



(43) International Publication Date
15 June 2017 (15.06.2017)

(10) International Publication Number
WO 2017/100507 A1

(51) International Patent Classification:

C05B 7/00 (2006.01) *C05G 3/00* (2006.01)
C05B 17/00 (2006.01) *C05G 3/08* (2006.01)
C05C 3/00 (2006.01)

(21) International Application Number:

PCT/US2016/065721

(22) International Filing Date:

9 December 2016 (09.12.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/266,281 11 December 2015 (11.12.2015) US

(71) Applicant: **KOCH AGROMONIC SERVICES, LLC**
[US/US]; 4111 E. 37th Street N., Wichita, Kansas 67220
(US).

(72) Inventors: **BOBECK, Drew**; 4111 E. 37th N., Wichita,
Kansas 67220 (US). **GILES, Jessica**; 4111 E. 37th N.,
Wichita, Kansas 67220 (US). **KELLY, Robert**; 4111 E.
37th N., Wichita, Kansas 67220 (US). **STAPLES, Stuart**;
4111 E. 37th N., Wichita, Kansas 67220 (US). **WADE,**
Brian; 4111 E. 37th N., Wichita, Kansas 67220 (US).
WERTZ, Stacey; 4111 E. 37th N., Wichita, Kansas 67220
(US).

(74) Agent: **MACKENZIE, Stephen**; 4111 E. 37th St. N.,
Wichita, Kansas 67229 (US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY,
TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments (Rule 48.2(h))

(54) Title: ACID RESISTANT UREASE INHIBITOR CONTAINING FERTILIZER COMPOSITIONS

(57) Abstract: The present invention provides novel acid resistant fertilizer compositions that comprise a particulate urease inhibitor containing urea source, a particulate acidic fertilizer, and a basic component. The basic component is used to treat the surface of either the particulate urease inhibitor containing urea source or the particulate acidic fertilizer, or both of them independently to provide an improved urease inhibitor storage time when the particulate urease inhibitor containing urea source is blended and stored with the particulate acidic fertilizer. Methods of making and using the compositions are also provided.



WO 2017/100507 A1

ACID RESISTANT UREASE INHIBITOR CONTAINING FERTILIZER COMPOSITIONS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional Patent Application No. 62/266281, filed on December 11 2015, which is hereby incorporated by reference in its entirety.

5 TECHNICAL FIELD

The present disclosure relates to novel acid resistant fertilizer compositions that comprise a particulate urease inhibitor containing urea source, a particulate acidic fertilizer, and a basic component, and methods of making and using the acid resistant fertilizer compositions.

BACKGROUND

10 Nitrogen losses due to ammonia volatilization occur with urea or urea-based fertilizers, in part, because of rapid hydrolysis of urea on or near the soil surface by naturally occurring urease enzyme. A urease inhibitor such as an N-alkyl phosphoric triamide or N-alkyl thiophosphoric triamide (particularly N-(n-butyl) thiophosphoric triamide, NBPT) can slow down the enzymatic breakdown of urea by inhibition of the urease enzyme. This provides an effective means of
15 managing losses of nitrogen in the form of ammonia from surface-applied urea containing fertilizers.

An N-alkyl phosphoric triamide or N-alkyl thiophosphoric triamide urease inhibitor such as NBPT can be applied onto a granular fertilizer formulation by first blending the concentrated solution of the N-alkyl thiophosphoric triamide that is dissolved in a solvent such as a glycol or
20 glycol derivative or a mixed solvent of a glycol or glycol derivative and a liquid amide. (see U.S. Patent No. 5,698,003). Alternatively, an N-alkyl phosphoric triamide or N-alkyl thiophosphoric triamide urease inhibitor such as NBPT can be introduced into the urea melt to form an incorporated urea fertilizer (see WO 2015/027244). In addition, a highly concentrated dry formulation of NBPT such as AGROTAIN® DRI-MAXX nitrogen stabilizer, which can
25 adhere to the urea granules without adding additional moisture to the blend, can be used to treat urea granules to make a NBPT-containing urea as well. (see U.S. Patent No. 9,034,072).

Although N-alkyl phosphoric triamide or N-alkyl thiophosphoric triamide such as NBPT is reasonably stable under normal storage conditions such as room temperature and neutral pH, it is well known that acidic conditions may lead to rapid disappearance of NBPT. See, for example, Apparent persistence of N-(N-butyl) thiophosphoric triamide is greater in alkaline soils, Engel et al, Soil Science Society of America Journal (2013), 77(4), 1424-1429.

BRIEF SUMMARY OF THE INVENTION

The primary objective of the present disclosure is to develop an economic and stable fertilizer composition that comprises a particulate urease inhibitor containing urea source, a particulate acidic fertilizer such as phosphate or sulfate fertilizer or a combination thereof, and a suitable basic component that is used to treat either the particulate urease inhibitor containing urea source or the particulate acidic fertilizer or both of them independently, wherein the impact of the acidic characteristics of the particulate acidic fertilizer to the urease inhibitor may be substantially mitigated to provide the improved storage life for the acid sensitive urease inhibitor such as NBPT.

Urease inhibitor containing urea based fertilizers and phosphate or sulfate based fertilizers can provide different nutrients to soils and/or plants to supply one or more nutrients essential to the growth of plants. Although fertilizers comprising different nutrients may be applied to soils or plants separately, it may be beneficial to prepare, package, transport, store and/or use a single fertilizer composition.

However, some fertilizers may be mutually incompatible for variety of reasons. For example, the storage life for certain urease inhibitors such as NBPT could be substantially shortened in acidic conditions when urease inhibitor-containing urea fertilizer granules are blended with an acidic blend partner such as monoammonium phosphate (MAP), diammonium phosphate (DAP), ammonium sulfate, ammonium hydrogensulfate, or any acidic fertilizer that comprises, for example, any form of sulfate or phosphate. It has been observed that a urease inhibitor such as NBPT may decompose almost completely within 1-2 weeks after the blending of the NBPT-containing urea and one or more acidic fertilizers such as MAP.

Surprisingly, certain basic components applied to the surface of particulate acidic fertilizers provide unexpected stability for NBPT when NBPT treated urea is blended with the

basic component treated acidic fertilizers. Examples of acidic fertilizers that can be treated include MAP, DAP, ammonium sulfate, rock phosphate, or Micro-Essentials® SZ (MESZ (12-40-0-10S-1Zn)). Using a basic material to treat an acidic fertilizer generally may not be a reasonable approach because acid and base may react even when both are in solid form.

5 Alternatively, the same surprising benefits are realized by treating the surface of the particulate urease inhibitor containing fertilizer with certain basic component. This basic component treated composition may also provide unexpectedly longer NBPT storage life time when it is blended with an untreated acidic fertilizer.

10 Thus, by using a basic component to treat the surface of either a particulate urease inhibitor containing urea source or a particulate acidic fertilizer, or both of them independently, the present disclosure provides novel economic and acid resistant urease inhibitor containing fertilizer compositions that may provide longer storage life for an acid sensitive urease inhibitor such as NBPT.

15 In one embodiment, the present disclosure provides a particulate fertilizer composition comprising a basic component and a particulate acidic fertilizer having a surface, wherein the surface of the particulate acidic fertilizer is treated with the basic component. The weight percentage range of the basic component can be 0.001% to 20 % by weight and the weight percentage range of the particulate acidic fertilizer can be 99.999 % to 80 % by weight.

20 The particulate acidic fertilizer that is treated with the basic component provides 14-1500 days of half-life under accelerated NBPT stability lab test condition for a urease inhibitor when the basic component treated particulate acidic fertilizer is blended with a particulate urease inhibitor containing urea source.

25 In another embodiment, the present disclosure provides a particulate fertilizer composition comprising a basic component and a particulate urease inhibitor containing urea source having a surface, wherein the surface of the particulate urease inhibitor containing urea source is treated with the basic component.

30 The particulate urease inhibitor containing urea source that is treated with the basic component provides 14-1500 days of half-life under accelerated NBPT stability lab test condition for the urease inhibitor when the basic component treated particulate urease inhibitor containing urea source is blended with a particulate acidic fertilizer.

In a further embodiment, the present disclosure provides an acid resistant fertilizer composition comprising

- i). a particulate acidic fertilizer having a surface;
- ii). a particulate urease inhibitor containing urea source having a surface; and
- iii). a basic component,

wherein the surface of at least one of i) or ii) is treated with iii).

The acid resistant fertilizer composition provides 14-1500 days of half-life under accelerated NBPT stability lab test condition for the urease inhibitor.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the below terms have the following meanings unless specified otherwise:

“Basic component treated”, “treated with a basic component”, or any term referring to the manner of the treatment on the surface of a particulate acidic fertilizer or a particulate urease inhibitor containing urea source in the present disclosure means that a suitable basic component is added and adhered onto the surface of either the particulate acidic fertilizer or the particulate urease inhibitor containing urea source to provide sufficient protection for the urease inhibitor such as NBPT. Although it is desirable to cover as much surface of a particulate fertilizer as possible with a suitable basic component, as far as NBPT is sufficiently protected or the decomposition rate of NBPT is sufficiently slowed down, the actual percentage of the covered surface of a particulate fertilizer may vary from 10% to 100%, 20% to 100%, 30% to 100%, 40% to 100%, 50% to 100%, 60% to 100%, 70% to 100%, 80% to 100%, 90% to 100%, or 95% to 100%. The percentage of the covered surface in the present disclosure primarily means the percentage of the visible outer surface of the particulate fertilizer particles instead of the total surface area that may include the surface area of small pores within the particulate fertilizer particle.

“Half-life storage time” or “half-life” of a urease inhibitor such as NBPT in the present disclosure means the amount of time required for the amount of urease inhibitor such as NBPT to decrease to half of its initial value prior to the blending of the particulate acidic fertilizer and the particulate urease inhibitor containing urea source. In the present disclosure, a fertilizer blend to

be tested for the urease inhibitor half-life storage time is stored in sealed jar at ambient condition after the particulate acidic fertilizer is blended with the urease inhibitor containing urea source. The urease inhibitor content is analyzed by high pressure liquid chromatography (HPLC), which is known to those skilled in the art. In some situations, the half-life storage time is long. At the
5 time the data is collected, the urease inhibitor content is still above 50% of the original urease inhibitor content. For such examples, the actual urease inhibitor content and the days passed after the blending is recorded. For example, the NBPT content in Example 33 of the present disclosure reached half of the original content on day 91 (half-life). The half-life storage time of 91 days is thus recorded as the NBPT half-life. The NBPT content in Example 34 of the present
10 disclosure is 71% on day 28 when the data is collected. The value 71% is well above 50%. The actual days after the blending (28 days) and the remaining NBPT (71%) content is provided.

There is a long-felt-need to develop economic acid resistant urease inhibitor containing fertilizer compositions that provide multiple nutrients such as nitrogen, phosphate and sulfate. NBPT is the most widely used urease inhibitor to mitigate the nitrogen losses due to the
15 ammonia volatilization for urea or urea-based fertilizers. However, NBPT is very sensitive to acidic conditions. The most widely used phosphate and sulfate fertilizers are often very acidic and will decompose NBPT very quickly if they are blended with NBPT containing urea sources. It has been observed that NBPT may decompose almost completely within 1-2 weeks after the blending of the NBPT-containing urea and one or more acidic fertilizers such as MAP.

20 Previous efforts to mitigate the problem have been tried to treat the particulate fertilizers with some coating materials such as wax or polymeric coatings. To date, there is no satisfactory acid resistant NBPT containing multi-nutrient composition that has been disclosed. Thus, the primary objective of this disclosure is to develop an economic and acid resistant NBPT containing fertilizer composition for this long-felt-need.

25 In one embodiment, the present disclosure provides a particulate fertilizer composition comprising a basic component and a particulate acidic fertilizer having a surface, wherein the surface of the particulate acidic fertilizer is treated with the basic component.

The particulate acidic fertilizer that is treated with the basic component provides 14-1500 days of half-life under accelerated NBPT stability lab test condition for a urease inhibitor

when the basic component treated particulate acidic fertilizer is blended with a particulate urease inhibitor containing urea source.

In another embodiment, the present disclosure provides a particulate fertilizer composition comprising a basic component and a particulate urease inhibitor containing urea source having a surface, wherein the surface of the particulate urease inhibitor containing urea source is treated with the basic component.

The particulate urease inhibitor containing urea source that is treated with the basic component provides 14-1500 days of half-life under accelerated NBPT stability lab test condition for the urease inhibitor when the basic component treated particulate urease inhibitor containing urea source is blended with a particulate acidic fertilizer.

In a further embodiment, the present disclosure provides an acid resistant fertilizer composition comprising

- i). a particulate acidic fertilizer having a surface;
 - ii). a particulate urease inhibitor containing urea source having a surface; and
 - iii). a basic component,
- wherein the surface of at least one of i) or ii) is treated with iii).

The acid resistant fertilizer composition provides 14-1500 days of half-life under accelerated NBPT stability lab test condition for the urease inhibitor.

In any embodiment in the present disclosure, any particulate fertilizer may be treated with at least one additional layer of another material that may include but is not limited to a petroleum product, a wax, a paraffin oil, a bitumen, an asphalt, a lubricant, a coal product, an oil, canola oil, soybean oil, coconut oil, linseed oil, tung oil, vegetable wax, animal fat, animal wax, a forest product, tall oil, modified tall oil, tall oil pitch, pine tar, a synthetic oil, a synthetic wax, a synthetic lubricant, an ethylene-vinyl acetate copolymer, an ethyleneacrylic acid copolymer, an ethylene-ethyl acrylate copolymer, an ethylene-vinyl alcohol copolymer, ethylene-vinyl, alcohol-vinyl acetate terpolymers, polyurethane polymer, alkyd resin, a surfactant, soap or a combination thereof. The at least one additional layer of another material may be applied prior to or after the treatment of a basic component to a particulate acidic fertilizer or a particulate urease inhibitor containing urea source.

In one aspect, the at least one additional layer of another material has a weight percentage range of 0.01% to 5 % by weight of the total weight of the particulate fertilizer that is treated by the at least one additional layer of another material. In another aspect, the weight percentage range is 0.02% to 1.0 % by weight. In another aspect, the weight percentage range is 0.04% to 0.5 % by weight. In one aspect, the at least one additional layer of another material is a wax.

In any embodiment in the present disclosure, the particulate acidic fertilizer may be any acidic fertilizer or a fertilizer composition comprising an acidic component. The particulate acidic fertilizer may provide a pH value lower than 7 when it is dissolved or partially dissolved in water. A particulate acidic fertilizer in the present disclosure may include any material that comprises any form of phosphate or sulfate. For example, phosphate may include any material comprising any form of PO_4^{3-} , HPO_4^{2-} , $\text{H}_2\text{PO}_4^{2-}$, H_3PO_4 or any combination thereof. Sulfate may include any material comprising any form of SO_4^{2-} , HSO_4^- , H_2SO_4 , or any combination thereof. A particulate acidic fertilizer in the present disclosure may be selected but is not limited to monoammonium phosphate (MAP), diammonium phosphate (DAP), ammonium sulfate, ammonium hydrogensulfate, rock phosphate, super phosphate, serpentine super phosphate, reactive phosphate rock, NPSZ, Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn), triple super phosphate, struvite, or any combination thereof. In one aspect, the particulate acidic fertilizer is selected from MAP, DAP or ammonium sulfate.

In any embodiment in the present disclosure, the particulate urea source may be urea or urea-formaldehyde polymers, or any combination thereof. The solid form of a urea source may be pellets, prills, pastilles, flakes, granules, or a combination thereof. In one aspect, a urea source is urea granules.

In any embodiment in the present disclosure, the urease inhibitors may be N-alkyl phosphoric triamides or N-alkyl thiophosphoric triamides according to Formula I:



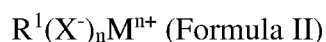
wherein X is oxygen or sulfur, and R^1 and R^2 are independently hydrogen, C_1 - C_{12} alkyl, C_3 - C_{12} cycloalkyl, C_6 - C_{14} aryl, C_2 - C_{12} alkenyl, C_2 - C_{12} alkynyl, C_5 - C_{14} heteroaryl, C_1 - C_{14} heteroalkyl, C_2 - C_{14} heteroalkenyl, C_2 - C_{14} heteroalkynyl, or C_3 - C_{12} cycloheteroalkyl. In one

aspect, the urease inhibitor in the present disclosure is N-(n-butyl) thiophosphoric triamide (NBPT).

In any embodiment in the present disclosure, the particulate urease inhibitor containing urea source may be made by mixing a urease inhibitor such as NBPT with a urea source such as urea granules. For example, NBPT may be applied onto urea granules by a concentrated solution of NBPT that is dissolved in a solvent such as a glycol or glycol derivative or a mixed solvent of a glycol or glycol derivative and a liquid amide. (see U.S. Patent No. 5,698,003). Other solvents such as glycerol, glycol ethers, amines, and DMSO may also be used. Alternatively, NBPT may be introduced into the urea melt to form an NBPT incorporated urea fertilizer (see WO 2015/027244). In addition, a highly concentrated dry formulation of NBPT such as AGROTAIN DRI-MAXX® nitrogen stabilizer, which can adhere to the urea granules without adding additional moisture to the blend, can be used to treat urea granules to make a NBPT-containing urea as well. (see U.S. Patent No. 9,034,072).

In any embodiment in the present disclosure, a basic component may be any suitable substance that can accept hydrogen ions (protons) released from an acidic fertilizer.

In one aspect, a basic component may be an organic carboxylic or a sulfonic acid salt according to Formula (II):



wherein R^1 is independently hydrogen, substituted or non-substituted C_1 - C_{30} straight or branched alkyl, substituted or non-substituted C_1 - C_{30} straight or branched alkenyl, substituted non-substituted C_3 - C_8 cycloalkyl, or substituted or non-substituted C_5 - C_6 aromatic carbon or heterocyclic ring; (X^-) is a (COO^-) or (SO_3^-) ; M^{n+} is metal ion, wherein the metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn; n is 1, 2, 3, or 4.

In one aspect, the carboxylic acid or sulfonic acid salt has a structure according to Formula (II) wherein R^1 is independently hydrogen, substituted or non-substituted C_8 - C_{20} straight or branched alkyl, substituted or non-substituted C_8 - C_{20} straight or branched alkenyl, substituted or non-substituted C_3 - C_6 cycloalkyl, or substituted or non-substituted benzene ring;

M^{n+} is a metal ion, wherein the metal is Mg, Ca, or Al; and n is 1, 2, or 3. In another aspect, the carboxylic acid or sulfonic acid salt according to Formula (II) is a stearate, wherein the metal is Mg, Ca, or Al; and n is 2 or 3.

In one aspect, a basic component may be a metal oxide, metal hydroxide, metal alkoxide with C₁-C₃₀ straight or branched carbon chain, metal sulfate, metal bisulfate, metal carbonate, or metal bicarbonate, wherein the metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn. In another aspect, the basic component is MgO, Mg(OH)₂, CaO, Ca(OH)₂, Al₂O₃, Al(OH)₃, or lime (Lime is a calcium-containing inorganic material in which carbonates, oxides and hydroxides predominate).

In one aspect, a basic component may be an amine compound, which is a primary, secondary, or tertiary, straight or branched hydrocarbon amine. The hydrocarbon is C₁-C₃₀ straight or branched alkyl, C₁-C₃₀ straight or branched alkenyl, C₃-C₈ cycloalkyl, or benzene ring, wherein the hydrocarbon is optionally substituted with hydroxyl, amino, or [(-NH)(CH₂CH₂)]_xNH₂, wherein x is 1, 2, 3, 3, or 4. In another aspect, the amine compound is triethylenetetramine (TETA), trimethylamine (TEA), monoethanolamine (MEA), triethanolamine, diethanolamine, or aniline.

In one aspect, the basic component is MgO.

In one aspect, the basic component in the present disclosure is a solid that can sufficiently adhere to the surface of a particulate fertilizer.

In one aspect, the basic component in the present disclosure is a liquid that can provide a coating layer on the surface of a particulate fertilizer.

In any embodiment in the present disclosure, the fertilizer composition may further comprise a nitrification inhibitor. The nitrification inhibitor may be selected from 2-chloro-6-trichloromethylpyridine, 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazol, dicyandiamide (DCD), 2-amino-4-chloro-6-methyl-pyrimidine, 1,3-benzothiazole-2-thiol, 4-amino-N-1,3-thiazol-2-ylbenzene sulfonamide, thiourea, guanidine, 3,4-dimethylpyrazole phosphate, 2,4-diamino-6-trichloromethyl-5-triazine, poly etherionophores, 4-amino-1,2,4-triazole, 3-mercapto-1,2,4-

triazole, potassium azide, carbon bisulfide, sodium trithiocarbonate, ammonium dithiocarbamate, 2,3-dihydro-2,2-dimethyl-7-benzofuranol methylcarbamate, N-(2,6-dimethylphenyl)-N-(methoxyacetyl)-alanine methyl ester, ammonium thiosulfate, 1-hydroxypyrazole, 3-methylpyrazole-1-carboxamide, 3-methylpyrazole, 3,5-dimethylpyrazole, 1,2,4-triazole ,
5 derivatives thereof, and any combination thereof. The nitrification inhibitor may be added as a separate particulate component at any time or be mixed with the urease inhibitor treated urea source prior to be treated with a basic component of the present disclosure. In one aspect, a nitrification inhibitor is DCD or 2-chloro-6-trichloromethylpyridine. In one aspect, the weight percentage of the nitrification inhibitor is 0.01% to 10% of the total weight of the final fertilizer
10 composition blend. In one aspect, the weight percentage of the nitrification inhibitor is 1% to 5% of the total weight of the final fertilizer composition blend.

In any embodiment of the present disclosure, a particulate acidic fertilizer or a particulate urease inhibitor containing urea source with their surface treated with a suitable basic component may provide 14-1500, 28-1500, 60-1500, or 90-1500 days of NBPT half-life under accelerated
15 NBPT stability lab test condition from the time when the particulate acidic fertilizer and the particulate urease inhibitor containing urea source are blended. In one aspect, a particulate acidic fertilizer or a particulate urease inhibitor containing urea source with their surface treated with a suitable basic component may provide 14-1000, 28-1000, 60-1000, or 90-1000 days of NBPT
20 half-life under accelerated NBPT stability lab test condition from the time when the particulate acidic fertilizer and the particulate urease inhibitor containing urea source are blended. In another aspect, a particulate acidic fertilizer or a particulate urease inhibitor containing urea source with their surface treated with a suitable basic component may provide 14-500, 28-500, 60-500, or 90-
25 500 days of NBPT half-life under accelerated NBPT stability lab test condition from the time when the particulate acidic fertilizer and the particulate urease inhibitor containing urea source are blended. In another aspect, a particulate acidic fertilizer or a particulate urease inhibitor containing urea source with their surface treated with a suitable basic component may provide 14-250, 28-250, 60-250, or 90-250 days of NBPT half-life under accelerated NBPT stability lab test condition from the time when the particulate acidic fertilizer and the particulate urease inhibitor containing urea source are blended.

In any embodiment of the present disclosure, a particulate acidic fertilizer or a particulate urease inhibitor containing urea source with their surface treated with a suitable basic component may provide 25% to 1000%, 50% to 1000%, 75% to 1000%, or 100%-1000% improvement of the NBPT half-life storage time compared to a particulate acidic fertilizer or a particulate urease inhibitor containing urea source that is not treated with a basic material.

During the NBPT half-life storage time test in the present disclosure, the blend to be tested is stored in a small container with repeated opening and closing to accelerate the degradation of NBPT. Thus, the testing method used in the present disclosure is an accelerated NBPT stability lab testing method comparing to the standard real world storage condition. The exact impact of the accelerated NBPT stability lab testing method to each example is not yet predictable. However, the impact may be very significant in certain blends. For example, NBPT has 12-18 months of half-life when ammonium sulfate is blended with ATU (AGROTAIN® stabilizer Treated Urea. AGROTAIN® stabilizer contains NBPT as its active ingredient) and stored under normal industrial storage condition. When the exact same ammonium sulfate and ATU are blended under the accelerated testing conditions in a small sealed container with frequent opening and closing, the NBPT half-life is about 38 days.

The NBPT half-life storage time results for the exemplified examples in the present disclosure may be obtained by the accelerated lab testing method wherein the blended particulate fertilizers are kept in a small sealed container with frequent opening and closing for sample collection and analysis.

The NBPT half-life storage time results for the exemplified examples in the present disclosure may also be obtained under standard real world storage conditions or normal industrial storage conditions in which the container/bag for the mixture is not repeatedly opened and closed as performed in the accelerated NBPT stability lab test.

Those skilled in the art will appreciate that different acidic fertilizers may have very different acidity. The stronger the acidity, the shorter the NBPT half-life storage may be observed.

In any embodiment of the present disclosure, the weight percentage range of the urease inhibitor in a particulate urease inhibitor containing urea source is 0.01% to 5 % by weight. In one aspect, the range is 0.02% to 1.0 % by weight. In another aspect, the range is 0.04% to 0.5 % by weight.

5 In one aspect, the urease inhibitor in the present disclosure is NBPT. The weight percentage range of NBPT in the particulate NBPT containing urea source is 0.01% to 5 % by weight. In one aspect, the weight percentage range is 0.02% to 1.0 % by weight. In another aspect, the weight percentage range is 0.04% to 0.5 % by weight.

10 In any embodiment of the present disclosure, the weight percentage range of a basic component in a basic component treated particulate urease inhibitor containing urea source or a basic component treated particulate acidic fertilizer composition is 0.001% to 20 % by weight of the total weight of the basic component treated particulate urease inhibitor containing urea source or the basic component treated particulate acidic fertilizer. In one aspect, the weight percentage range is 0.1% to 5 % by weight. In one aspect, the weight percentage range is 0.2% to 15 2 % by weight. In another aspect, the weight percentage range is 0.25% to 1 % by weight.

In one aspect, the basic component in the present disclosure is MgO, Mg(OH)₂, CaO, Ca(OH)₂, Al₂O₃, Al(OH)₃, or lime.

20 In one aspect, the weight percentage range of the basic component in a basic component treated particulate acidic fertilizer composition or in a basic component treated particulate urease inhibitor containing urea source is 0.001% to 20 % by weight and the weight percentage range of the particulate acidic fertilizer or the particulate urease inhibitor containing urea source is 99.999 % to 80 % by weight. In one aspect, the weight percentage range of the basic component is 0.1% to 5 % by weight and the weight percentage range of the particulate acidic fertilizer or the particulate urease inhibitor containing urea source is 99.9 % to 95 % by weight. In one 25 aspect, the weight percentage range of the basic component is 0.2% to 2 % by weight and the weight percentage range of the particulate acidic fertilizer or the particulate urease inhibitor containing urea source is 99.8 % to 98 % by weight. In another aspect, the weight percentage range of the basic component is 0.25% to 1 % by weight and the weight percentage of the

particulate acidic fertilizer or the particulate urease inhibitor containing urea source is 99.75 % to 99 % by weight.

In one embodiment, the present disclosure provides a particulate fertilizer composition comprising a basic component and a particulate acidic fertilizer having a surface, wherein the surface of the particulate acidic fertilizer is treated with the basic component, wherein the basic component is MgO and the acidic fertilizer is selected from the group consisting of MAP, DAP, ammonium sulfate, NPSZ, MESZ, and any combination thereof, wherein the weight percentage range of MgO is 0.001% to 20 % by weight and the weight percentage range of MAP, DAP, ammonium sulfate, NPSZ, MESZ, or any combination thereof is 80% to 99.999 % by weight.

In one aspect, the weight percentage range of MgO is 0.1 % to 5 % by weight and the weight percentage range of MAP, DAP, ammonium sulfate, NPSZ, MESZ, or any combination thereof is 99.9 % to 95 % by weight. In one aspect, the weight percentage range of MgO is 0.2 % to 2 % by weight and the weight percentage range of MAP, DAP, ammonium sulfate, NPSZ, MESZ, or any combination thereof is 99.8 % to 98 % by weight. In one aspect, the weight percentage range of MgO is 0.25 % to 1 % by weight and the weight percentage range of MAP, DAP, ammonium sulfate, NPSZ, MESZ, or any combination thereof is 99.75 % to 99 % by weight.

In one embodiment, the present disclosure provides a particulate fertilizer composition comprising MgO and a particulate NBPT containing urea source having a surface, wherein the surface of the particulate NBPT containing urea source is treated with MgO, wherein the weight percentage range of MgO is 0.001% to 20 % by weight and the weight percentage range of the particulate NBPT containing urea source is 80% to 99.999 % by weight. In one aspect, the weight percentage range of MgO is 0.1 % to 5 % by weight and the weight percentage range of the particulate NBPT containing urea source is 99.9 % to 95 % by weight. In one aspect, the weight percentage range of MgO is 0.2 % to 2 % by weight and the weight percentage range of the particulate NBPT containing urea source is 99.8 % to 98 % by weight. In one aspect, the weight percentage range of MgO is 0.25 % to 1 % by weight and the weight percentage range of the particulate NBPT containing urea source is 99.75 % to 99 % by weight.

In any embodiment of the present disclosure, the diameter range of the particulate acid fertilizer particles or the particulate urease inhibitor containing urea source particles is 0.1 mm to

10 mm. In one aspect, the diameter range is 0.2 to 7.5 mm. In another aspect, the diameter range is 0.5 mm to 5 mm.

In any embodiment of the present disclosure, the diameter of basic component particles may be suitable in a very wide range as far as basic component particles can adhere to the surface of either the particulate acid fertilizer or the particulate urease inhibitor containing urea source. For example, a suitable basic component such as MgO may be as small as a nanopowder, which may have less than 50 nm diameter.

In one embodiment, the present disclosure provides a method of making a basic component treated particulate acidic fertilizer compositions comprising providing a particulate acidic fertilizer having a surface; and contacting the basic component with the surface of the particulate acidic fertilizer.

In another embodiment, the present disclosure also provides a method of making a basic component treated particulate urease inhibitor containing urea source compositions comprising providing a particulate urease inhibitor containing urea source having a surface; and contacting a basic component with the surface of the particulate urease inhibitor containing urea source.

In one further embodiment, the present disclosure also provides a method of making an acid resistant fertilizer composition comprising i) a particulate acidic fertilizer having a surface; ii) a particulate urease inhibitor containing urea source having a surface; and iii) a basic component, said method comprising contacting the basic component with the surface of i) and blending the basic component treated i) with ii); or contacting the basic component with the surface of ii) and blending the basic component treated ii) with i); or contacting the basic component with the surface of i) and the surface of ii) independently, and blending the basic component treated i) with the basic component treated ii).

The weight percentage range of a particulate urease inhibitor containing urea source is 1% to 99% of the total weight of the blend of the particulate urease inhibitor containing urea source and a particulate acidic fertilizer. In one aspect, the weight percentage range of the particulate urease inhibitor containing urea source is 20% to 80%. In one aspect, the weight

percentage range of the particulate urease inhibitor containing urea source is 30% to 70%. In one aspect, the weight percentage range of the particulate urease inhibitor containing urea source is 40% to 60%. In another aspect, the weight percentage of the particulate urease inhibitor containing urea source range is 45% to 55%.

5 The weight percentage range of a particulate acidic fertilizer is 99% to 1% of the total weight of the blend of the particulate acidic fertilizer and a urease inhibitor containing urea source. In one aspect, the weight percentage range of the particulate acidic fertilizer is 80% to 20%. In one aspect, the weight percentage range of the particulate acidic fertilizer is 70% to 30%. In one aspect, the weight percentage range of the particulate acidic fertilizer is 60% to 10 40%. In another aspect, the weight percentage range of the particulate acidic fertilizer is 55% to 45%.

To ensure that a basic component covers as much the surface of a particulate fertilizer as possible when it is treated on the surface of a particulate acidic fertilizer or a particulate urease inhibitor containing urea source to provide sufficient protection for NBPT, for example, with at 15 least 14-1500 days of NBPT half-life storage time, an inert fluorescent tracer may be applied after the treatment of a suitable basic component of the present disclosure. An even distribution of the suitable basic component may be indicated when a UV black light is shined on the treated urea. An inert fluorescent tracer may be but are not limited to 1,5-naphthalenedisulfonic acid disodium salt (1,5-NDSA), 2-amino-1-naphthalenesulfonic acid, 5-amino-2-naphthalenesulfonic 20 acid, 4-amino-3-hydroxyl-1-naphthalenesulfonic acid, 6-amino-4-hydroxyl-2-naphthalenesulfonic acid, 7-amino-1,3-naphthalenedisulfonic acid, potassium salt, 4-amino-5-hydroxy-2,7-naphthalenedisulfonic acid, 5-dimethylamino-1-naphthalenesulfonic acid, 2,6-naphthalenedicarboxylic acid, dipotassium salt, 2-anthracenesulfonic acid, sodium salt, quinoline (CAS Registry No. 91-22-5), 1-ethylquinaldinium iodide, dibenzofuransulfonic acid, Brilliant 25 Acid Yellow 8G (CAS Registry No. 2391-30-2, i.e. Lissamine Yellow FF, Acid Yellow 7), 1,3,6,8 pyrenetetrasulfonic acid, and tetrasodium salt. The term “inert” means that the fluorescent tracer is not chemically reactive to any part of the composition of the present disclosure.

In one aspect, the present disclosure provides that the base treated acidic fertilizer has acceptable spreader test result according to European Standard EN13739-2 for solid fertilizer distributors. In one aspect, the base treated acidic fertilizer provides a coefficient of variation value of less than 15%. In another aspect, the base treated acidic fertilizer provides a coefficient of variation value of less than 15%. In one aspect, the base treated acidic fertilizer is MgO treated MAP, DAP, or a combination thereof. In one aspect, the weight percentage of MgO in the MgO treated MAP or DAP is 0.1 to -2%. In one aspect, the weight percentage of MgO in the MgO treated MAP or DAP is 0.2 to -1.5%.

The term “about” in the present disclosure is intended to encompass + or -5% of the value indicated.

Examples 1-43 are prepared for the NBPT stability testing. Examples 44-90 are under “accelerated NBPT stability lab test” conditions.

Example 1

Magnesium Oxide Treated Diammonium Phosphate

Add 0.375 g of magnesium oxide (MgO) powder to 75 g of diammonium phosphate (DAP) in a glass jar. The lid is securely fastened and the jar is shaken until the powder is evenly distributed over DAP particles. The MgO weight percentage of the MgO treated DAP is about 0.5% of the total weight.

Examples 2-15 in Table 1 are made essentially the same as Example 1.

Table 1:

Ex. No.	Basic component (g): Particulate Acidic Fertilizer (g)	Weight percentage of basic component (%)
2	MgO (0.281g): DAP (75g)	0.375
3	MgO (0.188g): DAP (75g)	0.25
4	MgO (0.094g): DAP (75g)	0.125
5	Mg(OH) ₂ (0.375g) : DAP (75g)	0.5
6	Mg(OH) ₂ (0.188g) : DAP (75g)	0.25
7	Calcium stearate (0.375g) : DAP (75g)	0.5
8	Magnesium stearate (0.375g) : DAP (75g)	0.5
9	Magnesium stearate (0.188g) : DAP (75g)	0.25
10	Al(OH) ₃ (2g) : DAP (200g)	1.0

11	MgO (0.375g): Ammonium Sulfate (from UK,75g)	0.5
12	MgO (0.375g): Ammonium Sulfate (From Honeywell, 75g)	0.5
13	MgO (0.375g): MAP (75g)	0.5
14	MgO (0.375g): Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn) (75g)	0.5
15	MgO (0.375g): Rock Phosphate (75g)	0.5

Example 16

Magnesium Oxide and Wax Treated Diammonium Phosphate

Add 2000 g of DAP to a rotating drum coater and heat to 65 °C. At 65 °C, add 10 g of
5 MgO to the rotating drum coater. After about 1 minute, add 3.3 g of AlphaPlus® C₂₆₋₂₈ wax and all components are mixed for 10 minutes then cooled down to room temperature. The MgO weight percentage of the MgO and wax treated DAP is about 0.5% of the total weight. The wax weight percentage is about 0.16%.

Examples 17-32 in Table 2 are made essentially the same as Example 16.

10 Table 2:

Ex. No.	Basic Component (g):Wax(g):Particulate Acidic Fertilizer (g)	Weight percentage of basic component (%)	Weight percentage of wax (%)
17	Al(OH) ₃ (10g): HP 6034 Wax (3.3g): DAP (2000g)	0.5	0.16
18	Triethylenetetramine (TETA) (5g): AlphaPlus C ₂₆₋₂₈ wax (6.6g): DAP (2000g)	0.25	0.33
19	Ca(OH) ₂ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): DAP (2000g)	0.5	0.16
20	Al(OH) ₃ (10g): HP 1270 Wax (3.3g): DAP (2000g)	0.5	0.16
21	Al(OH) ₃ (20g): AlphaPlus C ₂₆₋₂₈ wax (6.6g): DAP (2000g)	1.0	0.33
22	Al(OH) ₃ (5g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): DAP (2000g)	0.25	0.16
23	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (6.6g): DAP (2000g)	0.5	0.33
24*	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (6.6g): DAP (2000g)	0.5	0.33
25	Lime (10g) : AlphaPlus C ₂₆₋₂₈ wax (3.3g): DAP (2000g)	0.5	0.16

26	KOH (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): DAP (2000g)	0.5	0.16
27	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): DAP (2000g)	0.5	0.16
28	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3 g): Ammonium Sulfate (UK, 2000g)	0.5	0.16
29	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): Ammonium Sulfate (Honeywell, 2000g)	0.5	0.16
30	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3 g): MAP (2000g)	0.5	0.16
31	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3 g): Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn) (2000g)	0.5	0.16
32	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3 g): Rock Phosphate (2000g)	0.5	0.16

*: The order of coating is reversed. The wax is added first at 65 °C for 10 minutes of coating, and then add Al(OH)₃ and mix for another 5 minutes.

Example 33

Calcium Stearate Treated AGROTAIN Stabilizer Treated Urea (ATU)

- 5 Add 0.625 g of calcium stearate to 125 g of AGROTAIN stabilizer treated urea (470 ppm NBPT) in a glass jar. The lid is securely fastened and the jar is shaken until the powder is evenly distributed over the treated urea. The calcium stearate weight percentage of the calcium stearate treated ATU is about 0.5% of the total weight. (In all examples, the NBPT concentration in the parenthesis for an ATU composition is the original NBPT concentration prior to the blend of a
- 10 DAP composition and an ATU composition).

Example 34 in Table 3 is made essentially the same as Example 33.

Table 3:

Ex. No.	Basic component (g): ATU (g)	Weight percentage of metal oxide/metal hydroxide/metal stearate (%)
34	Calcium Stearate (0.313g): ATU (470 ppm NBPT, 125g)	0.25

Example 35

MgO Treated AGROTAIN Stabilizer Treated Urea (ATU)

15

Add 2000 g of AGROTAIN stabilizer treated urea (540 ppm NBPT) to a rotating drum coater and heat to 65 °C. At 65 °C, 10 g of MgO is added. After about 1 minute, 3.3 g of Alpha Plus C₂₆₋₂₈ wax is added and all components are mixed for 10 minutes then cooled down to room temperature. The MgO weight percentage of the MgO and wax treated ATU is about 0.5% of the total weight. The wax weight percentage is about 0.16%.

Examples 36-43 in Table 4 are made essentially the same as Example 35.

Table 4:

Ex. No.	Basic component (g):Wax(g):ATU (ppm of NBPT, Weight of ATU)	Weight percentage of basic component (%)	Weight percentage wax (%)
36	Lime (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): ATU (570 ppm NBPT, 2000g)	0.5	0.16
37	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): ATU (640 ppm NBPT, 2000g)	0.5	0.16
38	Al(OH) ₃ (10g): HP 1270 wax (3.3g): ATU (610 ppm NBPT, 2000g)	0.5	0.16
39	Al(OH) ₃ (10g): HP 6034 wax (3.3g): ATU (600 ppm NBPT, 2000g)	0.5	0.16
40	Al(OH) ₃ (5g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): ATU (570 ppm NBPT, 2000g)	0.25	0.16
41	Ca(OH) ₂ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): ATU (540 ppm NBPT, 2000g)	0.5	0.16
42	KOH(10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): ATU (540 ppm NBPT, 2000g)	0.5	0.16
43	Al(OH) ₃ (10g): AlphaPlus C ₂₆₋₂₈ wax (3.3g): ATU (570 ppm NBPT, 2000g)	0.5	0.16

NBPT Stability Test

The purpose of the NBPT stability test is to determine if certain basic component can provide NBPT an extended storage life after ATU is blended with a particulate acidic fertilizer, when at least one of ATU or the particulate acidic fertilizer is treated with the basic component. One or more layers of variety of wax may be optionally applied. The half-life of NBPT is used to show the performance of the NBPT stability. If the NBPT content is still above half of the original content on the day that the data is collected, the actual NBPT content and the days from the time that the blend is prepared is recorded. For example, if the NBPT content is 65% on day

50 from the blend of ATU and the particulate acidic fertilizer, the “65% at day 50” is used to show the performance.

Mix 50:50 ratio of one ATU sample and one particulate acidic fertilizer sample in a container and shake extensively to provide a visually homogeneous blend. The moment that the homogeneous blend is obtained is recorded as time zero.

In the present disclosure, if the ATU sample and the particulate acidic fertilizer sample are 75 g each, an 8 oz. container (about 240 mL) may be used. If the ATU sample and the particulate acidic fertilizer sample are 150 g each, a 16 oz. container (about 240 mL) is used. The container is opened at regular intervals of 1 week, 2 weeks, 1 month, 2 months, 3 months, 6 months, 9 months, 12 months, or other time points as needed. The duration between each opening and closing is about 1-2 minutes. In real world situation, the “container” may be 600 kg or 1000 kg bulk bags with under plastic liner that is securely sealed until use. Because the container is constantly opened in the NBPT stability test method in the present disclosure, the oxygen and moisture may have significant impact compared to the real world storage conditions. The NBPT stability test in the present disclosure accelerates when is compared to the real world storage conditions. For example, when ammonium sulfate from UK blended with ATU and stored under the real world storage condition, the NBPT has 12-18 months half-life. When the exact same ammonium sulfate and ATU are blended under the NBPT stability testing conditions in a small container with frequent opening and closing, the NBPT half-life storage time is about 38 days. For this reason, the NBPT stability test in the present disclosure may be also referred as “accelerated NBPT stability lab test”.

To test the remaining NBPT content of an ATU sample, about ten grams of the blend are removed from the container on the day of testing. The green granules (ATU sample) are separated from the particulate acidic fertilizer. The green granules (ATU sample) are then submitted for HPLC analysis for NBPT content (recorded as ppm of NBPT converted to % of the original NBPT). HPLC testing is run using a standard C₁₈ column and 75 % water/ 25 % acetonitrile solution. The UV absorbance is measured at 214 nm. Example 44-90 are tested based on the foregoing described method.

Example 44

Fertilizer Composition of ATU and MgO Treated DAP, and NBPT Stability Performance

Add Example 1 to a glass jar containing AGROTAIN stabilizer treated urea (ATU) (660 ppm NBPT, the original NBPT concentration prior to the blend with DAP) in 50:50 by weight ratio (75 g for each component). The lid is securely fastened and the blend is shaken in the jar until homogenous. The half-life storage time of NBPT is 140 days.

5 Examples 45- 75 in Table 5 are made essentially the same as Example 44.

Table 5:

Ex. No.	Blend 1:1 (weight) of Example No. with ATU (original NBPT concentration, weight of ATU)	Acidic Fertilizer	Basic component	Half-life time (days) of NBPT/NBPT concentration at a certain day when the data is collected if the half concentration of NBPT is not achieved yet
45	Example 2 (75g) and ATU (450 ppm, 75g)	DAP	MgO	67% at day 56
46	Example 3 (75g) and ATU (450 ppm, 75g)	DAP	MgO	67% at day 56
47	Example 4 (75g) and ATU (450 ppm, 75g)	DAP	MgO	54
48	Example 5 (75g) and ATU (450 ppm, 75g)	DAP	Mg(OH) ₂	56% at day 56
49	Example 6 (75g) and ATU (450 ppm, 75g)	DAP	Mg(OH) ₂	49
50	Example 7 (75g) and ATU (590 ppm, 75g)	DAP	Calcium stearate	12
51	Example 8 (75g) and ATU (650 ppm, 75g)	DAP	Magnesium stearate	60% at day 14
52	Example 9 (75g) and ATU (650 ppm, 75g)	DAP	Magnesium stearate	14
53	Example 10 (75g) and ATU (730 ppm, 150g)	DAP	Al(OH) ₃	15
54	Example 11 (75g) and ATU (400 ppm, 75g)	Ammonium Sulfate (UK)	MgO	98% at day 91

55	Example 12 (75g) and ATU (400 ppm, 75g)	Ammonium Sulfate (Honeywell)	MgO	98% at day 91
56	Example 13 (75g) and ATU (400 ppm, 75g)	MAP	MgO	60% at day 91
57	Example 14 (75g) and ATU (400 ppm, 75g)	Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn))	MgO	73% at day 91
58	Example 15 (75g) and ATU (400 ppm, 75g)	Rock Phosphate	MgO	63% at day 91
59	Example 16 (150g) and ATU (680 ppm, 150g)	DAP	MgO	52% at day 180
60	Example 17 (150g) and ATU (660 ppm, 150g)	DAP	Al(OH) ₃	38
61	Example 18 (150g) and ATU (650 ppm, 150g)	DAP	TETA	37
62	Example 19 (150g) and ATU (680 ppm, 150g)	DAP	Ca(OH) ₂	34
63	Example 20 (75g) and ATU (660 ppm, 75g)	DAP	Al(OH) ₃	32
64	Example 21 (150g) and ATU (650 ppm, 150g)	DAP	Al(OH) ₃	30
65	Example 22 (150g) and ATU (680 ppm, 150g)	DAP	Al(OH) ₃	25
66	Example 23 (150g) and ATU (650 ppm, 150g)	DAP	Al(OH) ₃	25
67	Example 24 (150g) and ATU (650 ppm, 150g)	DAP	Al(OH) ₃	23
68	Example 25 (150g) and ATU (680 ppm, 150g)	DAP	Lime	23
69	Example 26 (150g) and ATU (680 ppm, 150g)	DAP	KOH	22
70	Example 27 (150g) and ATU (650 ppm, 150g)	DAP	Al(OH) ₃	16
71	Example 28 (150g) and ATU (640 ppm, 150g)	Ammonium Sulfate (UK)	Al(OH) ₃	49
72	Example 29 (150g) and ATU (640 ppm, 150g)	Ammonium Sulfate (Honeywell)	Al(OH) ₃	26
73	Example 30 (150g) and ATU (660 ppm, 150g)	MAP	Al(OH) ₃	9

74	Example 31 (150g) and ATU (660 ppm, 150g)	Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn))	Al(OH) ₃	9
75	Example 32 (150g) and ATU (660 ppm, 150g)	Rock Phosphate	Al(OH) ₃	20

Example 76

Add Example 33 (470 ppm NBPT) to untreated DAP with 1:1 ratio (75g: 75g). Securely fasten the lid and shake the blended mixture until visually homogenous. The half-life storage
5 time of NBPT is 94 days.

Examples 77- 90 in Table 6 are made essentially the same as Example 76.

Table 6:

Ex. No.	Blend of Example No. (original NBPT concentration, weight of ATU): Particulate Acidic Fertilizer (weight)	Acidic Fertilizer	Basic component	Half-life time (days) of NBPT/NBPT concentration at a certain day when the data is collected if the half concentration of NBPT is not achieved yet
77	Example 34 (500 ppm NBPT, 75g) and DAP (75g)	DAP	Calcium Stearate	28
78	Example 35 (540 ppm NBPT, 150g) and DAP (150g)	DAP	MgO	79
79	Example 36 (570 ppm NBPT, 150g) and DAP (150g)	DAP	Lime	40
80	Example 37 (490 ppm NBPT, 150g) and DAP (150g)	DAP	Al(OH) ₃	28
81	Example 38 (610 ppm NBPT, 150g) and DAP (150g)	DAP	Al(OH) ₃	23
82	Example 39 (600 ppm NBPT, 150g) and DAP (150g)	DAP	Al(OH) ₃	21

83	Example 40 (570 ppm NBPT, 150g) and DAP (150g)	DAP	Al(OH) ₃	20
84	Example 41 (540 ppm NBPT, 150g) and DAP (150g)	DAP	Ca(OH) ₂	10
85	Example 42 (540 ppm NBPT, 150g) and DAP (150g)	DAP	KOH	0
86	Example 43 (640 ppm NBPT, 150g) and Ammonium Sulfate (UK, 150g)	Ammonium Sulfate (UK)	Al(OH) ₃	49
87	Example 43 (640 ppm NBPT, 150g) and Ammonium Sulfate (Honeywell, 150g)	Ammonium Sulfate (Honeywell)	Al(OH) ₃	28
88	Example 43 (640 ppm NBPT, 150g) and MAP (150g)		Al(OH) ₃	9
89	Example 43 (640 ppm NBPT, 150g) and Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn) (150g)	Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn)	Al(OH) ₃	9
90	Example 43 (640 ppm NBPT, 150g) and Rock Phosphate (150g)	Rock Phosphate	Al(OH) ₃	9

Under similar testing conditions, the NBPT half-life storage time for some samples that is not treated with any basic component is provided in Table 7:

Table 7: NBPT half-life storage time for blends without basic component

Samples not treated with basic component	Half-life time (days) of NBPT
ATU alone	214
ATU and DAP	11
ATU and Ammonium Sulfate (UK)	38
ATU and Ammonium Sulfate (Honeywell)	18
ATU and MAP	9
ATU and Micro-Essentials SZ (MESZ (12-40-0-10S-1Zn)	9
ATU and Rock Phosphate	19

5

It is observed from the testing result in Table 7 that ATU sample not blended with an acidic fertilizer provides the longest NBPT half-life storage time. When ATU sample is blended

with an acidic fertilizer, the half-life storage time significantly dropped. For example, the NBPT half-life dropped by about 96% from 214 days to 9 days when ATU sample is blended with MAP. When MAP is treated with a suitable basic component such as MgO in Example 56, the NBPT stability is significantly improved to 60% NBPT at day 91.

5 Same acidic fertilizer from different sources may provide very different NBPT half-life storage time. For example, ammonium sulfate from United Kingdom (UK) provides more than 100% longer NBPT half-life storage time (38 days) comparing with ammonium sulfate from Honeywell in the United States (18 days).

10 Although some examples may show shorter half-life time of NBPT, it does not necessarily mean that the basic component is not suitable for the treatment of the particulate fertilizers. In one example, calcium stearate treated DAP in Example 50 only provides a NBPT half-life time of 12 days, conversely, the calcium stearate treated ATU in Example 77 provides an NBPT half-life time of 28 days. In another example, the NBPT half-life time for KOH treated ATU in Example 85 is zero (decomposes more than one half on the first day), the NBPT half-life
15 time for KOH treated DAP in Example 69 is 22 days.

Examples 91-98 are prepared for the NBPT stability testing. Examples 99-106 are for examples stored under normal industrial storage condition, instead of under the “accelerated NBPT stability lab test” conditions.

Example 91

20 Magnesium Oxide Treated Diammonium Phosphate

Add 6000 kg of diammonium phosphate (DAP) to a rotating barrel mixer and then add 16.5 kg of magnesium oxide (MgO) powder to the barrel mixer. Components are mixed for 6 minutes at ambient temperature. The MgO weight percentage of the MgO treated DAP is about
25 0.275% of the total weight.

Examples 92-94 in Table 8 are made essentially the same as Example 91.

Table 8:

Ex. No.	Basic component (kg): Particulate Acidic Fertilizer (kg)	Weight percentage of basic component (%)
92	MgO (33.0 kg): DAP (6000 kg)	0.550
93	MgO (49.5 kg): DAP (6000 kg)	0.825
94	MgO (66.0 kg): DAP (6000 kg)	1.100

Example 95

Magnesium Oxide Treated Diammonium Phosphate

- 5 Add 6000 kg of diammonium phosphate (DAP) to a rotating vertical auger blender and then add 16.5 kg of magnesium oxide (MgO) powder to the rotating vertical auger blender. Components are mixed for 6 minutes at ambient temperature. The MgO weight percentage of the MgO treated DAP is about 0.275% of the total weight.

Examples 96-98 in Table 9 are made essentially the same as Example 95.

10

Table 9:

Ex. No.	Basic component (kg): Particulate Acidic Fertilizer (kg)	Weight percentage of basic component (%)
96	MgO (33.0 kg): DAP (6000 kg)	0.550
97	MgO (49.5 kg): DAP (6000 kg)	0.825
98	MgO (66.0 kg): DAP (6000 kg)	1.100

NBPT stability test under normal industrial storage condition

- 15 The purpose of the NBPT stability test is to determine if certain basic component can provide NBPT an extended storage life after ATU is blended with a particulate acidic fertilizer, when at least one of ATU or the particulate acidic fertilizer is treated with the basic component. One or more layers of variety of wax may be optionally applied. The half-life of NBPT is used to show the performance of the NBPT stability. If the NBPT content is still above half of the original content on the day that the data is collected, the actual NBPT content and the days from
- 20 the time that the blend is prepared is recorded. For example, if the NBPT content is 65% on day

50 from the blend of ATU and the particulate acidic fertilizer, the “65% at day 50” is used to show the performance.

Mix 50:50 ratio of one ATU sample and one particulate acidic fertilizer sample in a blender and blend the mixture for a few minutes and put the mixture in a bag without further interruption. The moment that the blend is put in the bag is recorded as time zero. The sample is then taken out from the bag at certain time for NBPT concentration test.

Example 99

Add Example 91 to a rotating vertical auger blender containing AGROTAIN stabilizer treated urea (ATU) (640 ppm NBPT, the original NBPT concentration prior to the blend with DAP) in 50:50 by weight ratio (3000 kg for each component). The components are blended for approximately 6 minutes at ambient temperature before being bagged off. The NBPT concentration compared to the original NBPT concentration was 53% on day 217 and 17% on day 315.

Examples 100- 106 in Table 10 are prepared and tested essentially the same as Example 99.

Table 10:

Ex. No.	Blend 1:1 (weight) of Example No. with ATU (original NBPT concentration, weight of ATU)	Acidic Fertilizer	Basic component	NBPT concentration compared to original NBPT concentration
100	Example 92 (3000 kg) and ATU (640 ppm, 3000 kg)	DAP	MgO	71% on day 315
101	Example 93 (3000 kg) and ATU (640 ppm, 3000 kg)	DAP	MgO	80% on day 315
102	Example 94 (3000 kg) and ATU (640 ppm, 3000 kg)	DAP	MgO	83% on day 315
103	Example 95 (3000 kg) and ATU (640 ppm, 3000 kg)	DAP	MgO	56% on day 217; 11% on day 315
104	Example 96 (3000 kg) and ATU (640 ppm, 3000 kg)	DAP	MgO	98% on day 315
105	Example 97 (3000 kg) and ATU (640 ppm, 3000 kg)	DAP	MgO	102% on day 315

106	Example 98 (3000 kg) and ATU (640 ppm, 3000 kg)	DAP	MgO	86% on day 315
-----	--	-----	-----	----------------

The above values are based on analysis of the ATU samples and does not take into account NBPT transfer onto DAP.

It is observed from the Table 10 that the NBPT concentration in Examples 99-106 remains at least 70% of the original NBPT concentration at day 315 when the weight percentage of MgO in MgO treated DAP is 0.55% or higher. When the weight percentage of MgO in MgO treated DAP is 0.275% such as in Examples 99 and 103, the NBPT concentration are still more than 50% of the original NBPT concentration on day 217. The data demonstrated that MgO treated DAP Examples 99-106 provided surprisingly high and extended NBPT stability at normal industrial storage condition.

Spreader Test

The purpose of the spreader test is to evaluate if the MgO treated DAP fertilizer disclosed in the present disclosure may have significant variation comparing to the DAP that is not treated with MgO. Based on the European Standard EN13739-2 for solid fertilizer distributors, the value of coefficient of variation (CV) is used evaluate the variation. If the CV is more than 20%, it is unacceptable. The CV value between 15%-20% is considered poor performance. The CV value between 10%-15% is considered good performance. The CV value below 10% is considered excellent performance.

Production scale samples prepared according to the method for Example 98 are used for the spreader test. Spreaders are checked for correct working condition. Fertilizer is analyzed by Vicon grader box with compartments sized 0 to 2, 2 to 3.3, 3.3 to 4.75 and 4.75+ mm. Bogballe strength tester is measured in kg of force to crush a granule/prill. One liter measuring cylinder with digital scales are used for bulk density in kg/L. Collection trays 50cm by 50cm are spaced at one meter intervals across the spread width. One drive through with the trays 'lapped' back at half way across the bout. Fertilizer is transferred into tubes for visual assessment of the pattern.

The Maker/Model of the spreader is Amazone ZA-M. The disc/vane type is OM 24-36. The spreader width is 24 meter. The spreader height is 80 cm from side of disc. The tilt is zero degree. The PTO/Disc speed is 540 rpm. The application rate is 200 kg/Ha. The forward speed is 10 km/h.

5 The CV value for the MgO treated DAP is 6.68% (n=2, CV1=6.48%, CV2=6.88%). The CV value for the untreated DAP is 9.49% (n=2, CV1=7.95%, CV2=11.03%).

It is observed that the CV value for the second spreader test for the MgO treated DAP is almost no change (less than 6%) while the CV value for the second spreader test for the untreated DAP increased 39%.

10 Therefore, the MgO treated DAP disclosed in the present disclosure provides excellent spreader test result compared to the untreated DAP fertilizer.

15 The present invention provides an economic and acid resistant urease inhibitor containing fertilizer compositions that may provide multiple nutrients such as nitrogen, phosphate and sulfate to soil and/or plants.

20 It is understood that although the disclosure has been specifically described with reference to particular means and embodiments, skilled artisans will appreciate that the present invention is not limited to the particulars disclosed in the foregoing description. The present disclosure also extends to all equivalents, and various changes and modifications that may be made in the invention without departing from the spirit and scope thereof.

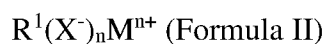
WHAT IS CLAIMED IS:

1. A fertilizer composition comprising a basic component and a particulate acidic fertilizer having a surface, wherein the surface of the particulate acidic fertilizer is treated with the basic component, wherein the weight percentage range of the basic component is 0.001% to 20 % by weight and the weight percentage range of the particulate acidic fertilizer is 99.999 % to 80 % by weight.

2. The fertilizer composition according to claim 1, wherein said particulate acidic fertilizer is selected from the group consisting of monoammonium phosphate (MAP), diammonium phosphate (DAP), ammonium sulfate, and ammonium hydrogensulfate, rock phosphate, super phosphate, serpentine super phosphate, reactive phosphate rock, NPSZ, Micro-Essentials® SZ (MESZ (12-40-0-10S-1Zn), triple super phosphate, struvite, and any combination thereof.

3. The fertilizer composition according to claim 1 or 2, wherein the basic component comprises:

i). an organic carboxylic or a sulfonic acid salt according to Formula (II):



wherein R^1 is independently hydrogen, substituted or non-substituted C_1 - C_{30} straight or branched alkyl, substituted or non-substituted C_1 - C_{30} straight or branched alkenyl, substituted non-substituted C_3 - C_8 cycloalkyl, or substituted or non-substituted C_5 - C_6 aromatic carbon or heterocyclic ring; (X^-) is a (COO^-) or (SO_3^-) ; M^{n+} is metal ion, wherein the metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn; n is 1, 2, 3, or 4;

ii). a metal oxide, metal hydroxide, metal alkoxide with C_1 - C_{30} straight or branched carbon chain, metal sulfate, metal bisulfate, metal carbonate, or metal bicarbonate, wherein the metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn; or

iii). an amine compound, wherein the amine compound is a primary, secondary, or tertiary, straight or branched hydrocarbon amine, wherein the hydrocarbon is C_1 - C_{30} straight or branched alkyl, C_1 - C_{30} straight or branched alkenyl, C_3 - C_8 cycloalkyl, or benzene ring, wherein

the hydrocarbon is optionally substituted with hydroxyl, amino, or $[(-\text{NH})(\text{CH}_2\text{CH}_2)]_x\text{NH}_2$, wherein x is 1, 2, 3, 3, or 4.

4. The fertilizer composition according to claim 3, wherein the basic component is selected from the group consisting of ammonium carbonate $((\text{NH}_4)_2\text{CO}_3)$, lithium oxide (Li_2O) , lithium hydroxide (LiOH) , lithium carbonate (Li_2CO_3) , barium oxide (BaO) , barium hydroxide $(\text{Ba}(\text{OH})_2)$, barium carbonate (BaCO_3) , magnesium oxide (MgO) , magnesium hydroxide $(\text{Mg}(\text{OH})_2)$, magnesium carbonate (MgCO_3) , calcium oxide (CaO) , calcium hydroxide $(\text{Ca}(\text{OH})_2)$, calcium carbonate (CaCO_3) , aluminum oxide (Al_2O_3) , aluminum hydroxide $(\text{Al}(\text{OH})_3)$, aluminum carbonate $(\text{Al}_2(\text{CO}_3)_3)$, sodium oxide (Na_2O) , sodium hydroxide (NaOH) , sodium carbonate (Na_2CO_3) , potassium oxide (K_2O) , potassium hydroxide (KOH) , potassium carbonate (K_2CO_3) , monoethanolamine (MEA), triethylenetetramine (TETA), trimethylamine (TEA), triethanolamine, diethanolamine, aniline, and any combination thereof.

5. The fertilizer composition according to claim 4, wherein the fertilizer composition provides an NBPT half-life of 14-1500 days under accelerated NBPT stability lab test condition when the fertilizer composition is contacted and stored with a particulate NBPT containing urea source.

6. A fertilizer composition comprising a basic component and a particulate urease inhibitor containing urea source having a surface, wherein the surface of the particulate urease inhibitor containing urea source is treated with the basic component, wherein the weight percentage range of the basic component is 0.01% to 20 % by weight and the weight percentage range of the particulate urease inhibitor containing urea source is 99.99 % to 80 % by weight.

7. The fertilizer composition according to claim 6, wherein the urease inhibitor is N-alkyl phosphoric triamide or N-alkyl thiophosphoric triamide according to Formula I:



wherein X is oxygen or sulfur, and R^1 and R^2 are independently hydrogen, C_1 - C_{12} alkyl, C_3 - C_{12} cycloalkyl, C_6 - C_{14} aryl, C_2 - C_{12} alkenyl, C_2 - C_{12} alkynyl, C_5 - C_{14} heteroaryl, C_1 - C_{14} heteroalkyl, C_2 - C_{14} heteroalkenyl, C_2 - C_{14} heteroalkynyl, or C_3 - C_{12} cycloheteroalkyl.

8. The fertilizer composition according to claim 6, wherein the urease inhibitor comprises N-(n-butyl) thiophosphoric triamide (NBPT).

9. The fertilizer composition according to claim 8, wherein the basic component comprises:

i). an organic carboxylic or a sulfonic acid salt according to Formula (II):



wherein R^1 is independently hydrogen, substituted or non-substituted C_1 - C_{30} straight or branched alkyl, substituted or non-substituted C_1 - C_{30} straight or branched alkenyl, substituted non-substituted C_3 - C_8 cycloalkyl, or substituted or non-substituted C_5 - C_6 aromatic carbon or heterocyclic ring; (X^-) is a (COO^-) or (SO_3^-) ; M^{n+} is metal ion, wherein the metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn; n is 1, 2, 3, or 4;

ii). a metal oxide, metal hydroxide, metal alkoxide with C_1 - C_{30} straight or branched carbon chain, metal sulfate, metal bisulfate, metal carbonate, or metal bicarbonate, wherein the metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn; or

iii). an amine compound, wherein the amine compound is a primary, secondary, or tertiary, straight or branched hydrocarbon amine, wherein the hydrocarbon is C_1 - C_{30} straight or branched alkyl, C_1 - C_{30} straight or branched alkenyl, C_3 - C_8 cycloalkyl, or benzene ring, wherein the hydrocarbon is optionally substituted with hydroxyl, amino, or $[(-NH)(CH_2CH_2)]_xNH_2$, wherein x is 1, 2, 3, 3, or 4.

10. The fertilizer composition according to claim 9, wherein the basic component is selected from the group consisting of ammonium carbonate $((NH_4)_2CO_3)$, lithium oxide (Li_2O) , lithium hydroxide $(LiOH)$, lithium carbonate (Li_2CO_3) , barium oxide (BaO) , barium hydroxide $(Ba(OH)_2)$, barium carbonate $(BaCO_3)$, magnesium oxide (MgO) , magnesium hydroxide $(Mg(OH)_2)$, magnesium carbonate $(MgCO_3)$, calcium oxide (CaO) , calcium hydroxide $(Ca(OH)_2)$, calcium carbonate $(CaCO_3)$, aluminum oxide (Al_2O_3) , aluminum hydroxide $(Al(OH)_3)$, aluminum carbonate $(Al_2(CO_3)_3)$, sodium oxide (Na_2O) , sodium hydroxide $(NaOH)$, sodium carbonate (Na_2CO_3) , potassium oxide (K_2O) , potassium hydroxide (KOH) , potassium

carbonate (K_2CO_3), monoethanolamine (MEA), triethylenetetramine (TETA), trimethylamine (TEA), triethanolamine, diethanolamine, aniline, and any combination thereof.

11. The fertilizer composition according to claim 10, wherein the fertilizer composition provides an NBPT half-life of 14-1500 days under accelerated NBPT stability lab test condition when the
5 fertilizer composition is contacted and stored with a particulate acidic fertilizer.

12. A fertilizer composition comprising:

- i). a particulate acidic fertilizer having a surface;
- ii). a particulate urease inhibitor containing urea source having a surface; and
- iii). a basic component;

10 wherein the surface of at least one of i) or ii) is treated with iii).

13. The fertilizer composition according to claim 12, wherein said particulate acidic fertilizer is selected from the group consisting of monoammonium phosphate (MAP), diammonium phosphate (DAP), ammonium sulfate, and ammonium hydrogensulfate, rock phosphate, super phosphate, serpentine super phosphate, reactive phosphate rock, NPSZ, Micro-Essentials® SZ
15 (MESZ (12-40-0-10S-1Zn), struvite, triple super phosphate, and any combination thereof.

14. The fertilizer composition according to claim 13, wherein the urease inhibitor is N-alkyl phosphoric triamide or N-alkyl thiophosphoric triamide according to Formula I:

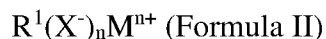


wherein X is oxygen or sulfur, and R^1 and R^2 are independently hydrogen, C_1 - C_{12} alkyl,
20 C_3 - C_{12} cycloalkyl, C_6 - C_{14} aryl, C_2 - C_{12} alkenyl, C_2 - C_{12} alkynyl, C_5 - C_{14} heteroaryl, C_1 - C_{14} heteroalkyl, C_2 - C_{14} heteroalkenyl, C_2 - C_{14} heteroalkynyl, or C_3 - C_{12} cycloheteroalkyl.

15. The fertilizer composition according to claim 14, wherein the urease inhibitor comprises N-(n-butyl) thiophosphoric triamide (NBPT).

16. The fertilizer composition according to claim 15, wherein the basic component is:

i). an organic carboxylic or a sulfonic acid salt according to Formula (II):



wherein R^1 is independently hydrogen, substituted or non-substituted C_1 - C_{30} straight or branched alkyl, substituted or non-substituted C_1 - C_{30} straight or branched alkenyl, substituted
 5 non-substituted C_3 - C_8 cycloalkyl, or substituted or non-substituted C_5 - C_6 aromatic carbon or heterocyclic ring; (X^-) is a (COO^-) or (SO_3^-) ; M^{n+} is metal ion, wherein the metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn; n is 1, 2, 3, or 4;

ii). a metal oxide, metal hydroxide, metal alkoxide with C_1 - C_{30} straight or branched carbon chain, metal sulfate, metal bisulfate, metal carbonate, or metal bicarbonate, wherein the
 10 metal is Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Ra, Al, Mn, Fe, Co, Cu, or Zn; or

iii). an amine compound, wherein the amine compound is a primary, secondary, or tertiary, straight or branched hydrocarbon amine, wherein the hydrocarbon is C_1 - C_{30} straight or branched alkyl, C_1 - C_{30} straight or branched alkenyl, C_3 - C_8 cycloalkyl, or benzene ring, wherein the hydrocarbon is optionally substituted with hydroxyl, amino, or $[(-NH)(CH_2CH_2)]_xNH_2$,
 15 wherein x is 1, 2, 3, 3, or 4;

wherein the weight percentage range of the basic component in the basic component treated particulate acidic fertilizer or the basic component treated particulate urease inhibitor containing urea source is 0.01% to 20 % by weight of the total weight of the basic component treated particulate acidic fertilizer or the basic component treated particulate urease inhibitor
 20 containing urea source.

17. The fertilizer composition according to claim 16, wherein the basic component is selected from the group consisting of ammonium carbonate $((NH_4)_2CO_3)$, lithium oxide (Li_2O) , lithium hydroxide $(LiOH)$, lithium carbonate (Li_2CO_3) , barium oxide (BaO) , barium hydroxide $(Ba(OH)_2)$, barium carbonate $(BaCO_3)$, magnesium oxide (MgO) , magnesium
 25 hydroxide $(Mg(OH)_2)$, magnesium carbonate $(MgCO_3)$, calcium oxide (CaO) , calcium hydroxide $(Ca(OH)_2)$, calcium carbonate $(CaCO_3)$, aluminum oxide (Al_2O_3) , aluminum hydroxide $(Al(OH)_3)$, aluminum carbonate $(Al_2(CO_3)_3)$, sodium oxide (Na_2O) , sodium hydroxide $(NaOH)$,

sodium carbonate (Na_2CO_3), potassium oxide (K_2O), potassium hydroxide (KOH), potassium carbonate (K_2CO_3), monoethanolamine (MEA), triethylenetetramine (TETA), trimethylamine (TEA), triethanolamine, diethanolamine, aniline, and a combination thereof.

18. The fertilizer composition according to claim 17, wherein the particulate acidic fertilizer is
5 selected from the group consisting of MAP, DAP, ammonium sulfate, NPSZ, MESZ, and any combination thereof, wherein the basic component is MgO .

19. The fertilizer composition according to claim 12, wherein the fertilizer composition provides an NBPT half-life of 14-1500 days under accelerated NBPT stability lab test condition.

20. A method of making the fertilizer composition of claim 1 comprising providing a particulate
10 acidic fertilizer having a surface; and contacting the basic component with the surface of the particulate acidic fertilizer.

21. A method of making the fertilizer composition of claim 6 comprising providing a particulate urease inhibitor containing urea source having a surface; and contacting a basic component with the surface of the particulate urease inhibitor containing urea source.

15 22. A method of the fertilizer composition of claim 12, said method comprising contacting the basic component with the surface of i) and blending the basic component treated i) with ii); or contacting the basic component with the surface of ii) and blending the basic component treated ii) with i); or contacting the basic component with the surface of i) and the surface of ii) independently, and blending the basic component treated i) with the basic component treated ii).

20 23. The fertilizer composition according to one of claims 5, 11 or 19, wherein the fertilizer composition provides a NBPT half-life of 14-250 days under accelerated NBPT stability lab test condition.

24. The fertilizer composition according to one of claims 5, 11 or 19, wherein the fertilizer composition provides a NBPT half-life of 14-500 days under accelerated NBPT stability lab test
25 condition.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/065721

A. CLASSIFICATION OF SUBJECT MATTER INV. C05B7/00 C05B17/00 C05C3/00 C05G3/00 C05G3/08 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C05B C05C C05G		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 908 433 A1 (CECA SA [FR]) 14 April 1999 (1999-04-14) paragraph [0006] - paragraph [0009]; examples claims	1-5,20
X	----- WO 2015/127219 A1 (ALCOA INC [US]) 27 August 2015 (2015-08-27) paragraph [0007] - paragraph [0008] paragraph [0029] - paragraph [0030] paragraph [0036] claims	1-5,20
X	----- FR 2 723 085 A1 (MEAC SA [FR]) 2 February 1996 (1996-02-02) page 3, line 27 - page 4, line 27 claims ----- -/-	1-5,20
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 16 March 2017		Date of mailing of the international search report 16/05/2017
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Cardin, Aurélie

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/065721

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 290 962 A (OZDOBA DALE M [US] ET AL) 1 March 1994 (1994-03-01) column 2, line 30 - column 3, line 3 column 4, line 63 - column 5, line 53 examples claims -----	1-5,20
X	WO 2015/132261 A1 (YARA INT ASA [NO]) 11 September 2015 (2015-09-11) claims -----	1-5,20
A	WO 2015/001391 A1 (BASF SE [DE]; BASF CHINA CO LTD [CN]) 8 January 2015 (2015-01-08) page 5, line 1 - line 15 page 17, line 4 - line 25 claims -----	12-19, 22-24
X	WO 99/15480 A1 (NORSK HYDRO AS [NO]; SNARTLAND SUSANNE GADMAN [NO]; ROEDSVIK JOHANNE []) 1 April 1999 (1999-04-01) claims examples -----	1-5
X	US 2015/329433 A1 (LV QINGHUI [CN] ET AL) 19 November 2015 (2015-11-19) paragraph [0011] claims -----	1-5
A	CN 103 102 214 A (SHIKEFENG CHEMICAL IND CO LTD) 15 May 2013 (2013-05-15) abstract -----	1-5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/065721

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-5, 20(completely); 12-19, 22-24(partially)

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-5, 20(completely); 12-19, 22-24(partially)

A fertilizer composition comprising an acidic particulate fertilizer having a surface treated with a basic component wherein the weight percentage range of the basic component is 0.001% to 20% by weight and the weight percentage of the particulate acidic fertilizer is 99.999% to 80% by weight and comprising eventually a particulate urease inhibitor containing urea source

2. claims: 6-11, 21(completely); 12-19, 22-24(partially)

A fertilizer composition comprising a particulate urease inhibitor containing urea source having a surface treated with a basic component wherein the weight percentage range of the basic component is 0.001% to 20% by weight and the weight percentage of the particulate urease inhibitor containing urea source is 99.999% to 80% by weight and eventually an acidic particulate fertilizer.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/065721

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0908433	A1	14-04-1999	AT 205464 T DE 69801628 D1 EP 0908433 A1 ES 2164406 T3 FR 2769518 A1 NO 984339 A	15-09-2001 18-10-2001 14-04-1999 16-02-2002 16-04-1999 12-04-1999
WO 2015127219	A1	27-08-2015	AU 2015218798 A1 CA 2939935 A1 EP 3107881 A1 US 2015239790 A1 WO 2015127219 A1	01-09-2016 27-08-2015 28-12-2016 27-08-2015 27-08-2015
FR 2723085	A1	02-02-1996	NONE	
US 5290962	A	01-03-1994	CA 2024791 A1 US 5290962 A	07-03-1991 01-03-1994
WO 2015132261	A1	11-09-2015	AU 2015226283 A1 CA 2941177 A1 CN 106414372 A EP 3114096 A1 US 2017066692 A1 WO 2015132261 A1	15-09-2016 11-09-2015 15-02-2017 11-01-2017 09-03-2017 11-09-2015
WO 2015001391	A1	08-01-2015	AR 097136 A1 UY 35645 A WO 2015001391 A1	24-02-2016 31-12-2014 08-01-2015
WO 9915480	A1	01-04-1999	AR 016656 A1 AU 9466098 A MY 119735 A NO 974374 A WO 9915480 A1	25-07-2001 12-04-1999 29-07-2005 23-03-1999 01-04-1999
US 2015329433	A1	19-11-2015	CN 103159550 A US 2015329433 A1 WO 2014101268 A1	19-06-2013 19-11-2015 03-07-2014
CN 103102214	A	15-05-2013	NONE	