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RESEARCH

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Rational durability of optical properties of chameleon effect of Omnichroma and Essentia composite thermocycled in black dark drinks (in vitro study)

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Abstract

Background: This study evaluated the durability of optical properties of chameleon effect of Omnichroma and Essentia composite thermocycled in black dark drinks. 180 specimens of 10 mm diameter × 2 mm thickness from each tested composite material were prepared; Omnichroma and Essentia. 60 specimens were thermo-cycled for 2500 and 5000 cycles in Coffee and Coca-Cola in addition to Distilled water as a reference group for color change evaluation. Color change (ΔE) was calculated and water sorption and solubility were measured after thermocycling for 2500 and 5000 cycles in different dark drinks and water. The surface chemical changes were assessed by FTIR. All data were statistically analyzed.

Results: In all tested groups, Omnichroma recorded the highest significant color change (35.80 ± 4.13) and sorption values (8.30 ± 0.48) on the contrary the least solubility value (− 8.29 ± 0.81) in all tested drinks after thermocycling to 5000.

Conclusions: Color durability of Omnichroma negatively affected in dark drinks. Water sorption of Omnichroma negatively affected after aging 3 and 6 months. Water solubility might not adversely affect the color change. Thermocycling in different dark drinks adversely affected the color stability of both selected Chameleon composite types.

Keywords: Omnichroma, Essentia composite resin, Color stability, Nano-spherical composite, Chameleon effect, Thermocycling, Esthetic restoration

Background

One of the most essential qualities of aesthetic restorative materials is their optical properties and color matching. Resin composites have been developed and modified over time to improve the cosmetic features of restorative materials. Initially many shades were developed about 32 to gain different translucency and opacities (Bakti et al. 2018).

The color variability of natural teeth induced manufacturers to create composites systems that include shades of varying opacities and translucency, commonly referred to as dentin and enamel shades, with the goal of simulating the optical properties of dentin and enamel by layering three or more shades. Furthermore, the procedure was simplified by two or one shade, and then they generated universal shade composites that match multiple teeth shades (de Abreu et al. 2021).

Resin composites with a blending effect, often known as the "Chameleon effect," in which the resin composite

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reflects the color of the surrounding tooth structure, improving the aesthetics. The chameleon effect is the ability to change the color to match the surrounding environment using nano-fillers that mimic light transmission, diffusion, and reflection (Chen et al. 2020).

Color stability is altered by pigment absorption when exposed to various staining media such as coffee, cola and water. Although resin composites are considered impermeable to water and highly stable, they negatively affect the restorative material by discoloration and chemical degradation of the filler resin link in the matrix (Mansouri and Zidan. 2019).

Universal shade resin composites with chameleon effects appear to be a promising new topic worth investigating. A few studies looked on the durability of composites with chameleon effects. This study evaluated the durability of optical properties of chameleon effect of Omnichroma and Essentia composite thermocycled in black dark drinks.

Omnichroma and Essentia composites are two examples of smart chromatic composites (Chameleon effect). Omnichroma is able to capture the shade color of the surrounding structure due to its evenly sized 260 nm spherical filler and the absence of uneven edges, as a result of its filler nature, polychromatic composites were developed, which could generate red to yellow hue as ambient light passed through the composite. Furthermore, it contains no dyes or pigments, thus it does not change color over time as a result of colorful drinks or meals (Sharma and Samant 2021). On the other hand, Essentia composite is the result of a combination of enamel and dentine technology advancements. Its fillers are a combination of highly dense nano-filler and well-distributed hybrid fillers in the micron range, resulting in differences that mimic natural tooth structure (Miletic et al. 2020).

Certain beverages including coffee and Coca-Cola may have an impact the physical qualities and appearance of composite restorations. The frequency of liquids consumed may have a direct impact on the qualities of restoration (Wakeel 2017). Most studies assessed the color stability of composite discs by immersing them in static solutions at 37 °C for a period of time, which measured discoloration and adsorption on the materials' surfaces, but this does not represent the true discoloration of the materials caused by absorption. Few research had taken into account the thermal strains and dynamic characteristics of the mouth cavity during beverage drinking (Ren et al. 2012).

The null hypothesis of this study is that supra-nano-composite (Omnichroma) has more stable color and durability than Hybrid-nano-composite (Essentia) in dark drinks. Thus this study evaluated the durability of optical properties of chameleon effect of Omnichroma and Essentia composite thermocycled in black dark drinks.

Method

Material

Omnichroma and Essentia universal shade composite were used for the study (Table 1).

Study design

A total no. of (360) specimens were prepared; (180) for each type of dental composite; Omnichroma and Essentia. Each composite type was divided into three groups ($n=60$) for each thermocycling (TC) solution (Distilled water (DW), Coffee, and Coca-Cola) and two subgroups ($n=30$); 2500 and 5000 cycles.

Specimens were prepared for each composite by using a split Teflon mold (10 mm diameter and 2 mm thickness) to produce standardized resin composite specimens.

Thermocycling test method

60 specimens of each composite type were thermocycled in DW,Coffee and Coca-Cola for 2500 and 5000 cycles,

Table 1 Materials used, specification, composition, lot number and manufacturer

Brand name	Specification	Composition	Lot No	Manufacturer
Omnichroma	A single universal shade exhibits the ultimate wide range color matching ability	Fillers: Uniform sized supra-nano spherical silica-zirconia filler Filler loading 79 wt% (68 vol %). Matrix: UDMA, TEGDMA	002E60	Tokuyama dental corporation 38–9 (Taitou-ku,Tokyo 110–0016,Japan
Essentia	A universal shade displays a great blending effect with packable consistency for easy placement	Fillers: prepolymerised silica and barium glass loading 81 wt% (65%vol) Matrix: UDMA, BIS-MEPP, BIS-EMA, BIS-GMA, TEGDMA	180410A	GC dental products corporation 2–285 (Toriimatsu cho, Kasugai, Aichi, Japan)

each cycle included immersion for 30 s into the hot path at 55 °C ±1 followed by immersion for 30 s into the cold path at 5 °C ±1 with 5 s delay between paths. The TC was done using a custom made TC unit.

DW; the TC unit contained a hot DW path (55 °C ± 1) and a cold DW path (5 °C ± (1) for 2500 cycles, groups; (Omnichroma DW 2500 and Essentia DW 2500) and for 5000 cycles, groups; (Omnichroma DW 5000 and Essentia DW 5000) (Ghavami-Lahiji et al. 2018).

A Coffee; coffee solution was prepared by adding 20 gm (Nescafé classic, Nestle, Egypt) to 1 liter of boiling water then chilled out to 55 °C. The TC unit included a hot coffee path (55 °C ± 1) and a cold DW path (5 °C ± 1) (Ren et al. 2012).The TC was performed for 2500 cycles, groups; (Omnichroma Coff 2500 and Essentia Coff 2500) and 5000 cycles, groups; (Omnichroma Coff 5000 and Essentia Coff 5000).

Coca-Cola; A Liter of Coca-Cola was used (Coca-Cola Company, Egypt). The TC unit contained a hot DW path (55 °C ± 1) and Coca-Cola included in a cold path (5 °C ± 1). The thermocycling was performed for 2500 cycles, groups; (Omnichroma cola 2500 and Essentia cola 2500) and 5000 cycles, groups; (Omnichroma cola 5000 and Essentia cola 5000). After thermocycling all specimens were stored in dark labeled vials for further testing.

Color measurements method

120 specimens were used from each composite type, ($n=40$) for each thermocycled solution. A spectrophotometer (VITA Easyshade Advance, Zahnfabrik, Bad Sackingen, and Germany) was used to record color measurements before and after the thermocycling process. Each specimen was washed and dried gently with tissue paper then calibration was done according to manufacture instruction; the instrument probe was placed in the calibration block holder, the probe tip was flush with and perpendicular to the calibration block,depresses the calibration block and following that a successful calibration was done at the top and bottom surfaces of each disc by placing the instrument probe perpendicular and flush to the disc surface against a white background (Kalantari et al. 2017). After all specimens were measured the mean value of three measurements ΔL, Δa, and Δb was recorded and all these measurements were repeated after thermocycling process. The change in color was calculated in the form of ΔE using this formula: $\Delta E=[\Delta L+\Delta a+\Delta b]^{½}$ (Kumah et al. 2019).

Water sorption and solubility test

60 specimens were used from each composite type, ($n=20$) for each thermocycled solution to measure the amount of water sorption and solubility in different drink solutions. Water sorption (W_{sp}) were measured as follow; the initial weight was measured by digital sensitive balance four digit numbers (ADEM sensitive balance, Germany) before the TC was performed. In which the specimens were stored in a desiccator at 37 °C for 22 h, followed by 2 more hours at 23 °C with silica gel beads then weighed in the digital sensitive balance. This weight is then recorded as the initial weight M_1. The mean diameter and the mean of the thickness of each sample were measured to determine the volume (V). After TC specimens removed and solutions blotted away from the surface until it was free from visible moisture then weighed again to gain (M_2) then specimens dried again in a desiccator at 37 °C for 22 h followed by 2 more hours at 23 °C with silica gel beads to get M_3 (Arregui et al. 2016). Water sorption (W_{sp}) was calculated by using the following equation: $W_{sp}=[M_2-M_3]/V$.

The Water solubility (W_{sl}) of different tested groups was calculated from weight loss after TC process and compared to dry weight of each specimen as mentioned previously at water sorption test. The values of water solubility (W_{sl}) calculated by using the following equation: $W_{sl}=[M_1-M_3]/V$.

FTIR characterization

The same specimens that used in color change test; ($n=120$) for each composite type were chemically characterized before and after TC by using a Fourier Transform Infra-Red spectrometer (FTIR-ATR) (FT-IR Spectrometer, Nicolet iS50, UK). All spectra were recorded in the range (400–4000 cm^{-1}). The chemical composition was analyzed qualitatively. Qualitative analysis was employed by interpreting the corresponding functional groups to the specific bands' wave numbers (Anand et al. 2017).

Statistical analysis

Data was collected and analyzed with SPSS for windows version 25, and the findings revealed a normal distribution. A one-way ANOVA was used to compare more than two groups in unrelated samples, followed by a Tukey post hoc test. An independent sample t test was used to compare two groups in unrelated samples. P-value was considered significant at ≤ 0.05.

Results

The color changes of the tested groups after TC are shown at Table 2 and Fig. 1. The statistical data of Omnichroma composite revealed that; Omnichroma Coff 5000 had the highest statistically significant (ΔE) value followed by Coff 2500, Cola 5000 and Cola 2500. Omnichroma DW 2500 had the least (ΔE) value which non-significant with DW 5000.

Essentia composite revealed that; Essentia Coff 5000 had the highest statistically significant (ΔE) value followed by Coff 2500, Cola 5000, Cola 2500 and DW 5000. Essentia DW 2500 had the least (ΔE) value.

Omnichroma had a higher statistically significant (ΔE) values among all tested groups as compared with Essentia composite with (p-values < 0.05).

The statistical data of water sorption is shown in Table 3 and Fig. 2. The statistics of water sorption of Omnichroma recorded that; the highest significant water sorption value was for Omnichroma Coff 5000 followed by Coff 2500. Whereas DW 2500 had the least significant (W_{sp}) value.

Table 2 The change in color (ΔE) values after TC 2500 and 5000 of Omnichroma and Essentia composite

Immersion solutions	DW Mean ± SD		Coffee Mean ± SD		Cola Mean ± SD		*p*-value
No.of cycles	2500	5000	2500	5000	2500	5000	
Omnichroma	6.76 ± 0.66	7.96 ± 0.61	27.98 ± 4.20	35.80 ± 4.13	10.49 ± 2.21	16.44 ± 0.87	< 0.001*
Essentia	4.03 ± 0.72	5.58 ± 1.64	14.67 ± 1.73	16.07 ± 2.26	6.36 ± 2.25	7.98 ± 0.97	< 0.001*
p-value	< 0.001*				0.010*	< 0.001*	

* Significant ($p < 0.05$)

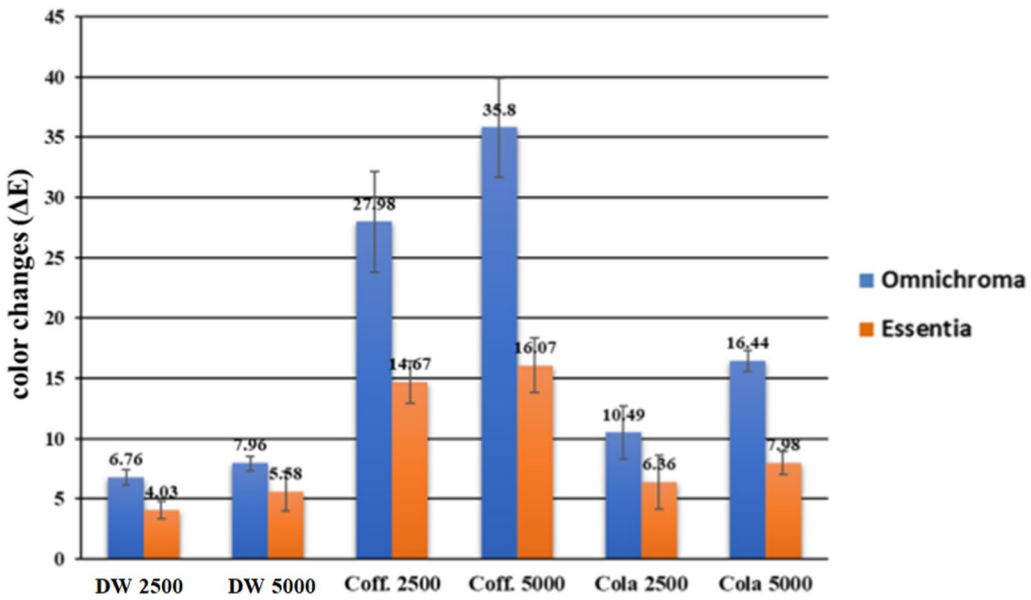

Fig. 1 The histogram showed: The change in color (ΔE) values after TC 2500 and 5000 of Omnichroma and Essentia composite

Table 3 The water sorption values in (μg/mm.^{3}) after TC 2500 and 5000 of Omnichroma and Essentia composite

Thermocycling solutions	DW Mean ± SD		Coffee Mean ± SD		Cola Mean ± SD		*p*-value
No.of cycles	2500	5000	2500	5000	2500	5000	
Omnichroma	3.36 ± 0.28	6.56 ± 0.75	7.14 ± 1.07	8.30 ± 0.48	1.39 ± 0.23	7.00 ± 1.80	< 0.001*
Essentia	1.31 ± 0.19	2.17 ± 0.15	1.42 ± 0.28	2.44 ± 0.40	1.52 ± 0.37	2.13 ± 0.30	< 0.001*
p-value	0.009*	0.003*	< 0.001*				

* Significant ($p < 0.05$)

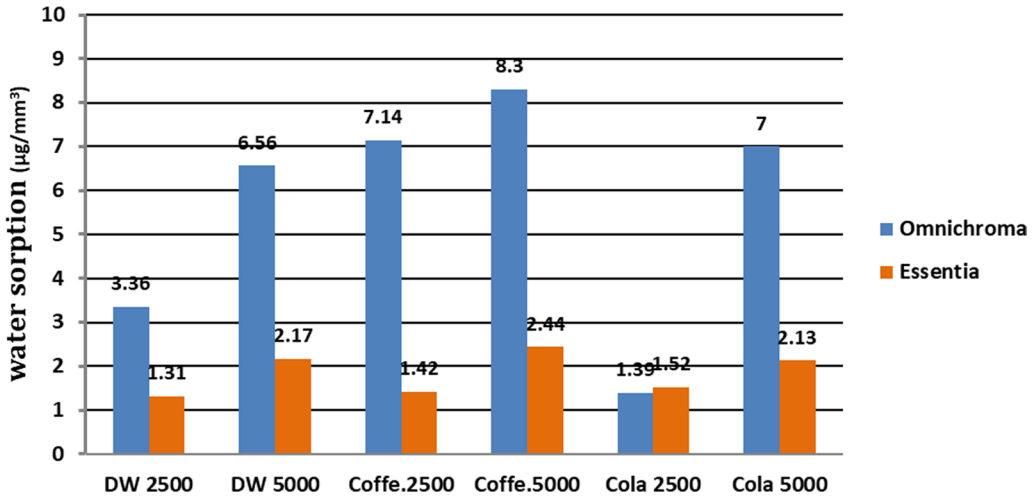

Fig. 2 The histogram showed water sorption values after TC 2500 and 5000 of Omnichroma and Essentia composite

Regarding Essentia composite; Coff 5000 had the highest significant water sorption value. There was a non-significant value in groups DW 2500, Coff 2500 and Cola 2500.

Comparing the statistical results of Omnichroma and Essentia the highest statistically significant (W_{sp}) value was for Omnichroma with (p-values < 0.05). Water sorption of Omnichroma was triples to fourth that of Essentia.

The statistical data of water solubility is shown at Table 4 and Fig. 3, Omnichroma composite revealed that; Cola 5000 had the highest significant (W_{sl}) value followed by Cola 2500. Whereas the least value was for group DW 2500. W_{sl} value in DW 5000 was non-significant with Coff 5000.

Regarding Essentia composite; the highest statistically significant (W_{sl}) value among all tested groups was Coff 5000 followed by Cola 5000, whereas the least value was DW 2500. There was a non-significant W_{sl} value between DW 5000 and Coff 2500.

The statistical comparison of water solubility between Omnichroma and Essentia revealed that; Essentia (W_{sl}) values were statistically significantly higher than Omnichroma.

Figures 4, 5, 6, 7, 8, 9, 10 and 11 showed FTIR characterization of solutions and different tested groups before and after TC, the spectrum of **DW** revealed the presence of well-defined OH bands at 630 and 3343 cm^{-1}. The band at 1646 cm^{-1} was characteristics for H–O–H.

The spectrum of the chemical structure of **Coffee** revealed the presence of well-defined bands at 628 and 3349 cm^{-1} which were characteristics for OH. The band at 1646 was characteristics for C=O group. Both functional groups C=O and OH which very characteristic to chemical structure of Gallic acid, caffeine, cholorogenic acid and protocatechuic acid.

The chemical structure of **Coca-Cola** revealed the presence of well-defined band at 622 and 3337 cm^{-1} which were characteristics for OH. The small band at 1081 was characteristics for CH_3 group. In addition to C=O band was detected at 1646. These bands are characteristic to chemical structure of carbonic acid, glucose, caramel and phosphoric acid.

The spectrum of Omnichroma before TC revealed the presence of well-defined bands at (464 and 804 cm^{-1}),

Table 4 The water solubility values in (µg/mm.^{3}) after TC 2500 and 5000 of Omnichroma and Essentia composite

Immersion solutions	DW Mean ± SD		Coffee Mean ± SD		Cola Mean ± SD		$p-$ value
No.of cycles	2500	5000	2500	5000	2500	5000	
Omnichroma	− 8.29 ± 0.81	− 2.36 ± 0.99	− 5.58 ± 0.86	− 2.33 ± 0.67	− 1.69 ± 0.53	2.11 ± 0.47	< 0.001
Essentia	− 2.72 ± 0.71	2.76 ± 0.77	3.22 ± 0.30	6.39 ± 0.80	2.20 ± 0.34	4.71 ± 0.82	< 0.001
$p-$ value	0.009	0.003	< 0.001*				

* Significant ($p < 0.05$)

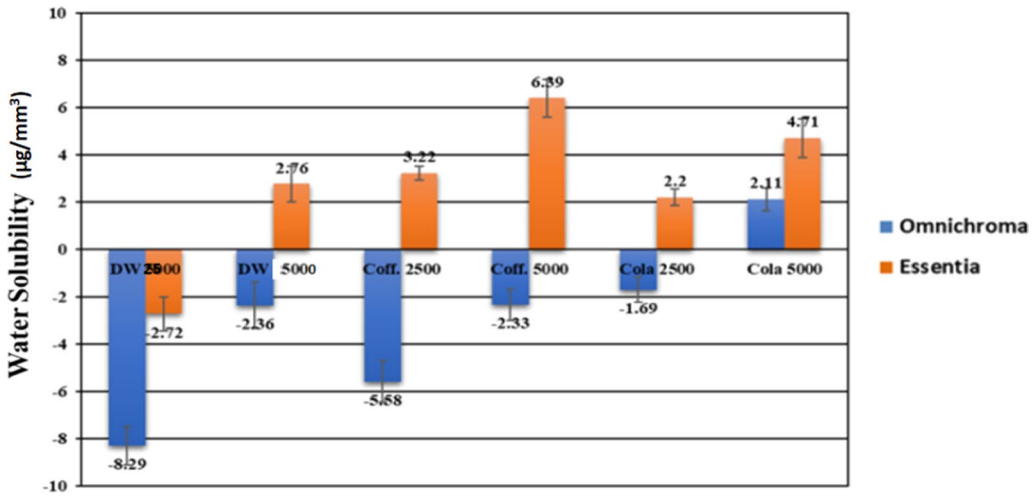

Fig. 3 The histogram showed water solubility values after TC 2500 and 5000 of Omnichroma and Essentia composite

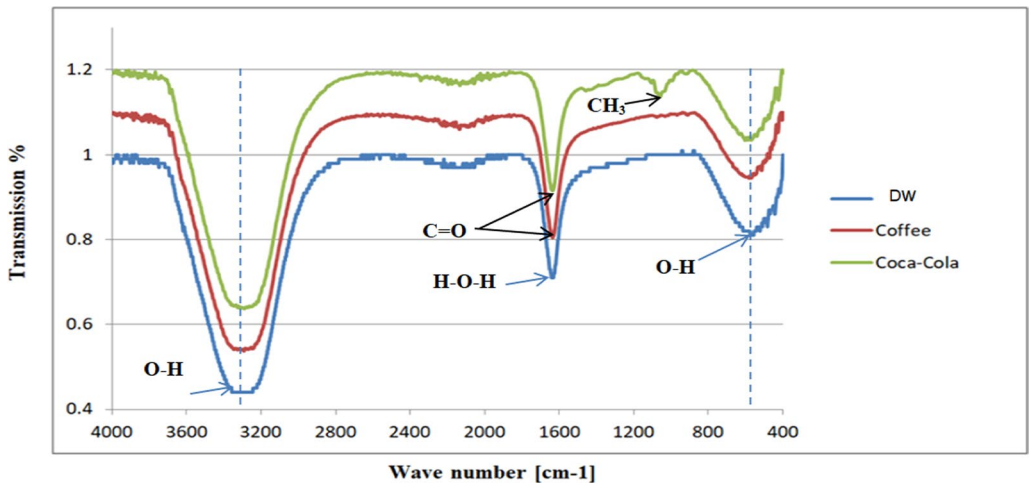

Fig. 4 FTIR spectra representing the chemical structure of DW, Coffee and Coca-Cola

(597–661 cm^{-1}) and (1051–1085 cm^{-1}) which were characteristic for Silica, $PO_{4\ (\upsilon 4)}$ and HPO_4 group. The different small bands at 1417, 1475 and 1555 cm^{-1} represented the ethyl group CH_2CH_3. The C=C, C=O–OH and CH_3 bands were captured at 1656, 1724 and (2945–2991) cm^{-1}.

The spectrum of Essentia before TC revealed the presence of bands at 489, 574,727 and 794 cm^{-1} which were characteristic for silica groups. The bands at 619, 1033 and 1124 cm^{-1} were characteristics for $PO_{4\ (\upsilon 4)}$, HPO_4 and C–O–C groups. The bands at 1213–1340 and at 1712 cm^{-1} represented the carbonyl group C=O. The bands at 1450 and 1529 cm^{-1} represented CH_2CH_3 group. Groups C=C, CH_3 and CH-OH were captured at 1633, 2937 cm^{-1} and (3621 and 3720) cm^{-1}.

The spectrum of **(Omnichroma DW 2500 and DW 5000)** revealed appearance of different bands of OH-CH functional groups at wave no (3581, 3625 and 3724 cm^{-1})**.** On the other hand the spectrum of **(Essentia DW 2500)** revealed that silica groups were right shifted at (489,574,727 and 794 cm^{-1}) to (470,729 and 792 cm^{-1}), respectively. The HPO_4 band was increased in the intensity and splitting to three tip bands at 960 -1016- 1114 cm^{-1} with broad extended wings from (837 to 1303 cm^{-1}), while C–O–C group was disappeared at band (1124 cm^{-1}). Whereas after 5000 thermocycles in **(Essentia DW 5000)** the broad band of HPO_4 at (960 -1016- 1114 cm^{-1}) and return again at (1029 cm^{-1}) and decreased in intensity. Reappearance of C=O at two peaks (1215 and 1336 cm^{-1}).

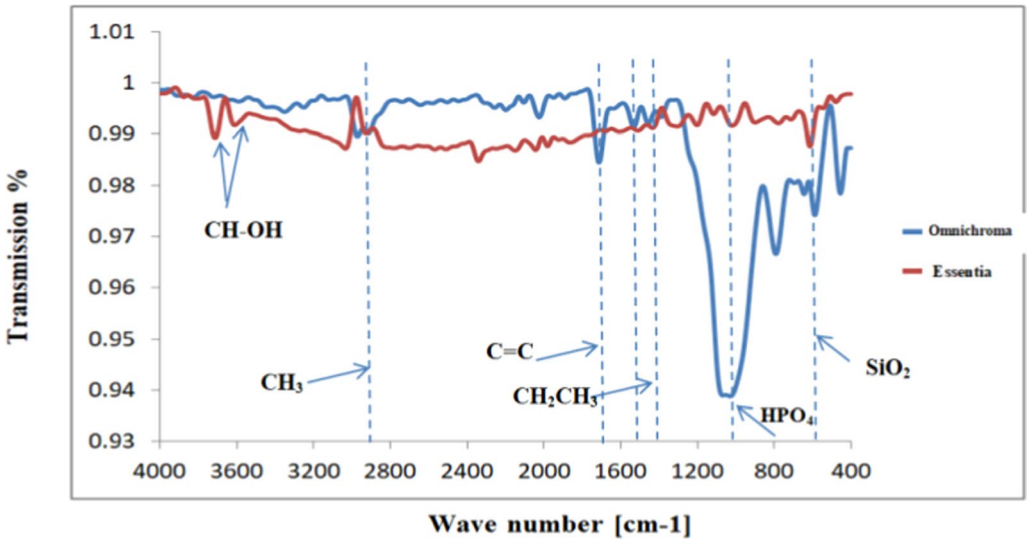

Fig. 5 FTIR spectra representing the chemical structure of Omnichroma and Essentia

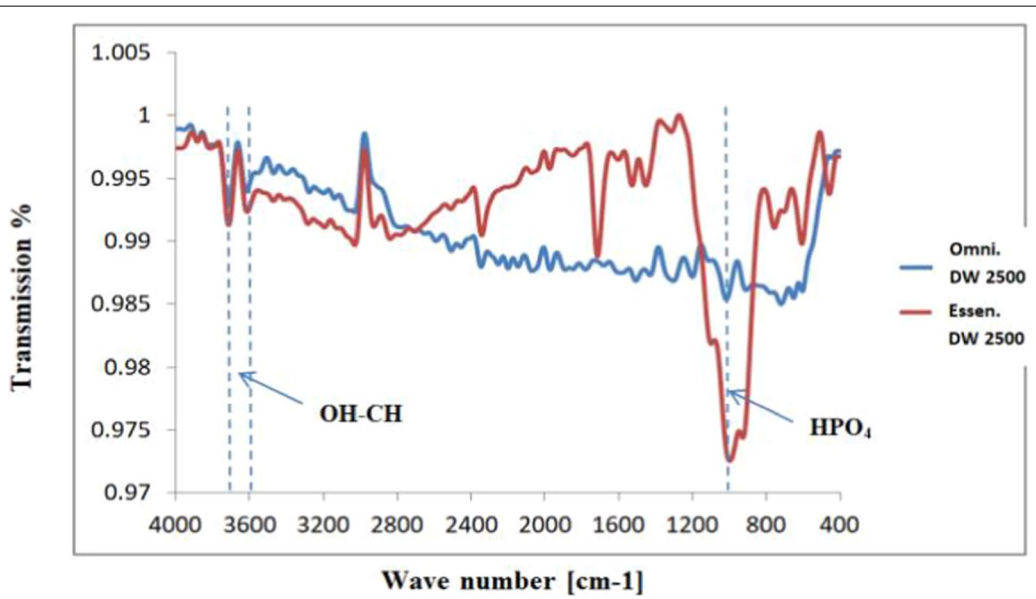

Fig. 6 FTIR spectra representing the chemical structure of Omnichroma DW 2500 and Essentia DW 2500

The spectrum of **(Omnichroma Coff 2500)** revealed left shifted at functional groups Si–O–Si, CH_2CH_3 and C=O–OH from (464, [1417, 1475, 1555] and 1724 cm^{-1}) to (468, [1486, 1562] and 1728 cm^{-1}), respectively. All bands increased in intensity compared to control. **(Omnichroma Coff 5000);** CH_2CH_3 group left shifted from (1417 and1475 cm^{-1}) to (1483 and 1546 cm^{-1}), respectively. All bands were slightly decreased intensity compared to control. On the other hand **(Essentia Coff 2500)** revealed right shift in many bands; for HPO_4, C–O–C, C=O, CH_2CH_3 and C=C. There was a slight increasing in intensity of all bands. **(Essentia Coff 5000)**; the spectrum revealed right shift in bands; silica, HPO_4, CH_2CH_3 and C=C. The intensity slightly decreased in all bands compared to control.

(Omnichroma Cola 2500); the functional groups of PO_4 and C=C were shifted to the right side from ([597–661] and 1656) to (603 and 1647 cm^{-1}), respectively. All bands increased in intensity compared to control. **(Omnichroma Cola 5000);** the spectrum revealed right

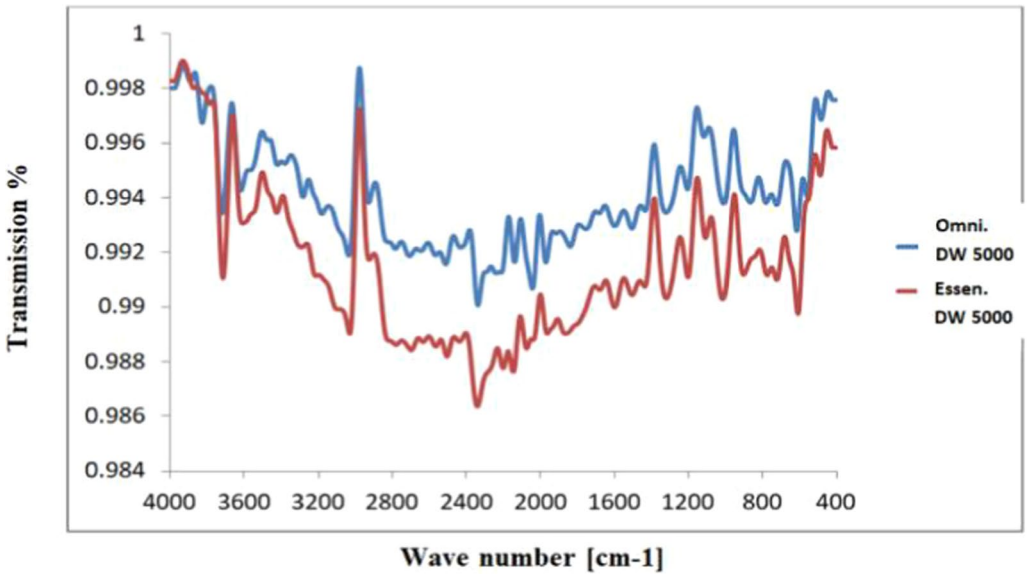

Fig. 7 FTIR spectra representing the chemical structure of Omnichroma DW 5000 and Essentia DW 5000

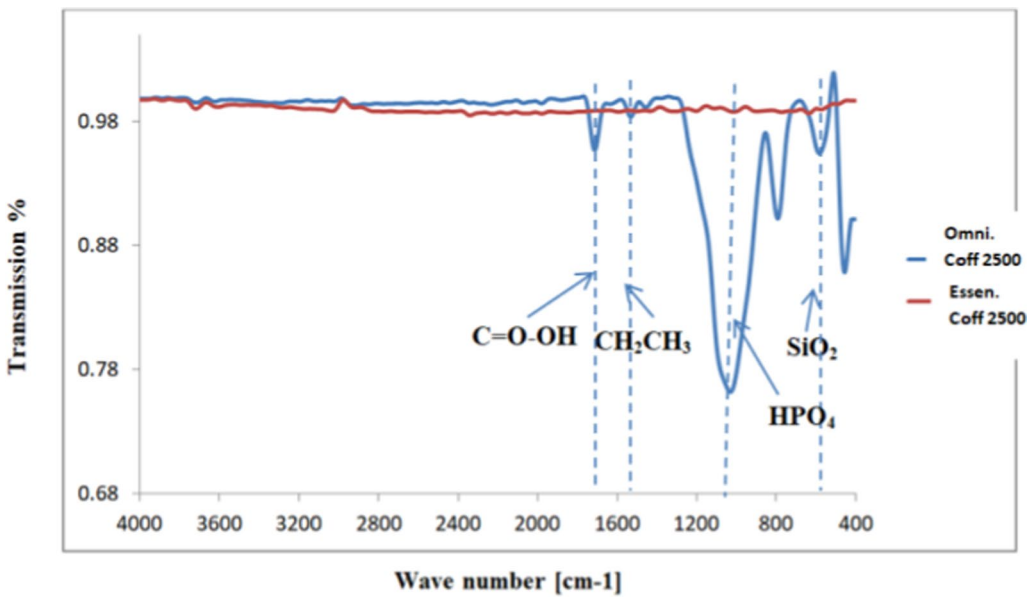

Fig. 8 FTIR spectra representing the chemical structure of Omnichroma Coff 2500 and Essentia Coff 2500

shift in functional groups of $PO_{4\ (\upsilon 4)}$ from (597–661) to (597–624 cm^{-1}). All intensities more decreased when compared to control. **(Essentia Cola 2500)**; the spectrum revealed right shift in the functional group C=C. Slight increase in intensity of all bands compared to control. **(Essentia Cola 5000)**; the spectrum revealed right shift in C=O, C=C and CH_3.The intensity of all bands was decreased compared to control.

Discussion

One of the main goals of aesthetic restorative dentistry is to develop a restoration that matches the optical qualities of the natural tooth. The current trend of reducing clinical restorative treatment time and simplifying color matching has promoted dental manufacturers to compete to develop a universal resin composite

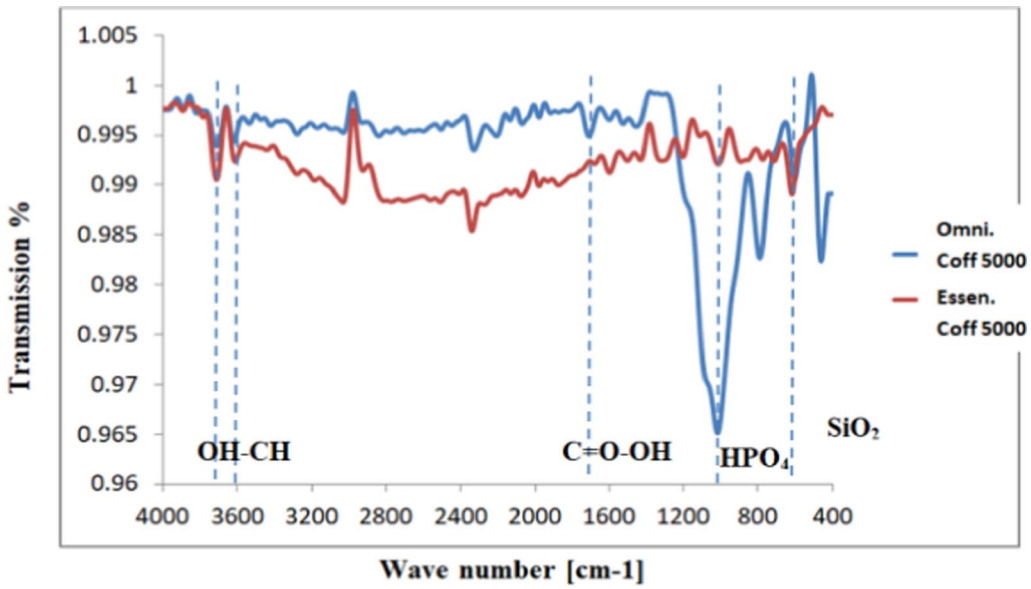

Fig. 9 FTIR spectra representing the chemical structure of Omnichroma Coff 5000 and Essentia Coff 5000

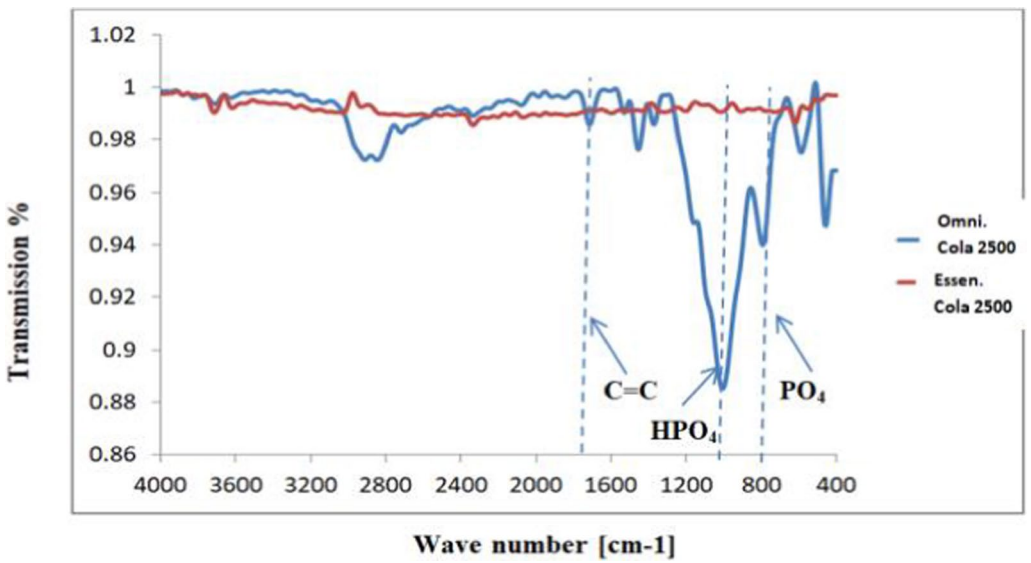

Fig. 10 FTIR spectra representing the chemical structure of Omnichroma Cola 2500 and Essentia Cola 2500

(single shade) that might potentially match a wide variety of classic shades (Oivanen et al. 2021).

This study evaluated the durability of optical properties for Omnichroma and Essentia resin composite with chameleon effect after thermocycling for 2500 and 5000 cycles in dark drinks (Coffee and Coca-Cola) which equals aging for (3 and 6 months) that might be precipitated due to water sorption, water solubility and chemical changes.

Color change is influenced by a number of elements, including water sorption and solubility, as well as chemical changes. Certain beverages like as (Coffee and Coca-Cola) might alter the physical qualities and appearance of composite restorations. Color stability can be assessed visually as well as through specialized tools. The CIE L*a* b* coordinates system and spectrophotometry were employed in this study. Because it is suited for determining minor color changes and has characteristics

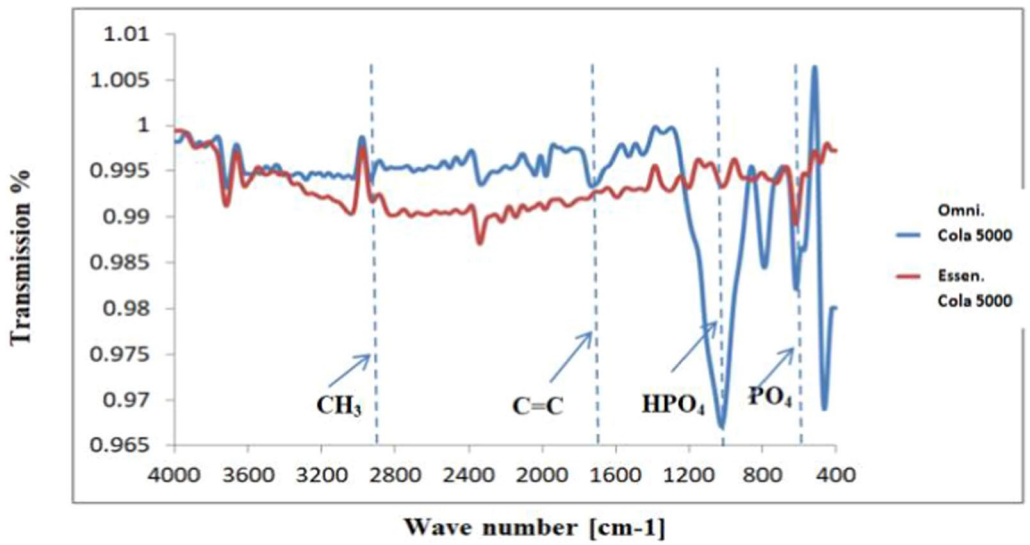

Fig. 11 FTIR spectra representing the chemical structure of Omnichroma Cola 5000 and Essentia Cola 5000

such as repeatability, sensitivity and objectivity, the CIE L*a*b* method was chosen to evaluate color change (ΔE) (Wakeel. 2017).

Presence of hydrophilic resin matrices may cause absorption of drinks in a greater degree than hydrophobic resin which contributing to discoloration by chemically degradation of filler resin bond in matrix. In this study the amount of water sorption and solubility was measured according ISO4049 to provide reliable results (Aydin et al. 2021). The chemical composition of all tested groups was qualitative analysis by using FTIR Spectrometer to record a wide spectrum range (400–4000 cm^{-1}). Interpretation of functional groups for both drinks and composite was necessary to record the effect of main functional groups in dark drinks on the internal composite composition.

The Omnichroma composite revealed higher significant change in color than Essentia after thermocycled to 2500 and 5000 cycle in DW. This might be attributed to the chemical composition of Omnichroma matrix which based on UDMA/TEGDMA which is more hydrophilic in nature and water sorption compared to Essentia matrix which is based on BISEMA/TEGDMA mainly, in agreement with (Aydin et al. 2021). The results assured with the higher water sorption data of Omnichroma in our study. Water sorption of Omnichroma was higher than Essentia after 2500 cycles and increased more after 5000 thermocycles.

Using of more than one type of Oligomers might be affected the absorption intensity of color spectra. The change of color in Omnichroma might be attributed to the absorption of water molecules in between polymeric chains that led to a more heterogeneous structure in the matrix (purity of oligomers) (Szczesio-Wlodarczyk et al. 2021). Adding to that it might be due to oxidation of unreacted double bond methyl groups was occurred. This explanation was assured by FTIR analysis results. The FTIR analysis revealed the appearance of different bands of OH–CH functional groups in Omnichroma, which led to attenuation of light reflection, might occur. Whereas the FTIR analysis of Essentia composite revealed increasing in the intensity of the HPO_4 band after 2500 cycle that recovered to the initial intensity after 5000 cycles, this might be attributed to adsorption of water molecules without bonding at the HPO_4 group that was lost again after 5000 cycles, in agreement with (Rahim et al. 2012).

The solubility of Omnichroma was lower than Essentia after thermocycled to 2500 cycles and both showed negative values. This might be attributed to incomplete dehydration of both types. In Omnichroma the matrix react with water molecules and bonding with OH–CH groups, this derived from FTIR results. Hence the solubility is lower for bonded molecules. Whereas the Essentia adsorbed water molecules on HPO_4 group without bonding as it was lost after 5000 thermocycles, That is explained the increased in solubility of Essentia after 5000 cycles, in agreement with (Tugba and Gonulol. 2017).

There was a high discoloration value reported after thermocycling of both types of composite in coffee after 2500 and 5000 cycles which was about double that of thermocycling in cola for 2500 and 5000 cycles. It means that Coffee caused more discoloration than cola in both groups, regardless type of investigated composite. It

might be attributed to the chemical structure of coffee containing a large number of yellow staining agents like Gallic acid, caffeine, cholorogenic acid, and protocatechuic acid that absorbed and penetrated to the organic phase of the composite. In which the FTIR analysis revealed left-shifting in functional groups Silica and right-shifted functional groups HPO_4, C=C in both types of composite. In addition to the increase in the intensities of all bands after 2500 thermocycling, this assured the entrance of coffee compounds into the structure of the composite. Whereas Cola contains Phosphoric acid which was not considered a strong colorant agent for composites, in agreement with (Korkut and Haciali. 2020).

The phosphoric acid entered into the chemical structure of both types of composite. This was derived from FTIR results as the functional groups of PO_4 and C=C that were shifted to the right side and increased in their intensities after 2500 thermocycling. As well as the temperature of the coffee might be act as an aging factor that accelerate the degree of intrinsic staining, especially after 5000 cycles. Increase temperature-induced thermal stresses that led to decreased bond strength and encouraged more water sorption and more inclusion of staining compounds. This matched with water sorption results of Omnichroma Coff 5000 and Essentia Coff 5000 after 5000 thermocycling in coffee that recorded highest significant water sorption value among all tested groups. This effect was more pronounced with high matrix contents of composite type led to more staining. That explained why Omnichroma composite recorded the more color change (ΔE) than Essentia type after thermocycling in 2500 cycles and increased after 5000 cycles, in agreement with (Abdul-Kareem et al. 2020).

Additionally, BisGMA /BisEMA/ TEGDMA as base monomer matrix in Essentia were shown to reduce color change and water sorption compared to UDMA/ TEGDMA formulations in Omnichroma which might be explained the decreased discoloration and sorption in Essentia in agreement with (Aydin et al. 2021).

High W_{Sl} values were recorded in both composite groups after 5000 thermocycling regardless thermocycling solution used. This might be due to loss of some chemical compounds due to thermal stresses induced from temperature fluctuation. The explanation was assured from FTIR results as the intensities of both types of composites were decreased after 5000 cycles. In addition to the acidic pH nature of both cola and coffee might be promoted the release of unreacted monomers and inorganic fillers, in agreement with (Camilotti et al. 2022).

The effect of W_{sl} on Essentia composite was more pronounced than Omnichroma, especially after 5000 thermocycling regardless type of drink used. This might be due to the different types of filler (Nanofillers blended with hybrid filler) in Essentia which increased in heterogeneity led to more irregular degradation on the surface in agreement with (Aminoroaya et al. 2021).

Some studies reported that results of W_{sl} might be not correlated with W_{sp} as water sorption was material-dependent, while solubility was material and medium-dependent. Many researchers have determined that materials with low sorption demonstrate low solubility. Whereas other studies suggested that materials with high water sorption do not necessarily demonstrate high solubility, as shown in this study (Miletic and Renata 2020).

In this study, all groups in Omnichroma except Cola 5000 and Essentia DW 2500 revealed –ve solubility values considering the possibility of incomplete dehydration of the materials, these negative values may be indicative of a low level of solubility rather than the complete absence of dissolution. These negative values have been explained by possible hydrolytic chemical reactions that result in the formation of hydroxides on the filler surface (Rusnac et al. 2021). In other studies, it has been suggested that negative values may be the result of hydrogen bonds connecting the absorbed water molecules to polar groups of the polymer chains, which cannot be removed entirely (Tugba & Gonulol. 2017).

The volume and size of fillers have an impact on the staining susceptibility of composites. The organic matrix was reduced when the filler size and quantity were increased. As a result, the degree of color change will be reduced. The staining could be caused by a high resin content and water adsorption; the resin matrix, which is a key component of composite resins, has been shown to be important for color stability; the higher the filler content, the better the color stability (Poggio et al. 2016). Essentia has more filler contents and better color stability in spite of nature of filler size and distribution.

Finally the null hypothesis of this study; Omnichroma has more stable color and durability than Essentia in dark drinks was refused.

Conclusions

1. The color durability of Omnichroma (supra-nano) versus Essentia composite (hybrid micro-nano type) negatively affected in both dark drinks after 3 and 6 months.
2. Thermocycling in different dark drinks adversely affected the color stability of both selected Chameleon composite types.
3. Coffee solution had a great negative effect on composite color stability than cola after 6 months of ageing,
4. Water sorption of Omnichroma negatively affected after aging 3 and 6 months, in contrary to water solubility.

5. Water solubility might not be adversely affecting the color change. Whereas water sorption might be adversely affecting the color.

Abbreviations
UDMA: Urethane dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate; BIS-MEPP: Bisphenole A ethoxylate dimethacrylate; BIS-EMA: Bisphenol A diglycidyl methacrylate ethoxylated; BIS-GMA: Bisphenol A-glycidyl methacrylate; TC: Thermocycling; DW: Distilled water; Coff: Coffee; Wsp: Water sorption; Wsl: Water solubility; FTIR: Fourier transform infrared spectroscopy; (ΔE): Color change.

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BA, AAM and HAS performed the study design. BA performed the whole methodology. BA, AAM and HAS analyzed the data. BA, AAM and HAS were the major contributors in writing the manuscript. All the authors read and approved the final manuscript.

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Competing interests
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