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WO 2025/059059 A1

(54) Title: SLURRY COMPOSITIONS COMPRISING MODIFIED NATURAL OIL SALTS, PROCESSES FOR PREPARING, AND APPLICATIONS THEREOF

(57) Abstract: A slurry composition comprising (i) a reaction product of (a) a maleated natural oil; and (b) base; (ii) at least one dispersed particle; and (iii) at least one solvent is disclosed in the present disclosure. Also disclosed is a ceramic coated separator; an energy storage device comprising the present ceramic coated separator, such as fuel cells, electrochemical cells, batteries, and capacitors; coating compositions; personal care composition; and agriculture compositions comprising the slurry composition of the present disclosure.

SLURRY COMPOSITIONS COMPRISING MODIFIED NATURAL OIL SALTS, PROCESSES FOR PREPARING, AND APPLICATIONS THEREOF

FIELD OF THE INVENTION

[0001] The presently disclosed process(es), procedure(s), method(s), product(s), result(s), and/or concept(s) (collectively referred to hereinafter as the "present disclosure") relates generally to slurry compositions comprising modified natural oils including their salts, and a process(es) for preparation thereof. The present disclosure further relates to various compositions derived from the present slurry composition.

[0002] Natural oils are abundant, inexpensive, and are derived from sustainable sources, and are one of the most promising raw materials for the synthesis of renewable compounds such as polymers, plastics, and plasticizers. These natural oils are inexpensive, highly abundant, come from reliable and sustainable sources, and have a high potential for modification. Natural oils are generally blends of different triglycerides, the esterification product of fatty acids and glycerol, and contain varying degrees of unsaturation (i.e., double bonds). Oils can be characterized by a hydroxyl value and fatty acid compositions. A difficulty with utilizing natural oils is that they are blends of triglycerides containing varying degrees of unsaturated double bonds which are relatively unreactive. To make these natural oils reactive, these unsaturated double bonds are generally chemically modified to make them reactive. For example, these unsaturated bonds can be reacted with maleates to provide natural oils chemically modified/functionalized with epoxide functional groups and succinic anhydride functional groups. These chemical modifications further allow the addition of many hydroxyl containing species to be introduced into the natural oils. The modified natural oils can be non-dispersible in water or alcohol. As a result, these oils can be incorporated into a wide variety of compositions and applications, for example personal care such as hair care, sun care, skin care, oral care; adhesives; coatings; paints; electronics; households; industrial and institutional (HI&I) compositions; inks; membranes; metal working fluids; oilfield chemicals; plastics and plasticizers; textiles; industrial products; biocides; nutraceuticals; and agrochemical compositions.

[0003] US Patent 9809538B2 describes a modified natural compound synthesized from an epoxidized natural fatty acid, maleated natural fatty acid, epoxidized natural oil, or maleated

natural oil and a lactam compound having at least one hydroxyl group, wherein the modified natural compound has utility in, e.g., adhesive or beverage compositions.

[0004] A discussion of the reaction scheme for the maleation reaction in vegetable oil is provided in the article "Maleated soybean oil and its multifunctional properties," by Gripp, Anna A., Steinberg, David C., published in Cosmetics Exhibition & Conference Proceedings, Barcelona, Mar. 22-24, 1994.

[0005] A discussion of the reaction scheme for the maleation reaction in vegetable oil is provided in the article "Microwave Assisted Syntheses of Vegetable Oil Based Monomer," by Rafael T. Alarcon et al., published in Journal of Polymers and the Environment 28:1265–1278, 2020.

[0006] A discussion of the generalized reaction between maleic anhydride and unsaturated vegetable oils is provided in the Handbook of Maleic Anhydride Based Materials: Syntheses, Properties and Applications by Osama M. Musa in chapter 3 page 166, published in Springer International Publishing Switzerland 2016.

[0007] US Patent No. 2754306A describes a reaction of soybean oil, maleic anhydride and iso-octyl alcohol to provide an improved plasticizer for nitrocellulose compositions.

[0008] PCT Publication No. 2019113068A1 describes a technology related to metalworking fluids comprising maleated soybean oil derivatives.

[0009] A discussion of maleic anhydride polymerization and modified plant oils with polyols is provided in the article "Polymerization of Maleic Anhydride–Modified Plant Oils with Polyols," by Tarik Eren, Selim H. Kusefoglu, Richard Wool published in Journal of Applied Polymer Science, Barcelona, Volume 90, Issue 1, Pages 197-202, 2003.

[0010] US Patent No.2754306A describes a reaction of soybean oil, maleic anhydride and iso-octyl alcohol to provide an improved plasticizer for nitrocellulose compositions.

[0011] PCT Publication No. 2005071050A1 describes a succinated triglyceride oil derived from maleating triglyceride oil from a plant or land animal for use as an emulsifying agent for metalworking fluids.

[0012] US Patent Application Publication No. 20180070584A1 describes an adjuvant composition that includes a maleated natural oil derivative obtained from the reaction of a maleated natural oil and a derivative compound such as polyoxyalkylene glycol, mono-alkyl polyoxyalkylene glycol, polyetheramine, alkyleneamine, alkanolamine, thiol-terminated polyoxyalkylene glycol, ammonia, Group IA metal hydroxide, Group IIA metal hydroxide or mixture thereof.

[0013] US Patent No. 10889693 B2 teaches a composition including a modified oil alkyl ester and/or modified oil aryl ester having the transesterification reaction product of an oil (soybean oil) and a surfactant having hydroxy group.

[0014] US Patent No. 5733970 A teaches an aqueous dispersed, epoxy crosslinked maleated oil (maleated glyceride oil) microgel polymers for protective coatings.

[0015] US Application Publication No. 20130210630 A1 teaches a self-emulsifying oil having a modified vegetable oil which is modified with a moiety more polar than the vegetable oil and the polar moiety is attached by a covalent bond to the vegetable oil and an active ingredient.

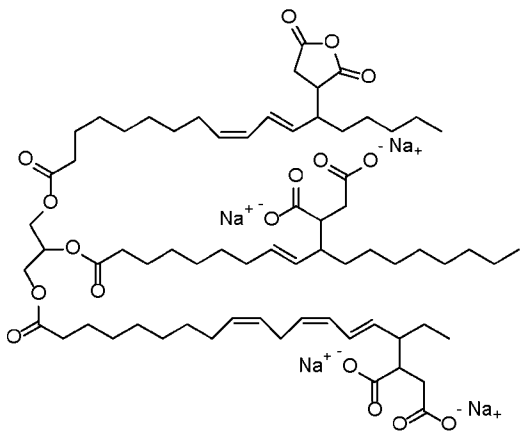
[0016] Despite the renewability, biodegradability, sustainability, and beneficial functions provided by natural fatty acids, natural oils, and their maleated counterparts, they exhibit properties that can limit their application. For example, maleated soybean oil is insoluble and non-dispersible in water or alcohols. As a result, these oils may tend to exude or phase-separate from formulated compositions. This feature makes their formulation more difficult, often requiring additional ingredients to facilitate solutions, emulsions, or dispersion. Natural and maleated natural oils may not impart the desired properties needed in end-uses, such as solubilization capability, glass transition, flexibility, shine, and/or plasticization. Consequently, the performance (including, but not limited to stability, resistance to phase separation, absorption, clean-up, solubility potential, staining potential, lubrication, film formation, uniformity of spreading, comedogenic tendency, ease of removal), may be less than desired. Finally, although such natural oils are an important renewable material, they are not always the formulator's first choice, and, in fact, often are not considered at all.

[0017] Accordingly, there still felt an utmost need for further modification of these modified natural oils which do not exhibit the limited properties of modified natural oils and for various compositions derived therefrom.

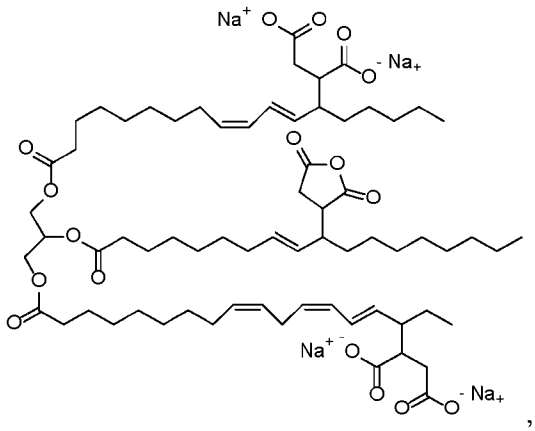
SUMMARY OF THE INVENTION

[0018] In one aspect, the present disclosure provides a slurry composition comprising: (i) a reaction product of (a) a maleated natural oil comprising a natural oil with maleated functionality; and (b) a base; (ii) at least one dispersed particle; and (iii) at least one solvent. In one non-limiting embodiment of the present disclosure, the reaction product comprises a maleated functionality fully or partially reacted with the base. In another non-limiting embodiment of the present disclosure, the base is selected from the group consisting of inorganic bases, organic bases, and mixtures thereof. In a still another non-limiting embodiment of the present disclosure, the maleated natural oil is selected from the group consisting of maleated avocado oils, maleated coconut oils, maleated corn oils, maleated cottonseed oils, maleated jojoba oils, maleated linseed oils, maleated nut oils, maleated olive oils, maleated palm oils, maleated raisin oils, maleated rapeseed oils, maleated safflower oils, maleated sesame oils, maleated soybean oils, maleated squash oils, maleated sunflower oils, maleated almond oils, maleated canola oils, maleated flaxseed oils, maleated grapeseed oils, maleated palm kernel oils, maleated peanut oils, maleated walnut oils, maleated chickpea oils, maleated clary sage oils, and mixture thereof. In one non-limiting embodiment of the present disclosure, the maleated natural oil is a maleated soybean oil.

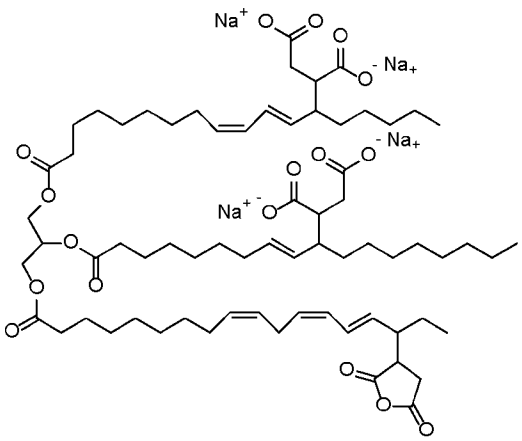
[0019] In one non-limiting embodiment of the present disclosure, the reaction product comprises one or more structures selected from the group consisting of the following structures:



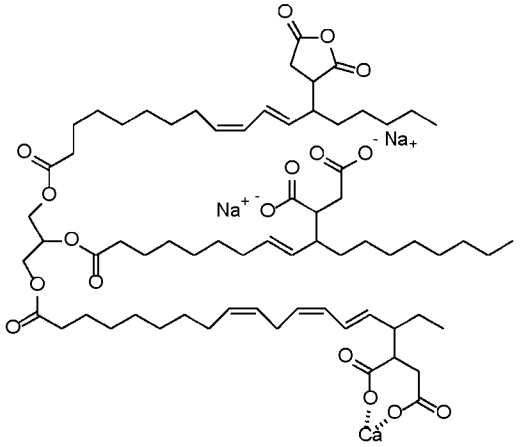
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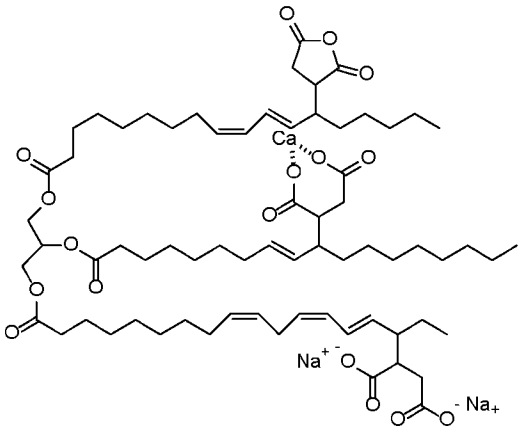
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- Na+
- Na+
Na+ -

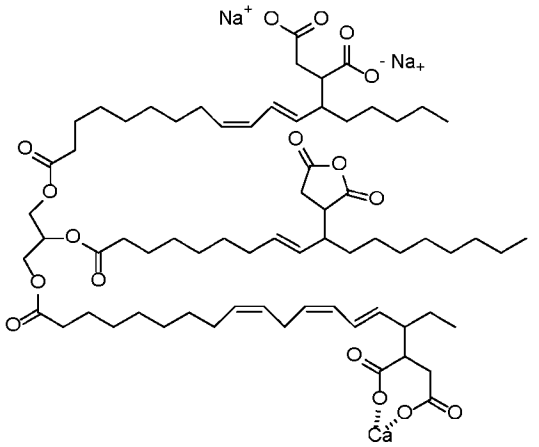
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- Na+
Na+ -
Ca

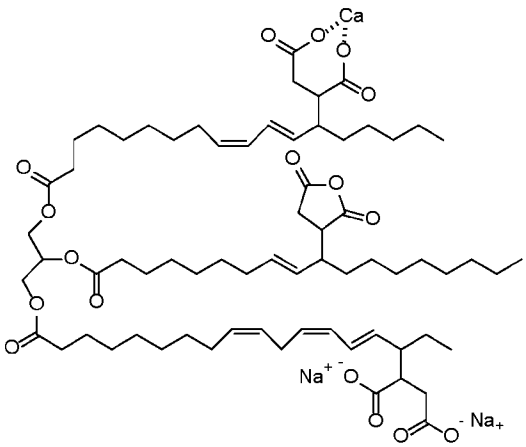
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Ca
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- Na+

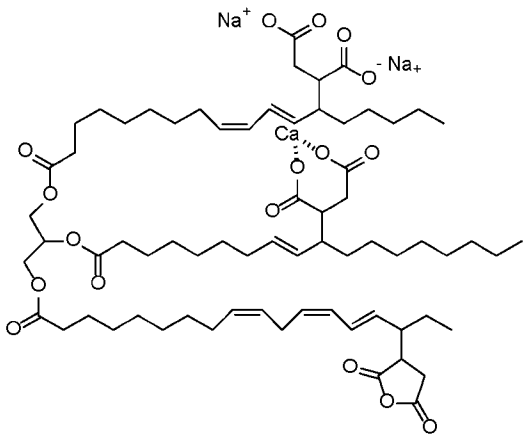
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Na+
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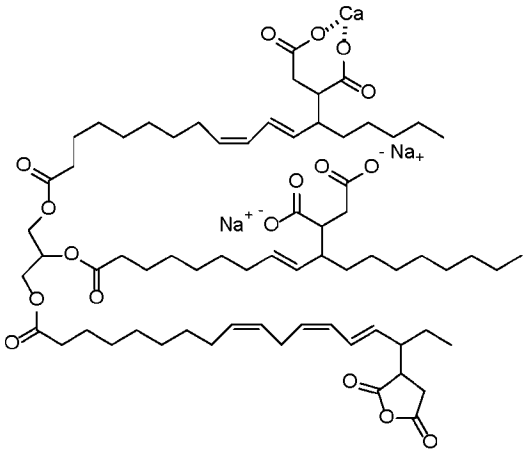
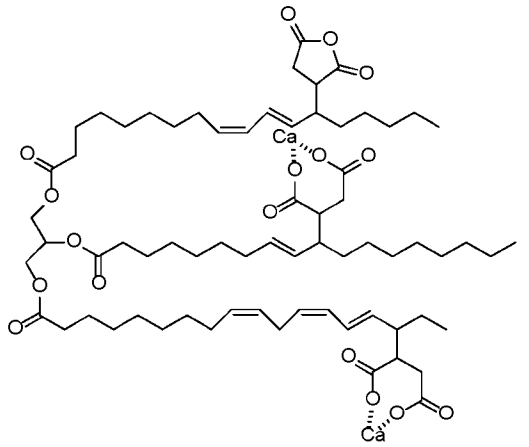
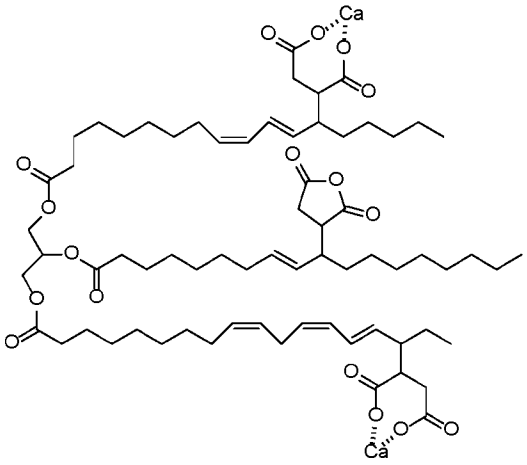
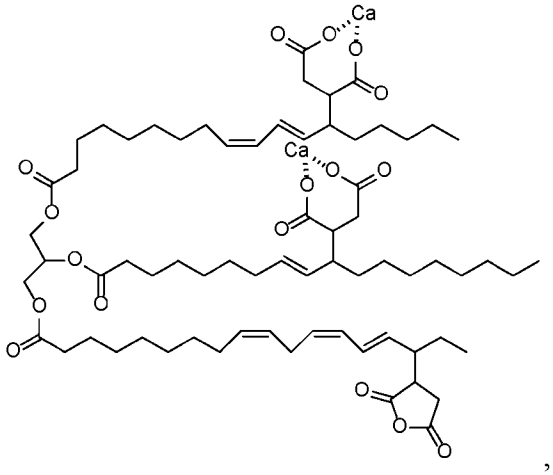
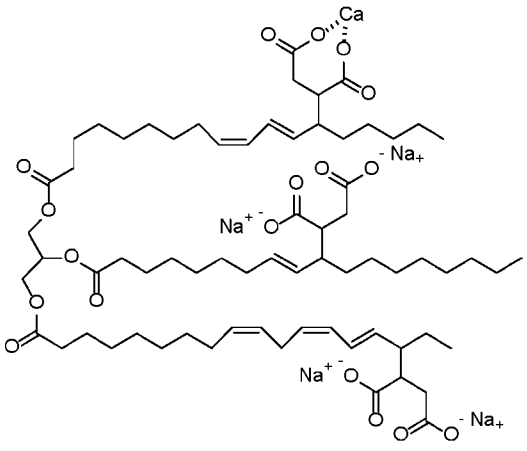
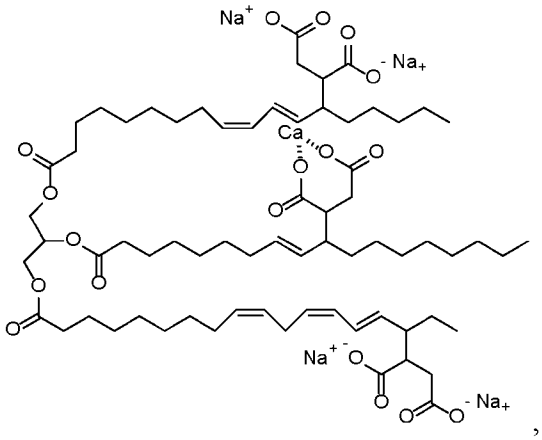
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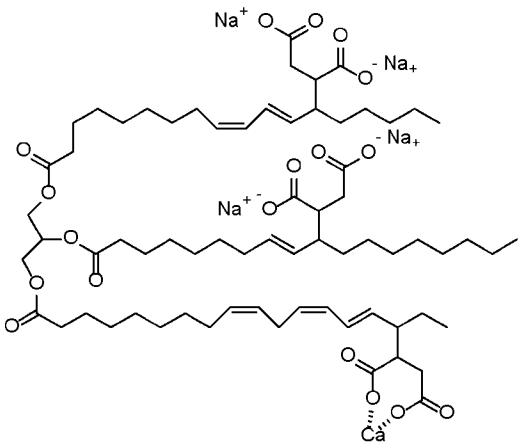
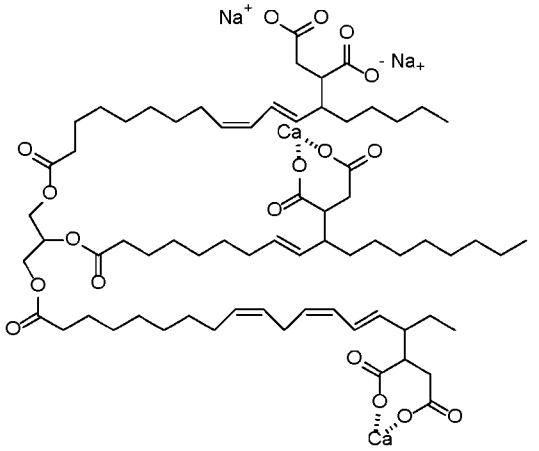
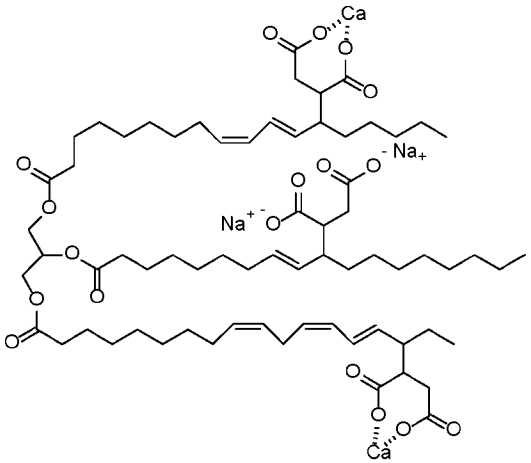
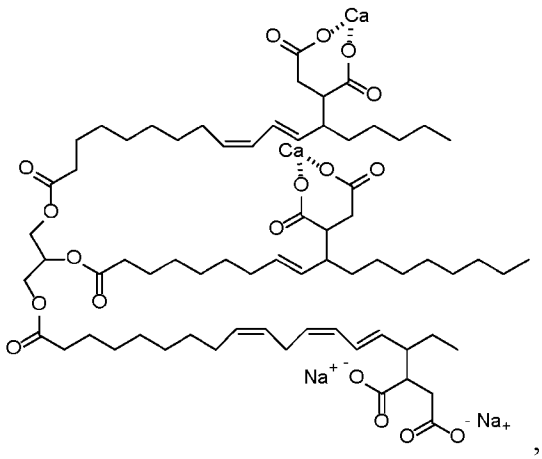
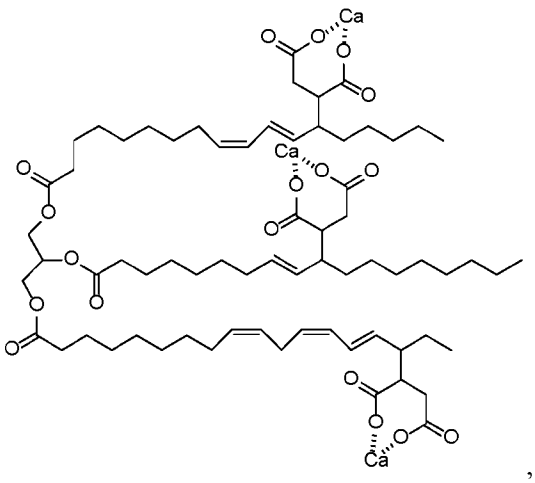
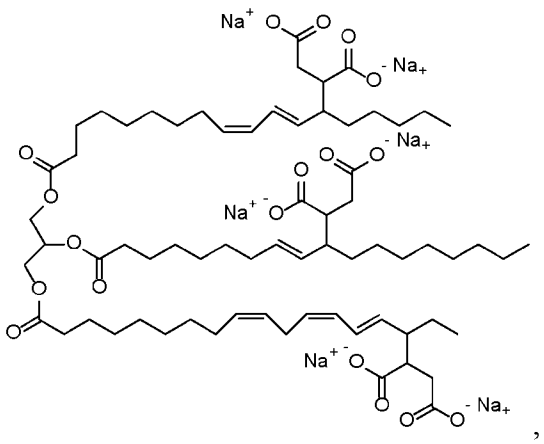

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and combinations thereof.

[0020] In another non-limiting embodiment of the present disclosure, the dispersed particle is selected from the group consisting of alumina, alumina oxide hydroxide, SiO_2, $BaSO_4$, TiO_2, SnO_2, CeO_2, ZrO_2, $BaTiO_3$, Y_2O_3, B_2O_3, carbon nano tube, ZnO, Al-doped Lithium Lanthanum Zirconate Oxide (LLZO), and combinations thereof. In a still another non-limiting embodiment of the present disclosure, the dispersed particle is in powder form. In a yet another non-limiting embodiment of the present disclosure, the dispersed particle has a particle size distribution (d50) in the range of from about 0.05 μm to about 50.0 μm.

[0021] In another non-limiting embodiment of the present disclosure, the solvent is selected from the group consisting of at least one aqueous solvent; alcohols; phenols, acetates; ketones; ethylene glycols; propylene glycols; amides; pyrrolidones; hydroxyesters; sulfoxides; lactones; anilines; hydrocarbons; halogenated solvents; aromatic solvents; glycol esters; and combinations thereof.

[0022] In a still another non-limiting embodiment of the present disclosure, the slurry composition is selected from the group consisting of agriculture compositions, biocidal compositions, ceramic slurry compositions, cleaning compositions, coating compositions, personal care composition , construction compositions, disinfecting compositions, energy compositions, food compositions, homecare compositions, industrial and institutional compositions, laundry compositions, nutraceutical compositions, oral care compositions, preservative compositions, textile compositions, carbon nano-tube compositions, battery compositions, and ceramic coated separators for batteries. In yet another non-limiting embodiment of the present disclosure, the slurry composition is a personal care composition, a coating composition, a food composition, an agricultural composition, or a carbon nanotube composition.

[0023] Another aspect of the present disclosure provides an energy storage device comprising the ceramic coated separator according to the present disclosure, wherein the energy storage device is selected from the group consisting of fuel cells, electrochemical cells, batteries, and capacitors.

[0024] Still another aspect of the present disclosure provides a battery, comprising: (i) at least one ceramic coated separator according to the present disclosure; (ii) at least one cathode; and (iii) at least one anode.

[0025] Another aspect of the present disclosure provides a coating composition comprising the slurry of the present disclosure. In one non-limiting embodiment of the present disclosure, the slurry is present in the range of from about 0.1 wt.% to about 95.0 wt.% of the coating composition.

[0026] Still another aspect of the present disclosure provides a personal care composition comprising the slurry of the present disclosure. In one non-limiting embodiment of the present disclosure, the slurry is present in an amount of from about 0.1 wt.% to about 95.0 wt.% of the personal care composition.

[0027] Another aspect of the present disclosure provides an agriculture composition comprising the slurry of the present disclosure. In one non-limiting embodiment of the present disclosure, the slurry is present in an amount of from about 0.1 wt.% to about 95.0 wt.% of the agriculture composition.

[0028] Another aspect of the present disclosure provides a carbon nanotube composition comprising the slurry of the present disclosure. In one non-limiting embodiment of the present disclosure, the slurry is present in an amount of from about 0.1 wt.% to about 95.0 wt.% of the carbon nanotube composition.

DETAILED DESCRIPTION OF THE INVENTION

[0029] Before explaining at least one embodiment of the inventive concept(s) in detail by way of exemplary drawings, experimentation, results, and laboratory procedures, it is to be understood that the inventive concept(s) is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings, experimentation and/or results. The inventive concept(s) is/are capable of other embodiments or of being practiced or carried out in various ways. As such, the language used herein is intended to be given the broadest possible scope and meaning; and the embodiments are meant to be exemplary - not exhaustive. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[0030] Unless otherwise defined herein, scientific, and technical terms used in connection with the present disclosure shall have the meanings that are commonly understood by those of ordinary skill in the art.

[0031] All patents, published patent applications, and non-patent publications mentioned in the specification are indicative of the level of skill of those skilled in the art to which this present disclosure pertains. All patents, published patent applications, and non-patent publications referenced in any portion of this application are herein expressly incorporated by reference in their entirety to the same extent as if each individual patent or publication was specifically and individually indicated to be incorporated by reference.

[0032] All of the compositions and/or methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the compositions and methods of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the compositions and/or methods and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit and scope of the invention. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept of the inventive concept(s) as defined by the appended claims.

[0033] As utilized in accordance with the present disclosure, the following terms, unless otherwise indicated, shall be understood to have the following meanings:

[0034] The use of the word "a" or "an" when used in conjunction with the term "comprising" in the claims and/or the specification may mean "one," but it is also consistent with the meaning of "one or more," "at least one," and "one or more than one." The use of the term "or" in the claims is used to mean "and/or" unless explicitly indicated to refer to alternatives only or the alternatives are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and "and/or." Throughout this application, the term "about" is used to indicate that a value includes the inherent variation of error for the device, the method being employed to determine the value, and/or the variation that exists among the study subjects. The use of the term "at least one of X, Y and Z" will be understood to include X alone, Y alone, and Z alone, as well as any combinations of X, Y and Z.

[0035] As used in this specification and claim(s), the words "comprising" (and any form of comprising, such as "comprise" and "comprises"), "having" (and any form of having, such as "have" and "has"), "including" (and any form of including, such as "includes" and "include") or "containing" (and any form of containing, such as "contains" and "contain") are inclusive or open-ended and do not exclude additional, unrecited elements or method steps.

[0036] The term "or combinations thereof" as used herein refers to all permutations and combinations of the listed items preceding the term. For example, "A, B, C, or combinations thereof" is intended to include at least one of: A, B, C, AB, AC, BC, or ABC, and if order is important in a particular context, also BA, CA, CB, CBA, BCA, ACB, BAC, or CAB. Continuing with this example, expressly included are combinations that contain repeats of one or more item or term, such as BB, AAA, MB, BBC, AAABCCCC, CBBAAA, CABABB, and so forth. The skilled artisan will understand that typically there is no limit on the number of items or terms in any combination, unless otherwise apparent from the context.

[0037] The term "each independently selected from the group consisting of" means when a group appears more than once in a structure, that group may be selected independently each time it appears.

[0038] The term "polymer" refers to a compound comprising repeating structural units (monomers) connected by covalent chemical bonds. Polymers may be further derivatized, crosslinked, grafted or end-capped. Non-limiting examples of polymers include copolymers, terpolymers, tetra polymers, quaternary polymers, and homologues. The term "copolymer" refers

to a polymer consisting essentially of two or more different types of monomers polymerized to obtain said copolymer.

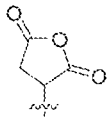
[0039] The term “reaction product” refers to a substance produced from a chemical reaction of one or more reactant substances.

[0040] The term “natural oil” refers to compounds comprising triglycerides and may contain varying levels of fatty acids, monoglycerides, diglycerides and triglycerides refer to oil derived from plants or animal sources. Natural oils also include fatty acid glyceryl esters, which are synthesized by reacting glycerol with 1, 2, or 3 molar equivalents of a fatty acid or a mixture of fatty acids. These compounds can be mono, di or triglycerides of a single fatty acid or a mixture of fatty acids.

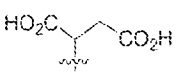
[0041] As used herein the terms, “maleated natural oil” or “natural oil with maleated functionality”, can be used interchangeable without limiting the scope of the present disclosure, and refer to natural oil comprising at least one maleated functionality. Accordingly, the term "maleation" or "maleated" as used hereafter should be understood to mean "functionalization" in so far as the use of functionalizing reagents other than maleic anhydride are contemplated for use in the present disclosure.

[0042] As used herein, the term “moiety” or “moieties” refers to a part or a functional group(s) of a molecule.

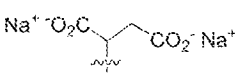
[0043] The terms, “maleated functionality” refers to moieties formed by attaching maleic anhydride to unsaturated fatty acyl chains, found in natural oils, by ene reaction. “Maleated functionality” includes, but is not limited to, the cyclic anhydride form (I), the diacid form (II), the disodium dicarboxylate form (III), other dicarboxylate salt forms, and the half ester form (IV). Since the carbon-carbon double bond of maleic anhydride becomes a saturated carbon-carbon single bond during the ene reaction, the “maleated functionality” pictured in I, II, III and IV might also be called by one of ordinary skill in the art succinic anhydride, succinic acid, succinate salt or succinate half ester functionality.



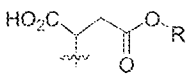
I



II



III



IV

[0044] The term "base", as used herein, refers to any substance which can alter the pH of a solution from a neutral pH of 7.0 to a basic pH (i.e., 7.1 to 14.0). Typically, a base is a substance of a large class of compounds with one or more of the following properties: bitter taste, slippery feeling in solution, ability to turn litmus blue and to cause other indicators to take on characteristic colors, ability to react with (neutralize) acids to form salts includes both organic base or an inorganic base and mixtures thereof.

[0045] The term "organic base", as used herein, includes ammonia, primary amines, secondary amines, tertiary amines, pyridine, imidazole, benzimidazole, histidine, guanidine, and mixtures thereof.

[0046] The term "inorganic base", as used herein, includes oxides of alkali metals and alkaline earth metals, hydroxides of alkali metals and alkaline earth metals, carbonates of alkali metals and alkaline earth metals, bicarbonates of alkali metals and alkaline earth metals, oxides of transition metals, hydroxides of transition metals, carbonates of transition metals, bicarbonates of transition metals, and combinations thereof.

[0047] The term "alkali metal base" includes oxides, hydroxides, carbonates, or bicarbonates of sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), and francium (Fr).

[0048] The term "alkali-earth metal base" includes oxides, hydroxides, carbonates, or bicarbonates of beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra).

[0049] The term "transition metal base" includes oxides, hydroxides, carbonates, or bicarbonates of scandium (Sc), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), yttrium (Y), zirconium (Zr), niobium (Nb), molybdenum (Mo), technetium (Tc), ruthenium (Ru), rhodium (Rh), palladium (Pd), silver (Ag), cadmium (Cd), hafnium (Hf), tantalum (Ta), tungsten (W), rhenium (Re), osmium (Os), iridium (Ir), platinum (Pt), gold (Au), mercury (Hg), rutherfordium (Rf), dubnium (Db), seaborgium (Sg), bohrium (Bh), hassium (Hs), meitnerium (Mt), darmstadtium (Ds) and roentgenium (Rg).

[0050] As used herein the term, "dispersed particles" refers to a substance added to the present slurry composition to improve the separation of particles and to prevent settling or clumping.

Suitable and non-limiting examples of such dispersed particles according to the present disclosure may include particles of alumina, alumina oxide hydroxide, SiO_2, $BaSO_4$, TiO_2, SnO_2, CeO_2, ZrO_2, $BaTiO_3$, Y_2O_3, B_2O_3, carbon nanotube, ZnO, aluminum-doped lithium lanthanum zirconate (Al-doped LLZO), and combinations thereof.

[0051] As used herein the term, "battery" includes a single electrochemical cell, or unicell, and/or one or more electrochemical cells connected in series and/or in parallel as known by those of skill in the art. Further suitable and non-limiting examples of battery according to the present disclosure can include, but are not limited to, rechargeable batteries, secondary batteries, and/or electrochemical cells. The battery according to the present disclosure may include a positive electrode (cathode) and a negative electrode (anode), wherein both electrodes include a carbon nanotube (CNT) material capable of absorbing and desorbing lithium in an electrochemical system, and wherein lithium metal powder is dispersed in the CNT of the anode or a cathode, a separator separating the cathode and the anode, and an electrolyte in communication with the cathode and the anode.

[0052] As used herein the term, "carbon nanotube" (CNT) means a hollow carbon structure having a diameter from about 4 nm to about 100 nm. Further, the "carbon nanotubes" (CNTs) according to the present disclosure can be any suitable type of carbon nanotube. Suitable and non-limiting examples of carbon nanotubes include, single-wall carbon nanotubes, double-wall carbon nanotubes, few-wall carbon nanotubes, multi-wall carbon nanotubes, bundle-type carbon nanotubes, or a combination thereof. Carbon nanotubes having a high electrical conductivity may be particularly suitable.

[0053] In one aspect, the present disclosure provides a slurry composition comprising (i) a reaction product of (a) a maleated natural oil comprising a natural oil with maleated functionality and (b) a base; (ii) at least one dispersed particle; and (iii) at least one solvent.

[0054] The reaction product according to the present disclosure includes a natural oil with maleated functionality wherein the maleated functionality is either fully or partially reacted with the base.

[0055] The maleated natural oil or the natural oil with maleated functionality as used in the present slurry composition includes a natural oil comprising at least one maleated functionality.

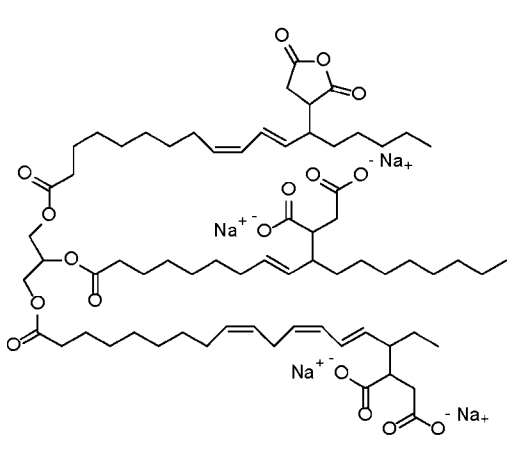
Suitable examples of such natural oils with maleated functionality can include, but are not limited to, maleated avocado oils, maleated coconut oils, maleated corn oils, maleated cottonseed oils, maleated jojoba oils, maleated linseed oils, maleated nut oils, maleated olive oils, maleated palm oils, maleated raisin oils, maleated rapeseed oils, maleated safflower oils, maleated sesame oils, maleated soybean oils, maleated squash oils, maleated sunflower oils, maleated almond oils, maleated canola oils, maleated flaxseed oils, maleated grapeseed oils, maleated palm kernel oils, maleated peanut oils, maleated walnut oils, maleated chickpea oils, maleated clary sage oils, and mixtures thereof. In a still another non-limiting embodiment of the present disclosure, the maleated natural oil is a maleated soybean oil.

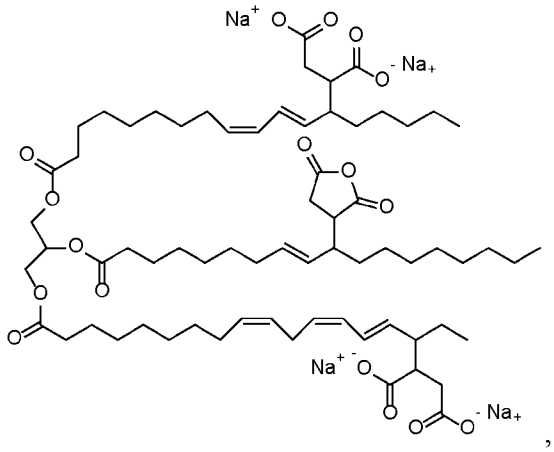
[0056] In one non-limiting embodiment of the present disclosure, the base can be selected from the group consisting of inorganic bases, organic bases, and mixtures thereof.

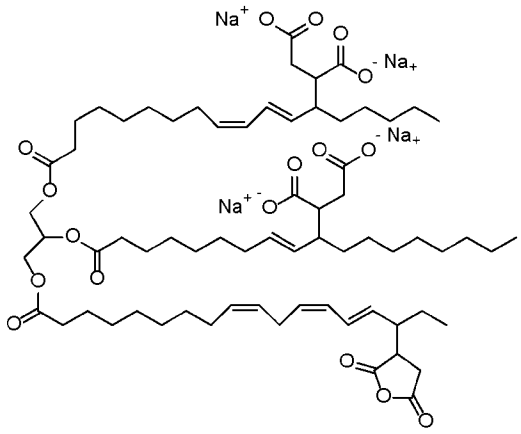
[0057] In one non-limiting embodiment of the present disclosure, the base can be inorganic base. Suitable examples of inorganic base can include, but are not limited to, oxides of alkali metals and alkaline earth metals, hydroxides of alkali metals and alkaline earth metals, carbonates of alkali metals and alkaline earth metals, bicarbonates of alkali metals and alkaline earth metals, oxides of transition metals, hydroxides of transition metals, carbonates of transition metals, bicarbonates of transition metals, and combinations thereof. In another non-limiting embodiment of the present disclosure, the alkali metals can be selected from the group consisting of lithium, sodium, potassium, rubidium, cesium, francium, and mixtures thereof. In yet another non-limiting embodiment of the present disclosure, the alkaline earth metal can be selected from the group consisting of beryllium, magnesium, calcium, strontium, barium, radium, and mixtures thereof. In a still another non-limiting embodiment of the present disclosure, the transition metal can be selected from the group consisting of scandium, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, yttrium zirconium, niobium, molybdenum, technetium, ruthenium, rhodium, palladium, silver, cadmium, hafnium, tantalum, tungsten, rhenium, osmium, iridium, platinum, gold, mercury, rutherfordium, dubnium, seaborgium, bohrium, hassium, meitnerium, darmstadtium, roentgenium, and mixtures thereof. In another non-limiting embodiment of the present disclosure, the inorganic base is selected from the group consisting of oxides, hydroxides, carbonates, and bicarbonates of sodium, calcium, and combinations thereof.

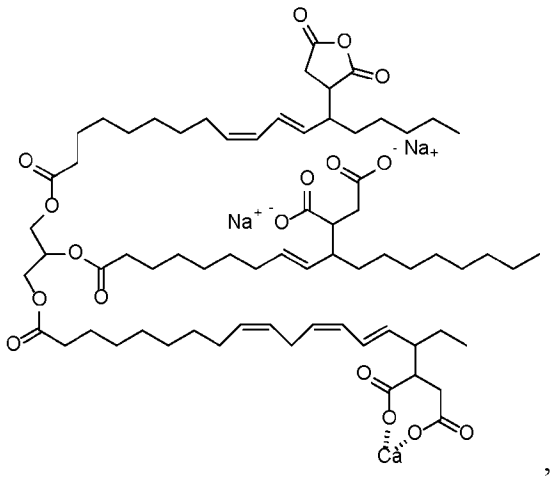
[0058] Further, the base suitable for the purpose of the present disclosure can be an organic base. Suitable examples of such organic base can include, but are not limited to, ammonia, primary amines, secondary amines, pyridine, imidazole, benzimidazole, histidine, guanidine, and mixtures thereof.

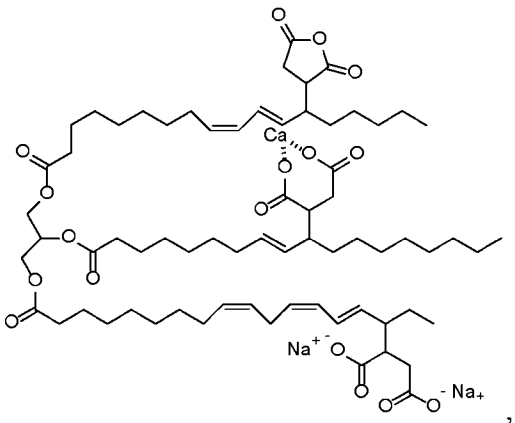
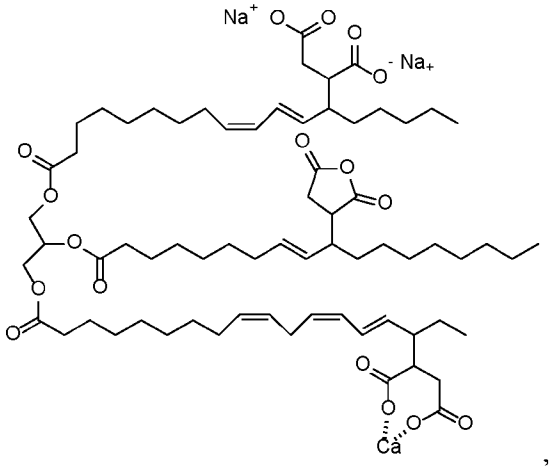
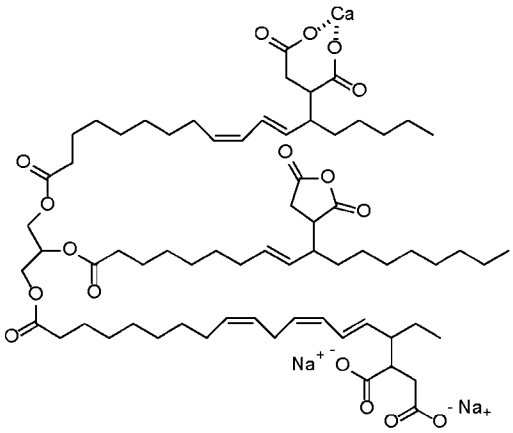
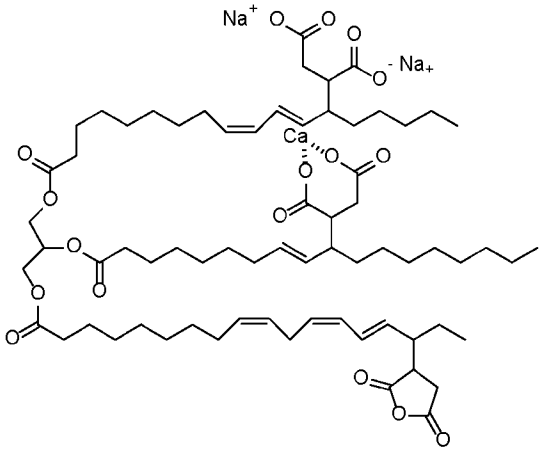
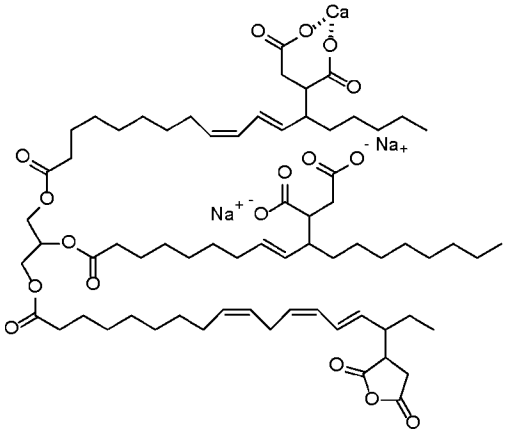
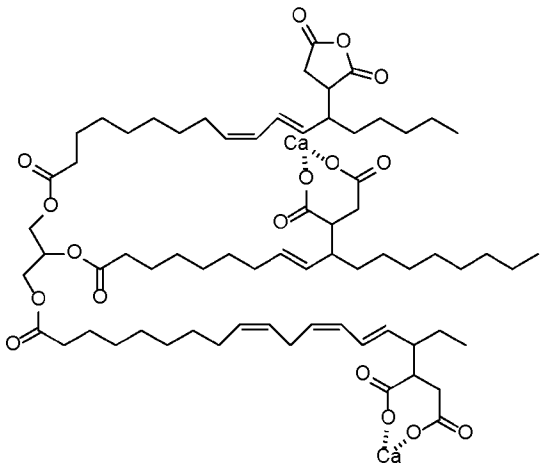
[0059] In one non-limiting embodiment of the present disclosure, the reaction product comprises one or more structures selected from the group consisting of the following structures:

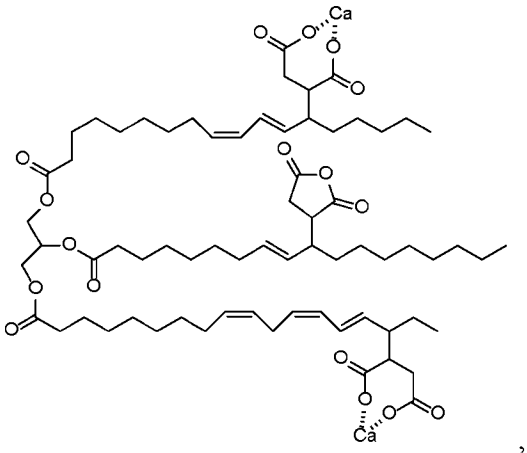
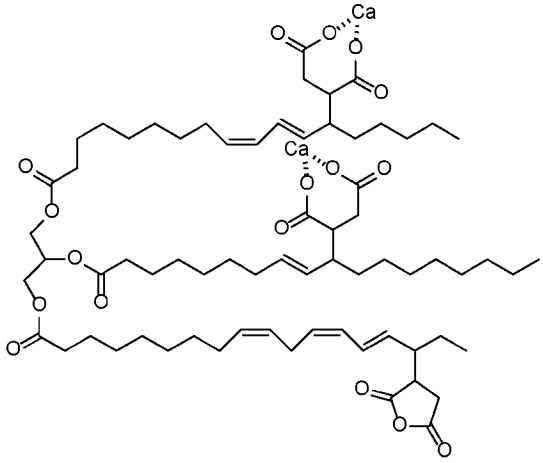
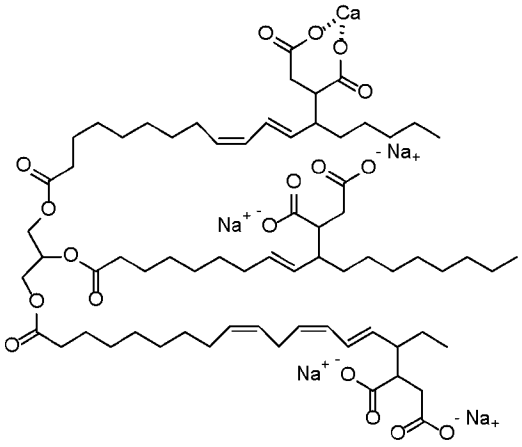
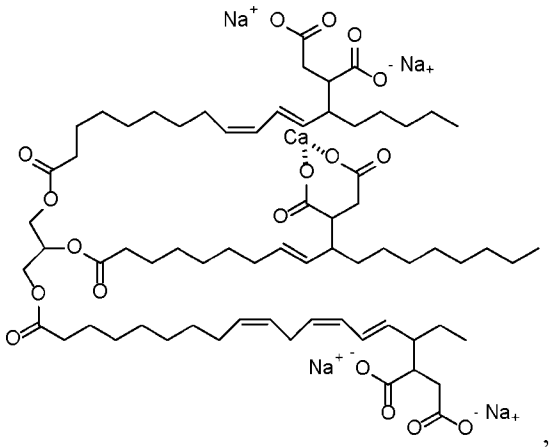
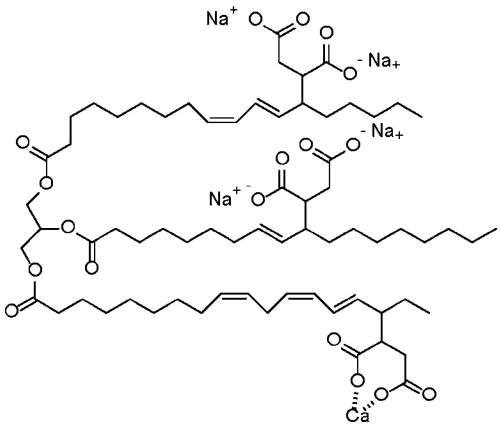
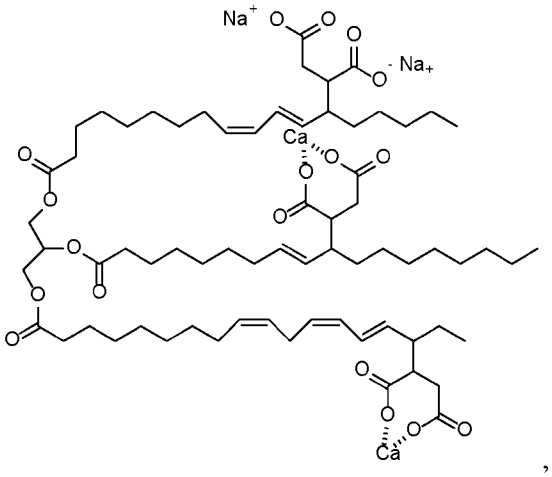

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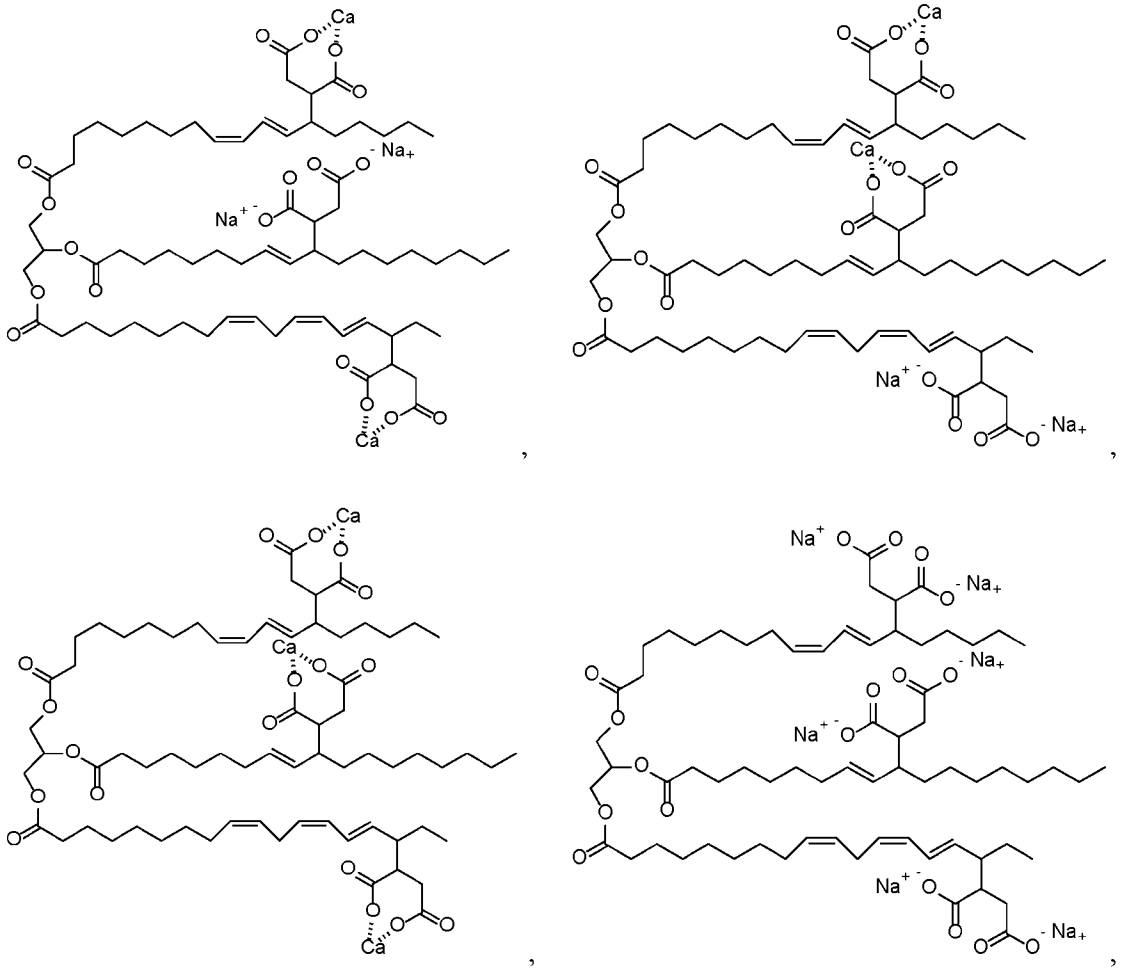

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and combinations thereof.

[0060] Further, the maleated natural oil or natural oil with maleated functionality in the present slurry composition can be prepared by the maleation of natural oils. During maleation, one or more of an α,β-unsaturated carboxylic acid or anhydride thereof, for example, maleic anhydride reacts with unsaturated fatty acyl chains present in natural oils. The maleation of natural oils can occur under heating in three different ways. The first one is known as "Ene" reaction (reaction between an allylic moiety and an enophile in a pericyclic reaction), obtaining a triglyceride structure with anhydride moieties (succinic anhydride). The second one is a radical addition, which consumes a double bond in the fatty acid, incorporating the succinic anhydride into the natural oil structure. The final reaction is also a radical addition that incorporates the maleic anhydride into the natural oil structure without consuming C=C bonds (fatty acid chain and maleic anhydride); this reaction occurs due to abstraction of hydrogen atoms from two alkenes groups.

[0061] The preparation of maleated natural oils is well known to persons skilled in the art. Accordingly, the maleated natural oils as used for the purpose of the present disclosure can be prepared by methods known in the related arts. In one non-limiting embodiment of the present disclosure, maleic anhydride and at least one natural oil can be reacted together at elevated temperatures. In one non-limiting embodiment of the present disclosure, the maleation can be carried out at a temperature varying in the range of from about 150 °C to about 300 °C. In another non-limiting embodiment of the present disclosure, the maleation can be carried out at a temperature of from about 170 °C to about 230 °C, or from about 200 °C to about 220 °C.

[0062] Further, the maleation can be carried out for a time period varying from about 0.5 hours to about 14 hours. In another non-limiting embodiment of the present disclosure, the reaction time can vary from about 1 hour to about 5 hours, or from about 2 hours to about 6 hours, or from about 6 hours to 10 hours.

[0063] In one non-limiting embodiment of the present disclosure, the mole ratio of maleic anhydride to natural oil can be equal to 1. In a still another non-limiting embodiment of the present disclosure, the mole ratio can vary from about 1 to about 2, or from about 1 to about 2.8, or from about 1 to about 3.2 moles of maleic anhydride for each mole of natural oil.

[0064] The maleated natural oil according to the present disclosure is reacted with a suitable base to form a reaction product. In one non-limiting embodiment of the present disclosure, the maleated natural oil and a suitable base are reacted together under pre-determined condition of temperature and for a pre-determined period of time to obtain the present reaction product. In one non-limiting embodiment of the present disclosure, the maleated natural oil is reacted with a suitable base at a temperature ranging from about 20 °C to about 120 °C. In another non-limiting embodiment of the present disclosure, the maleated natural oil is reacted with a suitable base at a temperature ranging from about 40 °C to about 100 °C. In another non-limiting embodiment of the present disclosure, the maleated natural oil is reacted with a suitable base at a temperature ranging from about 40 °C to about 49 °C, from about 50 °C to about 59 °C, from about 60 °C to about 69 °C, from about 70 °C to about 79 °C, from about 80 °C to about 89 °C, from about 90 °C to about 100 °C. In one non-limiting embodiment of the present disclosure, the maleated natural oil is reacted with a suitable base at a suitable temperature for a time ranging from about 30 minutes to about 6 hours.

In another non-limiting embodiment of the present disclosure, the maleated natural oil is reacted with a suitable base for about 1 hour, for about 2 hours, for about 3 hours, for about 4 hours, for about 5 hours or for about 6 hours.

[0065] The slurry composition according to the present disclosure can further comprises at least one dispersed particle. In one non-limiting embodiment of the present disclosure, the dispersed particle is selected from the group consisting of alumina, alumina oxide hydroxide, SiO_2, $BaSO_4$, TiO_2, SnO_2, CeO_2, ZrO_2, $BaTiO_3$, Y_2O_3, B_2O_3, carbon nano tube, ZnO, Al-doped Lithium Lanthanum Zirconate Oxide (LLZO), and combinations thereof. In another non-limiting embodiment of the present disclosure, the dispersed particles are in powder form. Further, the dispersed particles according to the present disclosure has a particle size distribution (d50) in the range of from about 0.05 μm to about 50.0 μm. In another non-limiting embodiment of the present disclosure, the particle size distribution can vary in the range of from about 0.05 μm to about 0.1 μm, or from about 0.11 μm to about 0.2 μm, or from about 0.21 μm to about 0.3 μm, or from about 0.31 μm to about 0.4 μm, or from about 0.41 μm to about 0.5 μm, or from about 0.5 μm to about 0.61, or from about 0.61 μm to about 0.7 μm, or from about 0.71 μm to about 0.8 μm, or from about 0.81 μm to about 9 μm, or from about 0.91 μm to about 1μm, or from about 1.1 μm to about 5 μm, or from about 6 μm to about 10 μm, or from about 11 μm to about 15 μm, or from about 16 μm to about 20 μm, or from about 21 μm to about 25 μm, or from about 26 μm to about 30 μm, or from about 31 μm to about 35 μm, or from about 36 μm to about 40 μm, or from about 41 μm to about 45 μm, or from about 46 μm to about 50 μm.

[0066] The solvent in the slurry composition of the present disclosure can be selected from the group consisting of at least one aqueous solvent; alcohols; phenols, acetates; ketones; ethylene glycols; propylene glycols; amides; pyrrolidones; hydroxyesters; sulfoxides; lactones; anilines; hydrocarbons; halogenated solvents; aromatic solvents; glycol esters, and combinations thereof. In one non-limiting embodiment of the present disclosure, the solvent can be selected from the group consisting of water, methanol, ethanol, isopropyl alcohol, propyl alcohol, butanol, terpineol, acetone, methyl ethyl ketone, ethyl isobutyl ketone, methyl isobutyl ketone, ethylene glycol, ethylene glycol methyl ether, ethylene glycol mono-n-propyl ether, propylene glycol, propylene glycol methyl ether, propylene glycol ethyl ether, propylene glycol butyl ether, propylene glycol propyl ether, dimethylformamide, dimethyl acetaamide, N-methyl-2-pyrrolidone (NMP), N-ethyl

pyrrolidone, dimethyl sulfoxide, gamma-butyrolactone, lactic acid methyl ester, lactic acid ethyl ester, β-methoxyisobutyric acid methyl ester, α-hydroxyisobutyric acid methyl ester, aniline, N-methylaniline, hexane; chloroform; toluene; propylene glycol monomethyl ether acetate (PGMEA), acetoacetate, and combinations thereof.

[0067] The slurry composition according to the present disclosure further comprises at least one functional ingredient selected from the group consisting of skin care agents, oral care agents, hair care agents, energy agents, construction agents, biocidal agents, preservative agents, nutraceutical agents, food agents, agricultural agents, coating agents, cosmetic agents, homecare agents, industrial and institutional agents, textile agents, laundry agents, cleaning agents, inorganic particles of ceramic compositions, and disinfecting agents.

[0068] The slurry composition according to the present disclosure can be used in various applications. In one non-limiting embodiment of the present disclosure, the slurry composition can be selected from the group consisting of agricultural compositions, biocidal compositions, ceramic slurry compositions, cleaning compositions, coating compositions, personal care composition, construction compositions, disinfecting compositions, energy compositions, food compositions, homecare compositions, industrial and institutional compositions, laundry compositions, nutraceutical composition, oral care compositions, preservative compositions, textile compositions, carbon-nanotube compositions, battery compositions, and ceramic coated separators for batteries.

[0069] In one non-limiting embodiment of the present disclosure, the slurry composition can be a personal care composition, a coating composition, a food composition, an agricultural composition, or a carbon nanotube composition

[0070] In one non-limiting embodiment of the present disclosure, the slurry composition can be a personal care composition. Suitable examples of such personal care compositions can include, but are not limited, cosmetic compositions, skin care compositions, sun care compositions, hair care compositions, nail care compositions, anti-perspirants, or deodorants, and cosmetic compositions.

[0071] In another non-limiting embodiment of the present disclosure, the slurry composition can be a coating composition suitable for various applications. Suitable examples of such coating

compositions can include, but are not limited to, architectural coatings, metal coatings, marine coatings, paints, decorative paints, interior paints, exterior paints, non-woven coatings, ceramic coatings, anti-corrosion coatings, flame retardant coatings, glass coatings, protective coatings, powder coatings, wood coatings, industrial coatings, anti-fouling coatings, thermal insulation coatings, water-based coatings, and solvent based coatings.

[0072] In another non-limiting embodiment of the present disclosure, the slurry composition can be an agriculture composition.

[0073] In yet another non-limiting embodiment of the present disclosure, the slurry composition can be used in ceramic coated separators for an energy storage device.

[0074] In a still another non-limiting embodiment of the present disclosure, the slurry composition can be a carbon nanotube composition.

[0075] Another aspect of the present disclosure provides a ceramic coated separator for an energy storage device, comprising: (i) the slurry composition of the present disclosure, wherein the slurry composition is a ceramic slurry composition; and (ii) a separator, wherein the ceramic slurry composition provides a coating that is in contact with at least a portion of the separator. In one non-limiting embodiment of the present disclosure, the ceramic slurry composition is coated on at least one surface of the separator forming a coating thereon. The ceramic slurry composition is coated on at least one surface of the separator, forming a coating thereon.

[0076] In another non-limiting embodiment of the present disclosure, the separator is comprised of polyolefins. The polyolefin can be selected from the group consisting of polyethylene, polypropylene, and combinations thereof.

[0077] In another non-limiting embodiment of the present disclosure, the separator is a pre-treated separator wherein the separator is pre-treated by at least one treatment selected from the group consisting of corona treatment, atmospheric plasma treatment, flame plasma treatment, chemical plasma treatment, ozone treatment, polyvinylidene fluoride (PVDF) treatment, and treatment with polydopamine.

[0078] In still another non-limiting embodiment of the present disclosure, the coating is uniformly distributed on the separator. In one more non-limiting embodiment of the present

disclosure, the coating has a mean thickness in a range of from about 0.5μm to about 5.0 μm. In another non-limiting embodiment of the present disclosure, the coating has a mean thickness in a range of from about 0.5 μm to about 0.61, from about 0.61 μm to about 0.7 μm, from about 0.71 μm to about 0.8 μm, from about 0.81 μm to about 9.0 μm, from about 0.91 μm to about 1.0 μm, or from about 1.1 μm to about 5.0 μm.

[0079] Yet another aspect of the present disclosure provides an energy storage device comprising the ceramic coated separator of the present disclosure. The energy storage device according to the present disclosure can be selected from the group consisting of fuel cells, electrochemical cells, batteries, and capacitors.

[0080] In another non-limiting embodiment of the present disclosure, the energy storage device is selected from the group consisting of a fuel cell, electrochemical cell, battery, and a capacitor.

[0081] Another aspect of the present disclosure provides a battery comprising: (i) at least one ceramic coated separator of the present disclosure; (ii) at least one cathode; and (iii) at least one anode.

[0082] Still another aspect of the present disclosure provides a method of making a ceramic coated separator, comprising: a) coating the slurry composition of the present disclosure on at least a portion of a separator by a method selecting from the group of methods consisting of doctor blading, bar coating, slot-die coating, dip coating, spin coating, direct gravure, reverse coating, and combinations thereof; b) drying the slurry composition coated on the separator obtained from the method step (a) by using an energy source selected from the group consisting of heat, ultraviolet (UV), light emitting diode (LED), electronic beam (EEB), and combinations thereof; and; c) conditioning the dried coating of method step (b) at a pre-determined temperature.

[0083] In one non-limiting embodiment of the present disclosure, the method step of drying (b) comprises heating the coated separator at a temperature in a range of from about 20 °C to about 80 °C for a time in a range of from about 5 seconds to about 10 minutes. In another non-limiting embodiment of the present disclosure, the method step of drying can be carried out at a temperature in a range of from about 50 °C to about 80 °C for a time in the range of from about 1 minute to about 10 minutes.

[0084] In another non-limiting embodiment of the present disclosure, the slurry layer on the separator is further conditioned at a temperature of up to 100 °C for up to 24 hours. In another non-limiting embodiment of the present disclosure, the conditioning can be carried out at a temperature in the range of from about 60 °C to about 80 °C for about 30 minutes. In one more non-limiting embodiment of the present disclosure, the method step of drying the slurry layer on the separator comprises heating the separator coated with the present slurry composition at a temperature in the range of from about 20 °C to about 80 °C and for a time period in the range of from about 5 seconds to about 10 minutes. In another non-limiting embodiment of the present disclosure, the temperature can vary in the range of from about 21 °C to about 30 °C, or from about 31 °C to about 40 °C, or from about 41 °C to about 50 °C, or from about 51 °C to about 60 °C, or from about 61 °C to about 70 °C, or from about 71 °C to about 80 °C.

[0085] Still another aspect of the present disclosure provides a coating composition comprising the slurry composition of the present disclosure. In one non-limiting embodiment of the present disclosure, the slurry composition can be present in an amount of from about 0.1 wt.% to about 1 wt.%; or from about 1 wt.% to about 2.5 wt.%; or from about 2.5 wt.% to about 5 wt.%; or from about 5 wt.% to about 10 wt.%; or 10 wt.% to about 15 wt.%; or from about 15 wt.% to about 20 wt.%; or from about 20 wt.% to about 25 wt.%; or from about 25 wt.% to about 30 wt.%; or from about 30 wt.% to about 35 wt.%; or from about 35 wt.% to about 40 wt.%; or from about 40 wt.% to about 45 wt.%; or from about 45 wt.% to about 50 wt.%; or from about 50 wt.% to about 55 wt.%; or from about 55 wt.% to about 60 wt.%; or from about 60 wt.% to about 65 wt.%; or from about 65 wt.% to about 70 wt.%; or from about 70 wt.% to about 75 wt.%; or from about 75 wt.% to about 80 wt.%; or from about 80 wt.% to about 85 wt.% ; or from about 85 wt.% to about 90 wt.%; or from about 90 wt.% to about 95 wt.%, based on the total weight of the coating composition.

[0086] In another non-limiting embodiment of the present disclosure, the coating composition can further comprises at least one additive in a range varied from about 0.1 wt.% to about 1 wt.%; or from about 1 wt.% to about 2.5 wt.%; or from about 2.5 wt.% to about 5 wt.%; or from about 5 wt.% to about 10 wt.%; or 10 wt.% to about 15 wt.%; or from about 15 wt.% to about 20 wt.%; or from about 20 wt.% to about 25 wt.%; or from about 25 wt.% to about 30 wt.%; or from about 30 wt.% to about 35 wt.%; or from about 35 wt.% to about 40 wt.%; or from about 40 wt.% to about

45 wt.%; or from about 45 wt.% to about 50 wt.%; or from about 50 wt.% to about 55 wt.%; or from about 55 wt.% to about 60 wt.%; or from about 60 wt.% to about 65 wt.%; or from about 65 wt.% to about 70 wt.%; or from about 70 wt.% to about 75 wt.%; or from about 75 wt.% to about 80 wt.%; or from about 80 wt.% to about 85 wt.% ; or from about 85 wt.% to about 90 wt.%; or from about 90 wt.% to about 95 wt.%; or from about 95 wt.% to about 99.9 wt.%, based on the total weight of the coating composition.

[0087] Suitable examples of additives used in the present coating composition can include, but are not limited to, film forming polymers, coalescent agents, emulsifiers, stabilizers, rheology modifiers, cosolvents, dispersing agents, defoamers, wet-edge additives, wetting agents, humectants, wax, colorants, thickeners, anticaking agents, antifoaming agents, UV absorbers, antifreeze agents, gel inhibitors, preservatives, hydrophobic agents, adhesion promoters, biocides, anti-oxidants, pigment, plasticizers, or combinations thereof.

[0088] Further, the coating composition of the present disclosure can be an aqueous or a non-aqueous composition used for various coating purpose including, but not limiting to, lacquer coating, primer coating, ink jet printing, top coating, varnish coating, architectural coating, wood coating, printing inks, or metallic or non-metallic coatings.

[0089] In another non-limiting embodiment of the present disclosure, the coating composition is coated on a substrate selected from the group consisting of porous and non-porous substrates, papers, non-woven materials, textiles, leather, wood, concrete, masonry, metals, non-metals, house wrap, building materials, fiberglass, polymeric articles, face masks, medical drapes and gowns, carpets, upholstery, tents, awnings, air bags, fabrics, ceramics, yarns, and woven, knitted, natural, synthetic or regenerated substrates.

[0090] Another aspect of the present disclosure provides a personal care composition comprising the present slurry composition. In one non-limiting embodiment of the present disclosure, the personal care composition can comprises the slurry composition in a range varied from about 0.1 wt.% to about 1 wt.%; or from about 1 wt.% to about 2.5 wt.%; or from about 2.5 wt.% to about 5 wt.%; or from about 5 wt.% to about 10 wt.%; or 10 wt.% to about 15 wt.%; or from about 15 wt.% to about 20 wt.%; or from about 20 wt.% to about 25 wt.%; or from about 25 wt.% to about 30 wt.%; or from about 30 wt.% to about 35 wt.%; or from about 35 wt.% to about 40 wt.%; or

from about 40 wt.% to about 45 wt.%; or from about 45 wt.% to about 50 wt.%; or from about 50 wt.% to about 55 wt.%; or from about 55 wt.% to about 60 wt.%; or from about 60 wt.% to about 65 wt.%; or from about 65 wt.% to about 70 wt.%; or from about 70 wt.% to about 75 wt.%; or from about 75 wt.% to about 80 wt.%; or from about 80 wt.% to about 85 wt.% ; or from about 85 wt.% to about 90 wt.%; or from about 90 wt.% to about 95 wt.%, based on the total weight of the personal care composition.

[0091] In another non-limiting embodiment of the present disclosure, the personal care composition can further comprises at least one personal care functional active ingredient in a range varied from about 0.1 wt.% to about 1 wt.%; or from about 1 wt.% to about 2.5 wt.%; or from about 2.5 wt.% to about 5 wt.%; or from about 5 wt.% to about 10 wt.%; or 10 wt.% to about 15 wt.%; or from about 15 wt.% to about 20 wt.%; or from about 20 wt.% to about 25 wt.%; or from about 25 wt.% to about 30 wt.%; or from about 30 wt.% to about 35 wt.%; or from about 35 wt.% to about 40 wt.%; or from about 40 wt.% to about 45 wt.%; or from about 45 wt.% to about 50 wt.%; or from about 50 wt.% to about 55 wt.%; or from about 55 wt.% to about 60 wt.%; or from about 60 wt.% to about 65 wt.%; or from about 65 wt.% to about 70 wt.%; or from about 70 wt.% to about 75 wt.%; or from about 75 wt.% to about 80 wt.%; or from about 80 wt.% to about 85 wt.% ; or from about 85 wt.% to about 90 wt.%; or from about 90 wt.% to about 95 wt.%; or from about 95 wt.% to about 99.9 wt.%, based on the total weight of the personal care composition.

[0092] Suitable examples of such personal care functional active ingredient can include, but are not limited, color agents, hair care agents, skin care agents, and sun care agents, or combinations of two or more thereof. Further, non-limiting examples of the personal care functional active ingredient used in the personal care composition of the present disclosure can include, but are not limited to, fragrances, preservatives, solvents, propellants, exfoliants, surfactants, skin cell renewal agents, anti-acne medications, antiperspirant compounds, sunscreens, decomposition products of oils or fats, water- insoluble ingredients, oxidizing agents, conditioning agents, humectants, pH adjusting buffers, waxes, mineral oils, emulsifiers, fatty substances, gelling agents, thickeners, moisturizers, emollients, hydrophilic or lipophilic active agent, antioxidants, sequestering agents, acidifying or basifying agents, fillers, dyestuffs, plant extracts, proteins, peptides, neutralizing agents, solvents, anti-dandruff ingredients, reducing agents, or combinations thereof.

[0093] In one non-limiting embodiment of the present disclosure, the personal care compositions can include, but are not limited to, cosmetic compositions, skin care compositions, sun care compositions, hair care compositions, nail care compositions, anti-perspirants, or deodorants, and cosmetic compositions. Further suitable and non-limiting examples of such composition can include, but are not limited to

[0094] body wash compositions, skin lotion compositions, sunscreen compositions, anti-wrinkle compositions, moisturizer compositions, facial cleaning compositions, lipstick compositions, lip-gloss compositions, mascara compositions, foundation compositions, anti-perspirant compositions, shaving compositions, hair conditioner compositions, anti-perspirant compositions, deodorant compositions, hair rinse compositions, hair shampoo compositions, hair styling compositions, make-up remover compositions, or oral care compositions.

[0095] In another non-limiting embodiment of the present disclosure, the personal care composition is an aqueous or non-aqueous formulation in the form of a spray, lotion, mousse, fluid, serum, solution, suspension, perm, emulsion, gel, mist, vesicles, dispersion, paste, cream, solid stick, shampoo, balm, wipe, milk, foam, jelly, or liquid.

[0096] Another aspect of the present disclosure provides an agricultural composition comprising the slurry composition of the present disclosure.

[0097] In one non-limiting embodiment of the present disclosure, the agricultural composition comprises the slurry in a range varied from about 0.1 wt.% to about 1 wt.%; or from about 1 wt.% to about 2.5 wt.%; or from about 2.5 wt.% to about 5 wt.%; or from about 5 wt.% to about 10 wt.%; or 10 wt.% to about 15 wt.%; or from about 15 wt.% to about 20 wt.%; or from about 20 wt.% to about 25 wt.%; or from about 25 wt.% to about 30 wt.%; or from about 30 wt.% to about 35 wt.%; or from about 35 wt.% to about 40 wt.%; or from about 40 wt.% to about 45 wt.%; or from about 45 wt.% to about 50 wt.%; or from about 50 wt.% to about 55 wt.%; or from about 55 wt.% to about 60 wt.%; or from about 60 wt.% to about 65 wt.%; or from about 65 wt.% to about 70 wt.%; or from about 70 wt.% to about 75 wt.%; or from about 75 wt.% to about 80 wt.%; or from about 80 wt.% to about 85 wt.% ; or from about 85 wt.% to about 90 wt.%; or from about 90 wt.% to about 95 wt.%, based on the total weight of the agriculture composition.

[0098] In another non-limiting embodiment of the present disclosure, the agricultural composition can further comprise one or more agriculturally active ingredient, and one or more additional ingredient. These ingredients in totality can be present in a range varied from about 0.1 wt.% to about 1 wt.%; or from about 1 wt.% to about 2.5 wt.%; or from about 2.5 wt.% to about 5 wt.%; or from about 5 wt.% to about 10 wt.%; or from about 10 wt.% to about 15 wt.%; or from about 15 wt.% to about 20 wt.%; or from about 20 wt.% to about 25 wt.%; or from about 25 wt.% to about 30 wt.%; or from about 30 wt.% to about 35 wt.%; or from about 35 wt.% to about 40 wt.%; or from about 40 wt.% to about 45 wt.%; or from about 45 wt.% to about 50 wt.%; or from about 50 wt.% to about 55 wt.%; or from about 55 wt.% to about 60 wt.%; or from about 60 wt.% to about 65 wt.%; or from about 65 wt.% to about 70 wt.%; or from about 70 wt.% to about 75 wt.%; or from about 75 wt.% to about 80 wt.%; or from about 80 wt.% to about 85 wt.% ; or from about 85 wt.% to about 90 wt.%; or from about 90 wt.% to about 95 wt.%; or from about 95 wt.% to about 99.9 wt.%, based on the total weight of the agriculture composition.

[0099] In one non-limiting embodiment of the present disclosure, the one or more agriculturally active ingredient used in the agricultural composition of the present disclosure includes fertilizers or pesticides. Suitable and non-limiting examples of such fertilizers or pesticides can include, but are not limited to, rodenticides, miticides, algicides, molluscicides, acaricides, avicides, insecticides, herbicides, ovicides, fungicides, germicides, antibiotics, antibacterials, antivirals, antifungals, antiprotozoals, anti-parasites, antimicrobials, or combinations thereof.

[00100] In another non-limiting embodiment of the present disclosure, one or more additional ingredient used can include an adjuvant or an inert ingredient. Suitable examples of adjuvants used in the agricultural composition of the present disclosure can include, but are not limited to, acidifying agents, buffering agents, anti-foam agents, defoaming agents, anti-transpirants, dyes and brighteners, compatibility agents, crop oil concentrates, oil surfactants, deposition agents, drift reduction agents, foam markers, feeding stimulants, herbicide safeners, spreaders, extenders, adhesive agents, suspension agents, gelling agents, synergists, wetting agents, emulsifiers, dispersing agents, penetrants, tank and equipment cleaners, adjusters, water absorbents, water softeners, or combinations thereof. Similarly, suitable examples of inert ingredients used in the agricultural composition of the present disclosure can include, but are not limited to, solvents, liquid carriers, solid carriers or fillers, surfactants, solubilizers, penetration enhancers, protective

colloids, thickeners, humectants, repellents, attractants, compatibilizers, bactericides, anti-freezing agents, crystallization inhibitors, colorants, tackifiers, binders, preservatives, pH adjuster, clarifiers, stabilizers, UV stabilizers, or combinations thereof.

[00101] In another non-limiting embodiment of the present disclosure, the agricultural composition is an adjuvant composition, a fertilizer composition, a nutrient composition, a plant strengthener composition, a seed coating composition, a soil conditioner composition, a livestock composition, a granular composition, a controlled release composition, a film coating composition, a pesticide composition selected from the group consisting of ovicide, rodenticide, insecticide, miticide, algicide, molluscicide, acaricide, avicide, fungicide and herbicide compositions, a germicide composition, an antibiotic composition, an antibacterial composition, an antiviral composition, an antifungal composition, an antiprotozoal composition, an anti-parasite composition, a wood preservation composition, or an antimicrobial composition. .

[00102] In another non-limiting embodiment of the present disclosure, the agricultural composition is in the form of an aqueous or a non-aqueous composition comprising a capsule suspension, an emulsifiable concentrate, an emulsion for seed treatment, a concentrated aqueous emulsion, a microemulsion, a suspoemulsion, an oil-in-water emulsion, a flowable concentrate for seed treatment, an oil dispersion, a suspension concentrate, a water dispersible granule or a wettable powder.

[00103] In still another aspect, the present disclosure provides a carbon nanotube composition comprising the slurry composition of the present disclosure.

[00104] In one non-limiting embodiment of the present disclosure, the carbon nanotube composition comprises the slurry in a range varied from about 0.1 wt.% to about 1 wt.%; or from about 1 wt.% to about 2.5 wt.%; or from about 2.5 wt.% to about 5 wt.%; or from about 5 wt.% to about 10 wt.%; or 10 wt.% to about 15 wt.%; or from about 15 wt.% to about 20 wt.%; or from about 20 wt.% to about 25 wt.%; or from about 25 wt.% to about 30 wt.%; or from about 30 wt.% to about 35 wt.%; or from about 35 wt.% to about 40 wt.%; or from about 40 wt.% to about 45 wt.%; or from about 45 wt.% to about 50 wt.%; or from about 50 wt.% to about 55 wt.%; or from about 55 wt.% to about 60 wt.%; or from about 60 wt.% to about 65 wt.%; or from about 65 wt.% to about 70 wt.%; or from about 70 wt.% to about 75 wt.%; or from about 75 wt.% to about 80

wt.%; or from about 80 wt.% to about 85 wt.% ; or from about 85 wt.% to about 90 wt.%; or from about 90 wt.% to about 95 wt.%, based on the total weight of the carbon nanotube composition of the present disclosure.

[00105] The carbon nanotube composition according to the present disclosure further comprises (i) about 0.01 wt. % to about 10.0 wt.% of carbon nanotube; and (ii) at least one solvent.

[00106] In one non-limiting embodiment of the present disclosure, the carbon nanotube can be selected from the group consisting of single wall nanotubes, double-wall carbon nanotubes, triple-wall carbon nanotubes, quadruple-wall carbon nanotubes, few-wall carbon nanotubes, multi-walled carbon nanotubes, carbon nanohorns, carbon nanofibers, short nanotubes, carbon particle nanotubes, and combinations thereof.

[00107] In one non-limiting embodiment of the present disclosure, the solvent present in the carbon nanotube composition can be selected from the group consisting of at least one aqueous solvent; alcohols; ketones; ethyleneglycols; propyleneglycols; amides; pyrrolidones; hydroxyesters; sulfoxides; lactones; anilines; hydrocarbons; halogenated solvents; aromatic solvents; glycol esters; and combinations thereof.

[00108] In another non-limiting embodiments of the present disclosure, the solvent can be selected from the group consisting of water, methanol, ethanol, isopropyl alcohol, propyl alcohol, butanol, terpineol, acetone, methyl ethyl ketone, ethyl isobutyl ketone, methyl isobutyl ketone, ethylene glycol, ethylene glycol methyl ether, ethylene glycol mono-n-propyl ether, propylene glycol, propylene glycol methyl ether, propylene glycol ethyl ether, propylene glycol butyl ether, propylene glycol propyl ether, dimethylformamide, dimethylacetamide, N-methyl-2-pyrrolidone (NMP), N-ethylpyrrolidone, dimethylsulfoxide, gamma-butyrolactone, lactic acid methyl ester, lactic acid ethyl ester, β-methoxyisobutyric acid methyl ester, α-hydroxyisobutyric acid methyl ester, aniline, N-methylaniline, hexane, chloroform, toluene, propylene glycol monomethyl ether acetate (PGMEA), and combinations thereof.

[00109] The reactions and compositions according to the disclosure may be analyzed by known techniques. Especially preferred are the techniques of ^{13}C nuclear magnetic resonance (NMR) spectroscopy, gas chromatography (GC), infrared (IR) spectroscopy, liquid chromatography (LC)

and gel permeation chromatography (GPC) in order to determine identity, residual monomer concentrations, molecular weight, and molecular weight distribution.

[00110] Further, certain aspects of the present disclosure are illustrated in detail by way of the following examples. The examples are given herein for illustration of the application and are not intended to be limiting thereof.

EXAMPLES

Example A: Grafting of Maleic Anhydride onto Natural Oils

Example A1: Grafting of Maleic Anhydride onto Soybean Oil

[00111] A 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen sparge adapter, and mechanical stirrer was charged with 600 g of soybean oil (SBO) and 204 g (3 mole equivalents based on SBO) of maleic anhydride. The mixture was sparged at room temperature with nitrogen for 15 minutes, heated slowly from room temperature to 210 °C and then held at 210 °C for 6-8 hours. Completion of the reaction was indicated by NMR, and LC indicated <0.5% of residual maleic anhydride.

Example A2: Grafting of Maleic Anhydride onto Palm Oil

[00112] A 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen sparge adapter, and mechanical stirrer was charged with 100 g of palm oil and 23 g (2 mole equivalents based on palm oil) of maleic anhydride. The mixture was sparged at room temperature with nitrogen for 15 minutes, heated slowly from room temperature to 210 °C and then held at 210 °C for 8-10 hours. The amber, viscous product was characterized by NMR, and LC indicated <1% of residual maleic anhydride. Yield was >96%.

Example A3: Grafting of Maleic Anhydride onto Canola Oil

[00113] A 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen sparge adapter, and mechanical stirrer was charged with 100 g of canola oil and 22.2 g (2 mole equivalents based on canola oil) of maleic anhydride. The mixture was sparged at room temperature with nitrogen for 15 minutes, heated slowly from room temperature to 210 °C and then held at 210 °C for 8-10 hours. The amber, viscous product was characterized by NMR, and LC indicated <1% of residual maleic anhydride. Yield was >96%.

Example A4: Grafting of Maleic Anhydride onto Sunflower Oil

[00114] A 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen sparge adapter, and mechanical stirrer was charged with 100 g of sunflower oil and 22.4 g (2 mole equivalents based on palm oil) of maleic anhydride. The mixture was sparged at room temperature with nitrogen for 15 minutes, heated slowly from room temperature to 210 °C and then held at 210 °C for 8-10 hours. The amber, viscous product was characterized by NMR, and LC indicated <1% of residual maleic anhydride. Yield was >96%.

Example A5: Grafting of Maleic Anhydride onto Castor Oil

[00115] A 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen sparge adapter, and mechanical stirrer was charged with 100 g of castor oil and 21 g (2 mole equivalents based on castor oil) of maleic anhydride. The mixture was sparged at room temperature with nitrogen for 15 minutes, heated slowly from room temperature to 210 °C and then held at 210 °C for 8-10 hours. The amber, viscous product was characterized by NMR, and LC indicated <1% of residual maleic anhydride. Yield was >96%.

Example B: Salts of Maleated Natural Oils

Example B1: Sodium Salt of Maleated Soybean Oil from Aqueous Sodium Hydroxide

[00116] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 100 g of product from maleation reaction A1 was heated to 90 °C, and a mixture of 20.20 g (3 mole equivalents based on soybean oil) of 50% aqueous sodium hydroxide and 70 g of water was added over 1 hour, controlling foaming. After completing the addition, the mixture was held at 90 °C for 3 hours. The product contained 70 weight % solids and was characterized by IR and NMR. Yield was >96%.

Example B2: Sodium Salt of Maleated Palm Oil from Aqueous Sodium Hydroxide

[00117] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 123 g of product from maleation reaction A2 was heated to 90 °C, and a mixture of 18.04 g (2 mole equivalents based on palm oil) of 50% aqueous sodium hydroxide and 45 g of water was added over 1 hour, controlling foaming. After completing the addition, the mixture was held at 90 °C for 3 hours. The product contained 70 weight % solids and was characterized by IR and NMR. Yield was >96%.

Example B3: Sodium Salt of Maleated Canola Oil from Aqueous Sodium Hydroxide

[00118] In a 1-L , 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 123 g of product from maleation reaction A3 was heated to 90 °C, and a mixture of 18.25 g (2 mole equivalents based on canola oil) of 50% aqueous sodium hydroxide and 45 g of water was added over 1 hour, controlling foaming. After completing the addition, the mixture was held at 90 °C for 3 hours. The product contained 70 weight % solids and was characterized by IR and NMR. Yield was >96%.

Example B4: Sodium Salt of Maleated Sunflower Oil from Aqueous Sodium Hydroxide

[00119] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 123 g of product from maleation reaction A4 was heated to 90 °C, and a mixture of 18.26 g (2 mole equivalents based on sunflower oil) of 50% aqueous sodium hydroxide and 45 g of water was added over 1 hour, controlling foaming. After completing the addition, the mixture was held at 90 °C for 3 hours. The product contained 70 weight % solids and was characterized by IR and NMR. Yield was >96%.

Example B5: Sodium salt of Maleated Castor Oil from Aqueous Sodium Hydroxide

[00120] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 123 g of product from maleation reaction A5 was heated to 90 °C, and a mixture of 17.15 g (2 mole equivalents based on castor oil) of 50% aqueous sodium hydroxide and 45 g of water was added over 1 hour, controlling foaming. After completing the addition, the mixture was held at 90 °C for 3 hours. The product contained 70 weight % solids and was characterized by IR and NMR. Yield was >96%.

Example C1: Sodium Salt of Maleated Soybean Oil from Sodium Carbonate

[00121] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 100 g of product from maleation reaction A1 was heated to 90 °C, and 27.86 g (3 mole equivalents based on soybean oil) of sodium carbonate dissolved in 85 g of water was added over 3 hours, controlling the foam formation. The reaction was held at 90 °C for 3 hours. The product contained 56 weight % solids and was characterized by IR. Yield was >96%.

Example D: Sodium Calcium Salt of Maleated Natural Oil

Example D1: Sodium Calcium Salt of Maleated Soybean Oil from Calcium Carbonate and Sodium Carbonate (7:3 ratio)

[00122] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 100 g of product from maleation reaction A1 was heated to 90 °C, and a mixture of 8.36 g (0.9 mole equivalents based on soybean oil) of sodium carbonate and 17.8 g (2.1 mole equivalents based on soybean oil) of calcium carbonate dissolved in 85 g of water was added over 3 hours, controlling the foam formation. The reaction was held at 90 °C for 3 hours. The product contained 60 weight % solids and was characterized by IR. Yield was >96%.

Example D2: Sodium Calcium Salt of Maleated Palm Oil from Calcium Carbonate and Sodium Carbonate (7:3 ratio)

[00123] In a 1-L , 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 122 g of product from maleation reaction A2 was heated to 90 °C, and a mixture of 11.55 g (0.9 mole equivalents based on palm oil) of sodium carbonate and 24.6 g (2.1 mole equivalents based on palm oil) of calcium carbonate dissolved in 122 g of water was added over 3 hours, controlling the foam formation. The reaction was held at 90 °C for 3 hours. The product contained 60 weight % solids and was characterized by IR. Yield was >96%.

Example D3: Sodium Calcium Salt of Maleated Canola Oil from Calcium Carbonate and Sodium Carbonate (7:3 ratio)

[00124] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 122 g of product from maleation reaction A3 was heated to 90 °C, and a mixture of 11.3 g (0.9 mole equivalents based on canola oil) of sodium carbonate and 24 g (2.1 mole equivalents based on canola oil) of calcium carbonate dissolved in 122 g of water was added over 3 hours, controlling the foam formation. The reaction was held at 90 °C for 3 hours. The product contained 60 weight % solids and was characterized by IR. Yield was >96%.

Example D4:_Sodium Calcium Salt of Maleated Sunflower Oil from Calcium Carbonate and Sodium Carbonate (7:3 ratio)

[00125] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 122 g of product from maleation reaction A4 was heated to 90 °C, and a mixture of 11.55 g (0.9 mole equivalents based on sunflower oil) of sodium carbonate and

24.6 g (2.1 mole equivalents based on sunflower oil) of calcium carbonate dissolved in 122 g of water was added over 3 hours, controlling the foam formation. The reaction was held at 90 °C for 3 hours. The product contained 60 weight % solids and was characterized by IR. Yield was >96%.

Example D5: Sodium Calcium Salt of Maleated Castor Oil from Calcium Carbonate and Sodium Carbonate (7:3 ratio)

[00126] In a 1-L , 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 122 g of product from maleation reaction A5 was heated to 90 °C, and a mixture of 10.6 g (0.9 mole equivalents based on castor oil) of sodium carbonate and 22.5 g (2.1 mole equivalents based on castor oil of calcium carbonate dissolved in 122 g of water was added over 3 hours, controlling the foam formation. The reaction was held at 90 °C for 3 hours. The product contained 60 weight % solids and was characterized by IR. Yield was >96%.

Example E1: Calcium Salt of Maleated Soybean Oil from Calcium Carbonate

[00127] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 100 g of product from maleation reaction A1 was heated to 90 °C, and a solution of 25.5 g (3 mole equivalents based on soybean oil) of calcium carbonate in 85 g of water was added over 3 hours, controlling the foam formation. The reaction was held at 90 °C for 3 hours. The product contained 60 weight % solids and was characterized by IR. Yield was >96%.

Example F1: Sodium Salt of Maleated Soybean Oil from Aqueous Sodium Hydroxide

[00128] In a 1-L, 4-neck kettle equipped with a thermocouple, condenser, nitrogen purge adapter, and mechanical stirrer, 123 g of product from maleation reaction A1 was heated to 90 °C, and a mixture of 9.04 g (2 mole equivalents based on soybean oil) of 50% aqueous sodium hydroxide and 80 g of water was added over 1 hour, controlling foaming. After completing the addition, the mixture was held at 90 °C for 3 hours. The product contained 70 weight % solids and was characterized by IR and NMR. Yield was >96%.

Example F2: Sodium and Diethanolamine Salt of Maleated Soybean Oil

[00129] In a one liter, 4-neck kettle equipped with a thermocouple, condenser, nitrogen adapter, and mechanical stirrer, 150 g of maleated soybean oil made according to Example A1 and 150 g of water were heated to 90 °C for 2 h. The mixture was cooled 60 °C and 15.1 g (1 mole equivalent

relative to MSBO) of diethanolamine diluted in 150 g of water was added over 30-45 minutes. The reaction mixture was held at 60 °C for 4-6 hours. The viscous, biphasic mixture was neutralized by adding 9.5 g (0.9 mole equivalent relative to MSBO) of 50 wt% aqueous sodium hydroxide over 15 minutes, and the mixture was held at 60 °C for 1-2 hours. The amber, viscous product was characterized by NMR and IR. Yield was >96%.

Example G: Toothpaste Compositions having a Slurry of Silica and Titanium Dioxide

[00130] Toothpaste compositions were made, using methods and equipment commonly used by those skilled in the art. Tables 1 and 2 detail the compositions made, including a list of ingredients used and their weight proportions. In a typical method, a tooth gel phase (comprising the toothpaste rheology modifier gums in the toothpaste liquid phase) was prepared first. Following this, the remaining ingredients were mixed under a vacuum of at least 28 inches Hg in a double planetary mixer. Toothpaste compositions comprising the sodium salt of maleated soybean oil of Example B1 or Gantrez™ S-97 p(MVE/MA) copolymer was made by dissolving these ingredients into the gel phase before processing under vacuum in the double planetary mixer. The essential oils/flavor mixture used in this example consisted of 8.34 wt.% 4-isopropyl *m*-cresol (IPMP), 25.00 wt.% eugenol, 25.00 wt.% eucalyptol, and 41.66 wt.% peppermint oil.

TABLE 1: Toothpaste Compositions containing Essential Oils

Ingredients	Compositions, weight %		
	G1	G2	G3
Glycerin	20.00	20.00	20.00
Aqualon™ CMC 7M8SF	0.90	1.15	1.15
Carboxymethyl cellulose	0.30	0.30	0.30
Sorbitol, 70%	19.00	19.00	19.00
Water	31.56	32.51	34.51
Sodium Fluoride	0.243	0.243	0.243
Sodium saccharin	0.30	0.30	0.30
Sodium hydroxide, 50%	1.20	---	---
Gantrez™ S-97	2.00	---	---
Example B1	---	2.00	---
Zeodent® 115 (silica)	20.00	20.00	20.00
Zeodent® 165 (silica)	1.50	1.50	1.50
Titanium dioxide, USP/FCC	0.50	0.50	0.50
Essential oils/flavor	1.00	1.00	1.00
Sodium loth paste gel auryl sulfate	1.50	1.50	1.50
TOTAL	100.00	100.00	100.00
pH (1:3 dispersion in water)	7.1	6.9	6.9

TABLE 2. Toothpaste Compositions containing Triclosan

Ingredients	Compositions, weight %		
	G4	G5	G6
Glycerin	20.00	20.00	20.00
Aqualon™ CMC 7M8SF	0.75	1.15	1.15
Carageenan	0.3	0.3	0.3
Sorbitol, 70%	19.00	19.00	19.00
Water	31.41	32.21	34.21
Sodium fluoride	0.243	0.243	0.243
Sodium saccharin	0.30	0.30	0.30
Sodium hydroxide, 50%	1.20	---	---
Gantrez™ S-97	2.00	---	---
Example B1	---	2.00	---
Zeodent® 115 (silica)	20.00	20.00	20.00
Zeodent® 165 (silica)	1.50	1.50	1.50
Titanium dioxide, USP/FCC	0.50	0.50	0.50
Peppermint oil, FCC	1.00	1.00	1.00
Sodium lauryl sulfate	1.50	1.50	1.50
Triclosan	0.30	0.30	0.30
TOTAL	100.00	100.00	100.00
pH (1:3 dispersion in water)	7.2	7.0	7.2

Example H: Retention of Essential Oils and Triclosan on Artificial Teeth

[00131] Sintered, calcium deficient, hydroxyapatite (HAP) discs were coated with a mucin protein pellicle layer by treating the discs overnight at 37 °C in a 1% mucin/electrolyte solution ("artificial saliva") before treatment. Toothpaste supernatant solutions were prepared by making a 1:1 slurry of toothpaste compositions of example G in de-ionized water and centrifuging at 4,500 × g for 45 minutes. The supernatant layer was poured off the top of the centrifuge tube and used as is.

[00132] Individual pellicle-coated HAP discs ("artificial teeth") were placed in culture tubes containing the toothpaste supernatant solutions and shaken in an incubating test tube shaker at 37 °C for 30 minutes. The treated discs were then well rinsed in de-ionized water, placed into fresh culture tubes containing artificial saliva, and further challenged by vigorously shaking on the test

tube shaker at 37 °C for 1 hour. The discs were then removed from the artificial saliva, rinsed in de-ionized water, and the compound of interest was extracted from the discs using a known weight of an organic solvent in which the compound was soluble. The concentrations of the compounds in the solvent extracts were determined using high performance liquid chromatography with UV detection. Error ranges given are standard deviations.

[00133] From Table 3, it is evident that the slurry composition of the present disclosure improves retention of essential oils/flavors on pellicle-coated HAP discs ("artificial teeth").

TABLE 3: Retention of Essential Oils on Pellicle-coated HAP Discs

Ingredient	Ingredient recovery (µg/disc) based on Toothpaste Compositions		
	G1	G2	G3
IPMP	5.20 ± 0.44	7.33 ± 0.15	3.80 ± 0.10
Eugenol	7.60 ± 0.72	9.80 ± 0.44	5.70 ± 0.00

[00134] From Table 4, it can be seen that the slurry composition of the present disclosure improves retention of triclosan on pellicle-coated HAP discs ("artificial teeth").

TABLE 4. Retention of Triclosan on Pellicle-coated HAP Discs

Ingredient	Ingredient recovery (µg/disc) based on Toothpaste Composition		
	G4	G5	G6
Triclosan	35.77± 6.65	63.87 ± 1.74	25.60 ± 0.28

Example I: Preparation of Water-based Carbon Nanotube (CNT) Dispersions

[00135] Water-based Carbon Nanotube dispersions of this example was made using different weight proportions of sodium salt of maleated soybean oil of example B1 and carboxymethyl cellulose CMC (Ambergum™ 1221, Ashland) as dispersant. In a typical experiment, dispersant of example B1 (0.25 g) was fully dissolved in 49.5 g of distilled water at a temperature of 5-35 °C and an overhead mixer speed of 200-1000 rpm for about 1-8 hours, until no particle was observable by the eye. Carbon nanotubes (JiangSu Cnano, 0.25 g) were added to the aqueous mixture, and the mixture in a closed container was shaken by hand for 30 seconds and placed the container in a sonicating bath for 15 minutes. The container was transferred to an ultrasonic mixer, utilizing a

cool water bath, and sonicated for about 2-4 hours. The container was removed from the ultrasonic mixer and cooled.

Example J: Analysis of Water-based Carbon Nanotube (CNT) Dispersions

[00136] Water-based CNT dispersions, prepared according to Example I, using different proportions of the dispersant of Example B1 and carboxymethyl cellulose CMC (Ambergum™ 1221, Ashland), were analyzed for particle size distribution and resistivity. As can be seen from the results in Table 5, the dispersant of Example B1 improves the particle size distribution and resistivity of the CNT dispersion, relative to carboxymethyl cellulose (CMC).

TABLE 5: Properties of CNT Dispersions using the Dispersant of Example B1

Dispersant Composition, wt.%		**Particle Size D_{50}, µm**	**Resistivity, kΩ**
Example B1	CMC		
0.0	1.0	24.7	0.4
0.5	0.5	12.1	0.8

Example K: Coatings Comprising a Slurry of Titanium dioxide, Calcium carbonate, Talc, and Clay

[00137] Paints comprising the sodium salt of maleated soybean oil (Example B1) or Indofil 731 as dispersant were made, using methods and equipment commonly used by those skilled in the art. Table 6 details the compositions made. Table 7 reports performance data.

TABLE 6: Paint Compositions having Slurries of TiO_2, $CaCO_3$, Talc, and Clay

Ingredients	Compositions, weight %	
	K1	K2
Water	10.00	10.50
Indofil 731	1.00	---
Example B1	---	0.50
Spectra A 1000	0.80	0.80
Advantage™ AM 1512A defoamer	0.30	0.30
Aquaflow™ NHS 300E	1.00	1.00
Phlex™ 110	0.2	0.2
Ti-Pure™ R-902+ (TiO_2)	21.00	21.00
O Carb (calcium carbonate)	2.00	2.00
Steatite (talc, 10 microns)	6.60	6.60
Calcined clay	6.00	6.00
Water	10.35	10.35
Propylene glycol	2.00	2.00
Texanol	1.50	1.50
Primal™ AC-261S	36.00	36.00
Aquaflow™ NHS 300E	0.35	0.35
Aquaflow™ NLS 200	0.80	0.80
Drewplus™ T-4507A	0.10	0.10

TABLE 7: Properties of Paint Compositions having Slurries of TiO_2, $CaCO_3$, Talc, and Clay

Performance	Compositions	
	K1	K2
Grind finish	6+	6+
Grind ICI	0.7	2.34
IN KU paint	120.5	109.7
ICI	2.33	2.12
BF	4040	2880
Gloss 20°/60°/85°	1.6/7.0/18.6	1.6/6.7/17.7
Contrast ratio	97.16	96.66
Yellowness index	1.52	1.81
Reducing strength	Control	104.57%
ΔE 5% green colorant	Control	0.78

Example L: Ceramic Slurry Preparation and Separator Characterization

[00138] Ashland Soteras™ CCS-A and deionized water were mixed for several minutes at 900 rpm. Ceramic particles were added, and the slurry was mixed at 1500 rpm for 1 hour. A 10 wt% aqueous solution of Soteras™ CCS-B was added by dropper, and the slurry was mixed for 5 minutes. A 10 wt% aqueous solution of dispersant of Example F2 was added to the slurry by dropper, and the slurry was mixed a further 30 minutes. Ambergum™ 1221 (Ashland, Inc., Wilmington, DE) was used as a comparative dispersant.

[00139] The slurry viscosity was measured by Brookfield viscometer, LV type, at 25 °C. The viscosity of the slurry was reduced by adding the dispersant.

[00140] Using a drawdown bar, the slurry was spread on a sheet of polyolefin separator film to form an even, uniform coating of ceramic layer. The coated film was cured in an oven at 60 °C for 1 minute. The cured film was removed from the oven and cooled to room temperature.

Gurley Porosity Test:

[00141] Gurley equipment was used to determine the air permeability of coated polyolefin films and the pristine, uncoated film. The Gurley number expresses the time required for 100 mL of air

to pass through a specific area of separator. The time differences between the coated films (usually longer) and a blank, uncoated polyolefin film were determined.

[00142] Gurley porosity measurements of the ceramic coated separators were measured using a Gurley densometer from TMI Machine, Inc. (New Castle, DE). Gurley increment results are presented as a percentage, an ideal Gurley increment measurement is no change (0%) compared to Gurley porosity measurement of a blank polyolefin substrate.

Thermal Shrinkage:

[00143] Ceramic-coated separators were heated at 150 °C for 1 hour in an air-convention oven. After 1 hour, the separator squares were examined and measured for thermal shrinkage. For shrinkage, the lower the number, the better the results.

[00144] The viscosity, Gurley increment, and thermal shrinkage of the slurries were measured and listed in Table 8. These unexpected properties indicate that ceramic coated separators are very useful in the field of Li-ion batteries.

TABLE 8. Slurries of Boehmite APYRAL® AOH 60 (Nabaltec AG, Germany):

Dispersant	wt.% in slurry			viscosity	Gurley	Thermal
	Boehmite	Binder	dispersant	cP	Increment, %	Shrinkage, %
None	33.3	1.7	0.0	742	17.9	15
Ambergum™ 1221 (comparative)	32.8	1.6	0.16	166	17.7	13
Example F2	32.9	1.6	0.12	84	13.5	38

[00145] While the compositions and methods of the disclosed and/or claimed inventive concept(s) have been described in terms of particular aspects, it will be apparent to those of ordinary skill in the art that variations may be applied to the compositions and/or methods and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit and scope of the disclosed and/or claimed inventive concept(s). All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept of the disclosed and/or claimed inventive concept(s).

We claim:

1. A slurry composition comprising:

(i) a reaction product of (a) a maleated natural oil comprising a natural oil with maleated functionality; and (b) a base;

(ii) at least one dispersed particle; and

(iii) at least one solvent.

2. The slurry composition according to claim 1, wherein the reaction product comprises a maleated functionality fully or partially reacted with the base.

3. The slurry composition according to claim 1, wherein the base is selected from the group consisting of inorganic bases, organic bases, and mixtures thereof.

4. The slurry composition according to claim 3, wherein the inorganic base is selected from the group consisting of oxides of alkali metals and alkaline earth metals, hydroxides of alkali metals and alkaline earth metals, carbonates of alkali metals and alkaline earth metals, bicarbonates of alkali metals and alkaline earth metals, oxides of transition metals, hydroxides of transition metals, carbonates of transition metals, bicarbonates of transition metals, and combinations thereof.

5. The slurry composition according to claim 4, wherein the organic base is selected from the group consisting of ammonia, primary amines, secondary amines, tertiary amines, pyridine, imidazole, benzimidazole, histidine, guanidine, and mixtures thereof.

6. The slurry composition according to claim 4, wherein the alkali metal is selected from the group consisting of lithium, sodium, potassium, rubidium, cesium, francium, and mixtures thereof.

7. The slurry composition according to claim 4, wherein the alkaline earth metal is selected from the group consisting of beryllium, magnesium, calcium, strontium, barium, radium, and mixtures thereof.

8. The slurry composition according to claim 4, wherein the transition metal is selected from the group consisting of scandium, titanium, vanadium, chromium, manganese, iron,

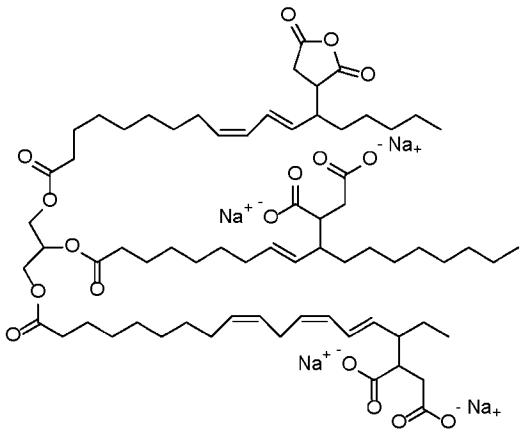
cobalt, nickel, copper, zinc, yttrium zirconium, niobium, molybdenum, technetium, ruthenium, rhodium, palladium, silver, cadmium, hafnium, tantalum, tungsten, rhenium, osmium, iridium, platinum, gold, mercury, rutherfordium, dubnium, seaborgium, bohrium, hassium, meitnerium, darmstadtium, roentgenium, and mixtures thereof.

9. The slurry composition according to claim 4, wherein the inorganic base is selected from the group consisting of oxides, hydroxides, carbonates and bicarbonates of sodium, calcium, and combinations thereof.

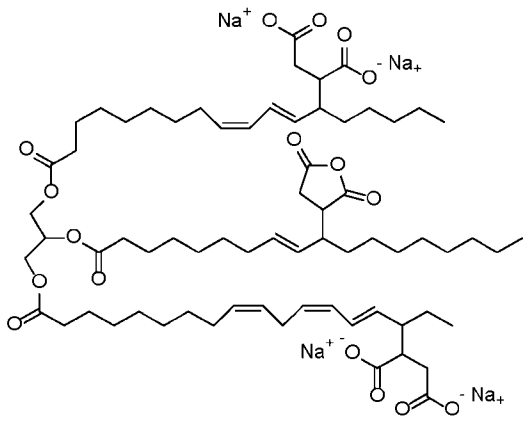
10. The slurry composition according to claim 1, wherein the maleated natural oil is selected from the group consisting of maleated avocado oils, maleated coconut oils, maleated corn oils, maleated cottonseed oils, maleated jojoba oils, maleated linseed oils, maleated nut oils, maleated olive oils, maleated palm oils, maleated raisin oils, maleated rapeseed oils, maleated safflower oils, maleated sesame oils, maleated soybean oils, maleated squash oils, maleated sunflower oils, maleated almond oils, maleated canola oils, maleated flaxseed oils, maleated grapeseed oils, , maleated palm kernel oils, maleated peanut oils, maleated walnut oils, maleated chickpea oils, maleated clary sage oils, and mixture thereof.

11. The slurry composition according to claim 1, wherein the maleated natural oil is a maleated soybean oil.

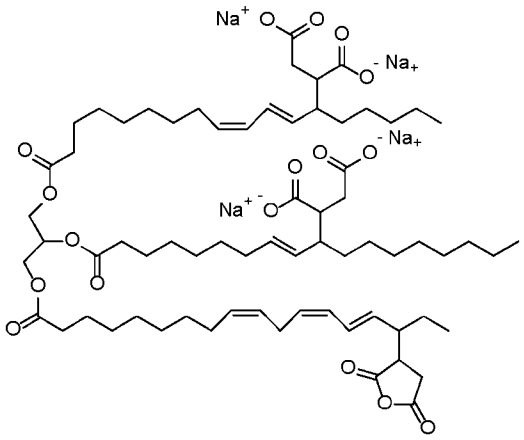
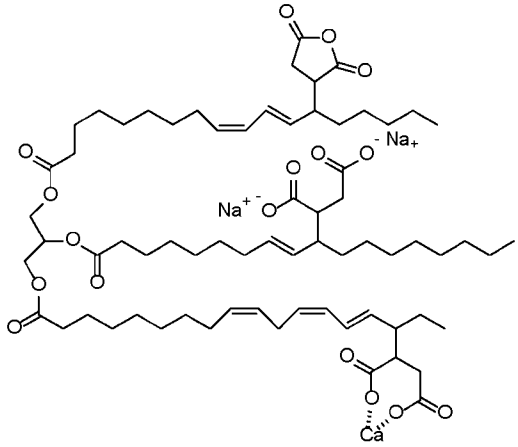
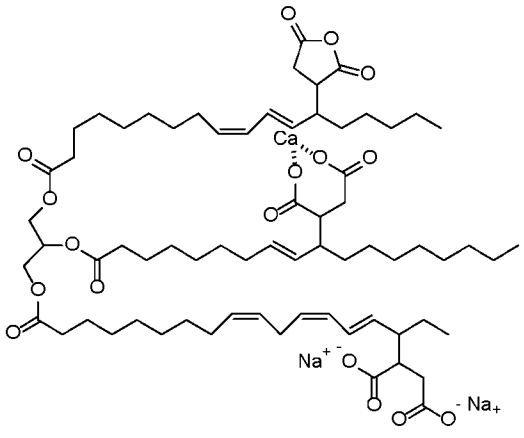
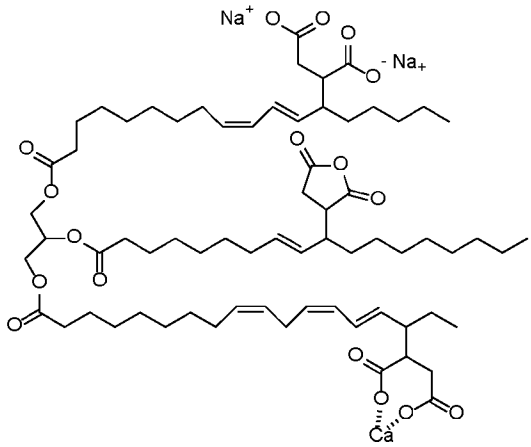
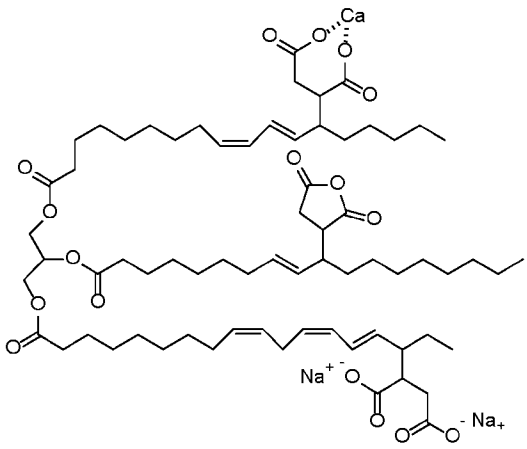
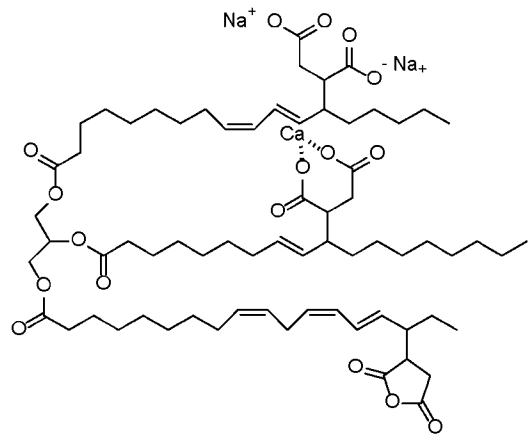
12. The slurry composition according to claim 1, wherein the reaction product comprises one or more structures selected from the group consisting of the following structures:

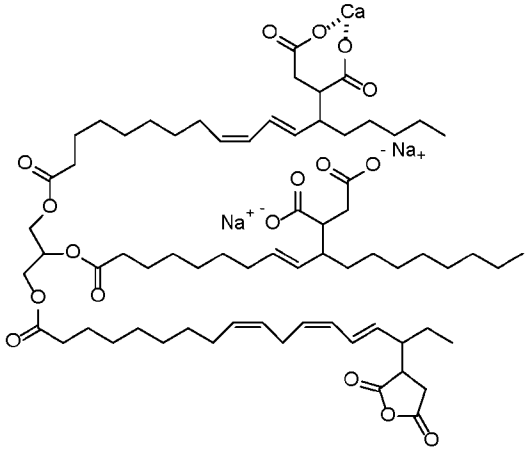
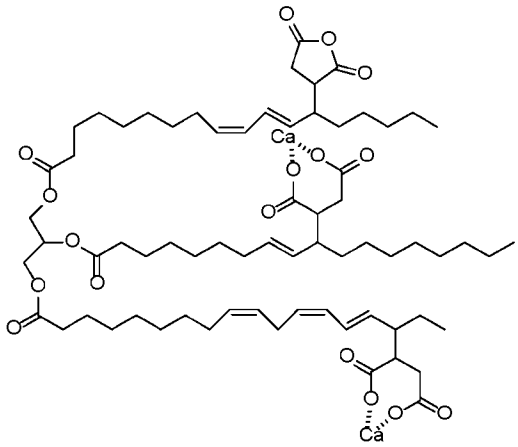
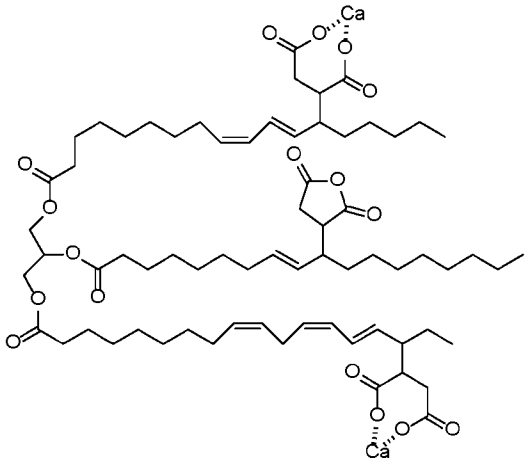
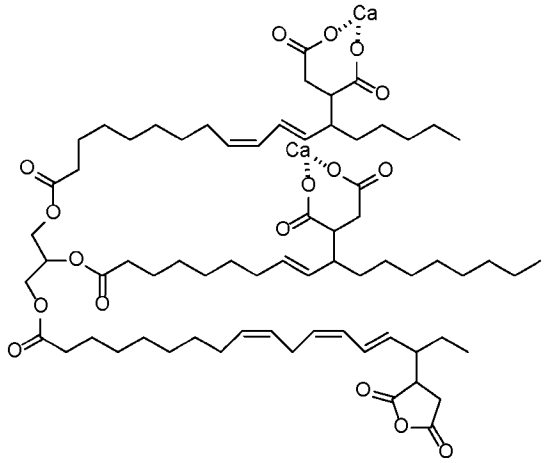
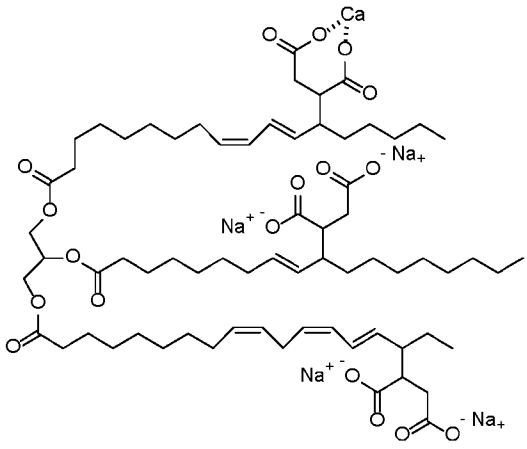
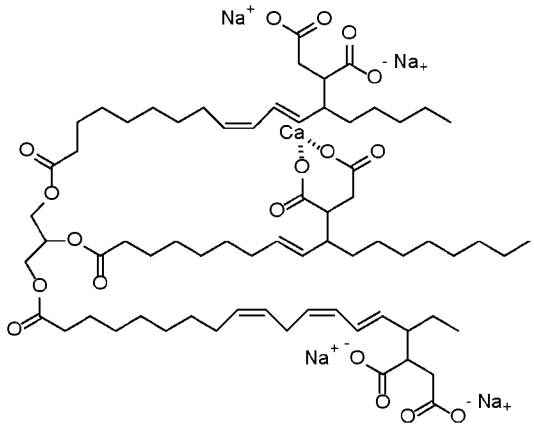


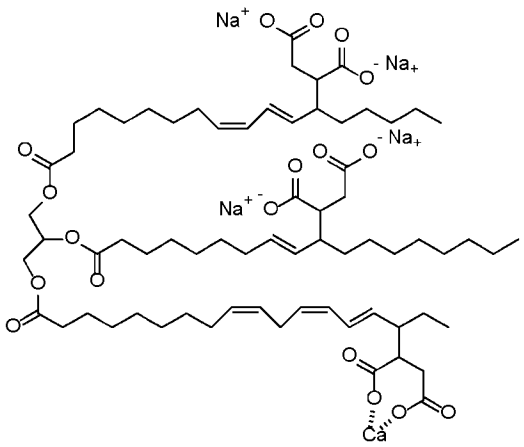
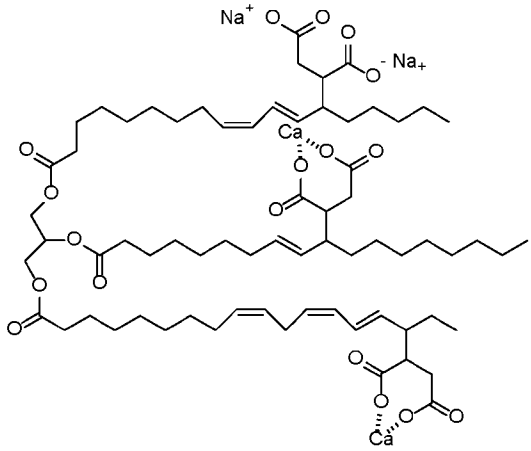
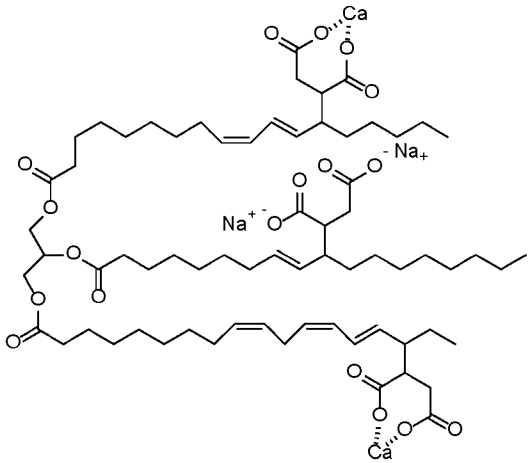
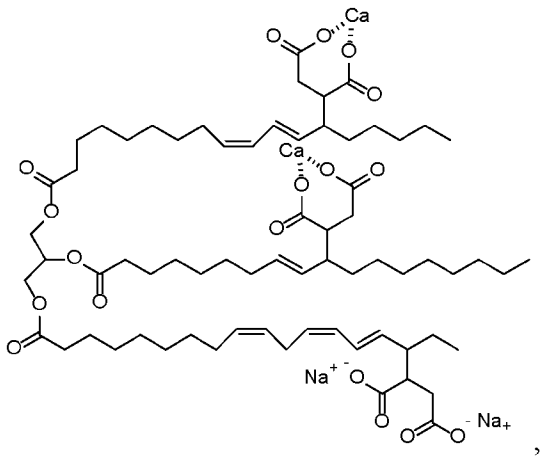
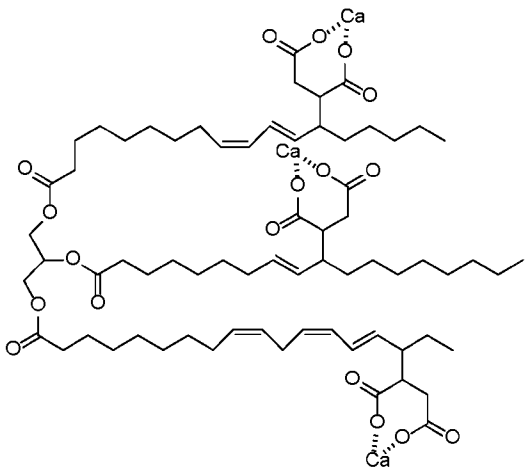
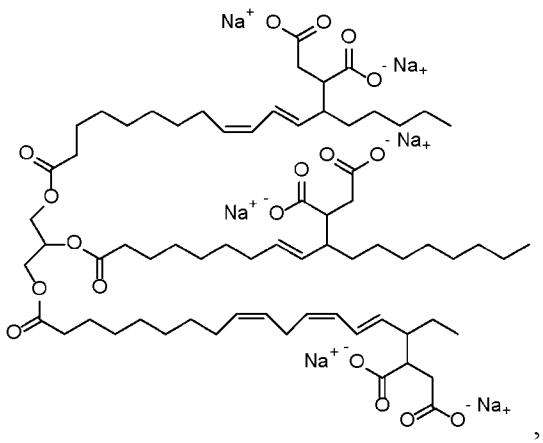
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and combinations thereof.

13. The slurry composition according to claim 1, wherein the dispersed particle is selected from the group consisting of alumina, alumina oxide hydroxide, SiO_2, $BaSO_4$, TiO_2, SnO_2, CeO_2, ZrO_2, $BaTiO_3$, Y_2O_3, B_2O_3, carbon nano tube, ZnO, Al-doped Lithium Lanthanum Zirconate Oxide (LLZO), and combinations thereof.

14. The slurry composition according to claim 1, wherein the dispersed particle is in powder form.

15. The slurry composition according to claim 1, wherein the dispersed particle has a particle size distribution (d50) in the range of from 0.05 μm to 50 μm.

16. The slurry composition according to claim 1, wherein the solvent is selected from the group consisting of at least one aqueous solvent, alcohols; phenols, acetates; ketones; ethylene glycols; propylene glycols; amides; pyrrolidones; hydroxyesters; sulfoxides; lactones; anilines; hydrocarbons; halogenated solvents; aromatic solvents; glycol esters and combinations thereof.

17. The slurry composition according to claim 16, wherein the solvent is selected from the group consisting of water, methanol, ethanol, isopropyl alcohol, propyl alcohol, butanol, terpineol, acetone, methyl ethyl ketone, ethyl isobutyl ketone, methyl isobutyl ketone, ethylene glycol, ethylene glycol methyl ether, ethylene glycol mono-n-propyl ether, propylene glycol, propylene glycol methyl ether, propylene glycol ethyl ether, propylene glycol butyl ether, propylene glycol propyl ether, dimethylformamide, dimethylacetoamide, N-methyl-2-pyrrolidone (NMP), N-ethylpyrrolidone, dimethylsulfoxide, gamma-butyrolactone, lactic acid methyl ester, lactic acid ethyl ester, β-methoxyisobutyric acid methyl ester, α-hydroxyisobutyric acid methyl ester, aniline, N-methylaniline, hexane; chloroform; toluene; propylene glycol monomethyl ether acetate (PGMEA), acetoacetate, and combinations thereof.

18. The slurry composition according to claim 1, wherein the composition further comprises at least one functional ingredient selected from the group consisting of skin care agents, oral care agents, hair care agents, energy agents, construction agents, biocidal agents, preservative agents, nutraceutical agents, food agents, agricultural agents, coating agents, cosmetic agents, homecare agents, industrial and institutional agents, textile agents, laundry agents, cleaning agents, inorganic particle of ceramic compositions, and disinfecting agents.

19. The slurry composition according to claim 1, wherein the slurry composition is selected from group consisting of agricultural compositions, biocidal compositions, ceramic slurry compositions, cleaning compositions, coating compositions, cosmetic compositions, construction compositions, disinfecting compositions, energy compositions, food compositions, hair care compositions, skin care compositions, nail care compositions, sun care compositions, homecare compositions, industrial and institutional compositions, laundry compositions, nutraceutical composition, oral care compositions, nutraceutical compositions, preservative compositions, textile compositions, carbon-nanotube compositions, battery compositions, and ceramic coated separators for batteries.

20. The slurry composition according to claim 1, wherein the slurry composition is a personal care composition, a coating composition, a food composition, an agricultural composition or a carbon nanotube composition.

21. A ceramic coated separator for an energy storage device comprising: (i) the slurry composition of claim 1, wherein the slurry composition is a ceramic slurry composition, and (ii) a separator, wherein the ceramic slurry composition provides a coating that is in contact with at least a portion of the separator.

22. The ceramic coated separator according to claim 21, wherein the ceramic slurry composition is coated on at least one surface of the separator, forming a coating thereon.

23. The ceramic coated separator according to claim 21, wherein the separator comprises a polyolefin.

24. The ceramic coated separator according to claim 23, wherein the polyolefin is selected from the group consisting of polyethylene, polypropylene, and combinations thereof.

25. The ceramic coated separator according to claim 21, wherein the separator has undergone at least one treatment selected from the group consisting of: corona treatment, atmospheric plasma treatment, flame plasma treatment, chemical plasma treatment, ozone treatment, polyvinylidene fluoride (PVDF) treatment, and treatment with polydopamine.

26. The ceramic coated separator according to claim 21, wherein the coating is uniformly distributed on the separator.

27. The ceramic coated separator according to claim 21, wherein the coating has a mean thickness in a range of from about 1 to about 5 μm.

28. An energy storage device comprising the ceramic coated separator of claim 21, wherein the energy storage device is selected from the group consisting of fuel cells, electrochemical cells, batteries, and capacitors.

29. A battery, comprising the ceramic coated separator of claim 21.

30. A battery comprising: (i) at least one ceramic coated separator of claim 21; (ii) at least one cathode; and (iii) at least one anode.

31. A coating composition comprising the slurry of claim 1.

32. The coating composition according to claim 31, wherein the slurry is in the range of from about 0.1 wt.% to about 95.0 wt.% of the composition.

33. The coating composition according to claim 31, further comprising at least one additive in the range of from 0.01 wt.% to 99.9 wt.%.

34. The coating composition according to claim 33, wherein the additive is selected from the group consisting of film forming polymers, coalescent agents, emulsifiers, stabilizers, rheology modifiers, cosolvents, dispersing agents, defoamers, wet-edge additives, wetting agents, humectants, wax, colorants, thickeners, anticaking agents, antifoaming agents, UV absorbers, antifreeze agents, gel inhibitors, preservatives, hydrophobic agents, adhesion promoters, biocides, anti-oxidants, pigments, and plasticizers.

35. The coating composition according to claim 31, wherein the coating composition is an aqueous or a non-aqueous composition used for lacquer coating, primer coating, ink jet printing, top coating, varnish coating, architectural coating, wood coating, printing inks, or metallic or non-metallic coatings.

36. The coating composition according to claim 31, wherein the composition is coated on a substrate selected from the group consisting of porous and non-porous substrates, papers, non-woven materials, textiles, leather, wood, concrete, masonry, metals, non-metals, house wrap, building materials, fiberglass, polymeric articles, face masks, medical drapes and gowns, carpets,

upholstery, tents, awnings, air bags, fabrics, ceramics, yarns, and woven, knitted, natural, synthetic or regenerated substrates.

37. A personal care composition comprising the slurry of claim 1.

38. The personal care composition according to claim 37, wherein the slurry is present in an amount of from about 0.1 wt.% to about 95.0 wt.% of the personal care composition.

39. The personal care composition according to claim 37, wherein the personal care composition further comprises at least one personal care functional active ingredient in the range of from about 0.01 wt.% to about 99.9 wt.%.

40. The personal care composition according to claim 39, wherein the personal care functional active ingredient is selected from the group consisting of color agents, hair care agents, skin care agents, sun care agents, and combinations thereof.

41. The personal care composition according to claim 37, wherein the personal care composition is selected from the group consisting of body wash compositions, skin lotion compositions, sunscreen compositions, anti-wrinkle compositions, moisturizer compositions, facial cleaning compositions, lipstick compositions, lip-gloss compositions, mascara compositions, foundation compositions, anti-perspirant compositions, shaving compositions, hair conditioner compositions, anti-perspirant compositions, deodorant compositions, hair rinse compositions, hair shampoo compositions, hair styling compositions, make-up remover compositions, and oral care compositions.

42. The personal care composition according to claim 37, wherein the personal care composition is an aqueous or non-aqueous formulation in the form of a spray, lotion, mousse, fluid, serum, solution, suspension, perm, emulsion, gel, mist, vesicle, dispersion, paste, cream, solid stick, shampoo, balm, wipe, milk, foam, jelly, or liquid.

43. An agricultural composition comprising the slurry of claim 1.

44. The agricultural composition according to claim 43, wherein the slurry is present in the range of from about 0.1 wt.% to about 95.0 wt.% of the agriculture composition.

45. The agricultural composition according to claim 43, wherein the agricultural composition further comprises from about 0.01 wt.% to about 99.9 wt.% of one or more agriculturally active ingredient and one or more additional ingredient.

46. The agricultural composition according to claim 45, wherein the agriculturally active ingredient is a fertilizer or a pesticide selected from the group consisting of rodenticides, miticides, algicides, molluscicides, acaricides, avicides, insecticides, herbicides, ovicides, fungicides, germicides, antibiotics, antibacterials, antivirals, antifungals, antiprotozoals, anti-parasites, and antimicrobials.

47. The agricultural composition according to claim 45, wherein the additional ingredient is an adjuvant or an inert ingredient.

48. The agricultural composition according to claim 47, wherein the adjuvant is selected from the group consisting of acidifying agents, buffering agents, anti-foam agents, defoaming agents, anti-transpirants, dyes and brighteners, compatibility agents, crop oil concentrates, oil surfactants, deposition agents, drift reduction agents, foam markers, feeding stimulants, herbicide safeners, spreaders, extenders, adhesive agents, suspension agents, gelling agents, synergists, wetting agents, emulsifiers, dispersing agents, penetrants, tank and equipment cleaners, adjusters, water absorbents, water softeners, and mixtures thereof.

49. The agricultural composition according to claim 47, wherein the inert ingredient is selected from the group consisting of solvents, liquid carriers, solid carriers or fillers, surfactants, solubilizers, penetration enhancers, protective colloids, thickeners, humectants, repellents, attractants, compatibilizers, bactericides, anti-freezing agents, crystallization inhibitors, colorants, tackifiers, binders, preservatives, pH adjuster, clarifiers, stabilizers, UV stabilizers, and mixtures thereof.

50. The agricultural composition according to claim 43, wherein the agricultural composition is an adjuvant composition, a fertilizer composition, a nutrient composition, a plant strengthener composition, a seed coating composition, a soil conditioner composition, a livestock composition, a granular composition, a controlled release composition, a film coating composition, a pesticide composition selected from the group consisting of ovicide, rodenticide, insecticide, miticide, algicide, molluscicide, acaricide, avicide, fungicide and herbicide compositions, a germicide composition, an antibiotic composition, an antibacterial composition, an antiviral composition, an antifungal composition, an antiprotozoal composition, an anti-parasite composition, a wood preservation composition, or an antimicrobial composition.

51. The agricultural composition according to claim 43, wherein the agricultural composition is in the form of an aqueous or a non-aqueous composition comprising a capsule suspension, an emulsifiable concentrate, an emulsion for seed treatment, a concentrated aqueous emulsion, a microemulsion, a suspoemulsion, an oil-in-water emulsion, a flowable concentrate for seed treatment, an oil dispersion, a suspension concentrate, a water dispersible granule or a wettable powder.

52. A carbon nanotube composition comprising the slurry of claim 1.

53. The carbon nanotube composition according to claim 52, wherein the slurry is present in an amount of from about 0.1 wt.% to about 95.0 wt.% of the carbon nanotube composition.

54. The carbon nanotube composition according to claim 52, wherein the carbon nanotube composition further comprises about 0.01 wt. % to about 10.0 wt.% of carbon nanotube; and a solvent.

55. The carbon nanotube composition according to claim 54, wherein the carbon nanotube is selected from the group consisting of single-wall carbon nanotubes, double-wall carbon nanotubes, triple-wall carbon nanotubes, quadruple-wall carbon nanotubes, few-wall carbon nanotubes, multi-walled carbon nanotubes, carbon nanohorns, carbon nanofibers, short nanotubes, carbon particle nanotubes, and combinations thereof.

56. The carbon nanotube composition according to claim 54, wherein the solvent is selected from the group consisting of at least one aqueous solvent; alcohols; ketones; ethyleneglycols; propyleneglycols; amides; pyrrolidones; hydroxyesters; sulfoxides; lactones; anilines; hydrocarbons; halogenated solvents; aromatic solvents; glycol esters and combinations thereof.

57. The carbon nanotube composition according to claim 54, wherein the solvent is selected from the group consisting of water, methanol, ethanol, isopropyl alcohol, propyl alcohol, butanol, terpineol, acetone, methyl ethyl ketone, ethyl isobutyl ketone, methyl isobutyl ketone, ethylene glycol, ethylene glycol methyl ether, ethylene glycol mono-n-propyl ether, propylene glycol, propylene glycol methyl ether, propylene glycol ethyl ether, propylene glycol butyl ether, propylene glycol propyl ether, dimethylformamide, dimethylacetamide, N-methyl-2-pyrrolidone

(NMP), N-ethylpyrrolidone, dimethylsulfoxide, gamma-butyrolactone, lactic acid methyl ester, lactic acid ethyl ester, β-methoxyisobutyric acid methyl ester, α-hydroxyisobutyric acid methyl ester, aniline, N-methylaniline, hexane, chloroform, toluene, propylene glycol monomethyl ether acetate (PGMEA) and combinations thereof.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/046020

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***C09B 67/42*** (2024.01); ***C09B 67/46*** (2024.01); ***C09D 17/00*** (2024.01); *C09B 67/46* (2024.01)

CPC: ***C09B 67/0071; C09B 67/0084; C09D 17/007;*** *C09B 67/0085*

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

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

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2014/145972 A2 (ETHOX CHEMICALS LLC) 18 September 2014 (18.09.2014) pg 12, ln 16-22; pg 14, ln 2-17; pg 15, ln 7-14; pg 18, ln 20-23; pg 21, ln 20 to pg 22, ln 9	1-4,6,10,13-20,43-51
A	US 2013/0289284 A1 (MUSA et al.) 31 October 2013 (31.10.2013) abstract; para [0012]; para [0032] scheme; para [0033]; para [0107]	1-4,6,10,13-20,43-51
A	US 2018/0070584 A1 (HUNTSMAN PETROCHEMICAL LLC) 15 March 2018 (15.03.2018) para [0018]; para [0034]; para [0086]; para [0108]	1-4,6,10,13-20,43-51
A	US 2009/0065736 A1 (JOHNSON et al.) 12 March 2009 (12.03.2009) entire document	1-4,6,10,13-20,43-51

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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

"D" document cited by the applicant in the international application

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 December 2024 (20.12.2024)	**13 January 2025 (13.01.2025)**

Name and mailing address of the ISA/US	Authorized officer
COMMISSIONER FOR PATENTS **MAIL STOP PCT, ATTN: ISA/US** **P.O. Box 1450** **Alexandria, VA 22313-1450** **UNITED STATES OF AMERICA**	**KARI RODRIQUEZ**
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/046020

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

Group I+: Claims 1-20 and 37-57, directed to a slurry composition comprising: (i) a reaction product of (a) a maleated natural oil comprising a natural oil with maleated functionality; and (b) a base; (ii) at least one dispersed particle; and (iii) at least one solvent. The compound of claim 1 will be searched to the extent that it encompasses the first species of claim 1, wherein the base is the first species of claim 3, wherein the base is consisting of an inorganic base; wherein the inorganic base is the first species of claim 4, wherein the inorganic base is consisting of oxides of alkali metals; wherein the oxide is the first species of claim 6, wherein the alkali metal is consisting of lithium; wherein the composition is the first species of claim 10, wherein the maleated natural oil is consisting of maleated avocado oil; wherein the composition is the first species of claim 13, wherein the dispersed particle is consisting of alumina; wherein the composition is the first species of claim 16, wherein the solvent is consisting of at least one aqueous solvent; wherein the composition is the first species of claim 19, wherein the slurry composition is selected from group consisting of agricultural compositions. It is believed that claims 1-4, 6, 10, 13-20, and 43-51 encompass this first named invention, and thus these claims will be searched without fee to the extent that they encompass the first species of claim 1. This first named invention has been selected based on the guidance set forth in section 10.54 of the PCT International Search and Preliminary Examination Guidelines. Applicant is invited to elect additional compounds of claim 1, wherein each additional compound elected will require one additional invention fee. Applicants must specify the claims that encompass any additionally elected compound. Applicants must further indicate, if applicable, the claims which encompass the first named invention, if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the "+" group(s) will result in only the first claimed invention to be searched. Additionally, an exemplary election wherein different actual variables are selected is suggested. An exemplary election would be a compound of claim 1, wherein the base is the second species of claim 3, wherein the base is consisting of an organic base; wherein the organic base is the first species of claim 5, wherein the organic base is consisting of ammonia; wherein the composition is the first species of claim 10, wherein the maleated natural oil is consisting of maleated avocado oil; wherein the composition is the first species of claim 13, wherein the dispersed particle is consisting of alumina; wherein the composition is the first species of claim 16, wherein the solvent is consisting of at least one aqueous solvent; wherein the composition is the first species of claim 19, wherein the slurry composition is selected from group consisting of agricultural compositions (i.e. claims 1-5, 10, 13-20, and 43-51).

Group II: Claims 21-36, directed to a ceramic coated separator for an energy storage device comprising: (i) the slurry composition of claim 1, wherein the slurry composition is a ceramic slurry composition, and (ii) a separator, wherein the ceramic slurry composition provides a coating that is in contact with at least a portion of the separator.

The groups of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features:

Group I+ includes the technical feature of a unique composition of claim 1, which is not required by any other invention of Group I+.

Group II requires a ceramic coated separator for an energy storage device, which is not required by Group I.

Common technical features:

The inventions of Groups I+ share the technical feature of a slurry composition comprising: (i) a reaction product of (a) a maleated natural oil comprising a natural oil with maleated functionality; and (b) a base; (ii) at least one dispersed particle; and (iii) at least one solvent.

The inventions of Group I+ and Group II share the technical feature of the slurry composition of claim 1.

These shared technical features, however, do not provide a contribution over the prior art, because the shared technical features are anticipated by WO 2014/145972 A2 to Ethox Chemicals LLC (hereinafter 'Ethox').

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

Ethox teaches a slurry composition comprising: (i) a reaction product of (a) a maleated natural oil comprising a natural oil with maleated functionality; and (b) a base; (ii) at least one dispersed particle; and (iii) at least one solvent (pg 12, ln 16-22, The instant invention also provides a polymer dispersion comprising: (a) a polymer; (b) a solvent; and (c) a bio-based dispersing agent comprising the reaction product of a natural triglyceridic oil, fatty acid oil or fatty acid oil derivative wherein said natural triglyceridic oil, fatty acid oil, or fatty acid oil derivative containing greater than about 80 percent of unsaturated or conjugated unsaturated fatty acids with a substrate capable of undergoing an ene or Diels Alder reaction to form an adduct that is further esterified and/ or neutralized with an alkanolamine or alkoxylated alkanolamine; see also pg 14, ln 2-17, In one embodiment of the present invention, an unsaturated natural oil or derivative thereof is modified by a process in which the double bonds and/or conjugated double bonds of the triglyceride oil chains are reacted via thermal condensation with an unsaturated substrate which is capable of undergoing an "ene" reaction or an Diels Alder reaction with the sites of unsaturation resulting in the formation of an adduct of the triglyceride oil. The adduct formed is preferentially an anhydride and the substrate reacted in this manner with the triglyceride oil is preferably maleic anhydride; see also pg 21, ln 20 to pg 22, ln 9, The non-aqueous pigment dispersion composition of the present invention is prepared by adding a pigment to a non-aqueous solution of a pigment dispersant... Thus, the pigment contained in the dispersion has a median particle size of not greater than 250 nm, preferably not greater than 200 nm with not greater than 30% of the pigment particles being impassable through the sieve having a mesh size of 300 nm).

As said compound was known in the art, this cannot be considered a special technical feature that would otherwise unify the inventions of Group I+ and II.

The inventions of Group I+ and II thus lack unity under PCT Rule 13.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☑ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: **1-4,6,10,13-20,43-51**

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.