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(71) Applicant: **OMS INVESTMENTS, INC.** [US/US]; 10250 Constellation Boulevard, Suite 2800, Los Angeles, CA 90067 (US).

(72) Inventors: **ESSINGER, James, F. Jr.**; 749 St. Thomas Court, Cincinnati, OH 45230 (US). **SHELL, Elizabeth, A.**; 819 Summertree Lane, Westerville, OH 43081 (US).

(74) Agents: **SPIEGLER, Alexander, H.** et al.; Hunton and Williams LLP, 2200 Pennsylvania Ave, NW, Washington, DC 20037 (US).

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(54) Title: NANO-SIZED WATER-BASED DISPERSION COMPOSITIONS AND METHODS OF MAKING THEREOF

(57) Abstract: The present invention relates to a nanoparticle-sized dispersion, and to methods of manufacture and use thereof. More particularly, the composition may comprise an aqueous continuous phase comprising an anionic surfactant, and a discontinuous hydrophobic phase comprising a branched or straight-chain polycarboxylic acid or a straight-chain monocarboxylic acid.

NANO-SIZED WATER-BASED DISPERSION COMPOSITIONS AND METHODS OF MAKING THEREOF

FIELD OF INVENTION

[0001] The present invention relates generally to a nanoparticle-sized dispersion, and to methods of manufacture and use thereof. More particularly, the composition may comprise an aqueous continuous phase comprising an anionic surfactant, and a discontinuous hydrophobic phase comprising a branched or straight-chain polycarboxylic acid or a straight-chain monocarboxylic acid.

BACKGROUND OF INVENTION

[0002] When an active ingredient is hydrophobic, it can be difficult to create a water-based composition of the active ingredient. Unacceptable phase separation by coalescence and growth of the solid particle are just two examples of ways in which such a composition can fail to remain evenly dispersed. These types of failures may be of high concern in industries in which the amount active ingredient allowed is highly regulated, such as, for example, the application of herbicides. If the composition is no longer evenly dispersed, one cannot maintain a consistent percentage of active ingredient in each application of the composition. This may be a concern if the solution is made for consumer use requiring long-term storage.

[0003] The current solution to this problem is the use of a nanoparticle-size dispersion to disperse hydrophobic active ingredients in a water-based composition. However, due to the noted failure of hydrophobic active ingredients to remain evenly dispersed in water-based compositions, a nanoformulation including a hydrophobic active ingredient is difficult to obtain and maintain.

[0004] Two forms of nanoparticle-size dispersions have been discovered: (1) a microemulsion where the discontinuous phase is a liquid; and (2) a solid nanoparticle dispersion. These forms require specific methods or the addition of specific components to allow the dispersion to remain intact.

[0005] The first type of common dispersion is a water-based microemulsion. A liquid hydrophobic phase is typically created for the hydrophobic active ingredient, requiring an excess of solvent. The solvent may be an organic solvent. A sufficient amount of an emulsifier must be included to microemulsify the liquid hydrophobic phase into the water phase. Microemulsions can advantageously allow a hydrophobic active ingredient to be dispersed in an aqueous phase, but the microemulsion process can prove costly due to the presence of a large amount of solvent, e.g. organic solvent, and/or the inclusion of an emulsifier component. Further, the presence of an emulsifier component increases the possibility of extraction of the active ingredient from the small particles. This extraction could cause physical failure of the formulation.

[0006] The second type of dispersion of hydrophobic ingredients in an aqueous solution is the solid nanoparticle dispersion, such as the solid lipid nanoparticle ("SLN") dispersion. For example, United States Patent 6,238,694 discloses a method of producing nanoparticles of less than 1 micron by heating a lipidic substance at a temperature at least equal to its melting point; heating a mixture comprising water, a surfactant and a co-surfactant at a temperature at least equal to the melting point of the lipidic substance; combining the mixture with the lipidic substance; obtaining a microemulsion; and diluting the microemulsion with 1 to 10 volumes of cold water to form solid nanoparticles. High-shear mixing is used in SLN to create the nanoformulation. A rotor or impellor, together with a stationary component known as a stator, or an array of rotors and stators, is used either in a tank containing the solution to be mixed, or in a pipe through which the solution passes, to create shear. This process can advantageously provide for a dispersion of the hydrophobic active ingredient in an aqueous solution.

[0007] Compared to a microemulsion, the SLN process does not require the addition of an emulsifier, extra solvent and/or an organic solvent component. However, the SLN process includes additional, cumbersome steps of making the nanoformulation, including diluting the

formulation in cold water, or the usage of high-shear mixing to create the nanoparticles. These additional step may be costly and can greatly increase production time.

SUMMARY OF EMBODIMENTS OF THE INVENTION

[0008] The present invention overcomes the deficiencies of the microemulsion and solid nanoparticle dispersion methods. Among other things, the invention provides for a nanoformulation and method of preparing a nanoformulation that reduces the need for costly organic solvents and emulsifiers, reduces the amount of solvent necessary, and limits the process steps in formulating the nanoformulation. Further, the methods described herein do not require dilution with cold water and/or high shear mixing, thereby reducing costs and allowing for a more efficient mixing process.

[0009] The nanoformulation may comprise a continuous phase and a discontinuous phase, where the continuous phase is an aqueous phase comprising an anionic surfactant, and where the discontinuous phase is a hydrophobic phase, comprising a liquid or solid, branched or straight-chain polycarboxylic acid or a straight-chain monocarboxylic acid.

[0010] It is an object of some embodiments to provide a method of making a nanoparticle-sized dispersion of a hydrophobic phase that does not require extra solvent, organic solvents, dilution in cold water, and/or high-energy agitation.

[0011] It is an object of some embodiments to provide a nanoparticle-sized dispersion of a hydrophobic active ingredient in a manner that reduces costs associated with excess steps and components.

[0012] It is an object of any of the embodiments described herein that the active ingredient may be a pesticide or an odorant, such as a repellent, an attractant, a perfume, or mixtures thereof.

[0013] It is an object of some embodiments to provide a method of making a nanoformulation in which a continuous aqueous phase comprising an anionic surfactant and a

discontinuous hydrophobic phase comprising a liquid or sold, branched or straight-chain polycarboxylic acid or a straight-chain monocarboxylic acid are mixed.

[0014] It is an object of some embodiments to provide a method of making a nanoformulation in which the nanoformulation requires less than 30 minutes of low-energy mixing to create the dispersion of the discontinuous phase in the continuous phase.

[0015] It is an object of some embodiments to provide a method of making a nanoformulation in which the steps of high-shear mixing and diluting the formulation with cold water are not required.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0016] The present invention relates to a nanoformulation comprising a continuous phase and a discontinuous phase, where the continuous phase is an aqueous phase the discontinuous phase is a hydrophobic phase. The continuous phase may comprise an anionic surfactant. The discontinuous phase may comprise a hydrophobic acid.

[0017] The invention also relates to methods of making nanoformulations. These methods do not require the use of extra solvent, organic solvents or emulsifiers, or the steps of diluting the microemulsion in cold water or high-shear mixing, as required by the prior art. As a result, the nanoformulations described herein may be made faster and may be produced with less components than the current methods used in the industry.

[0018] Once the discontinuous phase is suspended in the continuous phase, transparency of the resulting composition may be a visual indication that the dispersed phase contains particles with a particle size between 10 and 100 nm, indicative of a nanoformulation. "Transparent" as applied to a microemulsion means that the composition appears as a single phase without any particulate or colloidal material or a second phase being present when viewed by the naked eye. If a composition maintains transparency over a period of time, this may be indicative of the formulation maintaining the nanoformulation described herein.

The Continuous Phase

[0019] The continuous phase is the phase in which the discontinuous phase is dispersed.

[0020] In one embodiment, the continuous phase is an aqueous phase. The aqueous phase may include a surfactant, such as an anionic surfactant. In some embodiments, the anionic surfactant is a wetting agent. In some embodiments, the anionic surfactant has a hydrophilic-lipophilic balance value of greater than or equal to 20, greater than or equal to 25, greater than or equal to 30, greater than or equal to 35, or greater than or equal to 40. Suitable anionic surfactants may include sodium lauryl sulfate, sodium lauryl ether sulfate, ammonium lauryl sulfate, ammonium lauryl ether sulfate, triethanolamine lauroyl-L-glutamate, sodium myristyl sarcosinate, potassium laurate, sodium dodecane sulfonate, and sodium lauryl ethoxysulfate, sodium dodecyl benzene sulfonate, sodium cetyl sulfonate, sodium cetyl benzene sulfonate, and sodium lauroyl sarcosinate.

[0021] In some embodiments, the continuous phase is a room temperature composition. Because the hydrophobic active ingredient (contained in the dispersed phase, described below) may be a solid at room temperature, heating of the continuous phase prior to mixing with the dispersed phase may be required to maintain a liquid hydrophobic active ingredient during the mixing process. In some embodiments, the continuous phase is heated to more than 80 °C, more than 75 °C, more than 70 °C, more than 65 °C, more than 60 °C, more than 55 °C, more than 50 °C, more than 45 °C, or more than 40 °C. In some embodiments, the nanoformulation is allowed to cool to room temperature after the discontinuous phase has been mixed with the continuous phase.

The Discontinuous Phase

[0022] The discontinuous phase is the phase dispersed in the continuous phase. In some embodiments, the discontinuous phase is a hydrophobic phase. The discontinuous phase may comprise a hydrophobic acid.

[0023] In some embodiments, the hydrophobic acid may be a branched or straight-chain polycarboxylic acid or a straight-chain monocarboxylic acid. Suitable polycarboxylic acids may

include cyclic dicarboxylic acids such as the dimerization products of oleic acid. An example of a dimerization products of oleic acid is Westvaco Diacid® 1550, sold commercially by MeadWestvaco. Suitable straight-chain monocarboxylic acids may include lauric acid, myristic acid, and stearic acid.

[0024] In some embodiments, the discontinuous phase comprises a short-chain alcohol, such as a C_1–C_{14} alcohol. Suitable short-chain alcohols include 1-butanol and 1-hexanol. Without wishing to be bound by theory, it is believed that the short-chain alcohol can act as a co-solvent that can partition into both the continuous and discontinuous phases and can aid in the formation of nanoparticles.

[0025] In some embodiments, the discontinuous phase may comprise pesticides, herbicides, insecticides, rodenticides, molluscicides, and/or fungicides. The pesticides, herbicides, insecticides rodenticides, molluscicides, and/or fungicides may be a liquid or a solid at room temperature. The pesticides, herbicides, rodenticides, molluscicides, or fungicides may have a solubility of less than 20 g/L, less than 15 g/L, less than 10 g/L, or less than 5 g/L.

[0026] Suitable pesticides may include triticonazole, atrazine, florasulam, or pyrethrum. Suitable pesticides may also include aclonifen, benzofenap, bifenox, bromobutide, bromofenoxim, chlomethoxyfen, chlorbromuron, chlorimuron-ethyl, chlornitrofen, chlorotoluron, chlorthal-dimethyl, clomeprop, cloransulam-methyl, cyclosulfamuron, daimuron, desmedipham, dichlobenil, diclosulam, diflufenican, dimefuron, dinitramine, diuron, fenoxaprop-ethyl, fenoxaprop- P-ethyl, flamprop-methyl, flumetsulam, flumiclorac-pentyl, flumioxazin, flupoxam, fluridone, flurtamone, imazaquin, ipfencarbazone, isoproturon, isoxaben, isoxapyrifop, lenacil, linuron, mefenacet, methabenzthiazuron, metobenzuron, metosulam, naproanilide, neburon, norflurazon, orthosulfamuron, oryzalin, oxadiazon, oxyfluorfen, penoxsulam, phenmedipham, prodiamine, prometryn, propanil, propazine, propyzamide, pyrazolynate, pyributicarb, pyriftalid, pyrimisulfan, pyroxsulam, quinclorac, quizalofop-ethyl,

quizalofop-P-ethyl, siduron, simazine, tefuryltrione, terbuthylazine, terbutryn, thiazopyr, tralkoxydim, trietazine and/or derivatives thereof.

[0027] Suitable herbicides may include acetochlor, alachlor, ametryn, anilofos, atrazine, azafenidin, benfluralin, benfuresate, bensulide, benzfendizone, benzofenap, bromobutide, bromofenoxim, butachlor, butafenacil, butamifos, butralin, butylate, cafenstrole, carbetamide, chlorbromuron, chloridazon, chlorimuron-ethyl, chlorotoluron, chlorpropham, chlorthal-dimethyl, chlorthiamid, cinidon-ethyl, cinmethylin, clomazone, clomeprop, cloransulam-rnethyl, cyanazine, cycloate, cyclosulfamuron, daimuron, desmedipham, desmetryn, dichlobenil, diflufenican, dimefuron, dimepiperate, dirnethachlor, dimethametryn, dimethenamid, dinitramine, dinoterb, diphenamid, dithiopyr, diuron, EPTC, esprocarb, ethalfiuralin, ethofumesate, etobenzanid, ferioxaprop-ethyl, fenuron, flamprop-methyl, fluazolate, fluchloralin, flumetsulam, flumiclorac-pentyl, flumioxazin, fluometuron, fluorochloridone, flupoxam, flurenol, fluridone, fluroxypyr-1-methylheptyl, flurtamone, fluthiacet-methyl, hexazinone, indanofan, isoproturon, isouron, isoxaben, isoxaiflutole, lenacil, linuron, mefenacet, metamitron, metazachlor, methabenzthiazuron, methyldymron, metobenzuron, metobromuron, metolachlor, metosulam, metoxuron, metribuzin, molinate, monolinuron, naproanilide, napropamide, neburon, norfiurazon, orbencarb, oryzalin, oxadiargyl, oxadiazon, pebulate, pendimethalin, pentanochlor, pentoxazone, phenmedipham, piperophos, pretilachlor, prodiamine, profluazol, prometon, prometryn, propachlor, propanhl, propazine, propham, propisochlor, propyzamide, prosulfocarb, pyraflufen-ethyl, pyrazogyl, pyrazolynate, pyrazoxyfen, pyributicarb, pyridate, pyriminobac-methyl, quinclorac, quinmerac, siduron, simazine, simetryn, sulcotrione, sulfentrazone, sulfometuron, tebutam, tebuthiuron, terbacil, terbumeton, terbuthylazine, terbutryn, thenyichlor, thiazopyr, thidiazimin, thiobencarb, tiocarbazil, triallate, tribenuron, trietazine, trifluralin, and/or vernolate.

[0028] Suitable insecticides include cyfluthrin, cypermethrin, deltamethrin, fenpropathrin, fenvalerate, esfenvalerate, tralomethrin, acrinathrin, bifenthrin, resmethrin, tetramethrin,

propoxur, isoprocarb, xylylcarb, metolcarb, XMC, carbaryl, pirimicarb, carbofuran, methomyl, fenoxycarb, alanycarb, metoxadiazone, acephate, phenthoate, vamidothion, trichlorfon, monocrotophos, tetrachlorvinphos, dimethylvinphos, phosalone, chlorpyrifos, chlorpyrifos-methyl, pyridaphenthion, quinalphos, methidathion, methamidophos, dimethoate, fermothion, azinphos-ethyl, azinphos-methyl, salithion, diflubenzuron, chlorfluazuron, lufenuron, hexaflumuron, flufenoxuron, flucycloxuron, cyromazine, diafenthiuron, hexythiazox, novaluron, teflubenzuron, triflumuron, 4-chloro-2-(2-chloro-2-methylpropyl)-5-(6-iodo-3-pyridylmethoxy)pyridazin-3(2H)-one, tebufenozide, 1-(2,6-difluorobenzoyl)-3-[2-fluoro-4-(trifluoromethyl)phenyl]urea, boric acid, avermectin, triazamate, 1-(2,6-difluorobenzoyl)-3-[2-fluoro-4-(1,1,2,3,3,3-hexafluoropropoxy)phenyl]urea, 2-tert-butylimino-3-isopropyl-5-phenyl-3,4,5,6-tetrahydro-2H-1,3,5-thiadiazon-4-one, cartap, thiodicarb, 1-(2,6-difluorobenzoyl)-3-[2-fluoro-4-(1,1,2,2-tetrafluoroethoxy)phenyl]urea, bensultap, acetamiprid, nitenpyram, diacloden, buprofezin, thiocyclam, fenoxycarb, fenazaquin, fenpyroxymate, pyridaben, pyriproxyfen, hydramethylnon, chlorfenapyr, fenpyroximate, pymetrozine, pyrimidifen, tebufenpyrad, indoxacarb, sulfluramid, milbemectin, and/or paradichlorobenzene.

[0029] Suitable fungicides may include benzimidazole compounds such as benomyl, carbendazim, thiabendazole and thiophanate-methyl; phenylcarbamate compounds such as diethofencarb; dicarboxyimide compounds such as procymidone, iprodione and vinclozolin; azole compounds such as diniconazole, epoxyconazole, tebuconazole, difenoconazole, cyproconazole, flusilazole and triadimefon; acylalanine compounds such as metalaxyl; carboxyamide compounds such as furametpyr, mepronil, flutolanil and tolyfluanid; organophosphate compounds such as tolclofos-methyl, fosetyl aluminum and pyrazophos; anilinopyrimidine compounds such as pyrimethanil, mepanipyrim and cyprodinil; cyanopyrrrole compounds such as fludioxonil and fenpiclonil; antibiotics such as blasticidin-S, kasugamycin, polyoxin and validamycin; methoxyacrylate compounds such as azoxystrobin, kresoxim-methyl and metominostrobin; chlorothalonil; manzeb; captan; folpet; oxine-copper; basic copper

chloride; tricyclazole; pyroquilon; probenazole; phthalide; cymoxanil; dimethomorph; S-methylbenzo[1,2,3]thiadiazol-7-carbothioate; famoxadone; oxolinic acid; fluaziname; ferimzone; chlobenthiazone; isovaledione; tetrachloroisophthalonitrile; thiophthalimideoxybisphenoxyarsine; 3-iodo-2-propylbutylcarbamate; silver zeolite; silica gel silver; phosphate zirconium silver chloride; parahydroxy benzoic ester; sodium dehydroacetate and/or potassium sorbate.

[0030] In some embodiments, the discontinuous phase comprises odorants such as attractants, repellants, perfumes, or mixtures thereof. In other embodiments, the odorants may include cinnamon oil, rosemary oil, peppermint oil, mint oil, d-limonene, garlic oil, and/or geraniol. In some embodiments, the discontinuous phase is a room temperature composition. In some embodiments, the discontinuous phase contains a hydrophobic active ingredient that is a solid at room temperature. In some embodiments, the discontinuous phase is heated to create a true solution of the discontinuous phase prior to mixing with the continuous phase. In some embodiments, the discontinuous phase is heated to more than 80 °C, more than 75 °C, more than 70 °C, more than 65 °C, more than 60 °C, more than 55 °C, more than 50 °C, more than 45 °C, or more than 40 °C. In some embodiments, the nanoformulation is allowed to cool to room temperature after the discontinuous phase has been mixed with the continuous phase.

Compositions

[0031] The invention provides compositions comprising any of the continuous and discontinuous phases described herein. In some of the embodiments, the composition does not require an emulsifier. In some embodiments, the composition does not require organic solvents. In some embodiments, the composition does not require extra solvent. In some embodiments, extra solvent means that the solvent necessary to solubilize the hydrophobic compound is greater than the amount necessary to solubilize the hydrophobic compound in the presence of the hydrophobic acid as described herein. In some embodiments, the solvent necessary to solubilize the hydrophobic compound without the presence of a hydrophobic acid is more than 5 times greater, more than 7.5 times greater, more than 10 times greater, more than 12.5 times

greater, more than 15 times greater, more than 17.5 times greater, more than 20 times greater, more than 22.5 times greater, more than 25 times greater, more than 27.5 times greater, more than 30 times greater, more than 32.5 times greater, more than 35 times greater, more than 37.5 times greater, more than 40 times greater, more than 42.5 times greater, more than 50 times greater, more than 55 times greater, more than 60 times greater, more than 65 times greater, more than 70 times greater, or more than 75 times greater than the amount necessary to solubilize the hydrophobic compound in the presence of the hydrophobic acid as described herein.

[0032] In one embodiment, the discontinuous phase comprises atrazine, cyclocarboxypropyloleic acid, and 1-butanol, and the continuous phase comprises sodium lauryl sulfate and water. In one embodiment, the discontinuous phase comprises atrazine, cyclocarboxypropyloleic acid, and 1-butanol, and the continuous phase comprises sodium lauryl sulfate, sodium lauroyl sarcosinate, and water. In one embodiment, the discontinuous phase comprises atrazine, cyclocarboxypropyloleic acid, and 1-butanol, and the continuous phase comprises sodium lauroyl sarcosinate and water. In one embodiment, the discontinuous phase comprises triticonazole, cyclocarboxypropyloleic acid, and 1-butanol, and the continuous phase comprises sodium lauryl sulfate and water. In one embodiment, the discontinuous phase comprises atrazine, lauric acid, and 1-hexanol, and the continuous phase comprises sodium lauryl sulfate and water.

[0033] In one embodiment, the discontinuous phase comprises atrazine, myristic acid, lauric acid, and 1-hexanol, and the continuous phase comprises sodium lauryl sulfate and water. In one embodiment, the discontinuous phase comprises atrazine, cyclocarboxypropyloleic acid, stearic acid and 1-hexanol, and the continuous phase comprises sodium lauryl sulfate and water. In one embodiment, the discontinuous phase comprises atrazine, cyclocarboxypropyloleic acid, stearic acid and 1-butanol, and the continuous phase comprises sodium lauryl sulfate and water. In one embodiment, the discontinuous phase comprises atrazine, florasulam, stearic acid,

cyclocarboxypropyloleic acid, Jeffsol AG 1710, and 1-butanol, and the continuous phase comprises sodium lauryl sulfate and water. In one embodiment, the discontinuous phase comprises cinnamon oil, rosemary oil, peppermint oil, and cyclocarboxypropyloleic acid, and the continuous phase comprises sodium lauryl sulfate and water.

The Mixing Process

[0034] The invention provides for methods of making nanoformulations. In some embodiments, the discontinuous phase of any of the embodiments described herein is mixed with the continuous phase of any of the embodiments described herein. In some embodiments, the discontinuous phase is added to the continuous phase while the continuous phase is being mixed. In some embodiments, the mixing is performed using, for example, low-energy mixing, which may include mixing the composition at a tip-speed of less than 20 ft/s, less than 15 ft/s, or less than 10 ft/s. In some embodiments, the discontinuous phase is mixed with the continuous phase for a brief mixing of less than 30 minutes. In some embodiments, the resulting composition is a transparent. In some embodiments, the resulting composition is transparent for more than one hour, more than two hours, more than four hours, more than one day, more than two days, more than five days, more than a week, more than a month, more than two months, more than three months, more than six months, more than a year.

[0035] In some embodiments, the mixing process does not include the step of high-shear mixing, as may be necessary in the creation of a SLN formulation. In some embodiments, the mixing process does not require the use of cold dilution water, as may be necessary in the creation of a SLN formulation. In some embodiments, the mixing process does not include the steps described in United States Patent No. 6,238,694.

[0036] In some embodiments, the use of emulsifiers, extra solvent, or organic solvents is unnecessary to create the nanoformulation.

Methods of Use

[0037] In one embodiment, any of the compositions described herein are applied to an area using a sprayer. In one embodiment, the sprayer is an atomizing sprayer. In some embodiments, the sprayer contains an atomizing spray nozzle. In some embodiments, the atomizing spray nozzle is a full cone design nozzle, hollow cone design nozzle, air assist design nozzle, or a flat spray nozzle.

[0038] In one embodiment, the composition is applied to an area to control undesirable vegetation. In one embodiment, the composition is applied to an area to control pests, insects, molluscs, or rodents. In one embodiment, the composition is applied to the surface of a pest, insect, mollusc, or rodent. In one embodiment, the composition is applied to an area to control fungus. In any of the embodiments described herein, the area may include, but not be limited to, a field, a room, a surface, or a plant.

EXAMPLES

[0039] The following specific examples are presented to further illustrate and explain certain aspects of the present invention. However, the Examples are set forth for illustration only, and are not to be construed as limiting on the present invention. In the following examples, all percentages and parts are by weight unless otherwise specified.

[0040] The positive visual indication of transparency was used in the examples described herein to indicate that a nanoformulation was created.

EXAMPLE 1

[0041] A room temperature composition of atrazine technical powder, Westvaco Diacid® 1550, and 1-butanol was mixed with sodium lauryl sulfate powder and water using low-energy mixing. All components were kept at room temperature throughout the mixing process. The resulting composition had the following components in weight percentage:

Component	Wt %
Atrazine technical powder (98%)	0.22
Westvaco Diacid® 1550	2.00

1-butanol	0.40
Sodium lauryl sulfate powder	6.50
Water	90.88

[0042] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent at room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 2

[0043] A room temperature composition of atrazine technical powder, Westvaco Diacid® 1550, and 1-butanol was mixed with sodium lauryl sulfate powder, sodium lauroyl sarcosinate, and water using low-energy mixing. All components were kept at room temperature throughout the mixing process. The resulting composition had the following components in weight percentage:

Component	**Wt %**
Atrazine technical powder (98%)	0.22
Westvaco Diacid® 1550	2.00
1-butanol	0.40
Sodium lauryl sulfate powder	4.2
Sodium lauroyl sarcosinate (30% solution)	17.3
Water	75.88

[0044] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent at room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 3

[0045] A room temperature composition of atrazine technical powder, Westvaco Diacid® 1550, and 1-butanol was mixed with sodium lauroyl sarcosinate solution and water using low-

energy mixing. All components were kept at room temperature throughout the mixing process. The resulting composition had the following components in weight percentage:

Component	Wt %
Atrazine technical powder (98%)	0.22
Westvaco Diacid® 1550	2.00
1-butanol	0.40
Sodium lauroyl sarcosinate (30% solution)	29.67
Water	67.71

[0046] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent at room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 4

[0047] A room temperature composition of triticonazole technical powder, Westvaco Diacid® 1550, and 1-butanol was mixed with sodium lauryl sulfate powder and water using low-energy mixing. All components were kept at room temperature throughout the mixing process. The resulting composition had the following components in weight percentage:

Component	Wt %
Triticonazole technical powder 98%)	1.08
Westvaco Diacid® 1550	3.50
1-butanol	0.40
Sodium lauryl sulfate powder	16.50
Water	78.52

[0048] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent at room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 5

[0049] A hot composition of atrazine technical powder, lauric acid, and 1-hexanol was mixed with a hot mixture of sodium lauryl sulfate powder and water using low-energy mixing. The resulting composition had the following components in weight percentage:

Component	Wt %
Atrazine technical powder (98%)	0.22
Lauric Acid	2.00
1-hexanol	0.50
Sodium lauryl sulfate powder	8.90
Water	88.38

[0050] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent when allowed to cool to room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 6

[0051] A hot composition of atrazine technical powder, myristic acid, lauric acid, and 1-hexanol was mixed with a hot mixture of sodium lauryl sulfate powder and water using low-energy mixing. The resulting composition had the following components in weight percentage:

Component	Wt %
Atrazine technical powder (98%)	0.22
Myristic acid	0.68
Lauric acid	1.32
1-hexanol	0.50
Sodium lauryl sulfate powder	8.90
Water	88.38

[0052] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent when allowed to cool to room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 7

[0053] A hot composition of atrazine technical powder, stearic acid, Westvaco Diacid® 1550, and 1-hexanol was mixed with a hot mixture of sodium lauryl sulfate powder and water using low-energy mixing. The resulting composition had the following components in weight percentage:

Component	**Wt %**
Atrazine technical powder (98%)	0.22
Stearic acid	0.32
Westvaco Diacid® 1550	1.68
1-hexanol	0.50
Sodium lauryl sulfate powder	8.90
Water	88.38

[0054] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent when allowed to cool to room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 8

[0055] A hot composition of atrazine technical powder, stearic acid, Westvaco Diacid® 1550, and 1-butanol was mixed with a hot mixture of sodium lauryl sulfate powder and water using low-energy mixing. The resulting composition had the following components in weight percentage:

Component	Wt %
Atrazine technical powder (98%)	0.22
Stearic acid	0.32
Westvaco Diacid® 1550	1.68
1-butanol	0.40
Sodium lauryl sulfate powder	6.50
Water	90.88

[0056] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent when allowed to cool to room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 9

[0057] A hot composition of atrazine technical powder, florasulam, stearic acid, Westvaco Diacid® 1550, 1-butanol, and Jeffsol AG 1710 was mixed with a hot mixture of sodium lauryl sulfate powder and water using low-energy mixing. The resulting composition had the following components in weight percentage:

Component	Wt %
Atrazine technical powder (98%)	0.220
Florasulam	0.003
Stearic acid	0.320
Westvaco Diacid® 1550	1.630
1-butanol	0.400
Jeffsol AG 1710	0.050
Sodium lauryl sulfate powder	6.50
Water	90.877

[0058] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent when allowed to cool to room temperature and remained transparent when observed 15 minutes later.

EXAMPLE 10

[0059] A room temperature composition of cinnamon oil, rosemary oil, peppermint oil, and Westvaco Diacid® 1550 was mixed with sodium lauryl sulfate powder and water using low-energy mixing. All components were kept at room temperature throughout the mixing process. The resulting composition had the following components in weight percentage:

Component	**Wt %**
Cinnamon oil	0.31
Rosemary oil	1.15
Peppermint oil	1.15
Westvaco Diacid® 1550	1.00
Sodium lauryl sulfate powder	16.00
Water	80.39

[0060] Upon brief, low-energy mixing of less than 30 minutes, the resulting composition was transparent at room temperature and remained transparent when observed 15 minutes later.

CLAIMS

1. A nanoformulation comprising an aqueous continuous phase and a hydrophobic discontinuous phase, wherein the continuous phase comprises an anionic surfactant and the discontinuous phase comprises a hydrophobic branched or straight-chain polycarboxylic acid or a hydrophobic straight-chain monocarboxylic acid.

2. The nanoformulation of claim 1, wherein the anionic surfactant has a hydrophilic-lipophilic balance of greater than or equal to 25.

3. The nanoformulation of claims 1 or 2, wherein the anionic surfactant is sodium lauryl sulfate or sodium lauroyl sarcosinate.

4. The nanoformulation of any of the above claims, wherein the polycarboxylic acid is a dimerization product of oleic acid.

5. The nanoformulation of any of the above claims, wherein the straight-chain monocarboxylic acid is lauric acid, myristic acid, or stearic acid.

6. The nanoformulation of any of the above claims, wherein the discontinuous phase further comprises a pesticide.

7. The nanoformulation of claim 6, wherein the pesticide has a solubility of less than 10 g/L.

8. The nanoformulation of claims 6 or 7, wherein the pesticide is a liquid or a solid at 20 °C.

9. The nanoformulation of claims 6–8, wherein the pesticide is triticonazole, atrazine, florasulam, or pyrethrum.

10. The nanoformulation of any of the above claims, wherein the discontinuous phase further comprises odorants.

11. The nanoformulation of claim 10, wherein the odorants are attractants, repellants, perfumes, or mixtures thereof.

12. The nanoformulation of claims 10 or 11, wherein the odorant is cinnamon oil, rosemary oil, peppermint oil, mint oil, d-limonene, or geraniol.

13. The nanoformulation of any of the above claims, wherein the nanoformulation does not comprise an emulsifier.

14. The nanoformulation of any of the above claims, wherein the nanoformulation does not comprise an organic solvent.

15. The nanoformulation of any of the above claims, wherein the nanoformulation does not comprise extra solvent.

16. A method of making a transparent nanoformulation comprising mixing

a) an aqueous continuous phase comprising an anionic surfactant, and

b) a hydrophobic discontinuous phase comprising a hydrophobic branched or straight-chain polycarboxylic acid or a hydrophobic straight-chain monocarboxylic acid.

17. The method of claim 16, wherein the nanoformulation is mixed for less than 30 minutes.

18. The method of claims 16 or 17, wherein the nanoformulation is made without the step of high-shear mixing.

19. The method of any of claims 16–18, wherein the nanoformulation is made without the step of diluting the mixture of the aqueous continuous phase and the hydrophobic discontinuous phase in cold water.

20. The method of any of claims 16–19, wherein the anionic surfactant has a hydrophilic-lipophilic balance of greater than or equal to 25.

21. The method of any of claims 16–20, wherein the anionic surfactant is sodium lauryl sulfate or sodium lauroyl sarcosinate.

22. The method of any of claims 16–21, wherein the polycarboxylic acid is a dimerization product of oleic acid.

23. The method of any of claims 16–22, wherein the straight-chain monocarboxylic acid is lauric acid, myristic acid, or stearic acid.

24. The method of any of claims 16–23, wherein the discontinuous phase further comprises a pesticide.

25. The method of claim 24, wherein the pesticide is liquid or solid at 20 °C.

26. The method of claims 24 or 25, wherein the pesticide is triticonazole, atrazine, florasulam, or pyrethrum.

27. The method of any of claims 16–26, wherein the discontinuous phase further comprises odorants.

28. The method of claim 27, wherein the odorants are attractants, repellants, perfumes, or mixtures thereof.

29. The method of claims 27 or 28, wherein the odorant is cinnamon oil, rosemary oil, peppermint oil, mint oil, d-limonene, or geraniol.

30. The method of any of claims 16–29, wherein the method is carried out without an emulsifier.

31. The method of any of claims 16–30, wherein the method is carried out without an organic solvent.

32. A method of using the nanoformulation of any of claims 1–14, wherein the nanoformulation is applied to an area using a sprayer.

33. The method of claim 32, wherein the sprayer comprises an atomizing spray nozzle.

34. The method of claim 33, wherein the atomizing spray nozzle is a full cone design nozzle, hollow cone design nozzle, air assist design nozzle, or a flat spray nozzle.

35. The method of claim 34, wherein the nanoformulation is applied to an area to control undesirable vegetation.

36. The method of claim 35, wherein the nanoformulation is applied to an area to control pests.

37. The method of claim 36, wherein the pests are insects, molluscs, or rodents.

38. The method of claim 32, wherein the nanoformulation is applied to an area to control fungus.

39. The method of any of claims 32–38, wherein the area is a field, a room, a surface, or a plant.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/033144

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A01N 25/04 (2015.01)
CPC - A01N 25/04 (2015.07)
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)
IPC(8) - A01N 25/04, 25/30, 53/08; A61K 9/06, 9/107, 31/415, 38/48 (2015.01)
CPC - A01N 25/04, 25/30, 53/08; A61K 9/06, 9/107, 31/415, 38/48 (2015.07) (keyword delimited)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 424/94.64, 405; 504/241, 255; 510/135, 427; 514/521, 531

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google Scholar, Google
Search terms used: colloid, emulsion, continuous, phase, dispersed, discontinuous, anionic, surfactant, nano, lipophilic, balance

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013/0137578 A1 (XU et al) 30 May 2013 (30.05.2013) entire document	1-3
Y	US 5,683,972 A (ZOCCHI) 04 November 1997 (04.11.1997) entire document	1-3, 16-18
Y	EP 0 480 690 A1 (IOLAB CORPORATION) 15 April 1992 (15.04.1992) entire document	16-18
A	WO 2011/010910 A1 (UNIVERSITI PUTRA MALAYSIA) 27 January 2011 (27.01.2011) entire document	1-3, 16-18

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 July 2015	19 AUG 2015
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/033144

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-15, 19-39
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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:

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.:

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.