Synergistic preservative blends

The present invention discloses synergistic preservative formulations comprising bactericidal and fungicidal compounds, a method of reducing the bacterial and fungal load of a preparation as well as the use of the synergistic preservative formulations according to the invention for reducing the bacterial and fungal load of preparations.

A wide variety of personal, household and industrial products, formulations and preparations need to be protected from contamination with bacteria and fungi. This is usually achieved by adding formaldehyde releasers and/or parabens because of the good bactericidal and fungicidal properties of these compounds.

However, these compounds of the state of the art suffer from some severe drawbacks, namely that their preservation capacity is so high that its effect continues even after, e.g. in case of a lotion, it is applied onto the skin, absorbed, distributed through the blood and deposited in the major organs of the body. Since formaldehyde and parabens impair enzyme function, there is the possibility of interference with the normal human cell and organ function.

Therefore, the technical problem to be solved by the present invention is to provide preservative formulations that avoid the disadvantages of those according to the state of the art. This problem is solved by reducing the necessary concentration of the formulation while still maintaining microbe control through the surprising and unexpected synergistic cooperation of at least two compounds.

It is therefore one object of the present invention to provide a preservative formulation comprising the combination of at least two compounds having bactericidal and/or fungicidal properties, wherein the respective combination is selected from the group consisting of methylisothiazolinone/piroctone olamine; caprylyl glycol/dehydroacetic acid; undecanol/dehydroacetic acid and lauryl alcohol/sorbic acid.

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The bactericidal compound is preferably present in a concentration of 1% to 5%, when the bactericidal compound is a methylisothiazolinone, and 25% to 75% when it is caprylyl glycol, undecanol and lauryl alcohol. Even more preferred, the bactericidal compound is present in a concentration of 1.5%% to 3% when it is a methylisothiazolinone, and 30% to 70% when it is caprylyl glycol, undecanol and lauryl alcohol.

The fungicidal compound is preferably present in a concentration of 25% to 99%. Even more preferably, the fungicidal compound according to the invention is present in a concentration of 30% to 95%.

All percentages are weight percentages unless otherwise stated.

The preferred isomer of methylisothiazolinone is 2-methylisothiazolin-3-one. However, other isomers are also within the scope of the invention.

It may be preferred that the preservative formulations according to the invention are combined with appropriate solvents. Preferably, said solvents are selected from the class of glycols. Most preferably, said solvents are selected from the group consisting of propylene glycol, butylene glycol and pentylene glycol.

The method of reducing the bacterial and fungal load of a preparation according to the present invention preferably comprises adding a preservative formulation comprising at least two compounds having bactericidal and/or fungicidal properties to the preparation to be conserved. The preferred bactericidal and fungicidal compounds, their preferred concentrations and combinations are as stated above.

Generally, the preparations according to the invention can be added to a wide variety of personal, household and industrial products, formulations and preparations.

Preferred preparations according to the invention are selected from the group consisting of cosmetic preparations such as lotions, creams, salves and ointments, cleaners, detergents, feminine hygiene products, wipes, pet care

preparations, hair preparations such as shampoos, conditioners, gels, fixatives and sprays.

Another object of the present invention is the use of the synergistic preservative formulations according to the invention for reducing the bacterial and fungal load of preparations. All details regarding the preferred bactericidal and fungicidal compounds, their preferred concentrations and combinations as well as the preferred preparations where the synergistic preservative formulations can be applied are the same as those given above.

The invention will now be described by way of the following, non-limiting examples.

Example 1

Preservative challenge testing was done to evaluate the performance of the blends in finished cosmetic preparations. Testing was conducted in a shampoo and a lotion base as described herein. A standardized mixed bacterial culture was prepared as follows. Three individual Tryptic Soy Agar slants of *Staphylococcus aureus* (ATCC 6538), *Escherichia coli* (ATCC 8739) and *Pseudomonas aeruginosa* (ATCC 9027) were incubated at approximately 35°C for ~24 hours. Each slant was then washed with 5 mL of sterile Phosphate Buffered Dilution Water (PBDW). The 5 mL was transferred to an additional 5 mL of BPDW for a total 10 mL individual bacterial suspension. The absorbance of each individual suspension was measured spectrophotometrically at 530nm after calibration of the instrument with a blank of PBDW. Each individual suspension was standardized to ~10^9 CFU/mL. Five mL was aseptically transferred from each individual suspension to one sterile specimen cup to create the "Mixed Bacteria". Then 40g of each shampoo and lotion sample was inoculated with 0.2 mL of the standardized bacterial solution and each sample was mixed well.

Two individual Sabouraud Agar slants of *Candida albicans* (ATCC 10231), and three Sabouraud Agar plates of *Aspergillus niger* (ATCC 16404) were incubated at approximately 30°C for ~24 hours and 5 days, respectively. The Candida slant was then washed with 5 mL of sterile Phosphate Buffered Dilution Water

(PBDW). The 5 mL was transferred to an additional 5 mL of BPDW for a total 10 mL individual *Candida* suspension. For the *Aspergillus,* a sterile cotton swab was immersed into a 10 mL tube of sterile PBDW and then dipped into a sterile tube of Tween 80. The swab was then run back and forth across each of the *Aspergillus* plates, transferring the spores to the 10 mL PBDW tube in between each spore removal process. One mL from each of the suspensions was transferred to a separate 9 mL PBDW tube. Each of these 1:9 suspensions was measured on a hemacytomter and the original suspensions were standardized to ~10^7 cells/mL. Seven mL was aseptically transferred from each individual suspension to one sterile specimen cup to create the "Mixed Fungi". Then 40g of each shampoo and lotion sample was inoculated with 0.4 mL of the standardized fungal solution and each sample was mixed well.

At days 0, 7, 14 and 28 days, sampling was done as follows. One gram of each sample was aseptically transferred to a separate 9 mL D/E neutralizing broth tube to form the 10^{-1} dilution. Serial dilutions were prepared through to a 10^{-6} dilution in BPDW. The serial dilutions for the bacterial cultures were plated by pour plate with Tryptic Soy Agar and incubated at ~35°C for 48 hours. Serial dilutons for the fungal samples were plated by pour plate with Sabouraud Agar and incubated at ~30°C for 72 hours. Plates were enumerated after the incubation period. Results are shown in Tables 1 and 2. The blends were effective in significantly reducing the bacterial and fungal counts over a 28 day period.

Table 1
Preservative Challenge Data
Mixed Bacterial Counts (CFU/gram)

Test Samples	Day 0	Day 7	Day 14	Day 28
Unpreserved lotion	1.0×10^7	1.3×10^5	1.4×10^4	1.4×10^3
Lotion + 95 ppm methylisothiazolinone + 0.5% piroctone olamine	1.7×10^7	<10	<10	<10
Lotion + 1% Caprylyl glycol + 0.5% Dehydroacetic acid	1.1×10^7	<10	<10	<10
Lotion + 0.5% undecanol + 0.5% Dehydroacetic acid	1.3×10^7	<10	<10	<10
Unpreserved Shampoo	9.2×10^6	2.5×10^7	2.0×10^7	2.2×10^6
Shampoo + 0.5% lauryl alcohol + 0.5% sorbic acid	1.2×10^7	<10	<10	<10

Inoculum:

Mixed Bacteria – approximately equal amounts of *P. aeruginosa*, *S. aureus* and *E. coli.* 9×10^5 to 5.5×10^6

Table 2
Preservative Challenge Data
Mixed Fungal Counts (CFU/gram)

Test Samples	Day 0	Day 7	Day 14	Day 28
Unpreserved lotion	5.0×10^5	2.1×10^5	3.2×10^5	1.1×10^4
Lotion + 95 ppm methylisothiazolinone + 0.5% piroctone olamine	1.0×10^5	<10	<10	<10
Lotion + 1% Caprylyl glycol + 0.5% Dehydroacetic acid	2.0×10^5	<10	<10	<10
Lotion + 0.5% undecanol + 0.5% Dehydroacetic acid	1.2×10^5	<10	<10	<10
Unpreserved Shampoo	9.8×10^5	2.1×10^5	2.6×10^4	3.4×10^3
Shampoo + 0.5% lauryl alcohol + 0.5% sorbic acid	3.0×10^5	<10	<10	<10

Inoculum:
Mixed Fungi – approximately equal amount of *C. albicans* and *A. niger.* 6.9×10^4 to 1.2×10^5

Example 2

Minimum inhibitory concentrations (MIC) were determined for individual components and binary formulations as follows. Individual bacterial suspensions of *S. aureus* (gram positive), *E. coli* and *P. aeruginosa* (both gram negative) and individual fungal suspensions of *C. albicans* and *A. niger* were prepared as described in Example 1. Each individual suspension was standardized with PBDW to yield a $\sim 10^8$ CFU/mL or $\sim 10^7$cells/mL for the individual bacteria and fungi, respectively.

The individual components and binary formulations were diluted in either DI water or propylene glycol (as appropriate for solubility) to yield a 10,000 ppm total starting active solution. From the 10,000 ppm solution, a 1:9 dilution was made in sterile Nutrient Broth to yield a 1,000 ppm active solution. Five mL of the 1,000 ppm dilution was transferred to five mL of sterile Nutrient Broth (NB) to yield a 500 ppm active solution. This dilution scheme was repeated down to 3.90 ppm active. The same dilutions were made in sterile Sabouraud Dextrose Broth (SDB) for the fungal MIC testing. The series of nine active solutions (3.9 ppm – 1000 ppm) was prepared for each of the five microorganisms to be tested.

From the *E. coli* suspension, 0.1 mL was added to each of the nine, 5-mL active solutions in NB. Each tube was mixed thoroughly. This was repeated for each of the bacterial suspensions. Similarly, 0.1 mL of the *C. albicans* suspension was added to each of the nine, 5-mL active solutions in SDB. This was repeated with *A.* niger in a separate set of dilutions. Each tube was mixed thoroughly. Controls were prepared for each organism by inoculating 5 mL of NB or SDB, as appropriate. All three sets of bacterial tubes were incubated at 35°C for 48 hours and the two sets of fungal tubes were incubated at 30°C for 72 and 120 hours. At the end of the incubation period, the tubes were mixed and visually inspected for turbidity compared to the control. The lowest concentration with a lack of turbidity was recorded as the Minimum Inhibitory Concentration (MIC). The results are shown in Tables **3** and **4**.

The synergism value is $(Q_A/Q_a + Q_B/Q_b)$. Q_A is the concentration of component A in the mixture, Q_a is the concentration of component A applied singly, Q_B is the concentration of component B in the mixture, Q_b is the concentration of component B applied singly. When the synergism value is less than one, the mixture is synergistic. Values for $(Q_A/Q_a + Q_B/Q_b)$ of 1 and greater than 1 represent an additive effect and an antagonistic effect, respectively.

Table 3
MIC values (in ppm) for preservative formulations versus bacteria

Organism type	Gram (+)	Gram (-)	Gram (-)
Organism name	*S. aureus*	*P. aeruginosa*	*E. coli*
ATCC strain number	**6538**	**9027**	**8739**
Caprylyl Glycol and Dehydroacetic acid blend	**500**	**500**	**500**
Q_A	250	250	250
Q_a	>1000	>1000	1000
Q_B	250	250	250
Q_b	500	500	500
$Q_A/Q_a + Q_B/Q_b$	**< 0.75**	**< 0.75**	**0.75**
Undecanol and Dehydroacetic acid blend	**1,000**	**500**	**1,000**
Q_A	500	250	500
Q_a	>1000	>1000	>1000
Q_B	500	250	500
Q_b	500	500	500
$Q_A/Q_a + Q_B/Q_b$	**< 1.5**	**< 0.75**	**< 1.5**

Table 4
MIC values (in ppm) for preservative formulations versus bacteria, yeast and fungus formulations with piroctone olamine

Organism type	Gram (+)	Gram (-)	Gram (-)	Mold	Yeast
Organism name	*S. aureus*	*P. aeruginosa*	*E. coli*	*A. niger*	*C. albicans*
ATCC strain number	**6538**	**9027**	**8739**	**16404**	**10231**
Methylisothiazolinone and Piroctone Olamine blend	**31.25**	**31.25**	**31.25**	**7.81**	**7.81**
Q_A	15.63	15.63	15.63	3.91	3.91
Q_a	250	62.5	62.5	500	250
Q_B	15.63	15.63	15.63	3.91	3.91
Q_b	62.5	62.5	62.5	62.5	62.5
$Q_A/Q_a + Q_B/Q_b$	**0.31**	**0.5**	**0.5**	**0.07**	**0.08**

Claims

1. A preservative formulation comprising the combination of at least two compounds having bactericidal and/or fungicidal properties, wherein the respective combination is selected from the group consisting of methylisothiazolinone/piroctone olamine; caprylyl glycol/dehydroacetic acid; undecanol/dehydroacetic acid and lauryl alcohol/sorbic acid.

2. The compound according to claim 1, wherein the bactericidal compound is present in a concentration of 1% to 5%, when the bactericidal compound is a methylisothiazolinone, and 25% to 75% when it is caprylyl glycol, undecanol and lauryl alcohol.

3. The compound according to claim 2, wherein the bactericidal compound is present in a concentration of 1.5% to 3% when it is a methylisothiazolinone, and 30% to 70% when it is caprylyl glycol, undecanol and lauryl alcohol.

4. The compound according to any of claims 1-3, wherein the fungicidal compound is present in a concentration of 25% to 99%.

5. The compound according to claim 4, wherein the fungicidal compound is present in a concentration of 30% to 95%.

6. A method of reducing the bacterial and fungal load of a preparation comprising adding the preservative formulation according to any of claims 1-5 to the preparation.

7. The method according to claim 6, wherein the preparation is selected from the group consisting of personal, household and industrial products, formulations and preparations.

8. The method according to claim 7, wherein the preparation is selected from the group consisting of cosmetic preparations such as lotions, creams, salves and ointments, cleaners, detergents, feminine hygiene

preparations, wipes, pet care preparations, hair preparations such as shampoos, conditioners, gels, fixatives and sprays.

9. Use of a preservative formulation according to any of claims 1-5 for reducing the bacterial and fungal load of preparations.