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ABSTRACT

Purpose: Investigate changes in optical properties of contact lenses materials (transmittance and reflectance) and lens care solutions (absorbance and fluorescence) resulting from its interaction.

Methods: From an experimental study, triplicate measurements of transmittance and reflectance of five contact lenses (Senofilcon A, Lotrafilcon B, Balafilcon A, Comfilcon A, and Omafilcon A), as well as absorbance and fluorescence of four lens care solutions (LCS) (ReNu MultiPlus, Biotrue, OPTI-FREE PureMoist, and AOSept Plus), were evaluated before and after 8 hours, one day and one week in storage. The outcomes were provided by Shimadzu UV3101-PC UV-vis-NIR spectrophotometer equipped with an integrating sphere, between 200-700 nm, and SPEX-Fluorolog 2 FL3-22 spectrofluorometer.

Results: All variables exhibited statistically significant differences over time. Comfilcon A showed the lowest ultraviolet radiation (UVR) A & B attenuation. Balafilcon A and Lotrafilcon B displayed a slight suppression of UVR. Senofilcon A was effective in UVR protection and showed less effect on the fluorescence of lens care solutions. Overall, the reflectance decreased after storage ($p < 0.05$). AOSept Plus absorbance and fluorescence demonstrated lower interactions than multipurpose solutions (MPS), and Lotrafilcon B induced more remarkable changes in optical properties of LCS than the other materials

Conclusion: The findings suggest that optical variables of lens care solutions and contact lenses changed mutually after storage, probably associated with biochemical and biophysical interactions between components and the release of some polymer compounds. These findings can provide additional information about the interaction of CL materials and LCS in clinical behavior.

Key Words: Contact lenses, lens care solutions, ultraviolet radiation, visible spectra, transmittance, fluorescence.

INTRODUCTION

In the contact lenses (CL) industry, improvements in the manufacturing processes, alternative designs, and modalities make them an attractive and effective option for vision correction [1]. In the last ten years, silicone-hydrogel (Si-Hy) materials have dominated CL international fits, particularly in the reusable lens category [2]. It is essential to follow disinfection procedures to remove deposits and metabolic by-products, minimize risk of inflammation [3], and avoid CL-related complications such as microbial keratitis [4,5].

Multipurpose solutions (MPS) are composed of several agents, such as preservatives known to have abacterial and bacteriostatic activity.[6]. However, MPS combination with some CL materials induced cell morphology modifications and cell viability loss [7]. In some associations, there is evidence that solutions induced significant differences in corneal staining and corneal infiltrative events [8–12]. These changes can affect CL clinical behavior, tending to decrease subjective comfort, and expose the eye to potential ocular problems [8,12–16]. The most used ingredients are polyhexamethylene biguanide (PHMB) and polyquaternium (PQ-1). Products that have PQ-1 in their composition have reported greater comfort and less relative corneal sensitivity than PHMB-based solutions [8,17]. Thus, PHMB exhibited a statistically significant corneal staining association compared with other agents, but without clinical relevance [18]. With a high spectrum of action, hydrogen peroxide-based solutions (H_2O_2) have the lowest incidence of corneal staining and infiltrative corneal problems [9,18], and demonstrated to be better tolerated by eyelid tissues compared to MPS [19]. Regarding comfort and tolerance, H_2O_2 solutions have presented a longer reported comfortable wearing time than the MPS [20].

Nowadays, there is evidence that uptake and release of lens care solutions (LCS) components in CL materials may occur [21]. Differences in physical properties of solutions have been reported [22] that can induce different changes in CL properties, including from an optical point of view [23] or in their physical dimensions [24]. The main optical characteristics of contact lenses are related to its transparency and the ability to block ultraviolet radiation (UVR). Excessive exposure to UVR may increase oxidative stress and cause ocular tissue damage [25]. According to the photobiological effect induced by each part of the UVR spectrum, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) has divided the ultraviolet spectrum into three wavebands: UVC between 200 and 280 nm, UVB between 280 and 315 nm, and UVA between 315 and 400 nm [26]. Considering eye protection, UVR filtering CL may be a particularly good alternative, as they block the light from all incidence angles [27–31], which is critical to avoid peripheral light focusing. As reported by Coroneo [32], there is a potential cause-effect relation between peripheral light focusing and some pathologies, such as pterygia and cortical cataracts. Compared to CL without UVR block filters, previous studies have shown that UV-blocking CL dramatically reduce the transmittance in UVR [33]. However, CL without UV-blocking monomers also have shown some attenuation of the UVR [34,35], explained previously by the silicone inherent ability to absorb some UVR [36]. After wear, the UV-blocking CL kept its filtering characteristics [37].

If multiple reflections are neglected, transmittance and reflectance are given by the result of transmitted and reflected light, respectively, and can be obtained experimentally through spectrophotometry, using an integrating sphere.

A previous study has detected significant differences in the UVR-visible transmittance of Lotrafilcon B material after storage in different MPS [38]. There are no earlier reported studies that evaluate if LCS fluorescence remains unchanged after storage with different CL materials. Despite being restricted to fluorescent compounds, fluorescence emission spectroscopy has the advantage of its selectivity and high sensitivity.

This study goal is to understand the interactions between CL and LCS in terms of optical properties. In this way, this research intends to investigate the UV-visible spectral changes of new and different monthly disposable CL and LCS through the analysis of transmittance and reflectance of CL and absorbance and fluorescence of LCS, comparing with the outcomes obtained after storage over time.

MATERIALS AND METHODS

Contact Lenses

Four commercially available Si-Hy CL (Senofilcon A, Lotrafilcon B, Balafilcon A and Comfilcon A) and one hydrogel CL (Omafilcon A) were included in this study. A total of 60 lenses were investigated after storage in disinfection solutions. The CL had an optical power between -1.00 D and -4.00 D, which corresponds to powers that showed no statistically significant effects in transmittance [39]. All the lenses are monthly disposable with no UV blocker, and with visibility tint, except Senofilcon A that is colorless, has a UV filter and is prescribed for biweekly replacement. Regarding surface properties, Balafilcon A and Lotrafilcon B are treated using gas plasma techniques. Their characterization is detailed in *Table 1.*

Table 1. Characterization of contact lenses used in this study

	Acuvue Oasys *Johnson&Johnson*	Air Optix Aqua *Alcon*	PureVision 2 *Bausch&Lomb*	Biofinity *CooperVision*	Proclear *CooperVision*
USAN	Senofilcon A	Lotrafilcon B	Balafilcon A	Comfilcon A	Omafilcon A
Water Content (%)	38	33	36	48	62
FDA Group	I	I	III	I	II
Light Transmittance (%)	UV blocker	≥96	≥95	≥97	≥90
Refractive Index	1.420	1.420	1.426	1.400	1.387
Principal Monomers	HEMA, PDMS, DMA + PVP	DMA, TRIS, SM, Visibility Tint	NVP, TPVC, NVA, PBVC, NCVE	2 silxane macromer	-
Surface Treatment	None	Plasma coating	Gas plasma oxidation	None	None

DMA, N,M-dimethylacrylamide; EGDMA, ethyleneglycol dimethacrylate; FDA, Food and Drug Administration; HEMA, hydroxyethyl methacrylate; MPDMS, monofunctional polydimethylsiloxane; NVA, N-vinyl amine acide; NVCE, N-carboxyvinyl ester; NVP, N-vinyl pyrrolidone; PBVC, poly-(dimethysiloxy) di-(sililbutanol) bis-(vinyl carbamate); PVP, polyvinyl pyrrolidone; TPVC, tris=(trimethyl siloxysilyl) propylvinyl carbamate; TRIS, trimethyl siloxysilyl; USAN, United states adopted name.

Lens Care Solutions

The reported compositions of the CL solutions investigated in this study are detailed in *Table 2*. The hydrogen peroxide-based solution (H_2O_2) used was AOSept Plus, and it was analyzed after the neutralization process (approximately 6 hours). Biotrue and OPTI-FREE PureMoist are MPS with wetting agents in their composition, Hyaluronate, and Hydraglide, respectively, specifically formulated for Si-Hy CL. During the *in vitro* trial, CL materials were stored in lens care solutions until analysis. The measurements were performed immediately after opening the blisters packets and 8, 24, and 168 hours afterward. Triple measurements of the samples were taken to enhance the accuracy of the measurements.

Table 2. Characterization of lens care solutions used in this study.

	ReNu MultiPlus *Bausch&Lomb*	OPTI-FREE PureMoist *Alcon*	Biotrue *Bausch&Lomb*	AOSept Plus *Alcon*
Preservative	PHMB (0.0001%)	Polyquad (0.0001%); MAPDA (0.0005%)	PHMB (0.00013%); Polyquad (0.0001%)	Hydrogen Peroxide (3%)
Buffer system	Boric acid; Sodium borate; Sodium chloride	Boric acid; Sorbitol	Boric acid; Sodium borate; Sodium chloride	Sodium Chloride
Chelating agent	Hydranate (0.03%); EDTA (0.1%)	Citrate; EDTA (0.05%); Hydraglide	EDTA; Hyaluronate	-

EDTA: Ethylenediamine tetraacetic acid; Hydraglide: polyoxyethylene-polyoxybutylene; MAPDA: myristamidopropyl dimethylamine (Aldox); PHMB: polyhexamethylene biguanide.

Transmittance and Reflectance Measurements

The optical transmittance (T%) and reflectance (R%) were measured with a Shimadzu UV3101-PC UV-vis-NIR spectrophotometer equipped with an integrating sphere in the detector system, as established by ISO recommendation. Measurements were taken at 0.5 nm intervals, from 200 to 700 nm. After opening the blisters, the lenses were removed with a tweezer with silicone tips and placed perpendicular to the light beam in an appropriate sample holder. The excess of solution was removed with absorbent paper. The baseline reference was made with white standard plates of barium sulfate ($BaSO_4$). Each CL was placed in a sterile vial containing 2 mL of each MPS, which corresponds to the usual solution volume used in a CL case. Vials with each lens-solution combination were labeled with a numerical code. The combinations of CL with H_2O_2 were preserved in their cases due to the need for neutralization. All lenses were compared in the different steps and with new CL. The outcomes of 8 hours of storage were reported with more emphasis due to their higher proximity with the usual immersion time during storage.

Absorbance and Fluorescence Measurements of LCS

For the several LCS tested, absorbance (A_λ) was measured with a Shimadzu UV3101-PC UV-vis-NIR spectrophotometer equipped with a liquid sample cuvette holder. The measurements were taken at 0.5 nm intervals, from 200 to 700 nm. For that, 1 mL of each LCS (and CL combination) was removed with a syringe and introduced in a high precision cuvette (4 transparent windows) quartz SUPRASIL. The same quartz cuvette was used to determine fluorescence spectra in a SPEX Fluorolog FL3-22 spectrofluorometer, with double monochromators in both excitation and emission. Two excitation wavelengths were used: 280 nm (with emission scan between 300 and 540 nm) and 350 nm (with emission scan between 370 and 680 nm). At 280 nm, it is possible to excite compounds such as surfactants or other compounds with aromatic groups. At 350 nm, other CL components can be detected. The integration time was 0.5 seconds, and 4 mm slits were used in both excitation and emission. All the measurements were performed at room temperature, which was maintained at 22 ± 2 ºC.

Statistical Analyses

The statistical analysis was performed with the Statistical Package for Social Sciences (SPSS) version 25.0. Descriptive data were presented in terms of mean ± standard deviation, and the normality of all variables was evaluated using Kolmogorov-Smirnov. The Friedman (ANOVA) test was performed when the time variable interfered in the same sample. In contrast, Kruskal-Wallis (1-way ANOVA test) was used for comparisons between the several groups of LCS and CL. For statistical purposes, $p \leq 0.05$ was considered statistically significant.

RESULTS

Effect of Lens Care Solutions on Transmittance and Reflectance of Contact Lenses

After storage in the different LCS, the transmittance of each material exhibited significant changes ranging between 3.7 ± 0.5 % and 95.9 ± 0.6 % in the UVR spectrum and 89.3 ± 0.1 % to 96.7 ± 0.1 % in the visible wavelength region, as can be observed in Tables 3 and 4, respectively. All CL materials demonstrated statistically significant differences in transmittance over time ($p < 0.001$).

Table 3. Average UVR transmittance (T_a) (expressed as mean ± SD; SD: standard deviation) of contact lenses new (zero time) and after 8, 24 and 168 hours of storage in the different lens care solutions.

UVC T_a (%) (240-280 nm)

	New		ReNu MultiPlus	OPTI-FREE PureMoist	Biotrue	AOSept	p
Senofilcon A	15.0 ± 4.7	8h	10.6 ± 2.9	12.3 ± 4.2	11.1 ± 3.4	9.8 ± 2.6	**0.044**
		24h	11.0 ± 3.4	12.7 ± 4.1	11.1 ± 3.2	10.7 ± 2.9	0.120
		168h	11.8 ± 3.3	13.7 ± 4.4	12.2 ± 3.5	11.6 ± 3.3	0.104
Lotrafilcon B	41.3 ± 14.9	8h	41.7 ± 14.6	37.1 ± 14.1	34.1 ± 13.8	34.6 ± 13.9	0.089
		24h	42.0 ± 14.9	35.7 ± 14.3	34.6 ± 14.3	35.9 ± 14.7	0.133
		168h	43.9 ± 14.7	38.7 ± 14.2	37.9 ± 14.8	36.8 ± 14.4	0.151
Balafilcon A	32.2 ± 6.9	8h	35.9 ± 7.6	36.1 ± 7.7	32.8 ± 7.3	26.7 ± 6.6	**< 0.001**
		24h	35.8 ± 7.5	38.0 ± 7.7	33.6 ± 6.8	27.9 ± 6.8	**< 0.001**
		168h	32.2 ± 7.5	36.6 ± 8.0	30.8 ± 7.4	28.2 ± 7.5	**< 0.001**
Comfilcon A	84.0 ± 4.8	8h	79.6 ± 5.5	82.0 ± 5.1	79.6 ± 6.00	72.6 ± 7.7	**< 0.001**
		24h	78.0 ± 5.9	81.8 ± 5.1	79.7 ± 5.8	72.5 ± 7.4	**< 0.001**
		168h	81.4 ± 6.0	83.1 ± 5.3	80.6 ± 6.3	75.5 ± 7.2	**< 0.001**
Omafilcon A	80.0 ± 11.0	8h	77.6 ± 11.4	80.3 ± 11.7	76.9 ± 12.0	77.8 ± 11.0	**< 0.001**
		24h	77.4 ± 9.7	81.0 ± 9.7	78.7 ± 11.0	79.2 ± 10.4	**< 0.001**
		168h	82.0 ± 11.6	82.0 ± 10.9	80.0 ± 12.1	80.7 ± 10.6	**0.001**

UVB T_a (%) (280-315 nm)

	New		ReNu MultiPlus	OPTI-FREE PureMoist	Biotrue	AOSept	p
Senofilcon A	5.0 ± 0.8	8h	3.8 ± 0.5	3.8 ± 0.6	3.8 ± 0.5	3.7 ± 0.5	0.753
		24h	3.8 ± 0.5	4.0 ± 0.7	4.0 ± 0.5	3.8 ± 0.6	0.538
		168h	4.6 ± 0.6	4.5 ± 0.7	4.5 ± 0.6	4.5 ± 0.6	0.883
Lotrafilcon B	76.1 ± 5.8	8h	74.8 ± 5.4	72.4 ± 6.6	70.8 ± 7.1	71.0 ± 7.3	**0.030**
		24h	74.2 ± 5.4	71.0 ± 6.5	71.1 ± 7.0	72.3 ± 7.3	0.098
		168h	73.1 ± 4.5	71.5 ± 5.7	72.4 ± 6.3	70.1 ± 6.4	0.164
Balafilcon A	52.7 ± 5.6	8h	56.8 ± 5.1	56.8 ± 5.2	53.7 ± 5.5	48.2 ± 6.0	**0.008**
		24h	58.1 ± 4.8	55.7 ± 5.3	53.7 ± 5.3	49.9 ± 6.0	**0.035**
		168h	56.6 ± 4.9	52.7 ± 5.2	51.6 ± 5.5	50.3 ± 5.8	0.128
Comfilcon A	91.8 ± 0.9	8h	89.4 ± 1.2	90.5 ± 1.1	89.5 ± 1.2	89.3 ± 2.2	**< 0.001**
		24h	88.1 ± 1.1	89.9 ± 0.9	89.0 ± 1.1	89.1 ± 1.8	**< 0.001**
		168h	91.3 ± 1.3	91.3 ± 1.1	90.0 ± 1.2	89.1 ± 1.9	**< 0.001**
Omafilcon A	86.5 ± 1.1	8h	84.4 ± 0.9	86.6 ± 0.8	84.0 ± 1.1	85.7 ± 1.2	**< 0.001**
		24h	84.0 ± 0.7	87.0 ± 0.9	85.8 ± 1.1	86.5 ± 0.9	**< 0.001**
		168h	88.5 ± 1.1	87.5 ± 1.2	87.2 ± 1.2	87.2 ± 1.2	**< 0.001**

UVA T_a (%) (315-400 nm)

Senofilcon A	53.1 ± 31.7	8h	48.6 ± 32.2	51.8 ± 31.3	49.9 ± 32.2	48.9 ± 32.4	0.651
		24h	50.6 ± 33.1	52.1 ± 32.1	49.4 ± 32.6	49.7 ± 32.9	0.435
		168h	50.9 ± 33.9	50.9 ± 30.6	49.4 ± 32.2	47.8 ± 31.6	0.959
Lotrafilcon B	90.4 ± 1.2	8h	87.9 ± 1.1	87.3 ± 1.3	86.5 ± 1.3	87.0 ± 1.3	**0.022**
		24h	87.9 ± 1.3	86.6 ± 1.4	87.5 ± 1.6	88.1 ± 1.5	**0.003**
		168h	84.9 ± 1.1	85.5 ± 1.3	87.4 ± 1.4	85.4 ± 1.4	**< 0.001**
Balafilcon A	86.3 ± 2.6	8h	87.9 ± 2.3	87.9 ± 2.4	86.7 ± 2.8	85.6 ± 3.2	**< 0.001**
		24h	88.3 ± 2.4	87.4 ± 2.4	86.0 ± 2.6	86.7 ± 3.1	**< 0.001**
		168h	86.3 ± 2.7	85.0 ± 2.9	85.3 ± 3.1	84.6 ± 3.2	**< 0.001**
Comfilcon A	94.0 ± 0.5	8h	93.8 ± 0.6	94.2 ± 0.3	93.9 ± 0.7	94.0 ± 0.6	**0.018**
		24h	92.3 ± 0.6	93.2 ± 0.5	93.3 ± 0.7	92.7 ± 0.6	**< 0.001**
		168h	95.7 ± 0.6	95.9 ± 0.6	94.4 ± 0.6	94.2 ± 0.7	**< 0.001**
Omafilcon A	91.2 ± 1.2	8h	88.7 ± 1.2	91.2 ± 1.4	89.5 ± 1.6	90.4 ± 1.2	**< 0.001**
		24h	89.1 ± 1.7	91.8 ± 1.5	91.7 ± 1.8	91.1 ± 1.3	**< 0.001**
		168h	92.8 ± 1.4	91.4 ± 1.1	91.3 ± 1.2	91.6 ± 1.4	**< 0.001**

Statistically significant differences between the groups (same material and different solutions) are presented in bold ($p \le 0.05$).

Table 4. Average visible transmittance (T_a) (expressed as mean ± SD; SD: standard deviation) of contact lenses new (zero time) and after 8, 24 and 168 hours of storage in the different lens care solutions.

Visible T_a (%) (400-700 nm)

	New		ReNu MultiPlus	OPTI-FREE PureMoist	Biotrue	AOSept	p
Senofilcon A	93.7 ± 0.4	8h	92.2 ± 0.5	92.3 ± 0.4	92.6 ± 0.5	92.6 ± 0.5	**< 0.001**
		24h	94.4 ± 0.4	93.5 ± 0.4	93.5 ± 0.5	94.0 ± 0.5	**< 0.001**
		168h	96.7 ± 0.4	90.9 ± 0.4	93.2 ± 0.4	91.6 ± 0.5	**< 0.001**
Lotrafilcon B	94.2 ± 0.2	8h	91.6 ± 0.2	91.1 ± 0.2	90.9 ± 0.2	90.9 ± 0.2	**< 0.001**
		24h	92.0 ± 0.1	91.1 ± 0.2	91.8 ± 0.2	92.3 ± 0.2	**< 0.001**
		168h	89.3 ± 0.1	90.0 ± 0.1	91.3 ± 0.2	89.7 ± 0.2	**< 0.001**
Balafilcon A	95.1 ± 0.3	8h	96.0 ± 0.3	96.1 ± 0.3	95.4 ± 0.3	95.6 ± 0.3	**< 0.001**
		24h	96.3 ± 0.3	95.5 ± 0.3	94.7 ± 0.3	96.4 ± 0.3	**< 0.001**
		168h	94.4 ± 0.3	94.1 ± 0.4	94.6 ± 0.4	94.2 ± 0.4	**< 0.001**
Comfilcon A	93.8 ± 0.1	8h	95.0 ± 0.8	95.6 ± 0.8	95.2 ± 0.8	95.2 ± 0.1	**< 0.001**
		24h	93.5 ± 0.7	93.6 ± 0.8	94.2 ± 0.1	93.4 ± 0.1	**< 0.001**
		168h	95.8 ± 0.1	96.7 ± 0.1	95.0 ± 0.1	94.8 ± 0.1	**< 0.001**
Omafilcon A	92.9 ± 0.6	8h	90.3 ± 0.6	93.0 ± 0.6	92.0 ± 0.6	91.9 ± 0.6	**< 0.001**
		24h	91.6 ± 0.6	94.0 ± 0.6	94.0 ± 0.6	92.6 ± 0.6	**< 0.001**
		168h	94.4 ± 0.7	92.5 ± 0.6	92.6 ± 0.7	93.5 ± 0.6	**< 0.001**

Statistically significant differences between the groups (same material and different solutions) are presented in bold ($p \le 0.05$).

Senofilcon A material showed an increase of UVR protection after storage in the LCS, reaching a maximum of 3.7 ± 0.5 % with the H_2O_2 solution for 8 hours in the UVB spectrum. A transmittance decrease was observed among new CL and after 8 hours of storage in all combinations of this material. After one week, Senofilcon A had a trend to recover the loss of transmittance. There were no statistically significant differences between the LCS combinations in the UVR range, except after 8 hours of storage in the UVC range ($p = 0.044$). Even without UVR blocker monomer, Lotrafilcon B and Balafilcon A materials exhibited meaningful suppression of UVR. In the Lotrafilcon B material, there was a statistically significant reduction of T (%) over time, with more evidence between zero time and after 8 hours of storage, except with ReNu MultiPlus in the UVC range. Regarding the Balafilcon A outcomes, H_2O_2 decreased the transmittance over time in all the UVR bands in opposition to MPS combinations. Comparing to zero-time values, H_2O_2 reduced 5.5% in UVC transmittance, 4.6% in UVB, and 0.6% in the UVA range after 8 hours of storage. As observed with the latter material, T (%) of Comfilcon A showed differences between MPS and H_2O_2, especially in the UVC spectrum. The Omafilcon A, which belongs to the same manufacturer, revealed a more significant UVR transmittance effect after 8 hours of storage with ReNu MultiPlus and Biotrue solutions.

Figure 1 supports these outcomes displaying the UV-visible spectra of the different lenses without the LCS influence (zero time) and after 8 hours of storage with LCS. Regarding the visible spectrum, a different shape of transmittance can be observed in all the combinations when compared with zero time of storage. All combinations showed T > 90%, except when Lotrafilcon B was stored for a week with ReNu MultiPlus, OPTI-FREE PureMoist and AOSept (Table 4). Senofilcon A, and Lotrafilcon B showed a decrease of T (%) after 8 hours of storage. In Senofilcon A, the solutions showed statistically significant differences, mainly between ReNu MultiPlus and OPTI-FREE PureMoist after one week (-5.8%). Lotrafilcon B reported more considerable differences between the control and after storage values, mostly under the effect of ReNu MultiPlus and AOSept. On the other hand, Balafilcon A and Comfilcon A experienced an increase in this variable in the same step, presenting the highest transparency values. Despite the differences found ($p < 0.001$), Balafilcon A showed less variation in T (%) after storage in the solutions compared to other materials in this range (Table 4).

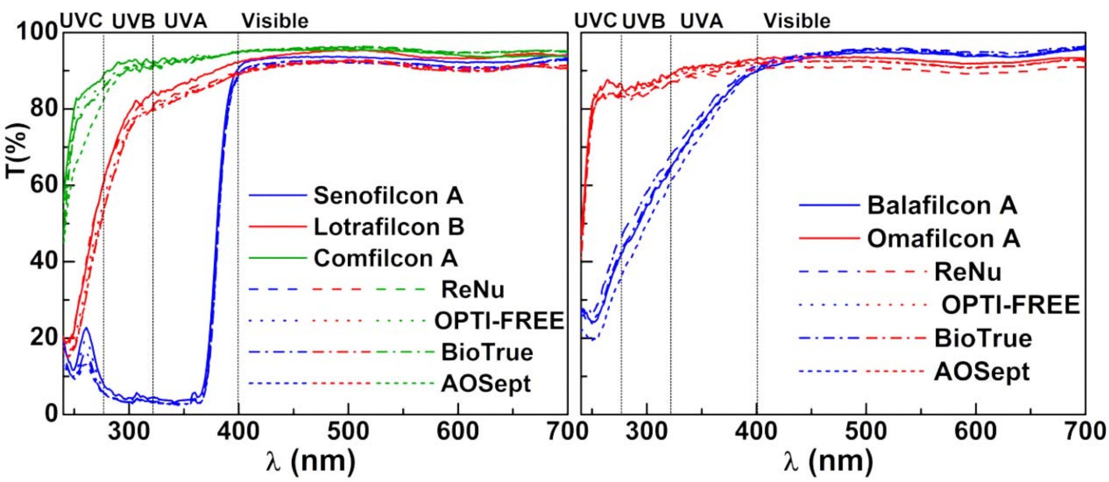

Fig. 1. Transmittance spectra (UVR-visible range) of contact lenses after 8 hours of storage in the different lens care solutions.

Contact lens materials are expected to have high transparency levels and reduced reflectance as shown in this study. Even though the variations were mild and of limited significance, all the materials showed a statistical difference in reflectance over time ($p<0.01$). Figure 2 represents the changes in average reflectance (R_a) of new CL and after 8 hours of storage in lens care solutions. H_2O_2 solution induced the higher mean values of UV-visible reflectance in Senofilcon A compared with MPS ($p<0.05$). On the other hand, this solution displayed the lower mean values of reflectance in Comfilcon A. After 8 hours of storage, all solutions reduced the R_a (%) values of CL, except when ReNu MultiPlus was combined with Lotrafilcon B. Regarding the outcomes obtained after 8 hours of storage, it can be observed that there is a more significant effect of LCS on the Omafilcon A material.

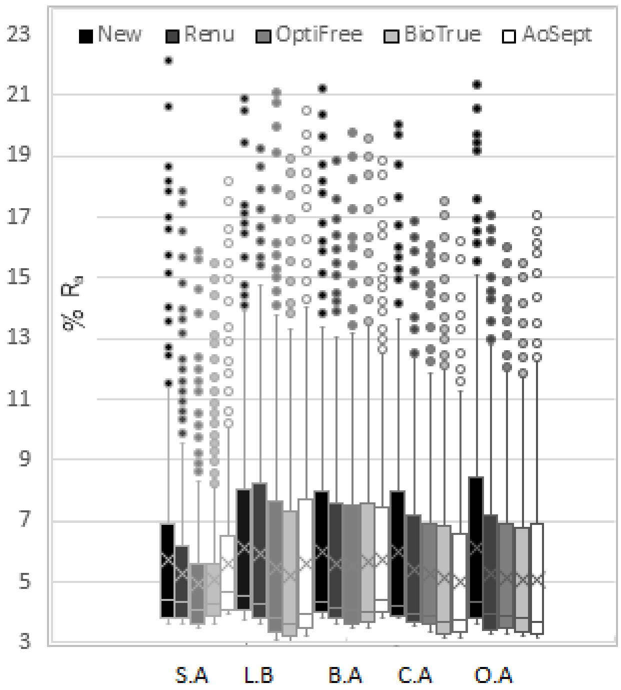

Fig. 2. UV-visible reflectance average of contact lenses after 8 hours of storage with lens care solutions. S.A: Senofilcon A; L.B: Lotrafilcon B; B.A: Balafilcon A; C.A: Comfilcon A; O.A: Omafilcon A.

Effect of Contact Lenses on Absorbance and Fluorescence of Lens Care Solutions

Figures 3 and 4 exhibit the fluorescence spectra for the excitation at 280 nm and 350 nm of LCS, before and after 8 hours of storage with the different CL materials. As can be observed and compared with spectra of the neat LCS (before immersion of CL), all the materials induced an increase of fluorescence intensity, except when AOSept is excited at 350 nm.

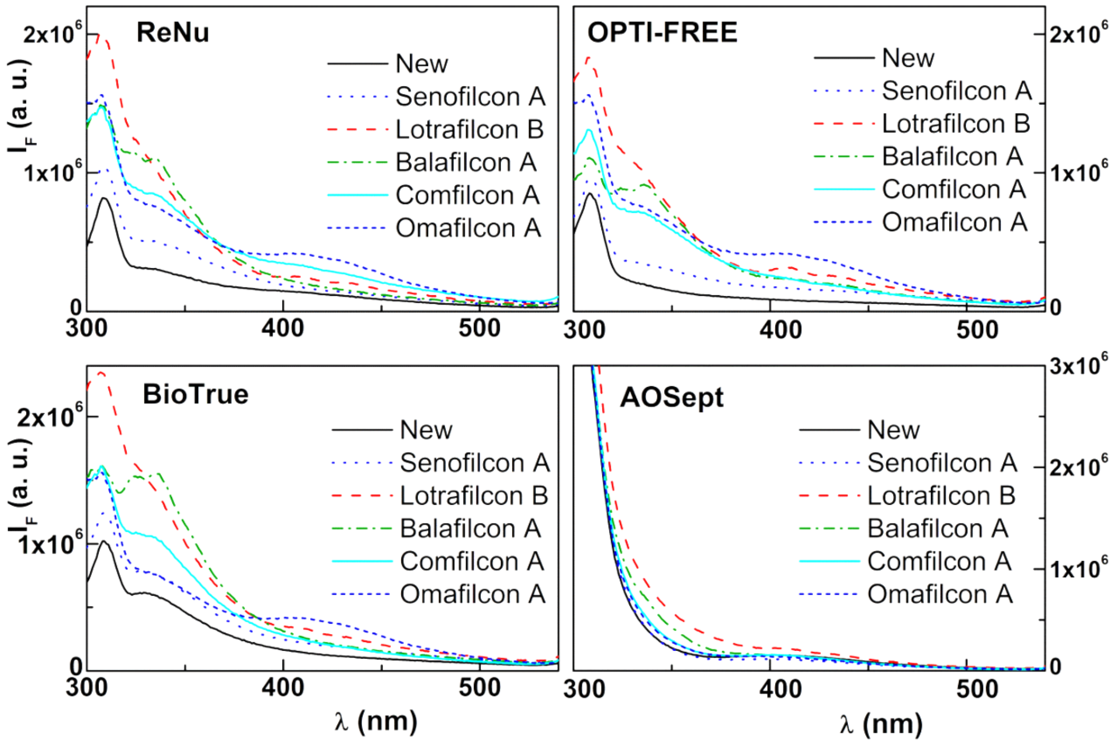

Fig. 3. UVB-UVA-visible fluorescence spectra for the excitation at 280 nm of lens care solutions analyzed after 8 hours of storage with contact lenses. S.A: Senofilcon A; L.B: Lotrafilcon B; B.A: Balafilcon A; C.A: Comfilcon A; O.A: Omafilcon A.

Regarding the differences in combinations after 8 hours of storage, it can be observed that Lotrafilcon B is the material that induced the highest effect on fluorescence intensity. The exception occurs for the ReNu MultiPlus solution excited at 350 nm. The most significant differences were detected when stored with Omafilcon A or Comfilcon B (both produced by the same manufacturer).

(In most situations) Lotrafilcon B increased fluorescence intensity values n MPS for more than double, with a higher emphasis in the UVB and UVA ranges of excitation at 280 nm after 8 hours of storage. On the other hand, Senofilcon A exhibited the lowest fluorescence emission (%) changes for all solutions when excited at 280 nm, compared with the other materials.

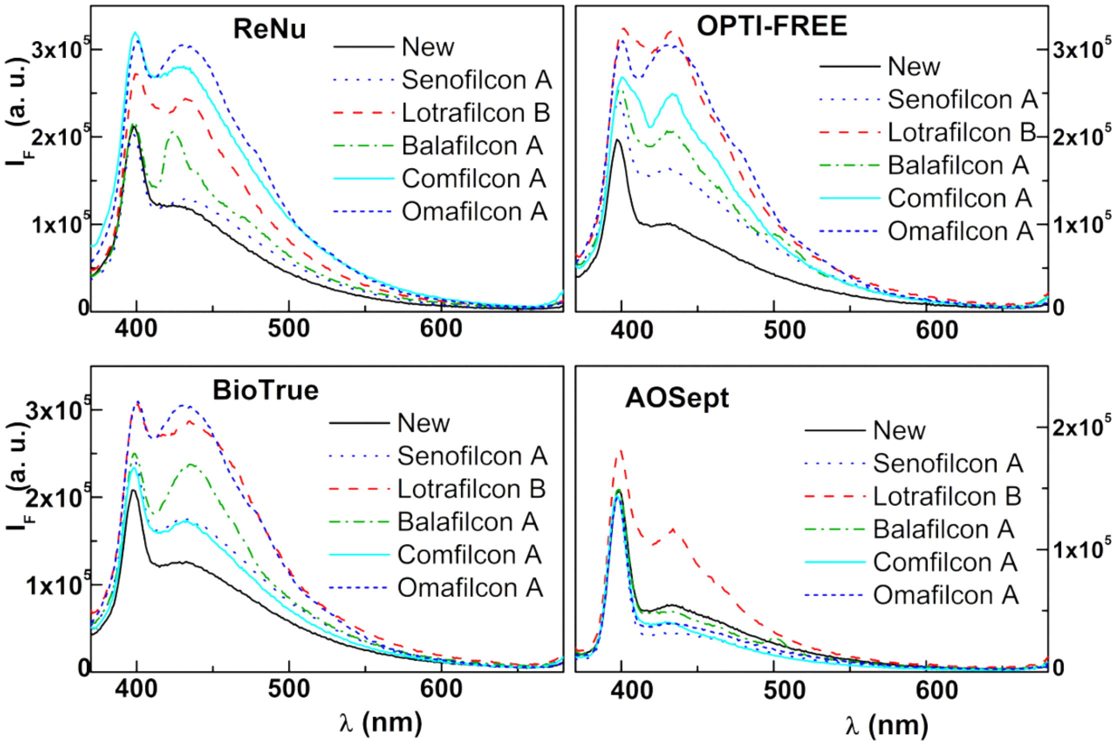

Fig. 4. UVA-visible fluorescence spectra for the excitation at 350 nm of lens care solutions analyzed after 8 hours of storage with contact lenses. S.A: Senofilcon A; L.B: Lotrafilcon B; B.A: Balafilcon A; C.A: Comfilcon A; O.A: Omafilcon A.

As shown in Fig. 3, the H_2O_2 solution (AOSept) displays different spectra for all the combinations compared to MPS solutions. These spectra exhibit light scattering effects (inner filter effect) in the lower wavelength region, indicating the presence of particles/aggregates of a few nanometers size (e.g., 15 – 30 Å, the typical diameter of surfactant micelles). In H_2O_2, the materials did not display such significant effects as MPS, being possible to infer that H_2O_2 showed higher resistance to the materials influence. In the visible range, the fluorescence emission of all the combinations was observed in the lower wavelength region (blue), evidencing the release of CL components with blue fluorescence.

In tables 5 and 6, the mean values of fluorescence intensity in different spectral regions are presented for excitation at 280 and 350 nm. Overall, the statistical analysis outcomes exhibited pronounced discrepancies between the materials. However, regarding the mean intensity values in the UVA region excited at 350nm, AOSept and OPTI-FREE PureMoist did not show statistically significant differences in materials effect. In all combinations, the Friedman ANOVA test reported substantial changes over time, with $p < 0.01$. Senofilcon A material has shown a trend to induce an increase in the fluorescence intensity in MPS solutions at all wavelengths.

Table 5. Average UVB, UVA and visible fluorescence intensity (F_a) for excitation at 280 nm (expressed as mean ± SD; SD: standard deviation) of lens care solutions new (zero time) and after 8, 24 and 168 hours of storage with the different contact lenses.

UVB F_a (intensity values x 10^{-6} a.u.) (300-315 nm)

	New		Senofilcon A	Lotrafilcon B	Balafilcon A	Comfilcon A	Omafilcon A	p
ReNu MultiPlus	0.68 ± 0.12	8h	0.92 ± 0.10	1.89 ± 0.09	1.40 ± 0.07	1.37 ± 0.09	1.46 ± 0.11	**< 0.001**
		24h	1.11 ± 0.08	1.70 ± 0.08	1.39 ± 0.06	1.37 ± 0.06	1.47 ± 0.06	**< 0.001**
		168h	1.24 ± 0.08	1.58 ± 0.07	1.47 ± 0.10	1.27 ± 0.15	1.34 ± 0.02	**< 0.001**
OPTI-FREE PureMoist	0.72 ± 0.01	8h	0.84 ± 0.10	1.71 ± 0.09	1.12 ± 0.06	1.12 ± 0.09	1.23 ± 0.11	**< 0.001**
		24h	1.12 ± 0.09	1.52 ± 0.08	1.03 ± 0.06	1.10 ± 0.07	1.26 ± 0.05	**< 0.001**
		168h	1.53 ± 0.08	1.35 ± 0.07	1.05 ± 0.08	1.00 ± 0.01	1.27 ± 0.18	**< 0.001**
Biotrue	0.89 ± 0.10	8h	1.13 ± 0.09	2.24 ± 0.10	1.54 ± 0.06	1.49 ± 0.10	1.27 ± 0.09	**< 0.001**
		24h	1.37 ± 0.07	2.00 ± 0.07	1.56 ± 0.04	1.41 ± 0.06	1.38 ± 0.05	**< 0.001**
		168h	1.53 ± 0.07	1.75 ± 0.06	1.47 ± 0.07	1.49 ± 0.16	1.45 ± 0.16	**< 0.001**
AOSept	3.35 ± 0.10	8h	3.67 ± 1.11	4.37 ± 1.26	3.63 ± 1.08	3.70 ± 1.16	3.51 ± 1.04	**< 0.001**
		24h	3.91 ± 1.19	4.05 ± 1.19	3.34 ± 0.97	3.56 ± 1.07	2.74 ± 0.74	**< 0.001**
		168h	3.88 ± 1.21	3.82 ± 1.20	3.86 ± 1.22	4.28 ± 1.46	4.63 ± 1.60	**< 0.001**

UVA F_a (intensity values x 10^{-6} a.u.) (315-400 nm)

	New		Senofilcon A	Lotrafilcon B	Balafilcon A	Comfilcon A	Omafilcon A	p
ReNu MultiPlus	0.24 ± 0.90	8h	0.39 ± 0.14	0.69 ± 0.40	0.70 ± 0.34	0.63 ± 0.22	0.61 ± 0.13	**< 0.001**
		24h	0.51 ± 0.17	0.70 ± 0.35	0.72 ± 0.34	0.82 ± 0.35	1.00 ± 0.39	**< 0.001**
		168h	0.59 ± 0.19	0.93 ± 0.45	0.67 ± 0.32	0.46 ± 0.19	0.47 ± 0.19	**< 0.001**
OPTI-FREE PureMoist	0.15 ± 0.00	8h	0.29 ± 0.10	0.69 ± 0.35	0.59 ± 0.19	0.53 ± 0.19	0.41 ± 0.17	**< 0.001**
		24h	0.51 ± 0.16	0.69 ± 0.31	0.61 ± 0.26	0.63 ± 0.26	0.85 ± 0.39	**< 0.001**
		168h	0.90 ± 0.31	0.81 ± 0.38	0.50 ± 0.22	0.28 ± 0.15	0.37 ± 0.20	**< 0.001**
Biotrue	0.41 ± 0.17	8h	0.54 ± 0.21	0.95 ± 0.49	0.96 ± 0.45	0.71 ± 0.30	0.54 ± 0.21	**< 0.001**
		24h	0.71 ± 0.25	0.92 ± 0.44	1.00 ± 0.44	0.87 ± 0.36	1.01 ± 0.44	**< 0.001**
		168h	0.82 ± 0.28	1.00 ± 0.46	0.82 ± 0.36	0.56 ± 0.26	1.56 ± 0.25	**< 0.001**
AOSept	0.38 ± 0.40	8h	0.38 ± 0.44	0.69 ± 0.56	0.53 ± 0.47	0.44 ± 0.44	0.42 ± 0.42	**< 0.001**
		24h	0.51 ± 0.47	0.55 ± 0.51	0.51 ± 0.43	0.45 ± 0.44	0.66 ± 0.35	**< 0.001**
		168h	0.47 ± 0.46	0.45 ± 0.56	0.48 ± 0.47	0.44 ± 0.50	0.47 ± 0.54	**0.022**

Visible F_a (intensity values x 10^{-6} a.u.) (400-540 nm)

	New		Senofilcon A	Lotrafilcon B	Balafilcon A	Comfilcon A	Omafilcon A	p
ReNu MultiPlus	0.08 ± 0.04	8h	0.10 ± 0.05	0.13 ± 0.07	0.11 ± 0.06	0.18 ± 0.09	0.22 ± 0.13	**< 0.001**
		24h	0.13 ± 0.05	0.14 ± 0.07	0.11 ± 0.06	0.20 ± 0.10	0.25 ± 0.01	**< 0.001**
		168h	0.15 ± 0.07	0.16 ± 0.08	0.10 ± 0.05	0.14 ± 0.06	0.14 ± 0.08	**< 0.001**
OPTI-FREE PureMoist	0.06 ± 0.02	8h	0.12 ± 0.04	0.17 ± 0.08	0.13 ± 0.06	0.13 ± 0.06	0.11 ± 0.05	**< 0.001**
		24h	0.17 ± 0.06	0.16 ± 0.08	0.12 ± 0.06	0.13 ± 0.06	0.15 ± 0.07	**< 0.001**
		168h	0.20 ± 0.09	0.17 ± 0.08	0.17 ± 0.04	0.65 ± 0.02	0.08 ± 0.03	**< 0.001**
Biotrue	0.09 ± 0.03	8h	0.13 ± 0.05	0.18 ± 0.09	0.14 ± 0.07	0.13 ± 0.07	0.13 ± 0.06	**< 0.001**
		24h	0.18 ± 0.07	0.16 ± 0.08	0.15 ± 0.07	0.15 ± 0.08	0.17 ± 0.09	**< 0.001**
		168h	0.20 ± 0.08	0.18 ± 0.08	0.15 ± 0.06	0.12 ± 0.05	0.11 ± 0.05	**< 0.001**
AOSept	0.07 ± 0.05	8h	0.05 ± 0.03	0.10 ± 0.07	0.70 ± 0.05	0.06 ± 0.05	0.06 ± 0.04	**< 0.001**
		24h	0.09 ± 0.05	0.10 ± 0.07	0.06 ± 0.04	0.07 ± 0.05	0.06 ± 0.09	**< 0.001**
		168h	0.08 ± 0.05	0.08 ± 0.06	0.07 ± 0.04	0.08 ± 0.06	0.08 ± 0.06	0.095

Statistically significant differences between the groups (same solution and different materials) are presented in bold ($p \leq 0.05$).

Table 6. Average UVA and visible fluorescence intensity (F_a) for excitation at 350 nm (expressed as mean ± SD; SD: standard deviation) of lens care solutions new (zero time) and after 8, 24 and 168 hours of storage with the different contact lenses.

UVA F_a (intensity values x 10^{-6} a.u.) (370-400 nm)

	New		Senofilcon A	Lotrafilcon B	Balafilcon A	Comfilcon A	Omafilcon A	p
ReNu MultiPlus	0.11 ± 0.10	8h	0.10 ± 0.06	0.12 ± 0.08	0.11 ± 0.07	0.14 ± 0.09	0.15 ± 0.09	**< 0.001**
		24h	0.12 ± 0.07	0.13 ± 0.08	0.10 ± 0.06	0.18 ± 0.09	0.18 ± 0.09	**< 0.001**
		168h	0.13 ± 0.07	0.13 ± 0.08	0.11 ± 0.06	0.16 ± 0.09	0.16 ± 0.08	**< 0.001**
OPTI-FREE PureMoist	0.10 ± 0.06	8h	0.12 ± 0.07	0.15 ± 0.07	0.13 ± 0.07	0.12 ± 0.08	0.11 ± 0.07	0.155
		24h	0.15 ± 0.08	0.15 ± 0.09	0.12 ± 0.08	0.12 ± 0.08	0.14 ± 0.08	0.496
		168h	0.15 ± 0.08	0.15 ± 0.09	0.12 ± 0.07	0.10 ± 0.06	0.11 ± 0.06	0.267
Biotrue	0.10 ± 0.06	8h	0.13 ± 0.07	0.16 ± 0.09	0.13 ± 0.07	0.12 ± 0.07	0.12 ± 0.07	**< 0.001**
		24h	0.16 ± 0.08	0.15 ± 0.08	0.14 ± 0.07	0.13 ± 0.07	0.14 ± 0.07	**< 0.001**
		168h	0.16 ± 0.09	0.15 ± 0.08	0.14 ± 0.07	0.14 ± 0.07	0.13 ± 0.07	**< 0.001**
AOSept	0.06 ± 0.05	8h	0.05 ± 0.05	0.07 ± 0.06	0.06 ± 0.05	0.06 ± 0.05	0.06 ± 0.05	0.077
		24h	0.06 ± 0.05	0.08 ± 0.07	0.06 ± 0.05	0.06 ± 0.06	0.07 ± 0.05	0.116
		168h	0.06 ± 0.05	0.06 ± 0.06	0.06 ± 0.05	0.06 ± 0.05	0.06 ± 0.05	0.583

Visible F_a (intensity values x 10^{-6} a.u.) (400-680 nm)

	New		Senofilcon A	Lotrafilcon B	Balafilcon A	Comfilcon A	Omafilcon A	p
ReNu MultiPlus	0.04 ± 0.05	8h	0.05 ± 0.05	0.08 ± 0.09	0.06 ± 0.06	0.10 ± 0.10	0.11 ± 0.11	**< 0.001**
		24h	0.07 ± 0.07	0.09 ± 0.09	0.06 ± 0.06	0.11 ± 0.11	0.12 ± 0.11	**< 0.001**
		168h	0.08 ± 0.07	0.09 ± 0.09	0.05 ± 0.05	0.08 ± 0.09	0.08 ± 0.08	**< 0.001**
OPTI-FREE PureMoist	0.04 ± 0.04	8h	0.06 ± 0.06	0.10 ± 0.10	0.07 ± 0.07	0.08 ± 0.09	0.06 ± 0.07	**< 0.001**
		24h	0.09 ± 0.08	0.10 ± 0.10	0.08 ± 0.08	0.08 ± 0.08	0.09 ± 0.09	**< 0.001**
		168h	0.10 ± 0.09	0.09 ± 0.09	0.06 ± 0.06	0.04 ± 0.04	0.05 ± 0.05	**< 0.001**
Biotrue	0.05 ± 0.05	8h	0.07 ± 0.06	0.11 ± 0.09	0.08 ± 0.08	0.06 ± 0.06	0.06 ± 0.06	**< 0.001**
		24h	0.10 ± 0.09	0.09 ± 0.09	0.09 ± 0.09	0.08 ± 0.08	0.08 ± 0.08	**0.009**
		168h	0.11 ± 0.01	0.09 ± 0.09	0.08 ± 0.07	0.07 ± 0.07	0.06 ± 0.06	**< 0.001**
AOSept	0.02 ± 0.02	8h	0.02 ± 0.02	0.04 ± 0.04	0.02 ± 0.02	0.02 ± 0.02	0.02 ± 0.02	**< 0.001**
		24h	0.03 ± 0.03	0.04 ± 0.05	0.02 ± 0.02	0.02 ± 0.03	0.03 ± 0.03	**< 0.001**
		168h	0.03 ± 0.03	0.03 ± 0.03	0.02 ± 0.02	0.02 ± 0.02	0.01 ± 0.02	**< 0.001**

Statistically significant differences between the groups (same solution and different materials) are presented in bold ($p \le 0.05$).

From the comparison of average absorbance (A_a) changes displayed in Fig. 5, it can be highlighted the increase of A_a produced by Comfilcon A in ReNu MultiPlus and OPTI-FREE PureMoist solutions. On the other hand, Lotrafilcon B and Balafilcon A exhibited the most visible influence on Biotrue and H_2O_2 solutions average absorbance.

As observed in fluorescence spectra, Senofilcon A reported the least impact on average absorbance for all solutions. Regarding H_2O_2, there is a different A_a behavior compared to other solutions, with a lower value both in the new solution (before immersion of CL) and in the others that had the lenses immersed.

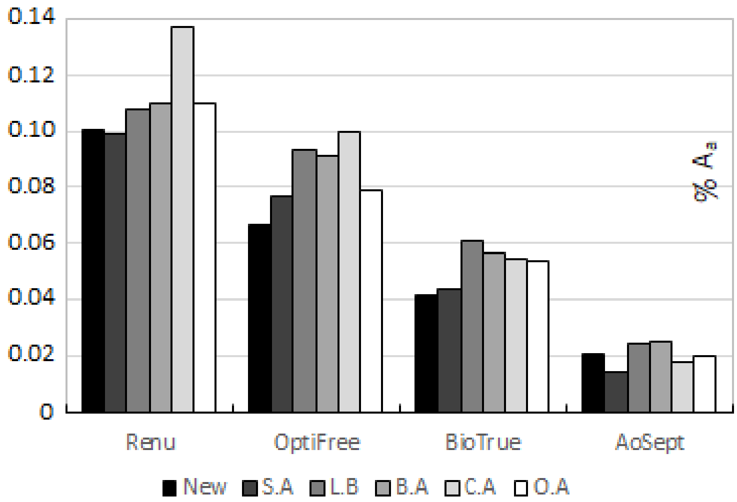

Fig. 5. Changes of UV-visible absorbance average (A_a) of lens care solutions analyzed after 8 hours of storage with contact lenses. S.A: Senofilcon A; L.B: Lotrafilcon B; B.A: Balafilcon A; C.A: Comfilcon A; O.A: Omafilcon A.

DISCUSSION

Considering the lens material and depending on the composition of lens care solutions (LCS), the behavior of studied variables was not monotonic, displaying systematic changes overtime during the disinfection and preservation process. Most of the reported changes can be associated with different physical properties of LCS, as shown by the Dalton et al. study [22]. The higher surface tension and lower pH of AOSept, compared to MPS, can explain its different behavior and greater resistance to the polymeric compounds of CL materials, as can be analyzed by the outcomes of absorbance and fluorescence (Figs. 3-5).

Andrasko's study [8] describes the percentage of corneal staining area after 2 hours of CL wear with different LCS. This effect was more significant in PHMB-based solutions, especially when combined with FDA Group II CL and some Si-Hy materials, like Balafilcon A material [40]. In this work, Omafilcon A (FDA Group II) had the most considerable effect on the fluorescence of ReNu MultiPlus when excited at 350 nm (Table 6), and Balafilcon A displayed an increase in their UVR transmittance caused by MPS (Table 3). In addition to inducing less ocular effect as presented in the study of Andrasko and coworkers, H_2O_2 showed to be a good option in the context of optical properties because it seems to be resistant to materials influence (Figs. 3-5), without causing considerable changes in the optical properties of CL (Fig. 1). A recent study [40] reported that H_2O_2 use is recommended for patients with poor lens hygiene or ocular allergies.PQ-1 is a tetra-ammonium compound with four positive charges, and PHMB is a neutral polyamine (with a sequence of NH groups). It is expected to find significant differences in the interactions between these two preservatives and different CL materials. This trial showed some differences in transmittance of materials between LCS that contain PQ-1 and PHMB as disinfectants in their composition. Still, the findings do not allow to conclude if there is a clear relationship between these constituents and their influence in the optical properties of products, as it was found a very similar fluorescence spectrum (Figs. 3-4). It would be interesting to study more specifically if these two compounds present different interaction modes with the polymer network of CL materials. It is expected that, after storage, CL dimensions would change due to the permeability of the polymer. This assumption was recently investigated by Smith and coworkers [24], who confirmed these changes, with LCS primary influence on CL diameter.

When stored in the LCS, Lotrafilcon B had a good performance (Fig. 1), similarly to the findings reported in another study that analyzed the impact of solutions on the modulus of CL [41]. In this sense, the LCS components give the material less hardness, which can induce less physiological risk. As in the present investigation, Young's study [42] reported a more extensive interaction between H_2O_2 and Lotrafilcon B, compared to MPS. As these authors showed, these solutions present different types of interactions with CL materials. In MPS, there is a chemical absorption process, while H_2O_2 revealed an irreversible change on the polymer network for its oxidative effect. The solutions improved the UVR blocking properties of Senofilcon A material. Benzotriazole monomer, incorporated in this material, promotes significant protection against UVR. UVR blocker CL can prevent incident light at all angles, displaying an essential role against peripheral light focusing [30]. This material exhibited less effect on fluorescence and absorbance of lens care solutions (Figs. 3-5), possibly due to the absence of tint additives. Comfilcon A showed the lowest percentage of absorbed light compared to the other materials (Fig. 6) that can be associated with the "Aquaform" technology. The material contains longer chains, charged with a lower silicon content, making the lens more flexible and with a higher wetting capability.

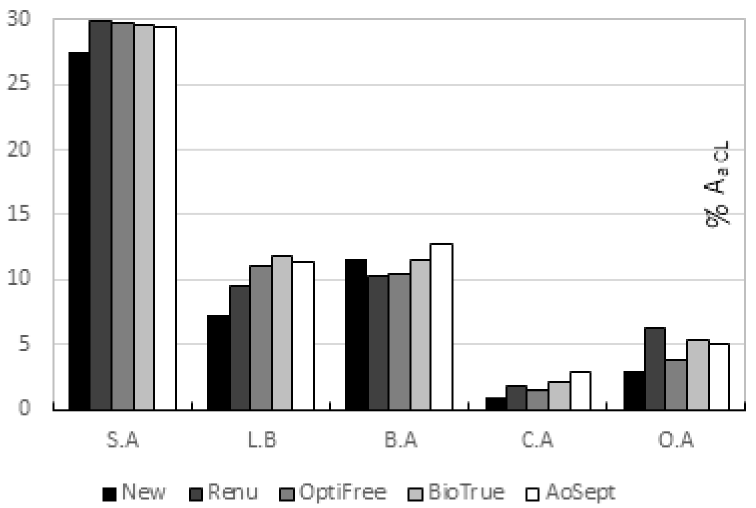

Fig. 6. Changes of UV-visible mean absorbed light percentage of contact lenses analyzed after 8 hours of storage with the different lens care solutions. S.A: Senofilcon A; L.B: Lotrafilcon B; B.A: Balafilcon A; C.A: Comfilcon A; O.A: Omafilcon A.

If multiple reflections are neglected from transmittance and reflectance measurements, the fraction of absorbed light can be estimated through the equation $R\lambda + T\lambda + A\lambda = 1$. Fig. 6 shows the changes in mean values of UV-visible absorbed light percentage of CL before immersion in LCS and after 8 hours of storage in the different solutions. It is possible to observe that CL materials had a trend to absorb more light after 8 hours of storage with the solutions, except in Balafilcon A material when combined with MPS. This phenomenon may indicate a significant interaction between CL materials and LCS components. In this sense, CL materials that showed a decrease in transmittance and reflectance may have absorbed the solutions components, which may cause a consequent increase in their light absorption. There are differences in the influence of lens care solutions in CL materials, considering their ionic content, that could justify the differences reported in Balafilcon A material. There was a higher T (%) reduction with AOSept in Balafilcon A lenses (FDA group 3) compared with the other CL groups. These results agree with the considerations done by Lorentz et al. and Guillon et al. [19,42], who have shown a higher interaction between the charged agents of products (e.g., surfactants, chelating agents, and preservatives) and ionic materials, which may cause changes in CL properties, as well as in their degradation.

In the same way, the CL water content can also affect their behavior within LCS. The CL polymer network contains free water that moves quickly within and out of the hydrogel material. Thus, hydrogel materials are suitable solvents for some hydrophilic or amphiphilic solutes included in cleaning systems (e.g., PHMB, EDTA, MAPDA, or surfactant molecules). In a study reported by Lira et al. [43], the refractive index of Comfilcon A, Senofilcon A, and Lotrafilcon B decreased after immersed in ReNu MultiPlus and AOSept solutions over 24 hours. These observations agree with the outcomes of this study, considering that, after immersed in the solutions, the materials water content increases, translating the consequent variations of the absorption of light by diffuse particles. The same study showed statistically significant differences in the surface roughness of Senofilcon A, Lotrafilcon B, and Comfilcon A caused by ReNu MultiPlus. MPS increased roughness can lead to a more considerable diffusion of light, resulting in decreased transmittance, which was estimated in this study, especially for Lotrafilcon B material.

There is experimental evidence of relaxation and swelling of the polymeric network close to the CL surface when the materials are exposed to LCS [23]. The latter study detected changes caused by MPS in the morphology of CL surface, which was more wrinkled, together with changes in CL optical properties, with variations of the Zernike coefficients. In the current investigation, Lotrafilcon B CL showed the most extensive increase in fluorescence than the other materials, except with ReNu MultiPlus solution excited at 350 nm (Figs. 3 and 4). This behavior can be explained by the interaction between the lens polymer and the solutions, which may be facilitated by the ultrathin (25 nm) continuous and hydrophilic plasma coating with a high refractive index of the surface treatment. Despite these outcomes, the same solutions used in the Lira study [44] showed an improvement in wettability of CL materials after 12 hours of storage, mainly in Lotrafilcon B and Balafilcon A materials. Compared with the study conducted by Ogbuehi [38], ReNu MultiPlus demonstrated the same trend to increase the transmittance of Lotrafilcon B after storage. This rationale allows concluding that an adsorption process of LCS components can be the precursor to CL materials optical variable changes and that can be associated with morphological variations on the lens surface. Compared with the effect of combinations in corneal staining reported by Andrasko [8], it is observed that conventional hydrogel CL (Omafilcon A) - that reported 57% of corneal staining area with ReNu MultiPlus - also showed a larger light absorption with ReNu MultiPlus (Fig. 6).

The same does not happen with Balafilcon B material, which presented a 73% corneal staining area with ReNu MultiPlus. In this study, ReNu MultiPlus was not the solution that induced the highest light absorption in this material.

Considering that CL materials have significant porosity, there are several transitions of molecules in their polymeric matrix. A recent study conducted by Gavara and Compañ showed an increase of Si-Hy materials ionic permeability associated with the confinement of ions in nanoscale water channels, involving possible decreased degrees of freedom for the diffusion of both water and ions [45].

The results revealed that the LCS fluorescence emission intensity increased over time (Tables 5-6), which may be associated with the release of some components from CL materials, being possible to predict that essential interactions between CL and LCS occurred during storage. Statistically significant differences were found over time ($p < 0.01$) during storage for the four wavebands (UVR and visible). Although there were substantial alterations in the visible spectrum, it may not represent clinical relevance in CL materials transparency. Overall, the T (%) of the materials was higher than 90% after 8 hours of storage with LCS.

There is a link between the outcomes found in LCS variables and the changes caused in the CL materials. It was possible to infer that, when LCS are in contact with a CL material, multiple interactions occur that can change the optical properties of CL materials and LCS mutually. These findings can provide additional information about the interaction of CL materials and LCS in the clinical setting. The efforts to improve comfort associated with CL wear, through the development of new materials, surface modifications, and new lens care products, have been evident in the CL industry. These changes have resulted in real clinical benefits [46]. However, total biocompatibility has not yet been achieved and one of the main problems still existing are the interactions mentioned in this work. Considering that hyaluronic acid enhances water retention [47] and does not affect the CL optical properties [48], it is an excellent topic to be developed in future investigations.

CONCLUSION

This investigation found significant changes in CL transmittance and reflectance, as well as in absorbance and fluorescence of LCS after storage. The selection of the solution to disinfect and preserve CL may represent an essential role in their clinical and optical performance due to their inherent interactions. Lotrafilcon B induced the most considerable effect on fluorescence and absorbance of the LCS, probably associated with the release of some compounds by chemical changes of the polymers (or other components). Senofilcon A has shown a low impact on the optical properties of solutions compared with the other materials. Its transmittance decreases after storage, while being a good option for blocking UVR. The peroxide-based solution exhibited more resistance to the influence of CL materials in its optical properties. Further, *in vivo* studies would be needed to understand better the clinical impact of these changes in optical properties, resulting from the combination of different contact lens materials with LCS.

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SUPPORTING INFORMATION - ATTACHED