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(54) Title:

QUICK DRYING POLYMERIC COATING

(57) Abstract:

Improved agriculturally useful products are provided, including solid materials such as nitrogenous fertilizers (e.g., urea), together with a polycarboxylated polymer selected from the group consisting of a salts of copolymers containing individual quantities of maleic and itaconic moieties. The polymer composition also includes from about 10-60% by weight of an organic drying agent such as a lower alcohol which enhances the quick drying properties thereof. The compositions may also include an amount of boron, and bimodal vinylic polymer made up of quantities of high and low molecular weight (MW) vinylic polymers such as PVA.

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(57) Abstract: Improved agriculturally useful products are provided, including solid materials such as nitrogenous fertilizers (e.g., urea), together with a polycarboxylated polymer selected from the group consisting of a salts of copolymers containing individual quantities of maleic and itaconic moieties. The polymer composition also includes from about 10-60% by weight of an organic drying agent such as a lower alcohol which enhances the quick drying properties thereof. The compositions may also include an amount of boron, and bimodal vinylic polymer made up of quantities of high and low molecular weight (MW) vinylic polymers such as PVA.



WO 2010/080896 A3

QUICK DRYING POLYMERIC COATING

CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of application SN 12/351,589; filed January 9, 2009, and
5 entitled QUICK DRYING POLYMERIC FERTILIZER ADDITIVE. This prior application is
incorporated in its entirety by reference herein.

BACKGROUND OF THE INVENTION

Field of the Invention

10 The present invention is broadly concerned with improved agriculturally useful, quick
drying coating compositions and methods wherein the compositions include one or more
polycarboxylated polymer salt and a volatile organic drying agent. More particularly, the
invention is concerned with such compositions and methods wherein a copolymer containing
respective quantities of maleic and itaconic moieties is supplemented with a volatile drying agent,
15 which may be mixed with or coated onto solids, such as solid nitrogenous fertilizer. In another
aspect of the invention, improved drying times are provided by adding boron, especially in
conjunction with vinylic polymer(s) having a majority of pendent functional groups thereof as
alcohols, and optionally containing both relatively low and high molecular weight (MW) polymer
fractions, to the copolymer-organic drying agent compositions.

Description of the Prior Art

20 U.S. Patent No. 6,515,090 describes a highly useful class of copolymers which have been
employed to good effect in a number of agricultural applications. For example, the '090 patent
discloses copolymers made up of varying percentages of maleic and itaconic moieties, and salts
25 thereof, which can be applied to solid fertilizers to achieve surprising increases in yields. In
normal practice, an aqueous copolymer mixture is applied by spraying or other means onto solid
fertilizers to provide fertilizer-polymer compositions.

30 Specialty Fertilizer Products, LLC of Leawood, Kansas, commercializes a series of
copolymers under the '090 patent. One such polymer, Nutrisphere-N® for granular nitrogen
fertilizers, is especially designed to be applied to a variety of solid or granular nitrogen fertilizers,
such as urea, ammonium salts, MAP, or DAP. This product is an approximately 40% by weight
solids aqueous dispersion of a 1:1 partial calcium salt copolymer of maleic and itaconic moieties
having a pH of from about 3.25-3.75.

-2-

However, it has been found that, depending principally upon the moisture content of the solid fertilizer, suboptimal field application procedures, or adverse ambient conditions such as very high humidity or low temperatures, problems with successful application of the above-mentioned compositions can arise. Specifically, the compositions are sprayed or otherwise deposited on the outer surfaces of solid fertilizers and the water is allowed to evaporate by mass transfer, leaving a solid polymer residue coating. However, if the composition drying time is excessive resulting in incomplete drying of the compositions, the coated products can be difficult to handle and apply. Indeed, in certain cases, relatively wet solid fertilizers with applied aqueous copolymer can create agglomerations within field application equipment making it difficult or even impossible to evenly spread the compositions across fields.

Mixtures of certain polycarboxylated polymers and organic solvents are known, see U.S. Patent No. 5,868,964, e.g., polyacrylic acid polymer plus methanol. However, owing to the type of polymer used, and/or the concentration of organic solvent, the polymer and solvent are essentially incompatible, resulting in viscous precipitates unsuitable for use in fertilizer compositions. Polycarboxylate polymer salts do not usually form stable solutions in the presence of significant concentrations of organic solvents such as methanol.

There is accordingly a need in the art for improved agricultural products such as solid fertilizers in contact with quick-drying polycarboxylated polymers, so as to alleviate polymer coating and drying problems, while at the same time not detracting from the yield benefits obtained using such polymers.

SUMMARY OF THE INVENTION

The present invention overcomes the problems outlined above and provides improved polymer-containing, quick drying compositions designed for application with or onto various solids such as fertilizers, methods of forming the quick drying compositions and polymer-supplemented solid products, and methods of fertilizing soil to enhance plant growth using polymer-coated fertilizer compositions.

In broad outline, the fertilizer compositions of the invention include a quantity of a solid, fertilizer and a polymer-containing composition in contact with the solid fertilizer. The polymer-containing composition as initially formulated and contacted with fertilizer includes a salt of a polycarboxylated polymer, namely a salt of a copolymer containing individual quantities of

-3-

maleic and itaconic moieties, along with a volatile organic drying agent or solvent. Thereafter, the drying agent evaporates, along with a substantial part of any water present, so that the fertilizer composition as applied to a field normally does not contain these components to any substantial degree, but rather is made up of the fertilizer plus the residue copolymer salt.

5 Surprisingly, it has been found that the selected polymer salts can be mixed with very high concentrations of organic drying agent to produce stable liquid polymer-containing compositions free of the incompatibility problems of the prior art. The final fertilizer composition can be prepared by applying such a polymer-containing composition directly onto the surface of solid
10 fertilizer compositions, while at the same time causing the rapid vaporization of excess moisture from the fertilizer compositions. This assures that the fertilizer compositions can be field-applied using normal spreaders or the like without the difficulties encountered with prior fertilizer compositions.

The methods of use of the fertilizer compositions involve applying the compositions onto
15 soil adjacent planted seeds or growing plants at normal nitrogen levels.

Further improved results are realized when the above-described polymeric coating compositions are supplemented by a minor amount of boron (usually in the form of boric acid). Still more advantageous is the use of boron in conjunction with a vinylic polymer, preferably polyvinyl alcohol (PVA), having a majority of the pendant functional groups thereof as alcohols.
20 Still more preferably, the vinylic polymer additive is in the form of a bimodal polymer having respective fractions of high MW and low MW vinylic polymer.

It has been found that the fertilizer compositions of the invention provide significant increases in crop yields, and that the presence of organic drying agents and other ingredients do not impede or otherwise alter such yield enhancements.

25

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is predicated upon the discovery that solid agriculturally useful products such as fertilizers can be improved through the use of quick drying polymeric compositions added to or applied onto the solid products. Such drying agents facilitate and
30 enhance the vaporization of moisture from the products, allowing easy use thereof.

-4-

Virtually any fertilizer may be treated with the polymeric compositions of the invention in order to lessen the formation of dust and to enhance the fertilizer efficiency thereof. In preferred forms, however, nitrogen-bearing or nitrogenous fertilizers are improved in accordance with the invention. For example, urea, ammonium sulfate, ammonium nitrate and mixtures thereof are prime candidates for use in the invention, and can be in any solid form such as prills or granules. The single most preferred solid fertilizer is granular urea.

As indicated above, the polycarboxylated polymers of the invention are selected from the group consisting of copolymers in acid form or as partial salts containing respective quantities of maleic and itaconic moieties. These polymers preferably exist as partial salts, and can include mixtures of different salts. Virtually any desired cationic species may be used in the formation of the polymeric salts from starting acid polymers, particularly the alkali metals, alkaline earth metals, ammonia, and the alkylamines (e.g., C1-C6 alkylamines such as triethylamine). The polymer salts of the invention are preferably in the form of aqueous dispersions, but non-aqueous organic dispersions may also be used.

The basic copolymers are described in US Patent No. 6,515,090, fully and completely incorporated by reference herein. In general, the copolymer salts should desirably contain from about 10-90% maleic moieties (more preferably from about 25-75%), and correspondingly from about 90-10% itaconic moieties (more preferably from about 75-25%). The copolymers may also contain other moieties apart from maleic and itaconic moieties, such as vinyl moieties. However, such other moieties should be present only up to a level of about 7%, i.e., the copolymers should contain about 93% maleic and itaconic moieties. Preferably, the copolymers consist essentially of maleic and itaconic moieties. One particularly preferred copolymer salt of this class is the previously-described Nutrisphere-N® for solid nitrogen fertilizers. More generally, such copolymer salts are preferably formed by the addition of a basic material (e.g., Ca, Mg, K, Na in the form of the oxides, hydroxides, or carbonates thereof) to achieve a desired pH in aqueous mixture, normally in the range of from about 1-4.

The volatile organic drying agent may be made up of one or more organic compounds, and is preferably selected from the group consisting of organic alcohols and ketones, and particularly the C1-C4 alkyl alcohols. For reasons of cost, ease of use and vapor pressure characteristics, methanol is the most preferred drying agent. More broadly, however, the drying agent may be selected from the group consisting of one or more organic compounds having a

-5-

vapor pressure of at least about 40 mmHg at Standard Temperature and Pressure (STP). This embraces many of the preferred lower alcohols such as methanol (127 mmHg), ethanol (59 mmHg) and isopropanol (42.7 mmHg).

The selected drying agent and polymer salt are preferably mixed together to form a polymer-containing composition designed to be applied to solid products such as nitrogenous fertilizers. In such cases the polymer-containing composition normally comprises the polymer salt dissolved, suspended, or dispersed in a liquid phase comprising water and the drying agent. The drying agent is normally used at a level of from about 5-60% by weight (more preferably about 30-50% by weight, and most preferably about 35-45% by weight) of the complete polymer-containing composition. Use of higher levels of drying agent with the simultaneous presence of high polymer solids concentration may require partial or essentially complete water removal by evaporation or other known means from the starting copolymer salt aqueous material. Thus, a preferred polymer-containing composition may include from about 20-70% by weight of copolymer salt (more preferably from about 30-60% by weight), from about 30-50% by weight drying agent (more preferably from about 35-45% by weight), and from about 10-50% by weight water (more preferably from about 10-25% by weight). An example of such a polymer-containing composition would include about 40% by weight maleic-itaconic copolymer salt, about 45% by weight methanol, and about 15% by weight water, and would have a pH 1-4 and a flash point of 74°F. Generally, the polymeric compositions should have a flash point of greater than 73°F.

Additional benefits are realized when compositions as described above are supplemented with boron alone, and more preferably in combination with bimodal vinylic polymers containing both high and low MW fractions. As used herein, "vinylic polymer" refers to any polymer or copolymer wherein a plurality of the repeat groups therein are vinyl alcohol moieties. Generally, the low molecular weight vinylic polymer is used in a greater quantity than the high molecular weight materials, typically at ratios of from about 1:2 to 1:20, more preferably from about 1:4 to 1:12, of the high MW to low MW materials.

The paradigm vinylic polymer is PVA. A large variety of PVAs are available commercially, and are typically distinguished on the bases of molecular weight and hydrolysis level, both ranging from "low" to "high." Low MW PVAs have a number averaged molecular weight M_n in the range of up to about 15,000 (e.g., from about 7,000-13,000) and a weight

-6-

averaged molecular weight Mw in the range of about 25,000 (e.g., from about 13,000-23,000). These materials also have hydrolysis values of from about 98.0-98.8% by mole, and a viscosity of from about 3.5-4.5 cps (as 4% aqueous solutions at 20°C). High MW PVAs have an Mn of about 70,000-101,000 and an Mw of 145,000 and above (e.g., from about 146,000-186,000),
5 hydrolysis values of 99.3+% by mole, and viscosities of from about 62-72 cps (as 4% aqueous solutions at 20°C).

Normally, PVA or other polymeric molecular weights in commercial products have a distribution of molecular weights within some range. This distribution may be relatively wide or quite narrow, depending on the specifics of a given product. Hence, these materials of
10 mixtures are often described by means of various averaged molecular weights (number or weight averaged), and this is useful in understanding the properties of the products since a very large percentage of all molecules in the sample and a large fraction of the weight of the sample will have molecular weights close to the averages. It is also common to depict molecular weight distributions in polymers by means of a diagram having molecular weight along a horizontal axis
15 and the relative abundance of molecules along a vertical axis. In the case of most polymer compositions, such diagrams are generally hump-shaped, typically having a single peak where the apex thereof represents the weight which is the most common molecular weight in the polymer composition; this is often termed the "peak molecular weight," referring to the weight of the highest fraction of polymer molecules, and not the highest molecular weight in the
20 composition. However, a bimodal vinylic polymer composition of the invention exhibits two humps or peaks in such a molecular weight diagram. If an average molecular weight measurement is taken of such a bimodal system, highly misleading results may occur, because there will be relatively few molecules near such an "average" value. Thus, a bimodal and single mode polymer composition may have the same "average" molecular weights, yet having very
25 different physical properties.

In the present invention, it was found that better results may be obtained using bimodal vinyl polymer compositions having high and low MW fractions, as compared with a normal composition of the same average molecular weight. Use of bimodal compositions gives the best features of both high and low molecular weight polymers.

30 The preferred bimodal PVA is made up of individual amounts of low and high MW PVA, with the low MW PVA being present at a level of from about 0.5-10% by weight of the complete

-7-

fertilizer coating composition, whereas the high MW PVA is present at a level of from about 0.1-4% by weight. The low MW PVA fraction is normally present in an amount greater than that of the high MW PVA fraction, with the previously-described high MW/low MW ratios being applicable.

5 It is well known that PVAs are highly biodegradable, water-soluble polymers that possess a range of properties, both in pure form and in solution. Such properties can make it difficult to formulate mixtures in certain situations. Thus, it is known that PVAs are at best poorly soluble in solutions that contain significant amounts of organic solvents, and precipitate in their presence. This is especially true of high or super-high hydrolysis level grades of PVA, which simply do not
10 dissolve in solutions having significant organic solvent levels in addition to water. It is also known that PVA reacts rapidly with borates to form what is conventionally called "silly putty" or "slime," which are insoluble crosslinked plastic materials.

PVAs of high or super-high hydrolysis levels can be used to create coatings that are smooth and non-hygroscopic. Unfortunately, such PVAs possess very high viscosities and tend
15 to make formulations which gel upon standing. Thus, these materials are *per se* impractical for fertilizer coating uses. On the other hand, low hydrolysis level PVAs exhibit low viscosities, but exhibit relatively high hygroscopic properties.

Unexpectedly, it has been discovered that combinations of boron with selected PVAs avoid the formation of insolubles while also retaining most of the water resistance of high MW
20 PVA and the low viscosity properties of low MW PVA. Particularly preferred in this context are the bimodal PVA compositions.

Preferred complete quick drying polymeric compositions in accordance with the invention include: (1) from about 20-50% by weight of one of more of the previously described maleic-itaconic copolymers (more preferably from about 35-45% by weight), advantageously in the
25 form of the preferred partial calcium salt copolymer, with carboxylate substitution by calcium at levels of from about 1-35% (more preferably from about 10-30%) of the carboxylates present, and a corresponding pH of from about 2.35-3.75 when the copolymer is in aqueous dispersion; (2) volatile organic solvent, preferably methanol, at a level of from about 5-60% by weight (more preferably from about 35-50% by weight); (3) low MW PVA at a level of from about 0.5-10%
30 by weight (more preferably from about 2-6% by weight); (4) high MW PVA at a level of from about 0.1-4% by weight (more preferably from about 0.2-2% by weight); (5) a ratio of high MW

-8-

PVA to low MW PVA of from about 1:2 to 1:20 (more preferably from about 1:4 to 1:12); (6) boric acid at a level of from about 0.5-5% by weight (more preferably from about 2-4% by weight); and (7) water as the balance of the composition. Such a preferred coating composition typically has a solids level of from about 25-55% by weight, more preferably from about 35-50% by weight.

Generally, the bimodal PVA is mixed with the maleic-itaconic copolymer with heating to a level of from about 80-110°C and agitation for a period of time to assure that the PVA fractions dissolve. The organic drying agent is then added with additional stirring, followed by boric acid addition. In preferred preparative procedures, an aqueous maleic-itaconic copolymer mixture at about 35% w/w solids content is placed in a reactor at room temperature and stirred vigorously. The low and high MW PVAs are then added, and the mixture is heated to 97°C with continued vigorous stirring. This mixture is allowed to cook for 45 minutes at 97°C to insure that all of the PVA materials dissolve. Vacuum distillation of the mixture is then initiated until it reaches a desired solids concentration of approximately 60-70% w/w, whereupon the mixture is allowed to cool to room temperature. Methanol is then added with vigorous stirring until the mixture becomes homogeneous. Finally, boric acid is added with further stirring until fully dissolved. The complete polymeric composition contains approximately 40% solids w/w.

The polymeric compositions made up of an aqueous copolymer salt and drying agent, with or without bimodal vinylic polymer and boron, can be applied to agriculturally useful solid products such as solid fertilizers by any convenient means, such as by spraying or dipping. The preferred polymeric compositions were found to be unexpectedly and surprisingly compatible and do not separate or precipitate solids. In general, the polymer-containing compositions are applied at a level of from about 0.1-1 gallons of polymer-containing composition per ton of fertilizer or other solid product (more preferably at a level of from about 0.3-0.8 gallons).

Although in preferred forms the ingredients of the coating compositions are mixed together to form complete products before application to solid fertilizer, it would be possible to separately apply the copolymer salt, drying agent, and other ingredients, especially if done substantially simultaneously or in quick succession. In such cases, the rate of application would be the same as that set forth above, considering the makeup of the two different applied substances. Moreover, the polymer compositions of the invention can be used on a variety of agriculturally useful products, such as seeds or soil amendments.

-9-

The quick drying compositions hereof may also be formulated including various dyes, pigments, colorants, tracing agents, etc. Such practices are well known in the agricultural arts. It is known that many dyes have poor compatibility with entirely aqueous formulations of high ionic strength. However, it was found that the present compositions containing appreciable
5 volatile organic components can more readily be supplemented with such dyes, and the effectiveness thereof in imparting color to solid fertilizers is enhanced by the presence of the preferred PVA.

The following Examples set forth preferred polymer-containing quick drying compositions of the invention and uses thereof. It is to be understood, however, that this
10 example is provided by way of illustration and nothing therein should be taken as a limitation upon the overall scope of the invention.

Example 1

A fertilizer composition was prepared by applying a liquid polymer-containing
15 composition onto granular urea at a rate of $\frac{1}{2}$ gallon of the liquid polymer-containing composition per ton of urea (urea + aqueous-methanol Nutrisphere-N®). The polymer-containing composition was made up of the above-described Nutrisphere-N® copolymer salt.

Another fertilizer composition was prepared using the aqueous Nutrisphere-N® product applied at the same rate as above onto granular urea, but without the methanol drying agent (urea
20 + aqueous Nutrisphere-N®).

A final test fertilizer was straight uncoated urea (uncoated urea).

These three fertilizer compositions were field-tested to determine the effect of the methanol drying agent on yields. This test was conducted in Courtland, KS in Crete silt loam soil, pH 6.5, organic matter 2.2%, Bray P-one ranging from 19 ppm, soil test potassium 380 ppm
25 ammonium acetate extractable K. A no-till irrigated corn was planted (May 2) at 32,000 plants/acre on 6 test plots. The planted corn received a fluid fertilizer starter (10-34-0) at a rate of 8 gal. per acre, banded 2x2 beside each row. Sprinkler irrigation water was provided from the Lovewell Reservoir in north central Kansas.

The respective solid fertilizer compositions were applied at two rates, 160 and 240 lb.
30 Nitrogen per acre, as a broadcast application immediately after corn planting. The 6 test plots were: uncoated urea/160 lb. N/A; urea + aqueous Nutrisphere-N/160 lb. N/A; urea + aqueous-

-10-

methanol Nutrisphere-N/160 lb. N/A; uncoated urea/240 lb. N/A; urea + aqueous Nutrisphere-N/240 lb. N/A; and urea + aqueous-methanol Nutrisphere-N/240 lb. N/A. There was no incorporation of N into the soil except that which occurred via sprinkler irrigation.

The test plots were harvested Nov. 2 by a plot combine taking the two center rows of each plot. Yield data was reported at 15.5% moisture.

Corn yield responses to the respective solid fertilizers were consistent and highly significant statistically (95% confidence interval). The magnitude of improvement in yield of no-till corn receiving urea + aqueous-methanol Nutrisphere-N versus uncoated urea was similar to that of urea + aqueous Nutrisphere-N polymer (Table 1).

These data indicate that the coating of urea with a high charge density copolymer salt has significant effects upon N use by corn with subsequent increases in corn yield and potential profitability for the grower. These data further confirm that the presence of the drying agent has no deleterious effects upon the performance of the polymer-coated urea.

Table 1

Enhancing N Availability for Irrigated Corn

Treatments	Form of N	Grain Yield
lb N/A		bu/A
160	Uncoated urea	173 b*
160	Urea + Nutrisphere-N®	193 a
160	Urea + Experimental formulation	196 a
240	Uncoated urea	180 b
240	Urea + Nutrisphere-N®	196 a
240	Urea + Experimental formulation	197 a
LSD _{.05}		11
CV%		3.8

*Means separated by Duncan's multiple range test

Example 2

In this Example, a series of drying tests were conducted using various compositions including Nutrisphere-N® for granular nitrogen fertilizers (referred to as “Polymer” in Table 2 below), described above.

The formulations included various amounts of methanol and certain had minor amounts of boric acid therein. Additionally, low and high molecular weight PVA was added to certain of the formulations. The low molecular weight PVA (Celvol 103 sold by Celanese Chemical) had a variable molecular weight, a hydrolysis $98.4\pm0.4\%$ by mole, and a viscosity of 4.0 ± 0.5 cps (4% solution). The high molecular weight PVA (Celvol 165 sold by Celanese Chemical) had a variable molecular weight, a hydrolysis of $98.4\pm0.4\%$ by mole, and a viscosity of 67 ± 5.0 cps (4% solution).

In each test, one drop of the corresponding polymeric formulation was placed on a petrie dish, followed by stirring with the tip of a pipette until the formulation was completely dry. The formulations and drying times are set forth in Table 2.

TABLE 2

Formulation No.	Polymer % w/w	Methanol % w/w	Boric Acid % w/w	Low MW PVA % w/w	High MW PVA % w/w	Water % w/w	Total Solids % w/w	Drying Time (min)
1	40.8	0.0	0.0	0.0	0.0	59.2	40.8	4.1
2	40.0	44.0	0.0	0.0	0.0	16.0	40.0	3.0
3	39.0	43.0	3.0	0.0	0.0	15.0	42.0	2.4
4	35.0	35.0	0.0	4.5	0.5	25.0	40.0	4.5
5	36.2	38.1	2.9	3.3	0.5	19.0	42.9	1.0

The above data demonstrates that improved drying times were realized in formulations 2, 3, and 5, as compared with the basic Nutrisphere-N® of Formulation 1. Surprisingly, the addition of boric acid (Formulation 3) also significantly decreased drying times as compared with Formulation 2. The best drying times were obtained through the use of Formulation 5, including the use of bimodal PVA. This was an unexpected result, because Formulation 5 contains significantly more water than Formulations 2 and 3, with a similar solids content. It is theorized that a synergistic effect is obtained through the formation of a polymer-boron-PVA adduct, which exhibits very short drying times.

Inasmuch as conventional granular nitrogen fertilizer products are typically coated to render them hard and resistant to moisture sorption, the petrie dish results of this test are predictive in a relative sense of the drying times of the formulations when applied to solid nitrogen fertilizers.

I claim:

1. A polymer-containing composition adapted for application to agriculturally useful solid products, said polymer-containing composition including a copolymer containing individual quantities of maleic and itaconic moieties, and an organic compound drying agent.

2. The polymer-containing composition of claim 1, said copolymer containing from about 10-90% by maleic moieties, and from about 90-10% by itaconic moieties.

3. The polymer-containing composition of claim 1, said drying agent selected from the group consisting of organic alcohols and ketones.

4. The polymer-containing composition of claim 3, said drying agent selected from the group consisting of C1-C4 alcohols.

5. The polymer-containing composition of claim 1, said organic drying agent being present at a level of from about 5-60% by weight.

6. The polymer-containing composition of claim 1, said copolymer being in partial salt form and having at least about 93% itaconic and maleic moieties.

7. The polymer-containing composition of claim 1, said composition comprising from about 20-70% by weight of said copolymer in partial salt form, from about 5-60% by weight methanol, and from about 10-50% by weight water.

8. The polymer-containing composition of claim 7, said copolymer salt being present at a level of from about 30-60% by weight, from about 30-50% by weight methanol, and from about 10-25% by weight water.

9. The polymer-containing composition of claim 1, including from about 0.5-5% by weight boron as boric acid.

-13-

10. The polymer-containing composition of claim 9, including an amount of bimodal vinyl polymer therein, said bimodal vinyl polymer including individual high and low molecular weight vinyl polymer fractions.

5 11. The polymer-containing composition of claim 10, said bimodal vinyl polymers comprising low MW PVA having a weight averaged molecular weight Mw of from about 13,000-23,000, and high MW PVA having a weight averaged molecular weight Mw of about 145,000 and above, said low MW PVA being present in an amount greater than said high MW PVA.

10 12. The polymer-containing composition of claim 11, the ratio of said high MW PVA to said low MW PVA being from about 1:2 to 1:20.

15 13. The polymer-containing composition of claim 12, said ratio being from about 1:4 to 1:12.

-14-

14. A polymer-containing composition adapted for application to a solid, nitrogenous fertilizer, said polymer-containing composition comprising:

- (1) from about 20-50% by weight of maleic-itaconic copolymer, in the form of a partial salt and having at least about 93% itaconic and maleic moieties therein;
- 5 (2) volatile organic solvent present at a level of from about 5-60% by weight;
- (3) low MW PVA at a level of from about 0.5-10% by weight;
- (4) high MW PVA at a level of from about 0.1-4% by weight;
- (5) a ratio of high MW PVA to low MW PVA of from about 1:2 to 1:20;
- (6) boric acid at a level of from about 0.5-5% by weight; and
- 10 (7) water.

15. The polymer-containing composition of claim 14, wherein:

- (1) said maleic-itaconic copolymer consists essentially of maleic and itaconic moieties and is present as a partial calcium salt with carboxylate substitution by calcium
15 at a level of from about 1-35%, and in an amount of from about 35-45% by weight;
- (2) said organic solvent comprises methanol and is present at a level of from about 35-50% by weight;
- (3) said low MW PVA is present at a level of from about 2-6% by weight and has a
20 weight averaged molecular weight Mw of from about 13,000-23,000;
- (4) said high MW PVA is present at a level of from about 0.2-2% by weight and has a weight averaged molecular weight Mw of from about 146,000-186,000;
- (5) said ratio is from about 1:4 to 1:12;
- (6) said boric acid is present at a level of from about 2-4% by weight; and
- 25 (7) water forms the balance of said composition.

16. The polymer-containing composition of claim 1, said copolymer salt consisting essentially of maleic and itaconic moieties.

30 17. The polymer-containing composition of claim 1, said copolymer salt having about a 1:1 ratio of maleic moieties to itaconic moieties.

18. The polymer-containing composition of claim 1, said drying agent selected selected from the group consisting of organic compounds having a vapor pressure of at least about 40 mmHg at STP.

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19. The polymer-containing composition of claim 1, said polymer-containing composition having a flash point of greater than 73 °F.

20. The fertilizer composition of claim 1, said polymer-containing
10 composition comprising a quantity of said copolymer salt suspended in a liquid phase comprising water and said drying agent.

-16-

21. A fertilizer product comprising:
a quantity of a solid fertilizer; and
a polymer-containing composition as set forth in claim 1 applied to said fertilizer.

5 22. The fertilizer product of claim 21, said fertilizer being a nitrogenous fertilizer.

23. The fertilizer product of claim 22, said fertilizer selected from the group consisting of urea, ammonium sulfate, ammonium nitrate, MAP, and DAP in the form of
10 granules or prills, said composition applied to the surface of said fertilizer at a level of from about 0.1-1 gallons of said polymer-containing composition per ton of said solid fertilizer.

24. The fertilizer product of claim 21, said fertilizer being urea, said composition being the composition set forth in claim 14.

15 25. The fertilizer product of claim 21, said fertilizer composition formed by spraying said polymer-containing composition onto said solid fertilizer.

26. The fertilizer product of claim 21, said copolymer containing from about
20 10-90% by maleic moieties, and from about 90-10% by itaconic moieties.

27. The fertilizer product of claim 21, said drying agent selected from the group consisting of organic alcohols and ketones.

25 28. The fertilizer product of claim 27, said drying agent selected from the group consisting of C1-C4 alcohols.

29. The fertilizer product of claim 21, said organic drying agent being present at a level of from about 5-60% by weight.

-17-

30. The fertilizer product of claim 21, said copolymer being in partial salt form and having at least about 93% itaconic and maleic moieties.

5 31. The fertilizer product of claim 21, said composition comprising from about 20-70% by weight of said copolymer in partial salt form, from about 5-60% by weight methanol, and from about 10-50% by weight water.

10 32. The fertilizer product of claim 31, said copolymer salt being present at a level of from about 30-60% by weight, from about 30-50% by weight methanol, and from about 10-25% by weight water.

33. The fertilizer product of claim 21, including from about 0.5-5% by weight boron as boric acid.

15 34. The fertilizer product of claim 33, including an amount of bimodal vinyl polymer therein, said bimodal vinyl polymer including individual high and low molecular weight vinyl polymer fractions.

20 35. The fertilizer product of claim 34, said bimodal vinyl polymers comprising low MW PVA having a weight averaged molecular weight Mw of from about 13,000-23,000, and high MW PVA having a weight averaged molecular weight Mw of about 145,000 and above, said low MW PVA being present in an amount greater than said high MW PVA.

25 36. The fertilizer product of claim 35, the ratio of said high MW PVA to said low MW PVA being from about 1:2 to 1:20.

37. The fertilizer product of claim 36, said ratio being from about 1:4 to 1:12.

-18-

38. A method of fertilizing soil comprising the step of applying the fertilizer product of claim 21 to soil.

39. The method of claim 38, said fertilizer being the fertilizer of claim 14.

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40. The method of claim 39, said fertilizer being the fertilizer of claim 15.

41. The method of claim 38, including the step of applying said fertilizer at a level of from about 0.1-1 gallons of said polymer-containing composition per ton of said solid fertilizer.

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42. The method of claim 38, said solid fertilizer being urea, said polymer-containing composition being the composition of claim 14.

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-19-

43. A method of forming a fertilizer composition comprising the steps of:
providing a quantity of a solid, nitrogenous fertilizer;
applying a polymer-containing composition onto said solid fertilizer, said polymer-
containing composition including a salt of a copolymer containing individual
quantities of maleic and itaconic moieties, and an organic compound drying
agent.

44. The method of claim 43, said solid fertilizer selected from the group
consisting of urea, ammonium nitrate, ammonium sulfate, and mixtures thereof.

45. The method of claim 43, said solid fertilizer being granular.

46. The method of claim 43, said copolymer salt containing from about 10-
90% by maleic moieties, and from about 90-10% by itaconic moieties.

47. The method of claim 46, said copolymer salt having about a 1:1 ratio of
maleic moieties to itaconic moieties.

48. The method of claim 43, said drying agent selected from the group
consisting of organic alcohols and ketones.

49. The method of claim 48, said drying agent selected from the group
consisting of C1-C4 alcohols.

50. The method of claim 49, said drying agent being methanol.

51. The method of claim 43, said drying agent selected selected from the
group consisting of organic compounds having a vapor pressure of at least about 40 mmHg at
STP.

-20-

52. The method of claim 43, including the step of applying said polymer-containing composition as a surface coating onto said solid fertilizer.

53. The method of claim 52, including the step of spraying said polymer-containing composition onto said solid fertilizer.

54. The method of claim 43, said polymer-containing composition comprising a quantity of said copolymer salt suspended in a liquid phase comprising water and said drying agent.

55. The method of claim 54, said drying agent being methanol, and said methanol being present in the fertilizer composition at a level of from about 10-60% by weight.

56. The method of claim 55, said level being of from about 35-45% by weight.

57. The method of claim 56, said polymer-containing composition including from about 20-70% by weight of said copolymer salt, from about 10-60% by weight methanol, and from about 10-50% by weight water.

58. The method of claim 43, said polymer-containing composition including about 40% by weight of a salt of a maleic-itaconic copolymer salt, about 45% by weight methanol, and about 15% by weight water.

59. The method of claim 43, said polymer-containing composition being used at a level of from about 0.1-1 gallons of polymer-containing composition per ton of said solid fertilizer.

60. The method of claim 43, said polymer-containing composition being aqueous and having a pH of from about 1-4.

-21-

61. The method of claim 43, said polymer-containing composition including from about 0.5-5% by weight boron as boric acid.

5 62. The method of claim 61, including an amount of bimodal vinyl polymer therein, said bimodal vinyl polymer including individual high and low molecular weight vinyl polymer fractions.

10 63. The method of claim 62, said bimodal vinyl polymers comprising low MW PVA having a weight averaged molecular weight M_w of from about 13,000-23,000, and high MW PVA having a weight averaged molecular weight M_w of about 145,000 and above, said low MW PVA being present in an amount greater than said high MW PVA.

64. The method of claim 63, the ratio of said high MW PVA to said low MW PVA being from about 1:2 to 1:20.

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65. The method of claim 64, said ratio being from about 1:4 to 1:12.