

Microbiological Quality Management for the Production of Cosmetics and Toiletries

Author: Wolfgang Siegert, Schülke & Mayr GmbH, Germany

Introduction

Most cosmetics and toiletries contain water and a lot of ingredients are good nutrients for microorganisms. The demand to use compounds, which are readily biodegradable leads to improved growth conditions in modern formulations. Cosmetic production is not a sterile process and at least the storage temperature is nearly optimal for microbial growth. All factors for microbial attack (Figure 1) are fulfilled.

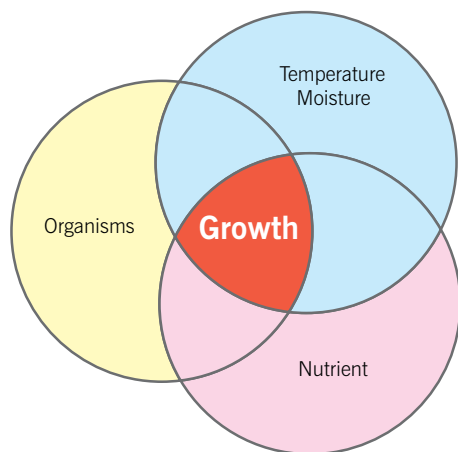


Figure 1. Basic conditions for microbial growth

To produce microbiologically faultless cosmetics and toiletries an integrated microbiological quality management is necessary, consisting of good raw material quality, good production hygiene and a validated preservative system. The influence of the non-woven, the production process, the choice of preservatives, preservative efficacy testing, responsible care and hygiene measures have also to be taken into consideration.

The Guidelines for Good Manufacturing Practice of Cosmetic Products (GMPC) from the Council of Europe are recommendations for the guidance of cosmetic manufacturers. The microbiological quality management (MQM) is a part of GMPC.

2. The need of preservation

Microorganisms can grow on almost every substance existing in nature and are often able to attack or even decompose them.

The biological degradation has to be stopped for a certain period. A preservative must be added, but for environmental reasons the preservative should be biodegradable, too. This is no conflict; for example at a concentration of ethanol between 50 and 90 % it is a good disinfectant, between 13 and 50 % it acts as preservative, but below 13 % ethanol will be biologically degraded to acetic acid (Figure 2).

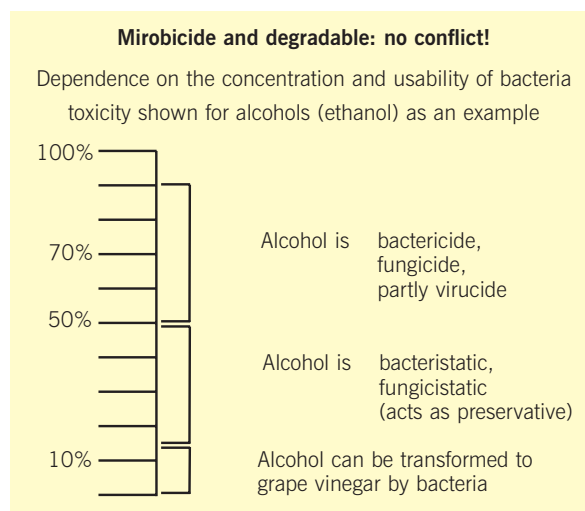


Figure 2. Microbial degradation of ethanol

3. The choice of preservatives

To select a preservative we have first to follow the legal demands. Not all actives are permitted in all markets like Europe, USA or Japan. Some actives are not permitted for baby products or contact with mucous membranes. Critical applications like wet toilet paper need special attention. Of course the preservative must be effective in the formulation. Incompatibilities with other ingredients of the formulations have to be avoided to guarantee the efficacy of the preservative over the whole shelf life of the product. Often marketing aspects like "free" of halogenated compounds, not animal tested or no negative assessment in test magazines will influence the decision for a preservative system.

Preservatives

All products that are claimed for cosmetic application have e.g. in Europe to be preserved according to the EU Cosmetic Directive. From the legal side all products from the Euxyl® range are permitted. For leave-on not all actives can be used. Special attention is necessary for the selection of preservatives for baby products, wet toilet paper, products for oral hygiene or products used near the eyes. They are used on sensitive skin areas, preservatives with a low sensitisation potential should be used. The use of Euxyl® K 702, based on Phenoxyethanol, Benzoic Acid, Dehydroacetic Acid, showed good skin tolerance, no allergies have been reported from the market within the last few years. Attention should be paid to the pH value when Euxyl® K 702 is used, it should be \leq pH 5.5, as only the free acids act as preservatives (figure 3).

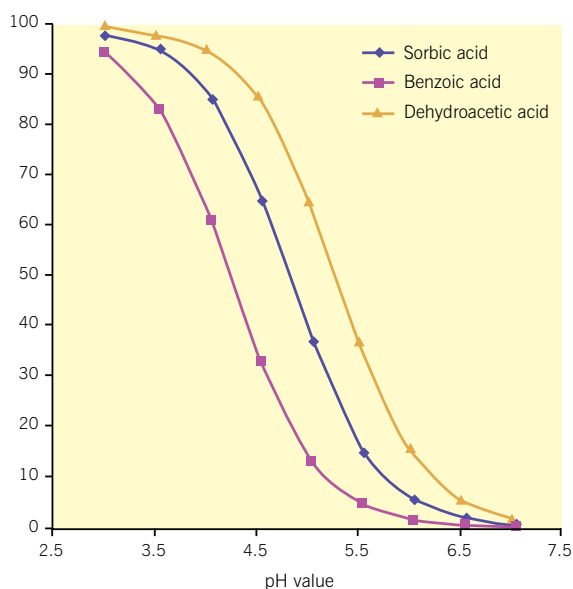


Figure 3. Amount of undissociated acid depending on the pH value

A new concept is the combination of two world-wide accepted ingredients - Phenoxyethanol with Ethylhexylglycerin as preservative enhancer (Euxyl® PE 9010). Based on its water solubility it can be used in clear gels, which is often a problem with Paraben based preservatives. The effectiveness of Euxyl® PE 9010 in several cosmetic formulations is far better than expected from the Phenoxyethanol. The only limitation is the use in formulations with higher detergent content like shampoos.

4. The MQM concept

Microbiological quality management (MQM) concept includes the following main topics:

- > Raw material
- > Formulation
- > Preservation
- > Production hygiene
- > Hygienic design

5. Hygienic design

From our experience often the issues of hygienic design and production hygiene are not observed properly. If unfavourable constructions and design as shown in figure 4 - 6 are present, it will be difficult to clean and disinfect the production line.

Often the question: "Is the system suitable for the intended use", should be answered negatively. In this case we recommend a review of production, design and engineering.

6. Cleaning procedure

For the cleaning evaluation a series of questions are useful:

- > Are there SOP's for cleaning and disinfection?
- > Does a hygiene plan exist?
- > Are the cleaning and disinfection procedures validated?

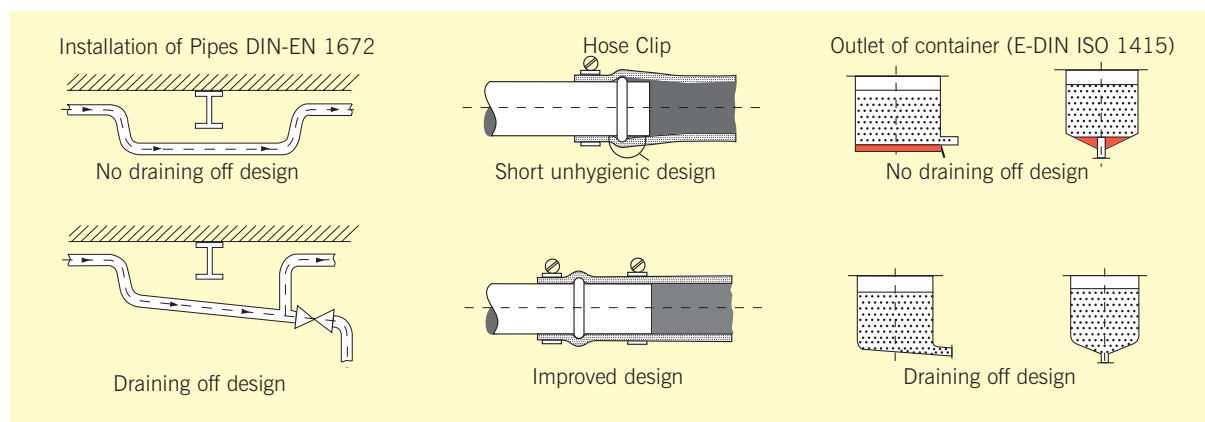


Figure 4

Figure 5.

Figure 6.

- > Is there a risk of recontamination with rinse water?
- > Are there fixed max. holding times for raw and bulk materials?
- > Are recycled packaging materials included in the disinfection plan?
- > Is the flooring included in the hygiene plan?
- > Who is responsible for cleaning/disinfection?
- > Are there checks and measures in place to control the above
- > etc.

7. Raw material quality

The raw material quality is an important factor. The following list shows some of the recommended measures and limits:

- > low microorganism content (< 1000 cfu/ml)
- > fixing microbiological limits in the raw material specification
- > random controls (e.g. with Mikrocount® combi - see figure 7)
- > special attention to water as raw material is necessary
- > ion exchanger common source of contamination
- > storage under good hygiene conditions (cool, dry, covered)
- > use "first in - first out" concept

4. Establish monitoring procedures.
5. Establish corrective actions.
6. Establish verification procedures.
7. Establish record-keeping and documentation procedures

The Critical Control Point (CCP) is the stage, step or phase, by which an endangerment is eliminated by purposeful and controlled measures or reduced to an acceptable level with the goal, to prevent, eliminate or reduce to an acceptable level the occurrence of the identified safety hazard.

8.2 Physical hazards

Often forgotten is the possibility of physical hazards. Especially food retailers ask during an audit for the control of physical hazards. The main risk is inclusion of glass or other sharp-edged impurities which can lead to cuts and bleeding. Possible sources are bottles, jars, light fixtures or utensils. Normally shatter proof light fixtures are requested.

8.3 Biological hazards

From the cosmetic directive a cosmetic put on the market within the community must cause no damage to human health when

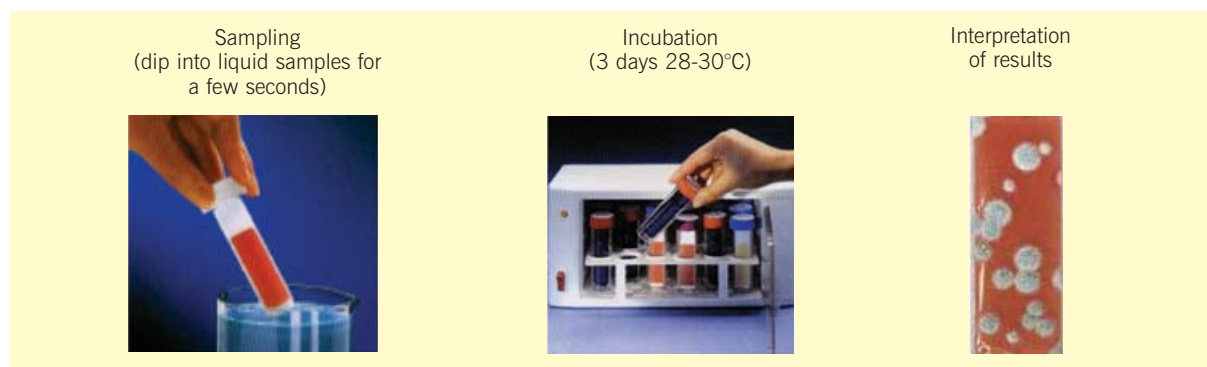


Figure 7. Evaluation of microbial contamination with Mikrocount® combi

8. The HACCP analyses

HACCP is a systematic approach to the identification, evaluation and control of product safety hazards.

8.1 HACCP Principles

The HACCP principles are defined by the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) as follows:

1. Conduct a hazard analysis.
2. Determine the critical control points (CCP's).
3. Establish critical limits.

applied under normal or reasonably foreseeable conditions. Which means biological hazards caused by pathogenic microorganisms which can be a risk for the consumers health have to be excluded. Additionally the product has to be stable if no minimum durability is labelled to at least 30 month. A product spoilage caused by microorganisms has to be also avoided.

8.4 Challenge testing

The stability of a cosmetic product has to be proven in a microbiological challenge test, e.g. the Koko test. In this test, a mixture of bacteria, yeast and moulds are inoculated 6 times

Preservatives

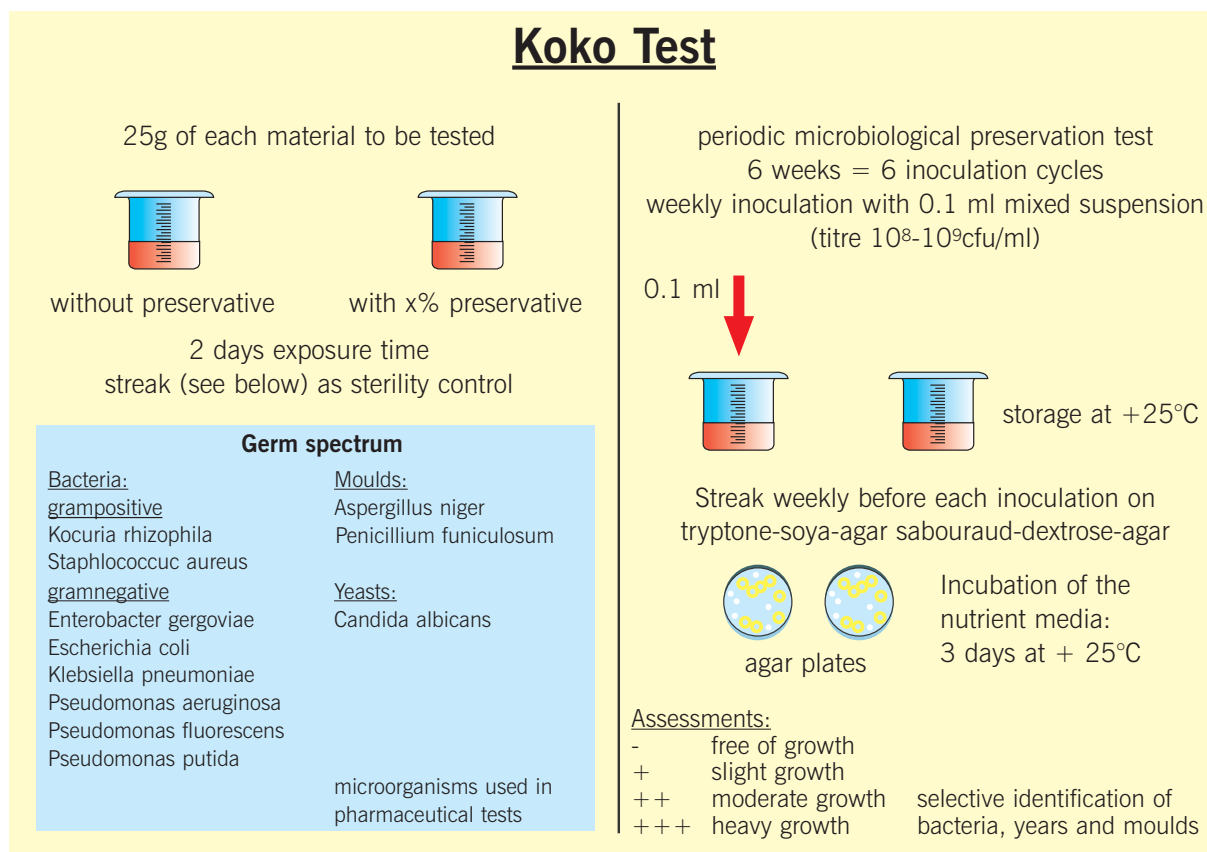


Figure 8. Evaluation of the microbial stability of cosmetic formulations

(once a week) into the test material (see figure 8), with the goal of keeping the test material germ free for this period. The inoculum contains pathogenic microorganisms such as germs which are well known for product spoilage. All species have to be cultivated separately and mixed directly before the addition, to ensure a constant composition and germ count of the inoculum. Its germ count is approximately 10^8 - 10^9 cfu/ml, which means a germ count of approximately 10^6 cfu/ml in the sample. A sample can be called well preserved, if it passes a period of six weeks under the above described laboratory conditions without showing microbial growth on the test batches. That means even after the sixth inoculation no microbial growth can be observed. From many years experience in the use of this test method these results can state the microbiological stability of 30 months which is recommended for cosmetic products.

8.5 Critical raw materials

In principle water and all water diluted raw materials can be contaminated. Highly concentrated materials are less critical and seldom contaminated. Water free but water solvable compounds

are normally safe. Water insoluble compounds can have a small water phase e. g. caused by condensing water. In the water phase microbial growth can occur. We have seen bacterial contamination in white oil and yeast contamination in natural oils in the past. Proper housekeeping which means regular draining of a condensing water phase is necessary for a safe storage of such compounds.

8.6 The total amount of preservative

The total amount of preservative is the sum of:

- > the preservative added to the water phase
- > the preservative added to the oil phase
- > the preservative added to the finished product
- > the preservative added to a premix
- > the preservative in the raw materials

The producer should know which and how much preservative is in the raw materials, if the preservative in the raw material changes the preservation may fail.



8.7 How to make sure the preservative is really added?

From our experience one of the main reasons of the failure of a preservative in a cosmetic product which has passed the preservative test is just to forget to add it. We recommend for a manual dosing to use the “four eye” principle. To guarantee this we recommend that one person is weighing the small compounds and provide a set of these raw materials for each batch. In the production another will control them and dosing them to a batch. For automatic dosing you should prefer mass flow-meters. Volumetric systems are less safe and dependent on the temperature. For these at least an alarm for an empty dosage system is necessary because these systems will also measure air.

8.8 Critical process

A hot process e.g. at 80°C will eliminate most contamination from the water and raw materials. In difference to this a cold process cannot eliminate this risk which means that the raw material quality will be a more critical factor.

Also highly viscous systems are more difficult to cope with. Often a preservative cannot be added at the end of the process which limits the possible selection of preservatives. Often the material is already filled at a higher temperature which leads to an increased formation of condensing water. A preservative which provides head space protection becomes more important.

8.9 Critical downtime

Long cold unpreserved phases (>3 h) should be prevented during the production process. The staff has to be trained that even during unplanned downtime this is guaranteed. We recommend installing special QC checks if a longer period occurs by accident. A typical mistake which lead to longer unpreserved phases is to add the water to a vessel the day before to be quicker at the next day in the first batch. If the water is preserved of course this can be done, but unpreserved it should never happen.

8.10 Critical contamination - control of bacillus spec.

Bacteria spores are difficult to kill. Temperatures above 100 °C are needed to kill them. Chemically, high amounts of formaldehyde or glutaraldehyde can kill bacterial spores as well as oxidising agents like chlorine, hydrogen peroxide or peracetic acid. Preservatives control only the vegetative form of bacillus species, but do not kill their spores. To prevent bacillus contamination in a cosmetic product they should not be present in the raw

materials. Specially critical could be raw materials derived from roots, leaves or mud. Of course any multiplication of bacillus species in pre-solutions has to be prevented. Which can be managed by the addition of normal preservatives. Bacillus spores should also not be brought in during the production process. That means no soil or dust should get into the product.

8.11 Change control

If anything is changed, in the formulation, in the raw material quality, in the production process or in the batch size the change has to be analysed if it has an influence on the microbial stability of the formulation.

Supposed minor changes can have severe influence on the susceptibility to microbial growth. For example a perfume composition can be a synergist to the preservative system. One glycol will reduce the active water value more than another. An extract can contain biocidal compound which another will not contain.

The same INCI name does not mean necessary the same compatibility. Often the impurities lead to more incompatibilities than the chemical itself. For example the change from carbomer in powder form to a liquid form has shown dramatic effects. The liquid material contained sulphite impurities from the polymerisation process, which destroyed the isothiazolinones which has been used for the preservation of the end product. Also sulphonates based on the production process can contain high amounts of sulphite.

Different pH values of raw materials have to be adjusted in the finished product. Otherwise the stability can be influenced or pH value can get out of activity limits of the preservative actives.

The upgrading of a formulation to a bigger batch size is not only critical for the galenic properties of emulsions. The bigger batch size leads to a longer heating period which means a good sanitation of raw material contamination but a possible destruction of biocides. The longer cooling period can lead to growing conditions for microbes before the preservative is added but also to a better distribution of the preservative in the water phase caused by the longer stirring time.

Normally the microbiological challenge test is done during the development of a formulation. A re-validation should be performed with the first production batch. Each change should be secured by a new microbiological test.

Preservatives

9. Plant hygiene checklist

The following checklist can help to identify critical points

- Treat water supply
- Add biocide as first raw material if the following process will not destroy it e.g. by to high pH value or to high temperature
- Protect pre-solutions with biocide
- Do not allow surface pooling of condensation
- Clean down frequently and thoroughly
- Add biocide to residual wash water
- Use a biocidal wash
- Avoid long pipework runs, dead spots, sharp bends
- Keep flexible hoses clean/dry
- Pay attention to filling machinery
- Keep empty containers and lids clean/dry
- Be aware of problems with plastic containers such as electrostatic attraction
- Keep the factory as clean as possible

10. Staff hygiene

The human factor plays a decisive role in the spread of microorganisms. In every manual operation in the production process there is a transfer of organisms from operator to product and to machine. After every break in work, hands which may appear clean should be disinfected, e.g. with an alcoholic rub-in disinfectant. Rings and bracelets should not be worn at work, as they hinder cleaning and disinfection. Care should obviously be taken to ensure that finger-nails are clean.

Minor wounds on fingers and hands must be carefully covered; fingerstalls or gloves are the appropriate protection.

The work clothing must also be regarded as a further source of contamination. The rule should be clothing that is always clean.

Hair is also a major microorganisms carrier. The wearing of caps should be obligatory. However, these caps must not be merely symbolic.

All these procedures must also apply to the factory manager, to visitors, and to engineers. Hygiene cannot be prescribed - it must be supported by training and the example of the management.

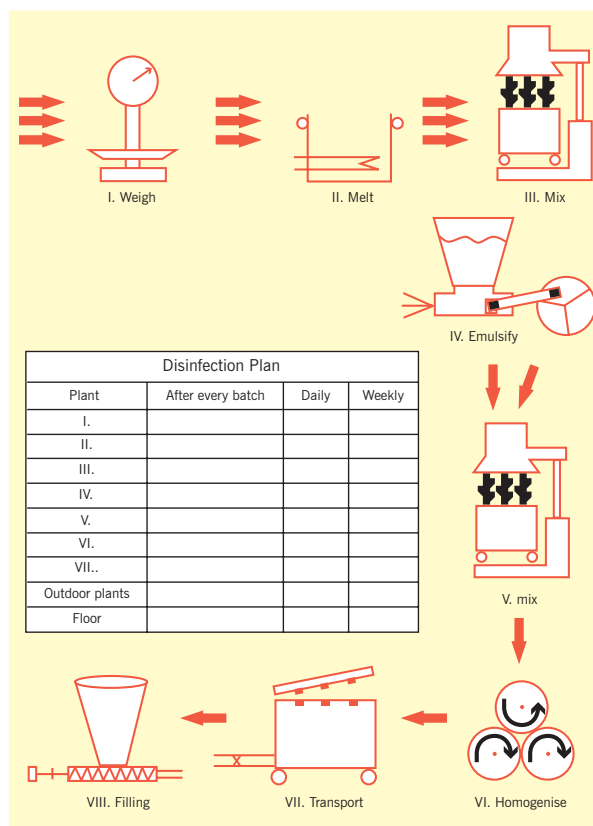


Figure 9. Example of a hygiene plan

11. Hygiene plan

For the efforts to improve production hygiene to be consistent, and in order to ensure and monitor the hygiene programme which must be introduced to this end, the following are required:

- the drawing-up of an organisation plan including a hygiene plan
- the carrying out of factory checks,
- the setting up of an in-house hygiene committee and the appointment of a hygiene consultant.

If possible, the hygiene consultant should not come from the direct work area, and he or she should be independent.

The hygiene plan sets out what, with what, how often, when and by whom the cleaning and disinfection must be carried out. Figure 9 gives an example of a hygiene plan which can be adapted to individual factory conditions. The cleaning and disinfection measures are decided on in accordance with the production process and product-specific conditions, and entered in the hygiene plan.

12. Summary

There are many parameters which can influence the quality of cosmetics.

In order to achieve a high quality, all these factors must be optimally adjusted to each other.

There are many ways in which a product can be contaminated by microorganisms. These then multiply to produce high bacterial counts. There are two ways of keeping them under control:

- ❑ good production hygiene
- ❑ a suitable preservative.

In order to be economical, and at the same time in order to minimise the toxicological risks for man and the environment, important conditions must be taken into consideration when choosing chemical preservatives.

It is necessary to analyse the procedures including the purchase of microbiologically faultless raw materials and auxiliary substances and the storage conditions to avoid loss of quality in raw materials. Intermediate products, the bulk goods and finished products and their storage, the validated cleaning and disinfection plans for the plant, and optimised toxicologically safe and environmentally acceptable preservation. A reduction of the

costs of preservation by avoiding over-dosing is possible. With this should come a simultaneous reduction in the number of customer complaints and hence an avoidance of a loss of image and the cost of disposal of material.

References

1. S. Leaper: The Campden Food and Drink Association; Technical Manual No. 38 HACCP: Practical Guidelines
2. DIN EN ISO14199 Safety of machinery - Hygiene requirements for the design of machinery
3. DIN EN 1672-2, Food processing machinery - Basic concepts - Part 2: Hygiene requirements
4. Karl-Heinz Wallhäußer: *Praxis der Sterilisation - Desinfektion - Konservierung*
5. Karl-Heinz Diehl: *Sicherung mikrobiologischer Produktqualität bei Kosmetika* Seifen - Öle - Fette - Wachse, 117. ed., No. 20/1991
6. K.-H. Diehl: *The key to microbiological quality assurance* Seifen - Öle - Fette - Wachse, 3/92
7. K.Weber, J.Siebert: *Organic acids, mild cosmetic preservatives, low sensitisation potential, comparative tests, colour stability* SÖFW-Journal 6/2003

Biography

Dipl. -Ing. Wolfgang Siegert

Trained as a Chemical Laboratory Assistant at Reichhold-Chemie. He studied chemical engineering technology and joined Schülke & Mayr in 1974. He started his job with the development of disinfectants and insecticides for veterinary application, followed by the development of synthesis methods for special chemicals and the management of the pilot plant. In 1985 he became head of the Application Department which advises customers in industry on microbiological quality management including the selection of preservatives and disinfectants.

Purchase Cosmetic Science Technology

Cosmetic Science Technology is the industry's leading reference book. It is published annually and is the only hardback sourcing guide for use by formulators, Heads of Research and Development, chemists and buyers working in the cosmetic and toiletries industry. Concise, comprehensive and accurate data on the latest raw materials and research is available in one definitive volume. Cosmetic Science Technology provides its readers with up-to-date, high quality, in-depth technical articles, covering all of the industry's main developments.

For purchase details, see our web site:
www.cosmeticsciencetechnology.com