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(54) Title: IMPROVEMENTS IN AND RELATING TO FERTILISER COMPOSITIONS

(57) Abstract: An aqueous urease inhibitor and/or nitrification inhibitor formulation including: i) an aqueous wax dispersion comprising: substantially 10-50% by weight high melting point emulsifying wax; water to make up to 100%; ii) at least one inhibitor active; wherein the amount of inhibitor active(s) is/are: 1wt% -30wt% of the aqueous wax dispersion at i); iii) a dispersing clay; wherein the amount of dispersing clay is 5wt% -50wt% of the aqueous wax dispersion at i).

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IMPROVEMENTS IN AND RELATING TO FERTILISER COMPOSITIONS

STATEMENT OF CORRESPONDING APPLICATIONS

This application is based on the specifications filed in relation to New Zealand Patent Application Number 756188 and New Zealand Patent Application 760305, the entire contents of each are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to improvements in and relating to fertiliser compositions. In particular the present invention relates to improvements in and relating to improvements in relation to fertiliser compositions relating to urease inhibitors and/or nitrification in inhibitors.

BACKGROUND ART

Large scale farming of animals for fibre, leather, meat and dairy production and use of nitrogen based fertilisers in agriculture will significantly increase as the human population grows from 7.7 billion to 9.8 billion by 2050[1].

The aforesaid intensification in agriculture will - unless solutions are found - have a severely negative impact on the environment unless solutions are found to counter nitrogen losses - via nitrous oxide (NO_2) greenhouse gas emissions; and (NO_3) leaching into waterways via nitrification - from nitrogen based fertilisers and animal urine.

NBPT and DMPP are respectively a urease inhibitor and a nitrification inhibitor both useful in respectively combatting NO_2 emissions (volatilisation) and NO_3 losses mentioned above.

Finding better ways to utilise inhibitor actives - including NBPT and DMPP (or other urease/nitrification inhibitors including N-(n-propyl) thiophosphoric triamide (NPPT) a urease inhibitor, and 2-(3,4-dimethyl-1H-pyrazol-1-yl) succinic acid (DMPSA) a nitrification inhibitor - in farming practice, to address the above concerns remains a priority.

There is a need to prevent environmental N losses and/or increase N use efficiency.

One problem that currently exists is how to efficiently apply nitrification inhibitors and urease inhibitors to land in need thereof.

Ideally, it would be good if there could be provided an aqueous nitrification inhibitor and/or urease inhibitor formulation which could coat a nitrogen or phosphate containing fertiliser granule.

Indeed, a further problem that needs to be addressed is that presently acidic fertilisers such as phosphate fertilisers degrade NBPT upon coming into contact therewith. This makes co-

application of urea with other acidic fertilisers to provide requisite nutrients in a single application step not possible.

It would therefore be ideal if either the coating of a urea granule/chip or the coating of a phosphorous fertiliser granule or chip could enable not only:

- enable urea and phosphorous to be mixed without adverse reaction, but also
- enable NBPT coated urea granules to also be mixed with the phosphate fertiliser granules without degradation of NBPT occurring, due to the low pH of phosphate fertilisers.

It would also be useful if there could be provided an aqueous formulation which can be used for suspending and holding in suspension NBPT rather than organic solvents which are flammable and can react with fertilisers.

Moreover, it would also be useful if the aqueous formulation can be used for also suspending and holding in suspension other urease/nitrification inhibitors including DMPP; NPPT; and DMPSA.

It would also be useful if there could be provided an aqueous formulation which can be used for suspending and holding in suspension urease/nitrification inhibitors which is made from renewable resources which are also non-toxic/biodegradable.

It would also be useful to have ready made pre-mixes of one or more of the main components of the aqueous formulation which are suitable for storage and transportation prior to addition of the inhibitor actives.

There is a need for an aqueous coating composition which includes NBPT in suspension which can be used for coating fertiliser granules including urea.

Alternatively, there is also a need for an aqueous coating composition which includes DMPP; NPPT; or DMPSA; therein, which can be used for coating fertiliser granules.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

Throughout this specification, the word "comprise", or variations thereof such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DEFINITIONS

The term 'inhibitor active(s)' as used herein refers to nitrification inhibitors or urease inhibitors including NBPT; DMPP; NPPT; or DMPSA.

The terms 'granule' and 'chip' as used herein are used interchangeably and refer to a small compact particle of substance. The particle will generally be of a size in the order of substantially between 1mm -10mm and most preferably between 2mm-5mm. The granule/chip may be naturally occurring or may be fashioned by human manipulation.

The term 'high melting point emulsifying wax' as used herein generally refers:

- First, to a high melting point wax which is generally malleable at fairly wide band of room temperatures (i.e. around 5°C - 45°C) and liquid at substantially at least 50°C but preferably around 80°C or above and as with all waxes are insoluble in water but soluble in organic non-polar solvents; and
- Secondly, the inclusion of an emulsifying agent to the high melting point wax.

SUMMARY OF THE INVENTION

The present invention generally relates to a new aqueous wax dispersion which includes a dispersing clay therein, which can be used to hold NBPT or other urease inhibitors/nitrification inhibitors in suspension for coating onto fertiliser granules.

According to a first aspect of the present invention there is provided an aqueous urease inhibitor and/or nitrification inhibitor coating formulation including:

i) an aqueous wax dispersion comprising:

- substantially 10-50% by weight high melting point emulsifying wax;
- water to make up to 100%;

ii) at least one inhibitor active;

wherein the amount of inhibitor active(s) present is/are substantially: 1wt% - 30wt% of the aqueous wax dispersion;

iii) a dispersing clay;

wherein the amount of dispersing clay is 5wt% -50wt% of the aqueous wax dispersion.

According to a second aspect of the present invention there is provided an aqueous urease inhibitor and/or nitrification inhibitor coating formulation substantially as described above wherein the formulation also includes:

iv) a xanthan or guar gum;

wherein the amount of xanthan or guar gum is 0.25wt% - 1wt% of the total urease inhibitor and/or nitrification formulation.

According to a third aspect of the present invention there is provided an aqueous urease inhibitor and/or nitrification inhibitor coating formulation substantially as described above wherein the high melting point emulsifying wax is a mineral wax or plant-based wax.

According to a fourth aspect of the present invention there is provided an aqueous urease inhibitor and/or nitrification inhibitor coating formulation substantially as described above wherein the mineral wax is a montan wax.

According to a fifth aspect of the present invention there is provided an aqueous urease inhibitor and/or nitrification inhibitor coating formulation substantially as described above wherein the clay is inert and has a particle size of substantially 20 microns or less.

According to a sixth aspect of the present invention there is provided an aqueous urease inhibitor and/or nitrification inhibitor coating formulation including:

i) an aqueous wax dispersion comprising:

- 10% by weight high melting point emulsifying wax in the order of 70kg;

- 90% water in the order of 630kg;

ii) an inhibitor active selected from one of the following: 210kg NBPT; 210kg DMPP; 210kg NPPT; 210kg DMPSA; or a 210kg mixture of NBPT and DMPP;

iii) 100kg dispersing clay;

iv) 2.5kg xanthan gum.

According to a seventh aspect of the present invention there is provided an aqueous urease inhibitor and/or nitrification inhibitor coating formulation

i) an aqueous wax dispersion comprising:

- 30% by weight high melting point emulsifying aqueous wax in the order of 210 kg;

- 70% water in the order of 490 kg;

ii) 200 kg NBPT or 200kg DMPP;

iii) 100 kg clay;

iv) 2.5kg guar gum.

According to an eighth aspect of the present invention there is provided an aqueous wax dispersion which includes:

- 10-50% high melting point emulsified mineral wax or plant-based wax;

- water to make up to 100%.

According to a ninth aspect of the present invention there is provided an aqueous wax dispersion which includes NBPT therein 1wt% - 30wt% of the aqueous wax substantially as described above.

According to a 10th aspect of the present invention there is provided an aqueous wax dispersion which includes an inhibitor active or a combination of a nitrification inhibitor and a urease inhibitor.

According to an 11th aspect of the present invention there is provided a wax dispersion substantially as described above wherein the mineral wax is montan wax.

According to a 12th aspect of the present invention there is provided a wax dispersion substantially as described above wherein the plant-based wax is selected from:

- carnauba wax;

- rice bran wax.

According to a 13th aspect of the present invention there is provided a fertiliser composition which includes a nutrient source in the form of a fertiliser granule or chip, the granule or chip coated with an aqueous urease and/or nitrification inhibitor coating formulation substantially as described above.

According to a 14th aspect of the present invention there is provided a fertiliser composition substantially as described above wherein the composition comprises a further outer layer of MgO.

According to a 15th aspect of the present invention there is provided a fertiliser composition substantially as described above wherein the amount of MgO added is 2% of the total weight of the fertiliser composition including the MgO.

According to a 16th aspect of the present invention there is provided a fertiliser composition substantially as described above wherein the MgO has a particle size of substantially 45 micron or less.

According to an 17th aspect of the present invention there is provided a fertiliser composition substantially as described above wherein the fertiliser chip or granule is urea.

According to a 18th aspect of the present invention there is provided a fertiliser blend including a quantity of a fertiliser composition substantially as described above wherein together with a quantity of a fertiliser selected from granular or chip forms of:

- Single super phosphate;
- Diammonium phosphate
- Monoammonium phosphate;
- Ammonium polyphosphate;
- Ammonia sulphate;
- Potassium chloride;
- Potassium sulphate;
- Potassium carbonate; or
- Potassium hydrochloride.

According to a 19th aspect of the present invention there is provided a method of protecting NBPT and/or DMPP from reacting with an acidic fertiliser granule comprising the steps of:

a) suspending at least one Inhibitor Active in an aqueous wax dispersion;

b) coating the resulting suspension from step a) as a first layer onto a fertiliser granule or chip;

c) coating a second layer of MgO onto said first layer.

According to a 20th aspect of the present invention there is provided a method for protecting NBPT coated onto a fertilizer granule from degradation by acidic fertilisers characterized by the step of encapsulating the NBPT layer underneath a further layer of MgO.

According to a 21st aspect of the present invention there is provided a method for protecting NBPT and/or DMPP coated onto a fertilizer granule from degradation by acidic fertilisers characterized by the step of including MgO in the coating formulation which coats the NBPT and/or DMPP (or other urease inhibitor/nitrification inhibitor) onto the fertilizer granule.

According to a 22nd aspect of the present invention there is provided an aqueous coating composition which comprises:

i) an aqueous wax dispersion comprising:

- substantially 10-50% by weight high melting point emulsifying wax;
- water to make up to 100%;

ii) a dispersing clay;

wherein the amount of dispersing clay is 5wt% -50wt% of the aqueous wax dispersion.

According to a 23rd aspect of the present invention there is provided an aqueous coating composition substantially as described above which in addition to the aqueous wax dispersion and dispersing clay includes a guar gum or xanthan gum.

According to a 24th aspect of the present invention there is provided an aqueous wax dispersion which comprises:

- high melting point wax being substantially 25% of the aqueous wax dispersion; and
- water being substantially 75% of the aqueous wax dispersion.

Preferably, the high melting point wax may be montan wax.

According to a 25th aspect of the present invention there is provided an aqueous wax dispersion substantially as described in the 24th aspect which additionally comprises:

- NBPT being 30wt% of the aqueous wax dispersion;
- kaolin clay being 5wt% of the aqueous wax dispersion.

BRIEF DESCRIPTION OF THE DRAWINGS

Further aspects of the present invention will become apparent from the ensuing description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows NBPT levels on urea over time comparing the present invention to a current commercially available solvent based NBPT formulation;

Figure 2 shows the aqueous emulsifying wax emulsion of the present invention including 30wt% NBPT both with and without gum;

Figure 3 shows the enclosed chamber used to collect volatilized ammonia from urea fertilizer applied to pasture; and

Figure 4 shows total ammonia volatilisation losses from the fertilisers studied over the first 7 days. Error bars indicate standard errors of the mean..

BEST MODES FOR CARRYING OUT THE INVENTION

EXAMPLE 1 – Method of manufacture part 1

The method for manufacturing the aqueous wax dispersion of the present invention comprises the steps of:

- Heating water to 95ºC;
- Adding powdered high melting point emulsifying wax to the heated water in a 50:50 ratio;
- Stirring the wax/water mixture above slowly until homogenous dispersion is achieved;
- Adding water to the dissolved wax/water mixture to obtain the desired water to wax ratio whilst slowly stirring;
- If required, cooling or allowing the aqueous wax dispersion to cool until it is at room temperature (i.e. 15ºC - 20ºC).

The aqueous wax dispersion produced above may be made in advance for later use and/or for shipping/transportation thereof.

The inhibitor additive such as NBPT may be added once the dispersion has cooled to room temperature.

EXAMPLE 2 – Method of manufacture part 2

The method for manufacturing an aqueous inhibitor formulation comprises the steps of:

- Adding powdered xanthate or powdered guar gum to the dispersing clay and blending together;
- Adding the gum/clay pre-mix to the aqueous wax dispersion from Example 1 whilst slowly stirring.

The aqueous wax dispersion produced above may be made in advance for later use and/or for shipping/transportation thereof.

- Once the gum/clay/wax dispersion cools to room temperature (around 15ºC - 25ºC) you can start to add the inhibitor active(s) thereto.

EXAMPLE 3

An aqueous urease inhibitor formulation having the following composition:

970kg Aqueous wax dispersion comprising:

97kg LICOCARE RBW™ manufactured by Clariant refer

https://www.clariant.com/en/Business-Units/Additives/Waxes/Licocare-RBW

in order of 10wt% of the aqueous wax dispersion;

873kg water to make up to 100%;

19.4kg NBPT in the order of 2wt% of the aqueous wax dispersion;

48.5kg kaolin clay in the order of 5wt% of the aqueous wax dispersion, wherein the particle size of the kaolin clay is 20 micron or less.

EXAMPLE 4

An aqueous urease inhibitor formulation having the following composition:

700kg aqueous wax dispersion comprising:

- 70kg LICOWAX KST™ manufactured by Clariant refer

  https://www.clariant.com/en/Solutions/Products/2014/03/18/16/33/Licowax-KST

  being 10wt% of the aqueous wax dispersion;

- 630kg water being 90wt% of the aqueous wax dispersion;

210kg NBPT being substantially 30wt% of the aqueous wax dispersion;

98kg calcium bentonite clay being substantially 14wt% of the aqueous wax dispersion;

2.1kg xanthan gum being substantially 0.3wt% of the aqueous wax dispersion.

EXAMPLE 5

An aqueous urease inhibitor formulation having the following composition:

970kg Aqueous wax dispersion comprising:

- 485kg LICOWAX KST™ manufactured by Clariant refer

https://www.clariant.com/en/Solutions/Products/2014/03/18/16/33/Licowax-KST

being 50% of the aqueous wax dispersion;

- 485kg water being substantially 50% of the aqueous wax dispersion;

291kg a 50:50 mixture of NBPT and DMPP being substantially 30wt% of the aqueous wax dispersion;

48.5kg kaolin clay being substantially 5wt% of the aqueous wax dispersion;

0.97kg guar gum being substantially 1wt% of the aqueous wax dispersion.

A pink coloured dye can be added as a final step to assist in using the formulation to coat fertiliser granules.

EXAMPLE 6

An aqueous wax dispersion which has the following composition:

- 250kg LICOWAX KLE manufactured by Clariant

  https://www.clariant.com/en/Solutions/Products/2014/03/18/16/33/Licowax-KLE-flakes

  being substantially 25% of the aqueous wax dispersion;

- 750kg water being substantially 75% of the aqueous wax dispersion.

EXAMPLE 7

This is the aqueous emulsifying wax dispersion of Example 6, but to which has been added:

- 300kg NBPT being 30wt% of the aqueous wax dispersion; and
- 50kg Kaolin clay being 5wt% of the aqueous wax dispersion.

EXAMPLE 8

1) Take 1000kg urea and place in rotating coating drum;
2) Add 100kg of the 0.3 Aqueous Urea formulation from Example 5, to the urea and start the coating drum;
3) Continue rotating the coating drum until all urea granules are coated with 0.3 aqueous NBPT formulation evidenced once the coated granules have changed colour to pink.

EXAMPLE 9

Here 980kg of urea is first coated with 0.3 NBPT aqueous formulation as per Example 8 and as per the additional steps:

4) 20kg of E45 powdered magnesium oxide is added to the coated urea having a layer of 0.3 NBPT aqueous formulation thereon and the coating drum is started again;

5) When all urea granules are evenly coated with E45 magnesium oxide and are free flow, generally after around 2 -3 minutes, the product can be from the coating drum.

EXAMPLE 10

Figure 1 shows the comparative results when granular ammonium sulphate is mixed 50:50 with urea coated with:

- a commercially available solvent based NBPT coating; or
- the 0.3 NBPT aqueous wax dispersion of Example 7.

The amount of NBPT was assessed at different time intervals from application to urea using HPLC. As can be seen the aqueous coating of the present invention (Southstar) retained the NBPT on the urea more effectively over a 24 hour period than the commercially available solvent based NBPT coating.

EXAMPLE 11

Here coated urea as per Example 9 is blended together in equal parts with granular ammonium sulphate (GAS).

EXAMPLE 12

Here urea is coated with the aqueous wax dispersion of Example 7 substantially following the methodology of example 8.

Importantly, as no gum has been added to the wax dispersion the urea needs to be coated within 24 hours of production of the aqueous wax dispersion, before the dispersion separates as shown in Figure 2.

EXAMPLE 13

An aqueous urease inhibitor formulation having the following composition:

970kg aqueous wax dispersion comprising:

- 242.5kg LICOcare RBW™

https://www.clariant.com/en/Business-Units/Additives/Waxes/Licocare-RBW

being 50% of the aqueous wax dispersion;

- 727.5kg water being substantially 50% of the aqueous wax dispersion;

58.2kg of NBPT being substantially 6wt% of the aqueous wax dispersion;

48.5kg kaolin clay being substantially 5wt% of the aqueous wax dispersion;

0.97kg guar gum being substantially 1wt% of the aqueous wax dispersion.

EXAMPLE 14

A fertiliser composition comprising:

- urea granules; coated with
- a layer of an aqueous urease inhibitor in form of 0.3 NBPT on the urea granules. For example as per Example 5 above.

The application process for applying the aqueous NBPT layer to the urea granules being substantially as per Example 8 with appropriate substitution of the 0.3NBPT from Example 5.

EXAMPLE 15

A fertiliser composition as per Example 14 the composition having a total weight of 1085kg and wherein the composition undergoes a further coating process to also include a further outer layer of E45 MgO covering the NBPT layer wherein the amount of MgO used to coat the granules of Example 14 is 21.7kg being 2% of the total weight 1106.7 kg of the NBPT/MgO coated urea granules.

The MgO coating being applied substantially as per the method of Example 9.

EXAMPLE 16

Here coated urea as per Example 15 is blended together in equal parts with - single super phosphate (SSP).

EXAMPLE 17

An aqueous urease inhibitor formulation having the following composition:

970kg Aqueous wax dispersion comprising:

485kg Carnauba wax in order of 50wt% of the aqueous wax dispersion;

485kg water to make up to 100%;

19.4kg NBPT in the order of 2wt% of the aqueous wax dispersion;

48.5kg kaolin clay in the order of 5wt% of the aqueous wax dispersion.

EXAMPLE 18

An aqueous urease inhibitor formulation having the following composition:

970kg Aqueous wax dispersion comprising:

97kg LICOCARE RBW™

https://www.clariant.com/en/Business-Units/Additives/Waxes/Licocare-RBW

in order of 10wt% of the aqueous wax dispersion;

873kg water to make up to 100%;

9.2kg DMPP in the order of 1wt% of the aqueous wax dispersion;

485kg kaolin clay in the order of 50wt% of the aqueous wax dispersion, wherein the particle size of the kaolin clay is 20 micron or less.

EXAMPLE 19

An aqueous urease inhibitor formulation having the following composition:

970kg Aqueous wax dispersion comprising:

485kg montan wax in order of 50wt% of the aqueous wax dispersion;

485kg water to make up to 100%;

19.4kg NPPT together NBPT (50:50 ratio) in the order of 2wt% of the aqueous wax dispersion;

48.5kg kaolin clay in the order of 5wt% of the aqueous wax dispersion.

EXAMPLE 20

This example relates to an independent study on the present invention which was undertaken by Lincoln University.

The objective of this study was to determine ammonia volatilisation losses from urea fertiliser containing different urease inhibitor formulations on soil with typical pasture plant coverage.

Experimental Design and Conditions

A standard gas capture system used in this study was similar to that used in the previous studies on ammonia volatilisation conducted at Lincoln University. Briefly, soil monoliths (20 cm diameter x 6 cm deep) were taken from a pasture paddock at the Lincoln University Research Dairy Farm. The intact monoliths contained a representative dairy pasture soil (Templeton Sandy Loam) with typical pasture coverage (perennial ryegrass/white clover). The monoliths were moved to the outdoor research facilities at Lincoln University where they were placed in the area adjacent to the ammonia measurement facilities. Stainless steel rings (20 cm diameter x 15 cm deep) were inserted 7.5 cm into the ground to enclose each separate monolith. The area outside the enclosures was also pasture to simulate standard field conditions. A clear Perspex lid was attached on top of each enclosure. Each enclosure had inlet and outlet holes allowing the air to be drawn through the chamber (Figure 1). The outlets were connected through PVC tubing to the acid gas trap system to collect ammonia. The system was calibrated and tested prior to the beginning of the experiment.

Prior to treatment application, soil moisture inside the enclosures was adjusted to field capacity with water. Five treatments were applied in a completely randomised design with four chambers assigned to each treatment (Table 1). Prior to application, fertiliser granules were sieved to the same diameter (1-2 mm) to prevent potential bias due to surface area differences resulting from granule size.

All fertiliser treatments were applied by broadcasting at the rate of 50 kg-N ha-1.

Treatments	Application rate	Replicates
1) Standard Urea	50 kg N/ha	4
2) Urea + NBPT coat + 2% Mg	50 kg N/ha	4
3) Urea + NBPT coat	50 kg N/ha	4

Ammonia gas from each chamber was collected continuously with 10% of the total flow directed through a manifold to the gas traps, where it was trapped in 0.05 M sulphuric acid.

Samples were collected daily between 3:00pm and 5:00 am after which fresh volumes of 0.05 M sulphuric acid were placed in the acid traps. Collected samples were then taken to the Lincoln University analytical laboratory and analysed for ammonium concentration using the flow injection analysis method. Daily air and soil temperature were recorded during the experiment.

Results

Immediately after the application to the pasture, a strong ammonia efflux was observed from the standard urea fertiliser, reaching 4.4 kg NH3-N ha-1. Strong volatilisation losses continued for

approximately 4 days, after which the daily emissions decreased to below 1 kg NH3-N ha-1 day-1.

In contrast, the application of the two formulations of urease inhibitor fertiliser had no initial peak comparable to that from the standard urea, and emissions occurred at relatively steady rates that mostly did not exceed 1 kg NH3-N ha-1 day-1.

Initial strong ammonia emissions from the standard urea resulted in significant cumulative losses during the first week after application as shown in Figure 4. Specifically, 24.8% of the fertiliser N was lost from the standard urea treatment in the first week. The losses were smaller after the first week, which can be attributed to the partial immobilisation and conversion of volatile ammonia into non-volatile forms. The total N losses as ammonia from the urease inhibitor treated fertilisers were significantly lower over the first 7 days, for the urea+NBPT coat + 2% Mg and urea+NBPT coat. These are equivalent to 68% and 55% reductions in ammonia losses in the urease inhibitor products compared with the standard urea.

The one week after application data is the most important indicator of the value of the urease inhibitor fertilisers compared to standard urea, since it is likely that rainfall would occur within or after a week in most parts of New Zealand. The likelihood of rainfall within 7 days is shown in Table 2.

Table 2 Average number of days per month where rain occurred in New Zealand locations*

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Hamilton	7.8	6.2	7.7	8.4	11.0	12.6	12.8	13.3	11.7	11.7	10.7	10.5	124.8
Christchurch	5.8	5.6	6.2	6.7	7.6	8.9	8.2	8.2	6.1	6.9	6.5	7.3	83.9
Taupo	7.7	6.7	7.3	7.4	8.7	10.9	10.9	11.4	10.7	10.6	8.2	9.2	108.5
New Plymouth	8.9	7.7	9.8	9.8	12.3	13.6	12.6	13.4	12.6	14.1	10.5	9.5	135.5
Napier	6.0	5.9	7.2	7.1	7.9	8.8	9.4	8.2	7.4	7.5	6.0	6.5	88.1
Whangarei	7.9	7.9	9.3	9.8	12.5	13.9	14.8	14.8	12.6	10.5	9.4	8.7	131.6
Palmerston North	7.1	6.9	7.7	8.2	9.9	12.2	11.6	13.0	11.9	11.8	10.3	11.1	120.7
Timaru	6.8	6.7	6.2	5.7	5.7	5.3	5.8	5.7	5.8	7.1	6.8	8.0	75.6
Invercargill	13.0	10.3	12.3	12.3	15.3	15.6	14.2	12.8	13.1	13.8	13.3	14.3	161.0

* Data are mean monthly values for the period 1981-2010.

(Source: niwa.co.nz/sites/default/files/mean_monthly_wet-days.xlxs).

After 7 days, the ammonia losses became similar for the different N fertilisers applied.

Conclusion

This experiment demonstrated that the urease inhibitor (NBPT) fertiliser formulations applied at a rate of 50 kg-N/ha significantly reduced ammonia volatilisation losses compared to the standard urea applied at the same rate. The efficacy of the four different formulations was

similar. The benefits of the urease inhibitors were most evident during the first week after the application, where the NBPT reduced the rate of urea hydrolysis and prevented the strong ammonia efflux typical for the standard urea.

FURTHER DISCUSSION OF THE INVENTION INCLUDING NON-LIMITING ALTERNATE WAYS TO IMPLEMENT THE INVENTION

The high melting point wax may generally be a mineral wax or plant-based wax.

The importance of a high melting point wax may be stated as the need to ensure the wax does not melt when exposed to direct sunlight and maintains integrity for free flow of chips/granules coated using the present invention. If these characteristics are not important to a given application of the present invention waxes having a melting point of substantially 50ºC may be employed.

In one preferred embodiment the mineral wax may be a Montan wax (also known as Lignite wax).

In other preferred embodiments the high melting point wax may be selected from rice bran wax, or carnauba wax.

In another embodiment the mineral wax may be a paraffin wax.

In some preferred embodiments the high melting point emulsifying waxes may be in powder form and selected from:

- LICOWAX KST™ (made from montan wax);
- LICOCARE RBW™ (made from rice bran wax);
- LICOWAX KLE™ (made from montan wax).

all manufactured and sold by Clariant with further details available from the weblinks noted in the Example sections above.

The inventors have found if wax is present at substantially 60% and water at 40% the resulting viscosity resembles that of treacle and therefore not suitable as a suspension formulation for coating fertilisers.

Whilst the present invention makes use of waxes it should be appreciated that resins or hydrogenated oils with properties similar to the high melting points waxes used in the present invention may also be employed.

Numerous emulsifying agents may be suitable for adding to the high melting point wax such as would be apparent to one skilled in the art including anionic and non-ionic emulsifiers or a

combination thereof. One suitable emulsifier may be polysorbate 60 and/or PEG 150. Further examples of suitable emulsifiers which can be employed are described in McCutcheons, 2018 Emulsifiers Detergents, North American Edition.

The dispersing clay may be any clay which has a particle size of less than 20 microns and is inert.

In one embodiment the dispersing clay may be kaolin clay.

In one embodiment 90% of the kaolin clay particles may be under 10 microns in size.

In another embodiment the dispersing clay be calcium bentonite may have a particle size of under 20 microns.

The clay and wax play an important role in the formulation as the inventors have surprisingly found they enable NBPT and other inhibitor actives to be stably held in suspension in water. As NBPT normally crystallizes in the presence of water.

The inventors have also found the guar gum or xanthan gum play a key role not only as a thickening agents enabling the viscosity of the formulation to be subtly increased, but also for enabling the NBPT or other inhibitor active to be held in suspension for prolonged periods of 3 to 6 months.

In particular, the guar or xanthan gum holds the clay and NPBT in a homogenous suspension together with the wax. Without the gum, the NBPT and clay separate out from the wax to form a lower emulsion layer and the wax forms a top emulsion layer.

In general, when the formulation of the present invention is to be used as a coating it may also include a coloured dye which can act as a visual indicator that the particles have been coated. The coloured dye may also be useful for showing you have the desired blend.

The invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, in any or all combinations of two or more of said parts, elements or features.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.

WHAT WE CLAIM IS:

1. An aqueous urease inhibitor and/or nitrification inhibitor coating formulation including:

i) an aqueous wax dispersion comprising:

- substantially 10-50% by weight high melting point emulsifying wax;

- water to make up to 100%;

ii) at least one inhibitor active;

- wherein the amount of inhibitor active(s) is/are substantially: 1wt% - 30wt% of the aqueous wax dispersion at i);

iii) a dispersing clay

- wherein the amount of dispersing clay is 5wt% -50wt% of the aqueous wax dispersion at i).

2. An aqueous urease inhibitor and/or nitrification inhibitor coating formulation as claimed in claim 1 further including:

- a xanthan or guar gum

wherein the amount of xanthan or guar gum is 0.25wt% - 1wt% of the total aqueous wax dispersion at i).

3. An aqueous urease inhibitor and/or nitrification inhibitor coating formulation as claimed in claim 1 wherein the high melting point emulsifying wax is mineral wax or plant-based wax.

4.. An aqueous urease inhibitor and/or nitrification inhibitor coating formulation as claimed in claim 1 wherein the mineral wax is a montan wax.

5. An aqueous urease inhibitor and/or nitrification inhibitor coating formulation as claimed in claim 1 wherein the clay is inert and has a particle size of substantially 20 microns or less.

6. An aqueous urease inhibitor and/or nitrification inhibitor coating formulation including:

i) an aqueous wax dispersion comprising:

- 10% by weight high melting point emulsifying wax in the order of 70 kg;

- 90% water in the order of 630 kg;

ii) an inhibitor active selected from one of the following: 210 kg NBPT; 210 kg DMPP; 210kg NPPT; 210kg DMPSA; or a 210kg 50:50 mixture NBPT and DMPP;

iii) 100 kg dispersing clay;

iv) 2.5kg xanthan gum.

7. An aqueous urease inhibitor and/or nitrification inhibitor coating formulation

i) an aqueous wax dispersion comprising:

- 30% by weight high melting point emulsifying wax in the order of 210kg ;

- 70% water in the order of 490kg;

ii) 200kg NBPT or 200kg DMPP;

iii) 100kg dispersing clay;

iv) 2.5kg guar gum.

8. An aqueous wax dispersion which includes:

- 10-50% high melting point emulsified mineral wax or plant-based wax;

- water to make up to 100%.

9. An aqueous wax dispersion which includes NBPT therein 1wt% - 30wt% of the aqueous wax dispersion in claim 8.

10. An aqueous wax dispersion as claimed in claim 8 which includes an inhibitor active or a combination of a nitrification inhibitor and a urease inhibitor.

11. An aqueous wax dispersion as claimed in claim 8 wherein the mineral wax is montan wax.

12. An aqueous wax dispersion as claimed in claim 8 wherein the plant-based wax is selected from:

- carnauba wax;

- rice bran wax.

13. A fertiliser composition which includes a nutrient source in the form of a fertiliser granule or chip, the granule or chip coated with an aqueous urease and/or nitrification inhibitor coating formulation as claimed in any one of the preceding claims.

14. A fertiliser composition as claimed in claim 13 wherein the composition comprises a further outer layer of MgO.

15. A fertiliser composition as claimed in claim 14 wherein the amount of MgO added is 2% of the total weight of the fertiliser composition including the MgO.

16. A fertiliser composition as claimed in claim 14 wherein the MgO has a particle size of substantially 45 micron or less.

17. A fertiliser composition as claimed in any one of claims 13 – 16 wherein the fertiliser chip or granule is urea.

18. A fertiliser blend including a quantity of a fertiliser composition as claimed in claim 16 together with a quantity of a fertiliser selected from granular or chip forms of:

- Single super phosphate;
- Diammonium phosphate
- Monoammonium phosphate;
- Ammonium polyphosphate;
- Ammonia sulphate;
- Potassium chloride;
- Potassium sulphate;
- Potassium carbonate; or
- Potassium hydrochloride.

19. A method of protecting NBPT and/or DMPP from reacting with an acidic fertiliser granule comprising the steps of:

a) suspending at least one Inhibitor Active in an aqueous wax dispersion;

b) coating the resulting suspension from step a) as a first layer onto a fertiliser or mineral granule or chip;

c) coating a second layer of MgO onto said first layer.

20. A method for protecting NBPT and/or DMPP coated onto a fertilizer granule from degradation by acidic fertilisers characterized by the step of encapsulating the NBPT and/or DMPP layer underneath a further layer of MgO.

21. A method for protecting NBPT and/or DMPP coated onto a fertilizer granule from degradation by acidic fertilisers characterized by the step of including MgO in the coating formulation which coats the NBPT and/or DMPP onto the fertilizer granule.

22. An aqueous coating composition which comprises:

i) an aqueous wax dispersion comprising:

- substantially 10-50% by weight high melting point emulsifying wax;

- water to make up to 100%;

ii) a dispersing clay;

wherein the amount of dispersing clay is 5wt% -50wt% of the aqueous wax dispersion.

23. An aqueous coating composition as claimed in claim 20 which further includes a guar gum or xanthan gum.

Figure 1

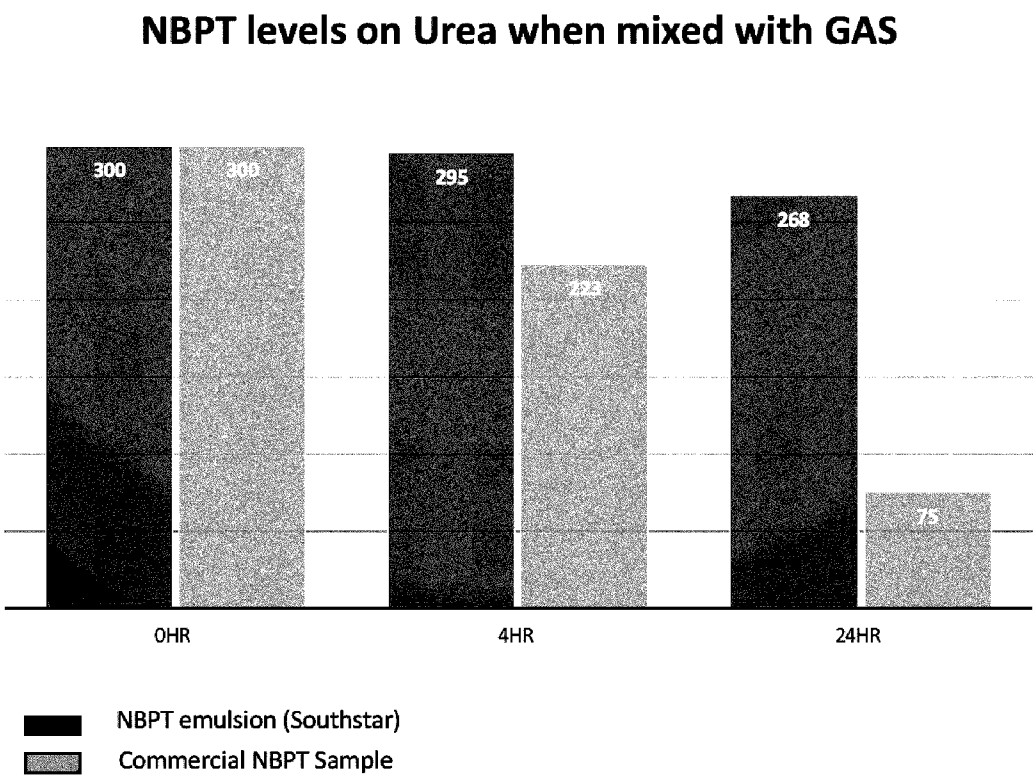
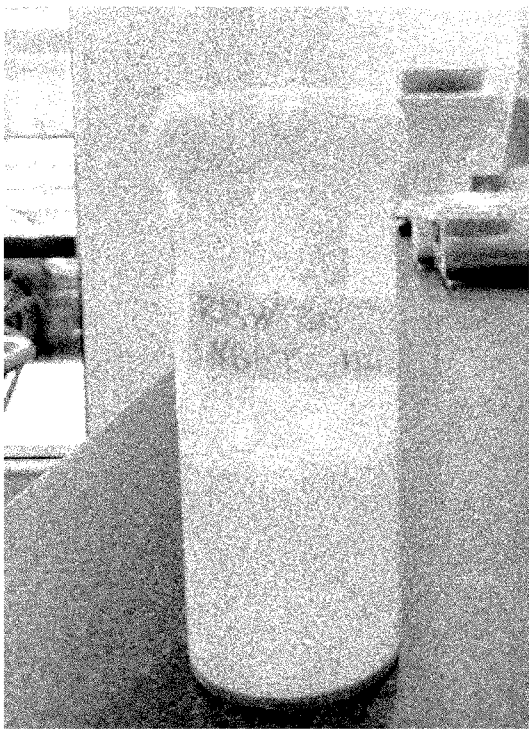
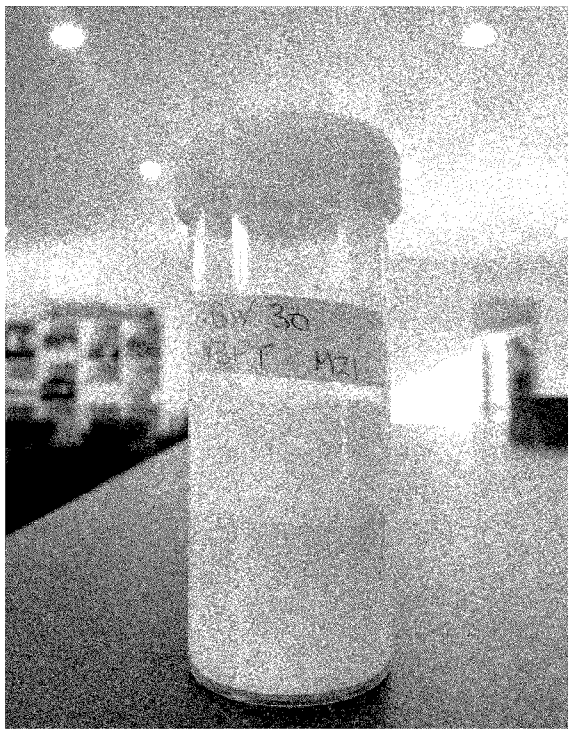

NBPT levels on Urea when mixed with GAS
300
309
295
223
268
75
0HR
4HR
24HR
NBPT emulsion (Southstar)
Commercial NBPT Sample

Figure 2





.

Figure 3

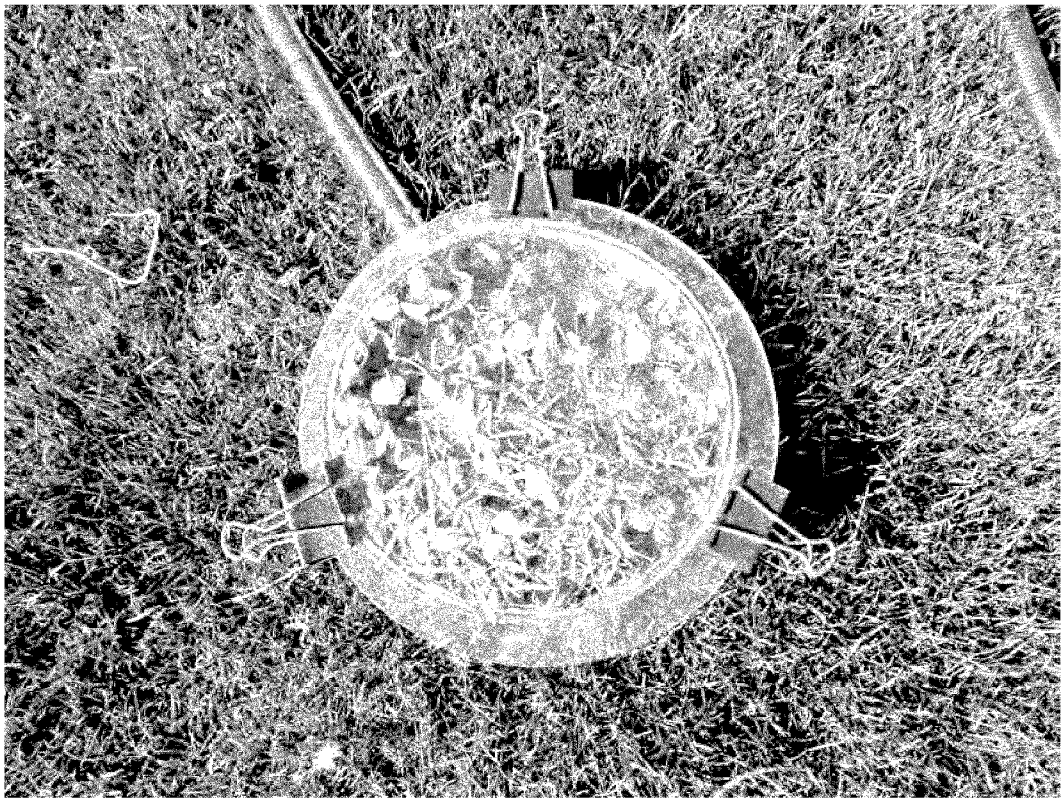
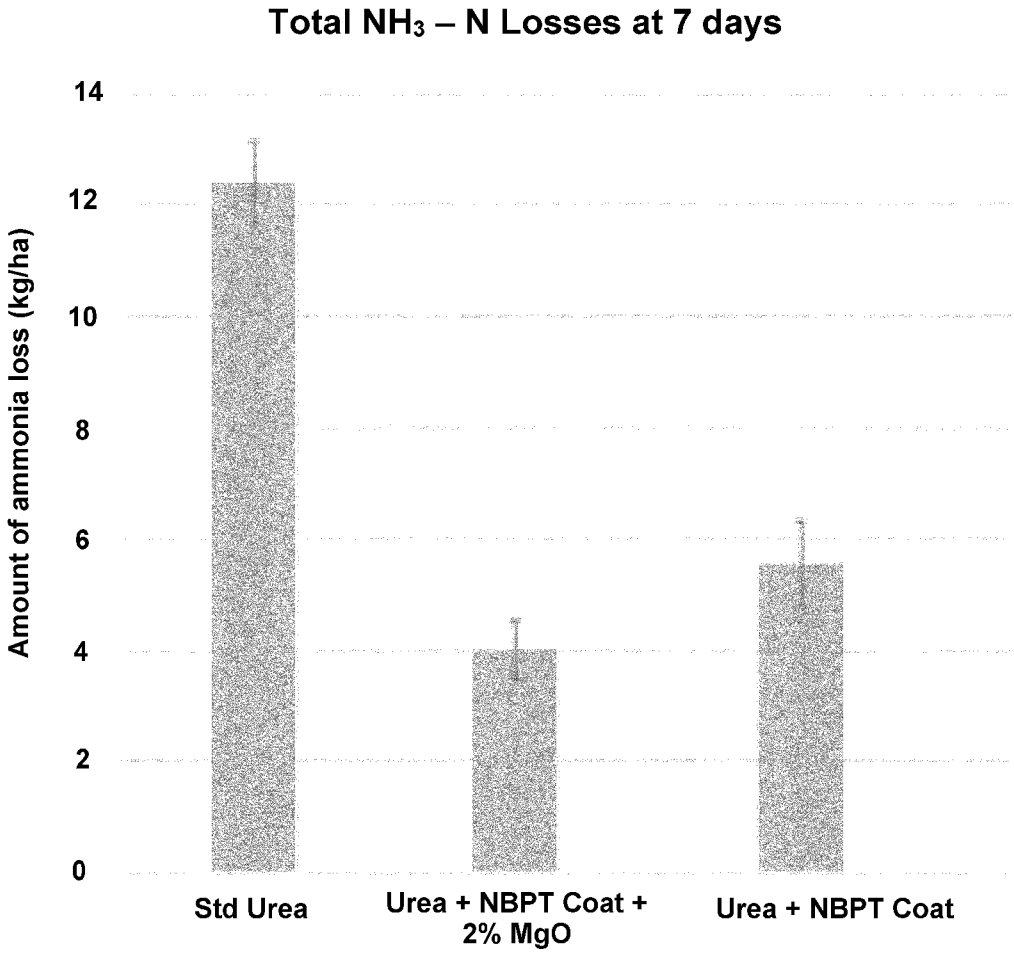


Figure 4


Total NH3 – N Losses at 7 days
Amount of ammonia loss (kg/ha)
14
12
10
8
6
4
2
0
Std Urea
Urea + NBPT Coat + 2% MgO
Urea + NBPT Coat

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2020/050087

A. CLASSIFICATION OF SUBJECT MATTER

C05G 3/90 (2020.01) C05G 5/30 (2020.01) C05C 9/00 (2006.01) C09D 191/06 (2006.01)

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)

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)

Classification Symbols C05G5/30/low, C05G3/90, C09D191/[00,06,08], C05G30/38, C05G9/[00,005]
Databases- CAPLUS, REGISTRY, BIOSIS, CABA, EMBASE, Google Scholar, Google Patent, GOOGLE, Internal IP Databases.
Keywords- urease inhibitor, nitrification inhibitor, wax, Palm, carnauba, montan, rice bran wax, NBTPT, NPTPT, DMPP, DMPSA, aqueous water suspension, emulsion, clay, coating, fertilizer, urea and like terms.
Applicant/Inventor search
Keywords- Zander (Regan Or Murray), South_Star searched in relevant databases.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

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

Date of the actual completion of the international search	Date of mailing of the international search report
1 December 2020	01 December 2020

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INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/NZ2020/050087**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/034375 A1 (SOUTH STAR FERTILIZERS LIMITED) 12 March 2015 Abstract,see page 19 final paragraph and first paragraph of page 20, examples (especially example 8), claims (especially 8, 16, 19, 23 & 25).	1-23
X	US 2764499 A (ROTHEUS B. PORTER Jr) 25 September 1956 Abstract, col 1 lines 63-67, top of col 3, col 3 lines 27-36, examples, claims.	8, 11-12 & 22
X	US 5743949 A (KAINZ) 28 April 1998 Abstract, col 3 lines 11-21, examples, claims.	8 & 11
X A	WO 2018/134765 A1 (KOCH AGRONOMIC SERVICES, LLC) 26 July 2018 Abstract, Background, page 3 lines 5-8, page 20 lines7- page 21 line 2,page 22 line 24-page 23 line 19, page 25 lines 24-28, examples (especially example 2) claims. Abstract, Background, page 3 lines 5-8, page 20 lines7- page 21 line 2,page 22 line 24-page 23 line 19, page 25 lines 24-28, examples (especially example 2) claims.	20-21 1-19 & 22-23
X A	US 2018/0208513 A1 (SABIC GLOBAL TECHNOLOGIES B.V.) 26 July 2018 Abstract, [0073]-[0076], [0079], [0081], [0097], ([0160], [0261], examples, claims, Abstract, [0073]-[0076], [0079], [0081], [0097], ([0160], [0261], examples, claims,	21-22 1-19 & 22-23
A	EP 2456737 B1 (SKW STICKSTOFFWERKE PIESTERITZ GMBH) 19 April 2017 Abstract, examples, claims (especially claim 1 & 10-11).	1-23

Supplemental Box

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1, 6, 7, 8 & 22 are directed to aqueous wax dispersions containing high melting point wax and the application of these dispersions in coatings for fertilizers. The feature of aqueous wax dispersions with a dispersing clay is specific to this group of claims (note: box VIII objections to claim 8 missing required dispering clay feature).
- Claims 19-21 are directed to methods for protecting the inhibitor material NBPT in fertilizer coatings. The feature of using MgO either as an external coating to the inhibitor containing coating or within these coatings is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

No ITP was issued as there was negligible effort to search the inhibitor actives, coating fertilizer granules/chips and protecting same from acidic degradation.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2020/050087

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:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

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 Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

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

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

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/NZ2020/050087**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
WO 2015/034375 A1	12 March 2015	WO 2015034375 A1	12 Mar 2015
		AU 2014218451 A1	19 Mar 2015
		AU 2014218451 B2	21 Jan 2016
		NZ 621175 A	28 Aug 2015
US 2764499 A	25 September 1956	US 2764499 A	25 Sep 1956
US 5743949 A	28 April 1998	US 5743949 A	28 Apr 1998
		DE 19546073 A1	12 Jun 1997
		EP 0783027 A2	09 Jul 1997
		JP H09176493 A	08 Jul 1997
WO 2018/134765 A1	26 July 2018	WO 2018134765 A1	26 Jul 2018
		AU 2018209446 A1	06 Jun 2019
		BR 112019014982 A2	28 Apr 2020
		CA 3050855 A1	26 Jul 2018
		CL 2019001396 A1	26 Jul 2019
		CN 110072827 A	30 Jul 2019
		EP 3571174 A1	27 Nov 2019
		MX 2019008456 A	13 Sep 2019
		US 2019382321 A1	19 Dec 2019
US 2018/0208513 A1	26 July 2018	US 2018208513 A1	26 Jul 2018
		US 10689306 B2	23 Jun 2020
		AR 105883 A1	22 Nov 2017
		CN 108026118 A	11 May 2018
		EP 3325491 A1	30 May 2018
		EP 3325491 B1	20 May 2020
		TW 201711984 A	01 Apr 2017
		WO 2017013573 A1	26 Jan 2017
EP 2456737 B1	19 April 2017	EP 2456737 A1	30 May 2012
		EP 2456737 B1	19 Apr 2017
		DE 102009034433 A1	27 Jan 2011
		WO 2011009572 A1	27 Jan 2011

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.