

Effect of Different Drinks Immersion on Color Stability And Degree of Cure of Two Types of Dental Resin Composite Material (An In Vitro Study)

Mustafa Rashad^{1*}, Amel Muhson Naji², Sahira Hassan Kareem³ and Hussain Al-Huwaizi⁴

¹Dentistry department, Dijlah University College, Al-Masafi Street, Al-Dora, Baghdad, 00964, Iraq

²Department of Optics Techniques, Dijlah University College, Al-Masafi Street, Al-Dora, Baghdad, 00964, Iraq

³Al-Esraa University/ Health and Medical Technologies college / Physical Therapy dept

⁴College of dentistry University of Baghdad

*Corresponding author

Mustafa Rashad, Dentistry department, Dijlah University College, Al-Masafi Street, Al-Dora, Baghdad, 00964, Iraq.

Received: February 02, 2026; **Accepted:** February 09, 2026; **Published:** February 16, 2026

ABSTRACT

Among the wide range of polymer matrices, polymethyl methacrylate (PMMA)-based matrices can be considered the most common polymer used in dental applications. Important parameters, such as conversion degree and change of color of two commercial brands; nano- filled composite resin, NovaPro (N), and micro-hybrid composite resin, VLADMIVA (V) were investigated after curing and immersing the dental specimens in different drinks for one and seven days at 37 °C. Raman spectroscopy was used to evaluate the degree of conversion (DC) by measuring the ratio of the absorption bands related to aromatic and methacrylate C = C stretching modes. These ratios were of the same value. CIE (Color Imaging Experiment) was used to investigate the color change of the filling resins. (N) composite has a noticeable color change in coffee after 24 hours and almost the same change after one week. Yogurt also has a great effect on the color stability for the same composite just after one-week immersion. Cola has a large effect on the color for the same composite after one-week immersion. For (D) composite, the effect of the drinks after immersion for 24 hours and after one week was within the acceptable limit and non-noticeable by the naked human eye, which means it has better color stability than the (N).

Keywords: Color Stability, Conversion Degree, Raman Spectroscopy, Vladmiva, NovaPro

Introduction

A wide scope of polymeric materials is usually utilized for different applications in dentistry [1]. Among them, since 1946, (PMMA) has become the leading material in this field [2,3]. It is characterized by low density, aesthetics, manipulation ease, and tailorable mechanical and physical properties [4]. The estimation of (DC) is very important because of its impact on the physical and mechanical properties of the dental material [5]. The elastic modulus increases during curing due to polymerization shrinkage [6,7]. Several papers related the shrinkage stress to the restoration of the composite material [7]. The DC can be calculated from the percentage of unreacted (C=C) carbon double bonds in the cured composite material in relation to the uncured material [5]. Several spectroscopic techniques are used for the measurement of DC [8], among them FT-Raman (FT-R).

However, DC values may show a variation in values for similar dental composite materials and technical methods or devices depending on the methods of specimen preparation and the type of spectral technique chosen, taking into consideration several variables, including the overlapped peaks and the method of measuring the amplitude and area of the peaks adopted in calculating the degree of polymerization [9]. There are several brands for esthetic restorations of both anterior and posterior teeth in different shades of dental fillings that are available on the market that are clinically selected, depending on their chemical composition, rheological properties, techniques applied in medical treatment, and whether they have low or high viscosity in addition to their color stability [10].

Different types of light-curing units can be categorized according to their curing mode and/or light source like mercury discharge lamp, quartz tungsten halogen light units (QTH), plasmaarc (PAC), Argon Laser, and light-emitting diode unit (LED) which

was introduced in the late 1990s. Its great advantage compared to other light sources is its energy efficiency, which makes it less energy-consuming compared to other light-curing devices, which is why they are battery operated [11]. Several factors can influence the dental resin, among them its water absorbability, composition, and the type of filler. Due to high water sorption, a hydrophobic matrix induces less water absorption and consequently less color change, while a hydrophilic matrix causes a white or opaque shade of dental resin color due to high water sorption [12].

In this study, we evaluated the color stability and (DC) by (FT-R) of (N) and (V) dental composite materials by LED. The variation in specimen color was measured after immersion in different beverages for one and seven days.

Materials and Method

Two brands were used in this study; nano-filled composite resin, NovaPro (N), universal composite, A2 shade, Missouri, USA. And micro-hybrid composite (A2 shade, VLADMIVA (V), Belgorod, Russia). The specimens were collected and stored in a glass cup filled with popular drinks, with the control drink being the distilled water (al Mansour company). Coca-Cola (Alwaaha company–Hilla, Kerbala), yogurt (state company for food industries, Abu Ghraib dairy factories product), coffee (Nescafe classic) was used.

Twelve disc-shaped specimens for each composite material with an inner diameter of 10.0 ± 0.1 mm and a thickness of 2.0 ± 0.1 mm were made by using a circular stainless steel mold. The resin was placed between two glass plates (3 mm) to maintain a constant distance between the light source and the resin sample and to achieve a smooth surface free from air bubbles. The plates were separated by a polyester mylar film matrix strip and then pressed. Then it was loaded with 500 grams of weight to get rid of entrapped air. LED light of intensity 1000 mW/cm² of wavelength (385-515nm) was used for 20 seconds to photopolymerize the samples from one side. The specimens were sanded with abrasive papers of grain sizes of 240, 400, 600, and 1200. For each drink, three specimens were prepared, making a total of 12 specimens for each composite resin. Liquids were replaced every 24 hours after immersion. The samples were soaked in distilled water or a specific type of drink for 24 hours, then 168 hours at 37 degrees Celsius.

Characterization

The analysis of the Raman spectrum was carried out by Teskan, Takram N1-541 with a 532 nm wavelength from Nd:YAG utilized as an excitation source. A power of 100 mW was employed and calibration was conducted with the silicon. The measurements were made before and after immersion in different drinks for both the chemical groups and the degree of conversion of the resin materials. The DC percent of the composites was calculated using the following formula [13]:

$$DD(\%) = 100 \times \left[1 - \left(\frac{H_2 / H_1, \text{ polymerized}}{H_2 / H_1, \text{ non-polymerized}} \right) \right]$$

where H_1 and H_2 correspond to the peak intensities at 1604 cm^{-1} and 1634 cm^{-1} , respectively.

In order to measure the color change of the material, we used

a spectrophotometer (Konica Minolta colorimeter, Japan). The device has a sphere with measurements of 10 mm opening. A color measurement was made depending on the change in the values of $L^*a^*b^*$. 10 degrees of standard observation angle with D65 illumination with white calibration was used. The L^* parameter represents the darkness of the color, so it has a value of 100 for the typical black. The b^* values are either (positive b^*) yellowness or (negative b^*) blueness while the a^* value is a measure of how red (positive a^*) or green (negative a^*) the object is. For example, if the color was neutral, the a^* b^* co-ordinates approach zero (white, gray, etc.) and the value increases for more saturated colors. The calculation of the color variation ΔE^* between two color positions is

$$\Delta E^* = [(L^*1 - L^*0)^2 + (a^*1 - a^*0)^2 + (b^*1 - b^*0)^2]^{1/2}. (1)$$

Statistical Analysis

With the help of SPSS for Windows, Version 13.0 (SPSS Inc., Chicago, IL) software, we used the ANOVA test to evaluate the color change for the materials after the effects of different drinks and to analyze the FT-Raman results for composites.

Results and Discussion

The Raman spectrum of an uncured sample of (N) composite is revealed in Figure 1a, with many peaks which are associated with specific vibrational frequencies. The major vibrational peaks can be attributed to silicon oxide (Si₂O) bending at 806.9 cm^{-1} , SiO₂ stretching at 1216.9 cm^{-1} , the C=C vibrational modes of the aromatic ring at 1439.7 and 1604 cm^{-1} and the modes of matrix methacrylate C=C at 1638 cm^{-1} [14]. By using the ratio between stretching from methacrylate and the aromatic ring, the reduction in carbon double bond due to the cross-linking reaction in the same Raman spectrum can be evaluated. Most importantly, by applying these ratios to non-polymerized composites and for samples after exposing them to LED light for 20 s, DC values were determined. As shown in Table 1, the obtained DC values of NovaPro composites after 7 days immersed in water, yogurt, cola, and coffee were found to be 70%, 67%, 66%, and 75%, respectively. These findings agree well with reports of DC in the literature [15].

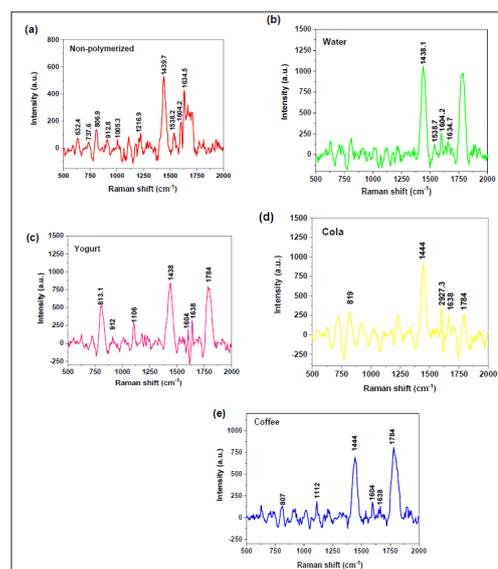


Figure 1: Raman Spectra Of The Novapro Before And After Immersion For Seven Days.

Figure 2 demonstrates the Raman responses measured for the Vladmiva composites of non- polymerized and polymerized samples with an LED light source for 20 s. The stretching vibration of C=C benzene rings at 1604 cm⁻¹ and the methacrylate C=C modes at 1638 cm⁻¹ are clearly observed. As we can see for Raman modes, we detected a change in the intensities of the Raman spectra as a function of drink type. It is interesting to see that this alteration occurs more obviously in the composites immersed in yogurt and coffee than the other composites. The corresponding DC of Vladmiva composites was calculated to be 63%, 81%, 73%, and 75% for water, coffee, cola, and yogurt, respectively.

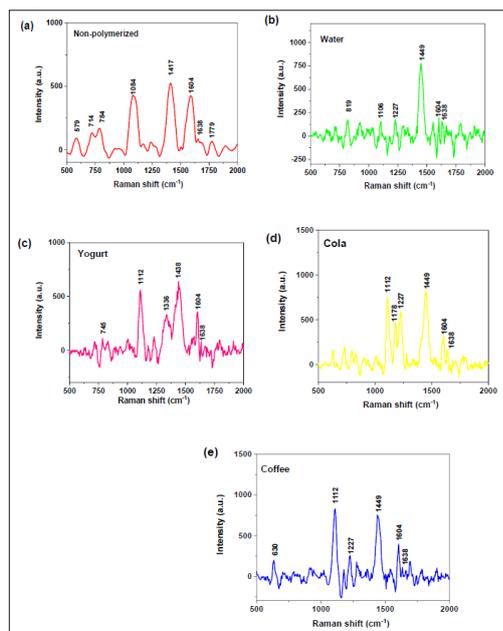


Figure 2: Raman spectra of the Vladmiva before and after immersion for seven days.

Table1: degree of conversion values of composites as a function of drink type. H2/H1 for non-polymerized of NovaPro and Vladmiva are 2.184 and 2.213, respectively.

Composite	Drink	H2/H1	DC (%)
N	Water	0.64	70
	Cola	0.72	66
	Coffee	0.55	75
	Yogurt	0.71	67
V	Water	0.81	63
	Cola	0.56	73
	Coffee	0.41	81
	Yogurt	0.51	75

The findings of the current work exhibited that the (DC) in the polymerized NovaPro composites by LED light reached a

Table 2: Color measurements for NovaPro and Vladmiva immersed in distilled water, cola, yogurt, and coffee

Color parameters	Immersion time (h)	Control		Yogurt		Cola		Coffee	
		N	V	N	V	N	V	N	V
L*	0	42.62	37.98						
	24	42.62	37.98	42.01	37.12	41.17	36.96	44.35	38.08
	168	42.62	37.98	41.67	36.98	41.67	39.50	44.99	38.37

magnitude of up to 70% only after 20 s of irradiation time. For Vladmiva, a magnitude of DC close to that was reached with NovaPro composites. Hence, the efficiency of the LED light to cure composites is significant, which results in a decrease in the polymerizing time. This decreasing provides the professional to cure the composites easier utilizing the laser, resulting in less annoyance for the patient, lowering of time consuming, and enhancement in physical merits. Incomplete curing causes defects of physical features, rapid solubility in oral environment, decreased resistance to leakage and changes in colour. The high values of DC were detected for both resins, indicating that the LED light generates a large amount of energy in a short time.

We can measure polymerization process by measuring (DC). It makes correlation to the amount of double bonds decreased during the process of light polymerization. When there is incomplete polymerization of a composite, this monomer will leak from the material to the wet environment [16]. Colour stability is an essential property of the composite material, and composite restorations should now have visual properties similar to those of the natural tooth in terms of translucency, reflection, and opacity. The samples were stored in drinks and distilled water for one and 7 days at 37 oC to create conditions similar to those in the oral cavity. By using (ΔE) we can compare the colour change between the samples before immersion in the drinks and after 24 h and 168 h, respectively. The normal human eye differentiates between individuals in the matter of colour change appreciation, as it is a combination of eyes. Values ($1 < \Delta E < 3.3$) were considered appreciable by the operator based on experience and knowledge. In order to distinguish colour changes in the composite, we used three different intervals. Values of $\Delta E \leq 1$ were regarded as not appreciable by the human eye and skilled operators. Finally, the values of (ΔE) which can be appreciated by a non-skilled person should be above 3.3 [17]. Composite materials have the ability to adsorb or absorb colorants as a result of contamination from exogenous sources. These sources, called extrinsic factors, are the main factors that cause discoloration of oral tissues and staining of restorations. From the above results, it is obvious that Nanova has a noticeable colour change in coffee after 24 hour and almost the same change after one week. Yogurt also has a great effect on the colour stability of the same composite after one- week immersion, but has no significant effect after the first 24 hour. Cola had a minor effect on the colour after 24 hour immersion but had a significant effect on the colour of the same composite after one week immersion. For Vladmiva, the effect of the drinks after immersion for 24 hour and after one week was within the acceptable limit and non-noticeable by the naked human eye, which means it has better colour stability than the Nanova type. The colour change in the composites could be due to adsorption and/or absorption of drink liquids by the material's surface rather than a chemical reaction. All data is expressed in the Tables (1,2).

a*	0	-1.34	0.49						
	24	-1.34	0.49	-1.65	0.41	-1.41	0.29	-0.68	0.37
	168	-1.34	0.49	-1.47	0.48	0.87	0.44	-0.41	0.94
b*	0	0.67	6.56						
	24	0.67	6.56	0.22	6.04	1.45	5.86	2.68	5.90
	168	0.67	6.56	1.09	6.45	1.86	6.00	5.20	7.18

Table 3: Color changes ΔE^* for NovaPro and Vladimiva composite resins immersed in distilled water, cola, yogurt, and coffee

Immersion time (h)	Color change (ΔE^*)							
	Control		Yogurt		Cola		Coffee	
	N	V	N	V	N	V	N	V
24	0 (0)	0 (0)	0.670(0.2)	1.016 (0.6)	1.715 (0.8)	1.570 (0.4)	7.468 (0.3)	0.46 (0.7)
168	0 (0)	0 (0)	1.095 (0.5)	1.012 (0.3)	2.539 (0.6)	.2625 (0.7)	10.521 (0.9)	0.739 (0.4)

*Standard deviations are in parentheses.

Conclusions

Raman spectroscopy is a reliable tool for evaluating the DC. The results showed that the DC was about 70% for both resins. This indicates that the LED light is sufficient to achieve good polymerization. NovaPro has a noticeable color change in coffee after 24 hours and almost the same change after one week. Yogurt also has a great effect on the color stability of the same composite just one week after immersion. Cola has a large effect on the color of the same composite after one week of immersion. For Vladmiva, the effect of the drinks after immersion for 24 hours and after one week was within the acceptable limit and non-noticeable by the naked human eye, which means it has better color stability than the NovaPro.

Conflict of Interest

Authors declare no conflicts of interest.

References

- Rokaya D, Srimaneepong V, Sapkota J, Qin J, Siraleartmukul K, et al. Polymeric materials and films in dentistry: An overview. *Journal of advanced research*. 2018. 14: 25-34.
- Zafar MS. Prosthodontic applications of polymethyl methacrylate (PMMA): An update. *Polymers*. 2020. 12: 2299.
- Nejatian T, Pezeshki S, Syed AUY. *Acrylic denture base materials*. Advanced Dental Biomaterials: Elsevier. 2019. 79-104.
- Hassan M, Asghar M, Din SU, Zafar MS. Thermoset polymethacrylate-based materials for dental applications. *Materials for Biomedical Engineering*: Elsevier. 2019. 273-308.
- Aung SZ, Takagaki T, Ikeda M, Nozaki K, Burrow MF, et al. The effect of different curing units on Vickers microhardness and degree of conversion of flowable resin composites. *Dental materials journal*. 2021. 40: 44-51.
- Bolaños-Carmona V, Benavides-Reyes C, González-López S, González-Rodríguez P, Alvarez-Lloret P. Influence of Spectroscopic Techniques on the Estimation of the Degree of Conversion of Bulk-fill Composites. *Operative Dentistry*. 2020. 45: 92-103.
- Kim RJ-Y, Kim Y-J, Choi N-S, Lee I-B. Polymerization shrinkage, modulus, and shrinkage stress related to tooth-restoration interfacial debonding in bulk-fill composites. *Journal of dentistry*. 2015. 43: 430-439.
- Seredin P, Goloshchapov D, Ippolitov Y, Vongsvivut J. Engineering of a biomimetic interface between a native dental tissue and restorative composite and its study using synchrotron FTIR microscopic mapping. *International Journal of Molecular Sciences*. 2021. 22: 6510.
- Khalil SK, Allam MA, Tawfik WA. Use of FT-Raman spectroscopy to determine the degree of polymerization of dental composite resin cured with a new light source. *European journal of dentistry*. 2007. 1: 072-079.
- Yeo HW, Loo MY, Alkhabaz M, Li KC, Choi JJE, et al. Bulk-fill direct restorative materials: An in vitro assessment of their physio-mechanical properties. *Oral*. 2021. 1: 75-87.
- Bahari M, Kahnemoui MA, Chaharom MEE, Kimyai S, Sattari Z. Effect of curing method and thermocycling on flexural strength and microhardness of a new composite resin with alkaline filler. *Dental Research Journal*. 2021. 18.
- da Silva Pedrosa M, Nogueira FN, de Oliveira Baldo V, Medeiros IS. Changes in color and contrast ratio of resin composites after curing and storage in water. *The Saudi Dental Journal*. 2021. 33: 1160-1165.
- Silva Soares LE, Martin AA, Barbosa Pinheiro AL. Degree of conversion of composite resin: a Raman study. *Journal of clinical laser medicine & surgery*. 2003. 21: 357-362.
- Luiz BK, Amboni RD, Prates LHM, Bertolino JR, Pires AT. Influence of drinks on resin composite: Evaluation of degree of cure and color change parameters. *Polymer testing*. 2007. 26: 438-444.
- Lassila L, Keulemans F, Vallittu PK, Garoushi S. Characterization of restorative short-fiber reinforced dental composites. *Dental Materials Journal*. 2020. 39: 992-999.
- Yap A, Lee H, Sabapathy R. Release of methacrylic acid from dental composites. *Dental materials*. 2000. 16: 172-179.
- Kim HS, Um CM. Color differences between resin composites and shade guides. *Quintessence International*. 1996. 27.

Copyright: © 2025 Mustafa Rashad, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.