# Opacity and Color Changes of Light-Cured Ideal Makoo (IDM)

**Ghavam M[1], Goodarzy A[2]**

[1] Assistant Professor, Dept of Operative Dentistry, Faculty of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[2] Dentist

**Statement of Problem:** Esthetic materials undergo some physical and mechanical changes, during their service in oral cavity.
**Purpose:** The aim of this study was the evaluation of the color and opacity stability of Ideal Makoo (IDM) composites and compare it with Tetric ceram.
**Material and methods:** Fifteen disk shaped samples of each material was divided into three groups of five. Different aging treatments were applied to each group. The contrast ratio of 1mm thickness and △E of the samples were evaluated at base line and after aging, using CIE system and Data Flash spectrophotometer. All the samples were kept at 37°C.
**Results:** Baseline opacity of IDM was relatively high (77.60%±8.6). Both materials showed increased opacity after aging. The highest △E belonged to IDM samples of B group, which was significantly more than Tetric Ceram ($P<0.05$). Tetric Ceram, also showed some degree of color change (△E=4.60 and 5.79, on black and white background, respectively), which is noticeable clinically.
**Conclusion:** The research showed that IDM can not be a reliable esthetic material, unless some improvements in the chemical composition will be achieved.

**Key words:** IDM- Tetric Ceram- CIE- Opacity- Color- Spectrophotometer- Composites.

***Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2004; Vol: 1, No. 1)***

An increasing demand for esthetic dentistry has been observed in recent years. This subject has been coupled with a rapid development of new restorative materials.
Dentists have sought and used alternatives to metal based materials for various reasons, such as esthetic demands, increased knowledge about esthetic materials, and the developments in adhesion techniques.(1)
Composites, introduced in mid 1960s, have developed significantly. Now, most commercial brands are light cured.
Unfortunately, in addition to some inherent physicomechanical shortcomings of composites which are beyond the scope of this paper, (2,3,4) they lack color stability, due to several reasons. The exact reasons of this color instability are not well known but the internal color change of organic substance has been proposed as the main reason. (2)
Surface staining, marginal staining due to microleakage, and change in surface morphology by wear, are other responsible causes.(5,6)
Although extrinsic staining minimizes by regular tooth cleaning and using proper adhesive techniques, intrinsic discoloration is

material dependent and difficult to control in clinical practice. In order to predict clinical results, several accelerated aging tests have been developed to assess color stability of resins. (7,8,9)

An important point is that the opacity of resin changes, too. This, not only affects the color of the material, but also gives the restoration a non-vital appearance. Both color and opacity instability ends to esthetic failure.

The aim of present study was to evaluate the opacity and color change of Ideal Makoo (IDM) light cure composite resin and compare it to Tetric Ceram.

**Materials and Methods:**

Two light-cured composites were used: IDM (Ideal Makoo) and Tetric Ceram (Vivadent). The selected shade was $A_2$.

The color parameters were determined in the commission international de 1' Eclairage lab (CIELAB) color order system.

The method of experiment was selected according to ISO 4049, 7491, 4892-2.

Fifteen disk shaped samples of each material were prepared according to the instruction of manufacturer.

The samples were 17 mm in diameter and 0.6 mm in thickness. Each group was randomly divided into three subgroups of five. The L* a* b* of the samples with both black and white standard backgrounds were measured at baseline, using Data Flash spectrophotometer.

In order to clarify the variables studied, a small description of L* a* b* is mentioned.

One of the experimental techniques to quantify color is a spectrophotometer and integrating sphere. From the reflectance values and tabulated color matching functions, the tristimulus values (X,Y,Z) can be computed relative to a particular light source. These tristimulus values are related to the amounts of the three primary colors required to give by additive mixture, a match with the color being considered. Typically, the tristimulus values are computed relative to the commission international de l' Eclairage (C.I.E.) source A (gas=filled incandescent lamp) or source C (average day light from over cast sky).

The C.I.E. L* a* b* color space, is characterized by uniform chromaticities. Value (black to white) is denoted as L*, where as chroma (a* b*) is denoted as red (+a*), green (-a*), yellow (+b*) and blue (-b*).

Differences between two colors can be determined from the following formula:

$$\Delta E(L^* a^* b^*) = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\right]^{\frac{1}{2}}$$

Opacity of the samples was also calculated at baseline. The opacity was represented by the contrast ratio, which is the ratio of the reflectance of a disk specimen (1.0 ± 0.05 mm thick) when backed by a black standard to that when backed by a white standard.(2-10)

Because of relative high viscosity of composites, it is probable that the thickness of the samples be a little uneven. In order to omit the effect of thickness on opacity, the following equation was used to determine the contrast ratio of one mm of the samples:(11)

$$CR_1 = 1- (1-CR_L)^{1/L}$$

In which, $CR_1$ = opacity of one mm.
$CR_L$ = opacity of the samples.
L = thickness of the sample in mm.

After baseline evaluations, the 3 subgroups were aged as following:

*Group A:* The samples were first kept in water and darkness for 24 hours, and then in a dry dark chamber for 6 more days.

*Group B:* The samples were first kept in xenotest apparatus in 100% relative humidity and under xenon lamp. Then, they were kept in darkness for another 6 days.

*Group C:* The samples were kept in darkness for seven days.

The temperature for all the samples was 37°C.

After the aging processes, the color and opacity of the samples were evaluated as stated before. The difference in color coordinants (L* a* b*) and opacity were analyzed. The following equation was used to calculate △E (difference in color):

$$\triangle E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

The results were analyzed using t students test.

**Results:**

Baseline opacities of IDM and Tetric Ceram were 77.60% ± 8.59 and 58.72% ± 2.70 respectively (P<0.05) (Table I).

Opacity changes in IDM and Tetric Ceram, was not significantly different, in any of the groups. (P>0.05) (Table I). L* increased in all the samples, but the difference in L* increase, was not significant between the two composites (P>0.05) (Tables II-VII).

a* increased in all the samples (Tables II-VII). This means that the samples became redder.

△a* in group B and on a black background was significantly more in IDM (P<0.05) (Table III). In other groups, this difference was not significant (P>0.05) (Tables II,IV,V,VI,VII).

b* decreased in all the samples. △b* of groups A and B were significantly more for IDM. (P<0.05) (Tables II,III,V,VI), but in group C, this was not significant. (P>0.05) (Tables IV,VII).

△E of the B samples, were significantly more in IDM, (P<0.05) (Tables III,VI) but this was not significant in other groups (P>0.05) (Tables II, IV, V, VII).

**Table I:** Base line opacity and its changes in different aging conditions

| Variable | Material | Mean | SD | t | P |
|---|---|---|---|---|---|
| Opacity at base line | IDM | 77.6027 | 8.5988 | 8.110 | 0.000* |
| | Tetric Ceram | 58.7291 | 2.7022 | | |
| Change in opacity in group A | IDM | 3.2344 | 1.1463 | 1.452 | 0.185 |
| | Tetric Ceram | 2.0310 | 1.4567 | | |
| Change in opacity in group B | IDM | 1.5740 | 1.4472 | -0.716 | 0.404 |
| | Tetric Ceram | 2.2306 | 1.4508 | | |
| Change in opacity in group C | IDM | 1.6236 | 1.5927 | -0.393 | 0.708 |
| | Tetric Ceram | 1.9382 | 0.8187 | | |

* Significant

**Table II:** Color changes on standard black background in group A

| Color Coordinants | Material | Mean | SD | t | P |
|---|---|---|---|---|---|
| △L* | IDM | 2.4796 | 0.4740 | 0287 | 0.781 |
| | Tetric Ceram | 2.4048 | 0.3397 | | |
| △a* | IDM | 0.1396 | 0.1144 | -1.581 | 0.153 |
| | Tetric Ceram | 0.2288 | 0.0560 | | |
| △b* | IDM | -1.4404 | 0.8251 | -2.509 | 0.036* |
| | Tetric Ceram | -0.6526 | 0.5092 | | |
| △E | IDM | 2.9660 | 0.4740 | 1.817 | 0.107 |
| | Tetric Ceram | 2.4812 | 0.3625 | | |

* Significant

**Table III:** Color changes on standard black background in group B

| Color Coordinants | Material | Mean | SD | t | P |
|---|---|---|---|---|---|
| △L* | IDM | 2.7254 | 0.5854 | 0.762 | 0.468 |
| | Tetric Ceram | 2.4760 | 0.4437 | | |
| △a* | IDM | 1.1822 | 0.1848 | 2.855 | 0.021* |
| | Tetric Ceram | 0.9122 | 0.1028 | | |
| △b* | IDM | -5.8544 | 0.5969 | -6.211 | 0.000* |
| | Tetric Ceram | -3.7520 | 0.4653 | | |
| △E | IDM | 6.5902 | 0.5577 | 6.200 | 0.000* |
| | Tetric Ceram | 4.6062 | 0.4482 | | |

* Significant

**Table IV:** Color changes on standard black background in group C

| | | Mean | SD | t | P |
|---|---|---|---|---|---|
| delta L* | IDM | 2.6704 | 0.6141 | 0.965 | 0.507 |
| | T.C | 2.4286 | 0.4779 | | |
| delta a* | IDM | 0.1224 | 0.0746 | -1.500 | 0.172 |
| | T.C | 0.1804 | 0.0593 | | |
| delta b* | IDM | -1.1244 | 0.2902 | -1.836 | 0.104 |
| | T.C | -0.7230 | 0.3935 | | |
| delta E | IDM | 2.9102 | 0.6280 | 0.991 | 0.354 |
| | T.C | 2.5720 | 0.4338 | | |

**Table V:** Color changes on standard white background in group A

| | | Mean | SD | t | P |
|---|---|---|---|---|---|
| delta L* | IDM | 1.3240 | 0.3572 | -1.063 | 0.319 |
| | T.C | 1.8032 | 0.9422 | | |
| delta a* | IDM | 0.0076 | 0.1996 | -0.544 | 0.601 |
| | T.C | 0.086 | 0.1163 | | |
| delta b* | IDM | -2.4758 | 1.4375 | -2.893 | 0.038* |
| | T.C | -05489 | 0.3912 | | |
| delta E | IDM | 2.9738 | 1.0157 | 1.697 | 0.128 |
| | T.C | 1.9134 | 0.9601 | | |

* Significant

**Table VI:** Color changes on standard white background in group B

| | | Mean | SD | t | P |
|---|---|---|---|---|---|
| delta L* | IDM | 2.2834 | 0.6628 | 1.0402 | 0.328 |
| | T.C | 1.8168 | 0.7500 | | |
| delta a* | IDM | 1.0994 | 0.2789 | 1.657 | 0.136 |
| | T.C | 0.8718 | 0.1292 | | |
| delta b* | IDM | -7.7784 | 0.6533 | -6.209 | 0.000* |
| | T.C | -5.4014 | 0.5533 | | |
| delta E | IDM | 8.2086 | 0.6100 | 5.981 | 0.000* |
| | T.C | 5.7962 | 0.6643 | | |

* Significant

**Table VII:** Color changes on standard white background in group C

| | | Mean | SD | t | p |
|---|---|---|---|---|---|
| delta L* | IDM | 2.2940 | 0.8002 | 1.013 | 0.355 |
| | T.C | 1.9018 | 0.3999 | | |
| delta a* | IDM | -0.0516 | 0.1410 | 0.389 | 0.708 |
| | T.C | -0.0804 | 0.0871 | | |
| delta b* | IDM | -1.3942 | 0.3672 | -1.490 | 0.175 |
| | T.C | -1.1132 | 0.2072 | | |
| delta E | IDM | 2.7192 | 0.7525 | 1.380 | 0.205 |
| | T.C | 2.2160 | 0.3139 | | |

## Discussion:

Translucency of the esthetic restorative materials has a great effect on vital appearance of the restoration. In an intact tooth, light passes through enamel and penetrates deep into dentin. This phenomenon gives the tooth a lively appearance.[12] Resin composites should simulate enamel and dentin in this respect. The opacity of one mm thickness of dental composites has been evaluated to be between 50% -70%. [2,11]

Inokoshi measured the opacity of 1 mm

thickness of seven different composites, and reported it to be between 50%-55% .[11]

In our study, the mean opacity of IDM, in 1 mm thickness, was 77.6027%, which seems to be high, because in 2 mm and 2.5 mm restorations, this value will increase to 95 and 98 percent, respectively. In other words, little light will reach the depth of IDM composites, and the restoration will not have a vital appearance. In addition, the relative high standard deviation (SD) of IDM samples, (Table I), means that the paste is not homogene, a problem which was also noticed during sample preparing.

The 1 mm opacity of Tetric Ceram, was 58.7291% ± 2.7, which was similar to other commercial composites. The opacity of composites depends on the difference in refractive indices of filler and resin, but the exact reason of opacity changes in time, is not known. Powers et al[13,14] reported gradual discoloration and an increase in opacity of resin composites stored at 43°C and 90% relative humidity.

Davis et al[15] reported a high degree of discoloration in resin modified glass ionomers after artificial aging. In our study, the change in opacity of tested material was not significant after aging. Anyway, all the samples showed an increase in opacity.

In the Tetric Ceram samples, the change in opacity, was not significantly different. It was the most in group B, and the least in group C.

In the IDM samples, opacity change in group A was much more than the other two groups and in group B was the least.

Both A and C groups of IDM showed more increase in opacity than Tetric Ceram, but the B group (light and humidity) showed less change than Tetric Ceram.

It has been reported that in majority of composite resins (more than two third), during polymerization, a decrease in opacity happens and most of this reduction happens at the first 20 seconds.[16]

The lower change in opacity of IDM samples in group B, can be the result of incomplete baseline polymerization of this material during 40 seconds recommended time of light curing. In this group, after keeping the sample in the chamber containing xenon lamp, the curing could have continued. Thus, less increase in opacity was observed.

Incomplete polymerization of IDM may be the result of high primary opacity of the material which lowers the light penetration. This problem has been considered elsewhere, in a study regarding its degree of conversion and polymerization shrinkage.[17]

As stated before, opacity alone is not enough to analyze the esthetic properties of a restorative material.

In this study, color stability of IDM and Tetric Ceram was also assessed.

Due to less opacity of Tetric Ceram samples, the standard background has more effect on this material. That is the reason why the difference in L* a* b* between the white and back standards was more in Tetric Ceram. The white background resembles the traditional liners under a composite restoration. The black background resembles the dark oral cavity.

L* increased in all samples and in all groups, but the increase was not significant between IDM and Tetric Ceram.

The a* coordinant increased slightly in all samples. The difference in a* changes, between IDM and Tetric ceram, was insignificant except for the B group cases which were tested on a black background. The changes of a* coordinant in IDM was more ($P<0.05$). The b* coordinant of all samples decreased in the testing conditions. The decrease was significantly different in A and B groups of IDM. ($P<0.05$). Generally change in blue yellow axis (b*) was more than green-red axis (a*).

In the CIE system, $\triangle E$ determines the color changes in different conditions.

If $\triangle E$ is less than 1, the color change is not perceptible by normal eyes. Between 1 and 3.3, normal eyes can distinguish the color change, but clinically it is not important. If △E is more than 3.3, then the color change is not clinically acceptable.[11]

Our study showed that in A and C groups, △E was acceptable for all the samples. Although △E was more in IDM Samples, it was not significant (P>0.05). In the B group, △E was significantly more in IDM samples (P<0.05). Anyway, our study showed that Tetric Ceram also has some degree of color instability. Krejci et al [18] have reported the color changes in Tetric Ceram to be clinically acceptable.

**CONCLUSIONS:**

The opacity of IDM and Tetric Ceram increased after aging. The baseline opacity of IDM was high; therefore, it is not reliable in esthetic treatments. Tetric Ceram after aging had acceptable opacity. The high primary opacity reduces light penetration, thus may lead to decreased degree of conversion. △E of IDM was significantly higher under the 100% relative humidity and Xenon lamp condition.

**References**

1- Roulet JF, Degrange M. Adhesion, the silent revolution in dentistry. Chicago: Quintessence;. 2000.

2- Craig R, Powers JM. Restorative Dental Materials. $11^{th}$ ed. St. Louis: Mosby;

3- Anusavice KJ, Phillips. Science of Dental Materials. 10th ed. Philadelphia: Saunders; 1996.

4- Soderholm KJ, Mariotti A. Bis GMA Based Resins in Dentistry: Are They Safe? J Am Dent Assoc. 1999; 130: 201-208.

5- Mclean JW. Some Physical Properties of a new cross linked plastic filling material. Br Dent J 1961; 110: 375-78.

6- Asmussen E. Factors affecting the color stability of restorative resins. Acta Odontal Scand 1983, 41: 11-18.

7- Asmussen E. An accelerated test for color stability of restorative resins. Acta Odontal Sand 1981, 39: 329-32.

8- Wozniak WT, Moser JB, Willis E, Stanford JW. Ultraviolet light stability of composite resins. J. Prosthet Dent 1985; 53: 204-209.

9- Hondrum SO, Fernandez R. The storage stability of dental composite resins: Seven-Year Results. Gen Dent 1997; July-Aug. 382-89.

10- Council on dental materials and devices 1977. J Am Dent 1977; 94: 1191-94.

11- Inokoshi S, Burrow MF, Kataumi M, Yamada T, Takutsu T. Opacity and color changes of tooth-colored restorative materials. Oper Dent 1996, 21: 73-80.

12- Roberson TM, Heyman Ho, Swift EJ. Art and science of operative dentistry. $4^{th}$ ed. St. Louis: Mosby; 2002.

13- Powers JM, Dennison JB, Lepeak PJ. Parameters that affect the color of direct restorative resins. J Dent Res 1978; 57: 876-80.

14- Powers JM, Fan PL, Raptis CN. Color stability of new composite restorative materials under accelerated aging. J Dent Res 1980; 59: 2071-74.

15- Davis BA, Friedl KH, Powers JM. Color stability of hybrid ionomers after accelerated aging. J Dent Res 1994; 73 Abstracts of Papers. P 220: Abs 950.

16- Makinson OF. Color changes on curing light- activated anterior restorative resins. Aust Dent J 1989 Apr, 34(2): 154-59.

17- Ghavam M, Jafarzadeh T, Alizadeh Osqui P. Evaluating the linear polymerization shrinkage of light cure IDM. J Dent Tehran University of Medical Sciences 2001; 14 (3).

18- Krejci L. Besek M. Clinical and SEM study of tetric resin composite in posterior teeth. 12-month results. Am J Dent 1994; 7(1): 27-30.