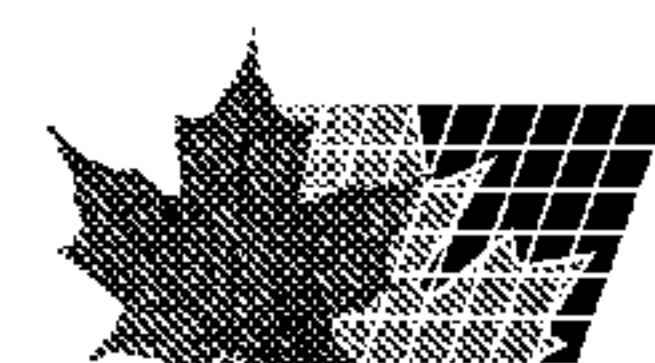
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(54) Title: LUBRICATING COMPOSITIONS

(57) Abrégé/Abstract:

The present invention relates to high lubricity compositions, which can be useful as steel wire rope lubricants. The lubricants are non-acidic and comprise additives that are low acidity and have a low percentage active sulfur containing compounds. The preferred compositions can increase the useful working life of a wire rope, particularly steel wire ropes, without decreasing performance.



ABSTRACT

The present invention relates to high lubricity compositions, which can be useful as steel wire rope lubricants. The lubricants are non-acidic and comprise additives that are low acidity and have a low percentage active sulfur containing compounds. The preferred compositions can increase the useful working life of a wire rope, particularly steel wire ropes, without decreasing performance.

TITLE

Lubricating Compositions.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to compositions, which can be useful as lubricants. In particular, the present invention is directed to a composition that contains a base fluid, a corrosion inhibitor, a lubricity agent, an extreme pressure additive and an anti-wear additive. The composition is useful as a wire rope lubricant.

2. Description of Prior Art

Lubrication is the control of friction and wear by the introduction of a friction-reducing substance between surfaces or bodies in relative motion. Lubricants are liquids or solids that act to reduce friction, heat, and wear when applied to these moving surfaces or bodies in relative motion. A liquid lubricant typically consists of a base fluid, which may be of petroleum origin (e.g. a base-stock oil), which can then be combined with additional chemical additives or agents that provide enhanced performance attributes. Designing a lubricant to maximize the control of friction and wear involves carefully balancing the properties and/or characteristics of both the base fluid and the performance enhancing chemical additives.

In general, base fluids can be either refined from petroleum crude oil or can be synthetic compounds, each with properties and/or characteristics that are suitable for lubrication. The process for making a lubricant base-stock oil from crude oil usually involves the separation of

lighter boiling materials such as gasoline, jet fuel, diesel, etc., from heavier components and the reduction of impurities, which may include several aromatics and polar compounds, through solvent refining, followed by dewaxing and hydrogenation.

A lubricant can include chemical additives or agents that may be added to the base fluid, which can be selected from one or more of the following: a detergent, a dispersant, an oxidation inhibitor, a corrosion inhibitor, an anti-wear agent, an extreme pressure additive, a foam depressant, a viscosity index improver, a pour-point depressant and a tackifier.

The type of base fluid as well as the number, type and concentration of chemical additives within a lubricant can be selected to suit the environment(s) where control of friction and wear are required. One area of particular interest is the formulation of lubricants that can provide lubrication on and within wire ropes, particularly steel wire ropes. However, lubricants that are suitable for a particular lubrication application (e.g. steel wire rope) may also be suitable for other lubricant applications (e.g. general purpose lubrication, small gear lubrication, mechanical linkage lubrication, etc.). As such, a lubricant that may have satisfactory performance qualities and/or characteristics for one specific application could also be useful in other applications.

Wire ropes have been compared to and referred to as “machines”, as they consist of a combination of parts, working together, to produce a specific end result. Wire rope “machines” generally consist of three components: the individual wires, the wire strands and the wire rope core. While few in number, these three basic components can vary greatly in both complexity and configuration. Despite this variation in complexity and configuration, however, the proper

working of the components of the wire rope, as well as the wire rope itself, usually require lubrication.

The standard wire rope design involves a predetermined number of individual metal wires helically wound in a fixed pattern around a central wire to form a metal wire strand. The metal wire strands are then helically wound in a fixed pattern around the core in a process referred to as "closing". The exact configuration of each wire rope, such as the number of individual wires in the wire strand, the helical angle and pattern of the individual wires within the wire strand as well as the wire strands around the core, the clockwise or counter clockwise rotation of the individual wires or wire strands and the type and configuration of the core, is determined by the service intended for the wire rope.

The basic unit of any wire rope is the metal wire. The individual metal wires used in the manufacture of wire ropes can be selected from several metals, including bronze, iron, and steel (e.g. stainless steel, high-carbon steel, etc.). Steel wire strengths are also available in several grades, the particular grade of the metal depending upon the use of the wire rope. Grades of wire rope have traditionally been referred to as traction steel, mild plow steel, plow steel, improved plow steel, and extra improved plow steel. The most common finishes for steel wires are "bright" (i.e. no protective coating) and coated (i.e. galvanized or zinc coated).

Wire ropes may be classified and identified by their construction, the number of wire strands per rope and the number of wires per strand. The nomenclature is derived from the number of wire strands in the rope, the number (nominal or exact) and arrangement of wires in each wire strand as well as a descriptive word or letter indicating the type of construction, i.e., the geometric arrangement of individual wires. These are nominal classifications, however, may

or may not reflect the actual construction (i.e. number of strands and number of wires per strand).

The helical direction of the individual wires within a wire strand, as well as wire strands in a wire rope, is referred to as the “lay”. “Regular lay” denotes wire rope in which the individual wires of the strand are laid in one direction and the wire strands are laid in the opposite direction. In regular lay rope, the exposed, outer surface of the individual wires, referred to as the wire “crowns”, appear to run substantially parallel to a longitudinal axis extending along the centre line of the wire rope. Because of the short length of these wire crowns, regular lay ropes resist the formation of kinks within the individual wires, as well as the failure (e.g. breakage) of the individual wires, either of which may result from crushing and/or distortion of the wire crowns. Unlike regular lay, “Lang lay” is configured so that the individual wires and wire strands are laid in the same direction and, as such, appear to run substantially diagonal to the longitudinal axis extending along the centre of the rope. Lang lay ropes can have greater flexibility and abrasion resistance than regular lay ropes, but may be more likely to twist, kink and crush.

The core of the wire rope supports the wire strands wrapped around it. Characteristics of the wire rope core can include the degree to which it is capable of resisting compression, crushing and distortion; the ability to retain sufficient lubricant to protect the inner surfaces of the wire strands against corrosion; and the flexibility of the core to withstand the continual bending to which the wire rope may be subjected during operation. The wire rope core provides a structure into which the wire strands can be embedded so as to preserve the shape of the rope under strain. The core may also serve to maintain the proper spacing of the outer wire strands

and inhibit unnecessary interstrand friction and wear. For wire rope lubrication, the core can lubricant so as to serve as an internal reservoir of lubricant for the wire.

Wire ropes can be supplied with a fibre core, which can consist of either natural or synthetic fibres, or a metal core. Metal cores provide more support to the outer wire strands than fibre cores. Relative to fibre cores, steel cores can be more resistant to crushing, can be more resistant to heat, can reduce the amount of stretch, and can increase the strength of the rope. As with the configuration of wire ropes themselves, the configuration of the wire rope cores can vary.

Metal cores can include Independent Wire Rope Cores (IWRC) and Wire Strand Cores (WSC). An IWRC can itself be comprised of a wire rope in which another, smaller wire rope forms its core. A WSC is an assembly where a single wire strand forms the core, as distinct from the multi-strand IWRC. While IWRCs and WSCs provide greater breaking strength and resistance to crushing or distortion than fibre cores, lubrication can be more difficult as a lubricant has less chance for interstitial (i.e. void or valley between individual wires) penetration within the core itself, which, for example, can decrease the metal cores ability to act as a reservoir for lubricant.

Fibre wire rope cores can be derived from either natural vegetable fibres (e.g. sisal, jute or hemp) or from synthetic materials (e.g. nylon, polypropylene or other suitable synthetic fibres). Fibre wire rope cores have lower breaking strength than wire ropes with metal cores such as IWRCs and WSCs. Unlike metal cores, however, fibre cores may decrease or inhibit interstrand nicking of interior strand wires that come in contact with metal cores.

Wire rope has been manufactured to accommodate varying environmental conditions in which the wire rope may be used, such as in cranes, hoists, drag lines, mining conveyances, elevators, ski lifts, as well as forestry and marine applications. In such applications, wire ropes can be exposed to a harsh working environment (i.e. any environment which may negatively impact the useful working life of the wire rope, such as high exposure to corrosive factors, high wear, high load, etc.). Harsh working environments may included cyclical stresses that result from the wire rope being frequently flexed, abraded and tensed under load, as well as exposure to corrosive agents (“corrodents”) and other materials that can increase wear. As a result of repeated or cyclical stress, wire ropes are subjected to compression, tension, torsion and shear stresses. So as to distribute these applied, repeated or cyclical stresses more effectively, the individual wires and wire strands of wire ropes are designed to more relative to each other. Because of the friction between the metal components of the wire rope, however, there can be significant resistance to this relative movement. It is the friction that results from this relative movement, as well as the interaction of the wire rope with related equipment (e.g. sheaves, drums, etc.) that can contribute to a decrease in the useful working life (i.e. hours-in-use) of the wire rope. Due to the costs associated with the replacement of wire ropes, particularly steel wire ropes, it is desirable, therefore, to maximize the useful working life of such wire ropes.

One example of a harsh working environment in which wire ropes, particularly steel wire ropes, can be used, is a mining operation. In particular, the uses of wire ropes associated with mining operations can include hoists, dragline excavators (“draglines”) and mining conveyances. The wire rope can be exposed to high loads, abrasive dust and corrodents. For operators of mining equipment, wire ropes can present a large equipment expense. It is important, therefore,

to maximize the useful working life of the wire rope, particularly wire rope used in harsh working environments.

Of particular interest is the harsh working environment that can be associated with nickel mining, such as in Sudbury, Ontario, Canada. The nickel deposits in and around Sudbury contain pentlandite, which is a sulfide ore of iron and nickel. Sulfides or sulfur containing compounds can be active corrodants, the presence of which may accelerate the corrosion of the metal components of wire ropes. It is advantageous, therefore, that the useful working life of any wire rope used in such harsh working environments not be adversely effected by the presence of the pentlandite ore. The expense associated with the use and maintenance of wire ropes is such that a constant search is underway for ways to increase their useful working life and/or decrease the frequency of their replacement.

One factor that can decrease the useful working life of wire ropes is wear. In general, wear is the removal of material from a solid surface as the result of mechanical, chemical or electrochemical action. Each individual metal wire in the wire strand as well as each wire strand itself can be in contact with other metal wires or wire strands over their entire length. Each geometric non-conformal contact between metal wires or between wire strands is theoretically along a line. Due to the elasticity of steel, however, this line can widen into a narrow band, whereby the geometric non-conformal contacts begin to approach geometric conformal contacts, when the wire rope is under cyclic loading. As a result, abrasive wear will increase over this narrow band while the rope is under load. In addition, wire ropes that operate over sheaves and drums are subjected to bending. In order to bend around a sheave or drum, the wire rope strands are forced to move relative to one another to compensate for the bend. The wires on the outer side (i.e. furthest from the sheave or drum) of the rope elongate while the wires on the inner side

(i.e. closest to the sheave or drum) compress. This is because the outer side of the wire rope has further to travel around the sheave than the inner side. Any such contact between individual metal wires and/or wire strands can lead to a loss of metal due to abrasive wear. Such losses due to abrasive wear can be particularly serious in wire ropes, for if they are not minimized with an effective lubricant, for example, they can lead rapidly to fatigue and/or mechanical failure of the wire rope.

In addition, under “extreme pressure” (e.g. high temperature and pressure) conditions, adhesive wear can occur in local hot spots on the individual metal wires at the points of metal to metal contact resulting in “spot-welding”. When the wires that have been spot-welded together move away from each other, metal is removed from one of the individual wires as these spot-welds break.

Under extreme pressure conditions, martensite formation (“burning”) can also occur. Martensite is a hard, non-ductile phase of steel formed when areas of individual wires are heated, followed by rapid cooling by the adjacent “cold” metal within the individual wires and/or other metal structures. As the affected area bends, it has less ability to absorb the stress and can crack more easily. This crack can, in turn, quickly spread through the wire and may lead to a complete wire break. Individual broken wires within wire ropes are commonplace for these reasons.

Wear can also be significant at “crossover points”. As a hoist drum rotates to lift a load, the wire rope is reeled on to the drum. In addition to the wire rope reeling onto the hoist drum, the wire rope translates back and forth along a horizontal axis extending between the flanges of the drum. This translation motion along the horizontal axis is reversed by the hoist drum flanges (i.e. the flanges forces the wire rope to begin translational movement in the direction opposite to

the previous movement along the horizontal axis). When the reversal occurs, the rope crosses wire rope previously reeled on the drum. This “crossover point” is a location of high load, stress and wear. As such, the crossover points are strategic wear locations that can limit the useful working life of the rope and can be important examination locations for lubrication performance.

Corrosion can also be common in some harsh working environments in which wire ropes may be used. Corrosion may also act to reduce the useful working life of the wire rope. Corrosion (e.g. rust) can be very broadly referred to as a process whereby a deterioration of metal and its properties can be caused by the chemical or electrochemical reaction between the wire rope metal and corrodents within the environment to which the metal is exposed. Corrosion usually results from the inherent tendency of non-noble metals to chemically or electrochemically revert to more stable compounds, such as metal oxides or metal sulfides. In the case of rust, for example, such corrosion can result in the decrease of the iron content of steel. Such a decrease can be referred to as “corrosive wear”. Corrosive wear can be of particular concern when steel wire ropes are used in high sulfur environments, such as in mining operations, which can include pentlandite.

One form of corrosive wear that can decrease the useful working life of a steel wire rope is intergranular corrosion. Intergranular corrosion, also known as interdendritic corrosion or intercrystalline corrosion, occurs when metal grain boundaries are attacked by corrodents. Intergranular corrosion occurs frequently at grain boundaries, usually with slight or negligible attack on the adjacent grains. The metal grain boundary is a narrow zone in a metal corresponding to where there is a transition from metal atoms arranged in an orderly crystallographic orientation to a less orderly orientation. The metal grain boundary separates one “grain” (i.e. an individual crystal in a polycrystalline metal or alloy) having orderly arranged

atoms, from the non-grain material having non-orderly arranged atoms. Due to the irregular orientation at the interface, the metal grain boundary is particularly susceptible to corrosion. By corroding the intergranular spaces, the metal of the individual wires may be weakened.

Acidic conditions may aggravate intergranular corrosion and as a result, can weaken the steel within the individual wires of a wire rope.

As a result of intergranular corrosion, the metal of the individual wire ropes may be more susceptible to “plastic flow”. Plastic flow refers to the non-elastic movement of solid material, such as metal, under intense pressure. Under load conditions, the metal of the individual wires flows like a very viscous liquid but does not revert to its original shape when the load is removed. If the non-plastic flow continues beyond work hardening, the metal may be weakened.

Due to abrasive wear, adhesive wear and corrosive wear, the metal of individual wires may be subject to fatigue at a faster rate, which can result in a decrease in the useful working life of the wire rope. Fatigue of the metal of the individual wires of the wire rope can result in a fracture, which forms even after exposure to stresses less than the tensile strength of the metal (e.g. cyclic stresses having a maximum value less than the tensile strength of the metal).

Many factors have been developed to improve the characteristics of the use and construction of wire ropes to increase their resistance to the forces that reduce the life of the wire rope. These include specialized manufacturing techniques, differing wire rope configuration (i.e. the lay of wire ropes) and the use of lubricants containing specialized additives.

A means of increasing the useful working life of wire ropes is through the use of lubricants. Lubrication permits relative movement to occur, with reduced adhesive and abrasive

wear. Lubricants, therefore, are important to the satisfactory performance of most operating wire ropes, particularly steel wire ropes. Wire rope lubricants are generally designed to perform the following functions. The first can include the reduction of friction between individual wires or wire strands as the individual wires or wire strands move relative to each other. By reducing friction, the use of lubricants can reduce abrasive and/or adhesive wear of the components of the wire rope. A second function can be to provide lubrication under a range of temperature and pressure conditions. Another function may also involve corrosive wear protection of the components of the wire rope. Correct wire rope lubrication also reduces the effects of friction in the grooves of sheaves and pulleys and on the faces and flanges of drums over which the wire rope passes. An unlubricated rope causes pulley grooves and drum faces and flanges to wear unevenly, resulting in increased friction and increased load on the wire rope.

Several factors of the working environment can influence lubricant selection including; the washing action of rain, salt spray or sea water; high ambient temperature which, by decreasing viscosity, can cause the lubrication to be thrown off by centrifugal force or drain off during storage; low ambient temperature that causes lubricants to become brittle and chip off; corrosive conditions (e.g. acidic conditions, high active sulfur, saline conditions, etc.); and abrasive wear material such as rock, coal, sand, etc. It is advantageous, therefore, that a wire rope lubricant overcome or minimize some or all of these factors, without decreasing the performance characteristics of the lubricants.

It is advantageous to have a non-acidic lubricant as well as additives which do not lead to increased acidity of the lubricant. The presence of acids in a lubricant may accelerate corrosive wear, particularly intergranular corrosion. It has previously not been possible to produce low acidity or non-acidic lubricants, however, without sacrificing some or all of the performance

characteristics of the lubricant. Therefore, it would be advantageous to produce a non-acidic composition that does not sacrifice some or all of the performance characteristics of previous lubricants.

It can be advantageous for the wire rope lubricant to have sufficient adhesive strength (i.e. tackiness) so that the lubricant is not removed from the wire rope by centrifugal forces, e.g. when the wire rope passes over sheaves, pulleys, etc., or other forces when the rope is in use. Wire rope lubricants should not be so adherent, however, that quantities of abrasive material accumulate within the wire rope so as to increase wear. This is particularly important for wire ropes used in mining operations. It is also advantageous that a wire rope lubricant also be sufficiently non-soluble in water so that it adheres to the coated components of the wire rope despite exposure to water, which otherwise may wash away the lubricant.

It is also advantageous for the lubricant to penetrate the wire rope so as to reach the core, thereby lubricating the entire wire rope. This can be particularly important in the case of IWRCs and WSCs. Because the individual metal wires, particularly those located internally within the wire rope, can be subject to metal loss due to wear, a wire rope lubricant should be capable of penetrating to the interior strands and then have sufficient adhesion to remain in place.

Finally, the lubricant must also have sufficient anti-wear properties, anti-corrosive properties and lubricity under most of its working conditions. Lubricity, also known as film strength, refers to the ability of a lubricant to provide a tough, low friction barrier between each of the components of the wire rope, thereby decreasing wear. The lubricity of a lubricant is enhanced by additive treatment. Anti-wear and anti-corrosive properties, usually also provided

by additives, allow the wire rope lubricant to reduce adhesive, abrasive and corrosive wear of the metal of the individual wires under a variety of conditions.

There are several common wire rope lubricants that contain, as base fluids, refined petroleum crude oil products including petrolatum and asphalt (i.e. bituminic) base compounds. The base fluids may also include grease, and light petroleum oils. Petrolatum is an odorless, tasteless, greasy substance, obtained as the residue from petroleum after the lighter and more volatile components have been removed. The purified residue is obtained in the form of a yellowish or decolorized semisolid or in the form of a clear to faintly yellow liquid (i.e. mineral oil). It is composed mostly of high molecular weight waxes. Typically, petrolatum compounds can be applied at temperatures above their melting point, normally in the range of 88°C to 110°C. As the hot petrolatum cools, it becomes semi-solid and may provide adequate lubrication for some wire rope applications. As petrolatum is translucent, the surface of wire ropes treated with this lubricant tend to be visible allowing for easy inspection of the individual wires and wire strands. Certain types of petrolatum based wire rope lubricants can include additives that can provide solubility and corrosion resistance. Petrolatum based wire rope lubricants, however, may tend to drip off the rope while in use. While at low temperatures petrolatum based lubricants may resist cracking, the melting and hot application of petrolatum based lubricants is disadvantageous.

Asphaltic based lubricants are derived from asphalt, which is a high molecular weight bituminous material occurring naturally or as a residue from the distillation of crude oil. They are applied within a range of 79°C to 177°C and solidify to a very dark, and in some cases, a brittle surface. Asphaltic materials were initially designed to act more as barrier to the environment than as a lubricant. Due to its dark colour, asphaltic based wire rope lubricants

hinder visual inspection of the wire ropes. Asphaltic based wire rope lubricants also tend to become brittle in cold climates.

Grease based lubricants utilize all types of thickeners depending on the service intended and are mostly applied by heating and flowing onto wires entering the stranding die during rope manufacture. Grease based lubricants, however, are difficult to apply to wire ropes which are in service.

The light petroleum oils can consist of paraffinic type hydrocarbon lubricant base-stock oils selected from Group I, II, and III base-stock oils according to API Publication 1509, *Engine Oil Licensing and Certification System* (14th Edition, American Petroleum Institute, 1986; “API Publication 1509”).

Several chemical additives can also be included in wire rope lubricants. These chemical additives can be added to a base fluid to impart or improve certain properties of the lubricant. Common petroleum product additives are: anti-foam agent, anti-wear additive, demulsifier, detergent, dispersant, emulsifier, extreme pressure additives (also known as “EP” additives), corrosion inhibitors, tackiness agents, pour-point depressants and viscosity index (V.I.) improvers.

Previously commercially known wire rope lubricants have evolved from asphaltic based wire rope lubricants to refined petroleum oil based wire rope lubricants. The asphaltic based and petrolatum based wire rope lubricants present handling problems when used in a range of operating conditions. For example, many of the asphalt-based wire rope lubricants currently in use are dark or opaque, which can mean that wire rope inspection and maintenance can be difficult and costly due to the need to remove the asphalt-based wire rope lubricant and then

reapply the lubricant after inspection. Furthermore, asphalt compounds may no longer be desirable for use in environmentally sensitive areas. Many petrolatum and grease based lubricants do not have the properties that result in a protective and effective lubricant. For example, many such petrolatum and grease based wire rope lubricants flow out of the wire ropes to which they have been applied a short time after application. Furthermore, grease based lubricants may not properly penetrate into the rope.

Asphaltic, petrolatum or grease based lubricants have also been formulated with anti-wear additives, EP additives and corrosion inhibitors which may contribute to an increase in the acidity of the wire rope lubricant formulation. However, these lubricants can be acidic, commonly with Total Acid Number (TAN) greater than 5. Acidic conditions can increase wear and lower the useful working life of the wire rope. As a result, present commercially available wire rope lubricants may provide satisfactory performance characteristics but may not increase the useful working life of wire ropes.

SUMMARY OF THE INVENTION

An aspect of the present invention is to provide a composition that provides satisfactory lubrication performance while increasing the useful working life of wire ropes, particularly steel wire ropes.

A further aspect of the present invention is to provide a composition, which can be used as a steel wire rope lubricant, having a Total Acid Number (TAN) of less than or equal to 5, preferably less than or equal to 3, more preferably less than or equal to 1, more preferably between 0.3 and 0.8, more preferably less than or equal to 0.3 and still more preferably 0.3.

A further aspect of the present invention is to provide a composition, which can be used as a steel wire rope lubricant, having a kinematic viscosity of between 20 ± 5 cSt and 250 ± 40 cSt at 40°C and a viscosity index of between 30 ± 10 and 120 ± 30 . Another aspect of the invention is a composition, which can be used as a steel wire rope lubricant, having an ISO VG rating of between ISO VG 15 and ISO VG 320.

A further aspect of the invention is to provide a composition, which can be used as, a steel wire rope lubricant, and which can be used under a variety of working conditions, which may include harsh working environmental conditions (i.e. harsh working environments in which corrosive agents or corrodents are present). For example, the composition can be used to lubricate steel wire ropes used in cranes, hoists, draglines, mining conveyances, elevators, ski lifts, forestry applications and various marine environments.

Still a further aspect of the invention is to provide a steel wire rope lubricant that is well suited for use in the mining industry.

Still a further aspect of the invention is to provide a steel wire rope lubricant that is well suited for use in the mining industry in which there is exposure to working environmental conditions in which pentlandite ore is present.

A further aspect of the present invention is a composition which comprises the following:

MCT TM 10	57.00 percent by volume (v/v)
MCT TM 60	32.26 percent by volume (v/v)
Alox TM 2283	2.14 percent by volume (v/v)
Trioctyl Trimelliate	5.00 percent by volume (v/v)
Additin TM RC2515	2.00 percent by volume (v/v)
Durad TM 150	0.50 percent by volume (v/v)
Irgamet TM 39	0.10 percent by volume (v/v)

A further aspect of the present invention is a wire rope lubricant which contains 1,2,4-benzenetricarboxylic acid tris(2-ethylhexyl) ester.

A further aspect of the present invention is a method of manufacturing a wire rope comprising the step of applying a composition of the present invention to the wire rope prior to closing. There is also provided a method of lubricating a wire rope with the composition of the present invention.

A further aspect of the present invention is a wire rope having a composition of the present invention applied thereto.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment is a translucent or clear, non-acidic, high lubricity composition that provides lubrication and reduces wear of the metal within wire ropes, particularly steel wire ropes, so as to increase the useful working life of wire ropes. More specifically, the wire rope lubricant is a clear or translucent wire rope lubricant that can be used in harsh environmental working conditions, such as those encountered, for example, in mining operations.

The lubricant disclosed herein can be clear or translucent. The translucence of the wire rope lubricant of the present invention can allow for simplified wire rope inspection, as removal of the wire rope lubricant for inspection of the wire is not required. The wire rope lubricant of the present invention also penetrates into the interstices of the wire rope. The lubricant of the present invention is accomplished by a combination of a base fluid, a corrosion inhibitor, a lubricity agent, an extreme pressure additive and an anti-wear additive having the preferred characteristics.

While preferred for use in association with ropes used in the mining industries (e.g. for use in mining conveyance ropes), wire rope lubricants of the present invention can also be used in association with wire ropes used in cranes, hoists, drag lines, elevators, ski lifts, forestry applications and various marine environments. Compositions of the present invention may also be suitable for other lubricant applications, such as, for example, general purpose lubrication, small gear lubrication and mechanical linkage lubrication.

Wire rope lubricants of the present invention may comprise from about 50 to about 95 percent by volume (v/v) of base fluid. The base fluid to be used in the present invention may comprise either a single base fluid or selection of base fluids. In addition to the base fluids, the wire rope lubricant may also comprise from about 0.2 to about 5.0 percent by volume (v/v) of a corrosion inhibitor or a selection of corrosion inhibitors, from about 1 to about 8 percent by volume (v/v) of a lubricity agent or a selection of lubricity agents, from about 0.1 to about 10 percent by volume (v/v) of an extreme pressure agent or a selection of extreme pressure agents and from about 0.1 to about 10 percent by volume (v/v) of an anti-wear agent or a selection of anti-wear agents. Preferable compositions may also contain from about 0.1 to about 5 percent by volume (v/v) of a tackiness agent or a selection of tackiness agents.

In a preferred embodiment, a composition is provided with 89.26 percent by volume (v/v) of a combination of Group I base-stock oils, namely MCT™ 10 and MCT™ 60; 2.14 percent by volume (v/v) of the rust inhibitor Alox™ 2283; 5 percent by volume (v/v) of the lubricity agent trioctyl trimellitate (TOTM); 2 percent by volume (v/v) of the EP agent, Additin™ RC2515; 0.5 percent by volume (v/v) of the anti-wear additive Durad™ 150; 1 percent by volume (v/v) of the tackifier Paratac™ and 0.1 percent by volume (v/v) of the copper corrosion inhibitor Irgamet™ 39.

Additives should generally be selected so as not to lead to, contribute to or result in an increase in acidity of the lubricant. Generally, the lower the TAN of the lubricant, the lower the acidity of the lubricant and conversely, the higher the TAN, the higher the acidity of the lubricant. TAN is the weight in milligrams of KOH required to neutralize the acid present in one gram of the lubricant, in accordance with standard ASTM (American Society for Testing and Materials) test method ASTM D664 or ASTM D974. An acidic lubricant can generally be classified as a lubricant with a TAN of greater than 5. The desired TAN of the composition should be less than or equal to 5, or more preferably less than or equal to 3, still more preferably less than or equal to 1, still more preferably between 0.3 and 0.8, less than or equal to 0.3 and still more preferably 0.3.

The composition of the present invention should have an ISO VG (International Standard Organization Viscosity Grade) between ISO VG 15 and ISO VG 320. Preferably, it is ISO VG 68. Laboratory measurements of viscosity normally use the force of gravity to produce flow through a viscometer, i.e. a calibrated capillary tube through which a liquid is allowed to pass at a controlled temperature in a specified time period. This measurement is called kinematic viscosity and has the units of centiStokes (cSt). Kinematic viscosity of lubricants refers to that lubricant's resistance to flow under gravity, as determined by the standard test method ASTM D445. The standard tests of the ASTM describe, identify, or specify characteristics of lubricants, including wire rope lubricants, as determined in accordance with standardized ASTM test methods. To determine kinematic viscosity, a fixed volume of the test fluid (i.e. a wire rope lubricant) is allowed to flow through a viscometer at a controlled temperature. The kinematic viscosity is the product of the measured flow time in seconds and the calibration constant of the

viscometer. Kinematic viscosity is measured in Stokes, expressed in square centimetres per second. The more customary unit is the centiStoke (cSt), which is one-hundredth of a Stoke.

In addition to kinematic viscosity, viscosity index (V.I.) is an empirical, unitless number indicating the effect of temperature change on kinematic viscosity. Liquids change viscosity with temperature, becoming less viscous when heated; the higher the V.I., the lower its tendency to change viscosity with temperature. The V.I. of a lubricant, with known kinematic viscosities at 40°C and at 100°C can be determined by comparing the lubricant with two standard lubricants in accordance with test method ASTM D2270. For example, a high-V.I. lubricant may be required wherever a relatively constant viscosity is required at widely varying temperatures.

The ISO VG classification system is a system for classifying industrial lubricants. Each ISO VG number designation corresponds to an approximation of the mid-point of a composition's kinematic viscosity range at 40°C. For example, a ISO VG 32 lubricant would be expected to have a kinematic viscosity within the range of 28.8 to 35.2 cSt, the mid-point of which is 32. The range of lubricants that would fall between ISO VG 15 and ISO VG 320 can encompass those lubricants having a kinematic viscosity of between 20 ± 5 cSt and approximately 250 ± 40 cSt at 40°C. It would be further understood that an ISO VG 68 lubricant would encompass those lubricants having a kinematic viscosity of between 61.2 cSt and 74.8 cSt.

Given the variety of environments in which wire ropes, particularly steel wire ropes, are used, it is preferable to have a wire rope lubricant that has a viscosity index of between 30 ± 10 and 120 ± 30 . More preferably, the composition should have a viscosity index of between 100 and 110. Still more preferably, the composition should have a viscosity index of 109.

Lubricants reduce the friction in machine components by producing a physical or chemical barrier between surfaces that slide or roll past each other. This is particularly important for wire ropes. It is necessary to provide sufficient lubrication under the majority of conditions to which a wire rope will be exposed in its useful working life. During its lifetime, a wire rope can be exposed to a variety of temperature and pressure conditions. Under these conditions, wire rope lubricants must be able to provide sufficient lubrication under boundary lubrication conditions.

Boundary lubrication occurs as a result of lubrication between two rubbing surfaces without development of a full-fluid lubricating film. The functioning of the wire rope under boundary lubrication can be made more effective by including additives such as a lubricity agent as well as extreme pressure and anti-wear additives. There are varying degrees of boundary lubrication, depending on the load, temperature and effectiveness of the lubricant. For low load and temperature conditions, lubricity additives may be sufficient. Anti-wear additives are commonly used in more severe boundary lubrication applications, e.g. higher temperature and load conditions in which lubricity agents may not properly function. The more severe cases of boundary lubrication are defined as extreme pressure conditions and can be combated with extreme pressure additives that inhibit surfaces in relative motion from fusing together at high local temperatures and high load.

Base Fluids

The base fluids of the composition can comprise petroleum derived base fluids, naphthenic base fluids and synthetic base fluids. Petroleum derived base fluids can include petroleum derived base-stock oils, which can comprise one or more of the Group I, II or III base-

stock oils as defined in API Publication 1509. Generally, API's categorization of base-stock oils is based on approximate composition, e.g. the percentage composition of sulfur and aromatic compounds. Group I base-stock oils are solvent refined base-stock oils which are characterized as having less than 90% saturated hydrocarbons (i.e. greater than 10% aromatics) and greater than 300 ppm of inactive sulfur. The viscosity index of Group I base-stock oils can be between approximately 80 and approximately 119. Group II and III base-stock oils can be characterized as having greater than or equal to 90% saturated hydrocarbons (i.e. less than or equal to 10% aromatic hydrocarbons) and less than or equal to 300 ppm of inactive sulfur. Group II base-stock oils have viscosity indices similar to that of Group I base-stock oils. Group III base-stock oils, however, may have viscosity indices of greater than or equal to 120.

The base fluids can also comprise naphthenic base fluids, characterized by saturated carbon atoms in a ring structure have the general formula C_NH_{2N} , and having viscosity indices of between approximately 40 to approximately 60.

Groups IV and V base fluids, according to API Publication 1509, can be characterized as polyalphaolefins (PAOs) or all other base fluids not included in Groups I to III, respectively.

The base fluid provides the majority of the liquid component of the lubricant as well as the majority of the preferred viscosity characteristics. The preferred base fluids are the petroleum derived base-stock oils selected from Group I, II or III base-stock oils. In addition, naphthenic base fluids or synthetic base fluids (i.e Groups IV and V base fluids) may be used as base fluids. More preferably, the base fluids for use in the lubricating composition can be Group I base-stocks oils.

Preferably, the base fluid(s) should provide a final target kinematic viscosity of the composition of between 20 ± 5 cSt and 250 ± 40 cSt at 40°C . More preferably, the base fluid(s) should provide a final target kinematic viscosity of the composition of 68 cSt at 40°C .

As for the viscosity index of the composition, the base fluid(s) should provide a final target viscosity index of the composition of between 30 ± 10 and 120 ± 30 , more preferably between 100 and 110 and most preferably 109.

A combination of one or more base fluids can be used in the composition of the present invention. In an embodiment, the base fluids can be selected from two base-stock oils. The first is MCTTM 10 (Imperial Oil, Canada), which has a kinematic viscosity of approximately 29.5 cSt at 40°C . MCTTM 10 is a Group I base-stock oil commercially available in Canada. The second is MCTTM 60 (Imperial Oil, Canada), which has a kinematic viscosity of approximately 263 cSt at 40°C . MCTTM 60 is also a Group I base-stock oil. These base-stock oils are blended to achieve a composition having a final target kinematic viscosity of approximately 68 cSt and final target viscosity index of approximately 109.

In the case of one or more base fluids, the percent by volume (v/v) of each base fluid used can be adjusted to allow for the viscometric impact of the other fluid chemical additives during manufacture to achieve a final target kinematic viscosity and final target viscosity index as noted above.

Corrosion Inhibitors

Corrosion inhibitors are additives that provide protection of lubricated metal surfaces against chemical attack by water or other corrodents (e.g. active sulfur). There are several types of corrosion inhibitors known to be used in wire rope lubricants. For example, polar compounds can act at the metal surface, protecting it with a film-barrier that helps to inhibit corrodents from coming in contact with the metal. Other compounds, for example, may absorb water by incorporating it into a water-in-oil emulsion so that the oil predominately contacts the metal surface. Another type of corrosion inhibitor combines chemically with the metal to form a non-reactive surface barrier.

In general, a small concentration of inhibitor is required to produce the inhibitory effect. Preferably, the concentration required to carry out the corrosion inhibitor function can be 0.1 to 5 percent by volume.

Corrosion inhibitors preferably include rust inhibitors and copper corrosion inhibitors. It would be understood, however, that corrosion inhibitors that protect against the corrosion of other metals may also be used. Such metals can include, for example, lead, zinc, tin, silver and antimony. The presence of these metals can depend on the composition of the material to which the lubricant is applied.

As for the polar compounds, these corrosion inhibitors typically contain nonpolar hydrocarbon "tails" attached to polar functionalities or "heads" such as amines, carboxylic acids and their salts, phosphates, polyhydric alcohols and metal sulfonates. The "heads" of these polar compounds can associate near the metal surface while the hydrocarbon "tails" extend away from the surface of the metal of the wire rope into the lubricant to provide both solubility of the

inhibitor within the lubricant and a protective layer. This orienting of the molecules can help to inhibit the formation of oxides on the metal surface that may weaken the metal of the wire rope. However, the presence of acidic “heads” may also result in acid initiated formation of oxides which can be associated with intergranular corrosion.

The presence of acidic “heads”, such as carboxylic acid, can lead to sufficiently acidic conditions in which intergranular corrosion of the metal may be accelerated. The presence of such acidic groups, while protecting against rust formation, may also lead to increased intergranular corrosion wear and weakening of the metal. As such, it would be understood that the use of unsuitable corrosion inhibitors that may lead to or contribute to an increase in acidity of the lubricant would usually be avoided.

Many commercially available oil soluble corrosion inhibitors are known. Chemically, these corrosion inhibitors can comprise, for example, basic metal phenolates, basic metal sulfonates, fatty acids, amines, esters of succinic acid, wax oxidates, triazole derivatives and alkylthiaziazoles. Examples of commercially available corrosion inhibitors include AloxTM 165, Ethyl HitecTM 536, Ethyl HitecTM 4313, HitecTM 538, MobiladTM C603, AdditinTM RC 4220, NaSulTM BSN, IrgametTM 30, IrgametTM 39, CobratecTM 122 and CobratecTM 911S.

Several known oil soluble corrosion inhibitors, however, may lead to or contribute to an increase in the acidity of the lubricant and thus may be detrimental to the wire rope. It is preferable, therefore, to use corrosion inhibitors that do not lead to or contribute to an increase in acidity of the lubricants. As such, “low acidity” corrosion inhibitors are preferred. Low acidity corrosion inhibitors may be defined as those corrosion inhibitors that do not lead to or contribute to an increase in the acidity of the lubricant, which can correspond to an increase in the TAN of

the lubricant. It would be preferable that the low acidity corrosion inhibitors do not increase the TAN of a lubricant beyond the preferred range

Preferred examples of oil soluble rust inhibitors that could be used include HitecTM 538, AloxTM 165 and AloxTM 2283. More preferably, the rust inhibitor is AloxTM 2283 (Alox Corporation, Niagara Falls, United States), which is a microcrystalline wax oxidate where the oxidation acids have been neutralized. AloxTM 2283 is composed of a 37% proprietary blend of petrolatum and oxidized petrolatum, calcium salts of the petrolatum oxidate blended with a minor amount of petroleum sulfonate and 63% hydrotreated oil.

Commercially available copper corrosion inhibitors that could be used in the present invention include IrgametTM 30, IrgametTM 39, CobratecTM 911S, CobratecTM 122 and Ethyl Hitec 4313. More preferably, the copper corrosion inhibitor is IrgametTM 39 (Ciba Speciality Chemicals, United States). IrgametTM 39 is a substituted benzotriazole or tolutriazole derivative that is used to reduce copper base alloy corrosion by sulfidic chemicals such as hydrogen sulfide. It may also protect the ferrous alloys in the wire. The protection of copper can be important as wire ropes may be used in association with mining equipment (e.g. wire ropes used in mining conveyances). In some locations in which mining for nickel is conducted (i.e. Sudbury, Ontario, Canada), there can be significant exposure of the wire rope to sulfidic pentlandite ore. This sulfidic pentlandite ore can be corrosive to the ferrous content of steel wire ropes. The use of copper corrosion inhibitors can be useful as it reacts with the sulfur compounds of this ore, thereby decreasing the ore's ability to contribute to the corrosion of the ferrous content within the steel wire ropes.

In assessing corrosion inhibitors, the wire rope lubricant may be subjected to tests that examine the extent of both iron corrosion, i.e. rust formation, and copper corrosion within the wire rope. Iron is an ingredient in the steel used in the manufacture of steel wire ropes, but copper typically is not. In operation, however, such steel wire ropes may come in contact with equipment, such as bronze bushings used in hoists and sheaves, manufactured from copper based alloys. As a result, the equipment manufactured from copper based alloys may be subject to copper corrosion. Additives that inhibit copper corrosion, therefore, may benefit this equipment. Most copper corrosion inhibitors work by forming a barrier film separating the copper based alloy from the metal surface, reducing the amount of active sulfur containing compounds which may contribute to the corrosion of the alloy. Active sulfur is sulfur which is not fully oxidized, and can further oxidize to become more acidic in the medium in which it is located (e.g. lubricants). Elemental or divalent sulfur, for example, is active sulfur whereas sulfur in a sulfonate group is fully oxidized and thus would not be considered active sulfur. In particular wire rope applications, the wire rope may be exposed to elevated levels of active sulfur or active sulphur containing compounds. The presence of active sulfur or active sulfur containing compounds can increase the corrosion of metal within the wire rope.

Rust inhibitors within a lubricant can be evaluated for the ability to control steel corrosion by way of standard test method ASTM D665B. The ASTM D665B test involves determining whether rust formation occurs on a steel pin, which has been coated with a lubricant containing the rust inhibitor, after a pre-determined period of time in the presence of salt water. If the lubricant containing the rust inhibitor results in the formation of rust, it is graded a fail. Similarly, copper corrosion inhibitors within a lubricant can be evaluated for the ability to control copper corrosion by way of standard test method ASTM D130, in which corrosion, if it

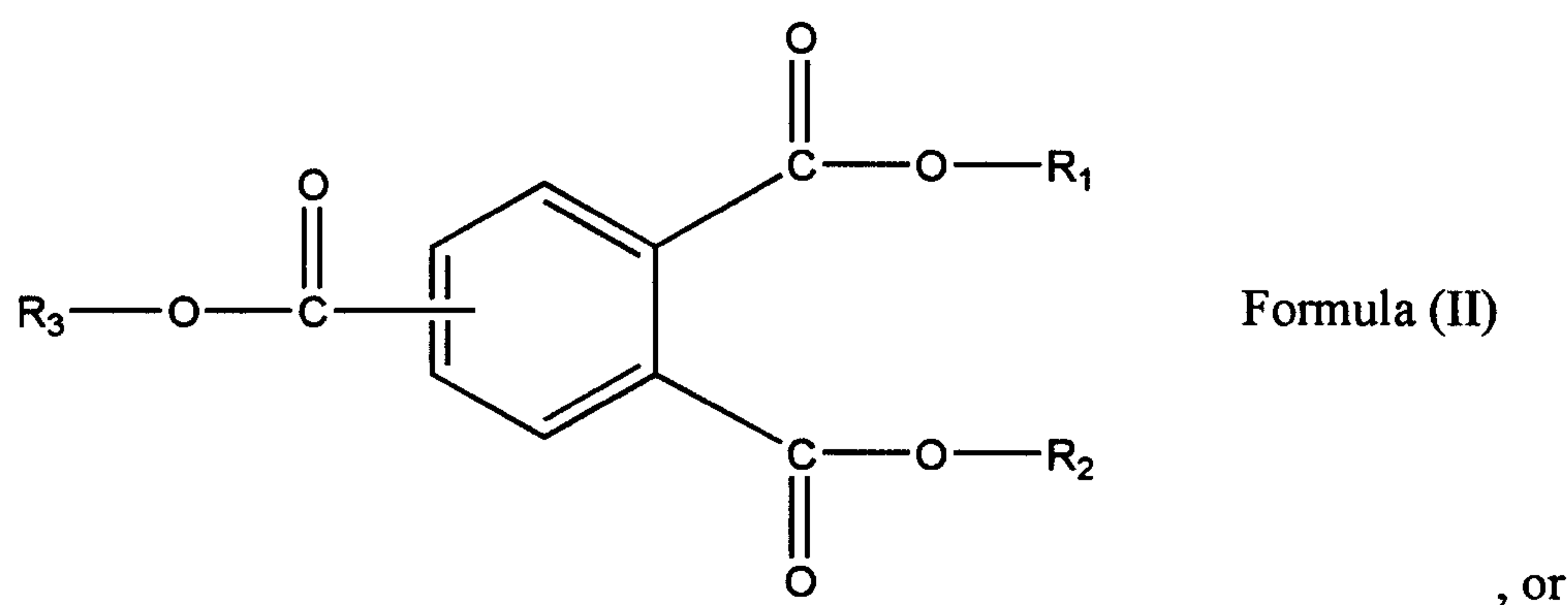
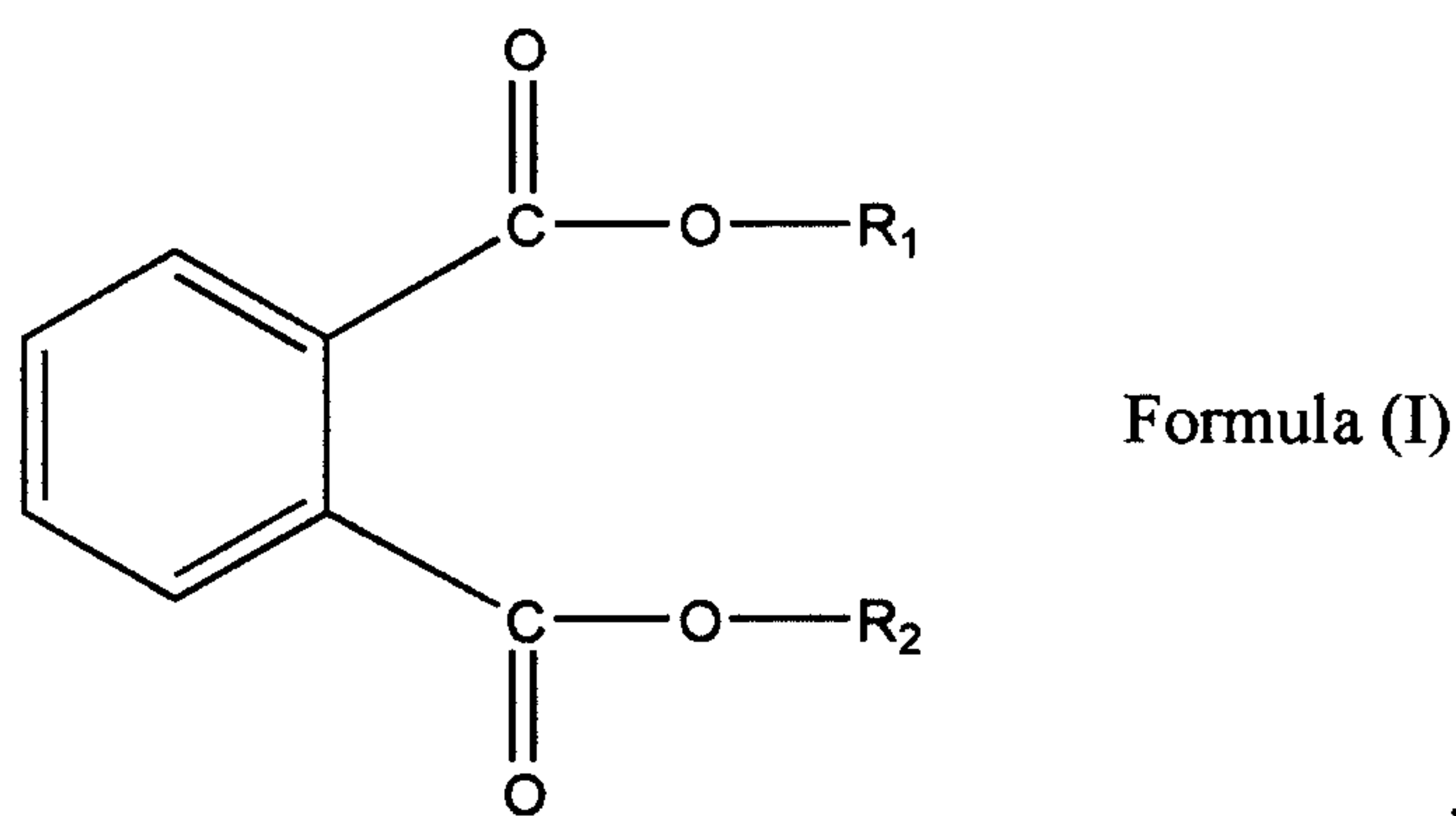
occurs, stains a test copper strip immersed in the lubricant containing the copper corrosion inhibitor. The stains are matched against photographs of standardized corroded strips. The results are then graded on a standard scale.

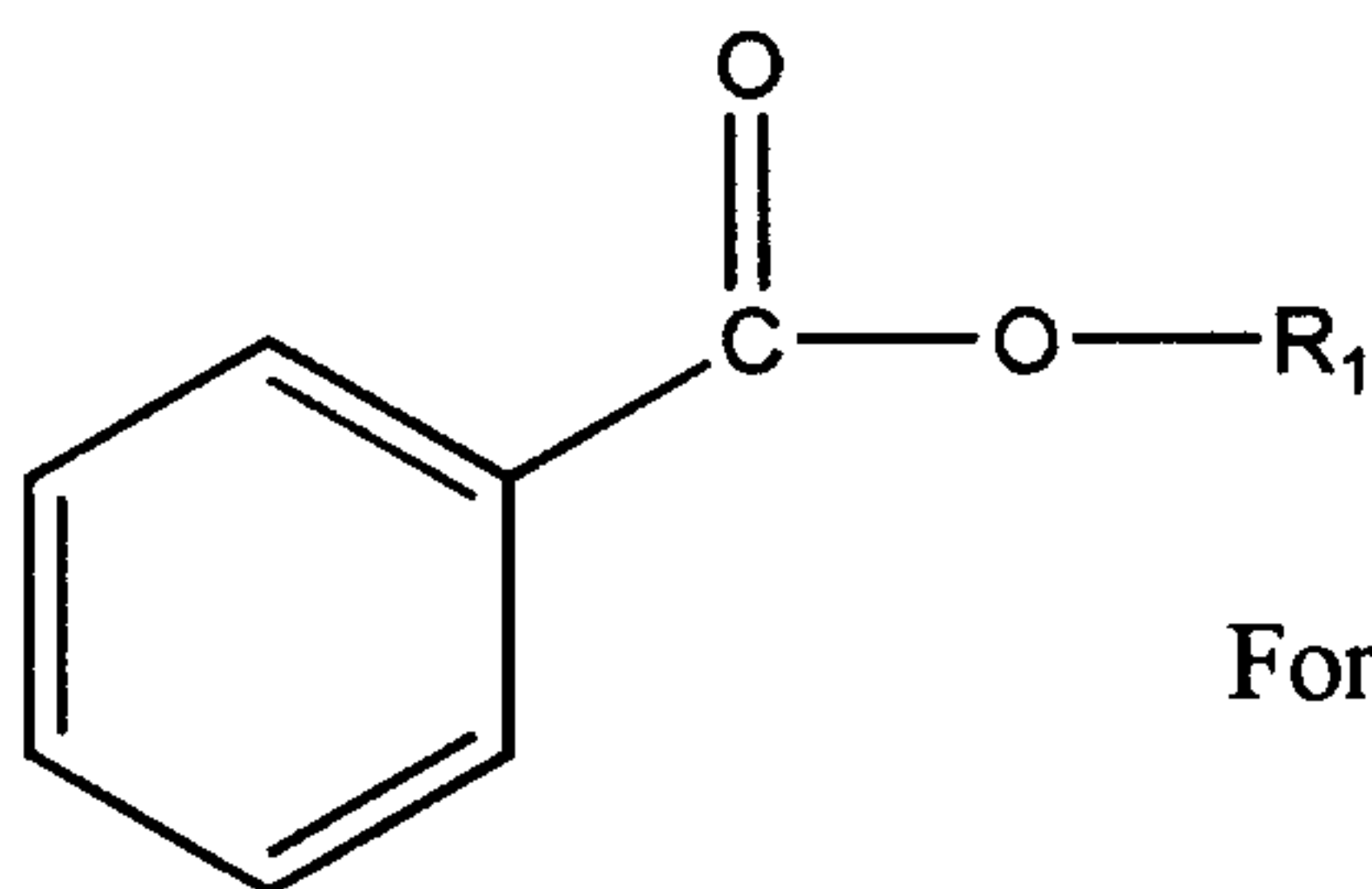
Lubricity Agents

Lubricity agents lower the boundary friction characteristics of a lubricant. Lubricity agents are sometimes referred to as film strength enhancers. In the context of a wire rope lubricant, a lubricity agent can increase the ability of a wire rope lubricant to decrease friction associated with the relative movement of components of the wire rope, thus decreasing metal loss through abrasive and adhesive wear. Lubricity agents can be physically adsorbed on metal surfaces and reduce friction even at relatively low temperature. This is in contrast to extreme pressure agents.

Many lubricity agents are commercially available. Chemically, lubricity agents may include organic fatty acids and amides, lard oils, vegetable oils, tallow, stearates, oleates, phosphoric acid esters, methyl esters and other derivatives of animal fat. Examples of commercially available lubricity include Emersol™ 110 (stearic acid), Emersol™ 213 (oleic acid), Emery™ 2203 (methyl tallowate esters), Emersol™ 2105 (lard oil), Carolubemet™ (methyl tallowate esters) and Additin™ RC 3580 (molybdenum dithiophosphate). Known lubricity agents may have adverse effects on the overall properties of wire rope lubricants in which they are found. More specifically, the acidic components of many known lubricity agents, such as, for example, stearic acid and oleic acid, may lead or contribute to an increased acidity of the lubricant. As such, the use of some known lubricity agents may increase wear and thus weaken the metal components of the wire rope.

It is preferable to use lubricity agents that do not lead to or contribute to an increased acidity of wire rope lubricants. The examples of known lubricity agents provided above, however, may contain substituent groups that can lead to or contribute to an increase in the acidity of wire rope lubricants in which these lubricity agents would be found. Such lubricity agents, therefore, would not usually be preferred for use in the composition. Instead, "low acidity" lubricity agents are preferred. Low acidity lubricity agents may be defined as those lubricity agents that do not contribute to an increase in the acidity of the wire rope lubricant (e.g. increase the TAN of a lubricant beyond the preferred range). A preferred example of suitable lubricity agents include phthalate ester compounds of formula (I), mellitate ester compounds of formula (II) and benzoate ester compounds of formula (III):





Formula (III)

wherein R_1 , R_2 and R_3 can be the same or different and may comprise substituted or unsubstituted straight or branched, saturated or unsaturated, including aromatic, hydrocarbon groups.

Preferably, R_1 , R_2 and R_3 may comprise substituted or unsubstituted straight or branched, saturated or unsaturated, including aromatic, hydrocarbon groups of C_3 to C_{20} . A preferred example of a lubricity agent consists of trioctyl trimellitate (TOTM) (Brascorp North America Ltd., Ontario, Canada), also known as 1,2,4-benzenetricarboxylic acid tris(2-ethylhexyl) ester.

A coefficient of friction found in many standard commercially available wire rope lubricants containing acidic lubricity agents, such as, for example, 0.08 to 0.13, can be achieved in the present composition with the use of "low acidity" lubricity agents. A lowering of the boundary friction characteristics of a lubricant would not be expected to be obtainable without the use of acidic lubricity agents common in many other wire rope lubricant formulations (e.g. stearic acid, oleic acid, tall oil fatty acids, etc.) The use of compositions containing lubricity agents that do not include such components is a benefit since it may be possible to ameliorate conditions that lead to or contribute to increased intergranular corrosion of the metal of wire ropes without detracting from lubrication performance of the lubricant.

Extreme Pressure and Anti-wear Agents

Boundary lubrication is desirable under very high pressure (e.g. heavy loading) and high temperature conditions and is achieved through the use of extreme pressure agents or additives (“EP” additives). EP additives are lubricant additives that inhibit metal surfaces in relative motion from welding and seizing under conditions of extreme pressure. EP additives can react with metal at the metal surface, under high pressures and temperatures to form substances that minimize welding, including spot-welding and subsequent wear. Highly active or “high activity” EP additives (i.e. high copper staining when assessed by ASTM D130) can react with metal at the metal surfaces in the area of frictional contact to form a low friction chemical film. More specifically, at the high local temperatures associated with metal-to-metal contact, an EP additive can combine chemically with the metal to form a surface film that inhibits the welding of opposing asperities and the consequent scoring that can be destructive to surfaces which undergo relative motion under high loads. Asperities are microscopic projections on metal surfaces resulting from normal surface-finishing processes. Interference between opposing asperities during relative motion may be a source of friction, and may lead to metal welding and scoring, i.e. distress marks on sliding metallic surfaces in the form of long, distinct scratches in the direction of motion. As the surfaces move relative to one another, collision of surface asperities produces localized flash temperature increases which activate the EP agents. EP agents react and plate out on the metal surface as a thin chemical film. Reactive compounds of sulfur, chlorine, or phosphorus are used to form these chemical films. Sulfide, chloride and phosphide films shear more easily than the metal itself; consequently, less frictional heat is generated and the potential for severe welding is reduced. Extreme-pressure agents function under boundary conditions where metal surfaces are in forceful intimate contact.

Anti-wear agents act by reducing metal-to-metal contact under moderate load conditions. For example, anti-wear additives, such as zinc dialkyldithiophosphates produce a film that protects the surface of the metal. As a result, this reduces friction and excessive wear. Other anti-wear additives may also contain reactive elements such as sulfur, phosphorus, etc. or a combination of these elements. These additives may also provide some degree of EP protection.

However, there can be problem associated with some known EP and anti-wear additives. Due to the reactive nature of the compounds contained therein, the presence of some EP additives may promote wear and intergranular corrosion within the wire rope. As such, there is a need to balance the protective activity of the EP and anti-wear additives with these deleterious effects, particularly the adverse corrosive effects, of the EP and anti-wear additives. It is preferred that the EP and anti-wear additives have a low percentage of active sulfur compounds, preferably less than 5%. It is further preferable that the EP and anti-wear additives do not significantly increase the acidity of the wire rope lubricant in which they are contained. It is preferred, therefore, that any EP and anti-wear additive to be used in the present invention have low active sulfur compound content, such as less than 10%, preferably $5\% \pm 2\%$, more preferably 0.5%, and not impact acidity into the wire rope lubricant. Such EP and anti-wear additives are generally referred to as medium or mild EP or anti-wear additives.

Many EP and anti-wear additives are commercially available. Chemically, these compounds can consist of zinc dithiophosphates, organic phosphates, acid phosphates, organic sulfur and chlorine compounds, sulfurized fats, sulfides and disulfides. Commercially available EP additives include, for example, AdditinTM RC 4410, AdditinTM RC 2540, AdditinTM RC 3180, AdditinTM RC 2515, SulpermTM 110 and LubrizolTM 5346. Preferred EP additives can

include AdditinTM RC 2515 and Sulperm 110, each having approximately less than 5% active sulfur compounds.

A preferred embodiment involves the use of AdditinTM RC 2515 (Rhein Chemie, Mannheim Germany) as the EP additive. AdditinTM RC 2515 is a catalytically sulfurized mixture of isobutylene, canola oil and the methyl esters of the fatty acids derived from canola oil. This is a medium to low activity EP additive as defined by ASTDM D130 copper corrosion test (e.g. medium to mild copper staining), which provides a balance of extreme pressure performance with low activity, so as not to promote wear. AdditinTM RC 2515 contains less than approximately 5% active sulfur compounds.

Commercially available anti-wear additives include DuradTM 310M, DuradTM 110, DuradTM 220, DuradTM 300, Tri-Cesyl-Phosphate and MolyvanTM A. Preferred anti-wear additives can include DuradTM 110, DuradTM 220, DuradTM 300, Tri-Cesyl-Phosphate. A preferred anti-wear additive is DuradTM 150 (Great Lakes Chemical Company, United States). DuradTM 150 is a tris-isopropylated phenyl phosphate ester. Such a phosphate ester is a mild anti-wear agent as defined by ASTDM D130 copper corrosion test. DuradTM 150 has a TAN of <0.1 and does not contain a significant amount of active sulfur compounds.

The effects of additives within a lubricant on wear can be demonstrated through standard test ASTM G77. Briefly, ASTM G77 is a method used to determine the extreme pressure or anti-wear properties of lubricants. A square steel block is placed below the circumference of a rotating steel ring, and the parts are immersed in the test lubricant. The load, i.e. the force applied to the ring on the block is increased during the test. A measurable wear scar is formed on the surface of the block, which was located below the steel ring. The test, therefore, can determine

the extent of steel wear, the coefficient of friction at a given load, as well as the wear scar volume, which is indicative of the amount of metal loss.

Timken EP test, as defined by ASTM D2782, is the measure of the extreme-pressure properties of a lubricant. The test utilizes a Timken machine, which consists of a stationary block pushed upward, by means of a lever arm system, against the rotating outer face of a roller bearing race, which is lubricated by the product under test. The test continues under increasing load until a measurable wear scar is formed on the block. Timken load is the heaviest load that a lubricant can withstand before the block is scored.

A common method of measuring wear can involve a “four-ball method”, such as the Four-Ball Wear Method as defined by ASTM D 2783. In this method, three steel balls are clamped together to form a cradle upon which a fourth ball rotates on a vertical axis. The balls are immersed in the lubricant under investigation. The Four-Ball Wear method can be used to determine the anti-wear and extreme pressure properties of lubricants operating under boundary lubrication conditions. They also help to define the activity of EP and anti-wear additives. The ASTM D 2783 standard test can be carried out at specified speeds, temperatures and loads, with the test being stopped when the seizure or “weld point” is reached. ASTM D 2783 provides the “load wear index”, which is the measure of the relative ability of a lubricant to inhibit wear under applied loads, and the “weld point”, which is the lowest applied load in kilograms at which the rotating ball seizes and welds to the three stationary balls.

Tackifiers

Tackifiers or tackiness agent are additives used to increase the adhesive properties of a lubricant, improve retention, and inhibit dripping and splattering. Several commercial examples of tackifiers are known. Commercially available tackifiers can include Infineum Paratac™, Lubrizol™ 5907 A, Functional Products V-176™ and Lumac Addco Addtac™. A preferred tackifier is Paratac™. Paratac™ is an approximately 2 million molecular weight polyisobutylene polymer.

The following non-limiting example provides an embodiment of the present invention.

EXAMPLE 1

A composition in accordance with the present invention has the following composition, as provided in Table I:

Table I Steel Wire Rope Lubricant	
Component	Percentage Volume
MCT™ 10	57.00%
MCT™ 60	32.26%
Alox™ 2283	2.14%
Trioctyl Trimelliate	5.00%
Additin™ RC2515	2.00%
Durad™ 150	0.50%
Paratac™	1.00%
Irgamet™ 39	0.10%

Table II provides the properties of the wire rope lubricant of Example 1:

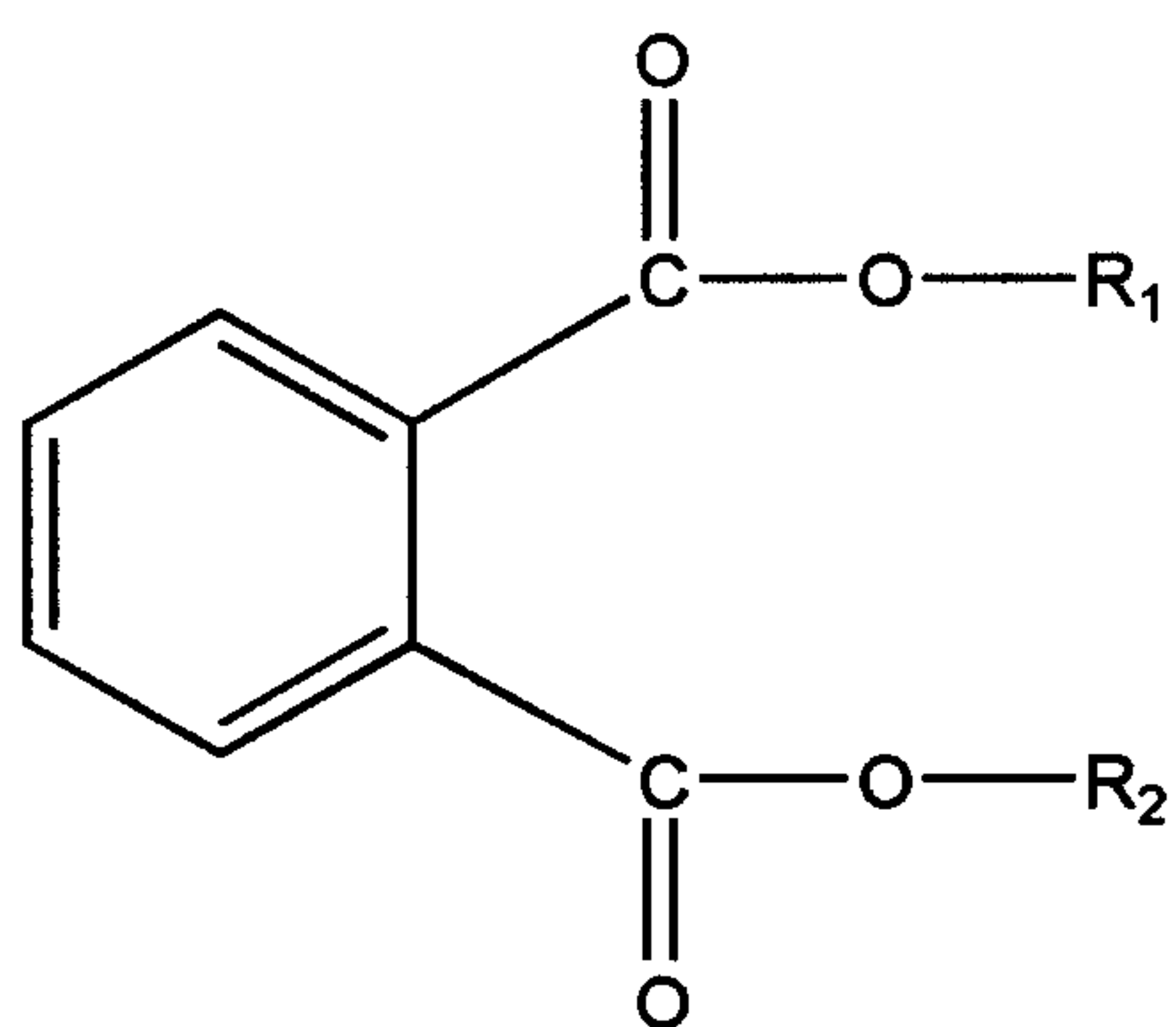
TABLE II Properties of Elbac K 68		
Property	Method	Result
Appearance	-	Clear & bright
Density at 15°C (or specific gravity?)	ASTM D4502	0.8875
Kinematic Viscosity (K.V.)	ASTM D445	
@100oC		9.11
@40oC		67.8
Viscosity Index (V.I.)	ASTM D 2270	109
Flash Point °C	ASTM D92	218
TAN	ASTM D664	0.3
Colour	ASTM D1500	<3.0
Rust Prevention	ASTM D665	Pass
Copper Corrosion	ASTM D130	1b
Oil Water Separability	ASTM D1401	32-0-48 (60 min.)
Timken Load	ASTM D 2782	<20 lbs
Load Wear Index	ASTM D 2783	30
Weld Point, kg	ASTM D 2783	200

Although the present invention has been described with respect to a specific preferred embodiment thereof, various changes and modifications may be suggested to one skilled in the art. Hence, it is intended that the present invention encompasses such changes and modifications as fall within the scope of the appended claims.

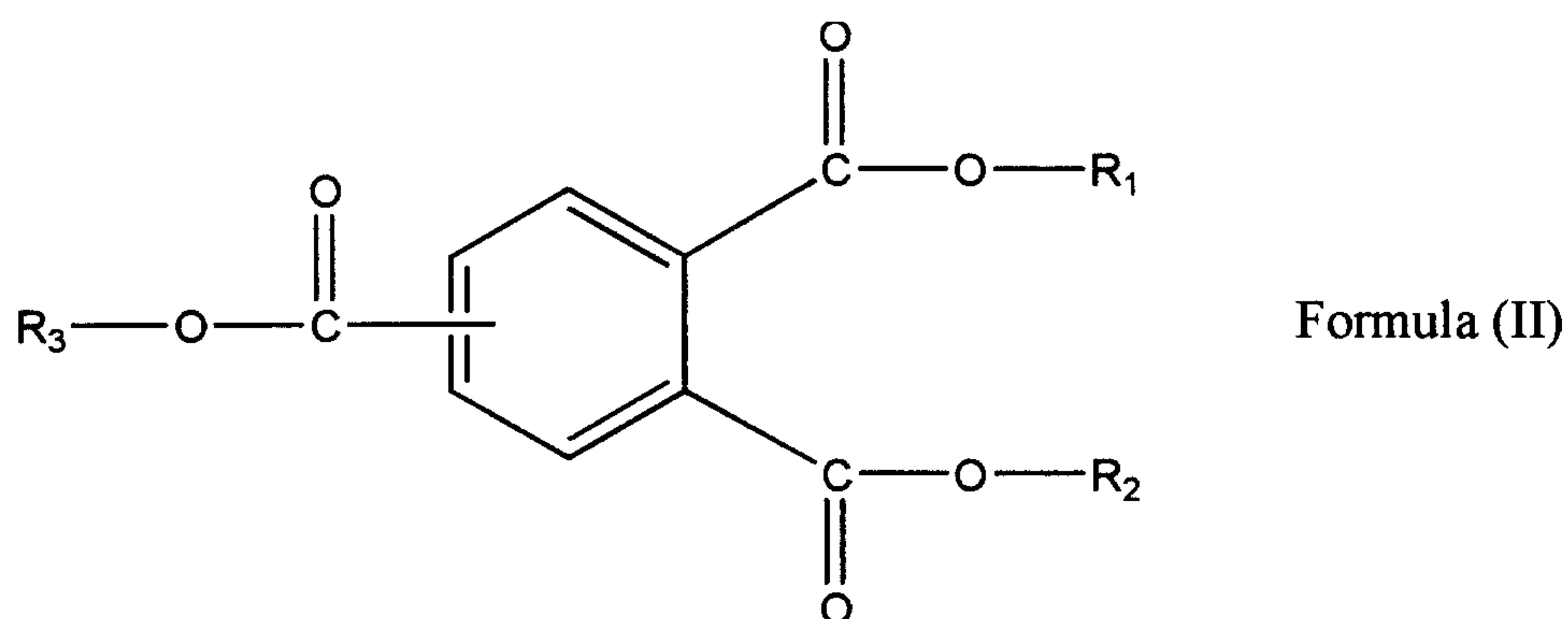
The embodiments of the present invention for which an exclusive privilege or property is claimed, are defined as follows:

1. A composition having a TAN of less than 5.0 and having a kinematic viscosity of between 20 ± 5 cSt and 250 ± 40 cSt at 40°C and a viscosity index of between 30 ± 10 and 120 ± 30 ; wherein the composition comprises:
 - (a) between 50 and 95 percent by volume (v/v) of a base fluid;
 - (b) between 1 and 8 percent by volume (v/v) of a low acidity lubricity agent;
 - (c) between 0.2 and 5.0 percent by volume (v/v) of a low acidity corrosion inhibitor;
 - (d) between 0.1 and 10 percent by volume (v/v) of an extreme pressure agent; and
 - (e) between 0.1 and 10 percent by volume (v/v) of an anti-wear agent.
2. The composition of claim 1, wherein the kinematic viscosity is 68 ± 10 cSt at 40°C and the viscosity index is between 100 and 110.
3. The composition of claim 1 or claim 2, wherein the TAN is less than 3.
4. The composition of any one of claims 1 to 3, wherein the TAN is less than 1.
5. The composition of any one of claims 1 to 4, wherein the TAN is between 0.3 to 0.8.
6. The composition of any one of claims 1 to 4, wherein the TAN is less than or equal to 0.3.
7. The composition of any one of claims 1 to 6, wherein the TAN is 0.3.

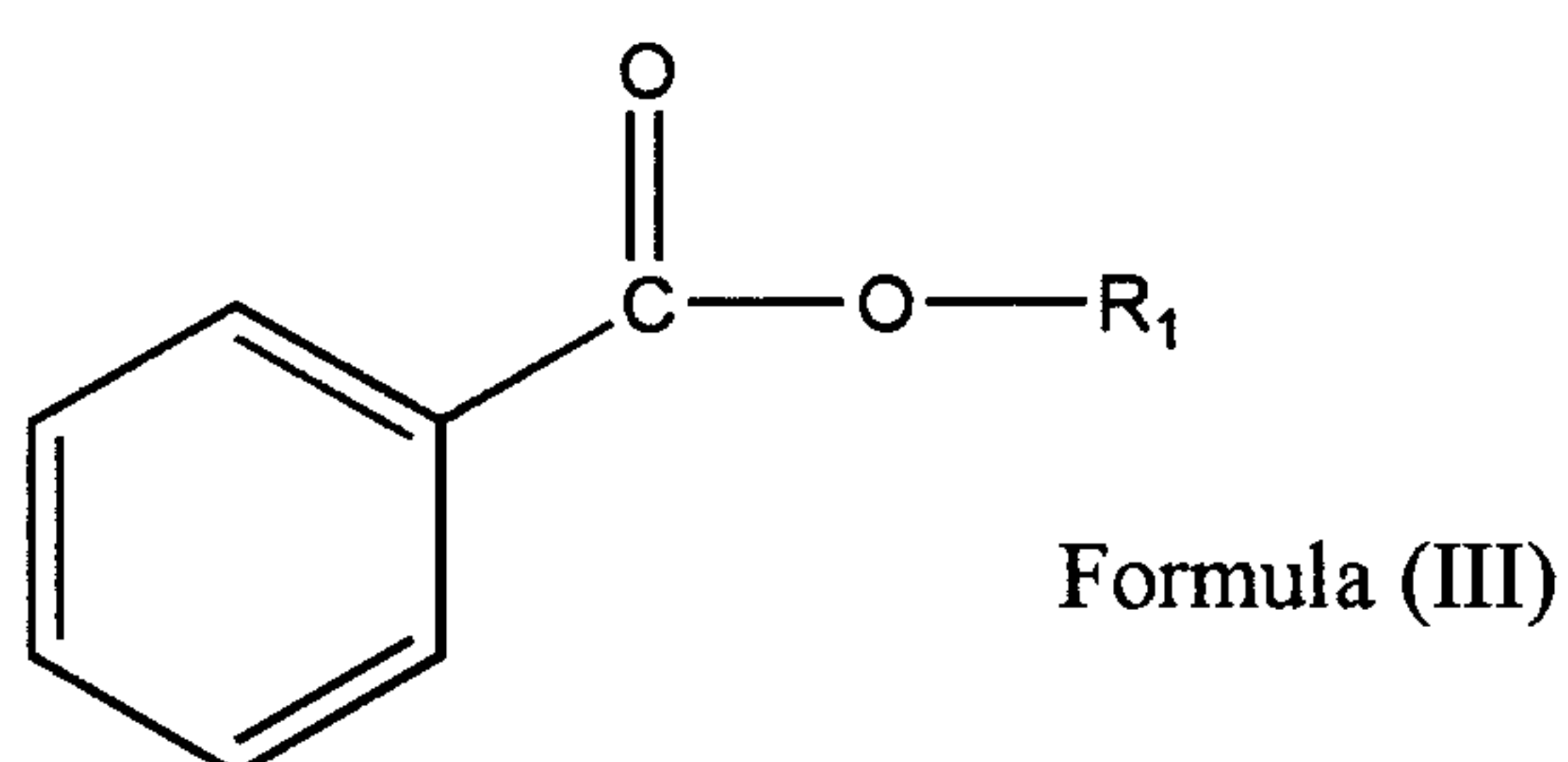
8. The composition of any one of claims 1 to 7, wherein the viscosity index is 109.
9. The composition of any of claims 1 to 8, wherein the base fluid is selected from the group consisting of petroleum derived base fluids, naphthenic base fluids and synthetic base fluids.
10. The composition of claim 9, wherein the base fluid is selected from Group I, II or III base-stock oils and Group IV or V base fluids.
11. The composition of claim 10, wherein the base fluid is selected from Group I, II or III base stock oils.
12. The composition of claim 11, wherein the base fluid is a combination of MCTTM 10 and MCTTM 60.
13. The composition of any one of claims 1 to 12, wherein the low acidity lubricity agents comprise compounds having the formula (I), (II) or (III);



Formula (I)



or



wherein R_1 , R_2 and R_3 can be the same or different and comprise substituted or unsubstituted straight or branched, saturated or unsaturated, including aromatic, hydrocarbon groups.

14. The composition of claim 13, wherein R_1 , R_2 and R_3 comprise substituted or unsubstituted straight or branched, saturated or unsaturated, including aromatic, hydrocarbon groups of C_3 to C_{20} .
15. The composition of claim 13 or 14, wherein the lubricity agent comprises 1,2,4-benzenetricarboxylic acid tris(2-ethylhexyl) ester.

16. The composition of any one of claims 1 to 15, wherein the corrosion inhibitor comprises a rust inhibitor, a copper corrosion inhibitor, or a combination thereof.
17. The composition of claim 16, wherein the rust inhibitor is selected from the group consisting of HitecTM 538, AloxTM 165 and Alox 2283.
18. The composition of claim 16 or 17, wherein the copper corrosion inhibitor is selected from a group consisting of substituted benzotriazole or substituted tolutriazole derivatives.
19. The composition of claim 16 or 17, wherein the copper corrosion inhibitor is selected from the group consisting of IrgametTM 30, IrgametTM 39, CobratecTM 911S, CobratecTM 122, and Ethyl Hitec 4313.
20. The composition of claim 19, wherein the copper corrosion inhibitor is IrgametTM 39.
21. The composition of any one of claims 1 to 20, wherein the extreme pressure agent has a percentage of active sulfur or active sulfur containing compounds of less than or equal to 10%.
22. The composition of claim 21 wherein the extreme pressure agent has a percentage of active sulfur or active sulfur compound of $5\% \pm 2\%$.
23. The composition of claim 21 wherein the extreme pressure agent has a percentage of active sulfur or active sulfur compound of 0.5%

24. The composition of any one of claims 1 to 23, wherein the anti-wear agent has a percentage of active sulfur or active sulfur containing compounds of less than or equal to 10%.
25. The composition of claim 21 wherein the antiwear agent has a percentage of active sulfur or active sulfur compound of $5\% \pm 2\%$.
26. The composition of claim 21 wherein the antiwear agent has a percentage of active sulfur or active sulfur compound of 0.5%.
27. The composition of any one of claims 21 to 23, wherein the extreme pressure agent is selected from the group consisting of AdditinTM RC 2515 and SulpermTM 110.
28. The composition of claim 27, wherein the extreme pressure agent is AdditinTM RC 2515.
29. The composition of any one of claims 24 to 26, wherein the anti-wear agent is selected from the group consisting of DuradTM 110, DuradTM 150, DuradTM 220, DuradTM 300, and tricresyl phosphate.
30. The composition of claim 29, wherein the anti-wear agent is DuradTM 150.
31. The composition of any one of claims 1 to 30 further comprising a tackifier.
32. A composition which comprises the following:

MCT TM 10	57.00 percent by volume (v/v)
MCT TM 60	32.26 percent by volume (v/v)
Alox TM 2283	2.14 percent by volume (v/v)
Trioctyl Trimellitate	5.00 percent by volume (v/v)
Additin TM RC2515	2.00 percent by volume (v/v)
Durad TM 150	0.50 percent by volume (v/v)
Irgamet TM 39	0.10 percent by volume (v/v)

33. The composition of claim 32 further comprising ParatacTM.
34. The composition of claim 33 further comprising 1.00 percent by volume (v/v) of ParatacTM.
35. A wire rope lubricant comprising 1,2,4-benzenetricarboxylic acid tris(2-ethylhexyl) ester.
36. The use of the composition of any one of claims 1 to 35 as a lubricant.
37. The use of the composition as recited in claim 36, wherein the lubricant is a wire rope lubricant.
38. The use of the composition as recited in claim 37, wherein the wire rope is a steel wire rope.
39. The use of the composition as recited in claim 38, wherein the steel wire rope is for use in a mining operation.
40. The use of the composition as recited in claim 39, wherein the mining operation further involves the mining of deposits containing pentlandite ore.
41. The use of the composition of claim 40 wherein the deposits contain nickel.
42. A method of manufacturing a wire rope comprising the step of applying the composition of any one of claims 1 to 35 to the wire rope prior to closing.
43. A method of lubricating a wire rope comprising the step of applying the composition of any one of claims 1 to 35 to the wire rope.
44. A wire rope having the composition of any one of claims 1 to 35 applied thereto.

45. The wire rope of claim 44, wherein the wire rope is a steel wire rope.