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ALKOXYLATED ALKYLAMINES / ALKYL ETHER AMINES WITH PEAKED DISTRIBUTION

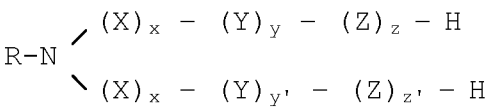
FIELD OF THE INVENTION

[0001] The present invention relates to processes for preparation of alkoxylated alkyl amines or alkoxylated alkyl ether amines with peaked distribution, surfactants comprising alkoxylated alkyl amines or alkoxylated alkyl ether amines with peaked distribution, and stable herbicidal formulations comprising alkoxylated alkyl amines or alkoxylated alkyl ether amines with peaked distribution.

BACKGROUND OF THE INVENTION

[0002] Alkoxylated alkyl amines and alkyl ether amines, particularly ethoxylated alkyl amines and ethoxylated alkyl ether amines, have many applications in industry. They can be usefully employed as adjuvants in pesticide formulations, textile processing aids, dye transfer inhibitors, acid thickeners, detergent boosters, degreasers, anti-static agents and the like.

[0003] Alkoxylated alkyl amines and alkoxylated alkyl ether amines are materials possessing the following general structures (I), respectively:



(I)

[0004] In conventional alkoxylated alkylamines, R is typically selected from a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms. In alkoxylated etheramines, R corresponds to the formula:

$$R^1 - O - (A)_a - (B)_b - (C)_c$$

where R^1 is typically a linear or branched, saturated or non-saturated alkyl group containing 8-22 carbon atoms, A and B are alkylene oxide groups containing 2 - 4 carbon atoms, C is alkylene group containing 3 - 4 carbon atoms, a, b each vary from 0 – 5, c is 1, X, Y, Z are alkylene oxide groups containing 2 - 4 carbon atoms, x is 1, and y, y', z, and z' each independently vary from 0 - 15.

[0005] As illustrated by general formula (I), the alkoxylated alkyl amines/ alkoxylated alkyl ether amines possess a surfactant structure which is composed of the lipophilic groups (R or R^1) and the hydrophilic groups (polyalkylene oxide). In their designed applications, the performance of alkoxylated alkyl amines and alkoxylated alkyl ether amines is dependent on a balance between the lipholicity and the hydrophilicity provided by these groups.

[0006] Even when the lipophilicity-hydrophilicity balance does exist, the performance of the alkoxylated alkyl amines/alkoxylated alkyl ether amines is not necessarily optimal. Traditionally, these materials are prepared from the base-catalyzed alkoxylation of the corresponding alkyl amines / alkyl ether amines. Such an alkoxylation reaction is actually the polymerization reaction of alkylene oxide that includes the characteristic propagation and chain transfer steps of the polymerization process. For this reason, the resulting alkoxylated alkylamine / alkyl ether amine is not a pure compound, but a mixture of many homologs.

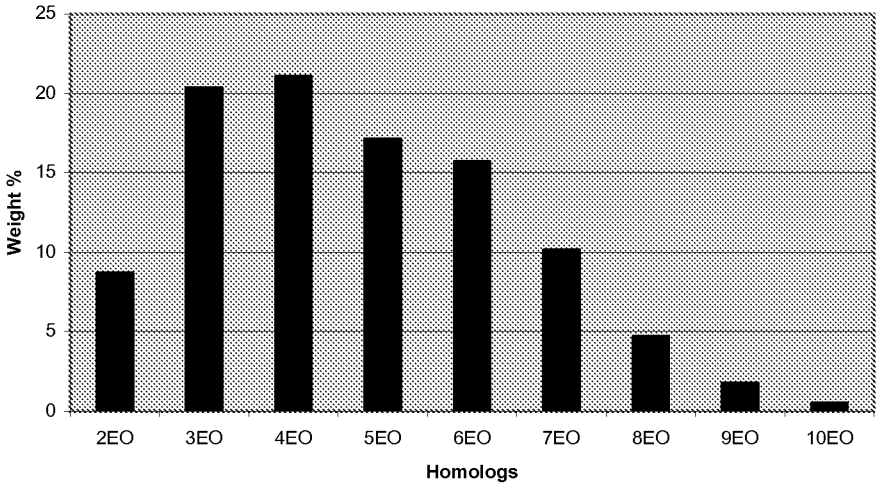


Figure 1: Homolog distribution of tallow amine prepared with 5 moles of ethylene oxide by the regular hydroxide-catalyzed process.

[0007] As an example, Figure 1 illustrates the homolog distribution of ethoxylated tallow amine prepared from the regular hydroxide-catalyzed ethoxylation of tallow amine with 5 moles of ethylene oxide. As shown in Figure 1, the resulting ethoxylated product is not a single compound containing 5 (CH_2CH_2O) units as the general structure (structure I, with 2x+y+y'+z+z'=5) may suggest. Instead, the product is a mixture of several homologs whose total ethylene oxide units varies from 2 to 10. Among these homologs, only those in the middle of the distribution range have the proper liphophilic-hydrophilic balance for certain applications and, therefore, are generally preferred. For example, in the case of an ethoxylated product comprising an average ratio of 5 alkylene oxide units per molecule, homologs having a desired lipophilic-hydrophilic balance typically range from 3EO to 5EO where "EO" is an ethylene oxide unit. Homologs with shorter EO chain length (< 3EO) or longer EO chain length (> 5EO) are not desirable for the applications for which a 5 EO/amine

ratio surfactant is ordinarily prescribed, since such longer and shorter homologs are either too lipophilic or too hydrophilic for the applications utilizing this product. For at least some applications, the presence of especially long species is particularly disadvantageous, e.g., species having an EO/amine ratio of more than about 1.5x the target ratio. Therefore, it is advantageous to develop an alkoxylation process that results in alkoxylated products with peaked distribution.

[0008] Accordingly, it is an object of the present invention to develop a process for preparation of alkoxylated ethoxylated alkyl amines and alkyl ether amines, particularly ethoxylated alkylamine and ethoxylated alkyl ether amine with peaked distribution having greatly minimized drawbacks compared to those associated with the acid-catalyzed process.

[0009] U.S. patent 4,483,941 describes the preparation of ethoxylated organic materials comprising a peaked distribution of homologs, as prepared by ethoxylation in the presence of BF_3 and metal alkyls or metal alkoxides, SiF_4 and metal alkyls or metal alkoxides, or mixtures of all these catalysts. The reference lists alcohols, alkyl phenols, polyols, aldehydes, ketones, amines, amides, organic acids and mercaptans as substrates that may be ethoxylated. The patent includes a long list of amines that are subject to ethoxylation, particularly including octylamine and hexadecylamine. Working examples describe ethoxylation of C_{12} to C_{14} alcohols.

[0010] East German patent DD 219,478 describes the ethoxylation of amines in the presence of Lewis acid catalysts. A number of working examples are included which embody reactions with C_{12} primary amine at ethylene oxide to amine ratios in the ranges of about 2, 3 and 6. At ratios

of about 3 and about 6, final reaction temperatures range from 179° to 207°C.

[0011] US patent 6,376,721 describes the alkoxylation of alcohols, amines, mercaptans and amides in the presence of a rare earth triflimide catalyst to obtain a peaked distribution of homologs. Working examples describe the ethoxylation of dodecanol.

[0012] Hreczuch & Szymanowski, *Recent Res. In Oil Chem., 2* (1998), pp. 63-76 describes ethoxylation in the presence of a calcium-based W7™ catalyst to obtain narrow range distributed ethoxylated alcohols. Fig. 6 of this reference also reflects the ethoxylation of tallowamine in the presence of this catalyst and provides a curve illustrating distribution of homologs. The reference explains that in conventional ethoxylation of an alcohol, the reaction rate constants increase for successive stages of oxyethylene, which results in a wide distribution of homologs and typically a significant fraction of unreacted alcohol. It is further explained that the kinetics of alkylamine ethoxylation are different from the kinetics of alcohol ethoxylation.

[0013] WO 02/38269 describes a catalyst comprising Ca sulfate, Ca acetate, low molecular weight Ca alcoholate and a crystalline phase in the form of organic Ca and sulfur compounds as a catalyst in the ethoxylation of alcohols to obtain a narrow distribution of homologs, and the use of such catalyst in the ethoxylation of organic substrates.

[0014] For a number of important commercial and industrial applications, it is desirable to provide alkoxylated alkyl(ether) amines that impart improved functional properties to formulations in which they are incorporated.

[0015] Among the particular applications in which alkoxylated alkylamine and alkoxylated etheramine

surfactants have been used is herbicidal formulations, such as aqueous liquid glyphosate formulations comprising a salt of glyphosate, wherein they may serve to increase the efficacy of the herbicide in controlling or destroying unwanted vegetation.

[0016] N-phosphonomethylglycine, otherwise known as glyphosate, is well known in the art as an effective post-emergent foliar applied herbicide. Glyphosate is an organic compound that at neutral pH, contains three acidic protonatable groups, and in its acid form is relatively insoluble in water. Glyphosate is, therefore, normally formulated and applied as a water-soluble salt. Although monobasic, dibasic and tribasic salts of glyphosate can be made, it has generally been preferred to formulate and apply glyphosate, in the form of a monobasic salt, for example as a mono-(organic ammonium) salt such as the mono (isopropylamine), often abbreviated to IPA, salt, or as either monobasic or dibasic ammonium salt.

[0017] When the terms "ammonium", "monoammonium" and "diammonium" are used herein to refer to salts of glyphosate, these terms apply strictly to inorganic ammonium, i.e., NH_4^+, unless the context demands otherwise. Glyphosate rates and concentrations given herein, even where the glyphosate is present as a salt or salts, are expressed as acid equivalent (a.e.) unless the context demands otherwise.

[0018] For many applications, glyphosate salts generally require the presence of a suitable surfactant for best herbicidal performance. The surfactant may be provided in the concentrate formulation, or it may be added by the end user to the diluted spray solution. The choice of surfactant can be very important since there are wide variations among surfactants in their ability to enhance

the herbicidal efficacy of glyphosate for particular applications.

[0019] Use of a highly concentrated aqueous formulation of glyphosate in the form of a salt made with the inorganic base ammonia and potassium is advantageous. Ammonia and potassium are low in cost, readily available, low in molecular weight, relatively soluble in water. Additionally, they are natural nutrients for the growth of plants and other organisms. Both potassium salts and ammonium salts have been used in substantial commercial volumes. Not all surfactants are as compatible with the potassium and ammonium salts at higher concentrations as they typically are with the isopropylamine salt, especially in concentrated aqueous liquid formulations. The use of ammonium salts of glyphosate for preparing aqueous concentrate formulations of glyphosate suitable for killing and controlling weeds and other plants has, however, been somewhat limited due to difficulties arising from chemical and physical properties thereof, lack of suitable surfactants for preparing high-loaded liquid concentrates of such salts, reduced weed control, and requirement for complex processes for preparing liquid ammonium glyphosate compositions.

[0020] Potassium salts have recently been introduced to the market and have been highly successful. However, potassium salts are not as easy to formulate as isopropylamine salts, for example. With respect to stability, especially as reflected in the cloud points of high load concentrates, the constraints on selection and concentration of surfactants in high load potassium salt solutions are generally more limiting than in the case of isopropylamine salts.

[0021] The economical preparation of high efficacy glyphosate salt solutions depends on selecting a suitable

surfactant or combination of surfactants, and providing an optimal concentration of the surfactant(s), often the highest concentration(s) that can be achieved without sacrifice of stability. Ethoxylated alkylamines have proven excellent bioefficacy in enhancing the herbicidal potency of glyphosate. However, in a concentrated glyphosate formulation with sufficient loading of the useful ethoxylated alkylamines, especially in potassium and ammonium glyphosate formulations, the formulation may not be stable at elevated temperature. Above a threshold glyphosate concentration, any substantial increase in the concentration of surfactant is typically only achievable at the expense of reducing glyphosate a.e. loading (concentration of glyphosate active). Likewise, any substantial increase in glyphosate a.e. loading of these products is often achievable only at the expense of surfactant concentration and may therefore impose a constraint on formulating to a surfactant concentration that is optimal for a desired application. Generally, it is desirable to develop an stable aqueous ammonium, potassium, or mixed salts glyphosate formulation (i) having high glyphosate a.e. loading, (ii) containing an ethoxylated alkylamine surfactant, and (iii) having a high enough concentration of that surfactant to provide formulation stability and efficacy sufficient for the application for which a given formulation is prepared. There is a constant objective of providing formulations of improved herbicidal efficacy, improved storage and handling characteristics, or reduced cost, or which meet two or more of such criteria.

[0022] In this context, a C_8 to C_{22} alkylamine substituted by reaction with two moles of alkylene oxide, i.e., a bis(hydroxyalkyl)amine has a high degree of compatibility with a glyphosate salt, but limited value as

an adjuvant to enhance the efficacy of the herbicide. C_8 to C_{22} alkylamines having longer chain alkylene oxide substituents are more effective as adjuvants but are not as compatible with concentrated aqueous solutions of glyphosate salts, and may cause the formulation to suffer from a relatively low cloud point, e.g., <35°C. For certain herbicidal applications, the optimal surfactant may typically have an average alkylene oxide to amine ratio between about 3 and about 6. But even where the surfactant possesses such an average ratio, it may contain some unavoidable fractions of <3:1 (EO to amine ratio) and >6:1 species, the presence of which can detract from either performance properties or stability of the formulation. In this case, species having a ratio of >8:1 may have a particularly adverse effect on stability. However, there are other applications where glyphosate formulations may typically include a surfactant wherein the average alkylene oxide to amine ratio is in the range of about 8 to about 12, or about 12 to about 18. Aqueous liquid concentrates comprising the latter surfactants are formulated in a manner which preserves stability despite the relatively long alkylene oxide chains, but it remains preferable to minimize the concentration of homolog species that are well above the target, e.g., in the case of a surfactant designed to have a ratio between 8 and 12, it may be preferable to minimize the fraction of homologs having an alkylene oxide/amine ratio >12:1, or in the case of a surfactant designed to have a ratio between 12 and 18, it may be preferable to minimize the fraction wherein the ratio is greater than about 20:1 or 22:1.

SUMMARY OF THE INVENTION

[0023] The present invention generally relates to an alkoxylation process for the preparation of alkoxylated

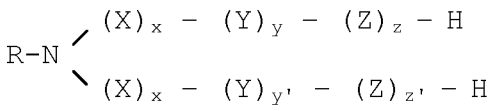
alkyl amines / alkoxylated alkyl ether amines with peaked distribution, to the products prepared therefrom and applications of same.

[0024] Specific processes are described for the preparation of ethoxylated alkylamines including a Lewis acid catalyzed process and a process of the present invention while promoting the peaked distribution of the ethoxylated products.

[0025] The present invention particularly relates to ethoxylated alkylamines and alkyletheramines that exhibit favorable compatibility with glyphosate and to glyphosate formulations comprising same. The specific ethoxylated alkylamines and alkyletheramines of the invention possess a peaked distribution of homologs that enables them to be compatible with glyphosate herbicide actives while retaining their characteristic adjuvancy. The ethoxylated alkylamines of the invention may further be useful in the preparation of glyphosate formulations of enhanced compatibility as compared to similar formulations which incorporate alkoxylated alkylamines of the prior art having a relatively flat or wide distribution of homologs.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Alkoxylated alkyl amines and alkoxylated alkyl ether amines of the invention are materials possessing the following general structure (I):



(I)

wherein R is selected from a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms or a group of the formula:

$$R^1 - O - (A)_a - (B)_b - (C)_c$$

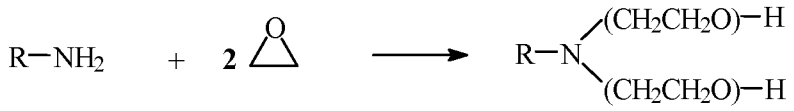
where R^1 is selected from a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms, A and B are alkylene oxide groups containing 2 - 4 carbon atoms, C is alkylene group containing 2 - 4 carbon atoms, a, b each vary from 0 – 5, c is 1, X, Y, Z are alkylene oxide groups containing 2 - 4 carbon atoms, x is 1, and y, y', z and z' each independently vary from 0 – 15.

[0027] By utilizing the terminology "alkoxylated alkyl(ether)amine", it is to be understood herein that the present inventors intend either or both of alkoxylated alkyl amines and alkoxylated alkyl ether amines. The alkoxylated alkyl amine / alkyl ether amine compositions of the invention are not single compounds as suggested by their general structure (I), but rather, they comprise a mixture of several homologs having varied polyalkylene oxide chain length. Among the homologs, only those with the number of total alkylene oxide units per mole of amine closer to the most prevalent alkylene oxide adduct are preferred; homologs whose number of total alkylene oxide units is much lower or much higher than the most prevalent alkylene oxide adduct are undesirable since they are too liphophilic or too hydrophilic to be suitable for the application for which the alkoxylated alkylamine / alkyl ether amine are designed. In certain applications, for example, as surfactants in certain herbicidal formulations, the homologs having alkylene oxide chains significantly longer than average are particularly disadvantageous with respect to stability.

[0028] Alkoxylated alkyl amines and alkoxylated alkyl ether amine are prepared from the reaction of the corresponding primary alkyl amine / alkyl ether amine with

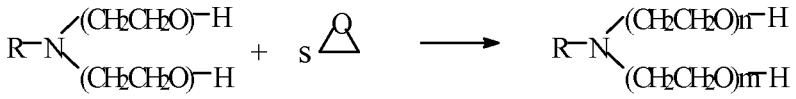
a selected number of moles of alkylene oxide. Using ethoxylated alkylamines (V) as an example, the prior art generally describes the synthesis of ethoxylated alkyl amines in a two-stage process:

(1) Reaction of two moles of ethylene oxide with the primary alkylamine (II) to yield the intermediate (III) (N,N-bis-(2-hydroxyethyl) N-alkylamine). No catalyst is required for this reaction.



(II) (III)

(2) Reaction of additional moles of ethylene oxide with the intermediate (III) to yield the desired final ethoxylated alkylamine product (V) not having a peaked distribution. This reaction requires the use of a catalyst.



(V)

$n+m = s+2$

[0029] Based on the type of catalysts, there are two types of ethoxylation processes described in the prior art. In the regular ethoxylation process commonly used in industry, the catalyst is a base, preferably a hydroxide such as sodium hydroxide or potassium hydroxide. We denote this as the "R" process. With this catalyst, the rate of the ethoxylation reaction is fast, and the formation of by-products, e.g., oxygenated hydrocarbons such as dioxane, and various (poly)ethylene glycol derivatives (EGDs), is

minimal. However, the catalyzed ethoxylation in the second stage follows a polymerization mechanism that includes its characteristic propagation and chain transfer steps. As a result, the ethoxylated product obtained does not have a peaked distribution of total ethylene oxide substitution and possesses higher concentration of the undesired (too lipophilic / too hydrophilic) homologs.

[0030] As recounted above, the prior art also describes another ethoxylation process designed to obtain a preferred peaked distribution of alkoxylated alcohols, aldehydes, ketones, or alkylamines. We denote this as the "S" process. In this process, the ethoxylation is catalyzed by a Lewis acid, preferably Boron Trifluouide, and follows a different mechanism. The resulting ethoxylated product possesses a peaked distribution, with highest concentration is of the homologs generally in the middle of the distribution range, or in any event more concentrated in a desired region than the homologs of an alkoxylated alkylamine. Because the concentration of the undesired homologs is lower in this case, the performance of the ethoxylated alkylamine / alkyl ether amine in the applications they are designed for is optimized. Still other processes for producing peaked distribution alkoxylated organic compounds use calcium or rare earth based catalysts.

[0031] However, so far as is known, neither peaked distribution alkoxylated alkylamines nor peaked distribution alkoxylated etheramines have been commercially available, and the use of alkoxylated alkylamines or etheramines has not been described in applications such as herbicidal formulations, or, more particularly, herbicidal formulations comprising glyphosate salts. One of the objects of the present invention is to cover the glyphosate

formulations with any alkylamines and etheramines with peaked EO distribution.

[0032] Generally, the peaked distribution alkoxylated alkylamines and etheramines of the present invention can be prepared by any process which provides the favorable distribution and/or favorable properties described herein.

[0033] Preferably, alkoxylation is conducted according to one or the other of two novel processes.

[0034] One process, the "S" process, utilizes a Lewis acid catalyst of the type taught by the prior art, but under conditions which differ from those employed in known prior art processes for alkoxylation of alkylamines. The other and generally preferred process, which we denote as the "N" process, optionally uses an alkaline catalyst of the type used in the conventional ("regular") process for the commercial manufacture of alkoxylated alkylamines, but proceeds under a set of conditions which nonetheless affords a peaked distribution by comparison to the commercially available surfactants.

[0035] According to the "S" process, an alkylamine or etheramine is reacted with an alkylene oxide in the presence of a Lewis acid catalyst, preferably boron trifluoride, within a preferred temperature range. It has been discovered that the ethoxylated alkylamines and alkyletheramines prepared from such a process exhibit improved compatibility with glyphosate while retaining their characteristic adjuvancy. Alternative catalyst systems promoting the peaked distribution can also be employed, and it is believe that the products prepared from the ethoxylation utilizing these alternative catalyst systems may also be useful in the context of the present invention. An example of such a system can be found in, for example, U.S. Patent No. 6,376,721 which utilizes a rare earth triflimide catalyst.

[0036] The typical "S" ethoxylation process according to the invention also involves two stages. In Stage 1, the formation of the intermediate (V) (N,N-bis(2-hydroxyethyl)-N-alkylamine or etheramine), is the same as that for the regular "R" process. In this stage, the intermediate (V) is prepared via the reaction of one mole of the selected alkyl (or alkylether) amine with two moles of the ethylene oxide or other alkylene oxide at temperature that varies preferably in the range from 160 – 190^{0}C and at pressure that preferably varies from 40 –90 psig. Typically, the intermediate (V) is prepared immediately prior to its catalyzed ethoxylation. However, for products based on tallow or coco amine, the Stage 1 can be by-passed by using the commercially available N,N-bis(2-hydroxyethyl)-N-alkylamine based on coco amine (Ethomeen C/12 from Akzo Nobel, Varonic K-202 from Degussa) or based on tallow amine (Ethomeen T/12 or Varonic T-202).

[0037] In the second stage of the "S" process, the intermediate (V) is reacted with additional quantity of ethylene oxide or other alkylene oxide in the presence of a catalyst. This catalyzed ethoxylation stage involves the mixing of the intermediate (V) with the desired catalyst in a pressure vessel, followed by the slow addition of the desired quantity of the ethylene oxide to the vessel while the temperature of the mixture in the vessel is carefully maintained in a certain range. The catalyzed ethoxylation of the intermediate (V) is an exothermic reaction and cooling is required to maintain the temperature in the preferred range.

[0038] However, unlike the "R" processes that utilize a basic (hydroxide) catalyst, Stage 2 of the "S" process utilizes a Lewis Acid catalyst. Boron trifluoride is the preferred catalyst, although other Lewis acid catalysts could be employed. Alternatively, the Lewis Acid catalyst

can be tin fluoride (SnF_4), or a boron trifluoride complex. Examples of boron trifluoride complexes useful in the context of the present invention include, but are not limited to members selected from the group consisting of boron trifluoride – ethylene oxide, boron trifluoride – diethyl ether, boron trifluoride - dibutyl ether, boron trifluoride - tetrahydrofuran, boron trifluoride- methanol, boron trifluoride - phosphoric acid and boron trifluoride - acetic acid and mixtures thereof.

[0039] In a preferred embodiment, boron trifluoride (BF_3) is the catalyst for the ethoxylation of alkylamine, and it is most effective when used at the BF_3 concentration ranging from 0.04 – 0.07% of the weight of the final ethoxylated product.

[0040] In addition to the catalyst, temperature is a critical factor in the new "S" ethoxylation process. In the "R" processes with the base (hydroxide) catalyst, the temperature can be anywhere between 110 – 190°C. However, for the "S" process of the present invention, it is preferred that the temperature be maintained in the range between 95 – 130^{0}C, preferably in the range of 110 – 120^{0}C. The normal catalyzed ethoxylation reaction of the intermediate (IV) does not occur at temperature higher than about 130^{0}C (possibly due to the destruction of the catalyst – ethylene oxide complex) or lower than about 95^{0}C.

[0041] One of ordinary skill in the art recognizes that there are various processes for making the peaked ethoxylates employed in the present invention and any of such ethoxylates, regardless of the method of their preparation, meeting the definition of degree of peaking herein are equally useful in the context of the invention.

[0042] Whereas the acid-catalyzed process (the "S" process) promotes the peaked ethoxylation distribution and thus enhances the performance of the resulting ethoxylated

alkylamine / alkyl ether amine, there are several drawbacks, including but not limited to the following that restricts its utilization and usefulness.

[0043] The catalyst (Boron Trifluoride) is not only expensive, but also a hazardous material. The use of this catalyst requires elaborated equipment for its storage and charging to the reactor.

[0044] The process also enhances the formation of undesired by-products, most noticeably dioxane and (poly)ethylene glycol derivatives (EGDs). Depending on the number of moles of ethylene oxide used in the ethoxylation process, the dioxane content in the ethoxylated products could be as high as 25000 ppm. Dioxane is perceived as a hazardous material and it is desirable that it be removed or minimized in the ethoxylated product. Because of its reasonable volatility, dioxane can be removed, e.g., by sparging the ethoxylation reaction product with nitrogen. However, removal of such a high concentration of dioxane requires additional equipment, greatly prolongs the cycle time and reduces the product yield. The concentration of EGDs may typically range from about 5% to about 10% by weight, much higher than that of dioxane. While it is not a hazardous material, the high content of EGDs lowers the concentration of the desired ethoxylated alkylamine, and thus may adversely affect the performance or effectiveness of the ethoxylated product in its application. Moreover, the EGDs are of substantially lower volatility than dioxane, and thus more difficult to separate from the alkoxylated amine surfactant.

[0045] The color of the resulting ethoxylated product degrades over time.

[0046] The process cannot be effectively utilized with propylene oxide.

[0047] The preferred process of the present invention, the "N" process, possesses the advantages of the above-described base-catalyzed and acid-catalyzed processes while eliminating or greatly reducing the drawbacks inherent in same. Specially, the "N" process enables the preparation of alkoxylated alkylamine / alkyl ether amine with the desired peaked alkoxylation distribution, thus ensuring optimum performance in their respective applications. Simultaneously, the "N" process utilizes a base catalyst, preferably a hydroxide or may in some embodiments proceed without a catalyst. As a result, the problem associated with the use of the acid-catalyst, including high cost and hazardous property of the catalyst, the formation of hazardous, undesired by-products, the prolonged cycle time, and the color degradation, are greatly minimized.

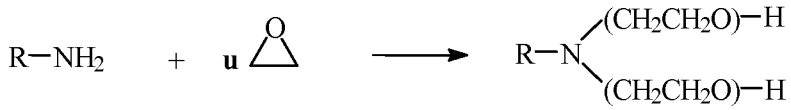
[0048] In accordance with the invention, the present inventors have discovered that polymerization can be conducted without the necessity of utilizing a catalyst, such as a Lewis acid, calcium-based or rare earth catalyst while achieving a more favorable peaked distribution of homologs than is found in otherwise identical commercially available surfactants having the same average total of alkylene oxide substituents. The preferred process, the "N" process, may optionally use an alkaline catalyst while still preserving the favorable peaked distribution that distinguishes the surfactant of the invention from the products of commerce. The novel process achieves the desired result by control of the conditions of the reaction and especially the temperature thereof. For alkoxylated alkylamines of modest average number of alkylene oxide units, it has surprisingly been discovered that the reaction can be conducted entirely in the absence of any catalyst. Because the reactivity of the growing alkylene oxide chain declines with chain length, it is preferred

that an alkaline catalyst be used during a portion of the conversion where the target average alkylene oxide to amine ratio is greater than about 6. Depending on the selection of amine, selection of alkylene oxide, exact process conditions and nature of the process equipment available, it may be preferable to conclude the alkoxylation in the presence of an alkaline catalyst at average alkylene oxide/amine ratios of about greater than about 6 or 7.

[0049] Using the ethoxylation of primary alkyl amine as an example, the process of the invention, the "N" process, can be illustrated by the following three stages:

Stage 1 of the "N" process: Uncatalyzed ethoxylation of the primary alkylamine.

[0050] In this stage, the starting primary alkylamine (II) is reacted with u moles of alkylene oxide, typically about 2 moles of ethylene oxide at high temperature to yield the same tertiary intermediate (III) (N,N-bis-(2-hydroxyethyl) N-alkylamine)

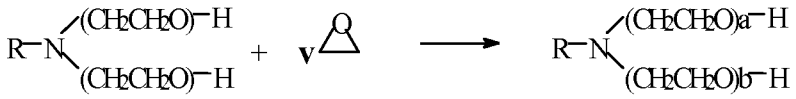


(II) (III)

[0051] The reaction temperature varies from 160 - 190^{0}C and pressure varies from 40 - 90 psig. Typically, the intermediate (III) is prepared immediately prior to its further alkoxylation. However, for ethoxylated products based on tallow or coco amine, the Stage 1 can be by-passed by using the commercially available N,N-bis(2-hydroxyethyl)-N-alkylamine based on coco amine (Ethomeen C/12 from Akzo Nobel, Varonic K-202 from Degussa) or based on tallow amine (Ethomeen T/12 or Varonic T-202).

Stage 2 of the "N" process: Further ethoxylation of the resulting tertiary amines under controlled temperature conditions.

[0052] No catalyst is necessary in this stage, and is preferably not used. Instead, the further reaction of the tertiary amine intermediate (III) with a selected additional moles (v) of ethylene oxide is promoted by the manipulation of the ethoxylation temperature. This stage yields the second tertiary amine intermediate (IV) with longer (CH_2CH_2O) chain length than that of the first intermediate (III)



(IV)
a+b = v+2

where a+b is greater than 2, typically greater than about 3, more typically greater than about 4, but also typically less than about 9 and more typically not greater than about 6. Where the sum of a and b meets the total target average alkylene oxide content for the ultimate surfactant product, the reaction product characterized as "intermediate (IV)" may constitute the final reaction product of the process. Where the ultimate target average number of alkylene oxide units exceeds about 6 or 7, the process preferably proceeds to stage 3.

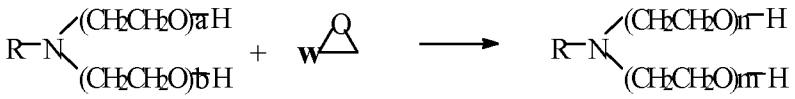
[0053] As discovered in this invention, the peaked distribution obtained in the "N" process is possible in the stage 2 by reacting the tertiary intermediate (III) with alkylene oxide at certain temperature in the absence of a catalyst. Within the selected temperature range, the alkoxylation can proceed, and the absence of the catalyst

facilitates the chain transfer between a newly alkoxylated molecule and another molecule of the tertiary intermediate (III), and results in the peaked distribution.

[0054] Both the number of moles of alkylene oxide and the alkoxylation temperature are critical factors. For the preparation of the ethoxylated products, the number of the moles of ethylene oxide used in this stage is preferred to be in the range of 1-8, typically between about 2 - 7, for example, in the range of 2 - 5. It is possible to use many sub-stages within stages 1 and 2 and end up with the same total EO addition. It is also possible to combine stages 1 and 2. However one must be mindful that ethoxylation performed in this stage with less than 2 moles of ethylene oxide normally results in final product without peaked ethoxylation distribution, while on the other hand, ethoxylation performed in this stage with more than 7 moles of ethylene oxide results in significant formation of by-products. In conducting the uncatalyzed ethoxylation, the temperature is preferably maintained in the range of about 90 to about 130^{0}C, more preferably in the range of about 100 to about 120^{0}C. Ethoxylation performed at lower than 90^{0}C or higher than 130^{0}C normally stops before all the ethylene oxide is consumed.

Stage 3 of the "N" process: Catalyzed ethoxylation

[0055] This stage is optional. In this stage, the second intermediate (IV) is reacted with the remaining quantity of alkylene oxide to yield the final product (V). Unlike the first two stages, a catalyst is required to facilitate the ethoxylation in this stage.



(V)

n+m = v+w+u

wherein u, v and w represent the moles of alkylene oxide employed over the 3 stages of the process, respectively.

[0056] In this optional stage, the alkoxylation is performed using the remaining quantity of alkylene oxide in the presence of a catalyst. Typically, the catalyzed alkoxylation in this stage can be performed at temperature in the range of 100 - 190^{0}C, and pressure between 40 -90 psig. The number of moles of alkylene oxide used in this stage varies, depending on the total number of moles of alkylene oxide used in the preparation (i.e., in all three stages). In general, to obtain maximum peaked distribution of the ethoxylated products, the number of moles of EO used in the third stage is maintained at the same or less than the number of moles of EO used in the second stage. Sodium hydroxide and potassium hydroxide are the preferred catalysts, though other hydroxide catalysts, including but not limited to lithium hydroxide, tetramethylammonium hydroxide, barium hydroxide, aluminum hydroxide, magnesium hydroxide, or complexes containing barium, magnesium and/or aluminum hydroxides, could be used. The sodium hydroxide or potassium hydroxide is most effective when the concentration of their active in the product mixture is 0.05% of the batch weight or higher.

[0057] In stages 1 and 3 of the "N" process, either or both of ethylene oxide or propylene oxide is preferably employed. Ethylene oxide is the alkylene oxide of choice in stage 2 of the "N" process. In the "N" process, the

number of moles (u) is preferably about 1-3, in another embodiment 1.5-2.4, and in still another embodiment about 2.0. The number of moles (v) is generally from about 0 to about 9, in another embodiment 1-7, and in still another embodiment about 2-5. It is generally preferred that u+v is greater than or equal to 4, for example, greater than or equal to about 5 or 6. In order to achieve higher levels of ethoxylation, i.e., where u+v is greater than about 6 or 7, stage 3 with w additional moles of alkylene oxide is preferably utilized. u + v + w is generally 15 or less.

[0058] In the "N" process according to this invention, the first stage and optional third stage are similar to the two stages of the regular (the "R" process), base-catalyzed ethoxylation processes. The second stage of the "N" process according to this invention is, however, the most important, because it provides the desired peaked alkoxylation distribution.

[0059] A general comparison of the "regular" or conventional process (the "R" process) for preparing tallow amine ethoxylate having at least 8 EO and the new "N-process" of the invention for preparing same is provided below.

Table A

	Regular Process	N Process
Stage 1		
- Tallowamine, mole	1	1
- EO, moles	2	2
- Temperature, ^{0}C	160 - 180	160 - 180
- Pressure, psig	90 maximum	90 maximum
Stage 2		
- Catalyst	NaOH / KOH	None
- Catalyst concentration, %	~ 0.2	-
- EO, moles	7.0	4
- Pressure, psig	90 maximum	90 maximum
- Temperature, ^{0}C	160 - 180	90 - 130
Stage 3		
- Catalyst	-	NaOH / KOH
- Catalyst concentration, %	-	
- EO, moles	-	3
- Temperature, ^{0}C	-	160 - 180
- Pressure, psig	-	90 maximum

[0060] Since water can undergo the catalyzed reaction with ethylene oxide to yield undesired by-products, it is important that all ethoxylation stages in the "R", "S" and "N" processes are performed under the anhydrous condition. To attain this condition, drying of the starting material (alkylamine or alkyl ether amine) and the ethoxylation equipment is done by heating the material and equipment to a temperature of 100 – 150^{0}C under nitrogen purging or vacuum, until the content of the water in the starting material is less than 0.1 percent, and preferably less than 0.05 percent, of its weight.

[0061] The preferred starting alkylamines include, but are not limited to, those derived from tallow, coconut oil,

soybean oil, palm kernel oil, corn oil, and mixtures thereof. The preferred starting ether amines include, but are not limited to, decyl ether amine, undecyl ether amine, dodecyl ether amine, tridecyl ether amine, tetradecyl ether amine, hexadecyl ether amine, octadecyl ether amine and mixtures thereof. In a preferred embodiment, it is preferred that the starting amines be of the formula:

$$R\text{-}NH_2$$

wherein R is selected from a linear or branched, saturated or non-saturated alkyl group containing an average of 8 – 22 carbon atoms; for example, 12-22 carbon atoms; or 16-22 carbon atoms. Here the number of carbons is expressed as an average because amines derived from natural oils comprise a mixture of alkyl groups of somewhat varying length. It is generally preferred that the weight average value of R, R^1 or R^2 be between about C_{12} and about C_{22}. In some applications, the average value is between about C_{14} and about C_{22} or between about C_{16} and about C_{22}. In one embodiment, it is particularly preferred that the alkoxylated alkyl(ether)amines used in the formulations of the invention be derived from primary amines having a molecular weight greater than about 200. Amines wherein the alkyl substituent contains between 16 and 18 carbon atoms may be especially advantageous, e.g., tallowamines which offer significant economic and commercial advantages in applications such as herbicidal formulations.

[0062] Alkoxylated alkylamine and alkoxylated etheramine surfactants as prepared by the preferred "N" process of the invention have not only a peaked distribution of desired homologs but also relatively low concentrations of dioxane, EGDs and other byproducts that may be detrimental to the intended end use. The dioxane content after a stripping step is typically not greater than 400 ppm, more typically not greater than 300 ppm, and

still more typically not greater than 200 ppm, while the total EGDs content, including a vinyl polyethylene glycol component, is less than about 5% by weight, more typically not greater than about 4% by weight, and most typically not greater than about 3% by weight, of the resulting ethoxylated product.

[0063] To compare alkylene oxide distribution in an alkoxylated alkylamine, use of degree of peaking is helpful. The degree of peaking (Σ3) is defined as the sum of the areas for the adjacent three most prevalent peaks. The relative degrees of peaking of ethoxylates prepared according to the process of the present invention was measured and compared to their counterparts prepared via conventional base-catalyzed ethoxylation.

[0064] For degree of peaking determinations, area percent determined by gas chromatography (GC) was used. The degree of peaking is expressed as a weight percentage (%). The higher the weight percentage, the more peaked the molecular weight distribution. The formula and method for determination of molecular weight distribution can be found in Narrow Alcohol Ethoxylates, Annual Surfactants Reviews, vol. 2, Ed. D. R. Karsa (1999), and, with some modification, can be adapted for alkoxylated alkylamines.

[0065] The alkoxylated alkyl amines having peaked distribution of the present invention are further characterized in having peaked distribution defined by a degree of peaking at least 5% greater than the degree of peaking in the distribution of a conventional alkoxylated amine composition prepared via conventional base catalysis. Typically, the degree of peaking may be at least 6% greater, preferably at least 7% greater than the degree of peaking in the distribution of a conventional alkoxylated amine composition prepared via conventional base catalysis, for which the conditions are described in Table A. In

still other embodiments, the degree of peaking is at least 10% greater than that found in the distribution of conventional peaked alkoxylated amine compositions prepared via conventional base catalysis.

[0066] A normalized peaking index may be defined as PI = $(W_0/2)^{1/2}(\Sigma 3)$ wherein PI is the peaking index, $\Sigma 3$ is the sum of the weight percentages of the three most prevalent homologs, and W_0 is the weight average ratio of alkylene oxide units per molecule in the alkoxylated alkylamine or alkoxylated etheramine composition. Preferably the PI is greater than 100, more preferably greater than about 102.

[0067] The preferred alkoxylated alkylamines with peaked distribution include, but are not limited to ethoxylated tallow amine with 3 to 15 EO, ethoxylated coco amine with 3 to 15 EO, and mixtures thereof. Preferred alkoxylated alkyl ether amines with peaked distribution include, but are not limited to ethoxylated dodecyl ether amine with 3 to 15 EO, ethoxylated tridecyl ether amine with 3 to 15 EO, ethoxylated tetradecyl ether amine with 3 to 15 EO, ethoxylated hexadecyl etheramine with 3 to 15 EO, ethoxylated octadecyl etheramine with 3 to 15 EO and mixtures thereof. In the formulation of aqueous glyphosate salt concentrates, several discrete ranges of EO/amine ratio are commonly used, e.g.: (i) a surfactant having a relatively low ratio in the range of about 3 to about 6 EO/amine, most typically about 5; (ii) a surfactant having an intermediate EO/amine ratio in the range between about 8 and about 12 EO/amine, more typically about 9 to about 11, most typically about 10; and (iii) a surfactant having a relatively high EO/amine ratio in the range between about 12 and about 18 EO/amine, more typically between about 13 and about 17, most typically about 15.

[0068] Though not required, a solvent that is inert toward the reaction with ethylene oxide can also be used to

improve the handling of the starting alkylamine or the resulting ethoxylated product, or to meet the minimum initial volume of material that is required for proper mixing action with ethylene oxide as required for each ethoxylation reactor. Aromatic solvents, such as xylene, toluene, alkylbenzenes such as ethylbenzene, hexylbenzene, dodecylbenzene, alkylnaphthalenes such as methyl and dimethylnaphthalene, isopropyl- and di-isopropylnaphthalene, or commercial aromatic solvents, such as Aromatic Solvent 100, 150 or 200 available at ExxonMobil, or organic ethers, such as dibutyl ether and the like are suitable solvents for the process of this invention.

[0069] Glyphosate formulations generally require one or more adjuvants in order to boost their herbicidal efficacy. The proportion of adjuvant employed in the formulation is typically about 5% or higher, about 7% or higher, or even about 10% or higher, in order to achieve significant boosting effect. The cost associated with the use of the adjuvants in glyphosate formulations is significant. Therefore, there is an ever increasing need to find a more effective and economical adjuvant for glyphosate.

[0070] Glyphosate is an acid with a very limited solubility in water while salts of glyphosate have very high solubility in water. Therefore, glyphosate formulations usually employ salts of glyphosate. Many types of counterions have been used commercially in glyphosate products. They include isopropylammonium (IPA^+), monoethanolammonium (MEA^+), diethanolammonium (DEA^+), triethanolammonium (TEA^+), sodium, trimethylsulfonium (TMS^+), potassium (K^+), and ammonium (NH_4^+). Potassium glyphosate is a preferred glyphosate salt employable in the context of the invention.

[0071] For liquid aqueous glyphosate concentrates, glyphosate loading is preferably 360 g ae/l or higher. It is known to those skilled in the art that many biologically useful surfactants cannot be reliably incorporated into glyphosate formulations at glyphosate, a.e., concentrations greater than 360 g/L without risk of phase separation at elevated temperatures. For such aqueous concentrates, therefore, an objective is to select a highly efficacious surfactant that can be used at relatively low concentration in glyphosate formulations to improve significantly the herbicidal efficacy of glyphosate. It is particularly preferred to identify and select a surfactant that can be formulated into stable glyphosate formulations including potassium and ammonium salts of glyphosate, at 470 - 600 g ae/l.

[0072] The present invention meets such objective in providing glyphosate formulations having favorable and/or improved stability and herbicidal efficacy comprising, as an adjuvant, at least one peaked distribution alkoxylated alkylamine surfactant. The aforementioned adjuvant can be employed at low concentration and is stable in various salts of glyphosate even at very high glyphosate concentration.

[0073] It is generally preferred that the total number of moles (2x + y + y' + z + z') of alkylene oxide used for the alkoxylation of the alkyl (or alkylether) amine varies from 3-25, from 3-20, or from 3 - 15; typically from 3-12, in many instances from 3-9.

[0074] Preferred examples of ethoxylated alkylamines according to the invention are ethoxylated versions based on cocoamine, tallow amine, soya amine, oleyl amine, palm amine and mixtures thereof.

[0075] In various exemplary embodiments, the ethoxylated amine of the invention is selected from the

group consisting essentially of ethoxylated tallowamine, ethoxylated cocoamine, ethoxylated alkyletheramine such as tridecyletheramine, each having from 3 to 15 moles of EO, and mixtures thereof.

[0076] A typical stable liquid glyphosate formulation according to the invention has a concentration of glyphosate in the range of 360 – 600 g ae/l, preferably 450 – 580 g ae/l, and the ratio of glyphosate (wt% ae) to the ethoxylated alkylamine surfactant with peaked distribution is between 2:1 to 25:1. Typically, ratio of glyphosate (wt% ae) to the ethoxylated alkylamine surfactant with peaked distribution is between 2.5:1 to 20:1, more typically between 3:1 to 15:1.

[0077] The ethoxylated alkylamine with peaked distribution of the invention is exemplified by having an enhanced cloud point of about 8 degrees in 54.8% K-glyphosate formulation with 10% peaked cocoamine-5EO surfactant when compared to the regular cocoamine-5EO having the same carbon chain length and average EO chain length prepared via conventional base catalysis.

[0078] The present invention encompasses not merely formulations of glyphosate, but also relates to other herbicidal compositions comprising at least one herbicidal active, and at least one surfactant, wherein said at least one surfactant comprises the alkoxylated alkylamine and/or alkylether amine with peaked distribution of the invention. A herbicidal composition according to the invention can optionally comprise other additives such as ammonium sulfate, potassium sulfate, potassium chloride, sodium sulfate, urea, glycols, or mixtures thereof. A contemplated composition can optionally include a synergist, quick-burn additive, humectant, co-herbicide, dye, pigment, corrosion inhibitor, thickener, dispersing agent, calcium sequestrant, defoamer, antifreeze, pour-

point depressant, process aids, or mixture thereof. Combinations of glyphosate salts and co-herbicide salts are specifically contemplated by the present invention. Preferably, additives used in glyphosate compositions of the present invention possess sufficient solubility or dispersibility in a concentrated aqueous potassium glyphosate solution at a pH of from about 4 to about 7 to allow desired concentrations to be attained.

[0079] Where a co-herbicide is included in the formulation, it is preferred that the co-herbicide be water-soluble, and more preferred that it be included in the form of an ammonium or potassium salt. Examples of suitable co-herbicides are the ammonium salts of acifluorfen, asulam, benazolin, bentazon, bialaphos, bromacil, bromoxynil, chloramben, clopyralid, 2,4-D, 2,4-DB, pelargonic acid, dalapon, dicamba, dichlorprop, diclofop, endothall, fenac, fenoxaprop, flamprop, fluazifop, fluoroglycofen, fomesafen, fosamine, glufosinate, haloxyfop, imazameth, imazamethabenz, imazamox, imazapyr, imazaquin, imazethapyr, ioxynil, MCPA, MCPB, mecoprop, methylarsonic acid, naptalam, nonanoic acid, picloram, sulfamic acid, 2,3,6-TBA, TCA and triclopyr. A preferred co-herbicide is the salt of glufosinate.

[0080] Formulations of the present invention may be generally prepared by mixing the glyphosate salt solution, prepared as outlined above, together with other ingredients in a suitable mixing vessel with agitation, such as a blender.

[0081] A typical aqueous concentrate according to the invention contains glyphosate acid equivalent in the range of from 30 to 45%, and from about 1.2 to about 22.5% surfactant. For application to a field in control of weeds, a typical formulation according to the invention

contains glyphosate acid equivalent in the range of from about 0.1 to 18 wt.%, typically 0.1 to 5 wt.%, more typically 0.2 to 3 wt.%, most commonly 0.5 to 2 wt.%. However, stronger mixtures, e.g., in the range from about 2 to about 15 wt.% surfactant may be desirable for some applications.

[0082] This invention also relates to a herbicidal method of using a contemplated composition in an amount effective to kill or control unwanted vegetation by diluting the composition in water and applying the diluted composition to foliage of the vegetation to be killed or controlled.

[0083] The glyphosate formulation of the invention should be applied to plant foliage at an application rate sufficient to give the desired effect. Application rates are usually expressed as amount of glyphosate a.e. per unit area of land treated, e.g. grams a.e. per hectare (g a.e./ha). What constitutes a "desired effect" varies according to the standards and practice of those who investigate, develop, market and use glyphosate products. For example, the amount of glyphosate a.e. applied per unit area to give, consistently and reliably, at least 85% control of a plant species as measured by growth reduction or mortality is often used to define a commercially effective rate.

[0084] Preferred compositions of the invention provide enhanced herbicidal efficacy by comparison with commercial standard formulations of glyphosate "Herbicidal efficacy," as used herein, refers to any observable measure of control of plant growth, which can include one or more of the actions of (1) killing, (2) inhibiting growth, reproduction or proliferation, and (3) removing, destroying, or otherwise diminishing the occurrence and activity of plants.

[0085] The selection of application rates that are biologically effective for a specific glyphosate formulation, such as a formulation of the present invention, is within the skill of the ordinary agricultural scientist. Those of skill in the art will likewise recognize that individual plant conditions, weather and growing conditions, as well as the specific formulation selected, will influence the degree of biological effectiveness achieved in practicing this invention. Useful application rates can therefore depend upon all of the above conditions. Much information is known about appropriate application rates for glyphosate formulations in general. Over two decades of glyphosate use and published studies relating to such use have provided abundant information from which a weed control practitioner can select glyphosate application rates that are herbicidally effective on particular species at particular growth stages in particular environmental conditions.

[0086] Various application methods may be employed including broadcast spraying, directed spraying or wiping the foliage with a diluted composition of this invention. Depending on the degree of control desired, the age and species of the plants, weather conditions and other factors, typically the glyphosate application rate is a herbicidally effective amount of about 0.1 to about 10 kg a.e./ha and preferably from about 0.25 to about 2.5 kg a.e./ha, although greater or lesser amounts may be applied.

[0087] The alkoxylated alkylamine with peaked distribution of the invention is preferably selected so that an aqueous concentrate containing K- glyphosate wt% a.i. of 54.8 ("wt% a.i." means weight percent active ingredient, in this case K glyphosate) and the peaked distribution alkoxylated alkylamine at a concentration of 10 wt% exhibits a cloud point greater than about 66°C.

More particularly, in a potassium glyphosate concentrate of such composition, a formulation containing 10 wt% of a peaked distribution cocoamine 5EO surfactant has a cloud point approximately 8°C higher than the otherwise identical formulation containing 10 wt% of a conventional cocoamine 5EO surfactant made by conventional base catalysis. Other otherwise identical K glyphosate solutions containing conventional alkoxylated alkylamine surfactants typically possess a cloud point of room temperature, or slightly above room temperature.

[0088] A typical stable liquid glyphosate formulation according to the invention has a concentration of glyphosate in the range of 360 – 600 g ae/l, preferably 450 – 580 g ae/l, and the ratio of glyphosate (wt% ae) to the ethoxylated alkylamine surfactant with peaked distribution is between 2:1 to 25:1. Typically, ratio of glyphosate (wt% ae) to the ethoxylated alkylamine surfactant with peaked distribution is between 2.5:1 to 20:1, more typically between 3:1 to 15:1. In exemplary embodiments of such formulations, the ratio of glyphosate (wt% ae) to the alkoxylated amine surfactant with peaked distribution may be between 3.5:1 to 8:1, or in particular instances between 4:1 to 6:1.

[0089] Although it is an important objective of the invention to provide surfactants suitable for producing stable high load aqueous liquid concentrates comprising potassium and ammonium glyphosate, it will be understood that the surfactants of the invention can also be used in solid glyphosate acid and glyphosate salt formulations. Ammonium and diammonium glyphosate, in particular are often supplied in dry, solid granular form. Dry formulations comprising sodium salts of glyphosate and or comprising glyphosate acid are also known. In this context, it will be understood that the term "stable" applies in the sense

that formulations comprising the surfactants of the invention are formulated so as to avoid excessive stickiness and/or syneresis.

[0090] The present inventors have established that superior properties are exhibited by the surfactants prepared by the novel processes described herein, and in particular that surfactants of the invention are distinguished by the distinctly higher cloud points compared to the cloud points exhibited by exemplary aqueous glyphosate salt concentrates which contain these surfactants. Thus, for example, the surfactants of the invention may be characterized by reference to an aqueous concentrate containing potassium glyphosate salt in a concentration of 54.8 wt.% of the active ingredient salt ("a.i."). Such formulation containing an alkoxylated alkylamine or alkoxylated etheramine of the invention has a cloud point at least 3°C higher, preferably at least 5°C higher, and in another embodiment at least 7°C higher than that of substantially similar glyphosate formulations containing conventional non-peaked ethoxylated alkylamines having the same distribution of carbon-chain length, and the same average EO chain length, prepared by conventional base catalysis, which is hereinafter defined as catalysis according to the conditions described in Table A, as the surfactant component.

[0091] Additionally, where alkoxylation is conducted in the substantial absence of catalyst until the average extent of substitution, i.e., the weight average value of the sum of (2x + y + y' + z + z') sometimes referred to herein as "W_0," has reached a value of 4, 5, 6, 7, 8 or 9, the surfactants of the invention contain relatively lower amounts of dioxane and EGDs including, but not limited to, vinyl polyethylene glycols.

[0092] It has been established that superior properties are exhibited by the surfactants prepared by the novel processes described herein, and in particular that surfactants of the invention are distinguished by the distinctly higher cloud points that are exhibited by exemplary aqueous glyphosate salt concentrates which contain these surfactants. Thus, for example, the surfactants of the invention may be characterized by comparison of the cloud points exhibited by a pair of reference aqueous concentrates, each consisting of potassium glyphosate salt in a concentration of 540 g/L, a.e., 5.5 wt.% alkoxylated alkyl(ether)amine surfactant having ≥3 EO groups, and 4.5 wt.% bis(2-hydroxyethyl)cocoamine. A first such reference formulation containing an adjuvant surfactant of the invention exhibits a cloud point at least about 3°C higher than the cloud point of a second reference formulation of identical composition but containing 5.5 wt.% of a reference surfactant rather than the adjuvant surfactant of the invention. For purposes of this comparison, the surfactant of the invention and the reference surfactant are each derived from a primary amine having a molecular weight of at least 200 (thus have the same distribution of carbon chain length), and have the same value of W_0 as defined herein. The reference surfactant is prepared by an NaOH-catalyzed reaction of the amine with alkylene oxide conducted under conventional conditions described hereinbelow.

[0093] Additionally, where alkoxylation is conducted in the substantial absence of catalyst until the average extent of substitution, i.e., the number average value of the sum of (2x + y + y' + z + z') sometimes referred to herein as "N_0" or "W_0," has reached a value of 4, 5, 6, 7, 8 or 9, the surfactants of the invention preserves a

relatively low concentration of dioxane, vinyl PEGs, and other EGDs.

[0094] It has further been observed that the frequency distribution of homologs in the surfactants of the invention typically differs in various ways from the frequency distribution for the homologs of the conventional alkoxylated alkylamine and alkoxylated etheramine surfactants of commerce. For example, in most instances, the degree of peaking is higher in the surfactants of the invention. The degree of peaking is defined as the sum of the number percentages of the three most prevalent homologs. For the surfactants of the invention, this sum, sometimes referred to herein as "Σ3," is in most instances higher by an increment of at least about 2 wt.%, more typically at least about 3%, often at least about 4 wt.%, 5 wt.%, or 6 wt.%, basis the entire surfactant, than the Σ3 value for a reference mixture of homologs having the same value of W_0, the same frequency distribution with regard to the number of carbon atoms in the substituent R, and the same identity of X, Y and Z as the surfactant of the invention. It has further been noted that the ratio of the degree of peaking for the surfactants of the invention to the corresponding reference mixture is typically at least about 1.05, more typically at least about 1.07 or 1.08, and in a majority of cases at least about 1.10. For purposes of this comparison, the reference mixture is an alkoxylated alkylamine or etheramine characteristic of the prior product of commerce, and is prepared by NaOH-catalyzed reaction of RNH_2 with alkylene oxide conducted entirely under autogenous pressure up to 90 psig at a temperature of 160° to 180°C and an NaOH concentration of 0.2 wt. %. It will be understood that, while not all commercial surfactants are necessarily prepared under the exact conditions here specified for the "reference mixture," a

surfactant of the invention which has a degree of peaking at least about 3 wt.% higher (or even 2 wt.% higher) than this reference composition will in at least most instances also have a degree of peaking higher than known commercially available alkoxylated amine surfactants which have the same values of W_0 and $\Sigma 3$ as the inventive and reference surfactants, the same frequency distribution with regard to the number of carbon atoms in the substituent R, and the same identify of X, Y and Z.

[0095] The degree of peaking varies with value of W_0, generally inversely therewith. For purposes of comparison, the degree of peaking may be normalized across a range of values for W_0 by definition of a "peaking index," computed by multiplying $\Sigma 3$ by a function of W_0. For example a peaking index may conveniently be defined as $(W_0/2)^{1/2}(\Sigma 3)$. As so defined, the peaking index for the surfactant of the invention is typically greater than the peaking index for the corresponding reference mixture by an increment of at least about 3, more typically at least about 5, 6, or 8%. The ratio of the peaking index for the surfactants of the invention to the peaking index for the corresponding reference surfactants is typically at least about 1.05, more typically at least about 1.07 or 1.08, and in most instances at least about 1.10.

[0096] However, it has further been observed that the homolog frequency distribution pattern varies somewhat among the surfactants of the invention, as it also does among the surfactants of the commerce. In a limited number of instances, analyses of the surfactants of the invention have indicated a degree of peaking and peaking index that have appeared to be actually lower than those of the comparative reference mixture, yet the novel surfactants still exhibit superior properties with respect to the cloud point of glyphosate salt concentrates. It is possible that

these aberrant results have been attributable to analytical error, but also possible that they accurately reflect the samples analyzed.

[0097] Even though not all surfactants of the invention are necessarily distinguished from the corresponding reference mixture or product of commerce by the degree of peaking or the peaking index, the homolog distribution for the surfactants of the invention also typically differs from the distribution for conventional alkoxylated surfactants of the prior art with respect to certain other characteristics. Among these are what may referred to as the "tailing index" and the "tilt ratio." With regard to stability of aqueous glyphosate salt concentrates, especially potassium or ammonium salt concentrates, it is generally preferred that a surfactant of given value for W_0 have a relatively low concentration of homologs whose degree of substitution, i.e., the value of (2x + y+ y' + z +z'), is significantly greater than W_0. Generally it is preferred that there not be a significant fraction of homologs whose number % prevalence (W_i) exceeds 1.5(W_0). For this purpose a tailing index may be defined as either β_1, β_2, β_3, β_{12}, or β_{23} where:

β_1 is the sum of the number percentages of homologs W_i from i = k to infinity where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$;

β_2 is the sum of the number percentages of homologs W_i from i = k+1 to infinity;

β_3 is the sum of the number percentages of homologs W_i from k +2 to infinity;

$\beta_{12} = \beta_2 + [(k+1) - W_0]W_k$;

$\beta_{23} = \beta_3 + [(k+1) - W_0]W_{k+1}$; and

k is an integer such $(W_0 - 1) < k \leq (W_0) < (k+1)$.

[0098] Related to the tailing index is a parameter that may be defined as the tilt ratio, a quotient of the sum of proportions of homologs having relatively low values of (2 x + y+ y' + z +z') over the sum of proportions of homologs having relatively high values for (2 x + y+ y' + z +z'). For example, an overlapping tilt ratio may be defined as α_{23}/β_{12} or α_{23}/β_{23} where:

α_2 is the sum of the number percentages of homologs W_i from i = 2 to k

$\alpha_{23} = \alpha_2 + (W_0 - k)W_{k+1}$

and β_1, β_2, β_{12}, and β_{23} are defined above.

[0099] According to a first classification of peaked distribution surfactants, it is preferred that the value of the degree of peaking (Σ3) of the mixture of homologs is at least about 0.34, and/or the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of the mixture is at least about 0.75, and/or the tilt ratio α_2/β_1 of the mixture is at least about 0.22, and/or the tilt ratio α_{23}/β_{12} of the mixture is at least about 0.38, and/or the tilt ratio α_{23}/β_{23} of the mixture of homologs is at least about 0.45, and/or the value of α_1 for the mixture is at least about 0.10, and/or the value of α_2 for the mixture is at least about 0.15, and/or the value of α_3 for the mixture of homologs is at least about 0.25, and/or the value of α_{23} for the mixture of homologs is at least about 0.23, where:

W_0 is the number average value of (2x + y + y' + z + z') in each of the mixtures of homologs, and

k is an integer such that $(W_o - 1) < k \leq W_o < (k + 1)$;

Σ3 = the sum in each mixture of the number percentages of the three most prevalent homologs contained therein,

α_1 is the sum of the number percentages of homologs W_i from i = 2 to (k-1) where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_2 is the sum of the number percentages of homologs W_i from i = 2 to k where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_3 is the sum of the number percentages of homologs W_i from i = 2 to (k+1) where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

β_1 is the sum of the number percentages of homologs W_i from i = k to infinity;

β_2 is the sum of the number percentages of homologs W_i from i = k+1 to infinity;

β_3 is the sum of the number percentages of homologs W_i from k +2 to infinity;

$\alpha_{23} = \alpha_2 + (W_0 - k)W_{k+1}$;

$\beta_{12} = \beta_2 + [(k+1) - W_0]W_k$; and

$\beta_{23} = \beta_3 + [(k+1) - W_0]W_{k+1}$.

When R is not of Formula III or Formula V, the value of W_0 in the mixtures of homologs of the surfactant is at least 3.5 and/or the vinyl polyethylene glycol content is typically not greater than about 4 wt.%, not greater than about 2 wt.%, or not greater than about 0.2 wt.%. Typically in accordance with such embodiments, the total EDGs content is not greater than about 5 wt.%, not greater than about 4 wt.%, or not greater than about 3 wt.%.

[00100] Preferably, the degree of peaking is at least about 0.34 and/or the peaking index is at least about 0.75. Still more preferably, the degree of peaking is at least about 0.34 and the peaking index is at least about 0.75 and the tilt ratio α_2/β_1 of the mixture is at least about 0.22. Alternatively or additionally, it is preferred that the value of α_1 for the mixture of homologs is at least about 0.10, at least about 0.12, more preferably at least about 0.15. In additional or other preferred embodiments, the

value of α_2 for the mixture is at least about 0.15, at least about 0.17, more preferably at least about 0.21. Similarly it is preferred that the value of α_3 for the mixture of homologs is at least about 0.25, more preferably at least about 0.30. Also, it may be preferred that the value of α_{23} for the mixture of homologs is at least about 0.23, more preferably at least about 0.25, still more preferably at least about 0.27. It may also be preferred that the tilt ratio α_{23}/β_{23} is at least about 0.38 and/or the tilt ratio α_{23}/β_{12} is at least about 0.12.

[00101] It may further be preferred that the homolog distribution meet certain further combinations of distributional values. For example, it is preferred that the value of α_1 is at least about 0.10 and the value of α_2 is at least about 0.15; and/or that the value of α_1 is at least about 0.10 and the value of α_3 is at least about 0.25; and/or that the value of α_1 is at least about 0.10 and the value of α_{23} is at least about 0.23; and/or that the value of α_2 is at least about 0.15 and the value of α_3 is at least about 0.25; and/or that the value of α_2 is at least about 0.15 and the value of α_{23} is at least about 0.23; and/or that the value of α_3 is at least about 0.25 and the value of α_{23} is at least about 0.23. It is further preferred that the mixture be characterized by satisfying all four, or at least three of the above preferred minimum values for α_1, α_2, α_3, α_{23}, i.e., embodying in the latter instances the following combinations:

alpha value/ combination	I	II	III	IV
$\alpha_1 \geq 0.10$	X	X	X	
$\alpha_2 \geq 0.15$	X	X		X
$\alpha_3 \geq 0.25$	X		X	X
$\alpha_{23} \geq 0.23$		X	X	X

[00102] A second classification of peaked distribution surfactants may be characterized by a combination of minimum values for a combination of at least five of the distributional parameters, e.g., a combination which includes the degree of peaking, Σ3, the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$, the tilt ratio α_2/β_1, the tilt ratio α_{23}/β_{12}, and the tilt ratio α_{23}/β_{23}. In this class of surfactants, the scope of which overlaps the classes defined above, the degree of peaking (Σ3) of the mixture of homologs is at least about 0.28 and the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of the mixture is at least about 0.62 and the tilt ratio α_2/β_1 of the mixture is at least about 0.16 and the tilt ratio α_{23}/β_{12} of the mixture is at least about 0.29 and the tilt ratio α_{23}/β_{23} of the mixture is at least about 0.34. It will be appreciated that this second classification of surfactants as defined by this combination of parameters extends beyond but overlaps the first classification as defined above. In surfactants within this second classification, the degree of peaking, Σ3, is preferably at least about 0.30, more preferably at least about 0.32, the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ is preferably at least about 0.65, more preferably at least about 0.68 and still more preferably at least about 0.72, and the tilt ratio α_2/β_1 is preferably at least about 0.16, at least about 0.18, more preferably at least about 0.20.

[00103] Typically in accordance with one or more of the foregoing embodiments, the tilt ratio α_{23}/β_{23} is between about 0.34 and about 1.42, between about 0.34 and about 1.30, between about 0.34 and about 1.20, between about 0.34 and about 1.10, or between about 0.34 and about 1.

[00104] Further in accordance with one or more of the foregoing embodiments the tilt ratio α_2/β_1 of the mixture is less than about 10, less than about 8, or less than about 6, and/or the tilt ratio α_{23}/β_{12} of the mixture is less than

about 12, less than about 10, or less than about 8, and/or the tilt ratio α_{23}/β_{23} of the mixture of homologs is less than about 15, less than about 12, or less than about 9, and/or the value of α_1 for the mixture is less than about 2, less than about 1.5, or less than about 1, and/or the value of α_2, α_3, and/or α_{23} for the mixture is less than about 2.5, less than about 2, or less than about 1.5.

[00105] Surfactants of the present invention may also be defined by various other combinations of one or more of the peaking parameters detailed herein. But it should be understood that the present invention encompasses any of a variety of combinations and permutations of the peaking parameters detailed herein. In particular, surfactants of the present invention may be defined by the combinations of peaking parameters set forth in the appended claims, and those included in the claims of U.S. Serial No. 60/743,715, the entire contents of which are herein incorporated by reference for all relevant purposes.

[00106] In particular, the surfactants may be defined by a the degree of peaking of at least about 0.34; and/or a peaking index of at least about 0.75; a tilt ratio α_2/β_1 of at least about 0.22; and/or a tilt ratio α_{23}/β_{12} of at least about 0.38; and/or a tilt ratio α_{23}/β_{23} of at least about 0.45 or between about 0.45 and 1.42; and/or a value of α_1 of at least about 0.10; and/or a value of α_2 of at least about 0.15; and/or a value of α_3 of at least about 0.25; and/or a value of α_{23} of at least about 0.23. The surfactants of the present invention may also be defined by these peaking parameters, but in alternative embodiments in which the tilt ratio α_{23}/β_{23} is between about 0.34 and about 1.30, between about 0.34 and about 1.20, between about 0.34 and about 1.10, or between about 0.34 and about 1.

[00107] By way of further example, surfactants of the present invention may be characterized by a degree of

peaking (Σ3) of at least 0.75, at least about 0.85, or at least about 0.95; and/or a peaking index, $(W_0/2)^{1/2}(\Sigma 3)$, of at least 1.10, at least about 1.25, or at least about 1.40; a tilt ratio α_2/β_1 of at least 1.15, at least about 1.25, or at least about 1.35; and/or a tilt ratio α_{23}/β_{12} of at least 1.25, at least about 1.35, or at least about 1.45; and/or a tilt ratio α_{23}/β_{23} of at least 2.25, at least about 2.35, or at least about 2.45; and/or a value α_1 of at least 0.41, at least about 0.55, or at least about 0.70; and/or a value α_2 for said mixture of homologs of at least 0.67, at least about 0.75, or at least about 0.90; and/or a value α_3 for said mixture of homologs of at least 0.83, at least about 0.95, or at least about 1.10; and/or a value α_{23} for said mixture of homologs is at least 0.70, at least about 0.75, or at least about 0.90.

[00108] By way of still further example, surfactants of the present invention may be characterized by a degree of peaking (Σ3) of less than 0.42, or less than about 0.38; and/or a peaking index, $(W_0/2)^{1/2}(\Sigma 3)$, of less than 0.84, or less than about 0.80; and/or a tilt ratio α_2/β_1 of less than 0.62, less than about 0.50, or less than about 0.40; and/or a tilt ratio α_{23}/β_{12} of less than 0.96, less than about 0.80, or less than about 0.65; and/or a tilt ratio α_{23}/β_{23} of less than 1.33, less than about 1.0, or less than about 0.75; and/or a value α_1 of less than 0.22, less than about 0.18, or less than about 0.14; and/or a value α_2 of less than 0.45, less than about 0.35, or less than about 0.25; and/or a value of α_3 of less than 0.60, less than about 0.45, or less than about 0.30; and/or a value α_{23} of less than 0.57, less than about 0.45, or less than about 0.35.

[00109] Within both the first classification and the second classification of peaked homolog distribution alkoxylated alkyl(ether)amine surfactants as described above, and various other of the above-described

surfactants, a highly advantageous subclass comprises those surfactants in which the value of k is 7 or greater. These relatively highly substituted alkoxylated alkyl(ether)amines contribute significantly to the efficacy of the glyphosate formulations obtained on dilution of the concentrate. However, conventional distribution alkoxylated alkyl(ether)amine surfactants wherein $k \geq 7$ tend to be relatively incompatible with glyphosate salts, especially with potassium salts. As a consequence, relatively high proportions of bis(hydroxyalkyl)cocoamines ("2EO cocoamine") are typically included in the formulations in order to avoid phase separation and impart satisfactory cloud points. In accordance with the invention, it has been found that the peaked distribution surfactants of the invention are generally of improved compatibility with glyphosate salts, even at high glyphosate, a.e., loadings, e.g., greater than or equal to 360 gpl, 400 gpl, 450 gpl, 480 gpl, 500 gpl, 540 gpl or even 600 gpl, and that favorable compatibility is preserved even for surfactants wherein $k \geq 1$. Moreover, such compatibility is realized without excessive use of the 2EO cocoamine which is of limited herbicidal value and derived from coconut oil which is relatively expensive. Advantage can be taken of this property in a variety of ways, e.g., by either: (i) increasing glyphosate loading at constant or enhanced surfactant to glyphosate ratio and/or peaked distribution surfactant to 2 EO cocoamine ratio; (ii) increasing peaked distribution surfactant to 2EO cocoamine ratio at constant or enhanced glyphosate to surfactant ratio and/or glyphosate loading; (iii) increasing surfactant to glyphosate ratio at constant or enhanced peaked distribution surfactant to 2EO cocoamine ratio and/or glyphosate loading. Moreover, the peaked distribution surfactant can be a peaked distribution

alkoxylated tallowamine, e.g., a ≥7EO tallowamine. Preferably, the peaked distribution surfactant is 8-10 EO tallowamine. Tallowamine is derived from tallow, which is widely available and relatively inexpensive.

[00110] Generally, the tilt ratio α_{23}/β_{23} differs from the same ratio for the corresponding reference mixture by an increment of at least about + 0.08, more typically at least about +0.10, and in most instances at least about 0.15. The ratio of the tilt ratio for the surfactant of the invention to the tilt ratio for the reference mixture is ordinarily at least about 1.05, more typically at least about 1.0, and in a majority of cases 1.15.

[00111] In certain embodiments, α_{23}/β_{23} may preferably be greater than about 1.42. The tilt ratio may also vary with the value of W_0, so that: in certain instances where W_0 is between 3 and 4.5, the tilt ratio α_{23}/β_{23} is at least about 1.90; where W_0 is between 4.5 and 5.5, the tilt ratio α_{23}/β_{23} is at least about 1.85; where W_0 is between 5.5 and 6.5, the tilt ratio α_{23}/β_{23} is at least about 1.75; where W_0 is between 6.5 and 8.5, the tilt ratio α_{23}/β_{23} is at least about 1.40; where W_0 is above 8.5, the tilt ratio α_{23}/β_{23} is at least about 1.42. Other empirical functions may provide alternative definitions of tailing index, tilt ratio and peaking index.

[00112] In accordance with the foregoing discussion regarding peaking of the present surfactants, in various embodiments of the present invention, the peaked distribution alkoxylated alkyl(ether)amine is an alkoxylated tallowamine, but is not 9EO or 10EO tallowamine. Further in accordance with these and other embodiments, the peaked distribution alkoxylated alkyl(ether)amine is 8EO tallowamine.

[00113] Because the peaking indices, tailing indices and tilt ratios reflect empirical observations of the

surfactants of the invention vs. the comparative reference mixtures that are indicative of the alkoxylated alkylamines and etheramines of commerce, it will be understood that there are variations from specimen to specimen whereby the range of values for the novel surfactants and the range of values for the reference mixtures and commercial surfactants can at least potentially be found to overlap with regard to at least one of these indices and perhaps in some instances with all of them. At the time of this application, that matter has not been fully explored. Thus, it is important to understand that the fundamental differences between the surfactants of the invention and those of the prior art is found in their respective effect on the cloud points of aqueous glyphosate salt concentrates, especially those comprising potassium and ammonium salts; and, of course, in the processes by which they are respectively prepared. In preferred embodiments, the surfactants of the invention also differ from prior art surfactants prepared by Lewis acid catalysis with respect to the concentration of dioxane, vinyl PEG and other EGDs.

[00114] Nevertheless, it is believed that, in general, the surfactants of the invention differ from the reference mixtures, and therefore from the prior art commercial surfactants, with respect to at least one of the parameters discussed above, i.e., the degree of peaking, the peaking index, the tailing index, and/or the tilt ratio, or by some combination thereof; at that these parameters have value in helping to characterize the surfactants of the invention.

[00115] The peaked distribution surfactants detailed herein are generally more highly substituted than the other surfactants (e.g., 2EO cocoamine) included in the formulation. These other surfactants generally exhibit conventional peak distribution and are generally referred to herein, including the appended claims, as unsubstituted

primary alkyl(ether)amines and/or primary alkyl(ether)amines N-substituted with, for example, up to 5 alkylene oxide units. In view of their favorable compatibility with aqueous solutions of glyphosate, these unsubstituted or N-substituted primary alkyl(ether)amines are typically referred to as solubilizing surfactants.

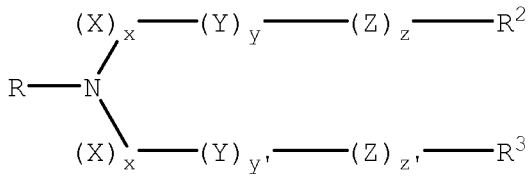
[00116] Incorporation of an unsubstituted or N-substituted primary alkyl(ether)amine (e.g., a bis(hydroxyalkyl) cocoamine) along with a relatively highly substituted (i.e., second and/or longer chain) peaked distribution polyalkoxylated alkyl(ether)amine surfactant into the formulation generally allows for stable glyphosate formulations at glyphosate loadings of at least about 180 g/l a.e., at least about 220 g/l a.e., at least about 240 g/l a.e., at least about 300 g/l a.e., at least about 360 g/l a.e., at least about 480 g/l a.e., at least about 540 g/l a.e., or at least about 600 g/l a.e.

[00117] As detailed elsewhere herein, glyphosate is typically formulated and applied as a water-soluble salt, including potassium and IPA salts. In various formulations containing an unsubstituted or N-substituted primary alkyl(ether)amine (e.g., a bis(hydroxyethyl)alkylamine) and a second peaked alkoxylated alkyl(ether) amine surfactant, the potassium salt is preferred while in others IPA salts are preferred. In further such preferred embodiments, the formulation comprises a mixture of potassium and IPA salts including, for example, a mixture of potassium and IPA glyphosate salts in a molar ratio of between about 90:10 and about 10:90, between about 80:20 and about 20:80, between about 70:30 and about 30:70, or between about 60:40 and about 40:60. In addition, formulations may be prepared that contain an unsubstituted or N-substituted primary alkyl(ether)amine, a second peaked alkoxylated

alkyl(ether)amine surfactant, and ammonium glyphosate, diammonium glyphosate, or sodium glyphosate.

[00118] Typically, the concentration of the sum of all alkoxylated alkyl(ether) amine components of the formulation is at least about 5% by weight and the weight ratio of glyphosate, a.e., to the total of alkoxylated alkyl(ether)amine surfactants is between about 2:1 and about 25:1.

[00119] Peaked distribution alkoxylated alkyl(ether)amines prepared in accordance with the present invention are typically characterized by a degree of peaking that is at least 5% higher than that of conventional alkoxylated alkyl(ether) amines having the same carbon-chain length and average alkylene oxide chain length prepared via conventional base-catalyzed ethoxylation. Typically, the peaked distribution polyalkoxylated alkyl(ether)amine corresponds to the following formula (I):



(I)

wherein X, Y and Z are alkylene oxide groups containing 2 - 3 carbon atoms, x is one, each of y, y', z and z' is an integer independently varying from 0 – 20, the sum of (y + y' + z + z') ≥ 1 or 4, each of R^2 and R^3 is independently selected from the group consisting of hydrogen, methyl and ethyl, and R is selected from a linear or branched, saturated or non-saturated alkyl group containing 12 - 22 carbon atoms and derived from a primary amine having a

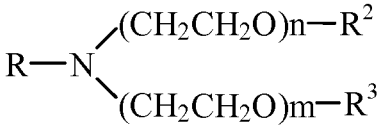
molecular weight of at least 200, and a group of the formula:

$$R^1-O-(A)_a-(B)_b--(C)_c-$$

Formula III

where R^1 is a linear or branched, saturated or non-saturated alkyl group containing 8 - 22 or 12 - 22 carbon atoms, each of A and B is an alkylene oxide group, and C is alkylene group containing 2-4 or 2- 3 carbon atoms, a and b each varies from 0 – 5, and c is 1. In various embodiments, the substituent R of Formula (I) is derived from tallow thereby providing a polyethoxylated tallowamine.

[00120] In various preferred embodiments, the peaked distribution polyethoxylated alkyl(ether)amine corresponds to formula (III)



(III)

wherein R is selected from a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms, or a group of the formula:

R'– O – (A)x – (B)y – (C)z – ,

wherein A and B are polyalkylene oxide groups, C is methylene group, R' is a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms, x, y and z vary from 0 to 5, each of n and m varies from 1 – 15, the sum of n and m is at least about 6, and each of R^2 and R^3 is independently selected from H, methyl or ethyl. In various embodiments, the substituent R of formula (III)

is derived from tallow thereby providing a polyethoxylated tallowamine.

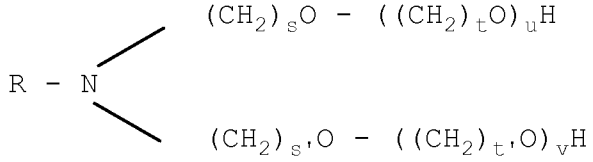
[00121] Generally, the total proportion of peaked distribution polyalkoxylated alkyl(ether)amine surfactant in the formulation is at least about 3 wt.%, typically from about 3 wt.% to about 10 wt.%. In various embodiments, the formulation comprises a mixture or, blend, of peaked distribution polyalkoxylated alkyl(ether)amines.

[00122] Typically, the peaked distribution (i.e., second or longer chain) polyalkoxylated alkyl(ether)amine contains an average total of at least about 6 alkylene oxide units per molecule. Generally, the total proportion of peaked distribution polyalkoxylated alkyl(ether)amine substituted with a total of at least about 6 alkylene oxide units is at least about 3 wt.% and preferably between about 3 wt.% and about 10 wt.% polyalkoxylated alkyl(ether)amine substituted with a total of at least about 6 alkylene oxide units.

[00123] As detailed elsewhere herein, peaked distribution alkoxylated amine surfactants may be prepared by the N process that provides advantages over the R process in that it provides greater control over the degree of alkylene oxide substitution while requiring less catalyst and provides advantages over the S process in that it provides greater control over the degree of alkylene oxide substitution while utilizing a conventional base catalyst rather than a Lewis acid catalyst that typically results in formation of undesired by-products including, for example, various EGDs, including vinyl polyethylene glycols. Typically, peaked distribution alkoxylated alkyl(ether)amines prepared in this manner may contain and be utilized to prepare glyphosate formulations containing less than about 5 wt.% EGDs, less than about 4 wt.% EGDs, or less than about 3 wt.% EGDs. Additionally or

alternatively, peaked distribution alkoxylated alkyl(ether)amines prepared in this manner may contain and be utilized to prepare glyphosate formulations containing less than about 4 wt.% vinyl polyethylene glycols, less than about 2 wt.% vinyl polyethylene glycols, or less than about 0.2 wt.% vinyl polyethylene glycols.

[00124] As noted herein, unsubstituted primary alkyl(ether)amines including, for example, unsubstituted primary alkyl(ether)amines derived from cocoamine may be incorporated into formulations of the present invention along with a peaked surfactant. Further in accordance with the present invention, a primary alkyl(ether)amine N-substituted with up to 5 alkylene oxide (e.g., ethylene oxide) may be incorporated into formulations along with a peaked surfactant. In various preferred embodiments, the N-substituted primary alkyl(ether)amine corresponds to formula (V)



(V)

wherein s, s', t, and t' are each independently from 2 to 4, the sum of u and v is from 0 to 3, and R is a linear or branched, saturated or non-saturated alkyl group containing 8-22 carbon atoms. Preferably, each of s, s', t, and t' are 2 (i.e., the alkylene oxide groups are ethylene oxide). Typically, the sum of u and v is 0. In various embodiments, the substituent R of formula (V) is derived from coconut oil, thereby providing a polyalkoxylated cocoamine. Thus, in various preferred embodiments, the N-substituted primary alkyl(ether)amine is 2EO to 5EO cocoamine and, in further preferred embodiments, 2EO cocoamine. It should be understood that the N-substituted

primary alkyl(ether)amine utilized in accordance with the present invention may be peaked. That is, the shorter chain amines may be prepared by the method used to prepare a peaked polyalkoxylated alkyl(ether)amine surfactant detailed herein, particularly where the shorter chain amine contains less than 3 ethylene oxide units.

[00125] Typically, the total proportion of unsubstituted or N-substituted primary alkyl(ether)amine in the formulation is at least about 2 wt.%, more typically at least about 3 wt.% and, still more typically, at least about 4 wt.%. Preferably, the formulation contains between about 2 and about 8 wt.%, more preferably between about 3 and about 7 wt.% and, still more preferably, between about 4 and about 6 wt.% unsubstituted or N-substituted primary alkyl(ether)amine. In various embodiments, the formulation comprises a mixture or, blend, of unsubstituted or N-substituted primary alkyl(ether)amine surfactants.

[00126] The weight ratio of peaked distribution (i.e., longer chain) alkoxylated alkyl(ether)amine to unsubstituted or N-substituted primary alkyl(ether)amine may be between about 20:80 and about 90:10, between about 30:70 and about 80:20, or between about 40:60 and about 75:25.

[00127] The present invention is directed to various glyphosate formulations containing a first (typically non-peaked) unsubstituted or N-substituted primary alkyl(ether)amine surfactant that exhibits one or more of the foregoing properties and a second, more highly substituted peaked distribution polyalkoxylated alkyl(ether)amine surfactant that exhibits one or more of the foregoing properties, as detailed in the appended claims.

[00128] Generally, the cloud point of formulations of the present invention containing an unsubstituted or N-

substituted primary alkyl(ether)amine and a peaked distribution alkoxylated alkyl(ether)amine is at least about 50°C, typically at least about 55°C, more typically at least about 60°C and, still more typically, at least about 65°C. More particularly, the cloud point of such formulations is typically at least about 3°C higher, at least about 4°C higher, at least about 5°C higher, or at least about 6°C higher than similar formulations containing, as the polyalkoxylated alkyl(ether)amine component, a conventional polyalkoxylated alkyl(ether)amine as prepared by conventional base catalysis and having the same distribution of carbon chain length, and the same average ratio of number of alkylene oxide units per amine molecule as the peaked distribution alkoxylated alkyl(ether)amine utilized in accordance with the present invention.

[00129] Advantageously, incorporating an unsubstituted or N-substituted primary alkyl(ether)amine and peaked distribution polyalkoxylated alkyl(ether)amine provides stable and efficacious glyphosate formulations at pHs greater than about 4.6, greater than about 4.7, greater than about 4.8, or greater than about 4.9. In particular, for glyphosate formulations containing ammonium glyphosate, stable and efficacious formulations are provided at pHs greater than about 6.0 or greater than about 6.5.

[00130] In various embodiments including an unsubstituted or N-substituted primary alkyl(ether)amine and peaked distribution polyalkoxylated alkyl(ether)amine, the peaked distribution alkoxylated alkyl(ether)amine is derived from tallowamine, provided it is not a 9EO or 10EO tallowamine and, in certain such embodiments, is 8EO tallowamine. Further in accordance with such embodiments and other embodiments, the weight ratio of peaked distribution polyalkoxyated alkyl(ether)amine to

unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is typically between about 20:80 and about 90:10, between about 30:70 and about 80:20, or between about 40:60 and about 75:25, provided the weight ratio is not 65:35. Further in accordance with such embodiments, when the peaked distribution polyalkoxylated alkyl(ether)amine is 9EO or 10EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the weight ratio of 9EO tallowamine or 10EO tallowamine to 2EO cocoamine is not 65:35.

[00131] Herbicidal formulations of the present invention also typically comprise at least about 3 wt.% or from about 3 wt.% to about 10 wt.% peaked distribution polyalkoxylated alkyl(ether)amine and/or at least about 2 wt.% or from about 2 wt.% to about 8 wt.% unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine, provided that the formulation does not comprise 5.85 wt.% peaked distribution polyalkoxylated alkyl(ether)amine and 3.15 wt.% unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine or 6.5 wt.% peaked distribution polyalkoxylated alkyl(ether)amine and 3.5 wt.% unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine. Further in accordance with these and other embodiments, when the peaked distribution polyalkoxylated alkyl(ether)amine is 9EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the formulation does not comprise 5.85 wt.% 9EO tallowamine and 3.15 wt.% 2EO cocoamine, and when the peaked distribution polyalkoxylated alkyl(ether)amine is 10EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the

formulation does not comprise 6.5 wt.% 10EO tallowamine and 3.5 wt.% 2EO cocoamine.

[00132] Glyphosate formulations of the present invention may further comprise one or more co-herbicides, in particular water-soluble co-herbicides. Examples of suitable co-herbicides are the ammonium salts of acifluorfen, asulam, benazolin, bentazon, bialaphos, bromacil, bromoxynil, chloramben, clopyralid, 2,4-D, 2,4-DB, pelargonic acid, dalapon, dicamba, dichlorprop, diclofop, endothall, fenac, fenoxaprop, flamprop, fluazifop, fluoroglycofen, fomesafen, fosamine, glufosinate, haloxyfop, imazameth, imazamethabenz, imazamox, imazapyr, imazaquin, imazethapyr, ioxynil, MCPA, MCPB, mecoprop, methylarsonic acid, naptalam, nonanoic acid, picloram, sulfamic acid, 2,3,6-TBA, TCA and triclopyr. In various embodiments, the co-herbicide is generally selected from the group consisting of 4-chlorophenoxyacetic acid (4-CPA) or a salt thereof, 2,4-dichlorophenoxyacetic acid (2,4-D) or a salt thereof, 3,4-dichlorophenoxyacetic acid (3,4-DA) or a salt thereof, 4-chloro-2-methylphenoxyacetic acid (MCPA) or a salt thereof, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) or a salt thereof, 2-(3-chlorophenoxy)propanoic acid (cloprop) or a salt thereof, 2-(4-chlorophenoxy)propanoic acid (4-CPP) or a salt thereof, 2-(2,4-dichlorophenoxy)propanoic acid (dichlorprop) or a salt thereof, 2-(3,4-dichlorophenoxy)propanoic acid (3,4-DP) or a salt thereof, 2-(2,4,5-trichlorophenoxy)propanoic acid (fenoprop) or a salt thereof, 2-(4-chloro-2-methylphenoxy)propanoic acid (mecoprop) or a salt thereof, 4-(4-chlorophenoxy)butanoic acid (4-CPB) or a salt thereof, 4-(2,4-dichlorophenoxy)butanoic acid (2,4-DB) or a salt thereof, 4-(3,4-dichlorophenoxy)butanoic acid (3,4-DB) or a salt thereof, 4-(4-chloro-2-methylphenoxy)butanoic acid (MCPB)

or a salt thereof, 4-(2,4,5-trichlorophenoxy)butanoic acid (2,4,5-TB) or a salt thereof, 3-amino-2,5-dichlorobenzoic acid (chloramben) or a salt thereof, 3,6-dichloro-2-methoxybenzoic acid (dicamba) or a salt thereof, 2,3,6-trichlorobenzoic acid (2,3,6-TBA) or a salt thereof, 2,3,5-trichloro-6-methoxybenzoic acid (tricamba) or a salt thereof, 4-amino-3,6-dichloro-2-pyridinecarboxylic acid (aminopyralid) or a salt thereof, 3,6-dichloro-2-pyridinecarboxylic acid (clopyralid) or a salt thereof, 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid (picloram) or a salt thereof, 3,5,6-trichloro-2-pyridinyl)oxyacetic acid (triclopyr) or a salt thereof, and combinations thereof. In various other embodiments, the co-herbicide is selected from the group consisting of diuron, fluometuron, prometryn, and combinations thereof. Salts of these and other suitable co-herbicides may be more soluble in glyphosate formulations than acid co-herbicides. Thus, in various embodiments, it may be preferred for the formulation to include a salt of a co-herbicide.

[00133] In accordance with embodiments in which the formulation is diluted in water for application to foliage of the vegetation to be killed or controlled, the diluted composition typically contains a co-herbicide including, for example, a co-herbicide selected from the group consisting of diuron, fluometuron, prometryn, and combinations thereof. The concentrate of glyphosate, a.e., in such diluted compositions is typically from about 0.5 to 2.0 wt.% or from about 0.5 to about 1.0 wt%, a.e while the concentration of co-herbicide in such diluted compositions is from about 0.25 to about 1.0 wt.% or from about 0.5 wt.% to about 1.0 wt.%. The weight ratio of glyphosate to co-herbicide in these diluted compositions is typically from about 0.5 to about 4.0 or from about 1.0 to about 2.0.

[00134] Further in accordance with the present invention it has been discovered that peaked distribution surfactants prepared in accordance with the present invention may be incorporated into stable and efficacious herbicidal formulations in the absence of an unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine. Typically in accordance with such embodiments, the formulation contains glyphosate and the peaked distribution surfactant at a weight ratio of glyphosate, a.e., to the peaked distribution alkoxylated alkyl(ether)amine of between about 90:1 and about 120:1. Further in accordance with such embodiments, the peaked distribution surfactant is typically present in the formulation at a concentration of at least about 5 wt.% and, more typically, from about 5 wt.% to about 10 wt.%. As noted, in addition to glyphosate and a peaked surfactant, formulations of the present invention may contain other components including, for example, glycerine and, more particularly, from about 2.5 wt.% to about 7.5 wt.% glycerine. Advantageously, these formulations typically exhibit a cloud point of at least about 70°C, at least about 75°C, at least about 80°C, at least about 85°C, or at least about 90°C and, more particularly, such cloud points at glyphosate concentrations of at least about 180 g/l, 220 g/l, 300 g/l, 360 g/l, or 380 g/l glyphosate, a.e.

[00135] The invention will now be illustrated by the following nonlimiting examples.

Example 1: Preparation of Ethylated Coco amine by the "S" process using 5 moles of Ethylene Oxide

[00136] Distilled coco amine (520g, 2.6 moles) was charged to a one-gallon stainless steel pressure vessel and then heated at 130°C under nitrogen purging for 30 minutes

to reduce its moisture content to less than 0.1%. Ethylene Oxide (230g, 5.23 moles) was then added to the pressure vessel over a period of 40 minutes while the temperature was maintained at 150 – 160^{0}C. Following a 30-minutes period of digestion, the reaction mixture was purged with nitrogen to remove the trace of ethylene oxide and analyzed. Its Total Amine Value is 194 mg KOH/g, indicating that the 2.00 moles of ethylene oxide has been consumed for the ethoxylation of 1 mole of coco amine.

[00137] The product mixture was then cooled to 100^{0}C. Boron Trifluoride – Phosphoric Acid complex (1.70g) was then injected to the reactor. The mixture was then heated to 110^{0}C, then ethylene oxide (330g, 7.5 moles) was added to the reactor over a 90 minutes period while the pressure was maintained at 50 psig. An exothermic reaction occurred; cooling was applied to maintain the temperature in the range of 110 – 120^{0}C throughout the addition of ethylene oxide. Upon completion of the ethylene oxide addition, the reaction mixture was digested for one hour at the same temperature and pressure. Analysis showed that the product mixture contains about 2000 ppm of dioxane. A combination of nitrogen purging and the in injection of water (to generate steam in situ) was then applied for two hours to strip the dioxane from the product mixture. The product mixture was then dried by nitrogen purging at 120^{0}C for one hour to reduce its moisture content to less than 0.5%. Its TAV is 133.4 mg KOH/g, indicating that a total of 5.0 moles of ethylene oxide have been consumed for the ethoxylation each mole of coco amine.

[00138] Figure 2 illustrates the homologs distribution of the resulting product (C/15S) and of the Ethomeen C/15, its commercially available counterpart that is prepared by the regular, hydroxide-catalyzed ethoxylation of the cocoamine with the same number of moles (5) of the ethylene

oxide. The peaked distribution of the homologs is indicated by their higher concentration (weight %) at the middle of the distribution range. As is shown in Figure 2, the most prevalent EO adduct is 4 in both processes even though 5 EO is added. The degree of peaking is 68 for C/15S and 60 for C/15.

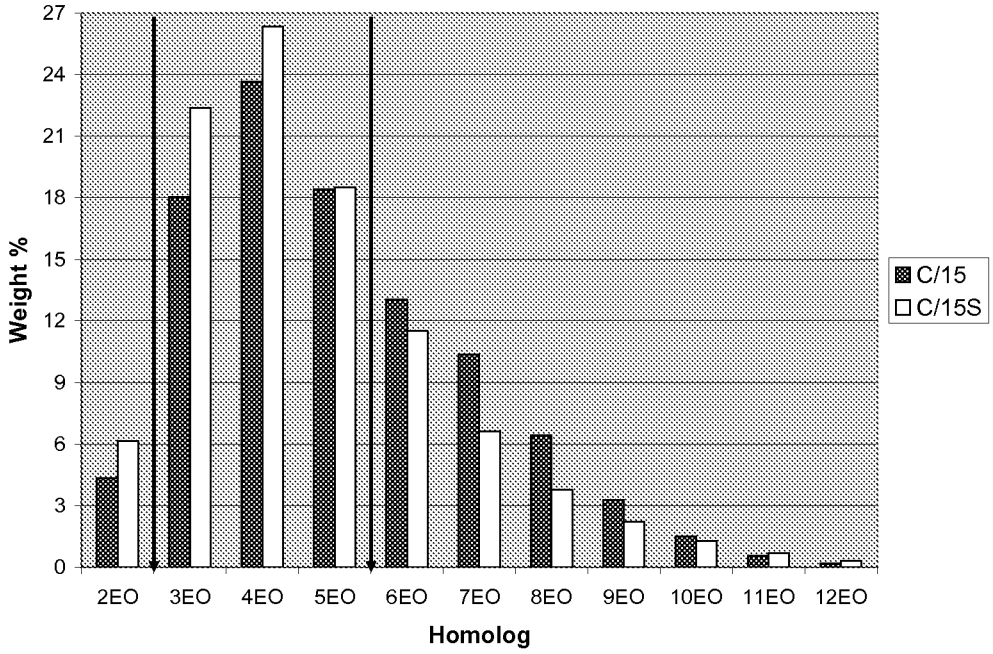


Figure 2: Homolog distribution of ethoxylated coco amine amine prepared with 5 moles of ethylene oxide by the "R" process (C/15) and "S" process(C/15S)

Example 2: Preparation of Ethoxylated Cocoamine by the "S" process using 6 moles of Ethylene Oxide

[00139] In this example, the first stage (ethoxylation of distilled cocoamine with 2 moles of ethylene oxide) was by-passed. The commercially available Ethomeen C/12 was used as the starting material. The ethoxylated of the Ethomeen C/12 with 4 moles of ethylene oxide in this example was catalyzed by Boron Trifluoride – Diethyl Ether Complex.

[00140] Ethomeen C/12 (750g, 2.59 moles) was charged to a one-gallon stainless steel pressure vessel and then heated at 130^{0}C under nitrogen purging for 30 minutes to reduce its moisture content to less than 0.1%. It was then cooled 100^{0}C. Boron Trifluoride – Diethyl Ether complex (1.56g) was then injected to the reactor. The mixture was then heated to 110^{0}C, then ethylene oxide (460g, 10.45 moles) was added to the reactor over a 60 minutes period while the pressure was maintained at 50 psig. An exothermic reaction occurred; cooling was applied to maintain the temperature in the range of 110 – 120^{0}C throughout the addition of ethylene oxide. Upon completion of the ethylene Oxide addition, the reaction mixture was digested for one hour at the same temperature and pressure. Analysis showed that the product mixture contains about 3000 ppm of dioxane. A combination of nitrogen purging and the in injection of water (4 % of batch weight, to generate steam in situ) was then applied for two hours to strip the dioxane from the product mixture. The product mixture was then dried by nitrogen purging at 120^{0}C for one hour to reduce its moisture content to less than 0.5%. Its TAV is 123.7 mg KOH/g, indicating that a total of 5.8 moles of ethylene oxide have been consumed for the ethoxylation each mole of the coco amine.

[00141] Figure 3 illustrates the homologs distribution of the resulting product (C/16S) and of the Ethomeen C/16, its commercially available counterpart that is prepared by the regular, hydroxide-catalyzed ethoxylation of the cocoamine with the same number of moles (6) of the ethylene oxide. The peaked distribution of the homologs is indicated by their higher concentration (weight %) at the middle of the distribution range. As is shown in Figure 3, the most prevalent EO adduct is 4 in both processes even

though 6 EO is added. The degree of peaking is 58 for C/16S and 49 for C/16.

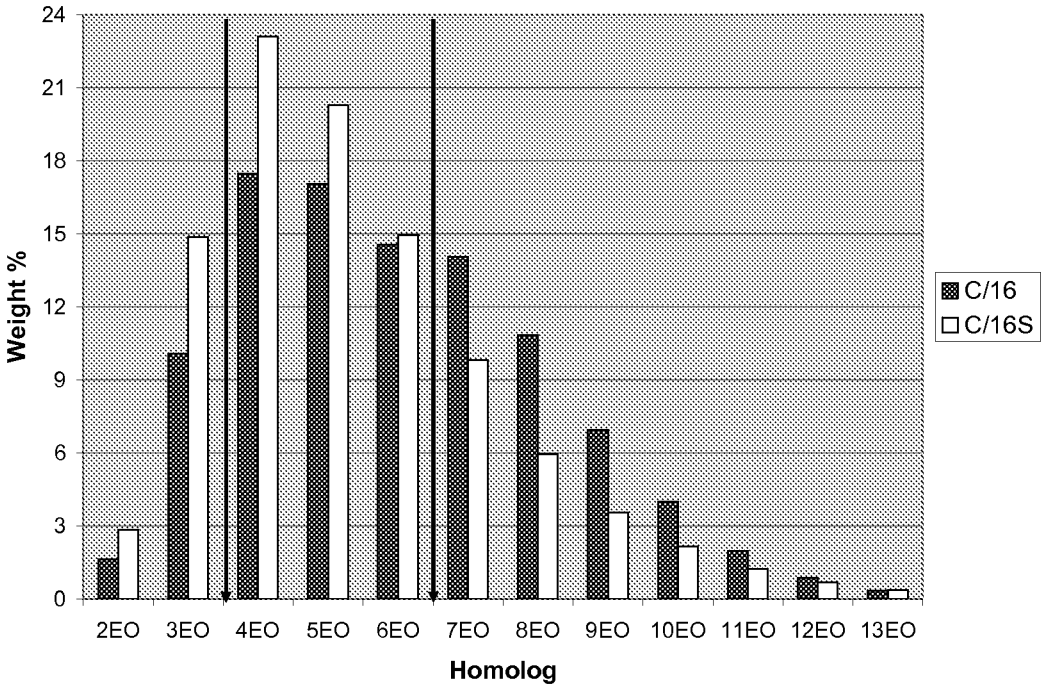


Figure 3: Homolog distribution of ethoxylated cocoamine prepared with a total of 6 moles of ethylene oxide by the "R" process (C/16) and the "S" process (C/16S)

Example 3: Compatibility of Ethoxylated Alkylamine with Potassium Glyphosate

[00142] Compatibility of cocoamine-5EO (C/15), cocoamine-6EO (C/16), and tallowamine-10EO (T/20) by the new BF3-catalyzed process (the "S" process) and by the "N" process were compared with the regular, hydroxide-catalyzed process (the "R" process) in potassium glyphosate solution. Solution Cloud Point was used to compare the solutions. As shown in Table 1, glyphosate formulas containing 10% ethoxylated alkylamine made by the peaked process have higher Cloud Point, indicating that it is more stable than the formula containing the ethoxylated alkylamine made by conventional processes.

Cloud Point Method

[00143] A sample of a stable, transparent formulation is first heated in a 90+°C water bath.

[00144] As the temperature of the sample increases "cloudiness" is usually observed. Heating is continued until the cloudiness of the solution is maximized, i.e., the polymeric components dissolved in the formulation precipitate out of solution. If the temperature exceeds 90°C and no cloudiness is apparent, the result is recorded as CP>90°C.

[00145] Next, the solution is slowly cooled by removing the formulation sample from the water bath while gently agitating the sample (e.g., by stirring with a thermometer) and monitoring the dissolution of the suspended polymeric material. When the cloud point temperature is reached the transition increases dramatically due to the remixing or dissolution of the precipitated or polymeric phase.

[00146] The temperature at which the formulation sample returns to transparency is recorded as the cloud point for that sample. This analysis is repeated on several different samples. The average observed cloud point of these samples is calculated and reported as the cloud point of the particular formulation tested.

Table 1: Cloud Point of concentrated glyphosate formula containing ethoxylated alkylamines prepared from the regular and the peaked processes

K-glyphosate wt% a.i.	**Surfactant wt%**	**Surfactant Description**	**CLOUD POINT (^{0}C)**	
			Peaked Process	**Comparative "R" Process**
54.8	10	Cocoamine-5EO	66 ("N")	58
54.6	10	Cocoamine-6EO	59 ("S")	RT separate *
54.6	10	Cocoamine-2EO:Tallowamine 10EO = 35:65 (wt./wt. Ratio)	44 ("S")	RT separate *
40.3	10	Tallowamine-9EO	75 ("N")	71
54.6	9	Cocoamine-2EO:Tallowamine 9EO = 35:65 (wt./wt. Ratio)	58 ("N")	52

RT – room temperature (at room temperature the surfactant is not sufficient soluble to avoid phase separation)

Water was used to balance the solutions to 100 wt%.

Example 4: Preparation of Ethoxylated Coco Amine using 6 Moles of EO (the "N" process)

[00147] Stage 1: Distilled coco amine (520g, 2.6 moles) was charged to a one-gallon stainless steel pressure vessel and then heated at 130^{0}C under nitrogen purging for 30 minutes to reduce its moisture content to less than 0.1%. Ethylene Oxide (230g, 5.23 moles) was then added to the pressure vessel over a period of 40 minutes while the temperature was maintained at 150 – 160^{0}C. Following a 30-minute period of digestion, the reaction mixture sampled and analyzed. Its Total Amine Value is 194 mg KOH/g,

indicating that the 2.00 moles of ethylene oxide has been consumed for the ethoxylation of 1 mole of coco amine.

[00148] Stage 2: The product mixture was then cooled to 115^{0}C. Ethylene oxide (320g, 7.27 moles) was then added to the pressure vessel over a period 50 minutes, while the temperature was maintained at 115-125^{0}C. Following a 60-minute period of digestion, the reaction mixture was purged with nitrogen, then samples and analyzed. Its Total Amine Value is 138 mg KOH/g, indicating that in this stage, 2.7 moles of ethylene oxide has been consumed for the ethoxylation of 1 mole of coco amine.

[00149] Stage 3: Potassium hydroxide (2.50g, 0.02moles) was charged to the pressure vessel. The reaction mixture was purged with nitrogen, then heated at 150^{0}C for 30 minutes under nitrogen purging to reduce its moisture content to less than 0.1%.

[00150] Ethylene Oxide (150g, 3.4 moles) was then added to the pressure vessel over a period of 20 minutes while the temperature was maintained at 150 – 160^{0}C. Following a 30-minute period of digestion, the reaction mixture was purge with nitrogen to remove the trace of unreacted ethylene oxide, then cooled to 50^{0}C and discharged. Its TAV is 120 mg KOH/g, indicating that a total of 6.1 moles of ethylene oxide have been consumed for the ethoxylation each mole of coco amine. The content of dioxane (about 150ppm) and EGDs (about 2.5%) of the final product are much lower than the content of dioxane (about 5000 ppm) and EGDs (about 7.5%) of its counterpart made by the acid-catalyzed process.

[00151] Figure 4 illustrates the homologs distribution of the resulting ethoxylated product (6NP) and of its counterpart that is prepared by the regular, hydroxide-catalyzed ethoxylation of the coco amine with the same number of moles (6) of the ethylene oxide (6RP) that has

the same Total Amine Value. The degree of peaking is 60 for 6NP and 49 for 6RP, indicating that the 6NP product made by the new process possesses a peaked ethoxylation distribution.

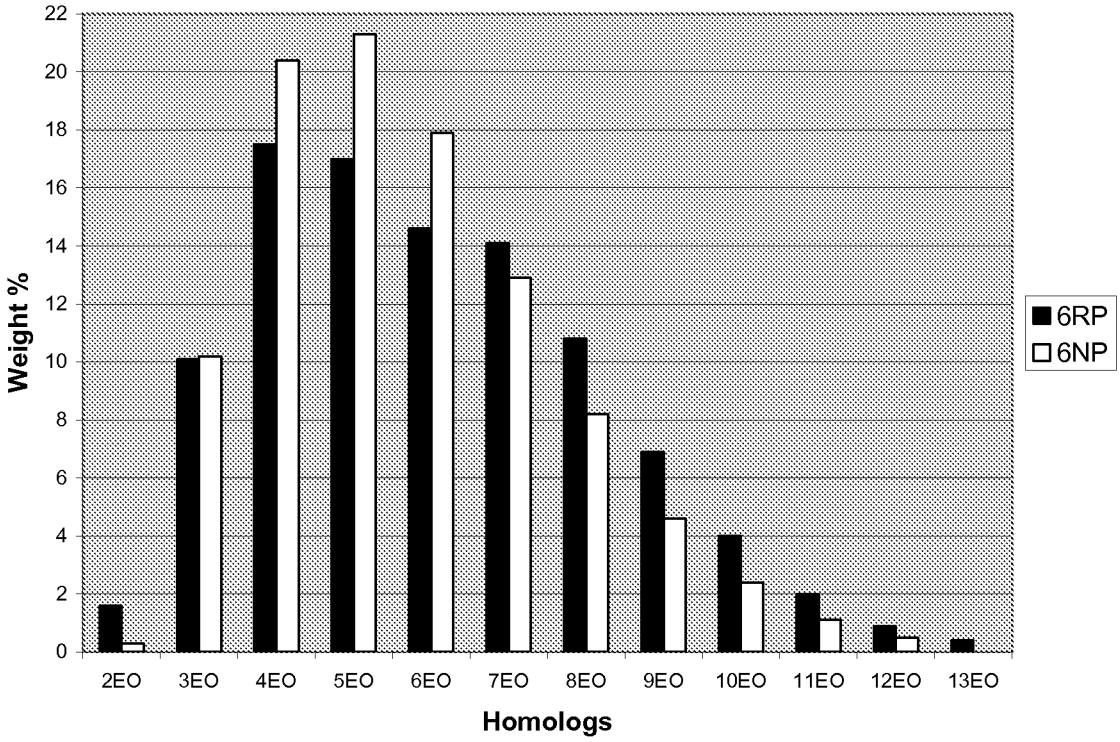


Figure 4: Homolog distribution of the 6-mole EO adduct of coco amine prepared by the regular ethoxylation process (6RP) and the new ethoxylation process (6NP).

[00152] The degree of peaking is 60 for 6NP and 49 for 6RP.

Example 5: Preparation of Ethoxylated Coco Amine by the "N" process using 8 Moles of Ethylene Oxide

[00153] Stage 1: Distilled coco amine (520g, 2.6 moles) was charged to a one-gallon stainless steel pressure vessel and then heated at 130^{0}C under nitrogen purging for 30 minutes to reduce its moisture content to less than 0.1%. Ethylene Oxide (230g, 5.23 moles) was then added to the pressure vessel over a period of 40 minutes while the

temperature was maintained at 150 - 160^{0}C. Following a 30-minute period of digestion, the reaction mixture sampled and analyzed. Its Total Amine Value is 194 mg KOH/g, indicating that the 2.00 moles of ethylene oxide has been consumed for the ethoxylation of 1 mole of coco amine.

[00154] Stage 2: The product mixture was then cooled to 115^{0}C. Ethylene oxide (460g, 10.46 moles) was then added to the pressure vessel over a period 75 minutes, while the temperature was maintained at 115-125^{0}C. Following a 60-minute period of digestion, the reaction mixture was purged with nitrogen, then samples and analyzed. Its Total Amine Value is 122 mg KOH/g, indicating that in this stage, 3.9 moles of ethylene oxide has been consumed for the ethoxylation of 1 mole of coco amine.

[00155] Stage 3: Potassium hydroxide (3.0g, 0.025 moles) was charged to the pressure vessel. The reaction mixture was purged with nitrogen, then heated at 150^{0}C for 30 minutes under nitrogen purging to reduce its moisture content to less than 0.1%. Ethylene Oxide (465g, 6.02 moles) was then added to the pressure vessel over a period of 20 minutes while the temperature was maintained at 150 - 160^{0}C. Following a 30-minute period of digestion, the reaction mixture was purge with nitrogen to remove the trace of unreacted ethylene oxide, then cooled to 50^{0}C and discharged. Its TAV is 101 mg KOH/g, indicating that a total of 8.08 moles of ethylene oxide have been consumed for the ethoxylation each mole of coco amine. The content of dioxane (about 200ppm) and EGDs (about 2.7%) of the final product are much lower than the content of dioxane (about 8000 ppm) and EGDs (about 9.0%) made by the acid-catalyzed process.

[00156] Figure 5 illustrates the homologs distribution of the resulting ethoxylated product (8NP) and of its counterpart that is prepared by the regular, hydroxide-

catalyzed ethoxylation of the coco amine with the same number of moles (8) of the ethylene oxide (8RP). The degree of peaking is 51 for 8NP and 42 for 8RP, indicating that the 8NP product made by the new process possesses a peaked ethoxylation distribution.

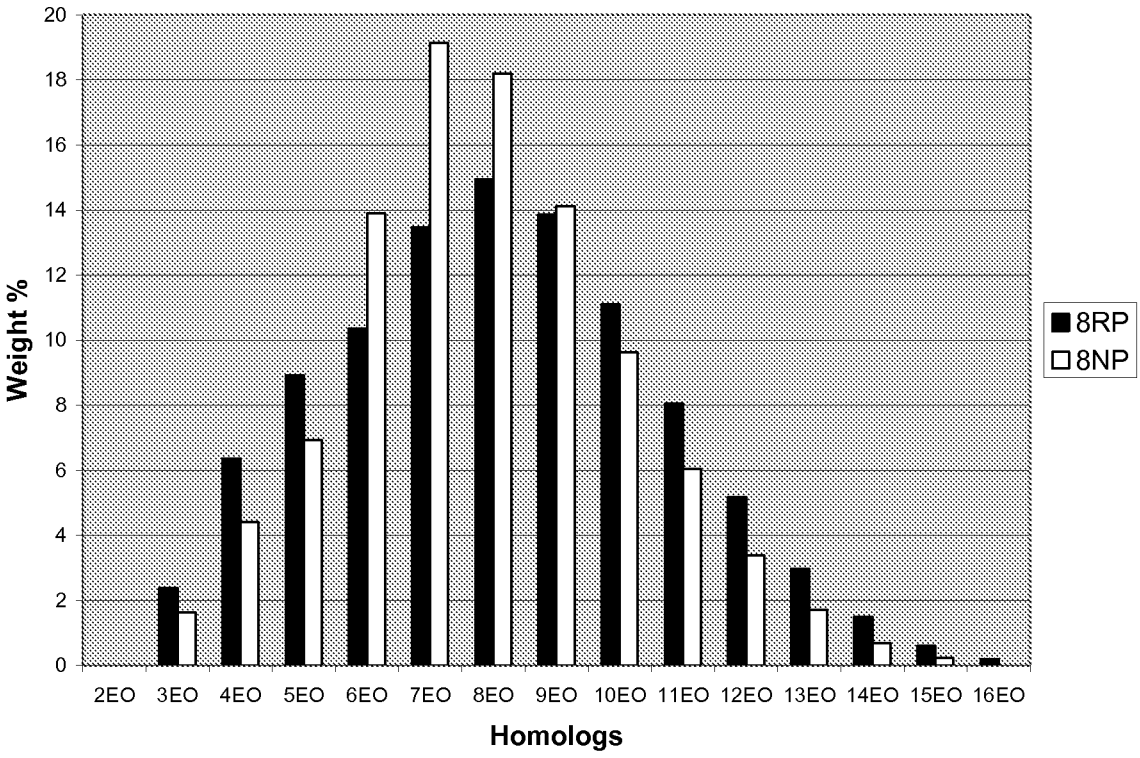


Figure 5: Homolog distribution of 8-mole EO adduct of coco amine prepared by the regular ethoxylation process (8RP) and the new ethoxylation process (8NP). The degree of peaking is 51 for 8NP and 42 for 8RP.

Example 6: Preparation of Ethoxylated Coco amine using 9 Moles of Ethylene Oxide

[00157] In this experiment, the Stage 1 Ethoxylation (non-catalyzed reaction of coco amine with 2 moles of ethylene oxide) was by-passed. Instead, the commercially available Ethomeen C/12, having a Total Amine Value of 195 mg KOH/g, was used as the starting material.

[00158] Stage 2: Ethomeen C/12 (700g, 2.43 moles) containing less than 0.1% water was charged to a one-gallon stainless steel pressure vessel, purged with nitrogen then heated to 115^{0}C. Ethylene oxide (450g, 10.22 moles) was then added to the pressure vessel over a period 75 minutes, while the temperature was maintained at 115-125^{0}C. Following a 60-minute period of digestion, the reaction mixture was purged with nitrogen, then samples and analyzed. Its Total Amine Value is 120 mg KOH/g, indicating that in this stage, 4.1 moles of ethylene oxide has been consumed for the ethoxylation of 1 mole of coco amine.

[00159] Stage 3: Potassium hydroxide (3.7g, 0.03 moles) was charged to the pressure vessel. The reaction mixture was purged with nitrogen, then heated at 150^{0}C for 30 minutes under nitrogen purging to reduce its moisture content to less than 0.1%. Ethylene Oxide (330g, 7.50 moles) was then added to the pressure vessel over a period of 20 minutes while the temperature was maintained at 140 - 150^{0}C. Following a 30-minute period of digestion, the reaction mixture was purge with nitrogen to remove the trace of unreacted ethylene oxide, then cooled to 50^{0}C and discharged. Its TAV is 93 mg KOH/g, indicating that total of 9.2 moles of ethylene oxide have been consumed for the ethoxylation each mole of coco amine in this preparation. The content of dioxane (about 200ppm) and EGDs (about 3.0 %) of the final product are much lower than the content of dioxane (about 12000 ppm) and EGDs (about 11.0%) of its counterpart made by the acid-catalyzed process.

[00160] Figure 6 illustrates the homologs distribution of the resulting ethoxylated product (9NP) and of its counterpart that is prepared by the regular, hydroxide-catalyzed ethoxylation of the coco amine with the same number of moles (9) of the ethylene oxide (9RP). The

degree of peaking is 50 for 9NP and 43 for 9RP, indicating that the 9NP product made by the new process according possesses a peaked ethoxylation distribution.

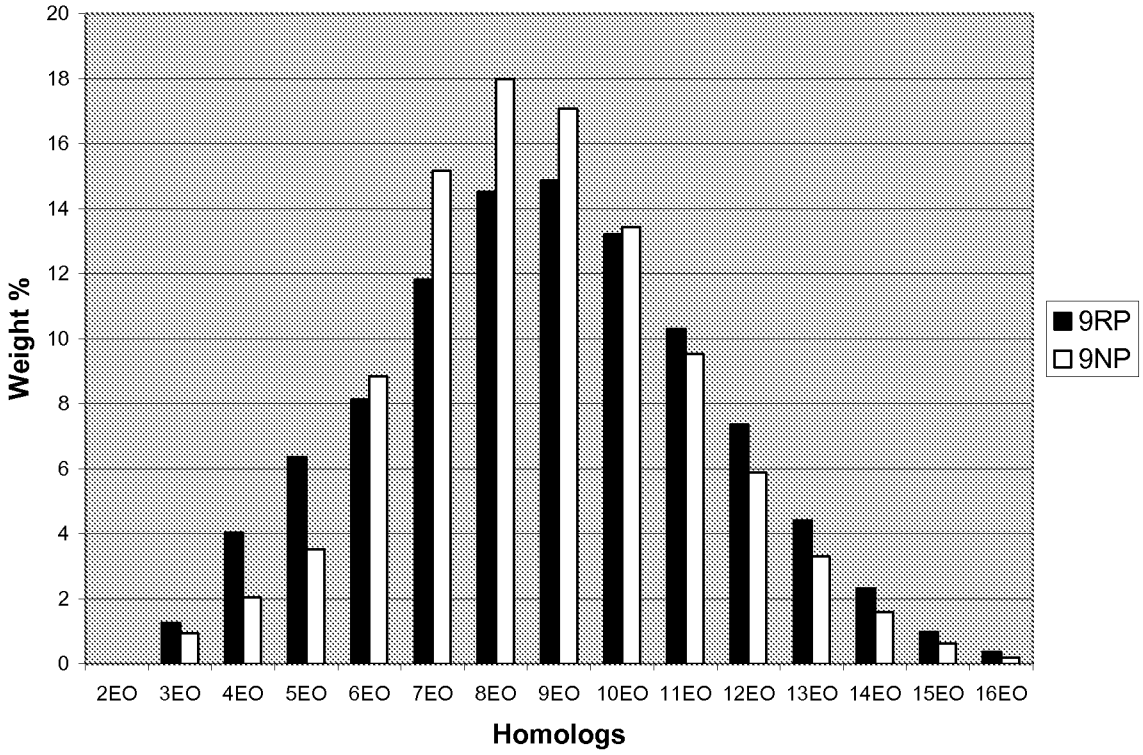


Figure 6: Homolog distribution of 9-mole EO adduct of coco amine prepared by regular ethoxylation process (9RP) and new ethoxylation process (9NP).

[00161] The degree of peaking is 50 for 9NP and 43 for 9RP.

Example 7: Effect of reduction of higher EO adduct on the cloud point of glyphosate formulations

[00162] Adding 0.2 % of PEG-600 (~13.6EO) into a 62% K-glyphosate solution resulted in a hazy product. However, adding ~25% diethylene glycol (2EO) into the same K-glyphosate solution resulted in a clear solution. This shows that, in concentrated glyphosate solutions, a higher

EO adduct has a much stronger adverse effect on the cloud point than a lower EO adduct. Therefore, even a slight reduction in concentration of the higher EO adduct could improve the cloud point of glyphosate formulation dramatically. This has been demonstrated in example 3.

Example 8: Homolog distribution of 9-mole EO adduct of tallowamine prepared by the "R" ethoxylation process and the "N" ethoxylation process of the present invention.

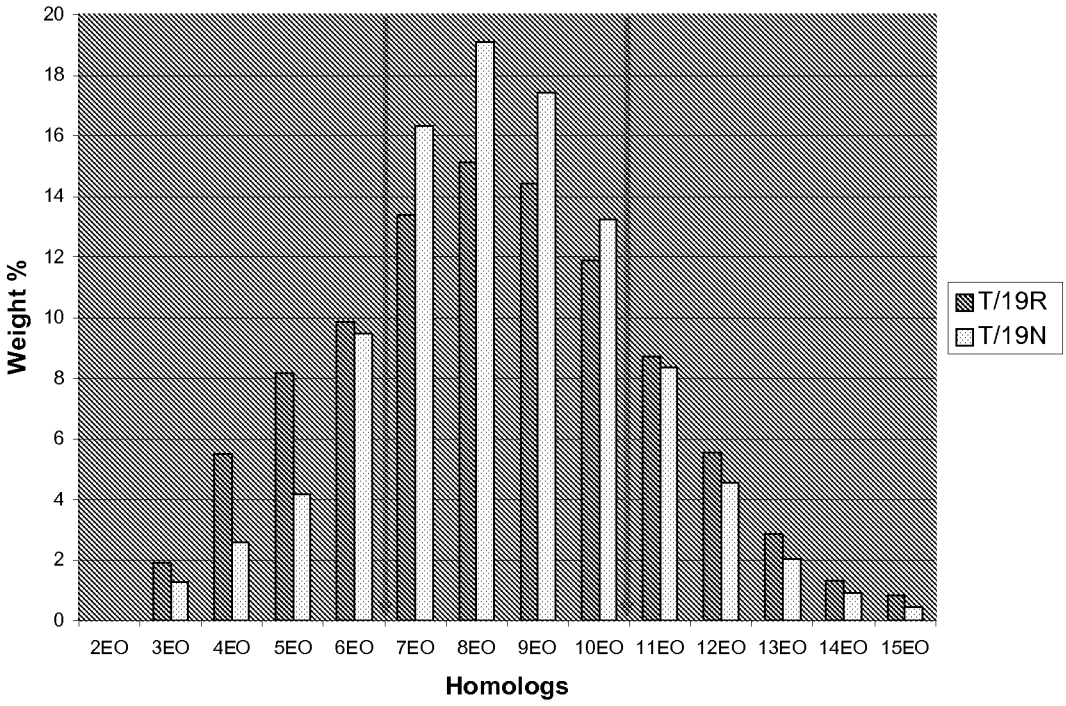


Figure 7: Homolog distribution of 9-mole EO adduct of tallowamine prepared by regular ethoxylation process (9R) and new "N" ethoxylation process (9N). The degree of peaking is 53 for T/19N and 43 for T/19R.

[00163] Product T/19N was produced using a very similar process as outlined in Example 6. General conditions have been also listed in Table A. The final Total Amine value i 1.50 for T/19N and 1.51 for T/19R.

[00164] In the following Examples 9-13, various surfactants identified in Table 2 were used in the compositions.

Table 2

Reference	Manufacturer	Trade Name	Description	EO/ molecule (theoretical)	EO/ molecule (measured)
S1	Akzo-Nobel	Witcamine 302S	Diethoxylated Cocoamine	2	2.04
S2	Akzo-Nobel	Witcamine TAM-105S	Ethoxylated Tallowamine	10	7.85
S3	Akzo-Nobel	Witcamine TAM-105S	Ethoxylated Tallowamine	10	8.38
S4	Akzo-Nobel	Witcamine TAM-105S	Ethoxylated Tallowamine	10	8.23
S5	Akzo-Nobel	Witcamine TAM-105S	Ethoxylated Tallowamine	10	8.06
S6	Akzo-Nobel	Witcamine TAM-80S	Ethoxylated Tallowamine	8	6.86
S7	Akzo-Nobel	Witcamine TAM-60S	Ethoxylated Tallowamine	6	5.70
S8	Akzo-Nobel	Witcamine TAM-105S	Ethoxylated Tallowamine	10	8.84
S9	Akzo-Nobel	Witcamine TAM-105S	Ethoxylated Tallowamine	10	8.05
S10	Akzo-Nobel	Witcamine TAM-105S	Ethoxylated Tallowamine	10	8.74
S11	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	10	7.95
S13	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	8	7.88
S14	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	9	8.84
S15	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	10	9.83
S16	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	9	8.56
S17	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	8	8.03
S18	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	10	9.90
S19	Akzo-Nobel	Witcamine TAM-105	Ethoxylated Tallowamine	10	10.32
S20	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	9	9.03

Reference	Manufacturer	Trade Name	Description	EO/ molecule (theoretical)	EO/ molecule (measured)
S21	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	9	8.61
S22	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	8	8.01
S24	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9	8.92
S26	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	10	9.94
S27	Akzo-Nobel	Ethomeen T/19N PP	Ethoxylated Tallowamine	9	8.52
S28	Akzo-Nobel	Ethomeen T/20N	Ethoxylated Tallowamine	10	9.36
S29	Akzo-Nobel	Ethomeen T/19R	Ethoxylated Tallowamine	9	9.06
S30	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9	9.05
S31	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9.2	9.31
S32	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9	9.00
S33	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9.2	9.22
S34	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9.2	9.22
S35	Akzo-Nobel	Ethomeen T/20N	Ethoxylated Tallowamine	10	9.66
S37	Akzo-Nobel	Ethomeen T/20S	Ethoxylated Tallowamine	8	8.09
S40	Akzo-Nobel	T/19N-T/20N Blend	Ethoxylated Tallowamine	na	10.00
S41	Akzo-Nobel	Witcamine Tam 105 NR	Ethoxylated Tallowamine	10	9.70
S42		alkoxylated etheramine (5EO)	Ethoxylated Etheramine	5	nm
S43		alkoxylated etheramine (4EO)	Ethoxylated Etheramine	4	nm
S44	Akzo-Nobel	Tam 105S/ Witcamine 302 (90/10)	Ethoxylated Coco / tallowamine blend	nm	nm
S45	Akzo-Nobel	Tam 105R/ Witcamine 302 (90/10)	Ethoxylated Coco / tallowamine blend	nm	nm
S46	Akzo-Nobel	Tam 105S/ Witcamine 302 (70/30)	Ethoxylated Coco / tallowamine blend	nm	nm
S47	Akzo-Nobel	Tam 105S/	Ethoxylated Coco /	nm	nm

Reference	Manufacturer	Trade Name	Description	EO/ molecule (theoretical)	EO/ molecule (measured)
		Witcamine 302 (60/40)	tallowamine blend		
S48	Akzo-Nobel	Tam 105S/ Witcamine 302 (50/50)	Ethoxylated Coco / tallowamine blend	nm	nm
S49	Akzo-Nobel	Tam 105R/ Tam 105S (60/40)	Ethoxylated Tallowamine Blend	10	nm
S50	Akzo Nobel	Ethoquad C12	Quaternary Ammonium Compound	2	nm
S51	Akzo-Nobel		Ethoxylated Coco / tallowamine blend	nm	nm
S52	Akzo-Nobel		Ethoxylated Coco / tallowamine blend	nm	nm
S53	Akzo-Nobel	Ethomeen S12	Ethoxylated Soyamine	2	nm
S54	Akzo-Nobel	Ethomeen T12	Ethoxylated Tallowamine	2	nm
S55	Akzo-Nobel		Ethoxylated Coco / tallowamine blend	nm	nm
S56	Akzo-Nobel		Ethoxylated Coco / tallowamine blend	nm	nm
S57	Akzo-Nobel	Ethomeen C/12	Ethoxylated Cocoamine	2	
S58	Akzo-Nobel	TAM 105	Ethoxylated Tallowamine	10.5	10.5
S59	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	8.5	8.56
S60	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9	9.00
S61	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9.5	9.37
S62	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	10	9.82
S63	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	8.5	8.56
S64	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9	8.96
S64	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	9.5	9.34
S64	Akzo-Nobel	Ethomeen T/19N	Ethoxylated Tallowamine	10	9.65

[00165] In the following Examples 9-13, various other components identified in Table 3 were used in the compositions.

Table 3

Component	Manufacturer		
C1	Cognis	Agnique DF 6889	Silicone Antifoam
C2	ADM	Citrosol 502	Citric Acid, 50%
C3	Akzo-Nobel	Glycerine	Glycerine
C4		Glucono-delta lactone	Gluconic Acid (Dry)
C5		oxalic acid	oxalic acid
C6		sorbitol	sorbitol
C7		TEG	Triethylene Glycol
C8		PG	Propylene Glycol
C9		Urea	Urea
C10		DEG	Dietheylene Glycol
C11		Gluconic Acid (liquid)	Gluconic Acid (50% soln)
C12	Avocado	IPA	Isopropyl Amine
C13	VWR	KOH (45%)	Potassium Hydroxide (45%)
C14	JT Baker	NH_3OH (30%)	Aqueous Ammonium Hydroxide
C15	JT Baker	Sodium Sulfite	Sodium Sulfite
C16	JT Baker	TEA	Triethanol amine
C17	Sigma	Fe Citrate	Iron Citrate
C18	Chemiron	$FeSO_4$/citric acid blend, 4.5% Fe	Fe Dopant Solution
C19		Ferric Sulfate Solution, 12% Fe	Ferric Sulfate Solution

Example 9: This example sets forth peak distribution data for various surfactants, including those prepared in accordance with the "R," "N", and "S" processes detailed herein.

Table 4

	EO Average, Corr.					
Sample ID	Rep1	Rep2	Average EO	± Range	N_o	k
S58					8.7447 6.8294	8 6
S57					0.0166	0
S1	2.04	2.04	2.04	0.00	0.1898	0
S2	7.86	7.84	7.85	0.01	7.7451	7
S3	8.37	8.38	8.38	0.01	7.9638	7
S4	8.24	8.22	8.23	0.01	7.9028	7
S5	8.10	8.03	8.06	0.04	7.8351	7
S6	6.89	6.83	6.86	0.03	7.2128	7
S7	5.68	5.72	5.70	0.02	6.5054	6
S8	8.83	8.85	8.84	0.01	8.1458	8
S9	8.05	8.05	8.05	0.00	7.8342	7
S10	8.73	8.76	8.74	0.02	8.1093	8
S11	7.95	7.96	7.95	0.01	7.7845	7
S58					8.7890	8
S13	7.89	7.87	7.88	0.01	7.7408	7
S14	8.82	8.86	8.84	0.02	8.1733	8
S15	9.84	9.82	9.83	0.01	8.5591	8
S16	8.55	8.56	8.56	0.00	8.0538	8
S17	8.01	8.05	8.03	0.02	7.8155	7
S18	9.91	9.90	9.90	0.01	8.6011	8
S19	10.35	10.29	10.32	0.03	8.6791	8
S20	9.00	9.05	9.03	0.03	8.2604	8
S21	8.62	8.60	8.61	0.01	8.0760	8
S22	8.03	8.00	8.01	0.02	7.8131	7
S1	2.05	2.06	2.05	0.00	0.1689	0
S24	8.93	8.91	8.92	0.01	8.2193	8
S58					8.7645	8
S26	9.95	9.93	9.94	0.01	8.6230	8
S27	8.50	8.54	8.52	0.02	8.0685	8
S28	9.35	9.36	9.36	0.01	8.4107	8
S29	9.06	9.05	9.06	0.01	8.1992	8
S30	9.04	9.07	9.05	0.02	8.2750	8
S31	9.33	9.29	9.31	0.02	8.3772	8
S32	8.98	9.02	9.00	0.02	8.2333	8
S33	9.22	9.22	9.22	0.00	8.3398	8
S34	9.22	9.22	9.22	0.00	8.3422	8
S35	9.68	9.63	9.66	0.02	8.5081	8

	EO Average, Corr.					
Sample ID	Rep1	Rep2	Average EO	± Range	N_o	k
S51	10.49	10.59	10.54	0.05	7.3126	7
S37	8.09	8.10	8.09	0.00	7.8660	7
S58	10.59	10.59	10.59	0.00	8.8236	8
S58	10.00	9.96	9.98	0.02	8.6171	8
S58					8.8165	8

Table 5

	Left End Concentrations			Tailing Indices			Adjusted Parameters		
Sample ID	alpha1	alpha2	alpha3	beta1	beta2	beta3	alpha23	beta12	beta23
	0.0559	0.1279	0.2451	0.8216	0.7495	0.6323	0.2152	0.7679	0.6622
S58	0.0709	0.1370	0.2339	0.6393	0.5732	0.4763	0.2173	0.5845	0.4929
S57	0.0055	0.0055	0.0055	0.0000	0.0000	0.0000	0.0055	0.0000	0.0000
S1	0.0633	0.0633	0.0633	0.0000	0.0000	0.0000	0.0633	0.0000	0.0000
S2	0.3919	0.5593	0.7182	0.6512	0.4839	0.3249	0.6777	0.5265	0.3654
S3	0.3183	0.4656	0.6162	0.6902	0.5428	0.3922	0.6108	0.5481	0.3976
S4	0.3395	0.4893	0.6429	0.6787	0.5289	0.3754	0.6279	0.5435	0.3903
S5	0.3649	0.5200	0.6739	0.6651	0.5100	0.3561	0.6485	0.5355	0.3814
S6	0.6472	0.7912	0.9166	0.4769	0.3330	0.2075	0.8179	0.4463	0.3063
S7	0.9184	1.0364	1.1125	0.2895	0.1714	0.0953	1.0748	0.2298	0.1330
S8	0.2721	0.3998	0.5392	0.7096	0.5819	0.4426	0.4201	0.6910	0.5616
S9	0.3630	0.5253	0.6790	0.6682	0.5059	0.3523	0.6535	0.5328	0.3778
S10	0.2803	0.4141	0.5517	0.7067	0.5729	0.4353	0.4291	0.6921	0.5579
S11	0.3820	0.5433	0.6940	0.6557	0.4944	0.3437	0.6615	0.5291	0.3761
S58	0.0557	0.1180	0.2231	0.8105	0.7482	0.6431	0.2009	0.7613	0.6653
S13	0.3712	0.5486	0.7198	0.6691	0.4917	0.3205	0.6755	0.5377	0.3649
S14	0.2031	0.3486	0.5191	0.7691	0.6236	0.4531	0.3782	0.7439	0.5941
S15	0.0985	0.1932	0.3318	0.8110	0.7163	0.5777	0.2707	0.7581	0.6388
S16	0.2386	0.3961	0.5757	0.7515	0.5940	0.4144	0.4058	0.7431	0.5843
S17	0.3286	0.5089	0.6873	0.6995	0.5191	0.3407	0.6544	0.5524	0.3736
S18	0.0847	0.1707	0.3041	0.8196	0.7335	0.6002	0.2509	0.7679	0.6534
S19	0.0833	0.1465	0.2529	0.7908	0.7276	0.6212	0.2187	0.7479	0.6553
S20	0.1754	0.3100	0.4786	0.7845	0.6500	0.4813	0.3539	0.7495	0.6061
S21	0.2283	0.3863	0.5627	0.7574	0.5995	0.4231	0.3997	0.7454	0.5861
S22	0.3369	0.5143	0.6931	0.6938	0.5163	0.3375	0.6597	0.5495	0.3709
S1	0.0323	0.0395	0.0395	0.0072	0.0000	0.0000	0.0395	0.0059	0.0000

	Left End Concentrations			Tailing Indices			Adjusted Parameters		
Sample ID	alpha1	alpha2	alpha3	beta1	beta2	beta3	alpha23	beta12	beta23
S24	0.1739	0.3195	0.4895	0.7900	0.6443	0.4744	0.3568	0.7580	0.6071
S58	0.0588	0.1170	0.2180	0.8038	0.7456	0.6446	0.1942	0.7593	0.6684
S26	0.0849	0.1738	0.3065	0.8197	0.7308	0.5981	0.2564	0.7643	0.6482
S27	0.2206	0.3702	0.5663	0.7717	0.6221	0.4261	0.3836	0.7615	0.6087
S28	0.1241	0.2317	0.3943	0.8142	0.7066	0.5440	0.2985	0.7700	0.6398
S29	0.2524	0.3597	0.4807	0.7135	0.6062	0.4852	0.3838	0.6921	0.5821
S30	0.1703	0.3025	0.4680	0.7885	0.6563	0.4908	0.3480	0.7522	0.6108
S31	0.1422	0.2653	0.4243	0.7996	0.6766	0.5175	0.3253	0.7532	0.6166
S32	0.1806	0.3078	0.4657	0.7783	0.6510	0.4932	0.3446	0.7486	0.6142
S33	0.1528	0.2781	0.4369	0.7949	0.6696	0.5108	0.3320	0.7523	0.6157
S34	0.1504	0.2719	0.4331	0.7975	0.6760	0.5148	0.3271	0.7559	0.6209
S35	0.1148	0.2137	0.3594	0.8075	0.7086	0.5629	0.2877	0.7572	0.6346
S51	0.0430	0.0943	0.1800	0.6782	0.6269	0.5412	0.1211	0.6621	0.6001
S37	0.3045	0.4870	0.6675	0.7171	0.5347	0.3541	0.6433	0.5591	0.3783
S58	0.0574	0.1181	0.2157	0.8089	0.7482	0.6506	0.1984	0.7589	0.6678
S58	0.0898	0.1722	0.3020	0.8107	0.7283	0.5984	0.2523	0.7599	0.6482
S58	0.0521	0.1146	0.2144	0.8091	0.7466	0.6468	0.1961	0.7581	0.6651

PCT

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Table 6

	Peaking Indicators		Tilt Ratios		
	sigma3	PI	alpha2 /beta1	alpha23 /beta12	alpha23 /beta23
	0.3362	0.7030	0.1557	0.2803	0.3250
S58	0.2713	0.5013	0.2142	0.3718	0.4410
S57	0.0000	0.0000			
S1	0.0000	0.0000			
S2	0.4531	0.8916	0.8588	1.2871	1.8545
S3	0.4303	0.8587	0.6747	1.1143	1.5360
S4	0.4389	0.8725	0.7210	1.1554	1.6089
S5	0.4404	0.8716	0.7818	1.2109	1.7001
S6	0.3538	0.6719	1.6589	1.8327	2.6706
S7	0.2382	0.4296	3.5802	4.6769	8.0825
S8	0.3999	0.8072	0.5634	0.6080	0.7481
S9	0.4489	0.8884	0.7861	1.2264	1.7298
S10	0.4057	0.8169	0.5859	0.6200	0.7692
S11	0.4460	0.8800	0.8286	1.2502	1.7588
S58	0.2989	0.6265	0.1456	0.2639	0.3020
S13	0.4804	0.9450	0.8199	1.2563	1.8513
S14	0.4717	0.9535	0.4533	0.5083	0.6365
S15	0.3843	0.7950	0.2382	0.3571	0.4238
S16	0.4903	0.9840	0.5271	0.5461	0.6945
S17	0.4951	0.9787	0.7276	1.1847	1.7515
S18	0.3769	0.7815	0.2083	0.3267	0.3840
S19	0.2984	0.6216	0.1852	0.2925	0.3338
S20	0.4608	0.9366	0.3951	0.4721	0.5839
S21	0.4869	0.9784	0.5100	0.5362	0.6819
S22	0.4903	0.9690	0.7413	1.2006	1.7785
S1	0.0072	0.0021	5.5139	6.6347	
S24	0.4760	0.9650	0.4045	0.4707	0.5877
S58	0.2881	0.6031	0.1455	0.2558	0.2906
S26	0.3723	0.7731	0.2120	0.3355	0.3957
S27	0.5160	1.0364	0.4797	0.5038	0.6302
S28	0.4425	0.9074	0.2846	0.3876	0.4665
S29	0.3570	0.7229	0.5041	0.5545	0.6593
S30	0.4580	0.9316	0.3837	0.4627	0.5698
S31	0.4384	0.8972	0.3317	0.4318	0.5275
S32	0.4475	0.9079	0.3955	0.4604	0.5611
S33	0.4441	0.9068	0.3498	0.4414	0.5393
S34	0.4486	0.9162	0.3409	0.4326	0.5268
S35	0.4005	0.8261	0.2647	0.3800	0.4534
S51	0.2508	0.4796	0.1391	0.1829	0.2018
S37	0.5072	1.0058	0.6791	1.1507	1.7007
S58	0.2904	0.6099	0.1460	0.2615	0.2972
S58	0.3634	0.7543	0.2124	0.3321	0.3893
S58	0.2885	0.6057	0.1416	0.2586	0.2948

Table 7

					Peaking Indicators		Tilt Ratios		
	Average EO	± Range	N_o	k	sigma3	PI	alpha2 /beta1	alpha23 /beta12	alpha23 /beta23
S58			8.7447 6.8294	8 6	0.3362 0.2713	0.7030 0.5013	0.1557 0.2142	0.2803 0.3718	0.3250 0.4410
S57			0.0166	0	0.0000	0.0000			
S1	2.04	0.00	0.1898	0	0.0000	0.0000			
S2	7.85	0.01	7.7451	7	0.4531	0.8916	0.8588	1.2871	1.8545
S3	8.38	0.01	7.9638	7	0.4303	0.8587	0.6747	1.1143	1.5360
S4	8.23	0.01	7.9028	7	0.4389	0.8725	0.7210	1.1554	1.6089
S5	8.06	0.04	7.8351	7	0.4404	0.8716	0.7818	1.2109	1.7001
S6	6.86	0.03	7.2128	7	0.3538	0.6719	1.6589	1.8327	2.6706
S7	5.70	0.02	6.5054	6	0.2382	0.4296	3.5802	4.6769	8.0825
S8	8.84	0.01	8.1458	8	0.3999	0.8072	0.5634	0.6080	0.7481
S9	8.05	0.00	7.8342	7	0.4489	0.8884	0.7861	1.2264	1.7298
S10	8.74	0.02	8.1093	8	0.4057	0.8169	0.5859	0.6200	0.7692
S11	7.95	0.01	7.7845	7	0.4460	0.8800	0.8286	1.2502	1.7588
S58			8.7890	8	0.2989	0.6265	0.1456	0.2639	0.3020
S13	7.88	0.01	7.7408	7	0.4804	0.9450	0.8199	1.2563	1.8513
S14	8.84	0.02	8.1733	8	0.4717	0.9535	0.4533	0.5083	0.6365
S15	9.83	0.01	8.5591	8	0.3843	0.7950	0.2382	0.3571	0.4238
S16	8.56	0.00	8.0538	8	0.4903	0.9840	0.5271	0.5461	0.6945
S17	8.03	0.02	7.8155	7	0.4951	0.9787	0.7276	1.1847	1.7515
S18	9.90	0.01	8.6011	8	0.3769	0.7815	0.2083	0.3267	0.3840
S19	10.32	0.03	8.6791	8	0.2984	0.6216	0.1852	0.2925	0.3338
S20	9.03	0.03	8.2604	8	0.4608	0.9366	0.3951	0.4721	0.5839
S21	8.61	0.01	8.0760	8	0.4869	0.9784	0.5100	0.5362	0.6819
S22	8.01	0.02	7.8131	7	0.4903	0.9690	0.7413	1.2006	1.7785

					Peaking Indicators		Tilt Ratios		
	Average EO	± Range	N_o	k	sigma3	PI	alpha2 /beta1	alpha23 /beta12	alpha23 /beta23
S1	2.05	0.00	0.1689	0	0.0072	0.0021	5.5139	6.6347	
S24	8.92	0.01	8.2193	8	0.4760	0.9650	0.4045	0.4707	0.5877
S58			8.7645	8	0.2881	0.6031	0.1455	0.2558	0.2906
S26	9.94	0.01	8.6230	8	0.3723	0.7731	0.2120	0.3355	0.3957
S27	8.52	0.02	8.0685	8	0.5160	1.0364	0.4797	0.5038	0.6302
S28	9.36	0.01	8.4107	8	0.4425	0.9074	0.2846	0.3876	0.4665
S29	9.06	0.01	8.1992	8	0.3570	0.7229	0.5041	0.5545	0.6593
S30	9.05	0.02	8.2750	8	0.4580	0.9316	0.3837	0.4627	0.5698
S31	9.31	0.02	8.3772	8	0.4384	0.8972	0.3317	0.4318	0.5275
S32	9.00	0.02	8.2333	8	0.4475	0.9079	0.3955	0.4604	0.5611
S33	9.22	0.00	8.3398	8	0.4441	0.9068	0.3498	0.4414	0.5393
S34	9.22	0.00	8.3422	8	0.4486	0.9162	0.3409	0.4326	0.5268
S35	9.66	0.02	8.5081	8	0.4005	0.8261	0.2647	0.3800	0.4534
S51	10.54	0.05	7.3126	7	0.2508	0.4796	0.1391	0.1829	0.2018
S37	8.09	0.00	7.8660	7	0.5072	1.0058	0.6791	1.1507	1.7007
S58	10.59	0.00	8.8236	8	0.2904	0.6099	0.1460	0.2615	0.2972
S58	9.98	0.02	8.6171	8	0.3634	0.7543	0.2124	0.3321	0.3893
S58			8.8165	8	0.2885	0.6057	0.1416	0.2586	0.2948

Table 8

	Nominal EO	Average EO (LC/MS)	Cloud point	NMR Total EO/alkyl	NMR Vinyl-PEG wt%**	HPLC PEG wt %	Total EGDs wt.%	TAE*** Calc.wt %
S58	10.0 blend	0.00 0.00						
S57	2.0	0.00						
S1	10.0	2.04	nm	2.0	0	0.0	0	(100% CAE)
S2	10.5	7.85	63	9.3	10.7	3.1	13.8	86.2
S3	10.5	8.38	72	9.9	10.0	2.8	12.8	87.2
S4	10.5	8.23	73	9.7	10.6	3.2	13.8	86.2
S5	10.5	8.06	78	9.2	8.8	2.8	11.6	88.4
S6	8.0	6.86	89	7.2	3.8	1.4	5.2	94.8
S7	6.0	5.70	> 90	5.7	2.0	0.9	2.9	97.1
S8	10.5	8.84	40	9.9	5.9	2.0	7.9	92.1
S9	10.5	8.05	70	9.2	9.1	2.4	11.5	88.5
S10	10.5	8.74	< RT	10.1	6.9	2.4	9.3	90.7
S11	10.0	7.95	45	9.0	5.4	2.4	7.8	92.2
S58	10.0	0.00	NA					
S13	10.0	7.88	Undissolved	8.1	1.7	1.3	3.0	97.0
S14	10.0	8.84	30	9.3	1.8	1.3	3.1	96.9
S15	10.0	9.83	< RT	10.7	2.3	1.3	3.6	96.4
S16	10.0	8.56	37	8.9	2.1	1.4	3.5	96.5
S17	10.0	8.03	43	9.0	2.1	1.1	3.3	96.8
S18	10.0	9.90	< RT	10.8	3.2	1.9	5.1	94.9
S19	10.0	10.32	< RT	10.7	0.0	2.8	2.8	97.2
S20	10.0	9.03	50	9.5	2.2	1.2	3.4	96.6
S21	10.0	8.61	65	9.0	2.4	1.4	3.8	96.2
S22	10.0	8.01	77	8.4	2.3	1.2	3.5	96.5
S1	2.0	2.05	nm	2.1	0	0.0	0	(100% CAE)

	Nominal EO	Average EO (LC/MS)	Cloud point	NMR Total EO/alkyl	NMR Vinyl-PEG wt%**	HPLC PEG wt %	Total EGDs wt.%	TAE*** Calc.wt %
S24	10.0	8.92	58	9.6	2.8	1.6	1.6	95.6
S58	10.0	0.00	NA					
S26	10.0	9.94	32	10.7	1.9	2.2	2.2	95.9
S27	9.0	8.52	66	9.1	2.7	2.0	2.0	95.3
S28	10.0	9.36	83	10.1	2.8	2.7	2.7	94.5
S29	9.0	9.06	57	9.2	0.6	1.7	1.7	97.7
S30	9.0	9.05	65	9.4	2.1	1.2	1.2	96.7
S31	9.0	9.31	59	9.5	1.5	0.9	0.9	97.6
S32	9.0	9.00	69	9.2	1.5	0.9	0.9	97.6
S33	9.0	9.22	62	9.5	1.5	0.9	0.9	97.6
S34	9.0	9.22	Undissolved	9.4	1.5	0.9	0.9	97.6
S35	10.0	9.66	50	10.3	1.9	0.9	0.9	97.2
S51	blend	10.54	nm	4.9****	0.0	0.0	0	100.0
S37	10.0	8.09	83	8.4	2.6	1.4	1.4	96.0
S58	10.0	10.59	Undissolved	10.9	0.0	1.2	1.2	98.8
S58	10.5	9.98	42	10.2	0.0	1.1	1.1	98.9
S58	10.0	0.00	NA					

*Corrected NMR still includes the PEG and vinyl-PEG in the EO/Alkyl and should be higher than LC/MS EO on TAE. The more PEG and Vinyl-PEG in the sample the larger the differences.
** Vinyl-PEG calculated from NMR data using average MW calculated from one half the EO/alkyl. Average MW for vinyl PEG may be too high when large amounts of vinyl-PEG are present.
***TAE wt% = 100 - PEG - (vinyl-PEG).
****This included 2EO of CAE while LC/MS data does not.

Example 10

Aqueous concentrate compositions were prepared containing potassium glyphosate salt, reported in g a.e./ liter, surfactants (shown above), and various other ingredients (shown above.)

Example 10

Table 9

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
C1A043A	540	4	K	S41	6	S1	4	na	na	C1	0.03	C2	0.54	60/40	70
C2A043B	540	4	K	S41	6.5	S1	3.5	na	na	C1	0.03	C2	0.54	65/35	51
C1B047A	540	4	K	S41	5.5	S1	4.5	na	na	C1	0.03	C2	0.54	55/45	81
C2B047B	540	4	K	S41	5.5	S1	4.5	na	na	C1	0.03	na	na	55/45	82
C3B047C	540	4	K	S41	6	S1	4	na	na	C1	0.03	na	na	60/40	71
C4B047D	540	4	K	S41	5.85	S1	3.15	na	na	C1	0.03	na	na	58.5/31.5	54
D1A048A	540	5	K	S41	5.2	S1	2.8	na	na	C1	0.03	na	na	65/35	72.5
D2B048C	540	4.8	K	S41	5.95	S1	2.55	na	na	C1	0.03	na	na	70/30	57
E1A051A	540	5	K	S41	5.6	S1	2.4	na	na	C1	0.03	na	na	70/30	53
E1B053A	540	4	K	S41	6	S1	4	na	na	C1	0.03	na	na	60/40	nm
E1C073A	540	4	K	S2	6	S1	4	na	na	C1	0.03	na	na	60/40	nm
F1A390B	540	4.8	K	S2	5.95	S1	2.55	na	na	C1	0.03	C4	1.5	70/30	72
F1B093A	600	5.2	K	S6	5.81	S1	2.49	na	na	C1	0.01	na	na	70/30	nm
F1C902	600	5.2	K	S42	6	S6	1	S1	1.5	C1	0.01	na	na	na	59
F1D336B	540	4	K	S2	6	S1	4	na	na	C1	0.03	na	na	60/40	88
F1E336C	540	4	K	S3	6	S1	4	na	na	C1	0.03	na	na	60/40	83
F1F336D	540	4	K	S4	6	S1	4	na	na	C1	0.03	na	na	60/40	84
F1F336E	540	4	K	S5	6	S1	4	na	na	C1	0.03	na	na	60/40	89
F1H377B	540	4.8	K	S2	5.95	S1	2.55	na	na	C1	0.05	na	na	70/30	81

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
F1I377C	540	4.8	K	S3	5.95	S1	2.55	na	na	C1	0.05	na	na	70/30	70
F1J377D	540	4.8	K	S4	5.95	S1	2.55	na	na	C1	0.05	na	na	70/30	73
F1K377E	540	4.8	K	S5	5.95	S1	2.55	na	na	C1	0.05	na	na	70/30	81
G1A382B	600	5.2	K	S47	8.3	na	na	na	na	C1	0.05	na	na	60/40	73
G1B382C	600	5.2	K	S48	8.3	na	na	na	na	C1	0.05	na	na	50/50	88
G1C382E	600	5.2	K	S2	5.4	S1	2.91	na	na	C1	0.05	na	na	65/35	61
G1D397E	600	5.2	K	S6	5.81	S1	2.49	na	na	C1	0.05	na	na	70/30	60
G1E397J	600	5.2	K	S42	6.3	S6	1	S1	1	C1	0.05	na	na	na	51
G1F903A	600	5.2	K	S42	6.3	S7	1	S1	1	C1	0.05	na	na	na	56
G1G903B	600	5.2	K	S42	6	S6	1	S1	1.3	C1	0.05	na	na	na	57
G1H903D	600	5.2	K	S43	7.3	S7	1	na	na	C1	0.05	na	na	na	52
G1I965A	540	4.8	K	S2	5.95	S1	2.55	na	na	C8	1.5	C1	0.05	70/30	nm
G1J965B	540	4.8	K	S2	5.95	S1	2.55	na	na	C7	1.5	C1	0.05	70/30	nm
G1K965C	540	4.8	K	S2	5.95	S1	2.55	na	na	C9	1.5	C1	0.05	70/30	nm
G1L965D	540	4.8	K	S2	5.95	S1	2.55	na	na	C10	1.5	C1	0.05	70/30	nm
G1M965E	540	4.8	K	S2	5.95	S1	2.55	na	na	C6	1.5	C1	0.05	70/30	nm
G1N965F	540	4.8	K	S2	5.95	S1	2.55	na	na	C11	1.5	C1	0.05	70/30	nm
H1A984B	600	5.2	K	S2	4.98	S1	3.32	na	na	C1	0.05	na	na	60/40	66
H1B984C	600	5.2	K	S2	4.38	S1	2.92	na	na	C1	0.05	na	na	52/48	74
H1C984D	600	6.8	K	S2	3.78	S1	2.52	na	na	C1	0.05	na	na	60/40	81
H1D984E	600	6.8	K	S2	3.78	S1	2.52	na	na	C1	0.05	C11	2	60/40	82

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
H1E984F	600	6.8	K	S2	4.1	S1	2.21	na	na	C1	0.05	na	na	65/35	70
H1F984G	600	6.8	K	S2	4.41	S1	1.89	na	na	C1	0.05	na	na	70/30	53
J1A984H	600	6	K	S2	4.75	S1	2.56	na	na	C1	0.05	na	na	65/35	57
J1B984I	600	6.1	K	S2	4.55	S1	2.45	na	na	C1	0.05	na	na	65/35	61
J1C984J	600	6.6	K	S2	4.23	S1	2.28	na	na	C1	0.05	na	na	65/35	66
J1D926A	540	4	K	S51	10	na	na	na	na	C1	0.038	C2	0.54	55/45	58
J1E926C	540	4	K	S26	5.5	S1	4.5	na	na	C1	0.038	C2	0.54	55/45	69
J1F943A	540	4	K	S24	6	S1	4	na	na	C1	0.05	na	na	60/40	68
J1G943B	540	4	K	S24	5.5	S1	4.5	na	na	C1	0.05	na	na	55/45	79
J1H954A	540	4.5	K	S24	5.75	S1	3.1	na	na	C1	0.05	na	na	65/35	63
J1I954A	540	5.3	K	S37	5.25	S1	2.25	na	na	C1	0.05	na	na	70/30	82
J1J954B	540	5.3	K	S37	5.63	S1	1.88	na	na	C1	0.05	na	na	75/25	64
J1K955A	540	4.9	K	S37	5.71	S1	2.45	na	na	C1	0.05	na	na	70/30	74
J1L955B	540	4.9	K	S37	5.3	S1	2.85	na	na	C1	0.05	na	na	65/35	84
J1M956A	540	4.7	K	S37	5.53	S1	2.98	na	na	C1	0.05	na	na	65/35	83
J1N981A	540	4.7	K	S37	5.95	S1	2.55	na	na	C1	0.05	C15	0.1	70/30	65
K2M978A	540	4.7	K	S24	4.68	S53	2.55	S1	1.28	C1	0.05	na	na	na	77
K2N978B	540	4.7	K	S24	4.25	S53	2.55	S1	1.7	C1	0.05	na	na	na	83
K4O978C	540	4.7	K	S24	4	S53	2.55	S1	1.96	C1	0.05	na	na	na	88
L5P419A	540	4	K	S10	5.5	S1	4.5	na	na	C1	0.05	na	na	55/45	84
M4Q419B	540	4	K	S10	6	S1	4	na	na	C1	0.05	na	na	60/40	73

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
N2R419C	540	4	K	S10	6.5	S1	3.5	na	na	C1	0.05	na	na	65/35	56
R3N456A	360	4.7	K	S17	4.34	S1	1.86	na	na	C1	0.05	na	na	70/30	>90
O4S957A	360	3	K	S17	9.65	na	na	na	na	C1	0.05	na	na	na	>90
M4S957B	360	4	K	S17	7.25	na	na	na	na	C1	0.05	na	na	na	>90
A6A478	360	5	K	S17	5.8	na	na	na	na	C1	0.05	na	na	na	nm
C8B483A	540	4.7	K	S24	5.95	S1	2.55	na	na	C1	0.05	na	na	70/30	50
D2C483B	540	4.7	K	S24	5.78	S1	2.72	na	na	C1	0.05	na	na	68/32	60
E7D483C	540	4.7	K	S24	5.53	S1	2.98	na	na	C1	0.05	na	na	65/35	70
F9E483D	540	4.7	K	S24	5.27	S1	3.23	na	na	C1	0.05	na	na	62/38	80
L4F491A	540	4	K	S24	5.5	S54	2.25	S1	2.25	C1	0.05	na	na	na	nm
N5H491B	540	4	K	S24	5.5	S54	2.7	S1	1.8	C1	0.05	na	na	na	nm
Q6M056C	540	4.3	K	S56	9.25	na	na	na	na	C1	0.05	na	na	65/35	61
T5N056D	540	4.3	K	S56	9.2	na	na	na	na	C1	0.05	C17	1.42	65/35	59
V1O056E	540	4.7	K	S55	8.45	na	na	na	na	C1	0.05	C17	1.42	55/45	62
W2R030	540	4	K	S34	4	S1	3	S42	3	C18	0.77	na	na	na	62
Z3Q032	540	4	K	S34	4	S1	3	S42	3	na	na	na	na	na	61
B8A153	360	5.00	K	S28	2.57	S27	2.50	S57	1.39	na	na	na	na	78/22	>95
C9C152	360	5.00	K	S28	2.28	S27	2.22	S57	1.95	na	na	na	na	70/30	>95
L6Z151	360	5.00	K	S28	2.00	S27	1.94	S57	2.52	na	na	na	na	61/39	>95
N5D150	360	4.00	K	S28	3.21	S27	3.12	S57	1.74	na	na	na	na	78/22	>95
R4F149	360	4.00	K	S28	2.85	S27	2.78	S57	2.44	na	na	na	na	70/30	>95

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
T2I148	360	4.00	K	S28	2.50	S27	2.43	S57	3.15	na	na	na	na	61/39	>95
A7L147	360	3.00	K	S28	4.28	S27	4.17	S57	2.32	na	na	na	na	78/22	>95
Z8A146	360	3.00	K	S28	3.80	S27	3.70	S57	3.26	na	na	na	na	70/30	>95
Q4C145	360	3.00	K	S28	3.33	S27	3.24	S57	4.20	na	na	na	na	61/39	>95
Q4A134	450	5.00	K	S28	2.73	S27	2.66	S57	1.48	na	na	na	na	78/22	>95
R7T133	450	5.00	K	S28	2.43	S27	2.37	S57	2.08	na	na	na	na	70/30	>95
T2L132	450	5.00	K	S28	2.13	S27	2.07	S57	2.68	na	na	na	na	61/39	>95
L3V653D	450	4.29	K	S28	2.66	S27	2.59	S57	2.78	na	na	na	na	65/35	>95
M5W653C	450	4.29	K	S28	2.48	S27	2.41	S57	3.13	na	na	na	na	61/39	>95
N6B653B	450	4.29	K	S28	2.30	S27	2.24	S57	3.48	na	na	na	na	57/43	>95
O8C653A	450	4.29	K	S28	2.13	S27	2.07	S57	3.83	na	na	na	na	52/48	>95
Q9D131	450	3.98	K	S28	3.43	S27	3.34	S57	1.86	na	na	na	na	78/22	87
R2F130	450	3.98	K	S28	3.05	S27	2.97	S57	2.61	na	na	na	na	70/30	>95
T3F129	450	3.98	K	S28	2.67	S27	2.60	S57	3.37	na	na	na	na	61/39	>95
L4M646D	450	3.91	K	S28	2.91	S27	2.83	S57	3.04	na	na	na	na	65/35	>95
P6N646C	450	3.91	K	S28	2.72	S27	2.64	S57	3.42	na	na	na	na	61/39	>95
A8R646B	450	3.91	K	S28	2.52	S27	2.46	S57	3.81	na	na	na	na	57/43	>95
C2P646A	450	3.91	K	S28	2.33	S27	2.27	S57	4.19	na	na	na	na	52/48	>95
F1A639D	450	3.60	K	S28	3.16	S27	3.08	S57	3.31	na	na	na	na	65/35	>95
G4D639C	450	3.60	K	S28	2.95	S27	2.87	S57	3.72	na	na	na	na	61/39	>95
H7C639B	450	3.60	K	S28	2.74	S27	2.67	S57	4.14	na	na	na	na	57/43	>95

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
L9N639A	450	3.60	K	S28	2.53	S27	2.46	S57	4.55	na	na	na	na	52/48	>95
N2L631D	450	3.33	K	S28	3.42	S27	3.33	S57	3.57	na	na	na	na	65/35	>95
P3F631C	450	3.33	K	S28	3.19	S27	3.10	S57	4.02	na	na	na	na	61/39	>95
R9K631B	450	3.33	K	S28	2.96	S27	2.88	S57	4.47	na	na	na	na	57/43	>95
T7L631A	450	3.33	K	S28	2.73	S27	2.66	S57	4.92	na	na	na	na	52/48	>95
A4Q128	450	3.00	K	S28	4.56	S27	4.44	S57	2.47	na	na	na	na	78/22	54
C7L127	450	3.00	K	S28	4.05	S27	3.94	S57	3.47	na	na	na	na	70/30	87
F9A126	450	3.00	K	S28	3.54	S27	3.45	S57	4.47	na	na	na	na	61/39	>95
D4B374	480	5.00	K	S28	2.88	S27	2.80	S57	1.56	na	na	na	na	78/22	66
E6D373	480	5.00	K	S28	2.56	S27	2.49	S57	2.19	na	na	na	na	70/30	>95
Q2C372	480	5.00	K	S28	2.24	S27	2.18	S57	2.82	na	na	na	na	61/39	>95
R3T652D	480	4.57	K	S28	2.62	S27	2.55	S57	2.74	na	na	na	na	65/35	>95
P7Q652C	480	4.57	K	S28	2.45	S27	2.38	S57	3.08	na	na	na	na	61/39	>95
L6R652B	480	4.57	K	S28	2.27	S27	2.21	S57	3.43	na	na	na	na	57/43	>95
F3V652A	480	4.57	K	S28	2.10	S27	2.04	S57	3.77	na	na	na	na	52/48	>95
T1W645D	480	4.17	K	S28	2.87	S27	2.79	S57	3.00	na	na	na	na	65/35	>95
M5Z645C	480	4.17	K	S28	2.68	S27	2.61	S57	3.38	na	na	na	na	61/39	>95
N6A645B	480	4.17	K	S28	2.49	S27	2.42	S57	3.76	na	na	na	na	57/43	>95
Q8D645A	480	4.17	K	S28	2.30	S27	2.24	S57	4.13	na	na	na	na	52/48	>95
R9E377	480	4.00	K	S28	3.60	S27	3.50	S57	1.95	na	na	na	na	78/22	45
P8F376	480	4.00	K	S28	3.20	S27	3.11	S57	2.74	na	na	na	na	70/30	81

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
Z4G375	480	4.00	K	S28	2.80	S27	2.72	S57	3.52	na	na	na	na	61/39	>95
D2H638D	480	3.84	K	S28	3.12	S27	3.04	S57	3.26	na	na	na	na	65/35	>95
E6I638C	480	3.84	K	S28	2.91	S27	2.84	S57	3.67	na	na	na	na	61/39	>95
F5N638B	480	3.84	K	S28	2.70	S27	2.63	S57	4.08	na	na	na	na	57/43	>95
H7T638A	480	3.84	K	S28	2.50	S27	2.43	S57	4.49	na	na	na	na	52/48	>95
N3O630D	480	3.56	K	S28	3.37	S27	3.28	S57	3.52	na	na	na	na	65/35	>95
A4V630C	480	3.56	K	S28	3.15	S27	3.06	S57	3.97	na	na	na	na	61/39	>95
F9A630B	480	3.56	K	S28	2.92	S27	2.84	S57	4.41	na	na	na	na	57/43	>95
Q6B630A	480	3.56	K	S28	2.70	S27	2.62	S57	4.85	na	na	na	na	52/48	>95
R7C380	480	3.00	K	S28	4.79	S27	4.67	S57	2.60	na	na	na	na	78/22	25
P5D379	480	3.00	K	S28	4.26	S27	4.15	S57	3.65	na	na	na	na	70/30	48
L4F378	480	3.00	K	S28	3.73	S27	3.63	S57	4.70	na	na	na	na	61/39	82
N6Q651D	510	4.86	K	S28	2.59	S27	2.52	S57	2.71	na	na	na	na	65/35	95
F8R651C	510	4.86	K	S28	2.42	S27	2.35	S57	3.05	na	na	na	na	61/39	>95
H2T651B	510	4.86	K	S28	2.24	S27	2.18	S57	3.39	na	na	na	na	57/43	>95
K1L651A	510	4.86	K	S28	2.07	S27	2.02	S57	3.73	na	na	na	na	52/48	>95
L3M644D	510	4.43	K	S28	2.84	S27	2.76	S57	2.96	na	na	na	na	65/35	>95
O5N644C	510	4.43	K	S28	2.65	S27	2.58	S57	3.34	na	na	na	na	61/39	>95
V6A644B	510	4.43	K	S28	2.46	S27	2.39	S57	3.71	na	na	na	na	57/43	>95
W8D644A	510	4.43	K	S28	2.27	S27	2.21	S57	4.08	na	na	na	na	52/48	>95
A9E637D	510	4.08	K	S28	3.08	S27	3.00	S57	3.22	na	na	na	na	65/35	80

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
C4F637C	510	4.08	K	S28	2.88	S27	2.80	S57	3.63	na	na	na	na	61/39	93
D6J637B	510	4.08	K	S28	2.67	S27	2.60	S57	4.03	na	na	na	na	57/43	>95
E7K637A	510	4.08	K	S28	2.47	S27	2.40	S57	4.44	na	na	na	na	52/48	>95
Q8L629D	510	3.78	K	S28	3.33	S27	3.24	S57	3.48	na	na	na	na	65/35	80
L2M629C	510	3.78	K	S28	3.11	S27	3.02	S57	3.92	na	na	na	na	61/39	92
P10629B	510	3.78	K	S28	2.89	S27	2.81	S57	4.35	na	na	na	na	57/43	>95
R3A629A	510	3.78	K	S28	2.66	S27	2.59	S57	4.79	na	na	na	na	52/48	>95
B4I650	540	5.14	K	S28	2.56	S27	2.49	S57	2.68	na	na	na	na	65/35	68
D6A649	540	5.14	K	S28	2.39	S27	2.33	S57	3.01	na	na	na	na	61/39	80
F2C648	540	5.14	K	S28	2.22	S27	2.16	S57	3.35	na	na	na	na	57/43	91
A3D647	540	5.14	K	S28	2.05	S27	1.99	S57	3.69	na	na	na	na	52/48	>95
Q5F643	540	4.70	K	S28	2.80	S27	2.73	S57	2.93	na	na	na	na	65/35	60
L7R642	540	4.70	K	S28	2.62	S27	2.55	S57	3.30	na	na	na	na	61/39	75
M4Q641	540	4.70	K	S28	2.43	S27	2.37	S57	3.67	na	na	na	na	57/43	88
N5Z640	540	4.70	K	S28	2.24	S27	2.18	S57	4.04	na	na	na	na	52/48	92
O8Y635	540	4.32	K	S28	3.05	S27	2.97	S57	3.19	na	na	na	na	65/35	48
P9W634	540	4.32	K	S28	2.85	S27	2.77	S57	3.59	na	na	na	na	61/39	66
T2A633	540	4.32	K	S28	2.64	S27	2.57	S57	3.99	na	na	na	na	57/43	80
Z3V632	540	4.32	K	S28	2.44	S27	2.37	S57	4.39	na	na	na	na	52/48	86
A4C628	540	4.00	K	S28	3.29	S27	3.20	S57	3.44	na	na	na	na	65/35	42
F6D627	540	4.00	K	S28	3.07	S27	2.99	S57	3.87	na	na	na	na	61/39	62

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
Q8E626	540	4.00	K	S28	2.85	S27	2.78	S57	4.31	na	na	na	na	57/43	77
A1F625	540	4.00	K	S28	2.63	S27	2.56	S57	4.74	na	na	na	na	52/48	85
D4L908	540	4.00	K	S27	6.00	S57	4.00	C1	0.01	C18	0.29	C2	0.48	60/40	61
E7O909	540	4.32	K	S27	5.74	S57	3.52	C1	0.01	C18	0.29	C2	0.48	62/38	60
F9P910	540	4.70	K	S27	5.45	S57	3.07	C1	0.01	C18	0.29	C2	0.48	64/36	58
L6Q911	540	5.14	K	S27	5.13	S57	2.64	C1	0.01	C18	0.29	C2	0.48	66/34	61
Z3A425	540	4.00	K	S27	5.00	S57	5.00	C1	0.01	C18	0.29	C2	0.48	50/50	81
X5C426	540	4.00	K	S27	5.50	S57	4.50	C1	0.01	C18	0.29	C2	0.48	55/45	75
B4A427	540	4.00	K	S27	6.00	S57	4.00	C1	0.01	C18	0.29	C2	0.48	60/40	59
D6P419	480	4.00	K	S27	6.75	S57	2.13	C1	0.01	C18	0.26	C2	0.44	76/24	61
F9L418	480	4.32	K	S27	6.24	S57	1.97	C1	0.01	C18	0.26	C2	0.44	76/24	68
M2T417	480	4.71	K	S27	5.88	S57	1.66	C1	0.01	C18	0.26	C2	0.44	78/22	68
N3R416	480	5.16	K	S27	5.50	S57	1.38	C1	0.01	C18	0.26	C2	0.44	80/20	57
Q1F413A	480	4.00	K	S27	6.39	S57	2.49	C1	0.01	C18	0.26	C2	0.44	72/28	83
Z1Q413B	480	4.00	K	S27	6.75	S57	2.13	C1	0.01	C18	0.26	C2	0.44	76/24	63
X4G414	480	5.16	K	S27	5.64	S57	1.24	C1	0.01	C18	0.26	C2	0.44	82/18	59
R7L913	540	4.00	K	S28	6.00	S57	4.00	C1	0.01	C18	0.29	C2	0.48	60/40	61
F8M914	540	4.32	K	S28	6.11	S57	3.15	C1	0.01	C18	0.29	C2	0.48	66/34	60
O8N013B	480	4.00	K	S28	6.39	S57	2.49	C1	0.01	C18	0.26	C2	0.44	72/28	52
L5P014B	480	5.16	K	S28	5.36	S57	1.51	C1	0.01	C18	0.26	C2	0.44	78/22	51
P7T915	540	4.00	K	S58	5.00	S57	5.00	C1	0.01	C18	0.29	C2	0.48	50/50	78

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	Cloud Point
Q9S916	540	4.00	K	S58	5.50	S57	4.50	C1	0.01	C18	0.29	C2	0.48	55/45	64
Z6F917	540	4.00	K	S58	6.00	S57	4.00	C1	0.01	C18	0.29	C2	0.48	60/40	42
W4G949	540	4.00	K	S59	6.00	S57	4.00	na	na	na	na	na	na	60/40	77
Y3I950	540	4.00	K	S60	6.00	S57	4.00	na	na	na	na	na	na	60/40	72
X1L951	540	4.00	K	S61	6.00	S57	4.00	na	na	na	na	na	na	60/40	61
Y2A952	540	4.00	K	S62	6.00	S57	4.00	na	na	na	na	na	na	60/40	50
A7D953	540	4.00	K	S63	6.00	S57	4.00	na	na	na	na	na	na	60/40	74
D8E954	540	4.00	K	S64	6.00	S57	4.00	na	na	na	na	na	na	60/40	67
E1F955	540	4.00	K	S65	6.00	S57	4.00	na	na	na	na	na	na	60/40	58
Q6A956	540	4.00	K	S66	6.00	S57	4.00	na	na	na	na	na	na	60/40	47

Example 11

Aqueous concentrate compositions were prepared containing a mixture of potassium and isopropylamine glyphosate salts, reported in g a. e./ liter, surfactants (shown above), and various other ingredients (shown above).

Example 11

Table 10

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Ratio (K:IPA)	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow :coco (wt./wt.)	Cloud Point
Q4A389	540	5.1	K/IPA	70/30	S19	4.32	S2	2.88	S1	0.8	C1	0.03	na	na	90/10	70
W7D074A	540	4.8	K/IPA	75/25	S19	4.59	S2	3.06	S1	0.85	C1	0.03	na	na	90/10	nm
Y2E349B	540	4.15	K/IPA	65/35	S44	10	na	na	na	na	C1	0.038	na	na	90/10	88
Z9F349F	540	4.15	K/IPA	75/25	S44	10	na	na	na	na	C1	0.038	na	na	90/10	73
B8Q349I	540	5	K/IPA	90/10	S44	8	na	na	na	na	C1	0.038	na	na	90/10	63
C6L349J	540	4	K/IPA	80/20	S44	10.15	na	na	na	na	C1	0.038	na	na	90/10	74
D5M349K	540	5.1	K/IPA	80/20	S44	8	na	na	na	na	C1	0.038	na	na	90/10	83
F3N360A	540	4	K/IPA	80/20	S2	10.16	S1	1.02	na	na	C1	0.038	na	na	90/10	70
L2O360B	540	4	K/IPA	80/20	S2	10.16	S1	1.02	na	na	C1	0.38	na	na	90/10	69
M4T360D	540	4	K/IPA	70/30	S45	6.09	S44	4.06	na	na	C1	0.038	na	na	90/10	61
Z1A360E	540	5.1	K/IPA	70/30	S45	4.8	S44	3.2	na	na	C1	0.038	na	na	90/10	69
Y5R360F	540	5.1	K/IPA	70/30	S45	8	na	na	na	na	C1	0.038	na	na	90/10	55
A6S366A	540	5.1	K/IPA	60/40	S45	4.8	S44	3.2	na	na	C1	0.038	na	na	90/10	78
B3W366B	540	5.1	K/IPA	70/30	S45	4.8	S44	3.2	na	na	C1	0.038	na	na	90/10	71
D9Y366C	540	4.8	K/IPA	75/25	S45	5.53	S44	2.98	na	na	C1	0.038	na	na	90/10	61
F7Z368A	540	5.1	K/IPA	80/20	S44	3.2	S45	4.8	na	na	C1	0.038	na	na	90/10	52
G4C385A	540	4.8	K/IPA	75/25	S49	7.65	S1	0.85	na	na	C1	0.038	na	na	90/10	61
H2D497A	540	135	K/IPA	80/20	S24	9	S1	1	na	na	C1	0.038	na	na	90/10	53
L1F497B	540	120	K/IPA	80/20	S24	8.1	S1	0.9	na	na	C1	0.038	na	na	90/10	58

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.): Surf(a.i.)	Salt Type	Ratio (K:IPA)	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow :coco (wt./wt.)	Cloud Point
F86497C	540	106	K/IPA	80/20	S24	7.2	S1	0.8	na	na	C1	0.038	na	na	90/10	64
A4C497D	540	135	K/IPA	70/30	S18	9.23	S1	1.02	na	na	C1	0.038	na	na	90/10	54
Z6D497E	540	120	K/IPA	70/30	S18	8.19	S1	0.91	na	na	C1	0.038	na	na	90/10	59
Y8F497F	540	106	K/IPA	70/30	S18	7.2	S1	0.8	na	na	C1	0.038	na	na	90/10	63
W5L497G	540	135	K/IPA	70/30	S24	10.25	na	na	na	na	C1	0.038	na	na	100	49
L3Q497H	540	120	K/IPA	70/30	S24	9.1	na	na	na	na	C1	0.038	na	na	100	55
M2R497I	540	106	K/IPA	70/30	S24	8	na	na	na	na	C1	0.038	na	na	100	59
Z2B500A	540	135	K/IPA	70/30	S24	9.23	S1	1.03	na	na	C1	0.038	na	na	90/10	70
N6T500B	540	120	K/IPA	70/30	S24	8.19	S1	0.91	na	na	C1	0.038	na	na	90/10	75
P9Y500C	540	106	K/IPA	70/30	S24	7.2	S1	0.8	na	na	C1	0.038	na	na	90/10	79

Example 12

Aqueous concentrate compositions were prepared containing potassium glyphosate salt or a blend of potassium and isopropyl amine glyphosate salts, reported in g a.e./ liter, surfactants (shown above), and various other ingredients (shown above). The pH of the compositions was adjusted by addition of isopropyl amine (C12), potassium hydroxide (C13), aqueous ammonium hydroxide (C14), or triethanol amine (C16).

Example 12

Table 11

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.):Surf(a.i.)	Salt Type	Ratio (K:IPA)	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow : coco (wt./wt.)	pH	Cloud Point
B4A929A	540	4.5	K/IPA	70/30	S24	7.24	S1	1.81	na	na	C1	0.038	C12	1	80/20	4.91	69
D7F929B	540	4.5	K/IPA	70/30	S24	7.24	S1	1.81	na	na	C1	0.038	C12	2	80/20	5.07	55
F9L929C	540	4.5	K/IPA	70/30	S24	7.69	S1	1.36	na	na	C1	0.038	C12	1	85/15	4.89	65
A6M929D	540	4.5	K/IPA	70/30	S24	7.69	S1	1.36	na	na	C1	0.038	C12	2	85/15	5.07	51
C2N957A	540	4.5	K	100	S52	8.9	na	na	na	na	C1	0.05	C12	1	60/40	4.87	66
L1P959A	540	4.3	K/IPA	70/30	S24	7.6	S1	1.9	na	na	C1	0.05	C12	1	80/20	4.89	69
M5Z959B	540	4.3	K/IPA	70/30	S24	7.39	S1	2.46	na	na	C1	0.05	C12	1	75/25	4.92	71
N6Q965A	540	5.3	K	100	S37	5.25	S1	2.25	na	na	C1	0.05	C12	1.5	70/30	4.93	65
P8Y965B	540	4.9	K	100	S37	5.3	S1	2.85	na	na	C1	0.05	C12	1.5	65/35	4.95	66
Y9Z965C	540	4.7	K	100	S37	5.53	S1	2.98	na	na	C1	0.05	C12	1.5	65/35	4.96	64
X8L966A	540	5.3	K	100	S24	4.5	S1	3	na	na	C1	0.05	C12	1.5	60/40	4.94	70
A7N966B	540	4.9	K	100	S24	4.89	S1	3.26	na	na	C1	0.05	C12	1.5	60/40	4.95	66
B6P980A	540	4.5	K	100	S24	4.9	S1	4.01	na	na	C1	0.05	C13	1.5	55/45	4.77	67
F2Y982A	540	4.5	K	100	S24	4.9	S1	4.01	na	na	C1	0.05	C13	2	55/45	4.88	63
G3X018A	540	4.5	K	100	S24	4.9	S1	4.01	na	na	C1	0.05	C14	2	55/45	4.8	69
H5A039	540	4.7	K	100	S24	5.1	S1	3.4	na	na	C1	0.05	C16	1.5	60/40	4.79	65
Y7D042A	540	4.5	K	100	S24	4.9	S1	4.01	na	na	C1	0.05	C16	2.5	55/45	4.88	76
X9F056A	540	4.7	K	100	S52	8.5	na	na	na	na	C1	0.05	C12	1.5	60/40	4.94	66
Z8G056B	540	4.7	K	100	S55	8.45	na	na	na	na	C1	0.05	C13	2.3	55/45	4.84	62

Example 13

An aqueous concentrate composition was prepared containing a di-ammonium salt of glyphosate, reported in g a.e./liter and surfactants (shown above).

Example 13

Table 12

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.):Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	Cloud Point
A1N572	450	4.5	2(NH_3OH)	S50	8.13	S27	4.48	na	na	na	na	na	na	<RT

Example 14

Aqueous concentrate compositions were prepared containing potassium glyphosate salt, reported in g a.e./liter, a polyethoxylated tallowamine surfactant (S34), and glycerine (C3).

Example 14

Table 13

Sample ID	Glyphosate (g a.e./L)	Gly(a.e.):Surf(a.i.)	Salt Type	Surf 1	wt%	Surf 2	wt%	Surf 3	wt%	Comp4	wt%	Comp 5	wt%	tallow: coco (wt./wt.)	Cloud Point
L4A012	360	120	K	S34	9.47	C3	4.8							na	91
M6D013	380	120	K	S34	9.47	C3	4.8							na	72
N8F034	360	103	K	S34	8.13	C3	6.55							na	85
O7G033	360	90	K	S34	7.12	C3	4.98							na	90
P2H036	360	90	K	S34	7.12	C3	6.96							na	88

Example 15

[00166] This example details tests conducted to evaluate the herbicidal effectiveness of spray compositions containing an exogenous chemical (i.e., glyphosate salt) described above in Examples 10-13.

[00167] The effectiveness of the compositions relative to a standard (Roundup® WeatherMAX) was determined at various application rates for a variety of plant species (velvetleaf, waterhemp, lambsquarter, barnyardgrass, soybeans, pitted morningglory, purslane, and prickly sida). Multiple tests were performed for various compositions. The results of a t-test comparing the performance of the various compositions to Roundup® WeatherMAX, pooled across application rates and multiple tests, are set forth in Table 14. Where performance of the samples varied from the standard, mean differences are reported at both 95%(*) and 99%(**) confidence levels.

[00168] The compositions were generally tested in accordance with the following procedure.

[00169] Seeds of the plant species indicated were planted in 85 mm square pots in a soil mix; the soil mix may be previously steam sterilized and prefertilized with, for example, a 12-12-12 NPK slow release fertilizer at a rate of approximately 3.6 kg/m^3. The pots were placed in a greenhouse with sub-irrigation. About one week after emergence, seedlings were thinned as needed, including removal of any unhealthy or abnormal plants, to create a uniform series of test pots.

[00170] The plants were maintained for the duration of the test in the greenhouse where they received a minimum of 14 hours of light per day. If natural light was insufficient to achieve the daily requirement, artificial light with an intensity of approximately 600 microeinsteins

was used to make up the difference. Exposure temperatures were not precisely controlled but averaged about 27°C during the day and about 21°C during the night with the relative humidity ranging from 25% to 75%. Plants were sub-irrigated throughout the test to ensure adequate soil moisture levels.

[00171] Application of glyphosate compositions was typically made by spraying with a track sprayer fitted with a Teejet 9501E flat fan nozzle with air pressure set at a minimum of 24 psi (165 kPa). The height of the spray nozzle was generally about 16 inches above the top of the plant material and generally calibrated to deliver a spray volume of 93 liters per hectare (l/ha). Treatments were made using dilute aqueous compositions. These could be prepared as spray compositions directly from their ingredients, or by dilution with water of preformulated concentrate compositions. The rate of glyphosate addition is not narrowly critical and typically ranges from 75 g a.e./ha to 800 g a.e./ha. After treatment, pots were returned to the greenhouse until ready for evaluation.

[00172] For evaluation of herbicidal effectiveness, all plants in the test were typically examined by a single practiced technician, who recorded percent control relative to an untreated check, a visual measurement of the effectiveness of each treatment by comparison with plants not treated with an herbicide.

Table 14

T-Test Pairwise Mean Comparisons For 60 Experiments
Formulations compared to Roundup® WeatherMAX as a Standard - Overall and by Species

**(99%)	Formulation is more/less efficacious than standard (p < 0.01)
*(95%)	Formulation is more/less efficacious than standard (p < 0.05)
I	*Formulation efficacy similar to standard (p<0.05)*

#Trials	Species	Composition (Roundup® WeatherMAX)	Mean	Composition Mean	Mean Diff	P-Value	n
	All	F1D366B	80.3	87.5	-7.2**	0.000	18
	All	F1E366C	80.3	84.4	-4.2**	0.005	18
	All	Z1A360E	80.3	83.6	-3.3*	0.014	18
	All	C1B047A	65.0	68.0	*-3.0*	0.426	5
	All	C3B047C	65.0	68.0	*-3.0*	0.305	5
	All	E1A051A	65.0	68.0	*-3.0*	0.208	5
	All	Z2B500A	71.4	74.1	-2.7**	0.002	210
	All	M2R497I	69.7	72.0	-2.4*	0.011	126
	All	M5Z959A	72.9	74.9	*-2.0*	0.193	54
	All	C4B047D	65.0	67.0	*-2.0*	0.178	5
	All	M4T360D	80.3	81.9	*-1.7*	0.250	18
	All	C2B047B	65.0	66.0	*-1.0*	0.704	5
	All	A6S366A	80.3	80.6	*-0.3*	0.772	18
	All	J1E926C	54.6	54.2	*0.4*	0.759	24
	All	N6Q965A	74.1	73.3	*0.8*	0.616	30
	All	H1A984B	67.5	66.7	*0.8*	0.843	12

#Trials	Species	Composition (Roundup® WeatherMAX)	Mean	Composition Mean	Mean Diff	P-Value	n
	All	X9Z965C	74.1	73.0	*1.1*	0.490	30
	All	P9Y500C	68.2	67.0	*1.2*	0.251	100
	All	Y8F497F	68.3	67.0	*1.3*	0.230	96
	All	J1F943A	76.4	74.9	*1.5*	0.204	173
	All	J1D926A	54.6	52.7	*1.9*	0.185	24
	All	H1E984F	67.5	65.4	*2.1*	0.435	12
	All	N6T500B	68.3	65.9	2.3*	0.028	96
	All	J1C984J	67.5	64.6	*2.9*	0.487	12
	All	H1D984E	67.5	64.2	*3.3*	0.180	12
	All	F2Y982A	76.4	72.5	3.9*	0.013	123
	All	H1C984D	67.5	61.3	6.3*	0.036	12
	All	J1B984I	67.5	61.3	*6.3*	0.146	12
	All	H1B984C	67.5	57.9	9.6**	0.003	12
12	Velvetleaf	L1P959A	67.5	85.0	*-17.5*	0.077	4
12	" "	B3W366B	85.0	90.8	-5.8**	0.001	6
12	" "	Z2B500A	75.4	78.4	-3.1*	0.034	28
12	" "	P9Y500C	75.4	77.7	*-2.4*	0.105	28
12	" "	M2R497I	79.2	80.6	*-1.5*	0.254	36
12	" "	J1E926C	62.9	64.2	*-1.3*	0.389	12
12	" "	F1E366C	85.0	85.8	*-0.8*	0.363	6
12	" "	M4T360D	85.0	85.0	*0.0*	1.000	6
12	" "	Z1A360E	85.0	85.0	*0.0*	1.000	6
12	" "	A6S366A	85.0	85.0	*0.0*	1.000	6
12	" "	N6T500B	76.7	76.6	*0.1*	0.960	24
12	" "	Y8F497F	76.7	75.4	*1.3*	0.247	24
12	" "	X9Z965C	84.2	82.2	*2.0*	0.166	12
12	" "	J1D926A	62.9	60.8	*2.1*	0.358	12
12	" "	N6Q965A	84.2	80.5	*3.7*	0.066	12
12	" "	J1F943A	63.8	58.9	*4.9*	0.250	24
12	" "	F2Y982A	43.3	35.0	*8.3*	0.241	12
12	Waterhemp	M5Z959A	84.7	92.3	-7.7*	0.025	6

#Trials	Species	Composition (Roundup® WeatherMAX)	Mean	Composition Mean	Mean Diff	P-Value	n
12	" "	Z2B500A	88.4	93.3	-4.9*	0.035	30
12	" "	J1F943A	88.5	88.9	*-0.4*	0.789	45
12	" "	F2Y982A	89.1	84.8	*4.3*	0.139	45
12	Lambsquarter	Z2B500A	73.2	78.4	-5.2**	0.010	62
12	" "	M5Z959A	73.1	72.8	*0.3*	0.865	38
12	" "	J1F943A	76.3	73.9	*2.4*	0.209	80
12	" "	F2Y982A	73.8	71.0	*2.8*	0.122	66
3	Barnyard Grass	Y8F497F	64.3	63.3	*1.0*	0.680	24
3	" "	J1D926A	46.3	44.6	*1.7*	0.368	12
3	" "	N6T500B	64.3	62.3	*2.0*	0.128	24
3	" "	J1E926C	46.3	44.2	*2.1*	0.376	12
3	" "	M2R497I	64.3	62.1	*2.2*	0.319	24
3	" "	P9Y500C	64.3	61.5	*2.8*	0.218	24
3	" "	Z2B500A	64.3	61.3	*3.0*	0.152	24
2	Soybeans	Z2B500A	64.6	72.1	-7.5**	0.001	12
2	" "	J1F943A	63.3	69.2	*-5.8*	0.328	6
2	" "	L1P959A	63.3	64.2	*-0.8*	0.876	6
7	Pitted Morningglory	M2R497I	71.0	72.9	*-1.9*	0.417	24
7	" "	Y8F497F	71.0	67.9	*3.1*	0.213	24
7	" "	Z2B500A	71.0	66.8	*4.3*	0.094	24
7	" "	P9Y500C	71.0	63.3	7.7**	0.004	24
7	" "	N6T500B	71.0	61.5	9.6**	0.000	24
1	Purslane	Z2B500A	34.2	47.5	*-13.3*	0.087	6
11	Prickly Sida	L1P366B	77.9	85.8	-7.9**	0.006	12
11	" "	M2R497I	63.8	69.9	-6.1**	0.001	42
11	" "	F1E366C	77.9	83.8	-5.8**	0.006	12
11	" "	Z1A360E	77.9	82.9	-5.0**	0.004	12
11	" "	C1B047A	65.0	68.0	*-3.0*	0.426	5
11	" "	C3B047C	65.0	68.0	*-3.0*	0.305	5
11	" "	E1A051A	65.0	68.0	*-3.0*	0.208	5
11	" "	P9Y500C	61.0	63.8	*-2.7*	0.158	24

#Trials	Species	Composition (Roundup® WeatherMAX)	Mean	Composition Mean	Mean Diff	P-Value	n
11	" "	M4T360D	77.9	80.4	*-2.5*	0.214	12
11	" "	N6T500B	61.0	63.3	*-2.3*	0.332	24
11	" "	C4B047D	65.0	67.0	*-2.0*	0.178	5
11	" "	N6Q965A	67.4	68.5	*-1.1*	0.631	18
11	" "	C2B047B	65.0	66.0	*-1.0*	0.704	5
11	" "	A6S366A	77.9	78.3	*-0.4*	0.754	12
11	" "	Z2B500A	61.0	61.5	*-0.4*	0.836	24
11	" "	Y8F497F	61.0	61.3	*-0.2*	0.933	24
11	" "	J1F943A	67.4	67.4	*0.0*	1.000	18
11	" "	X9Z965C	67.4	66.8	*0.6*	0.832	18
11	" "	H1A984B	67.5	66.7	*0.8*	0.843	12
11	" "	H1E984F	67.5	65.4	*2.1*	0.435	12
11	" "	J1C984J	67.5	64.6	*2.9*	0.487	12
11	" "	H1D984E	67.5	64.2	*3.3*	0.180	12
11	" "	H1C984D	67.5	61.3	6.3*	0.036	12
11	" "	J1B984I	67.5	61.3	*6.3*	0.146	12
11	" "	H1B984C	67.5	57.9	9.6**	0.003	12

Example 16

[00173] The following Tables 15-30 provide data used to calculate the peaking data set forth in Tables 4-7 above for surfactants described in Table 2. The data include weight fractions of homologs of varying molecular weight (MW)/varying EO substitution (EO/molecule).

[00174] Tables 26-30 provide average values of the data presented in Tables 15-25, and were used to calculate the peaking data set forth in Tables 4-7.

[00175] Mole fractions ($(mM)_i$) were calculated from the weight fractions (Wt. fraction) and molecular weights (MW) provided in the following Tables. $(mM)_i$ = (Wt. fraction/MW)*1000) From the mole fractions, mole percents were calculated, which were used to calculate N_0 (i.e., the weight average value of substitution, also referred to herein as W_0) and k (defined, for example, in [0097]). The remaining peaking parameters (e.g., α_1) shown in Tables 4-8 were calculated as detailed elsewhere herein including, for example, paragraphs [0097] - [0099].

Table 15

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S58	0.004659595	0	0.003447	0.005659	0.012375	0.025696	0.066933	0.119983	0.147302	0.175484	0.127694
S58	0.004303171	0	0.002756	0.004416	0.010532	0.024548	0.066407	0.113465	0.166074	0.167391	0.136084
S58	0.004470686	0.213049407	0.008372	0.007608	0.011304	0.025086	0.06168	0.09844	0.121493	0.133811	0.102306
S58	0.004460556	0.201555153	0.010161	0.007839	0.011538	0.028024	0.060625	0.094581	0.109391	0.145412	0.088024
S57	0.043220138	0.953115989	0.003664	0	0	0	0	0	0	0	0
S57	0.045231254	0.951316155	0.003453	0	0	0	0	0	0	0	0

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S58	0.116307	0.087776	0.047113	0.030888	0.017301	0.007575	0.003808	0	0	0.00	0	1
S58	0.113894	0.079652	0.050894	0.031073	0.016807	0.007453	0.004252	0	0	0.00	0	1
S58	0.096602	0.049882	0.032434	0.019446	0.008697	0.003337	0.001983	0	0	0.00	0	1
S58	0.095006	0.063062	0.041642	0.02286	0.009326	0.004329	0.002165	0	0	0.00	0	1
S57	0	0	0	0	0	0	0	0	0	0.00	0	1
S57	0	0	0	0	0	0	0	0	0	0.00	0	1

Table 16

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S1	0.004178117	0.954587516	0.041234	0	0	0	0	0	0	0	0
S1	0.003385644	0.956500021	0.040114	0	0	0	0	0	0	0	0
S2	0.001350508	0.0025694	0.015491	0.058181	0.096441	0.133243	0.156962	0.16269	0.135503	0.099589	0.068779
S2	0.001110162	0.002069202	0.016559	0.059577	0.106331	0.132005	0.152784	0.153871	0.134882	0.100943	0.069185
S3	0.001438311	0.001398038	0.012674	0.047453	0.078543	0.111181	0.140189	0.150562	0.141961	0.117297	0.080643
S3	0.00194547	0.001368616	0.012267	0.0478	0.081648	0.111067	0.13249	0.149388	0.140391	0.120591	0.082462
S4	0.001809481	0.001179808	0.014224	0.051978	0.083959	0.114587	0.136016	0.158678	0.143592	0.113507	0.076343
S4	0.001585028	0.001758825	0.01382	0.050644	0.089797	0.116152	0.141304	0.147081	0.145524	0.107886	0.077541

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S1	0	0	0	0	0	0	0	0	0	0.00	0	1
S1	0	0	0	0	0	0	0	0	0	0.00	0	1
S2	0.039525	0.017705	0.007153	0.002999	0.001167	0.000383	0.000269	0	0	0.00	0	1
S2	0.040239	0.018716	0.006957	0.003017	0.001209	0.000465	8.14E-05	0	0	0.00	0	1
S3	0.053799	0.032149	0.017944	0.007675	0.003228	0.001335	0.000529	0	0	0.00	0	1
S3	0.055129	0.032089	0.017933	0.009167	0.002658	0.001075	0.000532	0	0	0.00	0	1
S4	0.048518	0.028561	0.015994	0.006867	0.002751	0.001047	0.000391	0	0	0.00	0	1
S4	0.05118	0.02908	0.014363	0.007661	0.003441	0.000827	0.000355	0	0	0.00	0	1

Table 17

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S5	0.001406252	0.001505371	0.014261	0.056182	0.093469	0.122443	0.141443	0.149044	0.139461	0.107866	0.082591
S5	0.001312361	0.001568583	0.016261	0.05725	0.091528	0.123174	0.145578	0.157502	0.140723	0.108888	0.070624
S6	0.002420349	0.003747637	0.04989	0.128463	0.157211	0.154997	0.13482	0.124871	0.090947	0.065333	0.042323
S6	0.002442369	0.003678266	0.048518	0.137155	0.154923	0.16222	0.131647	0.12489	0.089132	0.066521	0.036023
S7	0.002743145	0.017793062	0.116937	0.221309	0.192981	0.156819	0.107903	0.076118	0.046766	0.025459	0.016114
S7	0.002620597	0.016779274	0.121876	0.205574	0.200662	0.155267	0.110525	0.075438	0.047196	0.0272	0.016425
S8	0.000868357	0.000658123	0.011444	0.044058	0.070209	0.094715	0.117685	0.13848	0.135902	0.119294	0.096534
S8	0.001160524	0.000841602	0.009001	0.037704	0.069915	0.092532	0.11871	0.139041	0.147466	0.124779	0.093834

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S5	0.043928	0.025207	0.012173	0.005867	0.002255	0.000589	0.00031	0	0	0.00	0	1
S5	0.043939	0.02416	0.010124	0.004768	0.001887	0.000419	0.000294	0	0	0.00	0	1
S6	0.021465	0.012007	0.00619	0.003156	0.00145	0.000563	0.000145	0	0	0.00	0	1
S6	0.01958	0.011247	0.006533	0.002884	0.00166	0.000683	0.000265	0	0	0.00	0	1
S7	0.008609	0.005228	0.002732	0.001294	0.000759	0.000293	0.000144	0	0	0.00	0	1
S7	0.009365	0.005105	0.003136	0.001584	0.000758	0.000279	0.000211	0	0	0.00	0	1
S8	0.066297	0.047531	0.028391	0.014342	0.008546	0.003812	0.001234	0	0	0.00	0	1
S8	0.073042	0.036526	0.026444	0.015663	0.00877	0.003322	0.001249	0	0	0.00	0	1

Table 18

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S9	0.000935588	0.001466597	0.015298	0.054576	0.091578	0.126043	0.149863	0.154515	0.138964	0.103758	0.073844
S9	0.000825764	0.001526884	0.015113	0.054874	0.091044	0.12395	0.150476	0.151473	0.144532	0.107077	0.071841
S10	0.001050956	0.000857765	0.00959	0.046435	0.071411	0.096394	0.125806	0.132753	0.14446	0.119585	0.0943
S10	0.001288192	0.000919244	0.010593	0.041447	0.0698	0.096696	0.121822	0.141326	0.141914	0.123416	0.090692
S11	0.001343143	0.001536865	0.01756	0.062435	0.094097	0.127564	0.148684	0.148181	0.145641	0.101541	0.069413
S11	0.001491458	0.00187102	0.017022	0.058957	0.096007	0.12685	0.149838	0.151986	0.14017	0.103031	0.070179
S58	0.005550676	0.001063963	0.0039	0.006043	0.009766	0.023101	0.056897	0.106457	0.138651	0.15702	0.150295
S58	0.005236132	0.000566615	0.00341	0.006754	0.011267	0.024157	0.058382	0.10281	0.14178	0.153244	0.154276

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S9	0.047142	0.023752	0.011404	0.004459	0.001618	0.000531	0.000253	0	0	0.00	0	1
S9	0.046734	0.023854	0.009691	0.004066	0.001737	0.000701	0.000483	0	0	0.00	0	1
S10	0.067439	0.042641	0.026637	0.011398	0.005966	0.002195	0.001082	0	0	0.00	0	1
S10	0.06788	0.043004	0.02734	0.012732	0.005878	0.002251	0.001001	0	0	0.00	0	1
S11	0.044229	0.021546	0.009579	0.004206	0.001446	0.000762	0.000237	0	0	0.00	0	1
S11	0.042953	0.022876	0.010329	0.004099	0.001616	0.000469	0.000255	0	0	0.00	0	1
S58	0.124328	0.096108	0.057108	0.035698	0.017274	0.007352	0.003388	0	0	0.00	0	1
S58	0.122217	0.092055	0.060223	0.036542	0.016887	0.007568	0.002626	0	0	0.00	0	1

Table 19

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S13	0.001647548	0.003356604	0.025697	0.06048	0.071719	0.13205	0.163068	0.172413	0.137994	0.093792	0.060801
S13	0.001539873	0.003583953	0.028308	0.061831	0.069135	0.130626	0.16533	0.16855	0.142917	0.093251	0.059578
S14	0.001945066	0.001784551	0.015046	0.030819	0.036182	0.082835	0.132557	0.168083	0.165128	0.134342	0.094864
S14	0.002103391	0.001996665	0.011611	0.026063	0.036202	0.08193	0.136694	0.171504	0.166924	0.134243	0.091437
S15	0.002626004	0.001113592	0.006076	0.013752	0.018429	0.041954	0.088248	0.133957	0.159492	0.162175	0.127939
S15	0.002691698	0.001052209	0.005227	0.012392	0.017594	0.040865	0.086981	0.142092	0.16252	0.157014	0.135931
S16	0.003036446	0.001415486	0.014643	0.03431	0.044245	0.095294	0.150092	0.175447	0.162434	0.120412	0.084459
S16	0.002951764	0.00185491	0.015614	0.035277	0.046898	0.089624	0.141503	0.182124	0.164376	0.124165	0.083064

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S13	0.036971	0.019674	0.011036	0.004907	0.002619	0.00116	0.000615	0	0	0.00	0	1
S13	0.034917	0.019546	0.010897	0.005723	0.002653	0.001063	0.00055	0	0	0.00	0	1
S14	0.060377	0.036196	0.0204	0.010452	0.004971	0.002757	0.001261	0	0	0.00	0	1
S14	0.062128	0.036318	0.02111	0.010437	0.00551	0.002722	0.001067	0	0	0.00	0	1
S15	0.100358	0.06377	0.039861	0.022225	0.010411	0.005133	0.002481	0	0	0.00	0	1
S15	0.097278	0.064938	0.038154	0.019356	0.009352	0.004424	0.002139	0	0	0.00	0	1
S16	0.052674	0.030789	0.016593	0.008182	0.003794	0.001388	0.00079	0	0	0.00	0	1
S16	0.05148	0.029886	0.015974	0.008419	0.003811	0.001872	0.001105	0	0	0.00	0	1

Table 20

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S17	0.001724583	0.003848646	0.024787	0.054139	0.061851	0.122138	0.165599	0.174046	0.143783	0.104878	0.065193
S17	0.001670928	0.002927736	0.023807	0.052916	0.059344	0.114601	0.168171	0.181264	0.147032	0.108827	0.05803
S18	0.002027116	0.001419467	0.005216	0.012294	0.014851	0.034417	0.078217	0.134324	0.165869	0.167837	0.140231
S18	0.002030029	0.000634687	0.004787	0.010722	0.015533	0.036318	0.081032	0.131283	0.169946	0.169917	0.135319
S19	0.007047142	0.004322792	0.004813	0.012309	0.014829	0.030032	0.057993	0.10391	0.136725	0.156758	0.138738
S19	0.007187536	0.002575303	0.0058	0.013481	0.017755	0.031781	0.059027	0.107935	0.137934	0.152836	0.142297
S20	0.00168835	0.001472909	0.009774	0.023971	0.035328	0.073166	0.127339	0.16512	0.167468	0.144178	0.104405
S20	0.001396726	0.001615905	0.008827	0.023551	0.033006	0.070541	0.121657	0.17077	0.168755	0.142139	0.106727

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S17	0.03628	0.021343	0.010679	0.005783	0.002465	0.001062	0.000399	0	0	0.00	0	1
S17	0.03873	0.021303	0.011172	0.005841	0.002725	0.001209	0.000429	0	0	0.00	0	1
S18	0.103543	0.066778	0.03905	0.019595	0.00962	0.003456	0.001254	0	0	0.00	0	1
S18	0.106666	0.066875	0.036448	0.019191	0.008435	0.003522	0.001342	0	0	0.00	0	1
S19	0.123033	0.091374	0.056838	0.033888	0.016994	0.007409	0.002987	0	0	0.00	0	1
S19	0.118259	0.088504	0.055724	0.032852	0.016529	0.006599	0.002925	0	0	0.00	0	1
S20	0.06465	0.040345	0.022032	0.010667	0.00532	0.00204	0.001038	0	0	0.00	0	1
S20	0.068066	0.041313	0.0223	0.010718	0.005475	0.001994	0.001147	0	0	0.00	0	1

Table 21

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S21	0.003350381	0.001845952	0.013747	0.033768	0.044104	0.08535	0.148342	0.174816	0.163715	0.129333	0.084434
S21	0.003041773	0.001641866	0.014505	0.033658	0.044158	0.09048	0.143892	0.176552	0.161663	0.128804	0.086336
S22	0.001424751	0.002941719	0.023004	0.056266	0.064414	0.121998	0.158378	0.180939	0.139865	0.103311	0.064962
S22	0.001308603	0.002608305	0.024347	0.053012	0.064536	0.119457	0.169994	0.175166	0.14598	0.104617	0.061424
S1	0.021721451	0.950139733	0.01421	0.001153	0.003357	0.003475	0.005944	0	0	0	0
S1	0.020024066	0.950234115	0.014256	0.002485	0.002066	0.003636	0.007298	0	0	0	0
S24	0.00212616	0.002452365	0.009542	0.022951	0.03558	0.070332	0.129521	0.169662	0.174491	0.144468	0.103955
S24	0.001984304	0.002008068	0.010444	0.024572	0.032854	0.068845	0.139977	0.168797	0.167691	0.150373	0.098288

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S21	0.052236	0.031329	0.017513	0.008715	0.004142	0.001902	0.001357	0	0	0.00	0	1
S21	0.053456	0.029891	0.016393	0.008849	0.004256	0.001633	0.000791	0	0	0.00	0	1
S22	0.038791	0.021731	0.011601	0.006036	0.00273	0.001065	0.000544	0	0	0.00	0	1
S22	0.038301	0.020911	0.010598	0.004985	0.001999	0.000583	0.000174	0	0	0.00	0	1
S1	0	0	0	0	0	0	0	0	0	0.00	0	1
S1	0	0	0	0	0	0	0	0	0	0.00	0	1
S24	0.066196	0.037869	0.0174	0.007759	0.003355	0.001532	0.00081	0	0	0.00	0	1
S24	0.064632	0.036169	0.019106	0.008828	0.003422	0.00142	0.000588	0	0	0.00	0	1

Table 22

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S58	0.005008676	0.003048997	0.004587	0.007937	0.010587	0.024841	0.05382	0.101208	0.137199	0.158745	0.153884
S58	0.005271586	0.005670631	0.003266	0.005954	0.011572	0.024457	0.05385	0.099992	0.13767	0.157208	0.151579
S26	0.000856385	0	0.004312	0.008731	0.014945	0.038931	0.083327	0.134354	0.158848	0.166525	0.1405
S26	0.000946779	0.000909504	0.005405	0.010154	0.015432	0.037506	0.081207	0.129917	0.162652	0.172098	0.138662
S27	0.000595464	0.001865071	0.015584	0.033257	0.043058	0.083807	0.137874	0.198152	0.17941	0.135565	0.08172
S27	0.000556655	0.002263978	0.014176	0.033711	0.042459	0.080298	0.138958	0.192382	0.183855	0.135538	0.083889
S28	0.000496751	0.001446867	0.007581	0.017595	0.023684	0.052718	0.09784	0.166227	0.177592	0.167999	0.116279
S28	0.000480063	0.001182859	0.008109	0.016543	0.022329	0.047552	0.101235	0.157675	0.189804	0.169168	0.121999

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S58	0.122529	0.089855	0.064018	0.034278	0.017298	0.00814	0.003016	0	0	0.00	0	1
S58	0.129364	0.090499	0.060865	0.033735	0.017941	0.007603	0.003502	0	0	0.00	0	1
S26	0.107541	0.067359	0.039174	0.019871	0.009041	0.003918	0.001766	0	0	0.00	0	1
S26	0.102729	0.067959	0.040324	0.020598	0.008655	0.003601	0.001245	0	0	0.00	0	1
S27	0.045674	0.024586	0.011874	0.004762	0.001559	0.000417	0.000243	0	0	0.00	0	1
S27	0.04626	0.025789	0.012005	0.005234	0.001816	0.000594	0.000215	0	0	0.00	0	1
S28	0.079881	0.046538	0.025538	0.012022	0.004508	0.001579	0.000475	0	0	0.00	0	1
S28	0.077455	0.044293	0.024881	0.011277	0.004156	0.001423	0.000437	0	0	0.00	0	1

Table 23

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S29	0.004132991	0.00119136	0.017731	0.046625	0.060708	0.06726	0.098773	0.119011	0.142103	0.135219	0.11051
S29	0.003792571	0.000525977	0.017876	0.048694	0.059657	0.071574	0.09968	0.121937	0.132588	0.132754	0.112739
S30	0.000966502	0.00166209	0.010705	0.024961	0.033696	0.068666	0.124876	0.160476	0.168772	0.151221	0.10231
S30	0.000928828	0.00146769	0.010061	0.022051	0.031183	0.067861	0.119769	0.169174	0.173102	0.146159	0.109432
S31	0.000918567	0.001609121	0.007485	0.016248	0.025779	0.061257	0.113244	0.156287	0.16942	0.156619	0.115967
S31	0.001282574	0.001427275	0.006959	0.016364	0.027743	0.065313	0.114392	0.160532	0.163906	0.151949	0.11411
S32	0.002302001	0.004117949	0.013812	0.025997	0.03162	0.068095	0.11749	0.160229	0.174858	0.154794	0.103914
S32	0.002546301	0.001966045	0.012691	0.027893	0.032658	0.070737	0.117922	0.154212	0.171483	0.149344	0.107962

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S29	0.082616	0.054155	0.032012	0.015774	0.007832	0.002875	0.001471	0	0	0.00	0	1
S29	0.081132	0.058667	0.031323	0.015717	0.006893	0.003142	0.001308	0	0	0.00	0	1
S30	0.072627	0.040227	0.021929	0.010287	0.004071	0.00164	0.000908	0	0	0.00	0	1
S30	0.070563	0.04079	0.020044	0.010487	0.004431	0.001957	0.000539	0	0	0.00	0	1
S31	0.075967	0.047987	0.02755	0.013329	0.005961	0.002958	0.001414	0	0	0.00	0	1
S31	0.078	0.049659	0.025237	0.013326	0.006347	0.002388	0.001066	0	0	0.00	0	1
S32	0.067683	0.038148	0.020279	0.00987	0.004368	0.001532	0.000891	0	0	0.00	0	1
S32	0.069897	0.041608	0.021456	0.01039	0.004389	0.00187	0.000976	0	0	0.00	0	1

Table 24

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.64
EO/molecule	1	2	3	4	5	6	7	8	9	10	11
S33	0.000904237	0.001821674	0.009346	0.018204	0.031213	0.061792	0.114983	0.16232	0.170505	0.149753	0.110211
S33	0.001343235	0.001426388	0.009147	0.01894	0.02934	0.064322	0.1169	0.153928	0.170687	0.15492	0.11097
S34	0.001015823	0.001706062	0.008758	0.019639	0.029661	0.061399	0.111688	0.156541	0.178453	0.154386	0.11637
S34	0.000735678	0.001527946	0.009337	0.018763	0.028063	0.062702	0.113187	0.164515	0.175349	0.148129	0.113445
S35	0.000350609	0.001388124	0.007012	0.014582	0.019355	0.049414	0.089684	0.144451	0.161817	0.162046	0.126906
S35	0.000593395	0.001353229	0.008112	0.016007	0.019589	0.047638	0.093344	0.1457	0.170724	0.154796	0.126943
S51	0.011998146	0.156177034	0	0	0.006533	0.019842	0.048089	0.090126	0.129382	0.136816	0.136081
S51	0.012077913	0.165600056	0.002921	0.007761	0.010647	0.021829	0.046822	0.080519	0.11346	0.125364	0.124572

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Totals
S33	0.077052	0.045687	0.024474	0.012197	0.005617	0.002455	0.001465	0	0	0.00	0	1
S33	0.076724	0.046489	0.023558	0.012038	0.005661	0.002315	0.001292	0	0	0.00	0	1
S34	0.073484	0.044664	0.022329	0.011435	0.005392	0.002136	0.000944	0	0	0.00	0	1
S34	0.075014	0.043223	0.025296	0.012293	0.005338	0.002194	0.000887	0	0	0.00	0	1
S35	0.099859	0.058337	0.036936	0.016006	0.00737	0.003134	0.001352	0	0	0.00	0	1
S35	0.09304	0.058305	0.033027	0.018099	0.00809	0.003184	0.001455	0	0	0.00	0	1
S51	0.111473	0.075242	0.044949	0.022002	0.008675	0.002212	0.000402	0	0	0.00	0	1
S51	0.105874	0.07789	0.05278	0.029485	0.013847	0.006062	0.00249	0	0	0.00	0	1

Table 25

MW (Daltons)	314.34	358.37	402.4	446.43	490.46	534.49	578.52	622.55	666.58	710.61	754.6
EO/molecule	1	2	3	4	5	6	7	8	9	10	1
S37	0.001474417	0.003055098	0.02037	0.042194	0.057343	0.11711	0.170641	0.176153	0.161203	0.111591	0.06737
S37	0.001558529	0.002489766	0.019575	0.043736	0.059541	0.120026	0.166995	0.18348	0.146282	0.11255	0.06923
S58	0.0028143	0	0.003613	0.006875	0.011602	0.024713	0.056718	0.099534	0.140004	0.158986	0.14397
S58	0.004661741	0	0.002696	0.006281	0.009662	0.026088	0.055527	0.094869	0.14172	0.159697	0.14749
S58	0.001939005	0.001462611	0.005976	0.011651	0.016147	0.039064	0.075864	0.1252	0.156541	0.161439	0.13951
S58	0.002333257	0.001382069	0.005447	0.011691	0.015504	0.036731	0.076624	0.1335	0.165743	0.159076	0.13039
S58	0.004437906	0.003183178	0.002936	0.005328	0.010946	0.023352	0.057439	0.098882	0.134367	0.152626	0.15075
S58	0.005259967	0	0	0.005765	0.010359	0.025218	0.058276	0.09988	0.134655	0.157799	0.14781

MW (Daltons)	798.67	842.7	886.73	930.76	974.79	1018.82	1062.85	1106.88	1150.91	1194.94	1238.97	
EO/molecule	12	13	14	15	16	17	18	19	20	21.00	22	Total
S37	0.037983	0.018258	0.009159	0.003786	0.001461	0.000598	0.000246	0	0	0.00	0	1
S37	0.038705	0.019278	0.009403	0.004178	0.001772	0.000537	0.00066	0	0	0.00	0	1
S58	0.130059	0.092769	0.060617	0.037729	0.018198	0.008157	0.003635	0	0	0.00	0	1
S58	0.131734	0.095291	0.06049	0.036578	0.016644	0.006883	0.003683	0	0	0.00	0	1
S58	0.10647	0.073757	0.044079	0.024564	0.010832	0.004171	0.001329	0	0	0.00	0	1
S58	0.106427	0.073656	0.043096	0.022723	0.010187	0.003919	0.001569	0	0	0.00	0	1
S58	0.13153	0.094241	0.063626	0.036622	0.018666	0.007504	0.003554	0	0	0.00	0	1
S58	0.130079	0.09465	0.062965	0.036968	0.018389	0.008113	0.00381	0	0	0.00	0	1

Table 26

EO/molecule	1	2	3	4	5	6	7	8	9	10
S58	0.004481383	0	0.003101	0.005038	0.011453	0.025122	0.06667	0.116724	0.156688	0.171437
S58	0.004465621	0.20730228	0.009266	0.007723	0.011421	0.026555	0.061153	0.09651	0.115442	0.139611
S57	0.044225696	0.952216072	0.003558	0	0	0	0	0	0	0
S1	0.003781881	0.955543768	0.040674	0	0	0	0	0	0	0
S2	0.001230335	0.002319301	0.016025	0.058879	0.101386	0.132624	0.154873	0.158281	0.135192	0.100266
S3	0.001691891	0.001383327	0.012471	0.047626	0.080095	0.111124	0.13634	0.149975	0.141176	0.118944
S4	0.001697255	0.001469317	0.014022	0.051311	0.086878	0.11537	0.13866	0.152879	0.144558	0.110697
S5	0.001359306	0.001536977	0.015261	0.056716	0.092499	0.122809	0.143511	0.153273	0.140092	0.108377
S6	0.002431359	0.003712952	0.049204	0.132809	0.156067	0.158609	0.133233	0.124881	0.090039	0.065927
S7	0.002681871	0.017286168	0.119407	0.213442	0.196821	0.156043	0.109214	0.075778	0.046981	0.026329

EO/molecule	11	12	13	14	15	16	17	18	19	20	SUM
S58	0.131889	0.115101	0.083714	0.049003	0.030981	0.017054	0.007514	0.00403	0	0	1.00
S58	0.095165	0.095804	0.056472	0.037038	0.021153	0.009011	0.003833	0.002074	0	0	1.00
S57	0	0	0	0	0	0	0	0	0	0	1.00
S1	0	0	0	0	0	0	0	0	0	0	1.00
S2	0.068982	0.039882	0.018211	0.007055	0.003008	0.001188	0.000424	0.000175	0	0	1.00
S3	0.081553	0.054464	0.032119	0.017939	0.008421	0.002943	0.001205	0.00053	0	0	1.00
S4	0.076942	0.049849	0.02882	0.015178	0.007264	0.003096	0.000937	0.000373	0	0	1.00
S5	0.076607	0.043934	0.024684	0.011148	0.005317	0.002071	0.000504	0.000302	0	0	1.00
S6	0.039173	0.020523	0.011627	0.006361	0.00302	0.001555	0.000623	0.000205	0	0	1.00
S7	0.01627	0.008987	0.005166	0.002934	0.001439	0.000758	0.000286	0.000177	0	0	1.00

Table 27

EO/molecule	1	2	3	4	5	6	7	8	9	10
S8	0.001014441	0.000749862	0.010222	0.040881	0.070062	0.093623	0.118198	0.138761	0.141684	0.122036
S9	0.000880676	0.001496741	0.015206	0.054725	0.091311	0.124997	0.150169	0.152994	0.141748	0.105417
S10	0.001169574	0.000888505	0.010092	0.043941	0.070605	0.096545	0.123814	0.137039	0.143187	0.121501
S11	0.0014173	0.001703943	0.017291	0.060696	0.095052	0.127207	0.149261	0.150083	0.142905	0.102286
S58	0.005393404	0.000815289	0.003655	0.006398	0.010516	0.023629	0.057639	0.104633	0.140216	0.155132
S13	0.00159371	0.003470278	0.027003	0.061156	0.070427	0.131338	0.164199	0.170481	0.140456	0.093521
S14	0.002024228	0.001890608	0.013328	0.028441	0.036192	0.082383	0.134625	0.169794	0.166026	0.134293
S15	0.002658851	0.0010829	0.005651	0.013072	0.018011	0.041409	0.087615	0.138025	0.161006	0.159595
S16	0.002994105	0.001635198	0.015129	0.034793	0.045572	0.092459	0.145797	0.178786	0.163405	0.122288
S17	0.001697756	0.003388191	0.024297	0.053528	0.060598	0.11837	0.166885	0.177655	0.145408	0.106853

EO/molecule	11	12	13	14	15	16	17	18	19	20	SUM
S8	0.095184	0.069669	0.042028	0.027417	0.015002	0.008658	0.003567	0.001242	0	0	1.00
S9	0.072843	0.046938	0.023803	0.010548	0.004263	0.001678	0.000616	0.000368	0	0	1.00
S10	0.092496	0.06766	0.042823	0.026988	0.012065	0.005922	0.002223	0.001041	0	0	1.00
S11	0.069796	0.043591	0.022211	0.009954	0.004153	0.001531	0.000615	0.000246	0	0	1.00
S58	0.152286	0.123273	0.094081	0.058665	0.03612	0.017081	0.00746	0.003007	0	0	1.00
S13	0.06019	0.035944	0.01961	0.010967	0.005315	0.002636	0.001111	0.000582	0	0	1.00
S14	0.093151	0.061253	0.036257	0.020755	0.010445	0.00524	0.002739	0.001164	0	0	1.00
S15	0.131935	0.098818	0.064354	0.039007	0.02079	0.009882	0.004779	0.00231	0	0	1.00
S16	0.083762	0.052077	0.030338	0.016284	0.008301	0.003803	0.00163	0.000948	0	0	1.00
S17	0.061611	0.037505	0.021323	0.010925	0.005812	0.002595	0.001135	0.000414	0	0	1.00

Table 28

EO/molecule	1	2	3	4	5	6	7	8	9	10
S18	0.002028572	0.001027077	0.005001	0.011508	0.015192	0.035367	0.079624	0.132804	0.167907	0.168877
S19	0.007117339	0.003449047	0.005306	0.012895	0.016292	0.030906	0.05851	0.105923	0.13733	0.154797
S20	0.001542538	0.001544407	0.009301	0.023761	0.034167	0.071854	0.124498	0.167945	0.168111	0.143159
S21	0.003196077	0.001743909	0.014126	0.033713	0.044131	0.087915	0.146117	0.175684	0.162689	0.129069
S22	0.001366677	0.002775012	0.023675	0.054639	0.064475	0.120728	0.164186	0.178052	0.142923	0.103964
S1	0.020872758	0.950186924	0.014233	0.001819	0.002712	0.003555	0.006621	0	0	0
S24	0.002055232	0.002230217	0.009993	0.023761	0.034217	0.069588	0.134749	0.169229	0.171091	0.147421
S58	0.005140131	0.004359814	0.003927	0.006946	0.011079	0.024649	0.053835	0.1006	0.137435	0.157976
S26	0.000901582	0.000454752	0.004859	0.009442	0.015188	0.038219	0.082267	0.132136	0.16075	0.169311

EO/molecule	11	12	13	14	15	16	17	18	19	20	SUM
S18	0.137775	0.105105	0.066826	0.037749	0.019393	0.009028	0.003489	0.001298	0	0	1.00
S19	0.140517	0.120646	0.089939	0.056281	0.03337	0.016761	0.007004	0.002956	0	0	1.00
S20	0.105566	0.066358	0.040829	0.022166	0.010692	0.005398	0.002017	0.001093	0	0	1.00
S21	0.085385	0.052846	0.03061	0.016953	0.008782	0.004199	0.001768	0.001074	0	0	1.00
S22	0.063193	0.038546	0.021321	0.011099	0.00551	0.002364	0.000824	0.000359	0	0	1.00
S1	0	0	0	0	0	0	0	0	0	0	1.00
S24	0.101122	0.065414	0.037019	0.018253	0.008294	0.003389	0.001476	0.000699	0	0	1.00
S58	0.152732	0.125947	0.090177	0.062441	0.034006	0.017619	0.007871	0.003259	0	0	1.00
S26	0.139581	0.105135	0.067659	0.039749	0.020235	0.008848	0.003759	0.001505	0	0	1.00

Table 29

EO/molecule	1	2	3	4	5	6	7	8	9	10
S27	0.000576059	0.002064524	0.01488	0.033484	0.042758	0.082052	0.138416	0.195267	0.181632	0.135552
S28	0.000488407	0.001314863	0.007845	0.017069	0.023006	0.050135	0.099538	0.161951	0.183698	0.168584
S29	0.003962781	0.000858669	0.017803	0.04766	0.060182	0.069417	0.099226	0.120474	0.137345	0.133987
S30	0.000947665	0.00156489	0.010383	0.023506	0.032439	0.068263	0.122323	0.164825	0.170937	0.14869
S31	0.00110057	0.001518198	0.007222	0.016306	0.026761	0.063285	0.113818	0.158409	0.166663	0.154284
S32	0.002424151	0.003041997	0.013251	0.026945	0.032139	0.069416	0.117706	0.15722	0.17317	0.152069
S33	0.001123736	0.001624031	0.009246	0.018572	0.030276	0.063057	0.115942	0.158124	0.170596	0.152337
S34	0.000875751	0.001617004	0.009048	0.019201	0.028862	0.062051	0.112438	0.160528	0.176901	0.151257
S35	0.000472002	0.001370676	0.007562	0.015295	0.019472	0.048526	0.091514	0.145075	0.16627	0.158421

EO/molecule	11	12	13	14	15	16	17	18	19	20	SUM
S27	0.082804	0.045967	0.025187	0.011939	0.004998	0.001687	0.000505	0.000229	0	0	1.00
S28	0.119139	0.078668	0.045416	0.02521	0.011649	0.004332	0.001501	0.000456	0	0	1.00
S29	0.111624	0.081874	0.056411	0.031668	0.015746	0.007363	0.003009	0.001389	0	0	1.00
S30	0.105871	0.071595	0.040509	0.020987	0.010387	0.004251	0.001799	0.000723	0	0	1.00
S31	0.115039	0.076984	0.048823	0.026394	0.013327	0.006154	0.002673	0.00124	0	0	1.00
S32	0.105938	0.06879	0.039878	0.020868	0.01013	0.004379	0.001701	0.000934	0	0	1.00
S33	0.110591	0.076888	0.046088	0.024016	0.012118	0.005639	0.002385	0.001379	0	0	1.00
S34	0.114908	0.074249	0.043943	0.023812	0.011864	0.005365	0.002165	0.000915	0	0	1.00
S35	0.126924	0.096449	0.058321	0.034982	0.017052	0.00773	0.003159	0.001403	0	0	1.00

Table 30

EO/molecule	1	2	3	4	5	6	7	8	9	10
S51	0.01203803	0.160888545	0.00146	0.003881	0.00859	0.020836	0.047456	0.085323	0.121421	0.13109
S37	0.001516473	0.002772432	0.019972	0.042965	0.058442	0.118568	0.168818	0.179816	0.153742	0.112071
S58	0.003738021	0	0.003155	0.006578	0.010632	0.0254	0.056123	0.097201	0.140862	0.159341
S58	0.002136131	0.00142234	0.005711	0.011671	0.015825	0.037897	0.076244	0.12935	0.161142	0.160258
S58	0.004848937	0.001591589	0.001468	0.005547	0.010653	0.024285	0.057858	0.099381	0.134511	0.155212

EO/molecule	11	12	13	14	15	16	17	18	19	20	SUM
S51	0.130327	0.108673	0.076566	0.048865	0.025744	0.011261	0.004137	0.001446	0	0	1.00
S37	0.068307	0.038344	0.018768	0.009281	0.003982	0.001617	0.000567	0.000453	0	0	1.00
S58	0.145736	0.130896	0.09403	0.060554	0.037154	0.017421	0.00752	0.003659	0	0	1.00
S58	0.134955	0.106449	0.073707	0.043588	0.023643	0.010509	0.004045	0.001449	0	0	1.00
S58	0.149287	0.130804	0.094445	0.063296	0.036795	0.018528	0.007808	0.003682	0	0	1.00

WHAT IS CLAIMED IS:

1. A stable herbicidal formulation which comprises:

a herbicidal active;

an unsubstituted primary alkyl(ether)amine or a primary alkyl(ether)amine that is N-substituted with up to five alkylene oxide units per molecule; and

a polyalkoxylated alkyl(ether)amine substituted with two alkylene oxide chains in peaked distribution and containing an average total of at least about 6 alkylene oxide units per molecule, wherein said peaked distribution alkoxylated alkyl(ether)amine is characterized by a degree of peaking that is at least 5% higher than that of the conventional non-peaked alkoxylated alkyl(ether)amines having the same carbon-chain length and average alkylene oxide chain length prepared via conventional base catalysis, wherein the conventional non-peaked alkoxylated alkyl(ether)amines are prepared by the NaOH-catalyzed reaction of RNH_2 with alkylene oxide conducted entirely under autogenous pressure up to 90 psig at a catalyst concentration of 0.2 wt.% and a temperature between 160° and 180°C.

2. A stable herbicidal formulation as set forth in claim 1 wherein the herbicidal active comprises glyphosate or a salt thereof.

3. A stable herbicidal formulation as set forth in claim 1 or 2 provided:

when the peaked distribution polyalkoxylated alkyl(ether)amine is 9EO or 10EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the weight

ratio of 9EO tallowamine or 10EO tallowamine to 2EO cocoamine is not 65:35,

when the peaked distribution polyalkoxylated alkyl(ether)amine is 9EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the formulation does not comprise 5.85 wt.% 9EO tallowamine and 3.15 wt.% 2EO cocoamine, and

when the peaked distribution polyalkoxylated alkyl(ether)amine is 10EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the formulation does not comprise 6.5 wt.% 10EO tallowamine and 3.5 wt.% 2EO cocoamine.

4. A stable herbicidal formulation as set forth in claim 1 or 2 provided, when the peaked distribution polyalkoxylated alkyl(ether)amine is 9EO or 10EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the weight ratio of 9EO tallowamine or 10EO tallowamine to 2EO cocoamine is not 65:35.

5. A stable herbicidal formulation as set forth in claim 1, 2, or 4 provided, when the peaked distribution polyalkoxylated alkyl(ether)amine is 9EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is 2EO cocoamine, the formulation does not comprise 5.85 wt.% 9EO tallowamine and 3.15 wt.% 2EO cocoamine, and when the peaked distribution polyalkoxylated alkyl(ether)amine is 10EO tallowamine and the unsubstituted primary alkyl(ether)amine or N-

substituted primary alkyl(ether)amine is 2EO cocoamine, the formulation does not comprise 6.5 wt.% 10EO tallowamine and 3.5 wt.% 2EO cocoamine.

6. A stable herbicidal formulation as set forth in any of claims 2 to 5 comprising potassium glyphosate.

7. A stable herbicidal formulation as set forth in any of claims 2 to 6 comprising a mixture of potassium glyphosate and isopropylammonium glyphosate.

8. A stable herbicidal formulation as set forth in claim 7 comprising a mixture of potassium glyphosate and isopropylammonium glyphosate in a molar ratio between about 90:10 and about 10:90.

9. A stable herbicidal formulation as set forth in claim 7 comprising a mixture of potassium glyphosate and isopropylammonium glyphosate in a molar ratio between about 70:30 and about 30:70.

10. A stable herbicidal formulation as set forth in any of claims 1 to 9 having a pH greater than about 4.6, greater than about 4.7, greater than about 4.8, or greater than about 4.9.

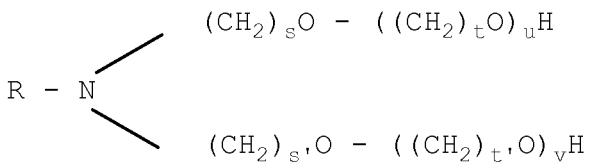
11. A stable herbicidal formulation as set forth in any of claims 1 to 10 wherein said N-substituted primary alkyl(ether)amine contains from 0 to 3 alkylene oxide units per molecule.

12. A stable herbicidal formulation as set forth in any of claims 1 to 10 wherein said N-substituted primary alkyl(ether)amine contains at least 0.1, at least 0.2, at least 0.5, at least 1, or at least 2 alkylene oxide units per molecule.

13. A stable herbicidal formulation as set forth in any of claims 1 to 10 wherein said N-substituted primary alkyl(ether)amine contains from 1 to 5 alkylene oxide units per molecule.

14. A stable herbicidal formulation as set forth in any of claims 1 to 13 wherein said alkylene oxide units are ethylene oxide.

15. A stable herbicidal formulation as set forth in any of claims 1 to 10 wherein said N-substituted primary alkyl(ether)amine corresponds to formula (V)



(V)

wherein s, s', t, and t' are each independently from 2 to 4, the sum of u and v is from 0 to 3, and R is a linear or branched, saturated or non-saturated alkyl group containing 8-22 carbon atoms, or R is a group of the formula:

R'– O – (A)x – (B)y – (C)z –

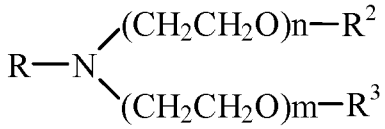
wherein A and B are polyalkylene oxide groups, C is methylene group, R' is a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms,

and x, y and z vary from 0 to 5.

16. A stable herbicidal formulation as set forth in claim 15 wherein each of s, s', t, and t' are 2.

17. A stable herbicidal formulation as set forth in claim 16 wherein the sum of u and v is 0.

18. A stable herbicidal formulation as set forth in any of claims 1 to 17 wherein the polyalkoxylated alkyl(ether)amine comprises a polyethoxylated alkyl(ether)amine substituted with two ethylene oxide chains in peaked distribution and corresponding to formula (III)



(III)

wherein R selected from a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms, or a group of the formula:

R'– O – (A)x – (B)y – (C)z –

wherein A and B are polyalkylene oxide groups, C is methylene group, R' is a linear or branched, saturated or non-saturated alkyl group containing 8 – 22 carbon atoms, x, y and z vary from 0 to 5, each of n and m varies from 1 – 15, the sum of n and m is at least about 6, and each of R^2 and R^3 is independently selected from H, methyl or ethyl, wherein said peaked distribution polyethoxylated

alkyl(ether)amine possesses a degree of peaking that is at least 5% higher than that of the conventional non-peaked ethoxylated alkyl(ether)amines having the same carbon-chain length and average EO chain length prepared via conventional base catalysis, wherein the conventional non-peaked alkoxylated alkyl(ether)amines are prepared by the NaOH-catalyzed reaction of RNH_2 with alkylene oxide conducted entirely under autogenous pressure up to 90 psig at a catalyst concentration of 0.2 wt.% and a temperature between 160° and 180°C.

19. A stable herbicidal formulation as set forth in any of claims 1 to 18 wherein said unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is derived from cocoamine.

20. A stable herbicidal formulation as set forth in any of claims 1 to 18 wherein said N-substituted primary alkyl(ether)amine is 2EO cocoamine.

21. A stable herbicidal formulation as set forth in any of claims 1 to 20 wherein said peaked distribution alkoxylated alkyl(ether)amine is derived from tallowamine.

22. A stable herbicidal formulation as set forth in claim 21 wherein said peaked distribution alkoxylated alkyl(ether)amine is 8EO to 10EO tallowamine.

23. A stable herbicidal formulation as set forth in any of claims 1 to 22 wherein the weight ratio of said peaked distribution polyalkoxylated alkyl(ether)amine to said unsubstituted primary alkyl(ether)amine or N-

substituted primary alkyl(ether)amine is between about 20:80 and about 90:10.

24. A stable herbicidal formulation as set forth in any of claims 1 to 22 wherein the weight ratio of said peaked distribution polyalkoxylated alkyl(ether)amine to said unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is between about 30:70 and about 80:20.

25. A stable herbicidal formulation as set forth in any of claims 1 to 22 wherein the weight ratio of said peaked distribution polyalkoxylated alkyl(ether)amine to said unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine is between about 40:60 and about 75:25.

26. A stable herbicidal formulation as set forth in any of claims 1 to 25 comprising at least about 3 wt.% peaked distribution polyalkoxylated alkyl(ether)amine substituted with a total of at least about 6 alkylene oxide units per molecule and at least about 2 wt.% unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine.

27. A stable herbicidal formulation as set forth in claim 26 comprising between about 3 and about 10 wt.% peaked distribution polyalkoxylated alkyl(ether)amine substituted with a total of at least about 6 alkylene oxide units per molecule and between about 2 and about 8 wt.% unsubstituted primary alkyl(ether)amine or N-substituted primary alkyl(ether)amine.

28. A stable herbicidal formulation as set forth in any of claims 1 through 27 wherein the weight ratio of glyphosate, a.e., to the total of alkoxylated alkyl(ether)amine surfactants is between about 2:1 and about 25:1.

29. A stable herbicidal formulation as set forth in any of claims 1 through 28 wherein the concentration of the sum of all alkoxylated alkyl(ether)amine components is at least about 5% by weight.

30. A stable herbicidal formulation as set forth in any of claims 1 through 29 having a cloud point of at least about 50°C, at least about 55°C, at least about 60°C, or at least about 65°C.

31. A stable herbicidal formulation as set forth in any of claims 1 to 30 containing not more than about 4 wt.%, not more than about 2 wt.%, or not more than about 0.2 wt.% vinyl polyethylene glycols.

32. A stable herbicidal formulation as set forth in any of claims 1 to 31 wherein the polyalkoxylated alkyl(ether)amine surfactant contains not more than about 4 wt.%, not more than about 2 wt.%, or not more than about 0.2 wt.% vinyl polyethylene glycols.

33. A stable herbicidal formulation as set forth in any of claims 1 to 32 containing not more than about 5 wt.%, not more than about 4 wt.%, or not more than about 3

wt.% (poly)ethylene glycol derivatives (EGDs).

34. A stable herbicidal formulation as set forth in any of claims 1 to 33 wherein the polyalkoxylated alkyl(ether)amine surfactant contains not more than about 5 wt.%, not more than about 4 wt.%, or not more than about 3 wt.% (poly)ethylene glycol derivatives (EGDs).

35. A stable herbicidal formulation as set forth in any of claims 1 through 34 further comprising a co-herbicide selected from the group consisting of 4-chlorophenoxyacetic acid (4-CPA) or a salt thereof, 2,4-dichlorophenoxyacetic acid (2,4-D) or a salt thereof, 3,4-dichlorophenoxyacetic acid (3,4-DA) or a salt thereof, 4-chloro-2-methylphenoxyacetic acid (MCPA) or a salt thereof, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) or a salt thereof, 2-(3-chlorophenoxy)propanoic acid (cloprop) or a salt thereof, 2-(4-chlorophenoxy)propanoic acid (4-CPP) or a salt thereof, 2-(2,4-dichlorophenoxy)propanoic acid (dichlorprop) or a salt thereof, 2-(3,4-dichlorophenoxy)propanoic acid (3,4-DP) or a salt thereof, 2-(2,4,5-trichlorophenoxy)propanoic acid (fenoprop) or a salt thereof, 2-(4-chloro-2-methylphenoxy)propanoic acid (mecoprop) or a salt thereof, 4-(4-chlorophenoxy)butanoic acid (4-CPB) or a salt thereof, 4-(2,4-dichlorophenoxy)butanoic acid (2,4-DB) or a salt thereof, 4-(3,4-dichlorophenoxy)butanoic acid (3,4-DB) or a salt thereof, 4-(4-chloro-2-methylphenoxy)butanoic acid (MCPB) or a salt thereof, 4-(2,4,5-trichlorophenoxy)butanoic acid (2,4,5-TB) or a salt thereof, 3-amino-2,5-dichlorobenzoic acid (chloramben) or a salt thereof, 3,6-dichloro-2-methoxybenzoic acid (dicamba) or a salt thereof, 2,3,6-trichlorobenzoic acid (2,3,6-TBA) or a salt thereof, 2,3,5-

trichloro-6-methoxybenzoic acid (tricamba) or a salt thereof, 4-amino-3,6-dichloro-2-pyridinecarboxylic acid (aminopyralid) or a salt thereof, 3,6-dichloro-2-pyridinecarboxylic acid (clopyralid) or a salt thereof, 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid (picloram) or a salt thereof, 3,5,6-trichloro-2-pyridinyl)oxyacetic acid (triclopyr) or a salt thereof, and combinations thereof.

36. A stable herbicidal formulation as set forth in any of claims 2 through 35 wherein the cloud point of said formulation is at least about 3°C higher than the cloud point of substantially similar glyphosate formulations of the same pH containing, as the polyalkoxylated alkyl(ether)amine component, a conventional non-peaked polyalkoxylated alkyl(ether)amine as prepared by conventional base catalysis and having the same distribution of carbon chain length, and the same average number of alkylene oxide units per amine molecule as said peaked distribution alkoxylated alkyl(ether)amine.

37. A stable herbicidal formulation as set forth in any of claims 2 to 36 wherein the glyphosate content is at least 180 g/l, at least 240 g/l, at least 300 g/l, at least 360 g/l, at least 480 g/l, at least 540 g/l or at least 600 g/l, a.e.

38. A stable herbicidal formulation as set forth in any of claims 2 to 37 comprising ammonium, diammonium, or sodium glyphosate.

39. A dry stable herbicidal formulation as set forth in claim 38.

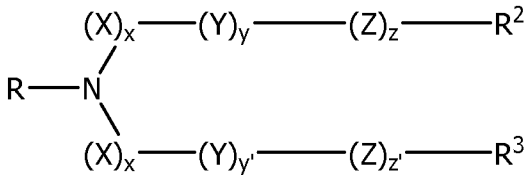
40. A stable herbicidal formulation as set forth in any of claims 2 through 39 further comprising a co-herbicide selected from the group consisting of diuron, fluometuron, prometryn, and combinations thereof.

41. A stable herbicidal formulation as set forth in claim 40 wherein the concentration of glyphosate is from about 0.5 to 2.0 wt.% or from about 0.5 to about 1.0 wt%, a.e.

42. A stable herbicidal formulation as set forth in claim 40 or 41 wherein the concentration of co-herbicide is from about 0.25 to about 1.0 wt.% or from about 0.5 wt.% to about 1.0 wt.%.

43. A stable herbicidal formulation as set forth in any of claims 40 through 42 wherein the weight ratio of glyphosate to co-herbicide is from about 0.5 to about 4.0 or from about 1.0 to about 2.0.

44. A stable herbicidal formulation as set forth in any of claims 2 to 17 or 19 to 43 wherein the polyalkoxylated alkyl(ether)amine substituted with two alkylene oxide chains in peaked distribution and corresponding to formula (I):



(I)

wherein X, Y and Z are alkylene oxide groups containing 2 - 3 carbon atoms, x is one, each of y, y', z and z' is an integer independently varying from 0 – 20, the sum of (y + y' + z + z') ≥ 4, each of R^2 and R^3 is independently selected from the group consisting of hydrogen, methyl and ethyl, and R is selected from:

(i) a linear or branched, saturated or non-saturated alkyl group containing 12 - 22 carbon atoms and derived from a primary amine having a molecular weight of at least 200, and

(ii) a group of the formula:

$$R^1-O-(A)_a-(B)_b--(C)_c-$$

Formula III

where R^1 is a linear or branched, saturated or non-saturated alkyl group containing 12-22 carbon atoms, each of A and B is an alkylene oxide group, and C is alkylene group containing 2- 3 carbon atoms, a and b each varies from 0 – 5, and c is 1, said peaked distribution alkoxylated alkyl(ether)amine being further characterized in that:

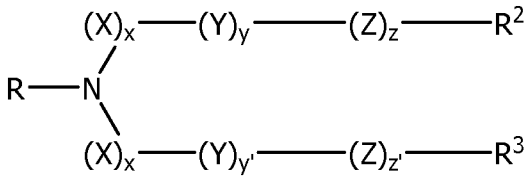
a first reference aqueous formulation consisting of 540 g/L K- glyphosate a.e., 5.5 wt.% of said peaked distribution polyalkoxylated alkyl(ether)amine and 4.5 wt.% bis(2-hydroxyethyl)cocoamine has a cloud point at least 3°C higher than the cloud point of a second reference aqueous formulation having the same pH as said first reference formulation and consisting of 540 g/L K-glyphosate a.e.,

5.5 wt.% of a reference polyalkoxylated alkyl(ether)amine and 4.5 wt.% bis(2-hydroxyethyl)cocoamine, said reference polyalkoxylated alkyl(ether)amine having the same number average value W_0, the same frequency distribution with regard to number of carbon atoms in the substituent R, and the same identity of X, Y and Z as said peaked distribution polyalkoxylated alkyl(ether)amine, wherein:

said reference polyalkoxylated alkyl(ether)amine is prepared by an NaOH-catalyzed reaction of RNH_2 with alkylene oxide conducted entirely under autogenous pressure up to 90 psig at a catalyst concentration of 0.2 wt.% and a temperature between 160° and 180°C; and

W_0 is the number average value of (2x + y + y' + z +z').

45. A stable herbicidal formulation as set forth in any of claims 1 to 43 wherein the polyalkoxylated alkyl(ether)amine is substituted with two alkylene oxide chains in peaked distribution and corresponding to formula (I):



(I)

wherein X, Y and Z are alkylene oxide groups containing 2 - 3 carbon atoms, x is one, each of y, y', z and z' is an integer independently varying from 0 - 20, the sum of (y + y' + z + z') ≥ 4, each of R^2 and R^3 is independently selected from the group consisting of hydrogen, methyl and ethyl, and R is selected from:

(i) a linear or branched, saturated or non-saturated alkyl group containing 12 - 22 carbon atoms and derived from a primary amine having a molecular weight of at least 200, and

(ii) a group of the formula:

$$R^1-O-(A)_a-(B)_b--(C)_c-$$

Formula III

where R^1 is a linear or branched, saturated or non-saturated alkyl group containing 12-22 carbon atoms, each of A and B is an alkylene oxide group, and C is alkylene group containing 2- 3 carbon atoms, a and b each varies from 0 - 5, and c is 1

and is characterized by one or more of the following:

W_0 is the number average value of (2x + y + y' + z + z') in each of said mixtures of homologs, and

k is an integer such that $(W_o - 1) < k \leq W_o < (k + 1)$;

$\Sigma 3$ = the sum in each said mixture of the number percentages of the three most prevalent homologs contained therein,

α_1 is the sum of the number percentages of homologs W_i from i = 2 to (k-1) where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_2 is the sum of the number percentages of homologs W_i from i = 2 to k where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_3 is the sum of the number percentages of homologs W_i from i = 2 to (k+1) where W_i is the number percentage

of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

β_1 is the sum of the number percentages of homologs W_i from i = k to infinity;

β_2 is the sum of the number percentages of homologs W_i from i = k+1 to infinity;

β_3 is the sum of the number percentages of homologs W_i from k +2 to infinity;

$\alpha_{23} = \alpha_2 + (W_0 - k)W_{k+1}$;

$\beta_{12} = \beta_2 + [(k+1) - W_0]W_k$; and

$\beta_{23} = \beta_3 + [(k+1) - W_0]W_{k+1}$.

46. A stable herbicidal formulation as set forth in claim 45 wherein the polyalkoxylated alkyl(ether)amine is characterized in that the sum of $(y + y' + z + z') \geq 4$, and is further characterized in that either:

the degree of peaking ($\Sigma 3$) of said mixture of homologs is higher than the degree of peaking obtained in a reference mixture of homologs of Formula I; and/or

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is higher than the peaking index obtained in a reference mixture of homologs of Formula I; and/or

the tailing index β_{12} and/or the tailing index β_{23} of said mixture of homologs is lower than the corresponding tailing index β_{12} and/or the tailing index β_{23} obtained in a reference mixture of homologs of Formula I; and/or

the tilt ratio α_{23}/β_{12} and/or the tilt ratio α_{23}/β_{23} of said mixture of homologs is higher than the tilt ratio obtained in a reference mixture of homologs of Formula I; and/or

the value of α_1 for said mixture of homologs is higher than the corresponding value obtained in a reference mixture of

homologs of Formula I; and/or

the value of α_2 for said mixture of homologs is higher than the corresponding value obtained in a reference mixture of homologs of Formula I; and/or

the value of α_3 for said mixture of homologs is higher than the corresponding value obtained in a reference mixture of homologs of Formula I; and/or where:

said reference mixture has the same value of W_0, the same frequency distribution with regard to number of carbon atoms in the substituent R, and the same identity of X, Y and Z as said peaked distribution polyalkoxylated alkyl(ether)amine wherein said reference mixture is prepared by NaOH-catalyzed reaction of RNH_2 with alkylene oxide conducted entirely under autogenous pressure up to 90 psig at a catalyst concentration of 0.2 number % and a temperature between 160° and 180°C;

when R is not of Formula III or Formula V, the value of W_0 in said mixtures of homologs of said peaked distribution polyalkoxylated alkyl(ether)amine is at least 3.5, wherein the vinyl polyethylene glycol content of the formulation is not greater than about 4 wt.% and/or the (poly)ethylene glycol derivative (EGD) content of the formulation is not greater than about 5 wt.%.

47. A stable herbicidal formulation as set forth in claim 45 wherein the polyalkoxylated alkyl(ether)amine is characterized in that the sum of $(y + y' + z + z') \geq 4$, and is further characterized in that either:

where W_0 is between 3 and 4.5, the tilt ratio α_{23}/β_{23} is at least about 1.90,

where W_0 is between 4.5 and 5.5, the tilt ratio α_{23}/β_{23} is at

least about 1.85,

where W_0 is between 5.5 and 6.5, the tilt ratio α_{23}/β_{23} is at least about 1.75,

where W_0 is between 6.5 and 8.5, the tilt ratio α_{23}/β_{23} is at least about 1.40,

where W_0 is above 8.5, the tilt ratio α_{23}/β_{23} is at least about 1.42.

48. A stable herbicidal formulation as set forth in claim 45 wherein the polyalkoxylated alkyl(ether)amine is characterized in that the sum of $(y + y' + z + z') \geq 1$, and is further characterized in that either:

the degree of peaking ($\Sigma 3$) of said mixture of homologs is at least about 0.34; and/or

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is at least about 0.75; and/or

the tilt ratio α_2/β_1 of said mixture of homologs is at least about 0.22; and/or

the tilt ratio α_{23}/β_{12} of said mixture of homologs is at least about 0.38; and/or

the tilt ratio α_{23}/β_{23} of said mixture of homologs is at least about 0.45; and/or

the value of α_1 for said mixture of homologs is at least about 0.10; and/or

the value of α_2 for said mixture of homologs is at least about 0.15; and/or

the value of α_3 for said mixture of homologs is at least about 0.25; and/or

the value of α_{23} for said mixture of homologs is at least about 0.23; and

when R is not of Formula III, the value of W_0 in said mixtures of homologs of said surfactant is at least 3.5 and/or the vinyl polyethylene glycol content of the formulation is not greater than about 4 wt.% and/or the (poly)ethylene glycol derivative (EGD) content of the formulation is not greater than about 5 wt.%.

49. A stable herbicidal formulation as set forth in claim 45 wherein the polyalkoxylated alkyl(ether)amine is characterized in that the sum of $(y + y' + z + z') \geq 1$, and is further characterized in that either:

the degree of peaking ($\Sigma 3$) of said mixture of homologs is at least about 0.28; and

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is at least about 0.62; and

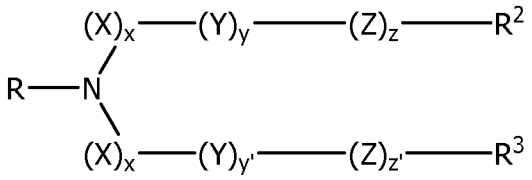
the tilt ratio α_2/β_1 of said mixture of homologs is at least about 0.16; and

the tilt ratio α_{23}/β_{12} of said mixture of homologs is at least about 0.29; and

the tilt ratio α_{23}/β_{23} of said mixture of homologs is at least about 0.34; and

when R is not of Formula III, the value of W_0 in said mixtures of homologs of said surfactant is at least 3.5 and/or the vinyl polyethylene glycol content of the formulation is not greater than about 4 wt.% and/or the (poly)ethylene glycol derivative (EGD) content of the formulation is not greater than about 5 wt.%.

50. An alkoxylated alkyl(ether)amine surfactant comprising a mixture of homologs corresponding to formula (I):



(I)

wherein X, Y and Z are alkylene oxide groups containing 2 - 3 carbon atoms, x is one, each of y, y', z and z' is an integer independently varying from 0 – 20, the sum of (y + y' + z + z') ≥ 1, each of R^2 and R^3 is independently selected from the group consisting of hydrogen, methyl and ethyl, and R is selected from:

(i) a linear or branched, saturated or non-saturated alkyl group containing 12 - 22 carbon atoms and derived from a primary amine having a molecular weight of at least 200, and

(ii) a group of the formula:

$$R^1- O - (A)_a - (B)_b --(C)_c -$$

Formula III

where R^1 is a linear or branched, saturated or non-saturated alkyl group containing 12-22 carbon atoms, each of A and B is an alkylene oxide group, and C is alkylene group containing 2- 4 carbon atoms, a and b each varies from 0 – 5, and c is 1, further characterized in that:

the degree of peaking (Σ3) of said mixture of homologs is at least about 0.34; and/or

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is at least about 0.75; and/or

the tilt ratio α_2/β_1 of said mixture of homologs is at least

about 0.22; and/or

the tilt ratio α_{23}/β_{12} of said mixture of homologs is at least about 0.38; and/or

the tilt ratio α_{23}/β_{23} of said mixture of homologs is at least about 0.45; and/or

the value of α_1 for said mixture of homologs is at least about 0.10; and/or

the value of α_2 for said mixture of homologs is at least about 0.15; and/or

the value of α_3 for said mixture of homologs is at least about 0.25; and/or

the value of α_{23} for said mixture of homologs is at least about 0.23;

where:

W_0 is the number average value of (2x + y + y' + z + z') in each of said mixtures of homologs, and

k is an integer such that $(W_o - 1) < k \leq W_o < (k + 1)$;

$\Sigma 3$ = the sum in each said mixture of the number percentages of the three most prevalent homologs contained therein,

α_1 is the sum of the number percentages of homologs W_i from i = 2 to (k-1) where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_2 is the sum of the number percentages of homologs W_i from i = 2 to k where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_3 is the sum of the number percentages of homologs W_i from i = 2 to (k+1) where W_i is the number percentage

of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

β_1 is the sum of the number percentages of homologs W_i from i = k to infinity;

β_2 is the sum of the number percentages of homologs W_i from i = k+1 to infinity.

β_3 is the sum of the number percentages of homologs W_i from k +2 to infinity;

$\alpha_{23} = \alpha_2 + (W_0 - k)W_{k+1}$;

$\beta_{12} = \beta_2 + [(k+1) - W_0]W_k$;

$\beta_{23} = \beta_3 + [(k+1) - W_0]W_{k+1}$; and

when R is not of Formula III, the value of W_0 in said mixtures of homologs of said surfactant is at least 3.5 and/or the vinyl polyethylene glycol content of the surfactant is not greater than about 4 wt.% and/or the (poly)ethylene glycol derivative (EGD) content of the surfactant is not greater than about 5 wt.%.

51. An alkoxylated alkyl(ether)amine surfactant as set forth in claim 50 wherein said peaked distribution alkoxylated alkyl(ether)amine is an alkoxylated tallowamine, provided that it is not 9EO or 10EO tallowamine, and/or said peaked distribution alkoxylated alkyl(ether)amine is 8EO tallowamine.

52. A surfactant as set forth in claim 50 or 51 wherein the degree of peaking, $\Sigma 3$ is at least about 0.34 and/or the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ is at least about 0.75.

53. A surfactant as set forth in claim 52 wherein the degree of peaking, $\Sigma 3$ is at least about 0.34 and the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ is at least about 0.75.

54. A surfactant as set forth in claim 53 wherein the tilt ratio, α_2/β_1 is at least about 0.22.

55. A surfactant as set forth in any of claims 50 to 54 wherein the value of α_1 for said mixture of homologs is at least about 0.10.

56. A surfactant as set forth in claim 55 wherein the value of α_1 for said mixture of homologs is at least about 0.12.

57. A surfactant as set forth in any of claims 50 to 56 wherein the value of α_2 for said mixture of homologs is at least about 0.15.

58. A surfactant as set forth in claim 57 wherein the value of α_2 for said mixture of homologs is at least about 0.17.

59. A surfactant as set forth in claim 58 wherein the value of α_2 for said mixture of homologs is at least about 0.21.

60. A surfactant as set forth in any of claims 50 to 59 wherein the value of α_3 for said mixture of homologs is at least about 0.25.

61. A surfactant as set forth in claim 60 wherein the value of α_3 for said mixture of homologs is at least about 0.30.

62. A surfactant as set forth in any of claims 50 to 61 wherein the value of α_{23} for said mixture of homologs is at least about 0.23.

63. A surfactant as set forth in claim 62 wherein the value of α_{23} for said mixture of homologs is at least about 0.25.

64. A surfactant as set forth in claim 63 wherein the value of α_{23} for said mixture of homologs is at least about 0.27.

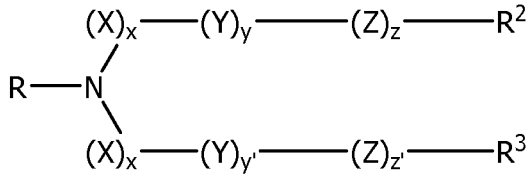
65. A surfactant as set forth in any of claims 50 to 64 wherein the value of α_1 is at least about 0.10 and the value of α_2 is at least about 0.15; and/or the value of α_1 is at least about 0.10 and the value of α_3 is at least about 0.25; and/or the value of α_1 is at least about 0.10 and the value of α_{23} is at least about 0.23; and/or the value of α_2 is at least about 0.15 and the value of α_3 is at least about 0.25; and/or the value of α_2 is at least about 0.15 and the value of α_{23} is at least about 0.23; and/or the value of α_3 is at least about 0.25 and the value of α_{23} is at least about 0.23.

66. A surfactant as set forth in any of claims 50 through 65 wherein $k \geq 7$.

67. A surfactant as set forth in any of claims 50 to 66 wherein the tilt ratio α_{23}/β_{23} is between about 0.45 and 1.42.

68. A surfactant as set forth in any of claims 50 to 66 wherein the tilt ratio α_{23}/β_{23} is between about 0.34 and about 1.30, between about 0.34 and about 1.20, between about 0.34 and about 1.10, or between about 0.34 and about 1.

69. An alkoxylated alkyl(ether)amine surfactant comprising a mixture of homologs corresponding to formula (I):



(I)

wherein X, Y and Z are alkylene oxide groups containing 2 - 3 carbon atoms, x is one, each of y, y', z and z' is an integer independently varying from 0 – 20, the sum of (y + y' + z + z') ≥ 1, each of R^2 and R^3 is independently selected from the group consisting of hydrogen, methyl and ethyl, and R is selected from:

(i) a linear or branched, saturated or non-saturated alkyl group containing 12 - 22 carbon atoms and derived from a primary amine having a molecular weight of at least 200, and

(ii) a group of the formula:

$$R^1 - O - (A)_a - (B)_b - (C)_c -$$

Formula III

where R^1 is a linear or branched, saturated or non-saturated alkyl group containing 12-22 carbon atoms, each of A and B is an alkylene oxide group, and C is alkylene group containing 2- 3 carbon atoms, a and b each varies from 0 - 5, and c is 1,

further characterized in that:

the degree of peaking ($\Sigma 3$) of said mixture of homologs is at least about 0.28; and

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is at least about 0.62; and

the tilt ratio α_2/β_1 of said mixture of homologs is at least about 0.16; and

the tilt ratio α_{23}/β_{12} of said mixture of homologs is at least about 0.29; and

the tilt ratio α_{23}/β_{23} of said mixture of homologs is at least about 0.34;

where:

W_0 is the number average value of (2x + y + y' + z + z') in each of said mixtures of homologs, and

k is an integer such that $(W_o - 1) < k \leq W_o < (k + 1)$;

$\Sigma 3$ = the sum in each said mixture of the number percentages of the three most prevalent homologs contained therein,

α_2 is the sum of the number percentages of homologs W_i from i = 2 to k where W_i is the number percentage of the homolog in which i equals the sum of the number of

alkylene oxide substituents $(2x + y + y' + z + z')_i$,

β_1 is the sum of the number percentages of homologs W_i from i = k to infinity;

β_2 is the sum of the number percentages of homologs W_i from i = k+1 to infinity.

β_3 is the sum of the number percentages of homologs W_i from k +2 to infinity;

$\alpha_{23} = \alpha_2 + (W_0 - k)W_{k+1}$;

$\beta_{12} = \beta_2 + [(k+1) - W_0]W_k$;

$\beta_{23} = \beta_3 + [(k+1) - W_0]W_{k+1}$; and

when R is not of Formula III, the value of W_0 in said mixtures of homologs of said surfactant is at least 3.5 and/or the vinyl polyethylene glycol content of the surfactant is not greater than about 4 wt.% and/or the (poly)ethylene glycol derivative (EGD) content of the surfactant is not greater than about 5 wt.%.

70. An alkoxylated alkyl(ether)amine surfactant as set forth in claim 69 wherein said peaked distribution alkoxylated alkyl(ether)amine is an alkoxylated tallowamine, provided that it is not 9EO or 10EO tallowamine, and/or said peaked distribution alkoxylated alkyl(ether)amine is 8EO tallowamine.

71. A surfactant as set forth in claim 69 or 70 wherein the degree of peaking, Σ3 is at least about 0.30.

72. A surfactant as set forth in claim 71 wherein the degree of peaking, Σ3 is at least about 0.32.

73. A surfactant as set forth in any of claims 70 to 72 wherein the peaking index is at least about 0.65.

74. A surfactant as set forth in claim 73 wherein the peaking index is at least about 0.68.

75. A surfactant as set forth in claim 73 wherein the peaking index is at least about 0.72.

76. A surfactant as set forth in any of claims 69 to 75 wherein the tilt ratio α_2/β_1 is at least about 0.16.

77. A surfactant as set forth in claim 76 wherein the tilt ratio α_2/β_1 is at least about 0.18.

78. A surfactant as set forth in claim 77 wherein the tilt ratio α_2/β_1 is at least about 0.20.

79. A surfactant as set forth in any of claims 69 through 78 wherein $k \geq 7$.

80. A surfactant as set forth in any of claims 69 to 79 wherein the tilt ratio α_{23}/β_{23} is between about 0.34 and 1.42.

81. A surfactant as set forth in claim 80 wherein the tilt ratio α_{23}/β_{23} is between about 0.34 and about 1.30, between about 0.34 and about 1.20, between about 0.34 and about 1.10, or between about 0.34 and about 1.

82. A surfactant as set forth in any of claims 50 to 81 characterized in that:

the degree of peaking ($\Sigma 3$) of said mixture of homologs is at least 0.75, at least about 0.85, or at least about 0.95; and/or

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is at least 1.10, at least about 1.25, or at least about 1.40; and/or

the tilt ratio α_2/β_1 of said mixture of homologs is at least 1.15, at least about 1.25, or at least about 1.35; and/or

the tilt ratio α_{23}/β_{12} of said mixture of homologs is at least 1.25, at least about 1.35, or at least about 1.45; and/or

the tilt ratio α_{23}/β_{23} of said mixture of homologs is at least 2.25, at least about 2.35, or at least about 2.45; and/or

the value of α_1 for said mixture of homologs is at least 0.41, at least about 0.55, or at least about 0.70; and/or

the value of α_2 for said mixture of homologs is at least 0.67, at least about 0.75, or at least about 0.90; and/or

the value of α_3 for said mixture of homologs is at least 0.83, at least about 0.95, or at least about 1.10; and/or

the value of α_{23} for said mixture of homologs is at least 0.70, at least about 0.75, or at least about 0.90.

83. A surfactant as set forth in any of claims 50 to 81 characterized in that:

the degree of peaking ($\Sigma 3$) of said mixture of homologs is less than 0.42, or less than about 0.38; and/or

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is less than 0.84, or less than about 0.80; and/or

the tilt ratio α_2/β_1 of said mixture of homologs is less than 0.62, less than about 0.50, or less than about 0.40; and/or

the tilt ratio α_{23}/β_{12} of said mixture of homologs is less than 0.96, less than about 0.80, or less than about 0.65; and/or

the tilt ratio α_{23}/β_{23} of said mixture of homologs is less than 1.33, less than about 1.0, or less than about 0.75; and/or

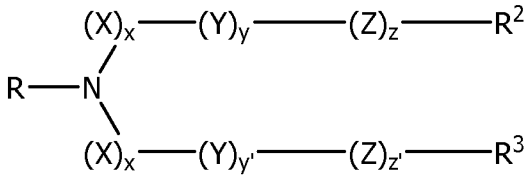
the value of α_1 for said mixture of homologs is less than 0.22, less than about 0.18, or less than about 0.14; and/or

the value of α_2 for said mixture of homologs is less than 0.45, less than about 0.35, or less than about 0.25; and/or

the value of α_3 for said mixture of homologs is less than 0.60, less than about 0.45, or less than about 0.30; and/or

the value of α_{23} for said mixture of homologs is less than 0.57, less than about 0.45, or less than about 0.35.

84. A polyalkoxylated alkyl(ether)amine surfactant substituted with two alkylene oxide chains in peaked distribution and corresponding to formula (I):



(I)

wherein X, Y and Z are alkylene oxide groups containing 2 - 3 carbon atoms, x is one, each of y, y', z and z' is an integer independently varying from 0 - 20, the sum of (y + y' + z + z') ≥ 4, each of R^2 and R^3 is independently selected from the group consisting of hydrogen, methyl and ethyl, and R is selected from:

(i) a linear or branched, saturated or non-saturated alkyl group containing 12 - 22 carbon atoms and derived from a primary amine having a molecular weight of at least 200, and

(ii) a group of the formula:

$$R^1 - O - (A)_a - (B)_b - (C)_c -$$

Formula III

where R^1 is a linear or branched, saturated or non-saturated alkyl group containing 12-22 carbon atoms, each of A and B is an alkylene oxide group, and C is alkylene group containing 2- 3 carbon atoms, a and b each varies from 0 - 5, and c is 1

and is characterized by one or more of the following:

W_0 is the number average value of (2x + y + y' + z + z') in each of said mixtures of homologs, and

k is an integer such that $(W_o - 1) < k \leq W_o < (k + 1)$;

Σ3 = the sum in each said mixture of the number

percentages of the three most prevalent homologs contained therein,

α_1 is the sum of the number percentages of homologs W_i from i = 2 to (k-1) where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_2 is the sum of the number percentages of homologs W_i from i = 2 to k where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

α_3 is the sum of the number percentages of homologs W_i from i = 2 to (k+1) where W_i is the number percentage of the homolog in which i equals the sum of the number of alkylene oxide substituents $(2x + y + y' + z + z')_i$,

β_1 is the sum of the number percentages of homologs W_i from i = k to infinity;

β_2 is the sum of the number percentages of homologs W_i from i = k+1 to infinity;

β_3 is the sum of the number percentages of homologs W_i from k +2 to infinity;

$\alpha_{23} = \alpha_2 + (W_0 - k)W_{k+1}$;

$\beta_{12} = \beta_2 + [(k+1) - W_0]W_k$; and

$\beta_{23} = \beta_3 + [(k+1) - W_0]W_{k+1}$, where

and is further characterized in that either:

the degree of peaking ($\Sigma 3$) of said mixture of homologs is higher than the degree of peaking obtained in a reference mixture of homologs of Formula I; and/or

the peaking index, $(W_0/2)^{1/2}(\Sigma 3)$ of said mixture of homologs is higher than the peaking index obtained in a reference mixture of homologs of Formula I; and/or

the tailing index β_{12} and/or the tailing index β_{23} of said mixture of homologs is lower than the corresponding tailing index β_{12} and/or the tailing index β_{23} obtained in a reference mixture of homologs of Formula I; and/or

the tilt ratio α_{23}/β_{12} and/or the tilt ratio α_{23}/β_{23} of said mixture of homologs is higher than the tilt ratio obtained in a reference mixture of homologs of Formula I; and/or

the value of α_1 for said mixture of homologs is higher than the corresponding value obtained in a reference mixture of homologs of Formula I; and/or

the value of α_2 for said mixture of homologs is higher than the corresponding value obtained in a reference mixture of homologs of Formula I; and/or

the value of α_3 for said mixture of homologs is higher than the corresponding value obtained in a reference mixture of homologs of Formula I; and/or where:

said reference mixture has the same value of W_0, the same frequency distribution with regard to number of carbon atoms in the substituent R, and the same identity of X, Y and Z as said peaked distribution polyalkoxylated alkyl(ether)amine wherein said reference mixture is prepared by NaOH-catalyzed reaction of RNH_2 with alkylene oxide conducted entirely under autogenous pressure up to 90 psig at a catalyst concentration of 0.2 number % and a temperature between 160° and 180°C;

when R is not of Formula III or Formula V, the value of W_0 in said mixtures of homologs of said peaked distribution polyalkoxylated alkyl(ether)amine is at least 3.5, wherein the vinyl polyethylene glycol content of the surfactant is not greater than about 4 wt.% and/or the (poly)ethylene glycol derivative (EGD) content of the surfactant is not

greater than about 5 wt.%.

85. A polyalkoxylated alkyl(ether)amine surfactant as set forth in claim 84 further characterized in that either:

where W_0 is between 3 and 4.5, the tilt ratio α_{23}/β_{23} is at least about 1.90,

where W_0 is between 4.5 and 5.5, the tilt ratio α_{23}/β_{23} is at least about 1.85,

where W_0 is between 5.5 and 6.5, the tilt ratio α_{23}/β_{23} is at least about 1.75,

where W_0 is between 6.5 and 8.5, the tilt ratio α_{23}/β_{23} is at least about 1.40,

where W_0 is above 8.5, the tilt ratio α_{23}/β_{23} is at least about 1.42.