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(54) Titre : TRISILOXANE ORGANOMODIFIE BIODEGRADABLE A FORT POUVOIR MOUILLANT
(54) Title: BIODEGRADABLE SUPERSPREADING ORGANOMODIFIED TRISILOXANE

(57) Abrégé/Abstract:

Disclosed herein are compositions comprising a polyether-modified siloxane of formula (I), the polyether-modified siloxane comprising a polyether radical of the formula (II). The polyether-modified siloxanes of formula (I) has a biodegradability of greater than 60%, and the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol. Processes for preparing a polyether-modified siloxane and uses thereof are also disclosed. The compositions and polyether-modified siloxanes disclosed here are useful as adjuvants in crop protection and as tankmix additives for a spray liquor.

$M_a D_b D'_c$ Formula (I)

$-R_3O[CH_2CH_2O]_m[CH_2CH(CH_3)o]_nR^5$ Formula (II)



ABSTRACT

Disclosed herein are compositions comprising a polyether-modified siloxane of formula (I), the polyether-modified siloxane comprising a polyether radical of the formula (II). The polyether-modified siloxanes of formula (I) has a biodegradability of greater than 60%, and the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol. Processes for preparing a polyether-modified siloxane and uses thereof are also disclosed. The compositions and polyether-modified siloxanes disclosed here are useful as adjuvants in crop protection and as tankmix additives for a spray liquor.



Formula (I)



Formula (II)

Biodegradable superspreading organomodified trisiloxane

5 Description of the invention:

10 In crop protection, in pesticides and also in the industrial non-crop sector, the biological efficacy of such pesticides or pesticide mixtures is frequently improved by using what are called adjuvants or else auxiliaries or additives. Efficacy is frequently also referred to as effectiveness. The Pesticides Safety Directorate (PSD, the executive branch of the Health and Safety Executive (HSE), a non-governmental public organization in Great Britain) defines an adjuvant as a substance other than water which is not itself pesticidally active but increases the effectiveness of a pesticide. (<http://www.pesticides.gov.uk/guidance/industries/pesticides/topics/pesticide-approvals/legislation/adjuvants-an-introduction>). These are either added to the aqueous spray liquor shortly before deployment and spray application (as tankmix additive) or incorporated directly into crop protection composition formulations. With regard to the use of the word adjuvant, patents or the literature often use the terms surfactant or wetting agent synonymously, but these are much too wide-ranging and can therefore be interpreted as more of an umbrella term. Because of the use envisaged here, the term "adjuvant" is employed.

20 In practice, there are numerous crop protection active ingredients which achieve acceptable effectiveness, i.e. practically relevant efficacy, only with the aid of adjuvants. The adjuvants help here to compensate for the weaknesses of the active ingredient, for example the UV sensitivity of avermectins (destroyed by ultraviolet radiation) or the water instability of sulphonylureas. More recent active ingredients are generally water-insoluble and, in order therefore to be able to spread effectively over a target = target organism = plant, adjuvants are indispensable for the aqueous spray liquor, in order to compensate for the poor wetting of surfaces by way of a physical influence on the aqueous solutions. In addition, adjuvants help to overcome technical application problems, such as low water application rates, different water qualities and the trend to increased application rates. The increase in pesticide efficacy and the compensation for weaknesses in the crop protection compositions by adjuvants are generally referred to as increasing the activity or enhancing the effect of the crop protection composition application.

30 In crop protection, in pest control and in the industrial sector, chemical or biological crop protection compositions (also called pesticides hereinafter) or pesticide mixtures are employed. These may be, for example, herbicides, fungicides, insecticides, growth regulators, molluscicides, bactericides, virucides, micronutrients and biological crop protection compositions based on natural products or living or processed microorganisms. Active pesticidal ingredients are listed in connection with their fields of use, for example, in 'The Pesticide Manual', 14th edition, 2006, The British Crop Protection Council; biological

active ingredients are specified in 'The Manual of Biocontrol Agents', 2001, The British Crop Protection Council. "Pesticide" is always used as a collective term hereinafter.

5 In order to be able to assess the agricultural potential and the activities of substances, it is necessary to carry out not only the laboratory and greenhouse experiments, but also realistic applications in agriculture, for example field trials.

10 In practice, crop protection compositions of this kind are often added to a tank with water as an ingredient and distributed in what is called the spray liquor with gentle stirring, in order to dilute the concentrated formulation of the active ingredient prior to spraying and to make it tolerable for the plants. Adjuvants are either incorporated into the crop protection formulation here prior to the tankmixing operation or added to the spray liquor as separate tankmix additives.

15 Adjuvants used are frequently synthetic surfactants, for example ethoxylated alcohols or alkyl polyglycosides. The use of water-soluble hydrophilic polyglyceryl esters as adjuvants in crop protection formulations is likewise known (WO 2002/034051, US 2006/0264330A1). In general, a feature common to these adjuvants is that they are water-soluble hydrophilic substances. Further adjuvants frequently used are additionally alkoxylated trisiloxane surfactants which lower the static surface tension of spray
20 liquors or water to a greater degree than the organic surfactants used in the past, for example nonylphenol ethoxylates. Trisiloxane surfactants have the general structure $\text{Me}_3\text{SiO-SiMeR-OSiMe}_3$ where the R radical is a polyether radical. The use of superspreading trisiloxane surfactants, for example, BREAK-THRU® S-240, Evonik Industries AG, in combination with a pesticide, leads to an improvement in pesticide uptake by the plant and generally to a rise in the efficacy or effectiveness thereof. US
6,734,141 states that this increase in effectiveness is occasioned specifically by a low surface tension and not necessarily by the spreading. The term "surface tension" is understood in the prior art to mean static surface tension. In the case of trisiloxanes, for example, static surface tension is about 20 to 25 mN/m.

25 WO1994022311 discloses superspreading compositions comprising polyether-modified siloxanes which may have two groups of polyethers: firstly polyethers having exclusively oxyethylene groups, and secondly polyethers which, in addition to oxyethylene groups, may also have oxypropylene groups. Experimental data are disclosed for modified siloxanes wherein the polyether residue contains exclusively oxyethylene groups. These are known, for example, as SILWET L-77.

30 A disadvantage of the prior art is that none of the superspreading trisiloxanes are biodegradable. For environmental reasons in particular, ever greater value is being placed on environmentally friendly products, particularly in order to gain popular acceptance with respect to chemical products in agriculture.

"Superspreading" in the context of the present invention is understood to mean that a 0.1 per cent by weight solution in water, after examination in accordance with ASTM E2044 – 99 (2012), has a diameter
35 of spread of at least 35 mm. Preferably, a droplet of a 0.1 per cent by weight solution in water having a volume of 50 μm^3 on a polypropylene film spreads to an area of at least 10 cm^2 . Preferably, the spread

is examined at 25°C; preferably, the spread is determined at a relative air humidity of 60% and a pressure of 1013 mbar.

"Readily biodegradable" within the scope of the present invention describes degradability according to OECD Method 301F CD, preferably as described in the examples.

5 It was an object of the present invention to overcome at least one disadvantage of the state of the art.

It has been found that, surprisingly, compositions comprising polyether-modified siloxanes as described in the claims are both superspreading and readily biodegradable.

The present invention provides compositions comprising polyether-modified siloxanes of formula (I)



10 with $M = R^1_3 SiO_{1/2}$, $D = R^1_2 SiO_{2/2}$, $D' = R^1 R^2 SiO_{2/2}$,

where

a is 2

b is between 0 and 0.1, preferably 0,

c is between 1.0 and 1.15,

15 preferably between 1.0 and 1.10, especially preferably between 1.00 and 1.05,

R^1 are independently hydrocarbyl having 1 to 8 carbon atoms, preferably methyl, ethyl, propyl or phenyl radicals, especially preferably methyl radicals,

R^2 are independently a polyether radical of the formula (II)

20 $-R^3 O [CH_2 CH_2 O]_m [CH_2 CH(CH_3) O]_n R^5$ Formula (II)

where

m = 3.4 to 11.0, preferably 3.6 to 9.9, more preferably 4.5 to 8.5,

n = 2.5 to 8.0, preferably 2.7 to 7.5, more preferably 3.0 to 6.0,

but with the provisos that:

25 m/n = 1.9 to 2.8,

R^3 are independently divalent hydrocarbyl radicals having 2 to 8 carbon atoms, preferably ethylene, propylene, 1-methylpropylene, 1,1-dimethylpropylene radical, especially preferably

$-CH_2 CH_2 CH_2-$,

R^5 is hydrogen,

the polyether-modified siloxanes of formula (I) having a biodegradability of greater than 60%, more preferably of greater than or equal to 63% and especially preferably of greater than or equal to 65%, the maximum value being 100%.

5 Preferably, the polyether radical, calculated without R^3O and calculated without R^5 , has a molar mass M (PE) calculated by $44 \text{ g/mol} * m + 58 \text{ g/mol} * n$ where the indices m and n relate to formula (II).

The preferred values of M (PE) are: lower limits M (PE) greater than 520 g/mol, preferably greater than 530 g/mol, more preferably greater than 535 g/mol; upper limit M (PE) less than 660 g/mol, preferably less than 630 g/mol, more preferably less than 600 g/mol.

10 Preferably, the value of M (PE) is greater than 520 g/mol and less than 660 g/mol, especially greater than 535 g/mol and less than 600 g/mol.

Preferably, the sum total of $m + n$ is greater than 9 up to 19, more preferably greater than 9.5 up to 15 and especially preferably greater than 10 up to 12.

15 More preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) with an index c between 1 and 1.05, where the indices of the polyether radical of formula (II) are m from 3.4 to 11.0 and n from 2.5 to 8.0.

More preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) with an index c between 1 and 1.05, where the ratio m/n is 1.9 to 2.8.

20 Especially preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) with an index c between 1 and 1.05, where the molar mass of the polyether residue $M(PE)$ is greater than 520 g/mol and less than 660 g/mol.

Especially preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) with an index c between 1 and 1.05, where the R^5 radical is hydrogen.

25 Especially preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) with an index c between 1 and 1.05, where the molar mass of the polyether residue $M(PE)$ is greater than 520 g/mol and less than 660 g/mol and the R^5 radical is hydrogen.

Preferably, the inventive compositions do not include any further polyether-modified siloxanes apart from those of formula (I).

30 One advantage of the inventive compositions is that they have superspreading properties in water in the sense defined above. For this purpose, the area of a droplet on a polypropylene film is determined as described in detail in the examples.

Preferably, the inventive compositions have, as a 0.1 per cent by weight solution in water, a spreading area of 10 to 60 cm^2 , preferably of 15 to 50 cm^2 and more preferably of 20 to 40 cm^2 . More preferably, the inventive compositions have the aforementioned spreads at a temperature of 25°C.

Polyether-modified siloxanes of formula (I) in which index c is at least 1.2 are known according to US 6,734,141 as non-spreading compounds and are excluded from the present invention.

Preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) where the index d is 1.0 to 1.05 and a 0.1 per cent by weight solution of these siloxanes in water has a spreading area of 15 to 60 cm².

More preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) having an index c between 1 and 1.05, where the m/n ratio is 0.8 to 2.8 and a 0.1% by weight solution of these siloxanes in water has a spreading area of 15 to 60 cm².

A further advantage of the inventive compositions is their biodegradability.

Biodegradability is preferably determined by the OECD 301 F method. More preferably, biodegradability is determined in accordance with OECD 301 F after 28 d at 22°C. Especially preferably, biodegradability is determined as described in the examples.

Preferably, the polyether-modified siloxanes of formula (I) in the inventive compositions have a biodegradability of greater than 60%, more preferably of greater than or equal to 63% and especially preferably of greater than or equal to 65%, the maximum value being 100%.

Preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) where the index d is 1.0 to 1.05 and biodegradability of the siloxanes is greater than 60%.

More preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) having a biodegradability of greater than 60%, and the index c is additionally between 1 and 1.05, where the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol and the R⁵ radical is hydrogen.

More preferably, the inventive compositions include the polyether-modified siloxanes of the formula (I) having a biodegradability of greater than 60%, and the index c is additionally between 1 and 1.05, where the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol, the R⁵ radical is hydrogen and a 0.1% by weight solution of these siloxanes in water has a spreading area of 15 to 60 cm².

Preferably, the inventive compositions do not include any non-biodegradable polyether-modified siloxanes.

In one particular embodiment, the present invention provides a composition comprising a polyether-modified siloxane of formula (I)



with $M = R^1_3SiO_{1/2}$, $D = R^1_2SiO_{2/2}$, $D' = R^1R^2SiO_{2/2}$,

where

5a

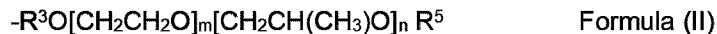
a is 2

b is between 0 and 0.1,

c is between 1.0 and 1.15,

each R¹ is independently hydrocarbyl having 1 to 8 carbon atoms,

5 each R² is independently a polyether radical of the formula (II)



where

m = 3.4 to 11.0,

n = 2.5 to 8.0,

10 but with the provisos that:

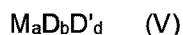
m/n = 1.9 to 2.8,

each R³ is independently a divalent hydrocarbyl radical having 2 to 8 carbon atoms,

R⁵ is hydrogen,

15 the polyether-modified siloxane of formula (I) having a biodegradability of greater than 60%, the maximum value being 100%, wherein the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol

The present invention further provides a process for producing polyether-modified siloxanes, in which, in a first step, an H-siloxane of the formula (V)



20 with M = R¹₃SiO_{1/2}; D = R¹₂SiO_{2/2}, D' = R¹R²SiO_{2/2},

where

a is 2,

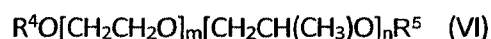
b is between 0 and 0.1,

d is between 1.16 and 3,

R¹ are independently hydrocarbyl having 1 to 8 carbon atoms, preferably methyl, ethyl, propyl or
5 phenyl radicals, especially preferably methyl radicals,

R² is hydrogen

is purified and, in a second step, is reacted in the manner of a hydrosilylation with a terminally unsaturated polyether of the formula (VI)



10 where

m = 3.4 to 11.0, preferably 3.6 to 9.9, more preferably 4.5 to 8.5,

n = 2.5 to 8.0, preferably 2.7 to 7.5, more preferably 3.0 to 6.0,

but with the provisos that:

m/n = 0.44 to 3.08, preferably 0.55 to 3.00, more preferably 0.8 to 2.8, especially preferably 1.9 to
15 2.8,

R⁵ are each independently hydrocarbyl radicals having 1 to 16 carbon atoms or hydrogen, preferably hydrogen or methyl, especially hydrogen,

R⁴ are independently monovalent terminally unsaturated hydrocarbyl having 2 to 8 carbon atoms, preferably CH₂=CH₂-, CH₂=CHCH₂-, CH₂=CHCH(CH₃)-, CH₂=CHC(CH₃)₂-, especially preferably
20 CH₂=CHCH₂-.

Preferably, the H-siloxane of formula (V) is purified in the first step of the process according to the invention by subjecting the H-siloxane to a suitable thermal separation process. Thermal separation processes are known by this term to those skilled in the art and include all processes based on the establishment of a thermodynamic phase equilibrium. Preferred thermal separation processes are
25 selected from the list comprising distillation, rectification, adsorption, crystallization, extraction, absorption, drying and freezing-out, particular preference being given to methods of distillation and rectification. Particular preference is given to distillation and rectification under standard pressure.

Especially preferred is distillation and rectification at standard pressure for the compounds of the formula (V) with R² = hydrogen and the indices a and b = zero and d = 1.16 to 1.22 at a top temperature of 142°C
30 under standard pressure for purification of the product.

Preferably, in the process according to the invention, no H-siloxanes of the formula (V) which have been subjected to any separation process other than a thermal separation process are employed.

The index d of the compounds of the formula (V) can be determined by prior art methods, preferably with the aid of ¹H NMR spectroscopy, more preferably by the method as described in the examples.

5 The hydrosilylation reaction in the process according to the invention is preferably catalysed with the aid of the platinum group catalysts familiar to those skilled in the art, more preferably with the aid of Karstedt catalysts.

10 The hydrosilylation reaction in the process according to the invention is preferably brought to a full conversion in relation to the hydrogen content of the H-siloxane of the formula (V). In the context of the present invention, full conversion is understood to mean that the conversion of SiH functions is > 99%. This is detected in a manner familiar to those skilled in the art, preferably by gas-volumetric means after alkaline breakdown. This can be done, for example, by reacting a sample of the reaction mixture with a butanolic sodium butoxide solution (w (sodium butoxide) = 5%) and concluding the amount of SiH functions still present from the amount of hydrogen formed.

15 The polyethers of the formula (VI) and the polyethers of the formula (II) may have a statistical construction. Statistical distributions are of blockwise construction with any desired number of blocks and with any desired sequence or are subject to a randomized distribution; they may also have an alternating construction or else form a gradient over the chain; more particularly they can also form any mixed forms in which groups with different distributions may optionally follow one another. Specific executions may result in restriction of the statistical distributions by virtue of the execution. For all ranges which are not affected by the restriction, there is no change in the statistical distribution.

20 Further preferably, it is also true of the polyethers of the formula (VI) in the process according to the invention that the polyether radical of formula (VI), calculated without R⁴O and calculated without R⁵, has a molar mass M (PE) calculated by $44 \text{ g/mol} \cdot m + 58 \text{ g/mol} \cdot n$ where the indices m and n are as defined for formula (II).

25 The preferred values for M (PE) are: lower limits for M (PE) greater than 520 g/mol, preferably greater than 530 g/mol, more preferably greater than 535 g/mol; upper limits for M (PE) less than 660 g/mol, preferably less than 630 g/mol, more preferably less than 600 g/mol.

Preferably, the value of M (PE) is greater than 520 g/mol and less than 660 g/mol, especially greater than 535 g/mol and less than 600 g/mol.

30 Preferably, the sum total of m + n is greater than 9 up to 19, more preferably greater than 9.5 up to 15 and especially preferably greater than 10 up to 12.

More preferably, R⁵ is hydrogen and the value of M (PE) is greater than 520 g/mol and less than 660 g/mol; especially preferably, R⁵ is hydrogen and the value of M (PE) is greater than 535 g/mol and less than 600 g/mol.

More preferably, the inventive H-siloxanes of the formula (V) have an index d between 1 and 1.05 and are reacted with terminally unsaturated polyethers of the formula (VI), where the indices m are from 3.4 to 11.0 and n from 2.5 to 8.0.

5 More preferably, the inventive H-siloxanes of the formula (V) have an index d between 1 and 1.05 and are reacted with terminally unsaturated polyethers of the formula (VI), where the m/n ratio is 0.8 to 2.8.

More preferably, the inventive H-siloxanes of the formula (V) have an index d between 1 and 1.05 and are reacted with terminally unsaturated polyethers of the formula (VI), where the m/n ratio is 1.9 to 2.8.

10 Especially preferably, the inventive H-siloxanes of the formula (V) have an index d between 1 and 1.05 and are reacted with terminally unsaturated polyethers of the formula (VI), where the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol.

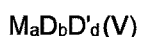
Especially preferably, the inventive H-siloxanes of the formula (V) have an index d between 1 and 1.05 and are reacted with terminally unsaturated polyethers of the formula (VI), where the R⁵ radical is hydrogen.

15 Especially preferably, the inventive H-siloxanes of the formula (V) have an index d between 1 and 1.05 and are reacted with terminally unsaturated polyethers of the formula (VI), where the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol and the R⁵ radical is hydrogen.

Especially preferably, the inventive H-siloxanes of the formula (V) have an index d between 1 and 1.05 and are reacted with terminally unsaturated polyethers of the formula (VI), where the R⁵ radical is hydrogen and where the m/n ratio is 1.9 to 2.8.

20 Preferably, the products of the process according to the invention do not include any further polyether-modified siloxanes that do not correspond to the products of the process according to the invention.

In one particular embodiment, the present invention provides a process for preparing a polyether-modified siloxane, in which, in a first step, an H-siloxane of the formula (V)



with $M = R^1_3 SiO_{1/2}$; $D = R^1_2 SiO_{2/2}$, $D' = R^1 R^2 SiO_{2/2}$,

25 where

a is 2,

b is between 0 and 0.1,

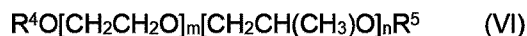
d is between 1.16 and 3,

R¹ are independently hydrocarbyl having 1 to 8 carbon atoms,

30 R² is hydrogen

8a

is purified and, in a second step, is reacted in the manner of a hydrosilylation with a terminally unsaturated polyether of the formula (VI)



where

5 m = 3.4 to 11.0,

 n = 2.5 to 8.0,

but with the provisos that:

m/n = 1.9 to 2.8,

each R^5 is independently hydrocarbyl radicals having 1 to 16 carbon atoms or hydrogen,

10 each R^4 is independently monovalent terminally unsaturated hydrocarbyl having 2 to 8 carbon atoms.

The inventive compositions can be produced by the prior art methods, but preferably by the process according to the invention.

15 The present invention further provides for the use of the inventive compositions and/or of the inventive process products as adjuvant in crop protection.

The inventive adjuvant is suitable with all crop protection compositions for all plants. Advantageously, the adjuvant is used together with herbicides, fungicides, insecticides, growth regulators and macro- and micronutrients (fertilizers), preferably with herbicides. The crop protection compositions and fertilizers may be either of synthetic origin or of biological and natural origin.

20 The inventive compositions may include further components. These further components may be selected from herbicides, fungicides, insecticides, growth regulators and fertilizers, preferably herbicides. Preferred fertilizers are macro- and micronutrients.

Preferably, the inventive compositions are used as a tankmix additive for spray liquors. Preferred use concentrations here are between 0.001% and 1% by volume, preferably between 0.01% and 0.5% by volume and more preferably between 0.02% and 0.15% by volume (also corresponding to about 0.1% by weight) of the spray liquor. This is equivalent to 10 to 3000 ml/ha when typically 100 to 1000 l of spray liquor per ha are deployed, and preferably an amount of adjuvant of 50 to 700 ml/ha, which are also added by the respective amounts of spray liquor irrespective of the total water application rate per ha.

Active substances are those which are approved and/or registered and/or listed in the individual countries for use on plants and crops in order to protect plants against damage, or to prevent yield loss as the result of pests or the like in a crop, or to eliminate undesirable accompanying flora, such as broad-leaved weeds and/or grass weeds, or to supply the plants with nutrients (also termed fertilizers). Active substances may be synthetic substances or else biological substances. Active substances may also be extracts, or natural substances, or antagonistically active organisms. They are usually also referred to as pesticides or plant protection agents. In general, active substances are incorporated into formulations for handling and efficiency purposes.

For use on plants or plant parts, crop protection composition formulations are usually diluted with water before the standard spraying through nozzles, and contain not only the active component but also other adjuvants such as emulsifiers, dispersing aids, antifrost agents, antifoams, biocides and surface-active substances such as surfactants. Active substances, especially fungicides, insecticides and nutrients, alone or in combination and having been provided with the other auxiliaries specified above, can also be applied to seeds (seed) of plants by various methods. Such methods are also referred to as seed treatment methods. The treatment of seed with fungicides and insecticides can protect plants in the early stage of growth from diseases and attack by insects.

The inventive compositions comprising the polyether-substituted siloxanes of the formula (I), the process according to the invention and the inventive use of the compositions and/or process products are described by way of example hereinafter, without any intention that the invention be restricted to these illustrative embodiments. If ranges, general formulae or compound classes are specified hereinafter, this shall encompass not only the corresponding ranges or groups of compounds that are explicitly mentioned, but also all sub-ranges and sub-groups of compounds which can be obtained by extracting individual values (ranges) or compounds. Where documents are cited in the context of the present description, it is intended that their content shall form a full part of the disclosure content of the present invention. Where percentages are given below, they are percentages in % by weight unless stated otherwise. In the case of compositions, the % figures, unless otherwise indicated, are based on the overall composition. Where average values are reported below, the averages in question are mass averages (weight averages), unless otherwise indicated. Where measurement values are reported above and below, these measurement values, unless stated otherwise, have been determined under a pressure of 101 325 Pa (standard pressure) and at a temperature at 25°C.

Examples

General methods and materials:

Trade name	
Silwet L-77	Product and trademark of Momentive
Silwet 806	Product and trademark of Momentive
BREAK-THRU S 240	Product and trademark of Evonik Degussa GmbH, Germany
BREAK-THRU S 278	Product and trademark of Evonik Degussa GmbH, Germany
BREAK-THRU S 233	Product and trademark of Evonik Degussa GmbH, Germany
Sylgard 309	Product and trademark of Dow Corning, USA

5

Synthesis

Preparation of $\text{Me}_3\text{SiO}[\text{SiMeHO}]_c\text{SiMe}_3$

10 An SiH-functional siloxane of the general formula $\text{Me}_3\text{SiO}[\text{SiMeHO}]_{1.2}\text{SiMe}_3$ was subjected to a fractional distillation under standard pressure. The fraction at a top temperature of 142°C was determined with the aid of a gas chromatograph to be the product having a purity of 99% by weight of 1,1,1,3,5,5,5-heptamethyltrisiloxane. Thus, the product of the formula (V) has an index d of 1.01.

Subsequently, the distillate and the starting siloxane were mixed in such a way as to obtain the following siloxanes: $\text{Me}_3\text{SiO}[\text{SiMeHO}]_{1.2}\text{SiMe}_3$, $\text{Me}_3\text{SiO}[\text{SiMeHO}]_{1.15}\text{SiMe}_3$, $\text{Me}_3\text{SiO}[\text{SiMeHO}]_{1.10}\text{SiMe}_3$, $\text{Me}_3\text{SiO}[\text{SiMeHO}]_{1.05}\text{SiMe}_3$ and $\text{Me}_3\text{SiO}[\text{SiMeHO}]_{1.01}\text{SiMe}_3$.

15 The determination of purity was conducted with the aid of ^1H NMR and ^{29}Si spectroscopy. These methods, especially taking account of the multiplicity of the couplings, are familiar to those skilled in the art.

With the aid of these siloxanes, 21 samples were produced analogously to the general preparation method which follows.

20

General synthesis method for hydrosilylation:

25 A 1000 ml three-neck flask equipped with stirrer and reflux condenser was initially charged with 0.5 mol of a polyether of the general formula $\text{CH}_2=\text{CHCH}_2\text{O}[\text{CH}_2\text{CH}_2\text{O}]_m[\text{CH}_2\text{CH}(\text{CH}_3)\text{O}]_n\text{R}^5$ and heated to 90°C. Subsequently, 10 ppm of Pt were added in the form of a toluenic solution of the Karstedt catalyst (Pt content 2 mol%). The mixture was stirred for 10 min and then 0.38 mol of SiH groups in the form of the SiH-functional siloxane $\text{Me}_3\text{SiO}[\text{SiMeHO}]_c\text{SiMe}_3$ was added dropwise within 15 min. An exothermic

reaction was observed; the reaction mixture was stirred at 90°C for a further 4 h. In all cases, it was no longer possible to detect any SiH functions by gas-volumetric means.

Table 1: Samples prepared; the R^5 , c , m , n , M (PE) and m/n data relate to formula (I) and, respectively, to formula (II); in the cases when $n = 0$, m/n is undefined and consequently not stated:

Sample	R^5	c	m	n	M (PE)	m/n
Tego XP 11022	H	1.00	8.0	3.3	543	2.45
Sample 1	H	1.01	7.8	0.0	343	---
Sample 2	H	1.20	6.0	3.0	438	1.98
Sample 3	H	1.01	10.0	0.0	440	--
Sample 4	Me	1.01	7.8	0.0	343	--
Sample 5	H	1.20	9.9	1.9	545	5.27
Sample 6	H	1.01	14.6	0.0	642	--
Sample 7	Me	1.01	12.3	0.0	541	--
Sample 8	H	1.01	12.3	0.0	541	--
Sample 9	H	1.01	9.9	1.9	546	5.27
Sample 10	H	1.01	8.0	3.3	543	2.45
Sample 11	H	1.01	6.2	4.7	545	1.32
Sample 12	H	1.01	4.9	5.6	540	0.88
Sample 13	H	1.01	3.4	10.2	741	0.33
Sample 14'	H	1.01	10.7	8.1	941	1.32
Sample 15'	H	1.01	14.4	7.0	1040	2.06
Sample 16'	H	1.05	8.0	3.3	543	2.45
Sample 17'	H	1.10	8.0	3.3	543	2.45
Sample 18	H	1.15	8.0	3.3	543	2.45
Sample 19	H	1.20	9.2	4.1	643	2.24
Sample 20	H	1.20	3.4	10.2	741	0.33
Sample 21	H	1.20	10.7	8.1	941	1.32

Samples 2, 5, 19, 20 and 21 are noninventive polyether siloxanes since the index c is too high. Samples 1, 3, 4, 6, 7 and 8 are noninventive since the index n is zero. Samples 5 and 9 are noninventive because the content of oxyethylene groups is too low.

5 Test solutions:

0.1% by weight solutions of the test substances in distilled water were made up.

Spreading test

10 Spreading was examined by applying a 50 µl droplet of the test solutions to a standard polypropylene film (of the Forco-OPP type, from Van Leer). The droplet was applied with a micropipette. The area of spread was measured 90 seconds after the application. The experiments were conducted at 23°C and a relative air humidity of 60%.

Surface tensions

15 Surface tensions were measured by the Wilhelmy plate method with a Kruss K 12 tensiometer at 25°C.

OECD biodegradability

Biodegradability was determined in accordance with OECD Method 301F by manometric respirometry at a temperature of 22°C ± 1°C. The degradation rate was determined within 28 days. The samples had
20 been analysed in a concentration of 100 mg/l and 28 mg/l both against a zero sample (mineral medium) and against a sodium benzoate solution of equal concentration. The values were recorded both after 14 days and after 28 days. After 14 days, no plateau phase had been reached yet. The sewage sludge samples used came from the sewage treatment plant belonging to the Ruhrverband water company, Sunthelle 6, 57392 Schmallenberg on 16 September 2014. The concentration used was 29.6 mg of dry
25 matter per litre of mineral medium; the pH was determined before the start of the experiments to be 7.4 ± 0.2.

Results of the interfacial activity study:

Comparative substances used for some commercial products, and substances according to US
30 6,734,141.

Surfactant B: $\text{Me}_3\text{SiO}-[\text{MeR}'\text{SiO}]_{1.20}-\text{OSiMe}_3$, with $\text{R}' = -(\text{CH}_2)_3-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_{10}(\text{CH}_2\text{CH}(\text{CH}_3)\text{O})_2-\text{H}$

Surfactant C: $\text{Me}_3\text{SiO}-[\text{MeR}'\text{SiO}]_{1.00}-\text{OSiMe}_3$, with $\text{R}' = -(\text{CH}_2)_3-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_{20}(\text{CH}_2\text{CH}(\text{CH}_3)\text{O})_5-\text{H}$

Surfactant D: $\text{Me}_3\text{SiO}-[\text{MeR}'\text{SiO}]_{1.00}-\text{OSiMe}_3$, with $\text{R}' = -(\text{CH}_2)_3-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_{12.5}-\text{H}$

BREAK-THRU S 233: $\text{Me}_3\text{SiO}-[\text{MeR}'\text{SiO}]_{1.20}-\text{OSiMe}_3$, with $\text{R}' = -(\text{CH}_2)_3-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_{9.9}(\text{CH}_2\text{CH}(\text{CH}_3)\text{O})_{1.9}-\text{H}$

5 BREAK-THRU S 240: $\text{Me}_3\text{SiO}-[\text{MeR}'\text{SiO}]_{1.20}-\text{OSiMe}_3$ with $\text{R}' = -(\text{CH}_2)_3-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_6(\text{CH}_2\text{CH}(\text{CH}_3)\text{O})_3-\text{H}$

BREAK-THRU S 278: $\text{Me}_3\text{SiO}-[\text{MeR}'\text{SiO}]_{1.20}-\text{OSiMe}_3$ with $\text{R}' = -(\text{CH}_2)_3-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_{7.8}-\text{Me}$

SILWET L77: $\text{Me}_3\text{SiO}-[\text{MeR}'\text{SiO}]-\text{OSiMe}_3$ with $\text{R}' = -(\text{CH}_2)_3-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_8-\text{Me}$

Adjuvant	Static surface tension [mN/m]	Spread diameter [mm]	Biodegradable
Tego XP 11022	22.9	70	yes
Sample 1	21.6		no
Sample 2	21.7		no
Sample 3	21.6	53	no
Sample 4	22.0	70	no
Sample 5	21.4	15	
Sample 6	22.8	15	
Sample 7	22.7	15	no
Sample 8	22.7	15	yes
Sample 9	21.9	30	
Sample 10	21.4	70	yes
Sample 11	22.3	80	
Sample 12	22.2	75	
Sample 13		16	
Sample 14'		15	
Sample 15'	26.8	11	
Sample 16'	21.7	60	yes
Sample 17'	21.7	60	yes
Sample 18	22.0	53	yes
Sample 19	23.5	16	
Sample 20	34.8	12	
Sample 21	25.3	12	
Surfactant B	24.1	14	
Surfactant C	28.2	10	
Surfactant D	23.8	13	
BREAK-THRU S 240	22.3	70	
BREAK-THRU S 278	22.0	70	
BREAK-THRU S 233	21.4	15	
Silwet 806	23.5	70	
Silwet L77	23.8	80	
Silguard 309	23.0	80	

Typical superspreaders show a spread diameter in this test of 35 mm or more.

It is found that biodegradable superspreaders have a very defined structure.

The polyether has to have a certain molar mass, but must not be too heavy either. In addition, the polyether has to have a certain number of $[\text{CH}_2\text{CH}(\text{CH}_3)\text{O}]$ groups, but a certain ratio between $[\text{CH}_2\text{CH}(\text{CH}_3)\text{O}]$ and $[\text{CH}_2\text{CH}_2\text{O}]$ groups still has to be maintained. Furthermore, the siloxane must not be too inhomogeneous.

- 5 The results show the advantageous use of the inventive substances.

Biodegradability results:

Adjuvant	Biodegradability [%]
Sample 8	60%
Sample 10	66%
Sample 1	< 60%
Sample 2	< 60%
Sample 7	7%
Sample 3	< 60%

- 10 The results show the easy biodegradability of the inventive substances.

Greenhouse experiments to determine the improvement in biological efficacy of a herbicide

- In a greenhouse, common meadowgrass (*Poa pratense*) was grown in pots. As soon as the plants had reached a height of about 5 to 7 cm, they were sprayed with spray liquor that contained the herbicide
- 15 Cato® (DuPont, Germany, active ingredient: rimsulfuron, concentration: 250 g of active ingredient/kg). The amount of spray that contained the active ingredient corresponded to 200 l/ha. Various adjuvants were added to the spray liquor. For each element of the experiment there were 3 pots that were treated in the same way. The pesticide dosage was 10 g/ha. Commercial standard wetting agents added to the tank were Break-Thru S240 and trisiloxane BREAK-THRU S233, each at 50 ml/ha. The dosage of Tego
- 20 XP 11022 was 100 ml/ha. The damage to the plants by the herbicide treatment is compared here to untreated plants and the efficacy of the sprayed treatment is expressed as a ratio to the untreated plants. The efficacy was scored in each of the 3 pots per element of the experiment by methods known to those skilled in the art 14 and 28 days after the treatment. The average was calculated and reported as results in the table as a percentage compared to the control without herbicide treatment.

Herbicide	Adjuvant	14 d	28 d
Cato, 10 ml/ha	none	50%	74%
Cato, 10 ml/ha	Tego XP 11022, 100 ml/ha	70%	94%
Cato, 10 ml/ha	BREAK-THRU S240, 50 g/ha	60%	84%
Cato, 10 ml/ha	BREAK-THRU S233, 50 g/ha	50%	83%

The results show that the inventive composition brought a distinct increase in action compared to herbicide treatment without wetting agent. The advantageous use of the inventive compositions compared to the prior art is shown by this experiment.

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

1. A composition comprising a polyether-modified siloxane of formula (I)



with $M = R^1_3SiO_{1/2}$, $D = R^1_2SiO_{2/2}$, $D' = R^1R^2SiO_{2/2}$,

where

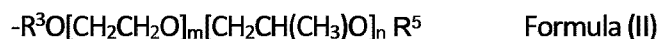
a is 2

b is between 0 and 0.1,

c is between 1.0 and 1.15,

each R^1 is independently hydrocarbyl having 1 to 8 carbon atoms,

each R^2 is independently a polyether radical of the formula (II)



where

m = 3.4 to 11.0,

n = 2.5 to 8.0,

but with the provisos that:

m/n = 1.9 to 2.8,

each R^3 is independently a divalent hydrocarbyl radical having 2 to 8 carbon atoms,

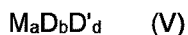
R^5 is hydrogen,

the polyether-modified siloxane of formula (I) having a biodegradability of greater than 60%, the maximum value being 100%, wherein the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol.

2. The composition according to claim 1, wherein b is 0.
3. The composition according to claim 1 or 2, wherein c is between 1.0 and 1.10.

4. The composition according to claim 1 or 2, wherein c is between 1.00 and 1.05.
5. The composition according to any one of claims 1 to 4, wherein each R¹ is independently a methyl, ethyl, propyl or phenyl radical.
6. The composition according to any one of claims 1 to 4, wherein each R¹ is independently a methyl radical.
7. The composition according to any one of claims 1 to 6, wherein m is 3.6 to 9.9.
8. The composition according to any one of claims 1 to 6, wherein m is 4.5 to 8.5.
9. The composition according to any one of claims 1 to 8, wherein n is 2.7 to 7.5.
10. The composition according to any one of claims 1 to 8, wherein n is 3.0 to 6.0.
11. The composition according to any one of claims 1 to 10, wherein each R³ is independently ethylene, propylene, 1-methylpropylene, or 1,1-dimethylpropylene radical.
12. The composition according to any one of claims 1 to 10, wherein each R³ is independently -CH₂CH₂CH₂-.
13. The composition according to any one of claims 1 to 12, wherein the polyether-modified siloxane of formula (I) has a biodegradability of greater than or equal to 63%.
14. The composition according to any one of claims 1 to 12, wherein the polyether-modified siloxane of formula (I) has a biodegradability of greater than or equal to 65%.

15. The composition according to any one of claims 1 to 14, wherein the sum total of $m + n$ is greater than 9 up to 19.
16. The composition according to claim 15, wherein the sum total of $m + n$ is greater than 9.5 up to 15.
17. The composition according to claim 15, wherein the sum total of $m + n$ is greater than 10 up to 12.
18. The composition according to any one of claims 1 to 17, wherein a 0.1 percent by weight solution of the polyether-modified siloxane of formula (I) in water has a spreading area of 10 to 60 cm².
19. The composition according to any one of claims 1 to 17, wherein a 0.1 percent by weight solution of the polyether-modified siloxane of formula (I) in water has a spreading area of 15 to 50 cm².
20. The composition according to any one of claims 1 to 17, wherein a 0.1 percent by weight solution of the polyether-modified siloxane of formula (I) in water has a spreading area of 20 to 40 cm².
21. The composition according to any one of claims 1 to 20, wherein the polyether-modified siloxane of the formula (I) has an index c between 1 and 1.05, where a 0.1% by weight solution of the siloxane in water has a spreading area of 15 to 60 cm².
22. The composition according to any one of claims 1 to 21, wherein the polyether-modified siloxane of the formula (I) has a biodegradability of greater than 60%, and the index c is additionally between 1 and 1.05, where the molar mass of the polyether radical $M(PE)$ is greater than 520 g/mol and less than 660 g/mol, the R^5 radical is hydrogen and a 0.1% by weight solution in water has a spreading area of 15 to 60 cm².
23. A process for preparing a polyether-modified siloxane, in which, in a first step, an H-siloxane of the formula (V)



with $M = R^1_3SiO_{1/2}$; $D = R^1_2SiO_{2/2}$, $D' = R^1R^2SiO_{2/2}$,

where

a is 2,

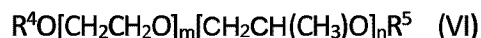
b is between 0 and 0.1,

d is between 1.16 and 3,

R^1 are independently hydrocarbyl having 1 to 8 carbon atoms,

R^2 is hydrogen

is purified and, in a second step, is reacted in the manner of a hydrosilylation with a terminally unsaturated polyether of the formula (VI)



where

m = 3.4 to 11.0,

n = 2.5 to 8.0,

but with the provisos that:

m/n = 1.9 to 2.8,

each R^5 is independently hydrocarbyl radicals having 1 to 16 carbon atoms or hydrogen,

each R^4 is independently monovalent terminally unsaturated hydrocarbyl having 2 to 8 carbon atoms,

wherein the molar mass of the polyether radical M(PE) is greater than 520 g/mol and less than 660 g/mol.

24. The process according to claim 23, wherein each R^1 is independently a methyl, ethyl, propyl or phenyl radical.
25. The process according to claim 23, wherein each R^1 is independently a methyl radical.
26. The process according to any one of claims 23 to 25, wherein m is 3.6 to 9.9.

27. The process according to any one of claims 23 to 25, wherein m is 4.5 to 8.5.
28. The process according to any one of claims 23 to 27, wherein n is 2.7 to 7.5.
29. The process according to any one of claims 23 to 27, wherein n is 3.0 to 6.0.
30. The process according to any one of claims 23 to 29, wherein each R^5 is independently hydrogen or methyl.
31. The process according to any one of claims 23 to 29, wherein each R^5 is independently hydrogen.
32. The process according to any one of claims 23 to 31, wherein each R^4 is independently $CH_2=CH_2-$, $CH_2=CHCH_2-$, $CH_2=CHCH(CH_3)-$, or $CH_2=CHC(CH_3)_2-$.
33. The process according to any one of claims 23 to 31, wherein each R^4 is independently $CH_2=CHCH_2-$.
34. The process according to any one of claims 23 to 33, wherein the H-siloxane of the formula (V) is purified by employing a thermal separation process.
35. Use of a composition as defined in any one of claims 1 to 22 or of a polyether-modified siloxane obtained by a process as defined in any one of claims 23 to 34 as an adjuvant in crop protection.
36. Use of a composition as defined in any one of claims 1 to 22 or of a polyether-modified siloxane obtained by a process as defined in any one of claims 23 to 34 as a tankmix additive for a spray liquor in a concentration of 0.001% to 1% by volume of the spray liquor.