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(54) Titre : COMPOSITION BIOCIDÉ SYNERGIQUE CONTENANT DE LA 2-METHYLISOTHIAZOLINE-3-ONE
(54) Title: SYNERGETIC BIOCIDAL COMPOSITION COMPRISING 2-METHYLISOTHIAZOLINE-3-ON

(57) **Abrégé/Abstract:**

The invention relates to a biocidal composition which can be added to materials which can be attacked by harmful micro-organisms. The composition comprises 2-methylisothiazoline-3-on as biocidal active ingredient and at least one other biocidal active ingredient. The biocidal composition is characterised in that the composition contains formaldehyde or a formaldehyde-depot material, 2-brom-2-nitro-1, 3 propandiol, polyhexamethylene biguanide, o-phenylphenol, pyrithione, n-butyl-1, 2-benzisothiazoline-3-on, n-hydroxymethyl-1, 2-benzisothiazoline-3-on or benzalkonium chloride as said other biocidal active ingredient.



ABSTRACT

The invention relates to a biocidal composition which can be added to materials which can be attacked by harmful micro-organisms. The composition comprises 2-methylisothiazoline-3-on as biocidal active ingredient and at least one other biocidal active ingredient. The biocidal composition is characterised in that the composition contains formaldehyde or a formaldehyde-depot material, 2-brom-2-nitro-1, 3 propandiol, polyhexamethylene biguanide, o-phenylphenol, pyrithione, n-butyl-1, 2-benzisothiazoline-3-on, n-hydroxymethyl-1, 2-benzisothiazoline-3-on or benzalkonium chloride as said other biocidal active ingredient.

Synergistic biocide composition comprising
2-methylisothiazolin-3-one
Description

The invention relates to a biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient (MIT), and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful microorganisms.

Biocidal agents are employed in many fields, for example in the control of harmful bacteria, fungi and algae. It has long been known to employ, in such compositions, 4-isothiazolin-3-ones (also termed 3-isothiazolones), since this group contains potent biocidal compounds.

One of these compounds is 5-chloro-2-methylisothiazolin-3-one. While it has a good biocidal action, it has various disadvantages on handling in practice. For example, the compound frequently triggers allergies in people handling it. Also, some countries have legal limits for the AOX value of industrial waste-water, i.e. a certain concentration of organochlorine, organobromine and organiodine compounds which are adsorbable to active charcoal must not be exceeded in the water. This prevents 5-chloro-2-methylisothiazolin-3-one from being used as much as would be desirable. Moreover, the stability of this compound is insufficient under certain conditions, for example at high pH values or in the presence of nucleophiles or reducing agents.

Another biocidally active, known isothiazolin-3-one is 2-methylisothiazolin-3-one. While the compound avoids the

various disadvantages of 5-chloro-2-methylisothiazolin-3-one, for example the high risk of allergy, it is substantially less biocidally active. A simple exchange of 5-chloro-2-methylisothiazolin-3-one by 2-methylisothiazolin-3-one is therefore not possible.

Also, it is already known to use combinations of various isothiazolin-3-ones or combinations of at least one isothiazolin-3-one and other compounds. For example, EP 0676140 A1 describes a synergistic biocidal composition comprising 2-methylisothiazolin-3-one (2-methyl-3-isothiazolin-3-one) and 2-n-octylisothiazolin-3-one (2-n-octyl-3-isothiazolin-3-one).

US 5328926 discloses synergistic biocide compositions which are combinations of 1,2-benzoisothiazolin-3-one (BIT) and an iodopropargyl compound (iodopropynyl compound). For example, 3-iodopropargyl-N-butylcarbamate is mentioned as one such compound.

The invention is based on the object of indicating a biocide composition which is substantially free from 5-chloro-2-methylisothiazolin-3-one, i.e. in which the weight ratio of MIT to 5-chloro-2-methylisosthiazolin-3-one is at least 100:1. Moreover, the components of the biocide composition are intended to act synergistically so that, when employed simultaneously, they can be used in lower concentrations compared with the concentrations required in the case of the individual components. This is intended to be less damaging to humans and the environment and to reduce the

costs of controlling harmful microorganisms.

This object is achieved by the invention by a biocide composition of the type mentioned at the outset, which comprises, as further biocidal active ingredient, formaldehyde (HCHO) or a formaldehyde-releasing substance, 2-bromo-2-nitro-1,3-propanediol (bronopol, BNP), polyhexamethylenebiguanide (PMG), o-phenylphenol (OPP), a pyrithione, preferably zinc pyrithione (ZnPy), sodium pyrithione (NaPy), copper pyrithione (CuPy) and iron pyrithione (FePy), N-butyl-1,2-benzisothiazolin-3-one (BBIT), N-hydroxymethyl-1,2-benzisothiazolin-3-one (HMBIT) and/or a benzalkonium chloride, preferably dimethylbenzylalkonium chloride (BAC). These further biocidal active ingredients can be present, in the biocide composition, in each case individually or in a combination of at least two of them, in addition to the MIT.

The biocide composition according to the invention is distinguished, inter alia, by the fact that the combination of MIT and one of the above-mentioned further biocidal active ingredients act synergistically and can therefore be used with a lower overall concentration of the biocidal components.

The biocide composition according to the invention has the advantage that it can replace active ingredients which have previously been used in practice, but which are disadvantageous with regard to health and the environment, for example 5-chloro-2-methylisothiazolin-3-one. Moreover, if required, the biocide composition according to the invention

can be prepared using only water as advantageous medium. Furthermore, the invention allows the composition to be adapted to specific uses by adding further active ingredients, for example with regard to an improved biocidal action, an improved long-term protection of the materials attacked by microorganisms, better compatibility with the materials to be protected, or an improved toxicological or ecotoxicological behavior.

The biocide composition according to the invention normally comprises the MIT and the above-mentioned further biocidal active ingredient in a weight ratio of from 1:100 to 100:1, preferably in the weight ratio of from 1:20 to 10:1.

The MIT and the above-mentioned further biocidal active ingredient are present, in the biocide composition, in an overall concentration of, preferably, 0.1 to 100% by weight, in particular 1 to 50% by weight, very especially preferably 1 to 20% by weight, in each case based on the entire biocide composition.

It is expedient to employ the biocides of the composition according to the invention in combination with a polar or unpolar liquid medium. In this context, this medium may, for example, already exist in the biocide composition and/or in the material to be preserved.

Preferred polar liquid media are water, an alcohol, such as an aliphatic alcohol having 1 to 4 carbon atoms, for example ethanol and isopropanol, an ester, a glycol, for example ethylene glycol, diethylene glycol, 1,2-propylene

glycol, dipropylene glycol and tripropylene glycol, a glycol ether, for example butyl glycol and butyl diglycol, a glycol ester, for example butyl diglycol acetate or 2,2,4-trimethylpentanediol monoisobutyrate, a polyethylene glycol, a polypropylene glycol, N,N-dimethylformamide or a mixture of such materials.

For example, aromatics, preferably xylene, toluene and alkylbenzols, and paraffins, unpolar esters, such as phthalates and fatty acid esters, epoxidized fatty acids and their derivatives, and silicone oils serve as unpolar liquid media.

The biocide composition according to the invention may also be combined simultaneously with a polar and an unpolar liquid medium.

In addition to MIT and the above-mentioned further biocidal active ingredients, the biocide composition according to the invention may additionally comprise one or more additional biocidal active ingredients which are selected to suit the field of application. Specific examples of such additional biocidal active ingredients are given hereinbelow.

Benzyl alcohol

2,4-Dichlorobenzyl alcohol

2-Phenoxyethanol

2-Phenoxyethanol hemiformal

Phenylethyl alcohol

5-Bromo-5-nitro-1,3-dioxane

Dimethyloldimethylhydantoin

Glyoxal

Glutardialdehyde

Sorbic acid

Benzoic acid

Salicylic acid

p-Hydroxybenzoic esters

Chloroacetamide

N-Methylolchloroacetamide

Phenols such as p-chloro-m-cresol

N-Methylolurea

N,N'-Dimethylolurea

Benzyl formal

4,4-Dimethyl-1,3-oxazolidine

1,3,5-Hexahydrotriazine derivatives

Quaternary ammonium compounds such as

N-alkyl-N,N-dimethylbenzylammonium chloride and

di-n-decyldimethylammonium chloride

Cetylpyridinium chloride

Diguanidine

Chlorohexidine

1,2-Dibromo-2,4-dicyanobutane

3,5-Dichloro-4-hydroxybenzaldehyde

Ethylene glycol hemiformal

Tetra(hydroxymethyl)phosphonium salts

Dichlorophene

2,2-Dibromo-3-nitrilopropionamide

3-Iodo-2-propynyl-N-butylcarbamate

Methyl N-benzimidazol-2-ylcarbamate

2-n-Octylisothiazolin-3-one

4,5-Dichloro-2-n-octylisothiazolin-3-one

4,5-Trimethylene-2-methylisothiazolin-3-one

Di-N-methyl-2,2'-dithiodibenzamide

2-Thiocyanomethylthiobenzothiazole

C-Formals, such as

2-hydroxymethyl-2-nitro-1,3-propanediol

Methylene bithiocyanate

Reaction products of allantoin with formaldehyde.

In addition, the biocide composition according to the invention may comprise other customary constituents which are known as additives to the skilled worker in the biocides field. Examples of these are thickeners, antifoams, pH regulators and stabilizers, perfumes, dispersants, coloring matter and stabilizers against discoloration, for example complexing agents, and against the degradation of active ingredient.

MIT is a known compound and can be prepared, for example, as described in US 5466818. The reaction product obtained can be purified for example by column chromatography.

HCHO, as is known, is widely available commercially.

BNP is commercially available, for example, from BASF AG, under the trade name "Myacide® AS".

PMG is available from Avecia under the trade name "Vantocil IB".

OPP is available from Bayer under the trade name "Preventol O extra".

Pyrithiones are available from Arch Chemicals, for example ZnPy under the trade name "Zinc-Omadine" and NaPy under the trade name "Natrium-Omadine". CuPy and FePy can be obtained by known methods by reacting NaPy with copper salts or iron salts, respectively.

BBIT is available from Avecia under the trade name "Vanquish 100".

HMBIT can be obtained by crystallizing a reaction mixture of formaldehyde and BIT.

BAC is available from Thor GmbH under the trade name "BAC 50".

The biocide composition according to the invention can be employed in very different fields. For example, it is suitable for use in paints, renderings, lignosulfonates, chalk suspensions, glues, photochemicals, casein-containing products, starch-containing products, bitumen emulsions, surfactant solutions, fuels, cleaners, cosmetic products, water circuits, polymer dispersions and cooling lubricants against attack by, for example, bacteria, filamentous fungi, yeasts and algae.

In these materials to be preserved, the biocides are generally employed in an overall concentration in the range of from 1 to 100 000 ppm, preferably 10 to 10 000 ppm, based

on all of the material to be preserved.

When used in practice, the biocide composition can be introduced either as a ready mix or by separately adding the biocides and the optional remaining components of the composition to the material which is to be preserved.

The examples illustrate the invention.

Example 1

This example demonstrates the synergism of the combinations of MIT and HCHO in the biocide composition according to the invention.

To this end, aqueous mixtures with different concentrations of MIT and HCHO were prepared, and the effect of these mixtures on *Pseudomonas aeruginosa* was tested.

In addition to the biocide component and water, the aqueous mixtures also comprised a nutrient medium, viz. a commercially available Müller-Hinton broth. The cell density was 10^6 cells/ml. The incubation time was 96 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

Table I hereinbelow shows the concentrations of MIT and HCHO used. It can also be seen from this table whether microbial growth took place (symbol "+") or not (symbol "-").

Thus, table I also shows the minimum inhibitory concentrations (MICs). Accordingly, an MIC value of 60 ppm results when only MIT is used, and an MIC value of 100 ppm when only HCHO is used. In contrast, the MIC values of mixtures of MIT and HCHO are markedly lower, that is to say the combination of MIT and HCHO acts synergistically.

Table I

Pseudomonas aeruginosa: MIC values of MIT + HCHO
at an incubation time of 96 h/25°C

MIT concentration (ppm)	HCHO concentration (ppm)										
	3	2	1	0.75	0.5	0.4	0.3	0.2	0.1	0.05	0
100	-	-	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	+
30	-	-	-	-	-	-	-	-	-	-	+
20	-	-	-	-	-	-	-	-	-	+	+
15	-	-	-	-	-	-	-	-	-	+	+
10	-	-	-	-	-	-	-	-	-	+	+
0	-	-	-	-	-	-	-	+	+	+	+

The synergism which is present is shown in the form of figures using the calculations of the synergistic index shown in table II. The synergistic index is calculated by the method of F.C. Kull et al., Applied Microbiology, vol. 9 (1961), p. 538. Here, the synergistic index is calculated using the following formula:

$$\text{Synergistic index SI} = Q_a/Q_A + Q_b/Q_B.$$

When applying this formula to the biocide system tested in the present context, the parameters in the formula

have the following meanings:

- Q_a = MIT concentration MIT/HCHO biocide mixture
- Q_A = concentration of MIT as the only biocide
- Q_b = HCHO concentration in the MIT/HCHO biocide mixture
- Q_B = concentration of HCHO as the only biocide.

If the synergistic index has a value of above 1, this means that antagonism is present. If the synergistic index assumes a value of 1, this means that an additive effect of the two biocides exists. If the synergistic index assumes a value of less than 1, this means that synergism of the two biocides exists.

Table II

Pseudomonas aeruginosa: calculation of the
synergistic index of MIT + HCHO
at an incubation time of 96 h/25°C

MIC at		Concentration	Q _a /Q _A	Q _b /Q _B	Syner- Gistic Index	
MIT	HCHO					
concen- tration	concen- tration	Total concen- tration of MIT + HCHO	MIT	HCHO		
Q _a	Q _b	Q _a + Q _b	(% by weight)	(% by weight)		Q _a /Q _A + Q _b /Q _B
(ppm)	(ppm)	(ppm)				
0	100	100	0.0	100.0	0.00	1.00
10	75	85	11.8	88.2	0.17	0.92
10	50	60	16.7	83.3	0.17	0.67
15	50	65	23.1	76.9	0.25	0.75
20	50	70	28.6	71.4	0.33	0.83
30	25	55	54.5	45.5	0.50	0.75
40	25	65	61.5	38.5	0.67	0.92
60	0	60	100.0	0.0	1.00	1.00

It can be seen from table II that the optimal synergism, i.e. the lowest synergistic index (0.67), of an MIT/HCHO mixture is obtained with a mixture of 16.7% by weight of MIT and 83.3% by weight of HCHO.

Example 2

Analogously to example 1, the synergism of MIT and BNP was shown with regard to the microorganism *Pseudomonas aeruginosa*.

Again, the experimental batches contained a Müller-Hinton broth as the nutrient medium. The cell density was 10^6 cells/ml. The incubation time was 72 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

The MIC values of the biocide composition tested can be seen from table III which follows. The MIC value was 40 ppm when only MIT was employed and 20 ppm when only BNP was employed.

Table III

Pseudomonas aeruginosa: MIC values of MIT + BNP
at an incubation time of 72 h/25°C

MIT concentration (ppm)	BNP concentration (ppm)							
	50	40	30	20	15	10	5	0
60	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	+
20	-	-	-	-	-	-	-	+
15	-	-	-	-	-	-	-	+
10	-	-	-	-	-	-	+	+
5	-	-	-	-	-	+	+	+
0	-	-	-	-	+	+	+	+

Synergism was present when MIT and BNP were employed simultaneously. The calculation of the synergistic index can be seen from table IV. Accordingly, the lowest synergistic index for *Pseudomonas aeruginosa* (0.63) was found for a mixture of 75.0% by weight of MIT and 25% by weight of BNP.

Table IV

Pseudomonas aeruginosa: calculation of the
synergistic index of MIT + BNP
at an incubation time of 72 h/25°C

MIC at		Concentration	Q_a/Q_A	Q_b/Q_B	Syner- gistic Index
MIT concen- tration	BNP concen- tration				
Q_a (ppm)	Q_b (ppm)	Total concen- tration of MIT + BNP $Q_a + Q_b$ (ppm)	MIT (% by weight)	BNP (% by weight)	$Q_a/Q_A +$ Q_b/Q_B
0	20	20	0.0	100.0	1.00
5	15	20	25.0	75.0	0.88
10	10	20	50.0	50.0	0.75
15	5	20	75.0	25.0	0.63
20	5	25	80.0	20.0	0.75
40	0	40	100.0	0.0	1.00

Example 3

Analogously to example 1, the synergism of MIT and PMG is shown with regard to the microorganism *Pseudomonas aeruginosa*.

Again, the experimental batches contained a Müller-Hinton broth as the nutrient medium. The cell density was 10^6 cells/ml. The incubation time was 48 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

The MIC values of the biocide compositions tested can be seen from table V which follows. The MIC value was 40 ppm when only MIT was employed and 30 ppm when only PMG was employed.

Table V

Pseudomonas aeruginosa: MIC values of MIT + PMG
at an incubation time of 48 h/25°C

MIT concen- tration (ppm)	PMG concentration (ppm)							
	100	75	50	40	30	20	10	0
50	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	+
20	-	-	-	-	-	-	-	+
15	-	-	-	-	-	-	-	+
10	-	-	-	-	-	-	-	+
7.5	-	-	-	-	-	-	-	+
5	-	-	-	-	-	-	-	+
0	-	-	-	-	-	+	+	+

Synergism was present when MIT and PMG were employed simultaneously. The calculation of the synergistic index can be seen from table VI. Accordingly, the lowest synergistic index (0.46) for *Pseudomonas aeruginosa* was found for a mixture of 33.3% by weight of MIT and 66.7% by weight of PMG.

Table VI

Pseudomonas aeruginosa:

calculation of the synergism of MIT + PMG

at an incubation time of 48 h/25°C

MIC at		Concentration	Q _a /Q _A	Q _b /Q _B	Syner- gistic index		
MIT concen- tration	PMG concen- tration						
Q _a (ppm)	Q _b (ppm)	Total con- centration MIT + PMG Q _a + Q _b (ppm)	MIT (% by weight)	PMG (% by weight)	Q _a /Q _A + Q _b /Q _B		
0	30	30	0.0	100.0	0.00	1.00	
5	20	25	20.0	80.0	0.13	0.67	0.79
5	10	15	33.3	66.7	0.13	0.33	0.46
7.5	10	17.5	42.9	57.1	0.19	0.33	0.52
10	10	20	50.0	50.0	0.25	0.33	0.58
15	10	25	60.0	40.0	0.38	0.33	0.71
20	10	30	66.7	33.3	0.50	0.33	0.83
40	0	40	100.0	0.0	1.00	0.00	1.00

Example 4

Analogously to example 1, the synergism of MIT and OPP was shown with regard to the microorganism Pseudomonas aeruginosa.

Again, the experimental batches contained a Müller-Hinton broth as the nutrient medium. The cell density was 10^6 cells/ml. The incubation time was 72 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

The MIC values of the biocide composition tested can be seen from table VII which follows. The MIC value was 40 ppm when only MIT was employed and 750 ppm when only OPP was employed.

Table VII

Pseudomonas aeruginosa:

MIC values of MIT + OPP at an incubation time of 72 h/25°C

MIT concen- tration (ppm)	OPP concentration (ppm)										
	750	500	375	250	200	150	50	37.5	25	12.5	0
50	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	+	+	+	+	+
25	-	-	-	-	-	-	+	+	+	+	+
20	-	-	-	-	-	-	+	+	+	+	+
15	-	-	-	-	-	-	+	+	+	+	+
12.5	-	-	-	-	-	+	+	+	+	+	+
10	-	-	-	-	-	+	+	+	+	+	+
7.5	-	-	-	-	+	+	+	+	+	+	+
5	-	-	+	+	+	+	+	+	+	+	+
2.5	-	-	+	+	+	+	+	+	+	+	+
0	-	+	+	+	+	+	+	+	+	+	+

Synergism was present when MIT and OPP were employed simultaneously. The calculation of the synergistic index can be seen from table VIII. Accordingly, the lowest synergistic index (0.52) for *Pseudomonas aeruginosa* was found for a

mixture of from 2.9 to 4.8% by weight of MIT and from 97.1 to 95.2% by weight of OPP.

Table VIII

Pseudomonas aeruginosa:

calculation of the synergism of MIT + OPP

at an incubation time of 72 h/25°C

MIC at		Total concentration MIT + OPP $Q_a + Q_b$ (ppm)	Concentration		Q_a/Q_A	Q_b/Q_B	Synergistic index
MIT concentration Q_a (ppm)	OPP concentration Q_b (ppm)		MIT (% by weight)	OPP (% by weight)			$Q_a/Q_A + Q_b/Q_B$
0	750	750	0.0	100.0	0.00	1.00	1.00
2.5	500	502.5	0.5	99.5	0.06	0.67	0.73
5	500	505	1.0	99.0	0.13	0.67	0.79
7.5	375	382.5	2.0	98.0	0.19	0.50	0.69
7.5	250	257.5	2.9	97.1	0.19	0.33	0.52
10	200	210	4.8	95.2	0.25	0.27	0.52
12.5	200	212.5	5.9	94.1	0.31	0.27	0.58
15	150	165	9.1	90.0	0.38	0.20	0.58
20	150	170	11.8	88.2	0.50	0.20	0.70
25	150	175	14.3	85.7	0.63	0.20	0.83
40	0	40	100.0	0.0	1.00	0.00	1.00

Example 5

Analogously to example 1, the synergism of MIT and ZnPy was shown with regard to the microorganism *Pseudomonas aeruginosa*.

Again, the experimental batches contained a Müller-Hinton broth as the nutrient medium. The cell density was 10^6 cells/ml. The incubation time was 72 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

The MIC values of the biocide composition tested can be seen from table IX which follows. The MIC value was 40 ppm when only MIT was employed and over 100 ppm when only ZnPy was employed.

Table IX
Pseudomonas aeruginosa: MIC values of MIT + ZnPy
 at an incubation time of 72 h/25°C

MIT concentration (ppm)	ZnPy concentration (ppm)							
	100	75	50	40	30	20	10	0
100	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	+
20	-	-	-	-	-	-	-	+
15	-	-	-	-	-	-	-	+
10	-	-	-	-	-	-	-	+
0	+	+	+	+	+	+	+	+

Synergism was present when MIT and ZnPy were employed simultaneously. The calculation of the synergistic index can be seen from table X. In the case of ZnPy, an MIC value of 100 ppm was used here as the basis for this calculation. Accordingly, the lowest synergistic index (0.35) for *Pseudomonas aeruginosa* was found for a mixture of 50% by weight of MIT and 50% by weight of ZnPy.

Table X

Pseudomonas aeruginosa:

calculation of the synergism of MIT + ZnPy

at an incubation time of 72 h/25°C

MIC at			Concentration		Q _a /Q _A	Q _b /Q _B	Syner- gistic index
MIT concen- tration	ZnPy concen- tration	Total con- centration MIT + ZnPy	MIT	ZnPy			
Q _a (ppm)	Q _b (ppm)	Q _a + Q _b (ppm)	(% by weight)	(% by weight)			Q _a /Q _A + Q _b /Q _B
0	100	100	0.0	100.0	0.00	1.00	1.00
10	10	20	50.0	50.0	0.25	0.10	0.35
15	10	25	60.0	40.0	0.38	0.10	0.48
20	10	30	66.7	33.3	0.50	0.10	0.60
30	10	40	75.0	25.0	0.75	0.10	0.85
40	0	40	100.0	0.0	1.00	0.00	1.00

Example 6

Analogously to example 1, the synergism of MIT and NaPy was shown with regard to the microorganism *Pseudomonas aeruginosa*.

Again, the experimental batches contained a Müller-Hinton broth as the nutrient medium. The cell density was 10^6 cells/ml. The incubation time was 96 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

The MIC values of the biocide composition tested can be seen from table XI which follows. The MIC value was 60 ppm when only MIT was employed and 200 ppm when only NaPy was employed.

Table XI

Pseudomonas aeruginosa: MIC values of MIT + NaPy
at an incubation time of 96 h/25°C

MIT concentration (ppm)	NaPy concentration (ppm)							
	300	200	150	100	75	50	25	0
100	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	+	+
30	-	-	-	-	-	-	+	+
20	-	-	-	-	-	+	+	+
15	-	-	-	-	-	+	+	+
10	-	-	-	-	+	+	+	+
0	-	-	+	+	+	+	+	+

Synergism was present when MIT and NaPy were employed simultaneously. The calculation of the synergistic index can be seen from table XII. Accordingly, the lowest synergistic index (0.63) for *Pseudomonas aeruginosa* was found for a mixture of 16.7% by weight of MIT and 83.3% by weight of NaPy.

Table XII

Pseudomonas aeruginosa:

calculation of the synergism of MIT + NaPy

at an incubation time of 96 h/25°C

MIC at		Total concentration MIT + NaPy $Q_a + Q_b$ (ppm)	Concentration		Q_a/Q_A	Q_b/Q_B	Syner- gistic index $Q_a/Q_A + Q_b/Q_B$
MIT concentration Q_a (ppm)	NaPy concentration Q_b (ppm)		MIT (% by weight)	NaPy (% by weight)			
0	200	200	0.0	100.0	0.00	1.00	1.00
10	150	160	6.3	93.8	0.17	0.75	0.92
10	100	110	9.1	90.9	0.17	0.50	0.67
15	75	90	16.7	83.3	0.25	0.38	0.63
20	75	95	21.1	78.9	0.33	0.38	0.71
30	50	80	37.5	62.5	0.50	0.25	0.75
40	50	90	44.4	55.6	0.67	0.25	0.92
60	0	60	100.0	0.0	1.00	0.00	1.00

Example 7

Analogously to example 1, the synergism of MIT and BBIT was shown with regard to the microorganism Pseudomonas aeruginosa.

Again, the experimental batches contained a Müller-Hinton broth as the nutrient medium. The cell density was 10^6 cells/ml. The incubation time was 72 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

The MIC values of the biocide composition tested can be seen from table XIII which follows. The MIC value was

40 ppm when only MIT was employed and over 500 ppm when only BBIT was employed.

Table XIII

Pseudomonas aeruginosa: MIC values of MIT + BBIT
at an incubation time of 72 h/25°C

MIT concentration (ppm)	BBIT concentration (ppm)							
	500	375	250	200	150	100	50	0
50	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	+
20	-	-	-	-	-	-	-	+
15	-	-	-	-	-	-	-	+
10	-	-	-	-	-	-	+	+
5	+	+	+	+	+	+	+	+
0	+	+	+	+	+	+	+	+

Synergism was present when MIT and BBIT were employed simultaneously. The calculation of the synergistic index can be seen from table XIV. In the case of BBIT, an MIC of 500 ppm was used here as the basis for this calculation. Accordingly, the lowest synergistic index (0.45) for *Pseudomonas aeruginosa* was found for a mixture of 9.1% by weight of MIT and 90.9% by weight of BBIT.

Table XIV

Pseudomonas aeruginosa:
calculation of the synergism of MIT + BBIT
at an incubation time of 72 h/25°C

MIC at			Concentration		Q_a/Q_A	Q_b/Q_B	Syner- gistic index
MIT	BBIT	Total con- centration MIT + BBIT	MIT	BBIT			
concen- tration	concen- tration						
Q_a	Q_b	$Q_a + Q_b$	(% by	(% by			$Q_a/Q_A +$
(ppm)	ppm)	ppm)	weight)	weight)			Q_b/Q_B
0	500	500	0.0	100.0	0.00	1.00	1.00
10	100	110	9.1	90.9	0.25	0.20	0.45
15	50	65	23.1	76.9	0.38	0.10	0.48
20	50	70	28.6	71.4	0.50	0.10	0.60
30	50	80	37.5	62.5	0.75	0.10	0.85
40	0	40	100.5	0.0	1.00	0.00	1.00

Example 8

The synergism of MIT and HMBIT toward the microorganism *Pseudomonas aeruginosa* was demonstrated in a manner similar to that described in example 1.

Again, the experimental batches contained a Müller-Hinton broth as nutrient medium. The cell density was 10⁶ microorganisms/ml. The incubation time was 48 hours at 30°C. Each sample was incubated in a shaker-incubator at 120 rpm.

Table XV hereinbelow shows the MIC values of the biocide composition tested. When MIT is used alone, the MIC value was 50 ppm and when HMBIT was used alone it was 150 ppm.

Table XV

Pseudomonas aeruginosa: MIC values of MIT + HMBIT
at an incubation time of 48 h/30°C

MIT concentration (ppm)	HMBIT concentration (ppm)							
	180	100	75	50	25	10	5	0
50	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	+	+
30	-	-	-	-	-	+	+	+
20	-	-	-	-	+	+	+	+
15	-	-	-	-	+	+	+	+
10	-	-	+	+	+	+	+	+
5	-	-	+	+	+	+	+	+
0	-	+	+	+	+	+	+	+

Synergism was present when MIT and HMBIT were employed simultaneously. Calculation of the synergistic index can be seen from table XVI. According to this table, the lowest synergistic index (0.63) for *Pseudomonas aeruginosa* was found for a mixture of 23.1% by weight of MIT and 76.9% by weight of HMBIT.

Table XVI

Pseudomonas aeruginosa:
calculation of the synergism of MIT + HMBIT
at an incubation time of 48 h/25°C

MIC at			Concentration		Q_a/Q_A	Q_b/Q_B	Syner- gistic index
MIT concen- tration	HMBIT concen- tration	Total con- centration MIT + HMBIT	MIT	HMBIT			
Q_a (ppm)	Q_b ppm)	$Q_a + Q_b$ ppm)	(% by weight)	(% by weight)			$Q_a/Q_A +$ Q_b/Q_B
0	150	150	0.0	100.0	0.00	1.00	1.00
5	100	105	4.8	95.2	0.10	0.67	0.77
15	75	90	16.7	83.3	0.30	0.50	0.80
15	50	65	23.1	76.9	0.30	0.33	0.63
20	50	70	28.6	71.4	0.40	0.33	0.73
30	25	55	54.5	45.5	0.60	0.17	0.77
40	10	50	80.0	20.0	0.80	0.07	0.87
50	0	50	100.0	0.0	1.00	0.00	1.00

Example 9

The synergism of MIT and BAC toward the microorganism *Pseudomonas aeruginosa* was demonstrated in a manner similar to that described in example 1.

Again, the experimental batches contained a Müller-Hinton broth as nutrient medium. The cell density was

10^6 microorganisms/ml. The incubation time was 48 hours at 25°C. Each sample was incubated in a shaker-incubator at 120 rpm.

Table XVII hereinbelow shows the MIC values of the biocide composition tested. When MIT is used alone, the MIC value was 40 ppm and when BAC was used alone it was 80 ppm.

Table XVII

Pseudomonas aeruginosa: MIC values of MIT + BAC
at an incubation time of 48 h/25°C

MIT concentration (ppm)	BAC concentration (ppm)								
	100	80	60	50	40	30	20	10	0
60	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	+
20	-	-	-	-	-	-	-	-	+
15	-	-	-	-	-	+	+	+	+
10	-	-	-	-	-	+	+	+	+
5	-	-	-	-	-	+	+	+	+
0	-	-	+	+	+	+	+	+	+

Synergism was present when MIT and BAC were employed simultaneously. Calculation of the synergistic index can be seen from table XVIII. According to this table, the lowest synergistic index (0.63) for *Pseudomonas aeruginosa* was found for a mixture of 11.1% by weight of MIT and 88.9% by weight of BAC and for a mixture of 66.7% by weight of MIT and 33.3%

by weight of BAC.

Table XVIII

Pseudomonas aeruginosa:
calculation of the synergism of MIT + BAC
at an incubation time of 48 h/25°C

MIC at			Concentration		Q _a /Q _A	Q _b /Q _B	Syner- gistic index
MIT concen- tration	BAC concen- tration	Total con- centration MIT + BAC	MIT	BAC			
Q _a (ppm)	Q _b (ppm)	Q _a + Q _b (ppm)	(% by weight)	(% by weight)			Q _a /Q _A + Q _b /Q _B
0	80	80	0.0	100.0	0.00	1.00	1.00
5	60	65	7.7	92.3	0.13	0.75	0.88
5	50	55	9.1	90.9	0.13	0.63	0.75
5	40	45	11.1	88.9	0.13	0.50	0.63
10	40	50	20.0	80.0	0.25	0.50	0.75
15	40	55	27.3	72.7	0.38	0.50	0.88
20	30	50	40.0	60.0	0.50	0.38	0.88
20	20	40	50.0	50.0	0.50	0.25	0.75
20	10	30	66.7	33.3	0.50	0.13	0.63
30	10	40	75.0	25.0	0.75	0.13	0.88
40	0	40	100.0	0.0	1.00	0.00	1.00

We claim:

1. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful microorganisms, characterized in that the composition comprises formaldehyde or a formaldehyde-releasing substance as further biocidal active ingredient.
2. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful microorganisms, characterized in that the composition comprises 2-bromo-2-nitro-1,3-propanediol as further biocidal active ingredient.
3. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful microorganisms, characterized in that the composition comprises polyhexamethylenebiguanide as further biocidal active ingredient.
4. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful

microorganisms, characterized in that the composition comprises o-phenylphenol as further biocidal active ingredient.

5. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful microorganisms, characterized in that the composition comprises a pyrithione as further biocidal active ingredient.

6. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful microorganisms, characterized in that the composition comprises N-butyl-1,2-benzoisothiazolin-3-one as further biocidal active ingredient.

7. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful microorganisms, characterized in that the composition comprises N-hydroxymethyl-1,2-benzoisothiazolin-3-one as further active ingredient.

8. A biocide composition, comprising 2-methylisothiazolin-3-one as biocidal active ingredient and at least one further biocidal active ingredient, as additive to materials capable of being attacked by harmful

microorganisms, characterized in that the composition comprises benzylalkonium chloride as further active ingredient.

9. A biocide composition as claimed in claim 8, characterized in that it comprises dimethylbenzylalkonium chloride as benzylalkonium chloride.

10. A biocide composition as claimed in any of claims 1 to 9, characterized in that the 2-methylisothiazolin-3-one and the further biocidal active ingredient are present in a weight ratio of 1:100 to 100:1.

11. A biocide composition as claimed in claim 10, characterized in that the 2-methylisothiazolin-3-one and the further biocidal active ingredient are present in a weight ratio of 20:80 to 80:20.

12. A biocide composition as claimed in any of claims 1 or 11, characterized in that the 2-methylisothiazolin-3-one is present in a concentration of from 1 to 50% by weight based on the entire biocide composition.

13. A biocide composition as claimed in any of claims 1 to 12, characterized in that the further biocidal active ingredient is present in a concentration of from 1 to 50% by weight based on the entire biocide composition.

14. A biocide composition as claimed in any of claims 1 to 7, characterized in that the 3-methylisothiazolin-3-one and the further biocidal active ingredient are present in a total concentration of from 1 to 100% by weight, based on the entire biocide composition.

15. A biocide composition as claimed in claim 14, characterized in that the 3-methylisothiazolin-3-one and the further biocidal active ingredient are present in a total concentration of from 1 to 30% by weight, based on the entire biocide composition.

16. A biocide composition as claimed in any of claims 1 to 15, characterized in that a polar and/or an unpolar liquid medium is/are present.

17. A biocide composition as claimed in claim 16, characterized in that the polar liquid medium present is water, an alcohol, a glycol, a glycol ether, a glycol ester, a polyethylene glycol, a polypropylene glycol, N,N-dimethylformamide, 2,2,4-trimethylpentanediol monoisobutyrate or a mixture of at least two of these substances.

18. A biocide composition as claimed in claim 17, characterized in that the polar liquid medium present is water.

19. The use of a biocide composition as claimed in any of claims 1 to 18 for controlling harmful microorganisms

20. A substance mixture or material, preserved against harmful microorganisms, characterized by a content of a biocide composition as claimed in any of claims 1 to 18.