Bactericidal Activity of Quaternium-15 and Its Decomposition Products against Aerobic Bacteria

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Abstract

Quaternium-15 (QN) is a formaldehyde (FA)-releasing substance used in cosmetics as an antimicrobial preservative. The purpose of this study was to examine the bactericidal properties of cosmetics containing QN. The amount of FA was measured in five types of commercial cosmetics containing QN. FA was detected in all the samples analyzed, and free FA concentrations ranged from 106.4 ppm to 493.5 ppm. However, QN was undetectable in the cosmetics samples (<0.001 w/w%). Preservative effectiveness testing was performed on these cosmetics using three strains of aerobic bacteria as test microorganisms (Staphylococcus aureus, Pseudomonas aeruginosa, and Bacillus subtilis). Bactericidal activity against the three bacteria was determined for all cosmetics samples. The release of FA due to QN decomposition was investigated. An aqueous QN solution (0.3 w/v%) was stored at a constant temperature of 25°C; the concentration of FA reached approximately 350 ppm after 50 days. QN concentration decreased over time and reached an undetectable level after 50 days. QN decomposition products other than FA were confirmed in this solution using high-performance liquid chromatography (HPLC) analysis. Bactericidal activity against S. aureus, P. aeruginosa, and B. subtilis was determined for QN. Further, similar bactericidal activity was found for QN decomposition products other than FA. Thus, QN and its decomposition products, including FA, play a major role in the preservative effect of cosmetics containing QN, and this effect was maintained at a virtually constant level for a long period.

Key words: quaternium-15, decomposition product, formaldehyde, bactericidal activity, aerobic bacteria.

1. Introduction

Preservative compounds are used in cosmetics to prevent microbial contamination. Some of these preservatives include formaldehyde (FA)-releasing compounds that release FA via decomposition or degradation1-3). The antibacterial activity of these compounds is mostly attributable to the release of FA, and in some cases, their chemical composition.

Quaternium-15 (QN) is a cosmetics preservative known by a variety of alternative names (e.g., Dowicil 200 and Dowici 175)4). It is used in cosmetic products at concentrations ranging from 0.1–1.0 w/w%5). The empirical formula and the chemical structure of this quaternary ammonium salt are shown in Fig. 1. QN cannot be used as a cosmetics preservative in Japan but has been widely used as a cosmetics ingredient in other countries6,7), including the U.S.A., Canada, the European Union, and the Association of Southeast Asian Nations.

Although studies have been conducted on the antimicrobial activity of QN8,9), the details of its antimicrobial properties have not been investigated because the molecule is unstable in an aqueous solution10). It has only been suggested that the free FA released during QN decomposition plays an important role10). FA is commonly known as an antibacterial substance11,12); however, there has been no demonstration that the antimicrobial activity of QN is exclusively attributable to the FA released during decomposition.

The aim of this study was to examine the bactericidal activity of QN and its decomposition products against aerobic bacteria, and to investigate the temporal change in the bactericidal activity upon QN decomposition.

2. Materials and Methods

2–1. Reagents

All reagents were purchased from Wako Pure Chemical Industries, Ltd. (Osaka, Japan).

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