ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 4, Issue – 5, September - 2021, Page No. : 235 - 242

Effect of different food colorants on color stability of polyetheretherketone and different polymers

[1]Dr.Shubhangi Agrawal**,** Post Graduate, Department of Prosthodontics and Crown & Bridge and Oral Implantology, Darshan Dental College & Hospital, Udaipur, India.

[2]Dr.Meenakshi Khandelwal, Principal, Professor and Head, Department of Prosthodontics and Crown & Bridge and Oral Implantology, Darshan Dental College & Hospital, Udaipur, India

[3]Dr.Vikas Punia , Professor, Department of Prosthodontics and Crown & Bridge and Oral Implantology, Darshan Dental College & Hospital, Udaipur, India

[4]Dr.Saransh Malot, Reader, Department of Prosthodontics and Crown & Bridge and Oral Implantology, Darshan Dental College & Hospital, Udaipur, India.

[5]Dr.Anand Porwal, Reader, Department of Prosthodontics and Crown & Bridge and Oral Implantology, Darshan Dental College & Hospital, Udaipur, India.

Corresponding Author: Dr. Shubhangi Agrawal, Post Graduate Department of Prosthodontics and Crown & Bridge and Oral Implant logy, Darshan Dental College & Hospital, Udaipur, India.

Citation of this Article: Dr. Shubhangi Agrawal, Dr. Meenakshi Khandelwal, Dr. Vikas Punia Dr. Saransh Malot, Dr. Anand Porwal, "Effect of different food colorants on color stability of polyetheretherketone and different polymers", IJDSIR- September - 2021, Vol. – 4, Issue - 5, P. No. 235 – 242.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Context: Color stability is one of the physical properties that affect the ability of material to retain their original color. Polyetheretherketone (PEEK) is an emerging material and very little data is available on color stability of the material.

Aims: This invitro study was conducted to evaluate and compare the color changes of Polyetheretherketone (PEEK), polymethylmethacrylate (PMMA) and indirect resin composite (IRC) caused by aging in commonly used pigment containing food/drink.

Settings and Design: Invitro analytical study

Methods and Material: 90 disks of (CAD/CAM) milled PEEK, PMMA and laboratory processed IRC were fabricated (n=30) and aged in three different media- cola, turmeric and tea respectively for 180 days for 10 min twice a day. Samples were immersed in each aging media. Color was determined by a portable spectrophotometer and calculated between different time points (ΔE).

Statistical analysis used: Multiple analysis of variance (ANOVA) of mean values was performed followed by Post hoc LSD test for pair wise comparisons. The level of significance was set at $p \leq 0.05$.

Results: Peek exhibited lowest color changes, while indirect composite resin exhibited highest changes. Turmeric solution caused the highest discoloration followed by tea and cola

Conclusions: Peek is more stable against discolorations than other dental polymers. Discoloration of polymers caused by turmeric is severe and esthetically unacceptable.

Keywords: Color stability, discoloration, polyetheretherketone, Polymethylmethacrylate, Indirect resin composite, aging media.

Introduction

Restorative and prosthetic materials used currently in the dentistry can be grouped into: metals, polymers, composites and ceramics. Polymer formed by the union of many repeating smaller monomer units is chemical compound consisting of large organic molecules. Over the years polymers are being commonly used in dentistry due to their favourable functional, physical, mechanical, proper esthetic properties and inexpensive equipment needed for its fabrication processes.[1]Despite of these advantages there has been associated disadvantage of color change.

Polymers used commonly for dental prosthesis fabrication include polymethylmethacrylate (PMMA) and BISGMA (Bisphenol A-glycidyl methacrylate) based resins. Over the years there has been constant development and modification in these materials to suit the restorative/prosthetic needs required for their desired use.

With the development of computer assisted design and computer assisted manufacturing (CADCAM) technology acrylic prosthesis can be fabricated by milling prepolymerized blocks of acrylic resin or by rapid phototyping technology without the need for other processing methods or flasking. In addition to its advantages during fabrication, CAD CAM fabricated prosthesis have improved material properties because denture bases are milled from prepolymerized acrylic resin blocks, which are polymerized under high pressure and temperature conditions. Further, the defects/errors caused during polymerization process like polymerization shrinkage, porosities, crazing etc are eliminated by this process.[2]

The indirect resin composites have a ‘micro hybrid’ filler with a diameter of 0.04–1 μ and the filler content was also twice that of the organic matrix. The mechanical properties and wear resistance is improved by increasing the filler load and polymerization shrinkage is reduced by reducing the organic resin matrix. These new composite resins have high amounts of filler content, which make them adequate for restoring posterior teeth.[3]

There is an introduction of new dental polymer called polyetheretherketone (PEEK) which is a polycyclic, aromatic, thermoplastic material that is semi-crystalline and has a linear structure. It is a biologically inert material. It has low elastic modulus. It is a very light material with a low density (1.32g / cm^3). PEEK has thermal stability up to 335.8°Cand is white, radiolucent, rigid material. It has low plaque affinity and is non allergic. It is used in producing fixed and removable prostheses due to its favorable chemical, mechanical and physical properties.[4]

Color stability is one of the most important clinical properties for all dental materials, and color changes are indicators of aging or damaging of the materials. The discoloration of dental materials after long-term use can be due to several factors. These factors include degradation of intrinsic pigments, and surface roughness stain accumulation, water sorption, dissolution of the ingredients.[5]Apart from these factors polishing ability, material composition, patient’s dietary and cleaning habits are key parameters achieving color stability mainly over a longer period of time.[6]

Discoloration of dental prostheses is measured as value over time by a spectrophotometer and is determined by

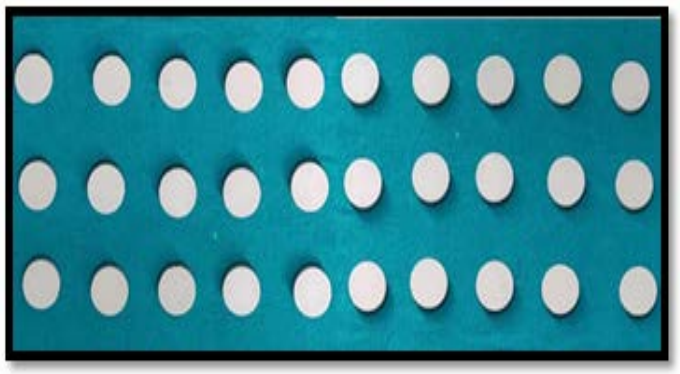
two essential factors: extrinsic factors which cause staining by chemical adhesion derive primarily from colorants of food products like caffeine-containing beverages or mouth rinses and from smoking; intrinsic factors are chemical reactions within the restoration material.[7-9]

With the advancement in dentistry, there is improvisation in existing materials and introduction of new materials. This study therefore aims to assess the discoloration on CAD CAM milled PEEK, PMMA and laboratory processed IRC.

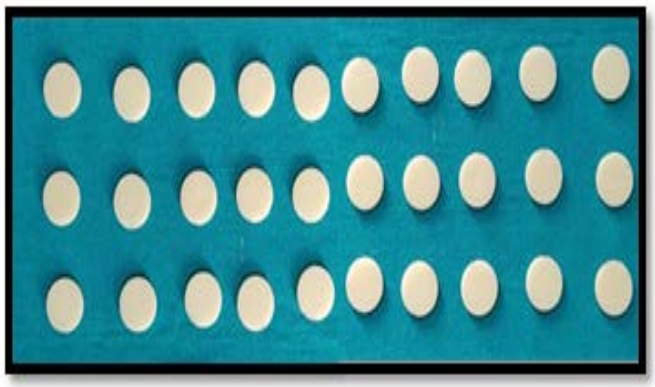
Subjects and Methods

30 specimens (figure 1) each of CAD CAM milled PEEK (Arum PEEK medium), PMMA (huge PMMA) and laboratory processed indirect resin composite (SR Nexco paste) were used in the study with diameter of 20mm and thickness of 3mm. The color of specimens of all groups were measured with a spectrophotometer using CIE (commission International de l'Eclairage) L*a*b relative to standard illuminant A, against a white background.The spectrophotometer was calibrated according to the manufacturer's recommendations by using the supplied white calibration standard before each measurement session. L* value ranges from zero (black) to 100 (white)and its refers to the lightness coordinate. The a* and b* are chromaticity coordinates in the red green axis and the yellow blue axis, respectively. Measurements were repeated 3 times for each specimen, and the mean value of the L*a* and b* data were calculated and designated as L,a,b.

Group 1



Group 2



Group 3

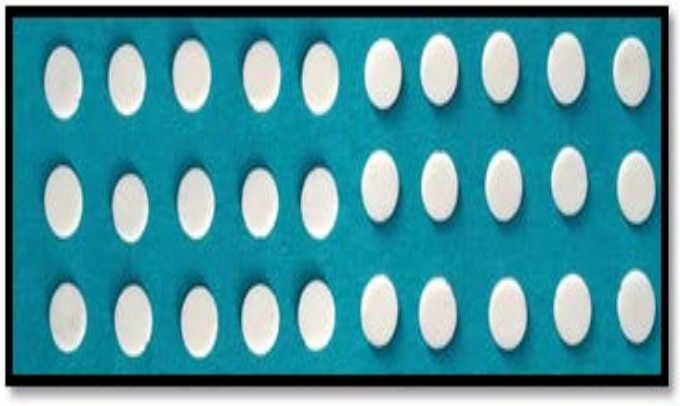


Figure 1: Milled test specimen

After initial evaluation, the specimens were stored in different aging media. 10 specimens of each group were immersed in Cola (Thums Up), turmeric (Everest Turmeric powder) and tea solutions (Brooke Bond, Taj Mahal, Tea bags) respectively. 50ml of cola was measured using measuring jar. Turmeric solution was prepared by

immersing 1gm of turmeric powder measured using electronic balance in 50ml of boiling water measured using measuring jar. Tea solution was prepared by immersing 1 teabag into 50 ml of boiling water measured using measuring jar for 2 minutes. Each specimen was immersed for 10 minutes twice a day in aging solutions for 180 days. The specimens were stored in artificial saliva for the remaining time in between immersion cycles.

After immersion in different aging media, the specimens were cleaned using ultrasonic cleaner. The color of all specimens groups were measured with a spectrophotometer using CIE (commission International de l'Eclairage) L*a*b relative to standard illuminant A, against a white background after 180 days of immersion in aging media, and were designated as L_2,a_2,b_2.(Figure 2)

Figure 2: Color measurement using spectrophotometer

Results

The results and statistical analysis of the study are summarized in Tables 1. Group I exhibited least color difference followed by group II and III respectively. Cola exhibited least color difference followed by tea and turmeric respectively. There was statistically significant difference between groups and ageing media.

Table 1: Summary Of Mean Color Difference ▲E Of All Groups (Materials) After Aging In Different Media.

Group	Aging Media			
	Subgroup A (COLA)	Subgroup B (TURMERIC)	Subgroup C (TEA)	Total Mean For Group
I	4.38± 2.73[a]	19.18±7.94[c]	5.68±1.64[a]	9.75[1]
II	6.02±4.52[a]	32.50±2.52[d]	5.95±4.93[a]	14.52[2]
III	4.98±2.41[a]	36.41±4.72[e]	11.267±6.65[b]	17.55[3]
Total Mean For Subgroup	5.13[A]	17.55[B]	7.63[C]	

The different numeric superscripted indicate that color difference value were significantly different at $p \leq 0.05$ among Groups (materials).

The different uppercase superscripted letters indicate that color difference value were significantly different at $p \leq 0.05$ among Subgroups (aging media).

The different lowercase superscripted letters indicate that color difference value were significantly different at $p \leq 0.05$ among two way interaction between materials and aging group.

Discussion

The use of complete, partial or fixed prosthesis has enabled prosthodontics to contribute to the character, charm and dignity of a person, thereby restoring that elusive esthetic appeal. Prosthesis should have intrinsic color stability and resistance to change in surface properties in order to have a high degree of esthetics and

longevity. After meticulous attention at every stage of treatment the ultimate success of any prosthesis is when esthetic and functional excellence is achieved. One of the common materials used for fabrication of prosthesis is dental polymers. Peek is the new polymer introduced in dentistry. In dentistry, polyetheretherketone (PEEK) is one of the high-performance thermoplastic. Due to its excellent mechanical, physical, and chemical properties it is applicable in a wide range of indications in the dental field. Even though PEEK is a plastic material with a low elastic modulus, the mechanical properties are adjustable by adding varying amounts of titanium oxide (TiO_2) as filler particles. Adding TiO2 as inorganic filler particles satisfies the optical properties for dental applications with PEEK and endorses extending the range of indications. Due to its outstanding biocompatibility and the high stability similar to human bone, the material is used in a variety of applications like for the fixed dental prosthetic framework (FDP) or the removable partial denture abutment framework, and as a material for provisional implant abutments.[4]

A large emphasis is laid over esthetics, in modern day dentistry. To match accurately the surrounding oral structures today prostheses and restorations are made with precision. As color is one of the most desirable properties of an esthetic restorative material, maintenance of matched color for the entire length of its service life may determine the success or failure of the material.[10]Intrinsic or extrinsic factors may cause discoloration. Intrinsic factors involve chemical changes of the material such as the oxidation of components. Extrinsic factors of discoloration include staining by adhesion or penetration of colorants from food components such as tea, cola and turmeric. Thus, it is important that the restorative material be resistant to changes in its intrinsic color.[7]

In the present study the evaluation of color change was performed on 30 discs of diameter 20mm and 3mm in thickness of each PEEK, PMMA and IRC respectively. These dimensions were used as normal prosthesis we give to the patient is of thickness 2-3 mm and 20 mm diameter of the specimens used allowed ease in manipulation, handling, as well as positioning of the specimen over the specimen holder of the aperture of the spectrophotometer, which was used for color measurements. This was similar to the dimension used by Darshana. P. Mundeet al[11] in their study. The specimens were of flat surface with shape as disks, as the extraoral spectrophotometer is capable of measuring color only of a flat surface.

Various chromatogen are present in Indian food. Some of these chromatogen containing foods/drinks include tea, coffee, colas, turmeric powder, red chilly powder, spices that are cooked in oil, etc. These are generally consumed on a daily basis and can adversely affect the color of the dental prosthesis. In the present study specimens were immersed in commonly consumed pigment containing food such as tea and cola solution which is a routine beverage consumed by most of the population, and turmeric which is the indianchromatogenic spice that is added to food routinely. Specimens were subjected to aging in these chromatogenic foods for 180 days to study the long term effect of pigment containing food on specimens. The specimens were subjected to the solutions intermittently i.e. twice a day for 10 minutes to closely simulate the in vivo conditions and then stored in artificial saliva continuously to simulate natural conditions. R.Veena Kumari et al.[7] and Neeraj Malhotra et al.[12] did a study in which they used similar beverages and duration.

In the present study color of specimens was measured by using spectrophotometer with CIELAB system. Three parameters (L*a*b*) used by CIELAB system to define color is as follows: L* refers to the lightness coordinate,

and its value ranges from zero (black) to 100 (white). In the red-green axis and yellow-blue axis, respectively, the a* and b* are chromaticity coordinates. Positive a* indicates a shifts to red, and negative values indicate a shift to green. Similarly, positive b* values indicate the yellow color change, and negative values indicate the blue color change.[13]

In the present study color was measured at between baseline and after aging in different media designated as $\blacktriangle E_1$.

The result of present study revealed that there was statistically significant difference between all groups (materials) for change in color. In present study PEEK specimens exhibited least change in color, followed by PMMA and IRC test specimens respectively. There was statistically difference between PEEK and other resins for color change at all intervals.

Peek showed least change in color than PMMA and IRC, it can be attributed to less absorption of water and less diffusion of water soluble colorants. PEEK is insoluble in all common solvents. It does not undergo hydrolysis. It is a stable polymer. Color change in PMMA and IRC is higher than PEEK. This can be attributed due to oxidation of polymer matrix or oxidation of unreacted double bonds in the residual monomers and the subsequent formation of degradation products from water diffusion. It has been found that because of high diffusion coefficient in comparison to methyl methacrylate based resins composite based resins can absorb water at a higher rate and thus stain more.

In this present study there was statistically significant difference between color changes in the three media used ie cola, turmeric and tea. Turmeric caused maximum staining followed by tea and cola. There was statistically significant difference between turmeric with other aging media.

Turmeric cause maximum stain and this can be attributed to the known high colorant nature and the natural staining capacity of turmeric. The yellow color of turmeric is due to curcumin (3%), which is the active substance, also known as Natural Yellow 3. Differential solubility and difference in particle size of a stain can also be the contributing factors. The concentration of the staining solution used could be the other factors involved. Similar results have been reported by Neeraj Malhotra et al[12] and Darshana .P. Munde et al.[11]

The tea solution showed more discoloration compared to the cola solution. According to Lai et al, both the affinity of the material to extrinsic stains and the diffusion of water molecules affect different polar properties of the tested materials. Hydrophobic materials are stained by hydrophobic solutions and hydrophilic materials with high water sorption are stained by hydrophilic colorants in aqueous solution. It was also reported that the adsorption of polar colorants onto the surface of the material causes the discoloration by tea. Tea contain considerable amount of flavonoid, which gives tea its functional properties and flavor; however, tea flavins in tea leaves are reported to be the cause of discoloration, which could be the reason for the stain ability of these materials. Similar results were found in study performed by Darshana. P. Mundeet al.[11]Um and Ruyter et al[14] reported that tea caused more discoloration than coffee after 48 hours of storage of five resin-based materials in coffee and tea solutions.

This study demonstrated that specimens in cola exhibited relatively low color change compared to tea and turmeric. This is similar to study conducted by Bagheriet al.[15] which revealed that cola did not produce as much discoloration as coffee and tea, which may be explained by the lack of a yellow colorant in cola.

The results of the present study indicate that peek exhibits better color stability among the polymers tested. Cad cam

materials (PEEK and PMMA) were more color stable than laboratory processed IRC. With respect to aging media turmeric solution caused maximum color changes in the tested materials. All the polymers tested in present study exhibited color changes which were visually perceptible. This can be due to longer duration of study and concentration of solution.

Although color stability is one of the variables that must be considered when choosing a material, it is of great importance to patients and clinicians when working in the esthetic zone. Color changes in dental prosthesis are evident from food/beverages that are consumed in day to day life. Clinicians and dental technicians should inform their patients about the discoloration potential of certain foods/beverages and recommend the most efficient home care.

Clinical implication of the study

The color stability of any polymer depends on the type of the material, the staining solutions, and the duration of exposure to the staining solutions

Color changes is caused by intrinsic and extrinsic factors

Intrinsic factors include chemical reactions within the restoration material triggered by heredity, age, and processing modes of placed restorations

Extrinsic factors are related to the surface absorption of staining solutions from exogenous sources or through the accumulation of plaque and surface stains.

Among the materials tested, peek has better color stability than other polymers.

Among the aging media, turmeric causes maximum discoloration of materials.

In the oral cavity, the flushing effect of saliva as well as the oral hygiene habits may reduce the extrinsic stains on the restorative material.

Conclusion

PEEK was found to be most color stable followed by PMMA and IRC. CAD CAM materials are more color stable than laboratory processed polymers.

Turmeric caused the greatest discoloration followed by tea and cola.

PEEK material shows excellent mechanical properties, resistance to high temperatures, inertness and elasticity modulus close to the elasticity modulus of bone. This can be used in FDP frameworks, CPD frameworks, implantology for fabrication of implant abutments and implant supported prosthesis framework.

CAD/CAM PMMA based polymer blocks, that are polymerized under high temperature and high pressure conditions, reduce residual monomer release, improve optical properties and improve stability of color. Thus, apart from their use as denture base materials they can be advocated for use in interim fixed dental prosthesis etc.

Indirect resin composite has the advantage of wear resistant, esthetic, and is relatively less prone to postoperative sensitivity. These materials are advocated for fixed prosthodontic applications such as inlays, onlays, interim FDP, veneering metal-free single unit crowns and short-span anterior bridges.

Further, clinical studies evaluating color stability of these materials are advocated.

References

1. Rad FH, Ghaffari T, Tamgaji R. Evaluation of the color stability of methyl methacrylate and nylon base polymer. J Dent. 2017;18(2):136-142.
2. Zafar MS. Prosthodontic Applications of Polymethyl Methacrylate (PMMA): An Update. Polym. J. 2020;12(10):2299-334.
3. Nandini S. Indirect resin composites. J. Conserv. Dent. 2010;13(4):184-194.

4. Skirbutis G, Dzingute A, Masiliunaite V, Sulcaite G, Zilinskas J. PEEK polymer's properties and its use in prosthodontics. A review. Stomatologija. 2018;20(2):54-58.
5. Imirzalioglu P, Karacaer O, Yilmaz B, Ozmen MSc I. Color stability of denture acrylic resins and a soft lining material against tea, coffee, and nicotine. J Prosthodont. 2010;19(2):118-24.
6. Heimer S, Schmidlin PR, Stawarczyk B. Discoloration of PMMA, composite, and PEEK.Clin Oral Investig. 2017;21(4):1191-200.
7. Kumari RV, Nagaraj H, Siddaraju K, Poluri RK. Evaluation of the effect of surface polishing, oral beverages and food colorants on color stability and surface roughness of nanocomposite resins. Journal of international oral health: J Int Oral Health. 2015;7(7):63-70
8. Addy M, Mahdavi SA, Loyn T. Dietary staining in vitro by mouthrinses as a comparative measure of antiseptic activity and predictor of staining in vivo. J Dent. 1995;23(2):95-9.
9. Cengiz S, Yuzbasioglu E, Cengiz MI, Velioglu N, Sevimli G. Color Stability and Surface Roughness of a Laboratory-Processed Composite Resin as a Function of Mouthrinse. J EsthetRestor Dent. 2015;27(5):314-21.
10. Padiyar N. Colour stability: An important physical property of esthetic restorative materials. Int J Clin Dent. 2010;1(1):81-84.
11. P.Darshana, MR Usha. Effect of Indian Chromatogens on Color Stability of commercially Available Different Tooth Colored Provisional Restorative Materials. Int J Oral Care Res. 2016;4(1):58-66.
12. Malhotra N, Shenoy RP, Acharya S, Shenoy R, Mayya S. Effect of three indigenous food stains on resin-based, microhybrid, and nanocomposites. J EsthetRestor Dent. 2011;23(4):250-7.
13. Powers JM, Lepeak PJ. Parameters that affect the color of denture resins. J Dent Res. 1977;56(11):1331-5.
14. Um CM, Ruyter I. Staining of resin-based veneering materials with coffee and tea. Quintessence Int. 1991;22(5):377-86.
15. Bagheri R, Burrow MF, Tyas M. Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials. J Dent. 2005;33(5):389–398.