COLOUR STABLITY OF COMMONLY USED ORTHODONTIC BONDING RESINS - AN INVITRO STUDY.

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Adhesive bonding is important for orthodontics, especially in terms of the fixation of brackets to teeth. This situation involves the joining of solid substrates or adherents by an intervening layer of adhesive agent. The surface characteristics are crucial to the success of the bond, as are the inherent properties of the adhesive. Many aspects of the situation are rather general. That is, they are not entirely restricted to the orthodontic context itself.

It is important foremost to have sufficient background of adhesive science to facilitate appreciation for the necessary properties of dental orthodontic adhesives.

This study was aimed at investigating the colour stability of the commonly used orthodontic bonding resins when exposed to light for the equivalent of 30 days, which was deemed adequate since the labial surfaces of crowns are not exposed to ambient light under ordinary conditions. And whether, the change in colour was of any clinical significance.

Classification *(0n the basis of polymerization initiation mechanism)*[1]

1. **Chemically activated / Auto – cured / Self cured**

a) **Two paste**

b) **One paste**

2. **Visible Light Cure / Photo – Cured**
3. **Dual Cured**
4. **Thermo – cured**

TYPES OF ORTHODONTIC ADHESIVES

During the last quarter of the twentieth century there were two competitive categories of non – metallic direct restorative biomaterials. They may be denoted as the **Salt matrix** and the **Resin matrix** that originated in the United Kingdom and the United States respectively.

During the 1990's a major development had been the hybridization of the technology underlying resin composites (RC) and glass ionomer cements (GIC). That is, components from both systems have been combined in various ways with the aim of developing materials that will ideally exhibit characteristics of each parent.

Salt Matrix Adhesive

These may be categorized into three groups –

1. **RM – GIC (Resin Modified Glass Ionomer's)**
2. **Compomers**
3. **Ionomer Modified Composites**

Resin Matrix Adhesives

The major category of orthodontic resins systems is based upon resin components. The orthodontic adhesive formulations share much in common with that of the restorative resins. They consist of two main components, an organic matrix and a powdered ceramic, such as, barium aluminoborate silica glass. Particles ranging in the size of 0.004 to 5 microns in diameter and the volume fraction may range from 30% to 75%.

OBJECTIVE OF THE STUDY

To evaluate the colour stability of commercially available orthodontic bonding resins,

and to compare the colour stability of ten commonly used orthodontic bonding resins.

MATERIALS AND METHODS

This study was designed to compare the change in colour of Ten commercially available orthodontic bonding resins after exposure to light and then comparing them to the unexposed samples of the same resin.

These ten commercially available resin samples of ten each were divided into two groups of ten samples each and labeled A, B, C, D, E, F, G, H, I, and J respectively for the commercially available orthodontic resins ,(as listed in Table 1).

The disc shaped samples of resins were cured using a metallic ring of 10 mm diameter with the inner surfaces of the ring coated with petroleum jelly, so that

the resin buttons would come out easily. The top and bottom surfaces of the ring were covered with cellulose strips, which were pressed between glass flats to remove excess resin. The light curable samples were photo polymerized in the rings for 20 seconds with a light curing lamp, whereas, the chemical curable samples were cured as per the manufacturer's guidelines and then removed from the rings respectively.

Button shaped samples prepared from each of the commercially available bonding resin systems were divided into two groups of five samples from each. The first group (e.g. A- EXP) were subjected to accelerated artificial photoaging with the use of a light emitting apparatus (Xenotest^{TM} 150 S, Atlas material testing technology, Geluhausen, Germany), involving exposure of the resin surfaces to a continuous radiation of 24 hours at 56 MJ/m^2 with $\lambda < 800$ nm. This procedure induces aging equivalent to 30 days of exposure to sunlight in the Indian subcontinent which was deemed adequate because the labial surfaces of crowns are not exposed to ambient light during ordinary conditions. The control group (e.g. A- ORG) was prepared just prior to colorimetric evaluation. The adhesive resin button was polished and placed on a tray of standard background with 75% reflectance. The buttons were colorimetrically evaluated with a colorimeter (Greta Macbeth Color i ^{TM} 5 Spectrophotometer)..

All the specimens were stored in a dark environment throughout the procedure except when cured and colour evaluated. After photo aging, a second colour determination was performed on the second group. Colour parameters were

averaged for each group, and colour differences (Δ E) induced by photo aging were calculated using the equation -

$$\Delta E = [(\Delta L^{*})^{2} + (\Delta a^{*})^{2} + (\Delta b^{*})^{2}]^{0.5}$$

L^{*} corresponds to the degree of lightness,

$+a^{*}$ = red and $-a^{*}$ = green , and

$+b^{*}$ = yellow and $-b^{*}$ = blue.

The Δ E values derived from the two colour recordings for the materials were analyzed with a one-way analysis of variance (ANOVA). The difference among groups was further investigated using Tukey multiple comparison test. To establish the statistical significance of the difference of the Δ E values of each adhesive and the Δ E threshold for clinical detection a paired t-test was used.

Table I Samples used in the study

S. No.	SAMPLE NAME	MATERIAL	MANUFACTURER
1.	A	ORTHO LITE	ORTHO SOURCE, N. Hollywood, CA, USA.
2.	B	ENLIGHT	ORMCO, Glendora, CA, USA.
3.	C	TRANSBOND XT	3M UNITEK, Monrovia, CA, USA.
4.	D	CONCISE	3M UNITEK, Monrovia, USA.

5.	E	RELI BOND	RELIANCE ORTHO, Itasca IL, USA.
6.	F	RIGHT ON	T P ORTHODONTICS, Indiana, USA.
7.	G	SUPERBOND	ORTHO SOURCE, N. Hollywood,CA, USA
8.	H	RELI ON	CLASS ONE ORTHODONTICS, Lubock TX.
9.	I	PHYTHON	T P ORTHODONTICS, Indiana, USA.
10.	J	LEOPARD	CLASS ONE ORTHODONTICS, Lubock TX.

Figure 1: Preparation of button shaped samples **Figure 2: Mounted samples for aging**

Figure 3: Xenotest^{TM} 150 S, Atlas material testing machine, Geluhausen, Germany

Figure 4: Greta Macbeth Color i ™ 5 Spectrophotometer

Figure 5: Mounted sample on the spectrophotometer

Figure 6: Sample as seen from inside for colorimetric evaluation

RESULTS

Study design: A comparative study consisting of 100 samples randomized into 10 groups is undertaken to compare the colour changes observed after photo – aging in ten commonly available orthodontic bonding resins with freshly prepared samples.

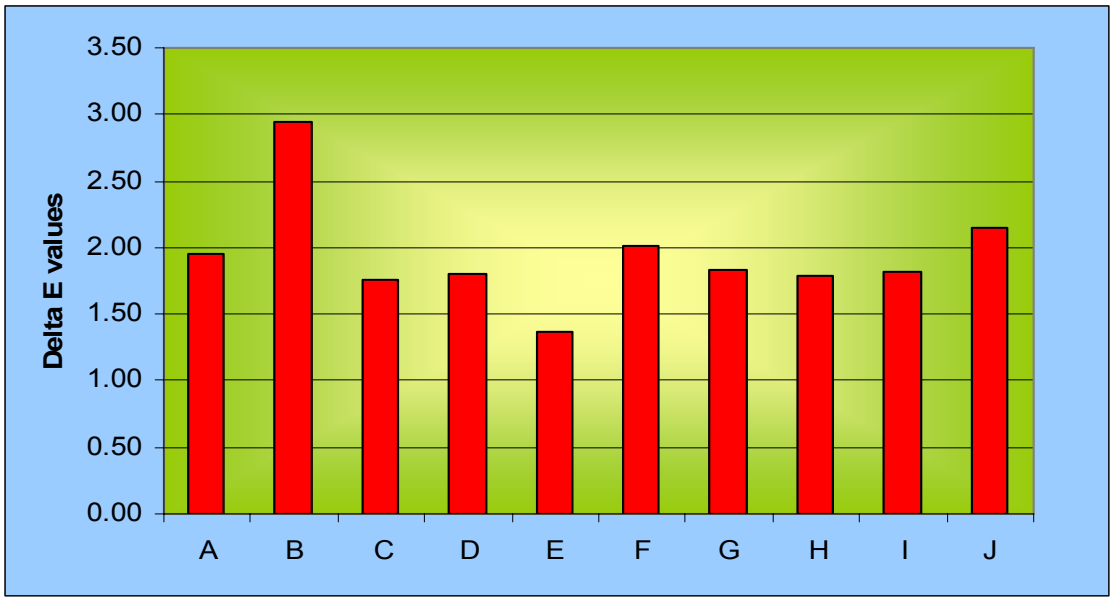
Table 2: Mean pattern ΔE values between 10 groups

Groups	Range	Mean ± SD
A	1.533-2.535	1.946 ± 0.29
B	1.420-4.308	2.938 ± 1.08
C	1.222-2.112	1.757 ± 0.33
D	1.268-2.228	1.809 ± 0.35
E	1.194-1.594	1.364 ± 0.15

F	1.811-2.251	2.019 ± 0.16
G	1.505-2.125	1.830 ± 0.20
H	1.482-2.182	1.785 ± 0.25
I	1.182-2.322	1.816 ± 0.40
J	1.861-2.561	2.152 ± 0.25
Significance by P value	F=8.904;P<0.001**	

Table 3: Pair wise comparison

	A	B	C	D	E	F	G	H	I	J
A	1.0	-	-	-	-	-	-	-	-	-
B	0.000	1.0	-	-	-	-	-	-	-	-
C	0.993	0.000	1.0	-	-	-	-	-	-	-
D	0.999	0.000	1.000	1.0	-	-	-	-	-	-
E	0.088	0.000	0.571	0.389	1.0	-	-	-	-	-
F	1.000	0.000	0.935	0.984	0.031	1.0	-	-	-	-
G	1.000	0.000	1.000	1.000	0.325	0.992	1.0	-	-	-
H	0.998	0.000	1.000	1.000	0.472	0.967	1.000	1.0	-	-
I	1.000	0.000	1.000	1.000	0.368	0.987	1.000	1.000	1.0	-
J	0.987	0.004	0.566	0.746	0.003	1.000	0.807	0.664	0.766	1.0



Statistical Methods: Analysis of variance has been used to find the significant difference of ΔE values between the 10 groups. The Post hoc Tukey test has been used to find the pair wise significance of ΔE values between the groups. Student t test was used to test the significance of Δ E values from the threshold value.

1. Analysis of Variance: F test for K Population means

Objective: To test the hypothesis that K samples from K Populations with the same mean.

Limitations: It is assumed that populations are normally distributed and have equal variance. It is also assumed that samples are independent of each other.

Method: Let the j^{th} sample contain n_j elements (j=1, 2…K). Then the total number of elements is

$$N = \sum nj \qquad x.j = \sum \frac{xij}{nj}$$

$$S_1^2 = \frac{\sum \sum_{i-1}^{n1} (x1 - \overline{x.j})^2}{N - K} \qquad S_2^2 = \frac{\sum_{i-1}^{n1} nj(\overline{x.j} - \overline{x..})^2}{K - 1}$$

$F=S_2^2/S_1^2$ which follows F distribution (K-1, N-K)

2. Tukey test

D=Q $\sqrt{\frac{MSE}{N/J}}$ **,** N is the total number of subjects and MSE is the mean square error in ANOVA, J is the number of groups to be compared.

3. Student t – test

Student t test was used to test the significance of Δ E values from the threshold value of 3.7. (P< 0.05/0.01)

All Δ E values of the samples evaluated are significantly less than the Δ E threshold for clinical detection 3.7 ($P<0.01^{**}$)

This test indicates that no group exhibited colour alterations above the detection limit

Statistical software: The Statistical software namely SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc**.**

SUMMARY

Colour alteration of adhesive during treatment and after debonding may be implicated in long-term enamel discolouration. The aim of this study was to assess the colour stability of light-cured and chemically cured adhesives subjected to artificial photoaging.

Disk-shaped specimens of adhesives were colorimetrically evaluated before and after artificial photoaging using a colorimeter. The measurement variable was the colour change (Δ E) of adhesives induced by artificial, accelerated photoaging.

The Δ E values derived from the two color recordings for the materials at pre- and post-aging intervals were statistically analyzed with a one-way analysis of variance (ANOVA), with the adhesive brand serving as a discriminating variable. Differences among groups were further investigated using the Tukey multiple comparisons test. . To establish the statistical significance of the difference of the Δ E values of each adhesive and the Δ E threshold for clinical detection, a paired *t*-test was used.

All the adhesives exhibited color change which, in none of the cases, exceeded the clinically detectable color change limit. The extent of the colour alterations of aged bonding systems may contribute to enamel discoloration after treatment.

Thus, it can be concluded that all the ten orthodontic bonding systems used in this study can be used for orthodontic bonding without significant risk of discolouration owing to photo aging.

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