Color Stability of New Composite Restorative Materials Under Accelerated Aging

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The color stability of seven microfilled and conventional composites under conditions of accelerated aging was evaluated by reflection spectrophotometry. During early aging the composites generally became darker, more chromatic, and more opaque. The in vitro *color stability of the microfilled composites was better and less influenced by erosion than the conventional composites.*

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Introduction.

The color stability of seven conventional composite restorative materials, an unfilled acrylic resin, and three glazes under conditions of accelerated aging was evaluated in an earlier study by reflection spectrophotometry.[1] After aging for 300 h, the composite materials had lower values of luminous reflectance and higher values of excitation purity, dominant wavelength, and contrast ratio, compared to values of baseline. In a 24-month clinical study of color stability of class 4 composite restorations, Dennison and associates[2] demonstrated that changes in color observed clinically correlated well with changes reported in the aforementioned *in vitro* study.

Recently new composite restorative materials with novel initiators, resin matrices, and fillers have become available. The purpose of this study was to evaluate the *in vitro* color stability of several new composites.

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Materials and methods.

The color of seven commercial composite materials, including three conventional composites (C, FF, and PR) and four microfilled composites (I, PF, SF, and SI), was evaluated under conditions of accelerated aging. The code, shade, batch number, and manufacturer are listed in Table 1 for each material studied.

Three disks (36 mm in diameter and 1.3 mm in thickness) were prepared for each material by polymerization in a metal die. The disks were placed in an oven at 37°C within 90 sec after initiating the mix and were stored for 24 h before making the baseline evaluation. Disks of the material accelerated by visible light (FF) were polymerized in the same die by exposing the open side through a thin glass plate to a tungsten-halogen light# with a blue filter. The arithmetic average roughness of a sample as measured from profile tracings† was 2.5 μm.

The disks were exposed to conditions of accelerated aging for a total of 900 h in a weathering chamber‡ at 43°C and 90% relative humidity. One surface of each sample was subjected continuously to the radiation of a 2500 watt ultraviolet (uv) light source§ filtered by borosilicate glass and to an intermittent water spray for 18 min every two h. The intensity of the uv radiation was measured with a uv meter∞ to be about 11.2 mWatts/cm^2 at the specimen position. Color evaluations were made

#Riluma bulb, Quarry, Inc., Ann Arbor, MI 48104
†Surfanalyzer 150, Gould, Inc., Instrument Systems Division, Cleveland, OH 44114
‡Weather-Ometer 25WR, Atlas Electric Devices Co., Chicago, IL 60613
§12-2881 Xenon Burner, Atlas Electric Devices Co., Chicago, IL 60613
∞Model J-221, Ultraviolet Products, Inc., San Gabriel, CA 91778

TABLE 1
CODE, NAME, BATCH NUMBER, AND MANUFACTURER OF PRODUCTS TESTED

Code	Product Name (Shade)	Batch Number	Manufacturer
Conventional Composites:			
C	Concise (Universal)	Paste A – 8Y21 Paste B – 8Y21	3 M Company St. Paul, MN 55101
FF	Fotofil (White)	Paste – F3762, ADM, 44092/76	Imperial Chemical Industries, Ltd. Macclesfield Cheshire, Great Britain
PR	Profile (Base Shade 55)	Base – 47812 Catalyst – 37901	S. S. White Company, Division of Pennwalt Corp. Philadelphia, PA 19102
Microfilled Composites:			
I	Isopast (Shade 22)	Base – 721078 Catalyst – 630179	Vivadent (USA), Inc. Buffalo, NY 14214
PF	Phaseafill (Shade GO)	Base – 026 Catalyst – 044	Phasealloy, Inc. El Cajon, CA 92021
SF	Superfil (Universal)	Universal – 80338 Catalyst – 80329	Harry J. Bosworth Co. Skokie, IL 60076
SI	Silar (Universal)	Universal – MPP-501 Catalyst – 49013-47	3 M Company

before weathering (baseline) and after exposure of 300, 600, and 900 h.

Curves of percent reflectance *versus* wavelength (λ) were obtained for each sample between 405 and 700 nm with a double-beam ultraviolet-visible spectrophotometer¶ and integrating sphere.** Luminous reflectance (Y), dominant wavelength (DW), and excitation purity (EP) were obtained for each sample backed by both a black// and a white standard.*[3] An estimate of the opacity of each material was obtained by calculation of the contrast ratio (CR), Y black standard/Y white standard.[4]

The spectrophotometric parameters (Y, DW, EP, and CR) were studied by analysis of variance[5] to determine the effects of aging. Scheffe intervals[6] at the 95% level of confidence were calculated for comparisons among means.

¶ACTA C III UV-Visible Spectrophotometer, Beckman Instruments, Inc., Irvine, CA 92664

**ASPH-U Integrating Sphere, Beckman Instruments, Inc., Irvine, CA 92664

//Part No. 375287, Beckman Instruments, Inc., Irvine, CA 92664

*Part No. 375285, Beckman Instruments, Inc., Irvine, CA 92664

Results.

Mean values and standard deviations of luminous reflectance (Y), dominant wavelength (DW), excitation purity (EP), and contrast ratio (CR) are listed in Tables 2 and 3 for the conventional and microfilled composites, respectively, at baseline. Changes in these parameters at each evaluation period are listed in the same tables. These changes were computed by subtracting the value of the parameter at 300, 600, and 900 h from the baseline value. Values of Scheffe intervals computed from analyses of variance were Y, 0.8; DW, 0.61 nm; EP, 0.011; and CR, 0.013 for comparisons among times at the 95% level of confidence.

Values of luminous reflectance (Y) decreased between 0 and 300 h for all products tested. Changes at 300 h ranged from −0.7% for PF to −10.6% for C. Between 300 and 900 h, luminous reflectance increased as much as 11.5% compared to 300-hour values for the conventional composites (C, FF, and PR, Table 2), but continued to decrease by as much as 6.2% for the microfilled composites (I, PF, SI, and SF, Table 3).

Values of dominant wavelength (DW) between 0 and 900 h increased for the

TABLE 2
SPECTROPHOTOMETRIC COLOR DATA AT BASELINE AND CHANGES IN COLOR AFTER AGING FOR CONVENTIONAL COMPOSITES

Code	Property	Baseline Value	Change in Parameter Compared to Baseline		
			300 h	600 h	900 h
C	Y	65.9 (0.3)*	−7.0†	−1.2	−0.2
	DW, nm	579.07 (0.05)	0.22	1.34	1.53
	EP	0.327 (0.004)	0.058	−0.089	−0.123
	CR	0.644 (0.012)	0.041	0.149	0.170
FF	Y	78.1 (1.5)	−7.3	−2.7	−1.5
	DW, nm	573.72 (0.11)	2.63	3.19	3.67
	EP	0.232 (0.008)	0.094	−0.045	−0.087
	CR	0.559 (0.029)	0.138	0.229	0.263
PR	Y	65.4 (1.5)	−4.3	−5.5	−3.2
	DW, nm	577.7 (2.3)	1.22	1.36	3.69
	EP	0.298 (0.011)	0.010	0.016	−0.121
	CR	0.624 (0.012)	0.015	0.050	0.198

*Mean of three replications with standard deviation in parentheses.
†Change equals the value at the specific times minus the value at baseline.

TABLE 3
SPECTROPHOTOMETRIC COLOR DATA AT BASELINE AND CHANGES IN COLOR AFTER AGING FOR MICROFILLED COMPOSITES

Code	Property	Baseline Value	Change in Parameter Compared to Baseline		
			300 h	600 h	900 h
I	Y	63.7 (0.4)*	−3.1†	−3.8	−5.2
	DW, nm	579.08 (0.02)	0.18	0.29	0.25
	EP	0.344 (0.005)	−0.015	−0.017	−0.025
	CR	0.647 (0.008)	0.009	0.018	0.020
PF	Y	58.0 (1.2)	−0.4	−1.1	−4.0
	DW, nm	578.73 (0.22)	−0.51	−0.63	−0.81
	EP	0.355 (0.002)	0.001	0.012	0.014
	CR	0.683 (0.020)	−0.003	−0.002	0.004
SF	Y	63.0 (0.2)	−2.4	−3.7	−5.1
	DW, nm	578.30 (0.08)	−0.08	0.17	0.11
	EP	0.321 (0.004)	0.003	0.025	0.026
	CR	0.621 (0.018)	−0.003	0.020	0.035
SI	Y	64.6 (0.1)	−3.8	−5.0	−4.6
	DW, nm	578.71 (0.04)	−0.05	0.16	0.12
	EP	0.326 (0.005)	0.016	0.042	0.051
	CR	0.624 (0.002)	−0.004	0.007	0.015

*Mean of three replications with standard deviation in parentheses.
†Change equals the value at the specific time minus the value at baseline.

conventional composites (C, FF, and PR), decreased for PF, and did not change significantly for I, SI, and SF. The dominant wavelength of FF and PR changed much more than that of either C or PF.

After 300 h of aging, the excitation purity (EP) of C, FF, and SI increased. Values of EP for PR, PF, and SF did not change significantly, whereas the value of EP of I decreased. Between 300 and 900 h,

the EP of the conventional composites (C, FF, and PR) decreased by as much as 41%, compared to baseline. The EP of I decreased about 7%, whereas those of PF, SI, and SF increased by as much as 16%.

The contrast ratio of all the composites increased after 900 h of aging, except that of PF, which did not change. Values of CR of the conventional composites changed between 26 and 47%, whereas those of the microfilled composites changed between 2 and 6% (except PF).

Discussion.

Color changes in composite restorations *in vivo* may be caused by the formation of colored degradation products, by changes in surface morphology because of wear, and by extrinsic staining. Accelerated aging in a weathering chamber appears to model the first two of these mechanisms.

During early aging, both the conventional and the microfilled composites generally became darker, more chromatic, and more opaque. Since deterioration of the surface was not yet evident, these changes in color are attributed to the formation of colored degradation products.

As accelerated aging continued, deterioration of the surface of the composites occurred (Fig.). The extent of deterioration was greater for the conventional composites than for the microfilled composites. The surface deterioration of the conventional composites caused them to appear lighter and much less chromatic after extended aging compared to early aging. The color parameters of the microfilled composites were much less affected by surface deterioration after extended aging. Changes in color of the microfilled composites after extended aging are attributed to the continuing formation of colored degradation products.

Conclusions.

The color stability of seven commercial composite restorative materials under conditions of accelerated aging was evaluated by reflection spectrophotometry at baseline and 300, 600, and 900 h. During early aging the composites generally became darker, more chromatic, and more opaque. Changes in color of the conventional composites during aging were influenced by erosion of the resin matrices and exposure of filler particles. Color stability of the microfilled composites under the *in vitro* conditions tested was better than that of the conventional composites and did not appear to be influenced as much by erosion.

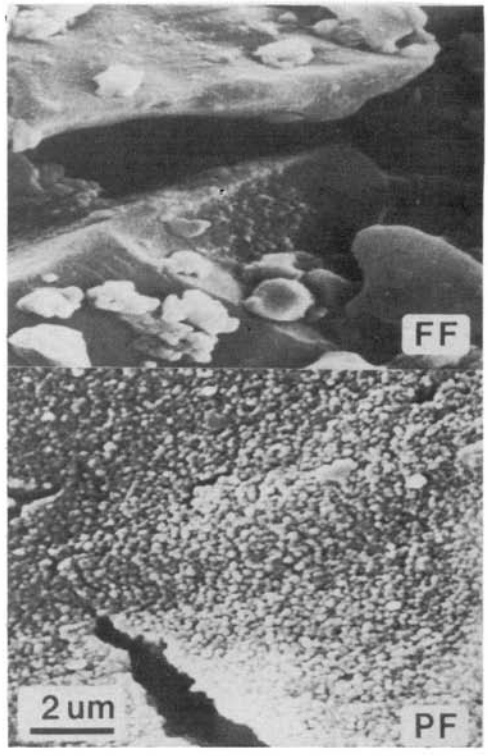

Fig. – Scanning electron photomicrograph of the surface of conventional composite (FF) and microfilled composite (PF) after 900 h of aging.

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