Talanta 80 (2009) 1016–1019

Contents lists available at ScienceDirect

Talanta

journal homepage: www.elsevier.com/locate/talanta

Short communication

Analysis of polyhexamethylene biguanide in multipurpose contact lens solutions☆

Anne D. Lucas*, Edward A. Gordon, Melvin E. Stratmeyer

U.S. Food and Drug Administration, Center for Devices and Radiological Health, OSEL/DB, 10903 New Hampshire Ave, Bldg 64 Room 4011, Silver Spring, MD 20993, USA

ARTICLE INFO

Article history:
Received 8 June 2009
Received in revised form 15 July 2009
Accepted 16 July 2009
Available online 23 July 2009

Keywords:
Contact lens
Polyhexamethylene biguanide
Liquid chromatography

ABSTRACT

The objective of this study was to establish a reasonably simple and reliable method to measure very low concentrations of polyhexamethylene biguanide (PHMB) in multipurpose contact lens solutions (MPSs). By using a weak cation exchange solid phase extraction cartridge to extract the PHMB from MPS, followed by HPLC analysis using an evaporative light scattering detector, low levels (0.1 ppm) of PHMB were detected. Application of this method to a series of off-the-shelf MPS with PHMB as the active ingredient demonstrated these solutions contain 1 ppm. The contact lens solution with hydrogen peroxide as the active ingredient gave no peak where the PHMB peak eluted. The Polyquad® contact lens solution generated a peak close to the retention time of PHMB. Recovery of PHMB from fortified hydrogen peroxide contact lens solution was good at 0.25 ppm and above; 105% with a RSD of 17% or less. The repeatability of the HPLC system ranged from 4 to 11% RSD; the reproducibility of the entire method was less than 17.5% RSD. Storage and stability studies indicated that storage of MPS with PHMB for chemical analysis are not temperature dependent, but are affected by the composition of the container in which the contact lens solution is stored.

Published by Elsevier B.V.

1. Introduction

PHMB[1] (polyhexamethylene biguanide) is a chemical germicide used in a variety of applications: as a preservative in wet wipe, to prevent microbial contamination in wound irrigation and sterile dressings, and to disinfect medical/dental utensils and trays. PHMB is also used as an active ingredient for recreational water treatment, in cosmetics, personal care products, fabric softeners, contact lens solutions, and hand washes [1]. This widely used biocide has been reviewed by EPA and noted, with the exception of occupational handlers, as having very low aggregate risk of adverse health effects to the public or environment [2].

This compound is a challenge to quantitate at low levels because it is a mixture of polymers with no distinctive chromophores [3] and is a polyelectrolyte with a mix of end groups [4]. Dye-binding assays [5–7] have limits of detection around 5 ppm and greater; the concentration of PHMB in some contact lens solutions is 1 ppm. High pressure liquid chromatographic (HPLC) using photodiode array detectors also are not sensitive enough because UV absorption of PHMB is too weak [7–9]. The mix of different end groups of the PHMB polymer prevents the possibility of quantitative derivitization. A capillary electrophoresis (CE) method [10] for determination of PHMB in eye drops was described with a limit of detection of 4 ppm. Other means of PHMB analysis include titrimetric methods [11] that do not have adequate levels of sensitivity or potentiometric titration methods that involve custom synthesis [12]. There appears to be no established method for measuring PHMB in contact lens solution or at sub-ppm levels.

In this paper, a method to reliably measure PHMB at sub-ppm levels in MPS[2] (multipurpose contact lens solution) is detailed. This was accomplished by developing a solid phase extraction method followed by HPLC analysis using an evaporative light scattering detector.

2. Materials and methods

2.1. Reagents and solutions

Several commercially available brands of MPS were purchased from local stores; six different brands contained PHMB as the active ingredient, two contained hydrogen peroxide, and the last one contained Polyquad® as the chemical disinfectant. Methanol and acetonitrile were obtained from Fisher Scientific (Waltham, MA, USA), and triethylamine (TEA), trifluoroacetic acid (TFA), and formic acid (FA) were from Sigma–Aldrich (St. Louis, MO, USA). Deionized water was produced with a Barnstead NANOpure Diamond water

☆ The mention of commercial products, their sources, or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products by the Department of Health and Human Services.

* Corresponding author. Tel.: +1 301 796 0283; fax: +1 301 796 9826.
E-mail address: anne.lucas@fda.hhs.gov (A.D. Lucas).

[1] Polyhexamethylene biguanide.

[2] Multipurpose contact lens solution.

0039-9140/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.talanta.2009.07.031

purification unit. The PHMB, trade name Cosmocil CQ (a 20% solution in water), was graciously donated by Arch Chemical Company (Norwalk, CT, USA).

2.2. HPLC method

Samples were analyzed using a Waters HPLC system, equipped with 515 pumps, a 717 plus autoinjector, a 996 photodiode array detector and an evaporative light scattering detector (PL-ELS2100, Polymer Laboratories) with Waters Empower chromatographic software. Settings for the evaporative light scattering detector were: evaporator 111 °C, nebulizer 80 °C, zero-grade nitrogen at 1.6 SLM (standard liters per minute). The photodiode array detector was set at 254 nm, but was not used for quantitation. Separation was performed on a Supelco Supelcosil™ LC-8 column (5 cm × 4.6 mm, 5 μm). The mobile phase component was 100% deionized water held isocratically for 4 min, then an immediate change to 50:50 water: a solution composed of acetonitrile (76%), water (9.5%), triethylamine (5%), and formic acid (9.5%), pH adjusted to 3.1 with formic acid for the next 2 min, then a linear gradient back to 100% water at 10 min. The flow rate was 2 ml/min and the injection volume was 0.25 ml.

2.3. Extraction of contact lens solutions

Extraction and concentration of PHMB from MPS were performed with weak cation exchange solid phase extraction cartridge from Waters (WCX Oasis 1 cc, 30 mg). Cartridges were first prewashed with two column volumes of 50:50 acetonitrile:distilled deionized water with 0.25% TFA, then two column volumes of acetonitrile, followed by two column volumes of distilled deionized water. Five ml of sample were then loaded onto the cartridge followed by washing with two column volumes of water, then with 0.5 ml of 50:50 acetonitrile:water with 0.02% TFA. PHMB was eluted with 0.5 ml of 50:50 water:acetonitrile with 0.25% TFA directly into 8 mm × 40 mm HPLC vials. Injection volume for the HPLC was usually 0.25 ml. HPLC vials were pre-washed with 50:50 water:acetonitrile with 0.25% TFA, then acetonitrile and left to air dry prior to use.

2.4. Storage stability studies

MPS brand A was used to examine the storage and stability of PHMB at three different temperatures (25 °C, 4 °C, and −20 °C). Using aseptic technique, approximately 20 ml of the MPS was placed in each of 12 separate 50 ml polypropylene test tubes. Four of these test tubes were left at room temperature (25 °C); four were placed in the refrigerator (4 °C), and four in a standard freezer (−20 °C). Over time, one test tube from each different temperature locale was removed and triplicate aliquots of 5 ml were extracted as previously described. In addition, the stability of PHMB in glass vials compared to polypropylene test tubes was examined by aseptically placing 20 ml of MPS brand A in glass or polypropylene containers and leaving them overnight at room temperature. The following day, triplicate extracts of the MPS brand A stored in glass vials was compared to triplicate extracts stored in polypropylene test tubes.

3. Results and discussion

3.1. Evaluation of dye binding methods

Initially, the colorimetric methods were explored because of the potential for high throughput and low cost. The method described by Rowhani and Lagalante [7] was tested first. However, the absorbance from a MPS with PHMB was roughly 100 times higher than the PHMB standard concentration. Other compounds in the MPS were probably exerting a large positive influence in this assay. The second colorimetric assay evaluated was detailed by Rosenthal et al. [5]. Again, the MPS overestimated the amount of PHMB, but only by a factor of four. The third colorimetric assay [6] overestimated the PHMB concentration in MPS by a factor of five. In addition, none of these assays were very sensitive; all the colorimetric methods had limits of detection around 5 ppm or greater. Because MPS labels state a concentration of 1 ppm of PHMB, a more sensitive and selective method was needed.

3.2. Solid phase extraction

A series of solid phase extraction cartridges were evaluated in sample extraction. Although PHMB is a cation, an anion exchange column and a lipophilic column were examined to see if they would trap interfering substances while permitting PHMB to pass through. However, significant interfering substances eluted with the PHMB from both the lipophilic and strong anion exchange columns. The weak and strong cation exchange columns were used to trap the PHMB while allowing most interfering substances to elute. Because it was possible to elute PHMB from the weak cation exchange column using less caustic conditions, this was the cartridge chosen. Coupling the solid phase extraction method to the colorimetric assays did not work as the strong acid needed to elute the PHMB occupied the binding sites for the dyes.

3.3. Detector performance

Although the reproducibility of the evaporative light scattering detector (ELSD) has been noted to be worse than UV [13] and the use of a gradient increases the variability of the analyte signal [14], this is a more sensitive detector for compounds without chromophores. The light scattering by the solute after removal of the eluent is measured [13]; detection is dependent on the amount of solute. Fig. 1 illustrates the difference between using an ELS detector (Fig. 1A) and a UV detector (Fig. 1B) in detecting PHMB extracted from contact lens solution brand A. The Refractive Index detector is useful for detecting compounds that do not absorb UV, it is not useful for gradient elution [15]. Attempts to generate a useful ion for mass spectroscopy with electrospray or atmospheric pressure ionization were not fruitful.

3.4. Recovery

MPS contain salts, surfactants, and other additives, as well as the active biocide; although not all brands are identical chemically or in quantity. Because the hydrogen peroxide contact lens solution gave no peak near the retention time of PHMB, it was used in the recovery studies as the best available approximation of a blank MPS. Recovery of hydrogen peroxide MPS fortified with 0, 0.125, 0.25, 0.5, and 1.0 ppm PHMB are depicted in Fig. 2. The recovery was determined from triplicate experiments each with triplicate samples. Recoveries were good, 107%, at the 0.25 ppm level and above (RSD 17% or less), but the error at the 0.125 ppm level was quite large (RSD 66%). The bias towards high recovery at low levels is likely due to intergration errors because of the steep gradient used and the increasing background and error of the detector over time (Section 3.6 Table 1).

3.5. Evaluation of commercially available contact lens solutions

Six different MPSs with PHMB as the active ingredient were purchased at local stores and analyzed. Fig. 3 details the PHMB levels found in these six different MPS with PHMB; the data represent triplicate experiments with each contact lens solution run in triplicate. The PHMB concentration in all the MPS was 1 ppm with RSD of 17.5% or less; this supported the utility of the method. The contact

Download English Version:

https://daneshyari.com/en/article/1246798

Download Persian Version:

https://daneshyari.com/article/1246798

Daneshyari.com