HHS Public Access

Author manuscript

Dermatitis. Author manuscript; available in PMC 2021 August 23.

Published in final edited form as:

Dermatitis. 2021 ; 32(4): 245–250. doi:10.1097/DER.0000000000000672.

Isothiazolinone Detection in Dish Soap and Personal Care Products: Comparison of Lovibond Isothiazolinone Test Kit and Ultrahigh-Performance Liquid Chromatography–Tandem Mass Spectrometry

Rebecca S. Kimyon, MD[*,†,‡], **Lun-Yi Zang, PhD**[§], **Paul D. Siegel, PhD**[§], **Lindsey M. Voller, BA**[*,†,‡], **Jamie P. Schlarbaum, MD**[*,†,‡], **Erin M. Warshaw, MD, MS**[†,‡,‖]

[*]University of Minnesota School of Medicine

[†]Department of Dermatology, Minneapolis Veterans Affairs Medical Center

[‡]Park Nicollet Contact Dermatitis Clinic, Minneapolis, MN

[§]Health Effects Laboratory Division, National Institute for Occupational Safety and Health Centers for Disease Control and Prevention, Morgantown, WV

[‖]Department of Dermatology, University of Minnesota Medical School, Minneapolis

Abstract

Background: Isothiazolinones are commonly used preservatives, which may cause allergic contact dermatitis. The Lovibond Isothiazolinone Test Kit (LITK) has been reported to successfully identify clinically relevant, occult isothiazolinones in patient personal care products.

Objective: The aim of the study was to analyze dish soaps and personal care products that do not declare isothiazolinones (“no-ISO”) for the presence of isothiazolinones via 2 methods: LITK and ultrahigh-performance liquid chromatography–tandem mass spectrometry (UHPLC-MS/MS).

Methods: No-ISO dish soaps (n = 9), a convenience sample of patient products (n = 6), and controls (positive [isothiazolinone declared], n = 5; negative, n = 2) were tested with LITK (X3) and UHPLC-MS/MS.

Results: Several no-ISO dish soaps and personal products were positive for isothiazolinones (LITK, n = 12; UHPLC-MS/MS, n = 3). Ultrahigh-performance liquid chromatography–tandem mass spectrometry specifically identified methylisothiazolinone alone in 1 no-ISO dish soap, methylchloroisothiazolinone in another, and both in a third. Using UHPLC-MS/MS as the criterion standard, we observed the accuracy of LITK for 9 dish soaps was poor (sensitivity, 66.7%; specificity, 20%) and very poor for 6 personal care products (sensitivity, 0%; specificity, 0%).

Address reprint requests to Rebecca S. Kimyon, BS, Park Nicollet Contact Dermatitis Clinic, 7550 34th Ave S UNIT 101, Minneapolis, MN 55450. kimyo002@umn.edu.

The authors have no funding or conflicts of interest to declare.

Conclusions: Personal products may contain undeclared isothiazolinones. The current study found that LITK had poor accuracy for testing dish soap and personal care products. Clinicians should be aware of these factors when managing patients with contact allergy to isothiazolinones.

Isothiazolinones are commonly used as biocides in industrial applications and preservatives in many household/personal care products. Allergic contact dermatitis (ACD) has been reported from the following isothiazolinones: methylisothiazolinone (MI), methylchloroisothiazolinone (MCI), benzisothiazolinone (BIT), octylisothiazolinone (OIT), and butyl-BIT (BBIT).[1] The most clinically relevant isothiazolinone, MI, used alone and in combination with MCI (MI/MCI), has been responsible for a worldwide epidemic of allergic contact dermatitis because of high sensitization potential and prevalent use in personal care products.[1]

The Lovibond Isothiazolinone Test Kit (LITK; Tintometer Group, Amesbury, United Kingdom; http://www.lovibondwater.com)[2] is a commercially available isothiazolinone colorimetric test developed for isothiazolinone analysis of cooling tower water.[2] Several reagents are added to the test sample in a stepwise manner; if isothiazolinones are present, the sample turns blue (Fig. 1). Reported sensitivity is greater than 0.75 ppm; however, a recent study showed that the minimum concentration varies by specific isothiazolinone (0.75 ppm for MI/MCI, 7.5 ppm for MI, and 3.0 ppm for BIT).[3]

Although developed for detecting isothiazolinones in water (not viscous personal products), 3 cases cite the use of LITK to successfully identify clinically relevant, occult isothiazolinones in patients' personal products including an antifoam agent added to a cutting oil,[3] wet wipes,[3] and a gel face mask.[4] In our clinic over the last year, we have intermittently used LITK in our patch test clinic. For example, a 57-year-old female patient presented with a 6-month history of facial/upper torso dermatitis. She was patch tested to the North American Contact Dermatitis Group standard series as well as several additional series and select personal care products. Final reading (96 hours) showed that the patient was positive to several allergens including a doubtful reaction to MCI/MI. She also had a doubtful (+/−) reaction to her Aveda Cherry Almond Softening Shampoo (tested semiopen; Aveda Corporation, Blaine, MN); however, she had tested negative to ingredients declared on the shampoo label. We suspected undeclared MI/MCI in the shampoo and performed LITK in a clinic, which was positive (Fig. 2).

Household products, which are not required to disclose full ingredients, are particularly problematic for isothiazolinone-sensitive individuals. In our clinic, we are especially concerned about dish soaps because of not only the frequent skin exposure but also the difficulty of full protection with gloves. Although several dish soaps do not declare isothiazolinones, we worry about occult presence.

The purpose of this study was to determine the presence of isothiazolinones in dish soaps without declared isothiazolinones ("no-ISO"). The LITK results were compared with the criterion standard, ultrahigh-performance liquid chromatography–tandem mass spectrometry (UHPLC-MS/MS). In addition, a convenience sample of personal care products was also tested with both methods.

METHODS

Sample Selection

An Internet search of dish soap ingredients was performed. We purchased all dish soaps (1) that did not declare isothiazolinones in the product packaging/website ingredient list and (2) that were either clear or translucent white (so as not to interfere with LITK colorimetric methods, n = 9). In addition, we tested a small convenience sample of patient personal care products (n = 5) and 100% vegetable glycerin (Table 1).

Negative controls (no isothiazolinones present) included sterile water and sodium lauryl sarcosinate 0.5% aqueous (aq) (“EasyFoam”; Ingredients to Die For, Austin, TX). Positive controls included 0.0004% aq MI/MCI (allergEAZE, Calgary, Alberta, Canada) and 4 dish soaps with isothiazolinones listed as ingredients (Table 2).

Lovibond Isothiazolinone Test Kit

Each sample/control was tested separately by 3 research assistants (R.S.K., J.P.S., L.M.V.) for a total of 3 tests. Researchers were not blinded to the product names but were blinded to the others’ results. The LITK procedures were performed per manufacturer instruction.[5] Briefly, 5 mL of each sample/control was diluted with 5 mL of sterile water before testing to allow for penetration of reagents. Four drops of KS461-dK1 were added to an empty, clear test tube. The diluted sample was added to the 10-mL mark. The test tube was shaken, and then, 15 drops of KS462-dK2 were added. The mixture was gently inverted. After 1 minute, 17 drops ofKS463-dK3 were added to the test tube, and the mixture was gently inverted. Next, after 1 minute, 15 drops of KS144-dK4 were added to the test tube, and the mixture was again gently inverted. After 1.5 minutes, 3 drops of the final reagent KS465-dK5 were added to the test tube. The samples were allowed to sit for 10 seconds before determining the result. Tested samples were compared with LITK’s color comparison chart; results were recorded in a binary fashion, positive or negative (Fig. 1).

Ultrahigh-Performance Liquid Chromatography–Tandem Mass Spectrometry

To prevent potential testing bias, samples and controls were blinded (identified by letter only) by the primary investigator (R.S.K.). Each sample and control (20 mL) were transferred to identical 50-mL sterile urine cups, blinded (to prevent potential testing bias), and mailed to the National Institute of Occupational Safety and Health, Centers for Disease Control and Prevention (Morgantown, WV), for analysis.

Reagents

Methylisothiazolinone (≥98%, CAS# 2682-20-4), BIT (96%, CAS# 2634-33-5), OIT (99.9%, CAS# 26530-20-1), atrazine-desethyl (99%, CAS# 6190-65-4, used as internal standard [IS]), and trichloroethylene were obtained from Sigma-Aldrich, Inc. (Millipore Sigma, St. Louis, MO). Methylchloroisothiazolinone (68%, CAS# 26172-55-4) obtained from Combi-Block, Inc. (San Diego, CA) is an aq mixture of MCI and MI at a ratio of MCI/MI (2/1), which was checked by MS method, and no contaminants were found. We used standard MI (≥98%) to calibrate (MI) in the mixture and then calculated (MCI) in the mixture. Butyl-BIT (95%, CAS# 4299-07-4) was purchased from Creative Dynamics,

Inc. (BOC Science, Shirley, NY). Acetonitrile (LC/MS grade), methanol (HPLC grade), and formic acid (LC/MS grade) were purchased from Fisher Chemical, Inc. (Battle Ground, WA). Water was made by Milli-Q (Milipore Sigma, Burlington, MA).

Sample Preparation

Each item listed in Tables 1 and 2 was weighed (600–700 mg) in an 8-mL glass vial and diluted for 5-fold (wt/wt) with a mixture consisting of 0.5% of formic acid in the presence of 6.25 ng/μL of IS. Each sample was vortexed for 30 seconds and then sonicated for 15 minutes. After briefly vortexing again, the samples were centrifuged for 25 minutes at 1360*g*, at 4°C. The top phase was filtered through a 13-mm, 0.2-μm PTFE syringe filter into 1.8-mL inactivated glass vials for UHPLC-MS/MS analysis.

The UHPLC-MS/MS Analysis

All isothiazolinones in products were analyzed by an UHPLC coupled to an ion trap mass spectrometer (Thermo Fisher Scientific, San Jose, CA) equipped with a heated electrospray ionization probe. Two microliters of extract or standard were injected onto an Acclaim RSLC Polar Advantage 2.2 μm 120 Å HPLC column (2.1 mm × 50 mm). The mobile phase consisted of 0.1% formic acid in acetonitrile (B) and 0.1% formic acid in water (A). The analytes were eluted from the column at a flow rate of 1.2 mL/minute using the following gradient elution program: 0-0.6 minutes - A/B was held at 91:9 then ramped to 55:45 A/B over the next 0.2 minutes. This was maintained for 1 minute and then ramped back to 91:9 A/B over the next 0.2 minutes where it was held for the remainder of the 3.00 minute run. The analytes were ionized by the heated electrospray ionization probe operated in positive mode. The MS detector was operated at MS/MS with collision-induced dissociation of 0 mode for MI, MCI, and BIT and at MS/MS with collision-induced dissociation of 28 for IS, BBIT, and OIT, respectively. The protonated molecular ions (M + 1) monitored were as follows: 0.00 to 0.45 minute for MI (116.2 *m/z*, retention time (RT) = 0.27 minute), 0.45 to 0.9 minute for MCI (150.1 *m/z*, RT = 0.54 minute), 0.9 to 1.45 minutes for BIT (152.3 *m/z*, RT = 1.1 minutes) and 1.35 to 1.8 minutes for IS (188 and 146 *m/z*, RT = 1.45 minutes), 1.8 to 2.4 minutes for BBIT (208.3 and 152 *m/z*, RT = 2.1 minutes), and 2.4 to 3.0 minutes for OIT (214.4 and 102 *m/z*, RT = 2.67 minutes) with their respective individual tune method. In cases where a compound with a similar *m/z* eluted close to the expected time, the MS/MS daughter ion spectra were examined to confirm that the compound was the isothiazolone of interest. Quantification of the analytes was performed using response factors calculated from their individual standard calibration curve using the ratio of ion counts from the analytes to that of the IS. The limits of quantification were as follows: MI, 150 pg/injection; MCI, 200 pg/injection; BIT, 230 pg/injection; BBIT, 70 pg/injection; and OIT, 75 pg/injection.

RESULTS

Lovibond Isothiazolinone Test Kit

Isothiazolinone presence in all controls was correctly identified with the LITK (Table 2). Of the 9 no-ISO dish soaps, 6 tested positive, and 2 tested negative. One sample was indeterminate because of crystallization with the test reagents. All of the 6 no-ISO personal care products tested positive (Table 1).

Ultrahigh-Performance Liquid Chromatography–Tandem Mass Spectrometry

Isothiazolinone presence in all controls was correctly identified using UHPLC-MS/MS with the exception of 1 control dish soap; Seventh Generation Free and Clear Dish Soap (Seventh Generation, Inc., Burlington, VT) declared both MI and BIT, but only MI was detected with UHPLC-MS/MS (Table 2). Of the 9 no-ISO dish soaps, 3 tested positive for isothiazolinones (MI and/or MCI); all were negative for BIT, BBIT, and OIT (Table 1). All 6 no-ISO personal care products tested negative with UHPLC-MS/MS (Table 1).

Comparisons of Results of LITK and UHPLC-MS/MS

Results for the 5 positive controls were 100% concordant; both methods indicated the presence of isothiazolinone(s). Results for the 9 no-ISO dish soaps showed complete concordance for 3 (LITK/UHPLC: 2 +/+ and 1 −/−) and complete discordance for 5 (4 +/− and 1 −/+). No isothiazolinones were detected via UHPLC-MS/MS for the no-ISO dish soap, which had indeterminate results with LITK. Excluding the latter, sensitivity and specificity of LITK for dish soap were 66.7% and 20.0%, respectively. Results for the 6 no-ISO personal care products were 100% discordant (all +/−), and sensitivity and specificity of LITK were both 0%. For all products tested (excluding controls and the indeterminate dish soap), the sensitivity and specificity of LITK were 66.7% and 9.1%, respectively.

DISCUSSION

Main Findings

This study has several important findings. Several no-ISO dish soaps were positive for isothiazolinones (LITK, n = 6; UHPLC-MS/MS, n = 3). Using UHPLC-MS/MS as the criterion standard, accuracy of LITK for 9 dish soaps was poor (sensitivity, 66.7%; specificity, 20%) and very poor for 6 personal care products (sensitivity, 0%; specificity, 0%).

Undeclared Isothiazolinones

This study revealed that several no-ISO dish soaps were positive for isothiazolinones. Previous studies have documented undeclared isothiazolinones in personal products using HPLC[6–8] including 1 of 100 Swedish moisturizers,[7] 1 of 60 Israeli cosmetics,[8] and 1 of30 Belgian cosmetics.[6] Case reports also document undeclared isothiazolinones including (1) mislabeling of wet wipes containing isothiazolinones (confirmed by LITK and discussion with product manufacturer)[3]; (2) isothiazolinone used in the preservation of raw materials of a face mask, unbeknown to the product manufacturer (confirmed by LITK and HPLC with UV detection)[4]; and (3) a leave-on cream found to contain isothiazolinones, likely from contamination from isothiazolinones used as a biocide in manufacturing machinery (presence of isothiazolinones presumed given negative patch tests to individual ingredients supplied by the product manufacturer).[9]

This phenomenon has been observed with other preservatives, particularly formaldehyde. Many studies have confirmed the presence of undeclared formaldehyde and/or formaldehyde releasers in leave-on and wash-off products via various chemical analytical methods.[7,8,10–15] Suspected mechanisms include contamination by product packaging or other manufacturing

processes, postformulation reactions, and endogenous release of formaldehyde by raw, botanical materials.[10,11] Occult parabens, phenoxyethanol, and acid preservatives in personal products have also been observed.[7,12]

Declared, But Not Detected, Isothiazolinones

One positive control dish soap (Seventh Generation Free and Clear) declared BIT, but this was not detected by UHPLC-MS/MS. This could be due to change in formulation, concentration below the detection limit, lack of recovery in the sample preparation process, degradation of isothiazolinones,[16] or package mislabeling. Previous studies show that personal products declaring specific preservatives may not contain those preservatives by chemical analysis. Gruvberger et al[7] found that 9 Belgian moisturizers did not contain the declared preservative(s), and Aerts et al[6] found that 1 of 6 rinse-off cosmetics and 2 of 8 detergents (all declaring isothiazolinones) did not contain all declared isothiazolinones.

Lovibond Isothiazolinone Test Kit Versus UHPLC-MS/MS

Although LITK was accurate for controls, most no-ISO products tested positive (dish soaps, 6/9; PCP, 6/6). There was poor agreement of LITK and UHPLC-MS/MS for dish soaps and personal care products (overall sensitivity, 66.7%; specificity, 9.1%). This is in contrast to the study by Kerre et al[4] in which the isothiazolinone presence in 6 personal products (4 declaring isothiazolinones, 1 positive control, and 1 negative control) was correctly identified with LITK.

The LITK manufacturer information states that colored or turbid samples may cause difficulty with interpretation but that chemicals commonly added to cooling towers should not interfere with results.[5] Further information on the LITK chemical components, reaction mechanisms, and factors impacting the accuracy of the assay is proprietary; however, Kerre et al[4] reported that the LITK assay is based on Folin-Ciocalteu reagent. This chemical reaction is very nonspecific and will react with most antioxidants, especially phenolic compounds.[17] Products with natural plant extracts (which are typically rich in phenolic antioxidants) may test positive with LITK. Based on chemical structure, we also hypothesize that phenoxyethanol and/or parabens could result in positive LITK tests; more research is needed, however, to verify this supposition. The nonspecific nature of LITK is supported by the false-positive result given by the polyol, glycerin (propane-1,2,3-triol; Table 1). Based on our results, although convenient, LITK may not be a reliable option for testing personal products.

LIMITATIONS

Limitations include small sample size. Many dish soaps (as well as personal care products) are colored and therefore not amenable to LITK testing. We tested all dish soaps available meeting study criteria. The small convenience sample of patient items was not meant to be conclusive; we include it here for interest. More studies are needed to investigate a broader range of personal products. The UHPLC-MS/MS analysis should be considered as semiquantitative. The reported levels of the isothiazolinones are relative to the atrazine-desethyl IS recoveries. This may have caused an overestimation of the more polar and

more water-soluble MI and MCI analytes. The potential of product matrix–associated ion suppression for individual analytes was also not evaluated and a potential source of error. In addition, several of the isothiazolinone levels, although above the limits of quantification, were below the lowest standard in the standard curve. Finally, there is a remote possibility that a soap(s) contained a isothiazolinone species that has not been reported in the literature and not part of our UHPLC-MS/MS analyses.

SUMMARY

Personal care products and dish soaps may contain occult isothiazolinones. The Lovibond Isothiazolinone Test Kit had poor accuracy (as compared with UHPLC-MS/MS) for testing dish soap and personal care products. Clinicians should be aware of these factors when managing patients with contact allergy to isothiazolinones.

Acknowledgments

This study involved the use of resources and facilities at the Minneapolis Veterans Affairs Medical Center, as well as the National Institute for Occupational Safety and Health of the Centers for Disease Control and Prevention. The contents do not represent the views of the US Department of Veterans Affairs or the US Government. The findings and conclusions of this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

REFERENCES

1. Herman A, Aerts O, de Montjoye L, et al.Isothiazolinone derivatives and allergic contact dermatitis: a review and update. J Eur Acad Dermatol Venereol2019;33(2) :267–276. [PubMed: 30284765]
2. Isothiazoline Test Kit. Lovibond. Available at: https://www.lovibond.com/en/PW/Water-Testing/Products/Test-Kits/Standard-Test-Kits/Non-Oxidising-Biocide-Kits/Isothiazoline-Test-Kit. Accessed May 5, 2020.
3. Tautvydaitė L, Friis UF, Thyssen JP, et al.Usability of a spot test for isothiazolinones. Contact Derm2020;82(3):165–167.
4. Kerre S, Naessens T, Theunis M, et al.Facial dermatitis caused by undeclared methylisothiazolinone in a gel mask: is the preservation of raw materials in cosmetics a cause of concern?Contact Derm2018;78(6):421–424.
5. Isothiazolinone Test Kit Instruction Manual. Tintometer GmbH. Available at: https://www.lovibond.com/ix_pim_assets/Wasseranalytik/Instruction_Manuals/Schnelltests/Standard_Test_Kits/Nicht_oxidierende_Biozide/MA-K25651-KW_Isothiazoline/MA-K25651-KW_gb.pdf. Accessed May 5, 2020.
6. Aerts O, Meert H, Goossens A, et al.Methylisothiazolinone in selected consumer products in Belgium: adding fuel to the fire?Contact Derm2015;73(3): 142–149.
7. Gruvberger B, Bruze M, Tammela M. Preservatives in moisturizers on the Swedish market. Acta Derm Venereol1998;78:52–56. [PubMed: 9498029]
8. Horev L, Isaksson M, Engfeldt M, et al.Preservatives in cosmetics in the Israeli market conform well to the EU legislation. J Eur Acad Dermatol Venereol2015; 29:761–766. [PubMed: 25175339]
9. Cervigón-González I, Conde-Salazar L, Torres-Iglesias L, et al.Eccema de contacto por metilcloroisotiazolinona/metilisotiazolinona (Kathon CG®) como contaminante del proceso de fabricación de una crema. Actas Dermosifiliogr2013;104(1):81–82. [PubMed: 22819363]
10. Liou YL, Ericson ME, Warshaw EM. Formaldehyde release from baby wipes: analysis using the chromotropic acid method. Dermatitis2019;30(3):207–212. [PubMed: 31045936]
11. Nikle A, Ericson M, Warshaw E. Formaldehyde release from personal care products: chromotropic acid method analysis. Dermatitis2019;30(1):67–73. [PubMed: 30570583]

12. Rastogi SC. Analytical control of preservative labelling on skin creams. Contact Derm2000;43(6):339–343.
13. Malinauskiene L, Blaziene A, Chomiciene A, et al.Formaldehyde may be found in cosmetic products even when unlabelled. Open Med (Wars)2015; 10(1):323–328. [PubMed: 28352713]
14. Ham JE, Siegel PD, Maibach H. Undeclared formaldehyde levels in patient consumer products: formaldehyde test kit utility. Cutan Ocul Toxicol2019; 38(2):112–117. [PubMed: 29719992]
15. Hauksson I, Pontén A, Isaksson M, et al.Formaldehyde in cosmetics in patch tested dermatitis patients with and without contact allergy to formaldehyde. Contact Derm2016;74(3):145–151.
16. Silva V, Silva C, Soares P, et al.Isothiazolinone biocides: chemistry, biological, and toxicity profiles. Molecules2020;25(4):991.
17. Everette JD, Bryant QM, Green AM, et al.Thorough study of reactivity of various compound classes toward the Folin-Ciocalteu reagent. J Agric Food Chem2010;58(14):8139–8144. [PubMed: 20583841]

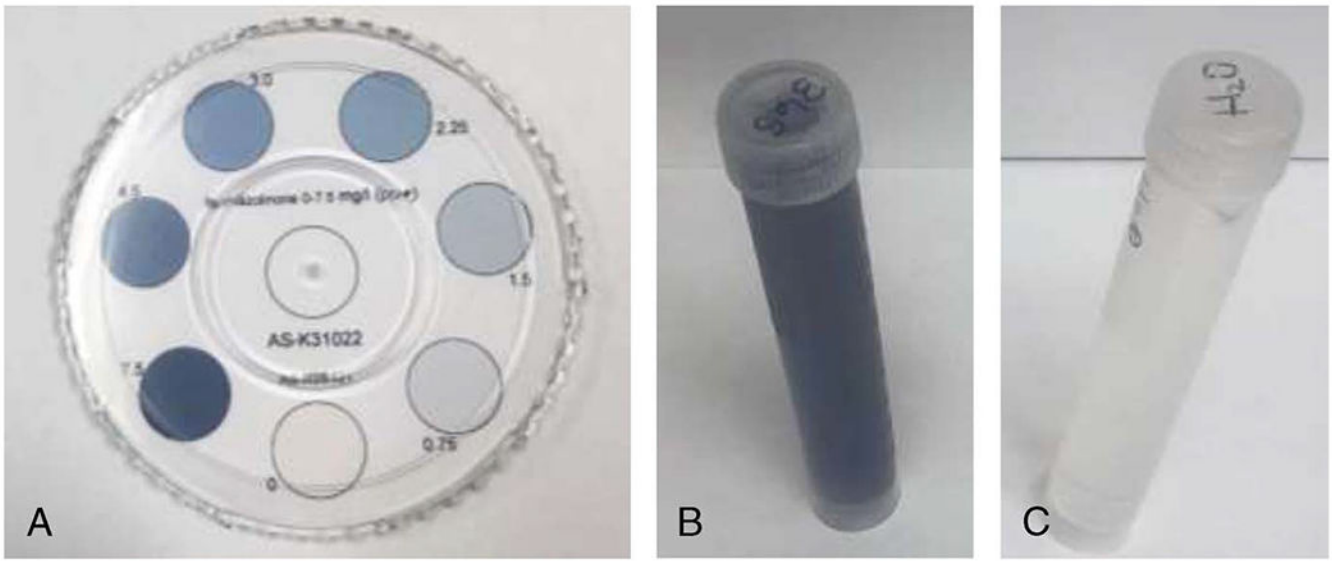

Figure 1.

A, Color comparison chart provided with the LITK. B, An example of a positive test with blue color change. C, An example of a negative test with no blue color change.

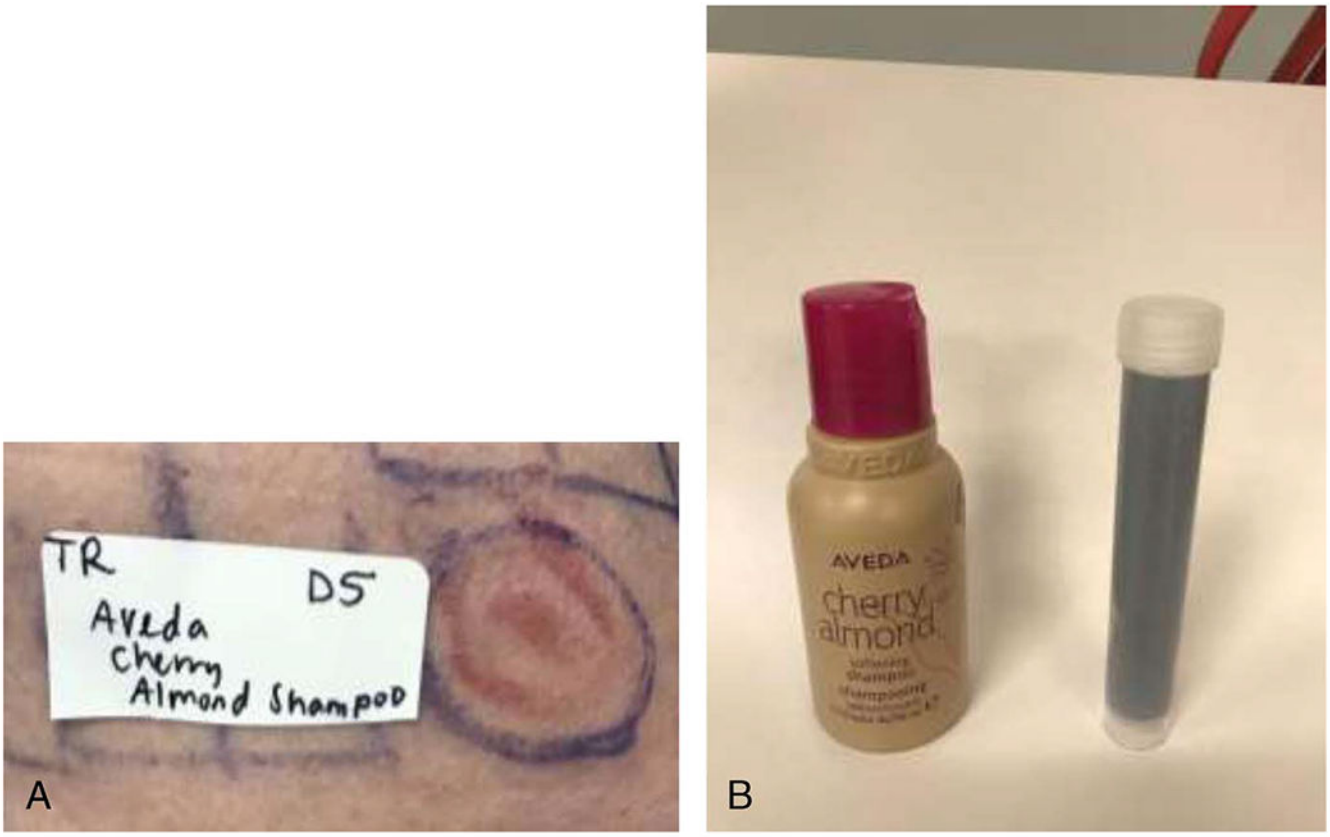

Figure 2.

A, Our patient's doubtful (+/−) reaction to Aveda Cherry Almond Softening Shampoo. B, Aveda Cherry Almond Softening Shampoo positive result with the LITK.

Dermatitis. Author manuscript; available in PMC 2021 August 23.

TABLE 1.

Results of Samples Tested With LITK and UHPLC-MS/MS

Sample	Declared Isothiazolinones	LITK Results (+/−)	UHPLC-MS/MS Results, μg/g*				
			MI	MCI	BIT	BBIT	OIT
Dish soaps							
(no isothiazolinones declared)							
Green Cricket Fragrance Free Dish Washing Liquid	"Biodegradable preservative"	+	27.2	8.2	ND	ND	ND
Attitude Baby Bottle & Dishwashing Liquid	None	−	7.9	ND	ND	ND	ND
The Unscented Company-Dish	None	+	ND	4.6	ND	ND	ND
Honest Dish Soap – Free and Clear	None	+	ND	ND	ND	ND	ND
Eco-Max Hypoallergenic Ultra Dish Wash	None	+	ND	ND	ND	ND	ND
ECOS Dishmate Dish Soap – Free and Clear	None	+	ND	ND	ND	ND	ND
Planet Ultra Dishwashing Liquid	None	+	ND	ND	ND	ND	ND
EcoMe Fragrance Free Dish Soap	None	?†	ND	ND	ND	ND	ND
Ecover Zero Dish Soap	None	−	ND	ND	ND	ND	ND
Other personal care products (no isothiazolinones declared)							
Free and Clear Shampoo	None	+	ND	ND	ND	ND	ND
Neutrogena T/Sal Therapeutic Shampoo	None	+	ND	ND	ND	ND	ND
Tide Free and Gentle Liquid Laundry Detergent	None	+	ND	ND	ND	ND	ND
Vanicream Gentle Facial Cleanser	None	+	ND	ND	ND	ND	ND
Aveda Cherry Almond Softening Shampoo	None	+	ND	ND	ND	ND	ND
Vegetable Glycerin 100%	None	+	ND	ND	ND	ND	ND

*The UHPLC-MS/MS results are semiquantitative.

†Indeterminate because of crystallization.

BBIT, butyl-benzisothiazolinone; BIT, benzisothiazolinone; LITK, Lovibond Isothiazolinone Test Kit; MCI, methylchloroisothiazolinone; MI, methylisothiazolinone; ND, not detected; OIT, octylisothiazolinone; UHPLC-MS/MS, ultrahigh-performance liquid chromatography–tandem mass spectrometry.

TABLE 2.

Results of Controls Tested With LITK and UHPLC-MS/MS

Control	Declared Isothiazolinones	LITK Results (+/−)	UHPLC-MS/MS Results, μg/g*				
			MI	MCI	BIT	BBIT	OIT
Positive controls							
MI/MCI 0.0004% aq	MI/MCI	+	6.5	4.3	ND	ND	ND
Seventh Generation Free and Clear Dish Soap	MI, BIT	+	19.0	ND	ND	ND	ND
Dawn Pure Essentials Dish Soap	MI	+	118.8	ND	ND	ND	ND
Babyganics Foaming Dish and Bottle Soap	MI	+	117.9	ND	ND	ND	ND
Puracy Natural Baby Dish Soap	BIT	+	ND	ND	537	ND	ND
Negative controls							
Sterile H_2O	None	−	ND	ND	ND	ND	ND
Sodium lauryl sarcosinate 0.5% aq	None	−	ND	ND	ND	ND	ND

*UHPLC-MS/MS results are semiquantitative.

BBIT, butyl-benzisothiazolinone; BIT, benzisothiazolinone; LITK, Lovibond Isothiazolinone Test Kit; MCI, methylchloroisothiazolinone; MI, methylisothiazolinone; ND, not detected; OIT, octylisothiazolinone; UHPLC-MS/MS, ultrahigh-performance liquid chromatography–tandem mass spectrometry.