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(19) **United States**(12) **Patent Application Publication**
Pederson et al.(10) **Pub. No.: US 2013/0146009 A1**(43) **Pub. Date: Jun. 13, 2013**(54) **MICROENCAPSULATED ENGINE
LUBRICANT ADDITIVES***C10M 149/08* (2006.01)*C10M 145/20* (2006.01)*C10M 149/18* (2006.01)*C10M 145/22* (2006.01)(75) Inventors: **Thomas C. Pederson**, Rochester Hills,
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508/447; 508/575; 508/258(73) Assignee: **GM Global Technology Operations
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ABSTRACT(21) Appl. No.: **13/313,188**(22) Filed: **Dec. 7, 2011****Publication Classification**(51) **Int. Cl.***F01M 9/02* (2006.01)*C10M 149/20* (2006.01)*C10M 149/16* (2006.01)

An engine lubricating system for an internal combustion engine. The system comprises a vehicle engine; a circulation system for providing a continuing flow of lubricant to the vehicle engine and engine components; and a lubricant disposed within the circulation system. The lubricant comprises a base oil and at least one microencapsulated oil additive. The microencapsulated oil additive is selectively released into the lubricant based one or more localized event. The localized event may include a predetermined temperature change, a predetermined pH change, a localized high friction contact, and combinations thereof.

MICROENCAPSULATED ENGINE LUBRICANT ADDITIVES

FIELD

[0001] The present disclosure relates to lubricant additives for engine oils, and related methods for releasing the same.

BACKGROUND

[0002] The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present technology.

[0003] Engine oil (hereinafter “oil”) may lubricate moving components of an engine. For example, oil may lubricate pistons that reciprocate in cylinders, a crankshaft that rotates on bearings, and a camshaft that drives intake and exhaust valves. Oil may reduce friction between moving components. Accordingly, oil may reduce friction-related wear and heating in the engine. Oil may also coat metal components to inhibit corrosion.

[0004] Additives may be included in the oil to increase performance of the oil. By way of example, oil may include antioxidant additives that prevent the oil from thickening, friction modifier additives that increase fuel economy, or dispersant additives that hold contaminants in suspension. Oil may include anti-foam additives that inhibit the production and retention of air bubbles on the surface and in the oil. Oil may also include detergent additives that reduce deposits in an engine.

[0005] Used oil drained from internal combustion engines may contribute to soil, surface water, and groundwater contamination if not properly managed. Traditionally, vehicle motor oil may be changed on a routine basis, for example, at mileage or time intervals. These intervals are generally conservative to avoid any possibility of engine damage, and thus, lead to the need to responsibly dispose of billions of gallons of used oil per year. Accordingly, there remains a need for improved oil and/or additives in order to decrease the oil consumption or increase the time intervals between oil changes.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] In various aspects, the present teachings provide an engine lubricating system for an internal combustion engine. The system comprises a vehicle engine, a circulation system for providing a continuing flow of lubricant to the vehicle engine and engine components, and a lubricant disposed within the circulation system. The lubricant comprises a base oil and at least one microencapsulated oil additive. The microencapsulated oil additive is selectively released into the lubricant based on one or more localized event. The localized event may include a predetermined temperature change, a predetermined pH change, a localized high friction contact, and combinations thereof.

[0008] In other aspects, the present teachings provide an engine oil lubricant comprising a base oil and at least one microencapsulated oil additive. The microencapsulated oil

additive is selectively released into the engine oil lubricant based on one or more localized event. By way of example, the oil additive may include antioxidants, friction modifiers, dispersants, detergents, antifoam agents, aeration reducers, and combinations thereof. The oil additive may have a polymer coating including, for example, polyurethane, polyurea, polyester, polycyanoacrylate, phenol-formaldehyde, melamine-formaldehyde resin, and combinations thereof.

[0009] In still other aspects, the present teachings include a method for providing the controlled release of additives in engine oil lubricant circulating within an engine. The method comprises providing a base engine oil including at least one microencapsulated oil additive, and selectively releasing the microencapsulated oil additive into the engine oil lubricant based on one or more localized event within the engine.

[0010] Further areas of applicability and various methods of providing the controlled release of additives in engine oil lubricant will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DETAILED DESCRIPTION

[0011] The following description is merely illustrative in nature and is in no way intended to limit the disclosure, its application, or uses. As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A or B or C), using a non-exclusive logical “or.” It should be understood that steps within a method may be executed in different order without altering the principles of the present disclosure. Disclosure of ranges includes disclosure of all ranges and subdivided ranges within the entire range.

[0012] The headings (such as “Background” and “Summary”) and sub-headings used herein are intended only for general organization of topics within the present disclosure, and are not intended to limit the disclosure of the technology or any aspect thereof. The recitation of multiple embodiments having stated features is not intended to exclude other embodiments having additional features, or other embodiments incorporating different combinations of the stated features.

[0013] As used herein, the word “include,” and its variants, is intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that may also be useful in the materials, compositions, devices, and methods of this technology. Similarly, the terms “can” and “may” and their variants are intended to be non-limiting, such that recitation that an embodiment can or may comprise certain elements or features does not exclude other embodiments of the present technology that do not contain those elements or features.

[0014] Spatially relative terms, such as “inner,” “outer,” “beneath,” “below,” “lower,” “above,” “upper,” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s). Spatially relative terms may encompass different orientations of the device in use or operation.

[0015] The broad teachings of the present disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent to the skilled practitioner upon a study of the specification and the following claims.

[0016] The present technology relates to microencapsulated additives for oil compositions, and in particular, lubricant oil compositions used to lubricate various vehicle engines and components thereof, including gasoline and diesel engines as well as engines in various hybrid type vehicles. Vehicular engine oils are generally complex mixtures of chemical compounds and, in the simplest of terms, can be characterized by a base oil stock, or base oil, and a combination of additives, which may be collectively described as an additive package that is selected to improve specific performance attributes. As will be discussed, the engine oil lubricant of the present technology generally includes a base oil and at least one microencapsulated oil additive. The microencapsulated oil additive is selectively released into the engine oil lubricant based on one or more localized event. The present technology also provides an engine lubricating system for an internal combustion engine. The system comprises a vehicle engine, a circulation system for providing a continuing flow of engine oil lubricant to the vehicle engine and engine components, and a lubricant disposed within the circulation system.

[0017] The sequestration of engine oil additives in a microencapsulated state enables a slow and continuous release of additives based on localized events over the service life of the engine oil lubricant. One advantage of the present technology is an increased efficacy for additives that benefit from controlling the time and/or location of their respective release to when (i.e., during heavy tow of a trailer, or uphill driving) or where (i.e., adjacent a piston) they are most needed. Microencapsulation of additives may also serve to reduce the total amount of additive required, thereby reducing costs and unwanted emissions. The additive may be contained within a vesicle and undergo release by diffusion or rupture of the vesicle due to a high friction contact with a piston. Alternatively, the encapsulation may be by entrainment within a solid particulate matrix that slowly dissolves and releases the microencapsulated additive. In various aspects, the release rate of the microencapsulated additive need not be entirely passive, rather it can be responsive to specific conditions or localized events, such as elevated temperatures, changing pH, high friction contact between moving parts, or severe operating conditions.

[0018] Base Oil Stock

[0019] Base oil stocks have traditionally included mineral oil and petroleum hydrocarbons derived from crude oil. Increasingly, however, synthetic base stocks, such as polyalphaolefin or synthetic esters, and related synthetics, such as alkylated naphthalenes and alkylated benzenes may be used. The present technology is applicable with mineral oil derived base oils, as well as synthetic ester derived base oils, and the like. In general, both the base oil and the additive(s) are selected to convey desired oil attributes at a level commensurate with the oil's intended application.

[0020] Many of the components of vehicle engine oil, including the base oil stock, may remain substantially unaffected during use. Certain components may be consumed and used up during vehicle use. Still other components, though largely unaffected themselves, may become contaminated with combustion products. The need to change the oil in a vehicle engine may be driven by either the need to remove contaminants or the need to replenish the additive package that may be progressively consumed or "used up" with vehicle engine use. Although most of the base oil stock itself does not typically "break down" under normal circumstances,

minor quantities that lubricate the cylinder walls and migrate past the piston rings of an engine may combust in the combustion chamber. Accordingly, as referenced herein, "used oil" may be viewed as primarily unused oil (or base oil stock) with contaminants—coupled with an absence of, or a reduced quantity of, additives. In various aspects, the base oil may be tailored such that it does not degrade, or experiences only limited degradation, prior to the release of the microencapsulated oil additives. In certain aspects, the base oil of a vehicle engine may not need to be changed, or at least as not as frequently. Instead, the present technology provides that additional microencapsulated oil additives may be added to the existing base oil. Accordingly, the microencapsulated oil additive may be provided in an amount from about 5 wt % to about 20 wt %, or about 10 wt % to about 15 wt % in excess of a theoretical amount of additive required for the expected life of the engine.

[0021] Oil Additives

[0022] Conventional approaches to ensuring an on-going flow of suitable oil additives and lubricating oil in a vehicle engine over the vehicle lifespan have generally been based on the draining and discarding of used oil after a suitable use period and replacing it with fresh oil. Historically, the use period has been based on time or on distance traveled. Improved understandings of the degradation mechanisms of vehicle oil has led to the development of certain algorithmic or measurement-based techniques to more accurately identify, or estimate, the remaining lubricating capability of the oil. Even with these more sophisticated approaches to identify the end of useful life of engine oil, generally enabling less frequent oil changes, the basic approach of discarding and replacing oil is still a dominant approach to ensuring proper lubrication for vehicle engines.

[0023] The approach adopted with the present teachings relates to the use of microencapsulated engine oil lubricant additives. Various additives may be added to engine oil to increase performance of the oil, and such additives may be used in a variety of applications. The present technology may be applicable to all types of oil additives. Non-limiting oil additives can include antioxidants, friction modifiers, dispersants, detergents, antifoam agents, aeration reducers, surface tension modifiers, viscosity modifiers, corrosion inhibitors, pour point depressants, and mixtures and combinations thereof. As discussed below, the additives of the present technology are microencapsulated (i.e., micrometer in scale) with a thermoplastic or polymeric shell coating that can be custom formulated and tailored for a specific controlled release during use.

[0024] Additives that inhibit oxidative degradation may greatly extend service life and protect against high temperature engine failure. Non-limiting antioxidants useful with the present technology may include various organo-molybdenum compounds in an effort to reduce phosphorous levels in gasoline engine oils. For example, HPE, MBBP, and MBDTBP, which represent three different hindered phenolics, may be used with the engine oils according to the present technology. The ester HPE (3,5-di-tert-butyl-4-hydroxyhydrocinnamic acid) represents a mono-cyclic hindered phenolic. The dimer MBDTBP (4,4'-methylenebis(2,6-di-tert-butylphenol)) and oligomer MBBP (non-volatile multi-ring (methylene bridged) tert-butylphenolics) are of the same general class of hindered phenolic antioxidants having a CH₂ bridge between the phenolic aromatic rings. Each of these hindered phenolics are of low volatility and considered effective

tive antioxidants in high-temperature lubricant applications. A nonylated diphenylamine (NDPA) may also be used, and may be combined with hindered phenolics.

[0025] Friction modifier additives may reduce the coefficient of friction, and result in less fuel consumption. The structure of certain useful friction modifier additives may consist of molecular platelets or layers that may easily slide over each other. Non-limiting examples include graphite, molybdenum disulfide, boron nitride, tungsten disulfide, and polytetrafluoroethylene. A molybdenum dithiocarbamate (MoDTC) may be used as a friction reducer, as the molybdenum source may have beneficial anti-wear properties in addition to its antioxidant properties. Organic friction modifiers may include non-polar hydrocarbon chains with a polar end group having an affinity to the metal engine surface, including organic fatty or carboxylic acids, esters, ethers, amines, amides, imides, and metallo-organic compounds.

[0026] Anti-wear oil additives prevent or minimize direct metal-to-metal contact between engine components, resulting in longer life due to higher wear and score resistance. Non-limiting anti-wear oil additives may include zinc dithiophosphate (ZDP), zinc dialkyldithiophosphate (ZDDP), and tricresylphosphate (TCP).

[0027] Detergent oil additives may neutralize strong acids in the lubricant (such as sulfuric and nitric acid produced in internal combustion engines) and remove neutralization products from metal surfaces. Detergents can also be provided to form films on engine components, preventing high temperature deposition of sludge and varnish. Non-limiting detergent oil additives may include phenolates, sulphonates, and phosphonates of alkaline and alkaline-earth elements, including calcium, magnesium, sodium, and barium. Dispersant oil additives may keep foreign particles in a dispersed form. Non-limiting dispersant oil additives may include hydrocarbon succinimides.

[0028] As oil ages, it may lose its tendency to dispel air bubbles, which may cause problems with hydraulic functions of the oil. Thus, anti-foam, aeration reducers, and surface tension modifiers as known in the art, such as dimethylsilicones and dimethylsiloxanes, may also be provided as microencapsulated oil additives.

[0029] Microencapsulation Material

[0030] As known in the art, a wide range of materials and methods for encapsulation are commercially available that provide for a variety of strategies to create the degree of durability and method of release suitable to the intended use in motor oils. The present technology is not dependent on, nor limited to, any particular type of microencapsulating material or production method. Non-limiting polymeric shell materials suitable for use with the microencapsulation of additives according to the present technology may include polyurethanes, polyureas, polyesters, polycyanoacrylates, phenol-formaldehyde, melamine-formaldehyde resins, and combinations thereof. It is envisioned that certain hydrophobic polymers, such as poly(methylmethacrylate), may also be used. Various physical and chemical methods of microencapsulation may be used, depending upon the oil additive and the desired polymeric shell coating to be used.

[0031] In various aspects, the polymeric shell is selected so as to not be soluble in the base oil and to not degrade unless intended, for example, based on a localized event. In order for the microencapsulated oil additives to freely travel into small areas and without entrapment in a typical oil filter or the like, the microencapsulated oil additive may be provided with an

average particle size of less than about 15 μm , less than about 10 μm , less than about 5 μm , less than about 4 μm , or less than about 3 μm , and even smaller. Larger average particle sizes may be used if the conditions are warranted and the particular circulation system accommodates larger particles. It should be understood that particle size and morphology may be tailored to achieve the desired performance; they may also be tailored to accommodate various oil filters, filtration systems and their related requirements. In various aspects the thickness of the polymeric shell may be tailored for specific uses and release triggers, and may be less than about 2 μm , less than about 1 μm , less than about 0.5 μm , or less than about 100 nm, and even smaller.

[0032] The overall microencapsulated particle size and/or coating thickness can be tailored to assure the microencapsulated oil additives are not retained in currently used oil filters, although the filter minimum capture size could be modified for use with microencapsulated oil additives of the present technology. Other reasons for tailoring the size may include the durability of microcapsules exposed to moderate shear stress under general engine operating conditions. For example, larger capsules commonly produced by mechanical dispersion methods (typically 50-500 μm) may rupture too rapidly. However, microcapsule sizes extending down into the nanometer range can be created using known physicochemical methods. The production of smaller capsule sizes in the range of 10 μm or less by mechanical dispersion has been demonstrated by use of higher mechanical shear energy.

[0033] The subsequent durability and sensitivity of the polymeric shell to break down or "release" under localized events of mechanical or thermal stress, or other environmental factors, can be controlled by selection of monomer variants and use of crosslinking agents. For example, shell polymers such as poly(4-vinylpyridine) can be created to respond to a changing chemical environment, which will swell and accelerate release of the oil additive material when the pH increases or decreases to a predetermined level. Other shell polymers can be created having a thermal profile may degrade and accelerate release of the oil additive material when the temperature increases to a predetermined level.

[0034] It should be understood that the size of the remnants of the polymer shells (post oil additive release) should be tailored such that they will continue to circulate within the lubricant without agglomeration or otherwise be susceptible to entrapment within a filter material. Thus, in various aspects, the polymer shell may be tailored such that it degrades to fragments having an average particle size of less than about 1 μm , or less than about 0.1 μm , after the localized event.

[0035] Dispensing

[0036] Oil additives may deplete during operation of the engine. Accordingly, a microencapsulated oil additive according to the present disclosure may serve to "dispense" additives into the oil to replenish depleted additives during certain conditions or localized events. Methods of the present technology provide for the controlled release of the oil additives based on localized events that can be custom tailored and designed by the specific encapsulation material used, as well as its thickness. Non-limiting examples include a predetermined temperature change, a predetermined pH change, a localized high friction contact, and combinations thereof.

[0037] In various alternate aspects, the microencapsulated oil additive may be used with a system capable of determining a concentration of microencapsulated oil additives in the oil,

capable of determining an amount of additives that have been depleted during engine operation (or determining the amount of used polymeric shell present), and/or capable of dispensing microencapsulated oil additives when their concentration has decreased below a concentration threshold. The engine lubricating system may be provided with excess microencapsulated additives, or be provided with a separate additional supply of microencapsulated additives, including procedures and protocols for dispensing excess microencapsulated additives into the engine oil. One exemplary system for dispensing additives can be found in U.S. patent application Ser. No. 12/534,411, published as 2010/0228400 on Sep. 9, 2010, assigned to GM Global Technology Operations, Inc. and incorporated by reference in its entirety.

[0038] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. An engine lubricating system for an internal combustion engine, the system comprising:

- a vehicle engine;
 - a circulation system for providing a continuing flow of lubricant to the vehicle engine and engine components; and
 - a lubricant disposed within the circulation system, the lubricant comprising a base oil and at least one microencapsulated oil additive,
- wherein the microencapsulated oil additive is selectively released into the lubricant based on one or more localized event.

2. The system of claim 1, wherein the oil additive is selected from the group consisting of antioxidants, friction modifiers, dispersants, detergents, antifoam agents, aeration reducers, and combinations thereof.

3. The system of claim 1, wherein the microencapsulated oil additive comprises an oil additive enclosed within a polymer coating selected from the group consisting of polyurethanes, polyureas, polyesters, polycyanoacrylates, phenol-formaldehyde, melamine-formaldehyde resins, and combinations thereof.

4. The system of claim 1, wherein the microencapsulated oil additive has an average particle diameter size of less than about 10 μm .

5. The system of claim 1, wherein the localized event comprises a predetermined change in temperature of the lubricant.

6. The system of claim 1, wherein the localized event comprises a predetermined change in pH of the lubricant.

7. The system of claim 1, wherein the localized event comprises a high friction contact between an engine component and the encapsulated oil additive disposed within the lubricant.

8. The system of claim 1, wherein the microencapsulated oil additive is provided in an amount from about 10 wt % to about 15 wt % in excess of a theoretical amount of additive required for the expected life of the engine.

9. An engine oil lubricant, comprising:

- a base oil; and
 - at least one microencapsulated oil additive,
- wherein the microencapsulated oil additive is selectively released into the engine oil lubricant based on one or more localized event.

10. The engine oil lubricant of claim 9, wherein the microencapsulated oil additive has an average particle diameter of less than about 10 μm .

11. The engine oil lubricant of claim 9, wherein the oil additive is selected from the group consisting of antioxidants, friction modifiers, dispersants, detergents, antifoam agents, aeration reducers, and combinations thereof.

12. The engine oil lubricant of claim 9, wherein the oil additive comprises a hindered phenolic antioxidant.

13. The engine oil lubricant of claim 9, wherein the microencapsulated oil additive comprises an oil additive enclosed within a polymer coating selected from the group consisting of polyurethanes, polyureas, polyesters, polycyanoacrylates, phenol-formaldehyde, melamine-formaldehyde resins, and combinations thereof.

14. The engine oil lubricant of claim 13, wherein the polymer coating degrades to fragments having an average particle size of less than about 1 μm after the localized event.

15. The engine oil lubricant according to claim 9, wherein the selective release of the microencapsulated oil additive is based on a localized event selected from the group consisting of a predetermined temperature change, a predetermined pH change, a localized high friction contact, and combinations thereof.

16. The system of claim 9, wherein the base oil comprises a mineral oil derived mixture.

17. The system of claim 9, wherein the base oil comprises a synthetic ester derived mixture.

18. A method of providing the controlled release of additives in engine oil lubricant circulating within an engine, the method comprising:

- providing a base engine oil including at least one microencapsulated oil additive; and
- selectively releasing the microencapsulated oil additive into the engine oil lubricant based on one or more localized event within the engine.

19. The method according to claim 18, wherein the localized event comprises at least one of a predetermined temperature change, a predetermined pH change, a localized high friction contact, and combinations thereof.

20. The method according to claim 18, wherein the microencapsulated oil additive comprises an oil additive enclosed within a polymer coating selected from the group consisting of polyurethanes, polyureas, polyesters, polycyanoacrylates, phenol-formaldehyde, melamine-formaldehyde resins, and combinations thereof.

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