

## usNeo™ - a Naturally Effective Deodorant and Antibacterial Active

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### Abstract

The effectiveness and ease of use of a new deodorant active based on natural usnic acid formulated in plant-derived 1,3-propanediol was investigated in different *in vitro* and *in vivo* studies. Determination of the minimum inhibitory concentrations (MIC) of the test active, showed it to be particularly effective against Gram-positive bacteria, many of which are responsible for causing body odour. These include *corynebacteria*, *staphylococci* and *propionibacteria* in particular. In an *in vivo* Sniff Test, the deodorising effect of the test active after 5 days of use was evaluated by the assessment of body odour over 48 hours at three time points. In addition, axilla swabs were taken during the Sniff Test to investigate the test active's effect on the under-arm bacterial population. In order to compare the test active to other established deodorant actives, *in vivo* tests were conducted also using triclosan and ethylhexylglycerin. The test active showed deodorising effects lasting at least 24 hours. Compared to the other deodorant actives, it demonstrated a better deodorising effect than ethylhexylglycerin and an equally as good effect as triclosan. The determination of bacterial counts showed that the deodorant formulation containing the test active produced the smallest reduction in bacterial numbers and therefore, out of the three actives tested, preserved the most skin flora. Thorough safety tests confirmed the test active to be safe to use as a deodorant active. The tests conducted therefore demonstrate that the test active is effective and safe to use.

### Introduction

A person's individual odour is genetically determined and can also be affected by food or medication<sup>(2, 4-6)</sup>. Although sweating plays an important role, the classic association of sweat and body odour is only part of the explanation. It is true that unwanted body odour occurs mainly in the axilla (underarm) area and the feet but odour is only indirectly caused by secreted sweat. It is actually caused by bacteria living on the skin which find ideal conditions for growth in the warm areas of the body that tend to stay moist. They metabolise certain compounds found in sweat, leading to the occurrence of unwanted body odour. The three most frequently used methods to deodorise (combat body odour) are to mask

the smell with perfume, to reduce the quantity of sweat and to inhibit odour-producing bacteria<sup>(1)</sup>.

Quantities of sweat can be reduced by using what are known as antiperspirants. In most cases these are metallic salts based on aluminium, zinc or manganese<sup>(2)</sup>. The most frequently-used antiperspirants are aluminium salts such as aluminium hydroxychloride, aluminium bromhydrate or aluminium sulphate. The volume of sweat produced is reduced by narrowing the sweat ducts. Antiperspirants form complexes with water, small scales of skin and lipids to create a protein mass which blocks the sweat glands. In this way the amount of sweat produced can effectively but not permanently be reduced. Furthermore antiperspirants have astringent effects on skin, tightening the sweat glands which are further narrowed.

Inhibition of body odour-causing bacteria is another important strategy for deodorisation. By inhibiting or deactivating odour-producing bacteria, there is no or only slight metabolism of sweat components thus preventing/reducing the occurrence of body odour. The microorganisms present in the underarm area include Gram-positive bacteria of the *Corynebacterium*, *Streptococcus*, *Propionibacterium* and *Micrococcus* genera as well as a yeast of the *Malassezia* genus. Bacteria responsible for production of body odour are *corynebacteria*, *streptococci* and *propionibacteria*<sup>(2, 3)</sup>. A complete sterilisation of skin however should be avoided, as normal skin flora provides protection against bacterial infection caused by foreign pathogenic bacteria<sup>(7)</sup>.

Since the use of the alum stone by the Romans<sup>(8)</sup>, a multiplicity of deodorants has been established. Among these are the synthetic substances triclosan and ethylhexylglycerin, which today are used frequently together with a range of different plant extracts or fractionated substances derived from plants. Although triclosan is approved both by the European and American health authorities, it is suspected that it may cause cross-resistance in microorganisms. Moreover it has been proven that certain quantities of applied triclosan have been detected in the body and the milk of nursing mothers. Triclosan

# Natural Ingredients

is also a chlorinated organic compound which may accumulate in the environment and there is evidence to suggest that it is an endocrine disrupter<sup>(15)</sup>. For these reasons the American EPA and FDA are conducting new safety evaluations on triclosan generally and as a component of cosmetics and household products<sup>(13, 15)</sup>. Therefore it is considered important to use natural deodorants. An example of a natural substance extracted from plants is usnic acid originating from *Usnea barbata*. It demonstrates anti-inflammatory, antioxidant and antimicrobial effects<sup>(9-11)</sup> and has been used previously as an active component in deodorants. All active ingredients in cosmetics have to fulfil certain criteria. Besides efficacy, the active has to be safe and also skin tolerant. That is to say, it must not have any mutagenic or toxic properties and cause no skin irritation or sensitisation.

The aim of this work has been to test a new formulation of usnic acid in a plant-derived solvent to verify its safety and effectiveness as a deodorant active. In an *in vivo* study on deodorant effectiveness, the test active was compared to the synthetic deodorant actives triclosan and ethylhexylglycerin.

## Material and Methods

### Test Active Composition

When designing the test active composition, it was deemed important to use sustainable raw materials. Plant derived

1,3-propanediol (Ecocert-certified) was chosen as a solvent. It is made by fermenting glucose obtained from corn. Besides compatibility with a range of solvents, 1,3-propanediol is gentle on the skin and acts as a moisturiser. To reduce changes in colour, an Ecocert-certified antioxidant substance and chelating agent, glutamic acid, N,N-diacetic acid, tetrasodium salt, was used. Tromethamine (Tris Amino), a primary amine was used as a solubiliser. The test active was developed and is produced by our company.

### Determination of Minimum Inhibitory Concentration (MIC)

To determine the minimum inhibitory concentration (MIC), the test active was tested at concentrations of 0.01% to 50.0% in a growth media containing bacteria and yeasts (respectively with 1.5-5.0 x10<sup>7</sup> colony forming units). After 48h incubation at 36°C (bacteria) and 30°C (yeasts), the preparations were examined for microbial growth. The lowest test active concentration to evoke an inhibitory effect was taken as the MIC value.

### Application Formula

For the *in vivo* efficacy and safety tests different roll-on-deodorant formulations were used based on the formula shown in Table 1. Formulations were made up containing 2% and 5% of the

Component	Portion [%]	INCI	Function
Water	89.65	Water	Solvent
Citric acid 50%	0.05	Citric Acid, Water	Buffer
Keltrol CG SFT	0.30	Xanthan Gum	Viscosity Control Agent
Phosal 75 SA	5.00	Phosphatidylcholine, Alcohol (and) Carthamus Tinctorius (Safflower) Seed Oil (and) Glycerides Sunflower Oil Monoglycerides and Diglycerides (and) Soy Acid (and) Cocos Nucifera (Coconut) Oil (and) Ascorbyl Palmitate (and) Tocopherol	Emulgator System
Glycerin	3.00	Glycerin	Humectant
Test active	2.00	Propanediol (and) Usnea Barbata (Lichen) Extract (and) Tromethamine (and) Tetrasodium Glutamate Diacetate (and) Water (and) Sodium Hydroxide	Active Ingredient
Preservative	qs		

Table 1. Formula for a Roll-on Deodorant Formulation Containing Test Active



test active, a formulation containing 0.3% triclosan and 1% ethylhexylglycerin and a control formulation without any proportion of active ingredient. The chosen concentrations corresponded to the actives' recommended maximum concentrations for deodorant applications. The control formulation was used in order to exclude any possible deodorising effects caused by the framework formulation or the preservatives. The stability of the deodorant formulations was verified over a 6 month storage period at room temperature and at 40°C.

## Methods Concerning Test Active Product Safety

In order to be able to guarantee the safe use of the test active and its formulation, different safety tests were conducted. The test active was tested for phototoxicity (according to OECD guideline no. 432) and mutagenicity (Ames test according to OECD guideline no. 471). The deodorant formulation was investigated in a skin irritation test (SPT) and an allergy certificate was issued in accordance with Directive 2003/15/EC Annex III.

### Sniff Test

To establish the effectiveness of the deodorant formulations, an *in vivo* Sniff Test study employing 20 test subjects was conducted. Study participants were healthy women and men with well discernible body odour. The average age of the test subjects was 39, the youngest being 24 and the oldest 61 years old. The degree of body odour was determined by olfactory means using trained specialists. Odour was categorised as follows:

1. Not detectable
2. Slight
3. Detectable
4. Strong
5. Very strong

At the start of the study during a conditioning phase lasting several days, participants used a perfume-free, pH neutral liquid soap without antibacterial, deodorant or antiperspirant actives added. The preconditioning phase lasted until the body odour could be easily detected on test subjects. The first olfactory determination of body odour was conducted 24 hours after the last shower during the conditioning phase (t0). Values measured at time t0 represent the individual body odour base values of the individual test subjects.

In the subsequent treatment phase, test subjects used the test deodorant formulation for five successive days on one armpit

and the control formulation without any active ingredient on the other. For everyday personal hygiene, test subjects used the same soap that had been used in the conditioning phase. At the end of the 5-day treatment phase, the test subjects took a final shower and applied the deodorant formulations. Twelve hours after this last application, the first of three olfactory measurements were taken (t1). The remaining determinations were carried out 24h (t2) and 48h (t3) after the last application.

For the analysis of the study results, mean values of the odour evaluations were established. These were compiled in a diagram for all four measurement times to make a direct comparison between the control formulation and the formulation containing the active ingredient. Furthermore the reduction of body odour was calculated. The odour value at measurement times t1, t2 or t3 was compared with the initial value t0 using the formula below.

$$\text{Odour Reduction [\%]} = \left(1 - \frac{t_x}{t_0}\right) \times 100$$

Formula 1. Calculation of Odour Reduction ( $t_x$  = Odour Value at Time  $t_x$ ;  $t_0$  = Odour Value at Time  $t_0$ )

### Determination of Bacterial Count

In addition to determining the deodorising effect in the Sniff Test, the influence of the deodorant formulations on bacterial counts in the underarm area was also investigated. To do this, 10 of the 20 test subjects participating in the Sniff Test also had swabs taken in the underarm area at times t0 and t2. The cotton swabs used were placed in 10 mL of 0.9 % NaCl solution and shaken in a vortex shaker. The inoculated NaCl solution was then cultivated at 32.5°C under aerobic conditions on CASO agar plates and under anaerobic conditions on blood agar plates. After a 5 day incubation period the number of colony forming units [CFU/mL] was determined.

$$\text{Bacteria Reduction [\%]} = \left(1 - \frac{N_{At_2}}{N_{Ct_2}}\right) \times 100$$

Formula 2. Calculation of Bacteria Reduction ( $N_{At_2}$  = Bacterial Count (active) at  $t_2$ ;  $N_{Ct_2}$  = Bacterial Control at  $t_2$ )

Calculations of bacterial reduction were made using Formula 2. It describes a comparison of bacterial numbers determined in armpits treated with active and control formulation. In this way the individual bacterial count was calculated for each test

subject. Then the average value was calculated from all 10 values of bacterial reduction.

A brief overview of the *in vivo* tests conducted is given in Figure 1.

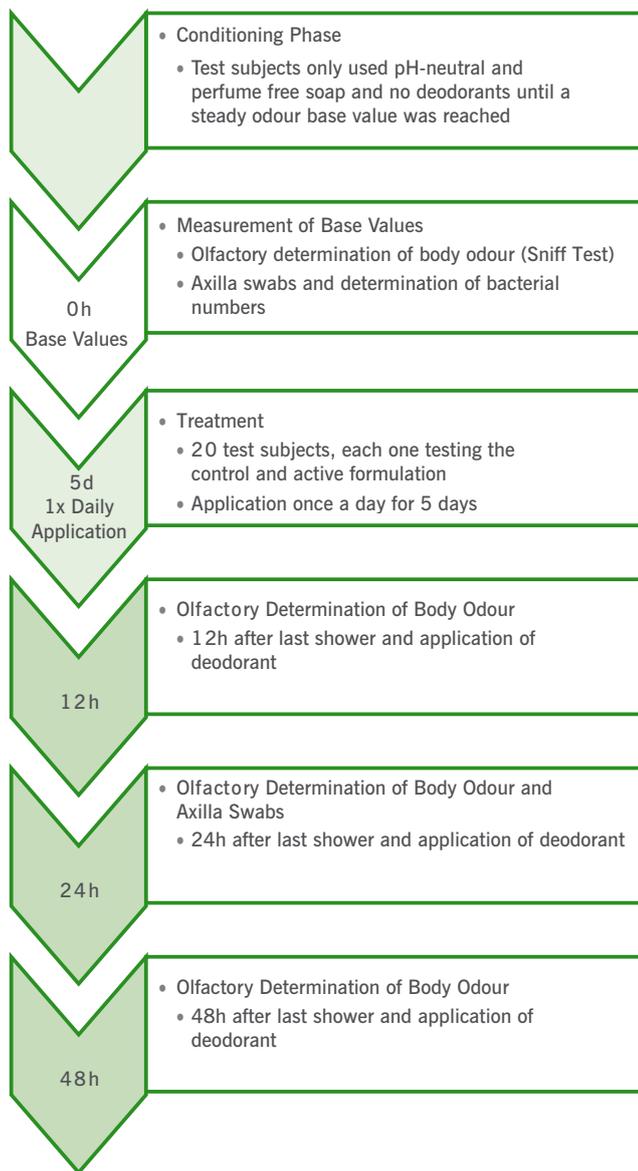


Figure 1. Sniff Test and Assessment of Bacterial Numbers

## Results

### Test Active Product Safety

#### Phototoxicity

In a study on phototoxicity according to OECD guideline no. 432 on mouse embryo fibroblasts (3T3), the test active

was classified as 'not phototoxic' in a concentration range of 7.81  $\mu\text{g/mL}$  to 1000  $\mu\text{g/mL}$ .

#### Mutagenicity (Ames Test)

The reverse Mutations Assay on *S. Typhimurium* and *E. Coli* (OECD Guideline 471) could not demonstrate any mutagenicity of the test active. Concentrations of 10.0  $\mu\text{g}$  per plate to 5000  $\mu\text{g}$  per plate were used.

#### Skin Irritation (SPT / RPT)

A roll-on deodorant formulation containing 5% of test active was used in a simple epicutaneous patch test (SPT) conducted on 50 test subjects and classified as 'not irritating to skin'. A repeated epicutaneous patch test (RPT) was not performed. However, during the Sniff Test entailing application of a deodorant formulation containing 2% and 5% for 5 days, the test active caused no skin irritations whatsoever in the test subjects.

#### Allergy Research

Based on an evaluation of allergy-releasing potential according to Directive 2003/15/EC Annex III, the test active is classified as non-allergenic.

The test active has not been tested on animals.

#### Minimum Inhibitory Concentration (MIC)

The minimum inhibitory concentrations of the test active were determined in order to investigate its specific antimicrobial properties. Special attention was paid to the Gram-positive *corynebacteria* and *streptococci*, due to the fact that they are responsible for producing body odour. In addition, the 'standard bacteria for testing adequate preservation' listed in the Pharmacopoea Europaea were used in the test.

Table 2 on page 5 shows the results of MIC determinations of the test active for 13 selected bacteria. The MIC values for Gram-positive bacteria are all below 0.05 % with one exception (*P. acnes*). In order to inhibit growth of the tested Gram-negative bacteria and fungi, relatively high test active concentrations of up to 10% were required.

#### Sniff Test

To determine the effectiveness of the deodorant formulations, an *in vivo* Sniff Test was carried out. Body odour was evaluated

Bacterium	ATCC/DSM	Gram	Comments	MIC <sub>Product</sub>
<i>Staphylococcus aureus</i>	ATCC: 6538	+	Skin flora; can cause skin infections	Ph.Eur. < 0.05 %
<i>Staphylococcus epidermidis</i>	ATCC: 12228	+	Skin flora; causes body odour	0.01 - 0.025 %
<i>Corynebacterium jeikeium</i>	DSM: 7171	+	Skin flora; causes body odour	0.01 - 0.025 %
<i>Corynebacterium xerosis</i>	DSM: 20743	+	Skin flora; causes body odour	< 0.05 %
<i>Corynebacterium amycolatum</i>	ATCC: 49368	+	Skin flora; causes body odour	0.01 %
<i>Propionibacterium acnes</i>	ATCC: 6919	+	Causative organism of acne	0.1 - 0.25 %
<i>Streptococcus mutans</i>	ATCC: 25175	+	Oral microflora; can cause dental caries	0.01 - 0.025 %
<i>Streptococcus faecalis</i>	ATCC: 19433	+	Faecal contaminant	0.01 - 0.025 %
<i>Escherichia coli</i>	ATCC: 8739	-	Gut flora; faecal contaminant	10 %
<i>Pseudomonas aeruginosa</i>	ATCC: 9027	-	Pathogen	Ph.Eur. 10 %
<i>Malassezia furfur</i>	ATCC: 6170		Yeast; skin flora; dandruff-causing agent	10 %
<i>Candida albicans</i>	ATCC: 10231		Yeast	Ph.Eur. < 0.05 %
<i>Aspergillus brasiliensis (niger)</i>	ATCC: 16404		Mould	Ph.Eur. 2.50 %

\*Ph. Eur.: Bacterium according to Ph. Eur. 5 Issue 2005: 5.1.3 Test for adequate preservative

Table 2. Minimum Inhibitory Concentrations (MIC)

on a scale of 1 to 5, where 1 represented weak and 5 a strong body odour. Figure 2 shows the results of odour evaluation and Figure 3 odour reduction as a percentage of the base value t0.

Figure 2 shows the results of the *in vivo* Sniff Test for the deodorant formulation containing 2% test active and control formulation without active ingredient (control) at times t0 (body odour base value), t1 (12h after last deodorant application,

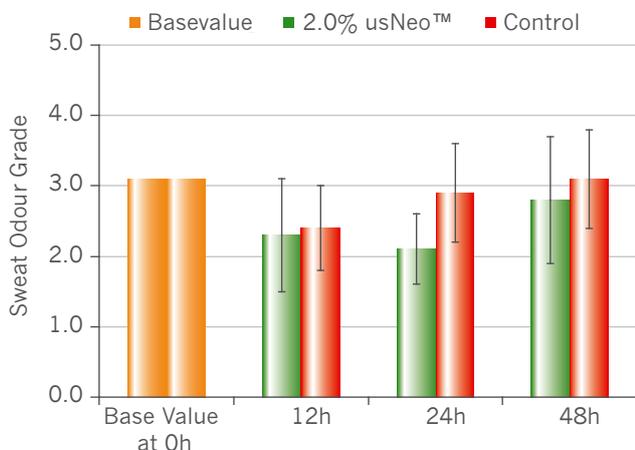


Figure 2. Results of the Body Odour Sniff Test (2% Test Active and Control)

t2 (24h after last deodorant application) and t3 (48h after last deodorant application). Measurement t0 was taken at the end of the conditioning phase and represents the body odour base value of test subjects. Body odour was evaluated and categorised as: 1= not detectable; 2= slight; 3= detectable; 4= strong; 5= very strong. After application of deodorants for 5 days, three further odour determinations were carried out (t1, t2, t3). It was observed that odour at t1 had reduced equally for the control and active formulation. At t2 the subjects treated with the test active formulation still showed a reduction in odour, while the odour level in the control group had already reached the original base value. After 48 hours (t3) the subjects treated with test active also had the same level of odour as at the outset.

Figure 3 on page 6 also shows Sniff Test results for the deodorant formulation containing 2% of the test active and the control formulation. However, here the calculated percentage reduction in odour, using formula 1 was shown in relation to the initial value t0, for times t0, t1 (12 hours), t2 (24 hours) and t3 (48 hours). Similarly to Figure 2, a reduction in odour at time t1 that continued to reduce over time could be observed for the control formulation. The

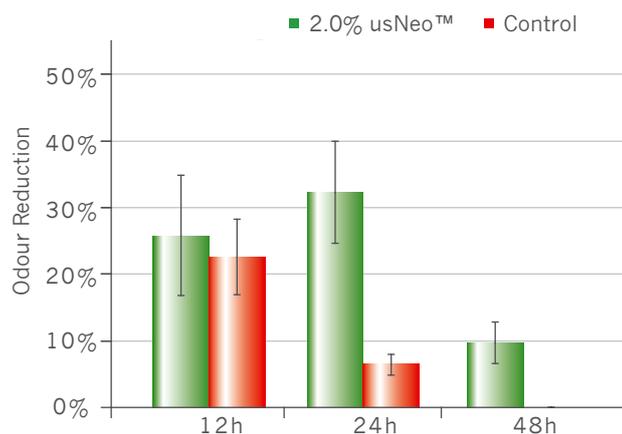


Figure 3. Odour Reduction Resulting from Sniff Test (Comparison of 2% usNeo™ Against t0)

deodorant formulation containing the test active caused a reduction in body odour for all three measurements.

Figure 4 shows the reduction of body odour after 5 days of using deodorant formulations containing 2% test active, 1% ethylhexylglycerin and 0.3% triclosan. Results are shown for measurement times t1 (12h), t2 (24h) and t3 (48h). 12 hours after last application of the deodorant formulations there was a reduction in body odour of 26% to 41%. The deodorant formulation containing triclosan showed the greatest reduction. At t2 (24 h) odour reduction by ethylhexylglycerin had reduced to 13%. Also reduction from triclosan had decreased (29%). At this point in time the test active caused an odour reduction of 32%. At t3 (48h) all three deodorant formulations showed a reduction in odour between 6% and 9%.

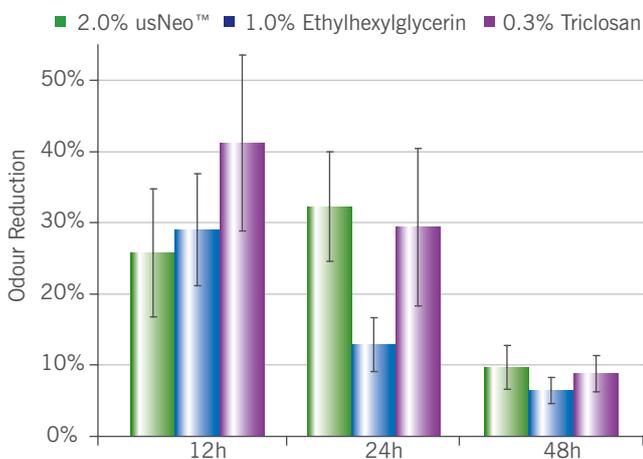


Figure 4. Comparison of Odour Reductions

## Bacterial Counts

The influence of deodorant formulations on bacterial counts in the underarm area was investigated by the determination of colony-forming units [CFU/mL]. Bacterial counts were obtained by plating out swabs taken in the underarm areas at measurement times t0 and t2.

Figure 5 displays logarithmic bacterial counts, determined at t0 (body odour base value measured at the end of the conditioning phase) and t2 (24 hours after the last deodorant application). Odour base value determined at t0 was approximately  $10^7$  CFU/mL. Bacterial counts of armpits treated with the control formulation at t2 (control) were similarly high ( $10^7$  CFU/mL) or higher ( $10^8$  CFU/mL). Treatments with deodorant formulations containing active ingredient (active) produced fewer consistent results: measurements were  $2 \times 10^6$  CFU/mL for treatment with the test active,  $5 \times 10^4$  CFU/mL for treatment with ethylhexylglycerin and only  $2 \times 10^3$  CFU/mL for treatment with triclosan.

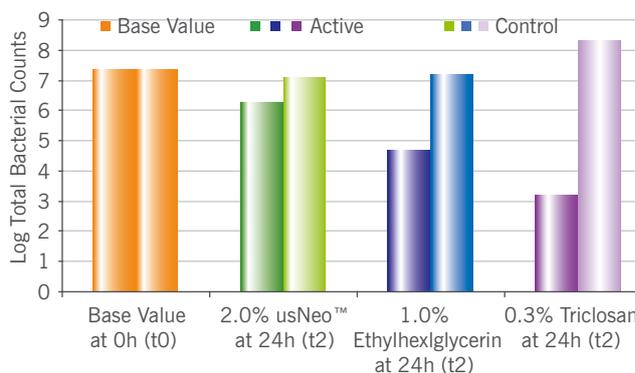


Figure 5. Comparison of Bacterial Counts at t0 and t2

Table 3 on page 7 shows the reduction in bacterial counts at t2 for treatments with 2% test active, 1% ethylhexylglycerin and 0.3% triclosan. Values shown are the results obtained from bacterial count reductions calculated individually applying Formula 2 for each test subject.

It can be seen that there are only very slight or no differences between the reduction of aerobic and anaerobic bacteria. When used at a concentration of 2%, the test active gave the least reduction in total bacterial count (86.45%). The use of 1% ethylhexylglycerin reduced the number of bacteria by 98.90% and 0.3% triclosan by 99.99%.

Active Ingredient	Concentration	Bacterial Reduction Aerobic	Bacterial Reduction Anaerobic	Bacterial Reduction Total
Test active	2.0%	86.60%	86.30%	86.45%
Ethylhexylglycerin	1.0%	98.80%	99.00%	98.90%
Triclosan	0.3%	99.99%	99.99%	99.99%

Table 3. Reduction in Bacterial Counts

## Discussion

The *in vitro* and *in vivo* tests performed were intended to investigate the effectiveness and safety of the test active. Since its effect is based on the antibacterial action against odour-causing bacteria, it was important to prove it possessed antimicrobial properties. In tests to determine minimum inhibitory concentrations, different microorganisms present on human skin and 'standard bacteria to test adequate preservation' as listed in the Pharmacopoea Europaea were employed. The results showed very good efficacy against Gram-positive bacteria. The growth of odour-forming *staphylococci*, *corynebacteria* and *propionibacteria* was inhibited at relatively low concentrations (0.05% to 0.25%) of the test active. Since the test active is not listed in the EU list of approved preservatives<sup>(16)</sup> coupled with the fact that it has rather low effectiveness against Gram-negative bacteria and moulds, the test active should not be used as a preservative. However it does completely fulfil the requirement to combat bacteria that cause body odour.

The theoretical deodorising effect of the test active was demonstrated in the MIC tests and subsequently proven in practical application in an *in vivo* study. The corresponding results are shown in Figures 2-4. Odour values determined at time t0 served as body odour base value. By using a pH neutral soap without perfume or deodorants, the individual body odour of test subjects could adjust to its natural level during the conditioning phase. The odour base value at time t0 was the same for both armpits since in both cases no deodorant was used. At t1 odour in both armpits was reduced by approximately one evaluation unit. This was primarily due to the previous shower as odour and odour-forming bacteria were reduced by washing. This effect was no longer observed at t2 in the armpits treated with control deodorant formulation (control), where body odour had reached its initial value after only 24 hours. Armpits treated with 2% test active however still showed a reduction in body

odour by one third compared to the base value. It was therefore possible to demonstrate that the test active had a deodorising effect that lasted 24 hours. At t3, 48 hours after application of deodorant formulations, body odour in armpits treated with 2% test active also had almost reached its initial value again. Any deodorising effects from preservatives could be ruled out since they were contained in both the control formulations and in the formulations containing the test active.

These results are much more obvious when displayed as body odour reduction (Figure 3) based on calculations using formula 1. Odour reduction results from the comparison of the base value at t0 and odour values measured at t1, t2 and t3. The effects regarding a reduction in body odour due to showering at t1 and the 24 hour deodorising effect of the test active at t2 already described and apparent from Figure 2, could also clearly be seen here. This other method of representing the results was chosen in order to make a meaningful comparison between the three deodorant formulations. In this way odour reductions of all three deodorant formulations at t1, t2 and t3 were compared in Figure 4. At t1 the test active and ethylhexylglycerin showed a comparable odour reduction of 26% and 29% respectively. The reduction in odour from triclosan was clearly higher (41%). These values however cannot be considered correct, since at that point in time, a body odour-reducing effect caused by showering must be taken in account for all three applications. Only after 24 hours (t2) odour reduction could be attributed solely to the effect of applying a deodorant. The test active (32%) and triclosan treatments (29%) were on a comparable level here. However, ethylhexylglycerin only showed around one third of the odour-reducing effect. At t3 all three formulations retained only a slight odour-reducing effect, with the test active showing the greatest effect at 10%.

Besides the effectiveness of the active ingredients in the Sniff Test, the influence of the deodorant formulation on the bacterial population in the armpit area was also investigated. The

numbers of colony-forming units determined at times t0 and t2 are shown in Figure 5. All six bacterial counts taken at t0 were on a similar level and were shown as a consolidated base value at t0. This is plausible since at the end of the conditioning phase (t0), all test subjects had detectable body odour (cf. Figure 2) and therefore high bacterial counts were to be expected. The Sniff Test established that after 24 hours, armpits treated with the control formulation had reached body odour base value again. This was also reflected in the corresponding bacterial counts at t2. Values of control formulations in test active and ethylhexylglycerin tests at t2 were only slightly below the base value measured at t0. Numbers measured after the application of the three active ingredients on the other hand differed greatly one from the other. In the Sniff Test, test active and triclosan applications showed similar deodorising effects at t2, but corresponding bacterial counts were completely different. After application of the test active, a bacterial count of  $2 \times 10^6$  CFU/mL was measured, corresponding to a bacterial reduction of 86.46% (see Table 3). Treatment with triclosan on the other hand, produced a bacterial reduction of 99.99% with an odour reduction similar to that of the test active. Likewise a high bacterial reduction of 98.90% was also achieved through treatment with ethylhexylglycerin. The test active caused the lowest reduction of total bacterial numbers in the axilla area and can therefore be considered to be the best out of the three deodorant actives tested at preserving the skin flora.

### Conclusion

Summing up the results the following statements can be made:

- The test active achieved the best 24 hour value in the Sniff Test and showed the best preservation of skin flora.
- Triclosan achieved the second best result in the Sniff Test with a 24 hour value comparable to the test active, however it eliminated the majority of the skin flora.
- Ethylhexylglycerin achieved the poorest 24 hour value in the Sniff Test and also eliminated a higher percentage of the skin flora than the test active.

In the Sniff Test the test active showed a comparable result to triclosan and was more effective than ethylhexylglycerin. At the same time it showed the lowest reduction of the total bacterial skin flora and can therefore be considered the most skin-friendly of the three deodorants tested. The test active provides effective plant-based deodorant activity without the negative properties associated with the organic chlorine based active triclosan. The research on allergy potential and the tests on

phototoxicity, mutagenicity and skin irritation carried out prove that the test active is safe to use. Therefore the test active formulated with a naturally active substance and a plant-derived solvent meets all the requirements when it comes to using a safe, effective and modern deodorant.

### References

1. Benohanian A. Antiperspirants and deodorants. *Clin Dermatol.* 2001; 19(4):398–405
2. Kanlayavattanakul M, Lourith N. Body malodours and their topical treatment agents. *Int J Cosmet Sci.* 2011; 33(4):298–311
3. Taylor D, Daulby A, Grimshaw S, James G, Mercer J, Vaziri S. Characterization of the microflora of the human axilla. *Int J Cosmet Sci.* 2003; 25(3):137–145
4. Bhutta MF. Sex and the nose: human pheromonal responses. *J R Soc Med.* 2007; 100(6): 268–274
5. Curran A, Rabin S, Furton K. Analysis of the uniqueness and persistence of human scent. *Forensic Sci Commun.* 2005; 7, 2
6. Preti G, Willse A, Labows JN, Leyden JJ, Wahl J, Kwak J. On the definition and measurement of human scent: comments on Curran et al. *J Chem Ecol.* 2006; 32(8):1613–1616
7. Herder. *Lexikon der biologie vierter band,* Spektrum Verlag; 1994
8. Plinius. *Naturkunde.* 35,52
9. Holbrook W P. *In vitro* activity of usnic acid against *staphylococcus aureus* and MRSA. Poster at a Joint Meeting of BDSR and NOR, 3-5 April (2007)
10. Ingólfadóttir K. Usnic acid. *Phytochemistry.* 2002; 61(7):729–36
11. Cocchietto M, Skert N, Nimis PL, Sava G. A review on usnic acid, an interesting natural compound. *Naturwissenschaften.* 2002; 89(4):137–46
12. Opinion on triclosan, SCCP, COLIPA n° P32, 19<sup>th</sup> plenary January 21<sup>st</sup> 2009
13. Triclosan: What consumers should know. FDA Consumer Health Information. 2010
14. Adolfsson-Erici M, Pettersson M, Parkkonen J, Sturve J. Triclosan, a commonly used bactericide found in human milk and the aquatic environment in Sweden. *Chemosphere.* 2002; 46(9-10):1485-9
15. Triclosan Facts, <http://www.epa.gov>
16. Regulation (EC) No 1223/2009 and 76/768 of the European Parliament and of the Council of November 2009 on Cosmetic Products; Annex V

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Julian Smits graduated in 2009 with a Dipl.-Ing. (FH) in Bioengineering at FH Aachen, Jülich Campus - University of Applied Sciences. He wrote his diploma thesis at TU Dresden, Institute of Molecular Cell Physiology and Endocrinology. He is currently a member of the R&D group at Cosmtochem International AG.

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Norbert Herbst is an engineer in Chemistry, Biotechnology and Economics. He spent 6 years as a scientist and Head of Cell Culture Fermentation at Schering-Plough Research Institute. This was followed by 4 years as Head of Production at Swiss Dairy Food Ltd. / Hochdorf Ltd., then 4 years as Operations Manager at Frutarom Switzerland Ltd. He is currently Head of R&D and Engineering at Cosmtochem International AG.

