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AVOIDANCE OF PRECIPITATION IN 3-ISOTHIAZOLONE FORMULATIONS

This invention relates to the avoidance of precipitation in 3-isothiazolone solutions.

3-isothiazolone compounds (hereafter "active ingredient" or AI) are a very important class of microbicides. Several species have been commercialized and are widely used to inhibit the growth of bacteria, fungi and algae. Among the most important isothiazolones are 2-methyl-3-isothiazolone ("MI"), 5-chloro-2-methyl-3-isothiazolone ("CMI"), and especially mixtures thereof. A 3/1 weight ratio mixture of CMI and MI is used in a wide variety of commercial applications around the world. CMI is naturally unstable and much research has been devoted to stabilizing it: without the presence of a stabiliser, a microbicide containing CMI steadily loses microbiocidal efficacy as the CMI decomposes.

U.S. 3,870,795 teaches the stabilization against chemical decomposition of 3-isothiazolone concentrates containing 25 weight percent (wt%) isothiazolone, by addition of metal nitrite or metal nitrate. Today the majority of commercial 3-isothiazolone products are stabilised with metal nitrate, usually magnesium nitrate. Typical products may contain between 1 and 20 wt% isothiazolone and a similar amount of nitrate salt.

Cupric salt (Cu^{2+}) is also known as a stabilizer for isothiazolones, normally in conjunction with magnesium nitrate. The cupric salt is conventionally used at a ratio of about 1:10 to AI since relatively small amounts of cupric ion are necessary for effective stabilization. Commercial isothiazolone products are known containing 1.5 wt% isothiazolone, 1.7 wt% magnesium nitrate and 0.15 wt% (ie 1500 ppm) copper nitrate. Some products have much lower levels of cupric ion: the Rohm and Haas product KATHON WTA (KATHON is a registered trade mark of Rohm and Haas Company) contains 1.5 wt% isothiazolone, 1.7 wt% magnesium nitrate, and just 0.015 - 0.02 wt% (150-200 ppm) of copper nitrate.

Although the use of magnesium nitrate and/or cupric salts as stabilisers enables isothiazolone products to retain their microbiocidal activity for considerable periods of time, other forms of decomposition, which do not significantly affect the level of AI in the composition, can cause problems. One of these is the occasional formation of a precipitate in the formulation during storage. The amount of isothiazolone which decomposes to form the precipitate is very small, so the efficacy of the product is barely affected: however the presence of the precipitate gives an undesirable appearance to users of the product, and it is clearly preferable from a commercial point of view to have a product which does not form such precipitates.

JP 02-304005 discloses compositions containing 0.1-15 wt% isothiazolone and 1-5000 ppm of copper ion, as well as nonionic surfactant and organic solvent: there is no nitrate salt present. These compositions are designed for the stabilisation of aqueous dispersions of polymers, where the presence of metal nitrates would lead to problems of "salt shock". The precipitation problem referred to in this document when nitrates are used as stabilisers is the result of general decomposition of the isothiazolone, and is quite different from that discussed above.

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We have discovered that the addition of extremely low levels of copper ion to isothiazolone-containing formulations can substantially reduce or prevent the problem of unsightly precipitation during storage. Accordingly in a first aspect the present invention provides a composition comprising

- a) from 0.1 to 20 wt% of a 3-isothiazolone
- b) from 0.1 to 25 wt% of a metal nitrate
- c) from 0.1 to 100 ppm of cupric (Cu^{2+}) ion
- d) a solvent.

A further aspect of the invention provides a method of reducing or preventing the formation of precipitate in a formulation containing from 0.1 to 20 wt% of a 3-isothiazolone and from 0.1 to 25 wt% of a metal nitrate, comprising incorporating therewith from 1 to 100 ppm of Cu^{2+} ion, and another spect of the invention comprises the use of Cu^{2+} ion to reduce or prevent the formation of precipitate in such a formulation.

The Cu^{2+} ion is preferably in the form of an inorganic copper salt such as copper nitrate, although other salts such as copper sulphate may be used. Preferred amounts of Cu^{2+} ion are from 1 to 10 ppm, and more preferably from 1 to 5 ppm. Greater amounts of copper ion may be added, but this is not necessary and merely adds to the expense.

Typical levels of 3-isothiazolone in such compositions are between 1 and 15 wt%, with levels of nitrate being between 1 and 19 wt%. A preferred formulation comprises from 12 to 16 wt% 3-isothiazolone, from 12 to 25 wt% magnesium nitrate, and from 1 to 5 ppm Cu^{2+} ion.

The metal nitrate is preferably magnesium nitrate, whilst the preferred 3-isothiazolone is a 3:1 mixture of 5-chloro-2-methyl-3-isothiazolone and 2-methyl-3-isothiazolone. Other possible 3-isothiazolones are 4,5-dichloro-2-methyl-3-isothiazolone, 2-n-octyl-3-isothiazolone and 4,5-dichloro-2-octyl-3-isothiazolone.

Preferred solvents are water or certain organic solvents. Examples of organic solvents include polyols, such as glycols or alcohols. Certain aliphatic or aromatic hydrocarbons may also be used. Preferred organic solvents are capped polyols.

Although Cu^{2+} salts are known to stabilise isothiazolones against decomposition when added at much higher levels, it was particularly surprising to discover that trace levels could dramatically affect the quite separate problem of unsightly precipitate formation on storage. It is believed that the Cu^{2+} may interfere catalytically with the reaction that results in the precipitate in a negative manner, thereby reducing the formation of precipitate without consuming the copper; hence the need for only extremely low levels.

EXAMPLES

Formulations of isothiazolone and magnesium nitrate were prepared, with and without added copper nitrate. They were evaluated for precipitate formation by storing at 55°C or 30°C and noting the number of days before a precipitate was observed. Decomposition is of course more rapid at 55°C, which is a preferred temperature for accelerated stability testing. The composition of each formulation and the results of the precipitate evaluation are given below:

1000 1000 1000 1000 1000 1000 1000 1000 1000 1000

five experiments were run, shown in Tables 1 to 5. In each case, the formulation was based in water. All percentages are weight percentages.

TABLE 1	A	B	C	D
5-chloro-2-methyl-3-isothiazolone	10.2	10.2	10.1	10.1
2-methyl-3-isothiazolone %	4.0	4.0	3.9	3.9
4,5-dichloro-2-methyl-3-isothiazolone %	0.5	0.5	0.5	0.5
magnesium nitrate %	15.7	13.3	13.2	13.4
magnesium chloride %	10.9	10.9	10.7	10.6
copper nitrate ppm	0	0	10	30
Cu ²⁺ ppm	50	500+	0	0
Days free of precipitate at 55°C	21	7	37+	37+
Precipitate after 37 days at 55°C ppm	50	500+	0	0

Note that the precipitate evaluation was terminated at 37 days.

TABLE 2	A	B	C	D
5-chloro-2-methyl-3-isothiazolone %	10.7	10.7	10.5	10.5
2-methyl-3-isothiazolone %	3.5	3.5	3.6	3.6
4,5-dichloro-2-methyl-3-isothiazolone%	0.4	0.4	0.4	0.4
Magnesium nitrate %	16.5	13.8	12.9	13.5
Magnesium chloride %	9.5	9.6	9.5	9.4
Copper nitrate ppm	0	0	9	30
Cu ²⁺ ppm	0	0	3	9
Days free of precipitate at 55°C	11	7	103+	103+
Precipitate after 103 days at 55°C ppm	500+	500+	0	0

Note that the precipitate evaluation was terminated at 103 days.

TABLE 3	A	B	C	D
5-chloro-2-methyl-3-isothiazolone plus				
2-methyl-3-isothiazolone %	14.1	14.1	14.1	14.1
Magnesium nitrate %	16.9	16.9	16.9	16.9
Copper nitrate ppm	0	9	24	44
Cu ²⁺ ppm	0	3	8	15
Days free of precipitate at 55°C	11	104+	104+	104+
Amount of precipitate after 104 days at 55°C	500+	0	0	0
Weeks free of precipitate at 30°C	12	15+	15+	15+
Amount of precipitate after 12 weeks at 30°C	25	0	0	0

Note that the precipitate evaluations were terminated at 104 days (15 weeks).

TABLE 4	A	B	C	D	E
5-chloro-2-methyl-3-isothiazolone plus					
2-methyl-3-isothiazolone %	14.1	14.1	14.1	14.1	14.1
Magnesium nitrate %	16.3	16.3	16.3	16.3	16.3
Copper nitrate ppm	0	0.3	1.5	3.0	8.9
Cu ²⁺ ppm	0	0.1	0.5	1.0	3.0
Days free of precipitate at 55°C	5	7	11	54+	54+
Amount of precipitate after 54 days at 55°C	500+	500+	25	0	0
Weeks free of precipitate at 30°C	4	4	4	8+	8+
Amount of precipitate after 8 weeks at 30°C	100	75	0-10	0	0

Note that the precipitate evaluations were terminated at 54 days (8 weeks).

TABLE 5	A	B	C	D	E
5-chloro-2-methyl-3-isothiazolone plus					
2-methyl-3-isothiazolone %	14.0	14.0	14.0	14.0	14.0
Magnesium nitrate %	16.4	16.4	16.4	16.4	16.4
Copper nitrate ppm	0	1.5	2.2	3.0	3.0
Cu ²⁺ ppm	0	0.5	0.75	1.0	1.0
Days free of precipitate at 55°C	7	7	23+	23+	23+
Amount of precipitate after 23 days at 55°C	50	0-10	0	0	0
Weeks free of precipitate at 30°C	3	3+	3+	3+	3+
Amount of precipitate after 3 weeks at 30°C	0-10	0	0	0	0

Note that the precipitate evaluations were terminated at 23 days (3 weeks).

In addition to the above experiments, commercial KATHON 886 sold by Rohm and Haas Company, which contains 15.8% 5-chloro-2-methyl-3-isothiazolone plus 2-methyl-3-isothiazolone and 13.9% magnesium nitrate, was evaluated for precipitate formation with added copper nitrate over a longer period. The results are shown in Table 6 below.

TABLE 6					
Expt	Cu ²⁺ (ppm)	Test length (days)	Days free of ppt at 55°C	Precipitate level at test end (ppm)	
				55°C	30°C
1	0	187	11	500+	150 ± 30
	1.0	187	187	0	0
2	0	187	11	500+	150 ± 30
	1.0	187	187	0	0

3	0	181	181	0	0
	1.0	181	181	0	0
4	0	181	19	500+	100± 5
	1.0	181	181	0	0
5	0	169	3	500+	500 ± 100
	1.0	169	169	0	0
6	0	169	14	500+	500 ± 100
	1.0	169	169	0	0
7	0	159	11	500+	150 ± 30
	1.0	159	159	0	0
8	0	159	11	500+	250 ± 30
	1.0	159	159	0	0
9	0	158	7	500+	250 ± 30
	1.0	158	158	0	0

Although it can be seen in the above Tables that the amount of precipitate formed even when no copper is present is very small, as previously explained it gives an unsightly appearance to the product, which is undesirable for commercial reasons. All the above results demonstrate clearly the effect of very small amounts of copper ion on the formation of precipitate: as little as 0.1 ppm of Cu^{2+} ion can substantially delay or prevent its appearance.

**CLAIMS:**

1. Composition comprising
 - a) from 0.1 to 20 wt% of a 3-isothiazolone
 - b) from 0.1 to 25 wt% of a metal nitrate
 - c) from 0.1 to 100 ppm of cupric (Cu^{2+}) ion
 - d) a solvent.
2. Composition according to claim 1, wherein the amount of Cu^{2+} ion is from 1 to 10 ppm.
3. Composition according to claim 2, wherein the amount of Cu^{2+} ion is from 1 to 5 ppm.
4. Composition according to any preceding claim wherein the 3-isothiazolone comprises 5-chloro-2-methyl-3-isothiazolone, 2-methyl-3-isothiazolone, 4,5-dichloro-2-methyl-3-isothiazolone, 2-n-octyl-3-isothiazolone or 4,5-dichloro-2-octyl-3-isothiazolone.
5. Composition according to claim 3 wherein the 3-isothiazolone comprises a 3:1 mixture of 5-chloro-2-methyl-3-isothiazolone and 2-methyl-3-isothiazolone.
6. Composition according to any preceding claim wherein the metal nitrate is magnesium nitrate.
7. Composition according to any preceding claim wherein the Cu^{2+} ion is copper nitrate.
8. Composition according to any preceding claim comprising from 12 to 16 wt% 3-isothiazolone, from 12 to 25 wt% magnesium nitrate, and from 1 to 5 ppm Cu^{2+} ion.
9. Method of reducing or preventing the formation of precipitate in a formulation containing from 0.1 to 20 wt% of a 3-isothiazolone and from 0.1 to 25 wt% of a metal nitrate, comprising incorporating therewith from 1 to 100 ppm of Cu^{2+} ion.
10. Use of Cu^{2+} ion to reduce or prevent the formation of precipitate in a formulation containing from 0.1 to 20 wt% of a 3-isothiazolone and from 0.1 to 25 wt% of a metal nitrate.

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ABSTRACT

AVOIDANCE OF PRECIPITATION IN 3-ISOTHIAZOLONE FORMULATIONS

The formation of unsightly precipitation in isothiazolone formulations during storage is avoided by the addition of ppm levels of a Cu^{2+} salt.

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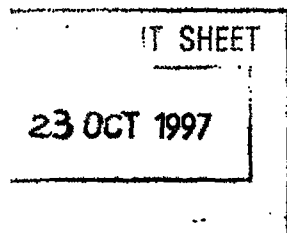
REPLACEMENT SHEETS		SG
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We have discovered that the addition of extremely low levels of copper ion to isothiazolone-containing formulations can substantially reduce or prevent the problem of unsightly precipitation during storage. Accordingly in a first aspect the present invention provides a composition comprising

- a) from 0.1 to 20 wt% of a 3-isothiazolone microbiocide;
- b) from 0.1 to 25 wt% of a metal nitrate stabilizer, provided that the metal nitrate is not copper nitrate;
- c) from 0.1 to 15 ppm of cupric (Cu^{2+}) ion stabilizer in the form of an inorganic salt; and
- d) water.



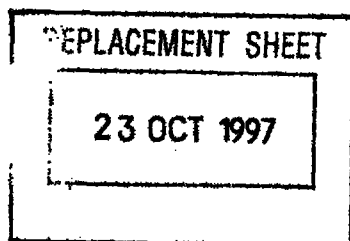
A further aspect of the invention provides a method of reducing or preventing the formation of precipitate in a formulation containing from 0.1 to 20 wt% of a 3-isothiazolone microbiocide and from 0.1 to 25 wt% of a metal nitrate stabilizer, provided that the metal nitrate is not copper nitrate, comprising incorporating therewith from 1 to 15 ppm of Cu^{2+} ion stabilizer, and another aspect of the invention comprises the use of Cu^{2+} ion stabilizer to reduce or prevent the formation of precipitate in such a formulation.

The Cu^{2+} ion is preferably in the form of an inorganic copper salt such as copper nitrate, although other salts such as copper sulphate may be used. Preferred amounts of Cu^{2+} ion are from 1 to 10 ppm, and more preferably from 1 to 5 ppm. Greater amounts of copper ion may be added, but this is not necessary and merely adds to the expense.

Typical levels of 3-isothiazolone in such compositions are between 1 and 15 wt%, with levels of nitrate being between 1 and 19 wt%. A preferred formulation comprises from 12 to 16 wt% 3-isothiazolone, from 12 to 25 wt% magnesium nitrate, and from 1 to 5 ppm Cu^{2+} ion.

The metal nitrate is preferably magnesium nitrate, whilst the preferred 3-isothiazolone is a 3:1 mixture of 5-chloro-2-methyl-3-isothiazolone and 2-methyl-3-isothiazolone. Other possible 3-isothiazolones are 4,5-dichloro-2-methyl-3-isothiazolone, 2-n-octyl-3-isothiazolone and 4,5-dichloro-2-octyl-3-isothiazolone.

Although Cu^{2+} salts are known to stabilise isothiazolones against decompositions when added at much higher levels, it was particularly surprising to discover that trace levels could



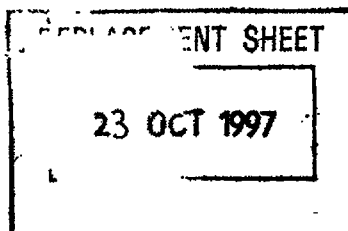
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dramatically affect the quite separate problem of unsightly precipitate formation on storage. It is believed that the Cu^{2+} may interfere catalytically with the reaction that results in the precipitate in a negative manner, thereby reducing the formation of precipitate without consuming the copper; hence the need for only extremely low levels.

EXAMPLES

Formulations of isothiazolone and magnesium nitrate were prepared, with and without added copper nitrate. They were evaluated for precipitate formation by storing at 55°C or 30°C and noting the number of days before a precipitate was observed. Decomposition is of course more rapid at 55°C, which is a preferred temperature for accelerated stability testing. The composition of each formulation and the results of the precipitate evaluation are given below:



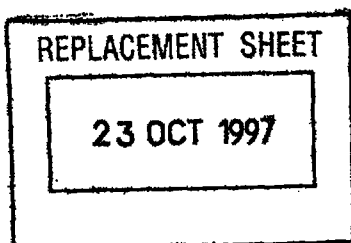
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CLAIMS:



1. Composition comprising
 - a) from 0.1 to 20 wt% of a 3-isothiazolone microbiocide;
 - b) from 0.1 to 25 wt% of a metal nitrate stabilizer, provided that the metal nitrate is not copper nitrate;
 - c) from 0.1 to 15 ppm of cupric (Cu^{2+}) ion stabilizer in the form of an inorganic salt; and
 - d) water.
2. Composition according to claim 1, wherein the amount of Cu^{2+} ion is from 1 to 10 ppm.
3. Composition according to claim 2, wherein the amount of Cu^{2+} ion is from 1 to 5 ppm.
4. Composition according to any preceding claim wherein the 3-isothiazolone comprises 5-chloro-2-methyl-3-isothiazolone, 2-methyl-3-isothiazolone, 4,5-dichloro-2-methyl-3-isothiazolone, 2-n-octyl-3-isothiazolone or 4,5-dichloro-2-octyl-3-isothiazolone.
5. Composition according to claim 3 wherein the 3-isothiazolone comprises a 3:1 mixture of 5-chloro-2-methyl-3-isothiazolone and 2-methyl-3-isothiazolone.
6. Composition according to any preceding claim wherein the metal nitrate is magnesium nitrate.
7. Composition according to any preceding claim wherein the Cu^{2+} ion is copper nitrate.
8. Composition according to any preceding claim comprises from 12 to 16 wt% 3-isothiazolone, from 12 to 25 wt% magnesium nitrate, and from 1 to 5 ppm Cu^{2+} ion.



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9. Method of reducing or preventing the formation of precipitate in a formulation containing from 0.1 to 20 wt% of a 3-isothiazolone microbiocide and from 0.1 to 25 wt% of a metal nitrate stabilizer, provided that the metal nitrate is not copper nitrate comprising incorporating therewith from 1 to 15 ppm of Cu^{2+} ion stabilizer.

10. Use of Cu^{2+} ion stabilizer in an amount of from 0.1 to 15 ppm to reduce or prevent the formation of precipitate in a formulation containing from 0.1 to 20 wt% of a 3-isothiazolone microbiocide and from 0.1 to 25 wt% of a metal nitrate stabilizer, provided that the metal nitrate is not copper nitrate.