

BÖLÜM 3

REZİN MATERYALLERDEN MONOMER SALINIMI

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1.REZİN MATERYALLER

Rezin bazlı materyaller, diş hekimliğinde estetik ve fonksiyonel restorasyonlar için yaygın olarak kullanılan temel malzemelerdendir. Bu materyaller; monomer matrisi, inorganik doldurucular ve bağlayıcı ajanlardan oluşan kompleks yapıları sayesinde klinik başarının birçok yönünü etkiler. Ancak resin materyallerin klinik uygulamalardaki en önemli biyolojik endişelerinden biri, polimerizasyon sonrası matriste kalan artık monomerlerin zamanla ağız ortamına salınmasıdır. Bu monomer salınımı, özellikle düşük polimerizasyon derecesine sahip materyallerde daha belirgin olup, hem çevre dokular üzerinde toksik etkilere neden olabilmekte hem de restorasyonun uzun vadeli stabilitesini olumsuz yönde etkileyebilmektedir. Salınan monomerlerin miktarı ve tipi; kullanılan monomer sistemine, polimerizasyon koşullarına ve materyalin içeriğine bağlı olarak değişiklik göstermektedir. Bu nedenle, modern resin materyallerin geliştirilmesinde, yalnızca mekanik performansın değil, aynı zamanda monomer salınımının da minimize edilmesi büyük önem taşımaktadır.

1.1. Resin Kompozitler

Kompozit; yeni bir materyal oluşturmak için birbiri içinde çözünmeyen farklı yapı ve özellikteki iki veya daha fazla maddenin fiziksel karışımı anlamına gelmektedir (1). Resin kompozitler, diş hekimliğinde ilk olarak 1960'ların ortalarında ön diş restorasyonlarında kullanılmak üzere ticari olarak piyasaya sürülmüştür (2). Bu materyallerin geliştirilmesiyle birlikte zamanla dayanıklılıkları artmış ve kullanım

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KAYNAKLAR

1. Ülkü SG, Ünlü N. Son 10 Yılda Kompozit Rezın Restorasyonlar: İn Vivo ve İn Vitro Çalışmalarla Bir Derleme. Necmettin Erbakan Üniversitesi Dis Hekimliği Dergisi (NEU Dent J), 2020;2(3):124-145. doi:10.51122/neudentj.2021.7
2. Peutzfeldt A. Resin composites in dentistry: The monomer systems. Eur J Oral Sci. 1997;105(2):97-116. doi:10.1111/j.1600-0722.1997.tb00188.x
3. Peutzfeldt A. Resin composites in dentistry: The monomer systems. Eur J Oral Sci. 1997;105(2):97-116. doi:10.1111/j.1600-0722.1997.tb00188.x
4. Asmussen E. Softening of BISGMA-Based Polymers by Ethanol and by Organic Acids of plaque. Scand J Dent Res. 1984;92(3):257-261. Doi:10.1111/j.1600- 0722.1984.Tb00889.x.
5. Asmussen E. Factors affecting the color stability of restorative resins. Acta Odontol Scand. 1983;41:11-18. doi:10.3109/00016358309162298
6. Munksgaard EC, Hansen EK, Kato H. Wall-to-Wall Polymerization Contraction of Composite versus Filler Content. Scand J Dent Res. 1987;95(6):526-531. doi:10.1111/j.1600- 0722.1987. Tb01970.XChristian.
7. Heboyann A, Vardanyan A, Karobari M. Dental Luting Cements: An Updated Comprehensive Review. Molecules. 2023;28(4):1619. doi:10.3390/molecules28041619.
8. Tanweer N, Qazi FUR, Das G, et al. Effect of Erosive Agents on Surface Characteristics of Nano-Fluorapatite Ceramic: An In-Vitro Study. Molecules. 2022;27(15):4691. doi:10.3390/molecules27154691
9. El-Deeb HA, Mobarak EH. Repair Bond Strength of High-viscosity Glass-ionomer Cements Using Resin Composite Bonded with Light- and Self-cured Adhesive Systems. Oper Dent. 2021;46(1):45-53. doi:10.2341/19-186-L
10. Sofan E, Sofan A, Palaia G, Tenore G, Romeo U, Migliau G. Classification Review of Dental Systems: From the IV Generation to the Universal Type. Ann Stomatol (Roma). 2017;8(1):1-17. doi:10.11138/Ads/2017.8.1.001. Vol VIII.
11. Van Landuyt KL, Snauwaert J, De Munck J, et al. Systematic review of the chemical composition of contemporary dental adhesives. Biomaterials. 2007;28(26):3757-3785. doi:10.1016/j.biomaterials.2007.04.044
12. Perdigão J, Araujo E, Ramos RQ, Gomes G, Pizzolotto L. Adhesive dentistry: Current concepts and clinical considerations. J Esthet Restor Dent. 2021;33(1):51-68. doi:10.1111/jerd.12692
13. Gunay A, Celenk S, Adiguzel O, Cangul S, Ozcan N, Cakmakoglu EE. Comparison of Antibacterial Activity, Cytotoxicity, and Fluoride Release of Glass Ionomer Restorative Dental Cements in Dentistry. Med Sci Monit. 2023;29: e939065-1. doi:10.12659/MSM.939065
14. Berzins DW, Abey S, Costache MC, Wilkie CA, Roberts HW. Resin-modified glass-ionomer setting reaction competition. J Dent Res. 2010;89(1):82-86. doi:10.1177/0022034509355919
15. Palmer G, Anstice HM, Pearson GJ. The Effect of Curing Regime on the Release of hydroxyethyl Methacrylate (HEMA) from Resin-Modified Glass-Ionomer Cements. J Dent. 1999;27(4):303-311. doi:10.1016/S0300-5712(98)00058.
16. Sulaiman TA. Materials in digital dentistry—A review. J Esthet Restor Dent. 2020;32(2):171-181. doi:10.1111/jerd.12566
17. Barutçigil K, Dündar A, Gül Batmaz S, Yıldırım K, Barutçugil Ç. Do resin-based composite CAD/CAM blocks release monomers? Clin Oral Investig. 2021;25(1):329-336. doi: 10.1007/s00784-020-03377-3.
18. Van Meerbeek B, Yoshihara K, Van Landuyt K, Yoshida Y, Peumans M. From Buonocore's Acid-Etch Technique to Self-Adhering Restoratives.A Status Perspective of Rapidly Advancing Dental Adhesive Technology. J Adhes Dent. 2020;22(1):7-34. doi:10.3290/j.Jad.A43994.
19. Sideridou I, Tserki V, Papanastasiou G. Effect of Chemical Structure on Degree of conversion in Light-Cured Dimethacrylate-Based Dental Resins. Biomaterials. 2002;23(8):1819-1829. doi:10.1016/S0142-9612(01)00308-8. Vol 23.; 2002.
20. Sideridou I, Tserki V, Papanastasiou G. Study of Water Sorption, Solubility and Modulus of

- elasticity of Light-Cured Dimethacrylate-Based Dental Resins. *Biomaterials*. 2003;24(4):655-665. doi:10.1016/S0142-9612(02)00380-0. Vol 24.
21. Silikas N, Watts DC. Rheology of Urethane Dimethacrylate and Diluent Formulations. *Dent Mater*. 1999;15(4):257-261. doi:10.1016/S0109-5641(99)00043-3.
22. Asmussen E, Peutzfeldt A. Influence of UEDMA BisGMA and TEGDMA on Selected Properties of Experimental Resin Composites. *Dent Mater*. 1998;14(1):51-56. doi:10.1016/S0109-5641(98)00009-8. Vol 14.
23. Bowen, Rafael L. Dental Filling Material Comprising Vinyl Silane Treated Fused Silica and a Binder Consisteng of the Reaction Product of Bis Phenol and Glycidyl Acrylate. 1962;27.
24. Bowen RL. Properties of a silica-reinforced polymer for dental restorations. *J Am Dent Assoc*. 1963;66(1):57-64. doi:10.14219/jada.archive.1963.0010
25. Moszner N, Fischer UK, Angermann J, Rheinberger V. A partially aromatic urethane dimethacrylate as a new substitute for Bis-GMA in restorative composites. *Dent Mater*. 2008;24(5):694-699. doi:10.1016/j.dental.2007.07.001
26. Charton C, Falk V, Marchal P, Pla F, Colon P. Influence of Tg, viscosity and chemical structure of monomers on shrinkage stress in light-cured dimethacrylate-based dental resins. *Dent Mater*. 2007;23(11):1447-1459. doi:10.1016/j.dental.2007.05.017
27. Henriks-Eckerman ML, Suuronen K, Jolanki R, Alanko K. Methacrylates in dental restorative materials. *Contact Dermatitis*. 2004;50(4):233-237. doi:10.1111/j.0105-1873.2004.00336.x
28. Morgan DR, Kalachandra S, Shobha HK, Gunduz N, Stejskal EO. Analysis of a dimethacrylate Copolymer (Bis-GMA and TEGDMA) Network by DSC and 13C Solution and solid-State NMR Spectroscopy. *Biomaterials*. 2000;21(18):1897-1903. doi:10.1016/S0142-9612(00)00067-3. Vol 21.
29. Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. *Dent Mater*. 2006;22(3):211-222. doi:10.1016/j.dental.2005.05.005
30. Asmussen E, Peutzfeldt A. Mechanical Properties of Heat Treated Restorative Resins for Use in the Inlay/Onlay Technique. *Scand J Dent Res*. 1990;98(6):564-567. doi:10.1111/j.1600-0722.1990.Tb01013.x.
31. Ohno H, Endo K, Hashimoto M. New mechanical retention method for resin and gold alloy bonding. *Dent Mater*. 2004;20(4):330-337. doi:10.1016/S0109-5641(03)00125-8
32. Chang JC. Amalgam repair with a 4-META resin. *J Prosthet Dent*. 2004;92(5):506-507. doi:10.1016/j.prosdent.2004.07.007
33. Nakabayashi N, Hiranuma K. Effect of Etchant Variation on Wet and Dry Dentin Bonding Primed with 4-META/Acetone. *Dent Mater*. 2000;16(4):274-9. doi:10.1016/s0109-5641(00)00017-8.
34. Yoshida Y, Nagakane K, Fukuda R. Comparative Study on Adhesive Performance of functional Monomers. *J Dent Res*. 2004;83(6):454-458. doi:10.1177/154405910408300604. Vol 83.
35. Ikemura K, Endo T. Effects of a new 4-acryloxyethyltrimellitic acid in a visible light-cured dental adhesive on adhesion and polymerization reactivity. *J Appl Polym Sci*. 1998;69(6):1057-1069. doi:10.1002/(sici)1097-4628(19980808)69:6<1057::aid-app2>3.0.co;2-f
36. Tani C, Itoh K, Hisamitsu H, Wakumoto S. Tani C, Itoh K, Hisamitsu H, Wakumoto S. Efficacy of Dentin Bonding Agents Combined with self-Etching Dentin Primers Containing Phenyl-P. *Dent Mater J*. 1993;12(2):219-224. doi:10.4012/Dmj.12.219. Vol 12.
37. Wang T, Nakabayashi N. Effect of 2-(Methacryloxy)Ethyl Phenyl Hydrogen Phosphate on adhesion to Dentin. *J Dent Res*. 1991;70(1):59-66. doi:10.1177/00220345910700011001. Vol 70.
38. Pashley EL, Agee KA, Pashley DH, et al. Effects of One versus Two Applications of an unfilled, All-in-One Adhesive on Dentine Bonding. *J Dent*. 2002;30(2-3):83-90. doi:10.1016/S0300-5712(02)00002-7.
39. Tay FR, Pashley. Aggressiveness of Contemporary Self-Etching Systems. I: Depth of Penetration beyond dentin Smear Layers. *Dent Mater*. 2001;17(4):296-308. doi:10.1016/S0109-5641(00)00087-7.
40. Duruk G, Akküc S, Uğur Y. Evaluation of residual monomer release after polymerization of

- different restorative materials used in pediatric dentistry. BMC Oral Health. 2022;22(1):232. doi:10.1186/s12903-022-02260-9.
41. Taira M, Urabe H, Hirose T, Wakasa K, Yamaki M. Analysis of Photo-Initiators in Visible-Light-Cured Dental Composite Resins. J Dent Res. 1988;67(1):24-28. doi:10.1177/00220345880670010401.
 42. Alvim HH, Campos NM, Vasconcellos WA, et al. Influence of different photoinitiators on polymerization kinetics and marginal microleakage in restorations using photopolymerizable dental composites. Pesqui Bras Odontopediatria Clin Integr. 2017;17(1):1-9. doi:10.4034/PBO-CI.2017.171.24
 43. Rueggeberg FA, Margeson DH. The effect of oxygen inhibition on an unfilled/filled composite system. J Dent Res. 1990;69(10):1652-1658. doi:10.1177/00220345900690100501.
 44. Komurcuoglu E, Olmez S, Vural N. Evaluation of residual monomer elimination methods in three different fissure sealants in vitro. J Oral Rehabil. 2005;32(2):116-121. doi:10.1111/j.1365-2842.2004.01405.x.
 45. Stansbury JW, Dickens SH. Determination of Double Bond Conversion in Dental Resins by near infrared Spectroscopy. Dent Mater. 2001;17(1):71-79. doi:10.1016/S0109-5641(00)00062-2.
 46. Şener, Y. (2019). Rezin esaslı fissür örtücülerin farklı ışık kaynaklarıyla polimerizasyonunu takiben ortaya çıkan artık monomer miktarının, yüzey sertliğinin ve bağlanma dayanımının incelenmesi (Doktora tezi). Çukurova Üniversitesi, Sağlık Bilimleri Enstitüsü, Adana, Türkiye.
 47. Altunsoy M, Botsalı MS, Tosun G, Yaşar A. Farklı Polimerizasyon Sürelerinin Adeziv Salınan Artık Monomer Miktarına Etkisi. Acta Odontol Turc. 2013;30(1):6-12.
 48. Gorgen V, Guler C. Residual Monomer in Dentistry: A Literature Review [Dis Hekimliginde Artık Monomerler: Bir Liteartur Derlemesi]. Med-Science. 2015;4(1):2024-2038. doi:10.5455/medscience.2014.03.8200
 49. Atkinson JC, Diamond F, Eichmiller F, Selwitz R, Jones G. Stability of Bisphenol A, Triethylene-Glycol Dimethacrylate, and Bisphenol A Dimethacrylate in Whole Saliva. Dent Mater. 2002;18(2):128-135. doi:10.1016/S0109-5641(01)00031-8.
 50. Ilie N, Bucuta S, Draenert M. Bulk-fill resin-based composites: an in vitro assessment of their mechanical performance. Oper Dent. 2013;38(6):618-625. doi:10.2341/12-395-L.
 51. Atmadja G, Bryant RW. Some factors influencing the depth of cure of visible light-activated composite resins. Aust Dent J. 1990;35(3):213-218. doi:10.1111/j.1834-7819.1990.tb05394.x.
 52. Ruyter I.E., Oysaed H. Conversion in different depths of ultraviolet and visible light activated composite materials. Acta Odontol Scand. 1982;40(3):179-192. doi: 10.3109/00016358209012726.
 53. Ferracane JL, Aday P, Matsumoto H, Marker VA. Relationship between Shade and Depth of Cure for Light-Activated Composite Resins. Dent Mater. 1986;2(2):80-84. doi:10.1016/S0109-5641(86)80057-4.
 54. AlShaafi MM. Factors affecting polymerization of resin-based composites: A literature review. Saudi Dent J. 2017;29(2):48-58. doi:10.1016/j.sdentj.2017.01.002.
 55. Guiraldo RD, Consani S, Consani RLX, et al. Light Energy Transmission through Composite by Material Shades. Bull Tokyo Dent Coll. 2009;50(4):183-190. doi:10.2209/Tdcpubication.50.183. Vol 50.
 56. Shortall AC. How light source and product shade influence cure depth for a contemporary composite. J Oral Rehabil. 2005;32(12):906-911. doi:10.1111/j.1365-2842.2005.01523.x
 57. Ceballos L, Victoria Fuentes M, Tafalla H, et al. Curing of Resin Composites at Different Exposure Times Using LED and Halogen. Med Oral Patol Oral Cir Bucal. 2009;14(1):E51-E56.
 58. Sideridou ID, Achilias DS. Elution study of unreacted Bis-GMA, TEGDMA, UDMA, and Bis-EMA from light-cured dental resins and resin composites using HPLC. J Biomed Mater Res B Appl Biomater. 2005;74(1):617-626. doi:10.1002/jbm.b.30252
 59. Munksgaard EC, Peutzfeldt A, Asmussen E. Elution of TEGDMA and BisGMA from a resin and a resin composite cured with halogen or plasma light. Eur J Oral Sci. 2000;108(4):341-345. doi:10.1034/j.1600-0722.2000.108004341.x

60. Gürsoy S, Alturfan EE. Bisfenol A İçerikli Resin Esaslı Dental Materyallerde Bisfenol A Salınımı ve İnsan Vücuduna Östrojenik Etkilerinin İncelenmesi. *Eur J Res Dent.* 2021;5(2):109-121. doi:10.29228/erd.14
61. Heil J, Reifferscheid G, Waldmann P, et al. Genotoxicity of Dental Materials. *Mutat Res.* 1996;368(3-4):181-194. doi:10.1016/S0165-1218(96)90060-9.
62. Veiga-Lopez A, Kannan K, Liao C, et al. Gender-specific effects on gestational length and birth weight by early pregnancy BPA exposure. *J Clin Endocrinol Metab.* 2015;100(11):E1394-E1403. doi:10.1210/jc.2015-1724
63. Durmaz E, Giray BK. Çevresel Bir Endokrin Bozucu: Bisfenol A ve Toksik Etkilerinin Değerlendirilmesi. *CSHD.* 2013;56(4):192-199.
64. Soto AM, Sonnenschein C. Environmental causes of cancer: Endocrine disruptors as carcinogens. *Nat Rev Endocrinol.* 2010;6(7):363-370. doi:10.1038/nrendo.2010.87
65. Park MA, Choi KC. Effects of 4-nonylphenol and bisphenol A on stimulation of cell growth via disruption of the transforming growth factor- β signaling pathway in ovarian cancer models. *Chem Res Toxicol.* 2014;27(1):119-128. doi:10.1021/tx400365z
66. Yılmaz MN. (2020) Dimetakrilat Resin İçeren Dental Restoratif Materyallerden Beyazlatma Sonrası Salımı (Uzmanlık Tezi). Atatürk Üniversitesi Diş Hekimliği, Klinik Bilimler Anabilim Dalı, Erzurum, Türkiye.
67. Akyüz S, Yarat A, Egil E. Bisfenol-A İçerikli Dental Materyallere Güncel Yaklaşım. *Clin Exp Health Sci.* 2011;1(3):190-195.
68. Atkinson A, Roy D. In Vivo DNA Adduct Formation by Bisphenol A. *Environ Mol Mutagen.* 1995;26(1):60-66. doi:10.1002/Em.2850260109. Vol 26.
69. Harorlı OT. (2009) Triethylene Glycol Dimethacrylate (TEGDMA)'ın Biyouyumluluğunun Hücre Kültürü Yöntemi ile Sitomorfolojik Olarak İncelenmesi (Doktora Tezi). Atatürk Üniversitesi. Sağlık Bilimleri Enstitüsü, Erzurum, Türkiye.
70. Stanislawski L, Lefeuvre M, Bourd K, et al. TEGDMA-induced toxicity in human fibroblasts is associated with early and drastic glutathione depletion with subsequent production of oxygen reactive species. *J Biomed Mater Res A.* 2003;66(3):476-482. doi:10.1002/jbm.a.10600.
71. Lefeuvre M, Amjaad W, Goldberg M, Stanislawski L. TEGDMA induces mitochondrial damage and oxidative stress in human gingival fibroblasts. *Biomaterials.* 2005;26(25):5130-5137. doi:10.1016/j.biomaterials.2005.01.014
72. Michelsen VB, Moe G, Strøm MB, Jensen E, Lygre H. Quantitative analysis of TEGDMA and HEMA eluted into saliva from two dental composites by use of GC/MS and tailor-made internal standards. *Dent Mater.* 2008;24(6):724-731. doi:10.1016/j.dental.2007.08.002
73. Samuelsen JT, Dahl JE, Karlsson S, Morisbak E, Becher R. Apoptosis induced by the monomers HEMA and TEGDMA involves formation of ROS and differential activation of the MAP-kinases p38, JNK and ERK. *Dent Mater.* 2007;23(1):34-39. doi:10.1016/j.dental.2005.11.037
74. Van Landuyt KL, Nawrot T, Geebelen B, et al. How much do resin-based dental materials release? A meta-analytical approach. *Dent Mater.* 2011;27(8):723-747. doi:10.1016/j.dental.2011.05.001
75. Gul P, Akgul N, Hakan Alp H, Kiziltunc A. Effects of composite restorations on oxidative stress in saliva: An in vivo study. *J Dent Sci.* 2015;10(4):394-400. doi:10.1016/j.jds.2014.05.006
76. Ansteinsso V, Solhaug A, Samuelsen JT, Holme JA, Dahl JE. DNA-damage, cell-cycle arrest and apoptosis induced in BEAS-2B cells by 2-hydroxyethyl methacrylate (HEMA). *Mutat Res Genet Toxicol Environ Mutagen.* 2011;723(2):158-164. doi:10.1016/j.mrgentox.2011.04.011
77. Örtengren U, Wellendorf H, Karlsson S, Ruyter IE. Water sorption and solubility of dental composites and identification of monomers released in an aqueous environment. *J Oral Rehabil.* 2001;28(12):1106-1115. doi:10.1046/j.1365-2842.2001.00802.x
78. Sideridou ID, Achilias DS. Elution study of unreacted Bis-GMA, TEGDMA, UDMA, and Bis-EMA from light-cured dental resins and resin composites using HPLC. *J Biomed Mater Res B Appl Biomater.* 2005;74:617-626. doi:10.1002/jbm.b.30252
79. Dahl JE, Pallesen U. Tooth bleaching--a critical review of the biological aspects. *Crit Rev Oral*

- Biol Med. 2003;14(4):292-304. doi: 10.1177/154411130301400406.
80. Michelsen VB, Moe G, Skålevik R, Jensen E, Lygre H. Quantification of organic eluates from polymerized resin-based dental restorative materials by use of GC/MS. *J Chromatogr B Analyt Technol Biomed Life Sci.* 2007;850:83-91. doi:10.1016/j.jchromb.2006.11.003
 81. Pitt JJ. Principles and applications of liquid chromatography-mass spectrometry in clinical biochemistry. *Clin Biochem Rev.* 2009;30(1):19-34.
 82. Schulz SD, Laquai T, Kümmerer K, et al. Elution of monomers from provisional composite materials. *Int J Polym Sci.* 2015;2015. doi:10.1155/2015/617407
 83. Ho CS, Lam CWK, Chan MHM, et al. Electrospray ionisation mass spectrometry: principles and clinical applications. *Clin Biochem Rev.* 2003;24:3-12.
 84. Wang Q, Bian Y, Zhang Y, et al. Development of sampling, pretreatment and detection methods for ephedrine and related substances in complex samples. *Microchemical Journal.* 2023;189. doi:10.1016/j.microc.2023.108538
 85. De Angelis F, Sarteur N, Buonvivre M, Vadini M, Štefl M, D'Arcangelo C. Meta-analytical analysis on components released from resin-based dental materials. *Clin Oral Investig.* 2022;26(10):6015-6041. doi:10.1007/s00784-022-04625-4
 86. Gul P, Alp HH, Özcan M. Monomer release from bulk-fill composite resins in different curing protocol. *J Oral Sci.* 2020;62(3):288-292. doi:10.2334/josnusd.19-0221
 87. Ferracane JL. Elution of Leachable Components from Composites. *J Oral Rehabil.* 1994;21(4):441-452. doi:10.1111/j.1365-2842.1994.tb01158.x. Vol 21.
 88. Mills RW, Jandt KD, Ashworth SH. Dental composite depth of cure with halogen and blue light emitting diode technology. *Br Dent J.* 1999;186(8):388-391. doi:10.1038/sj.bdj.
 89. Yoon TH, Lee YK, Lim BS, Kim CW. Degree of polymerization of resin composites by different light sources. *J Oral Rehabil.* 2002;29(12):1165-1173. doi:10.1046/j.1365-2842.2002.00970.x
 90. Wattanapayungkul P, Yap AUJ, Chooi KW, Lee MFLA, Selamat RS, Zhou RD. The effect of home bleaching agents on the surface roughness of tooth-colored restoratives with time. *Oper Dent.* 2004;29(4):398-403.
 91. Odabasi D, Guler C, Kucukaslan D. Evaluation of the amount of residual monomer released from different flowable composite resins. *BMC Oral Health.* 2024;24(1). doi:10.1186/s12903-024-04005-2
 92. Polydorou O, Beiter J, König A, Hellwig E, Kümmerer K. Effect of bleaching on the elution of monomers from modern dental composite materials. *Dent Mater.* 2009;25(2):254-260. doi:10.1016/j.dental.2008.07.004
 93. Gul P, Karatas O, Alp HH, Cam IB, Ozakar-İlday N. Monomer release from nanohybrid composites after bleaching. *J Oral Sci.* 2019;61(2):351-357. doi:10.2334/josnusd.18-0063
 94. Schuster L, Reichl FX, Rothmund L, et al. Effect of Opalescence® bleaching gels on the elution of bulk-fill composite components. *Dent Mater.* 2016;32(2):127-135. doi:10.1016/j.dental.2015.11.033
 95. Gökem Ulu Güzel K, Sönmez I. Assessment of monomer release from 3 different fissure sealants. *J Appl Biomater Funct Mater.* 2018;16(2):90-96. doi:10.5301/jabfm.5000380