The Saudi Dental Journal (2014) 26, 151–155

King Saud University

The Saudi Dental Journal

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Influence of extended light exposure curing times on the degree of conversion of resin-based pit and fissure sealant materials

Nazish Fatima *

Dr-Ishrat-Ul-Ebad Khan Institute of Oral Health Sciences, Dow University of Health Science, Karachi, Pakistan

Received 28 December 2013; revised 20 February 2014; accepted 6 May 2014
Available online 10 July 2014

KEYWORDS

Degree of conversion;
Pit and fissure sealants;
Curing time;
Spectrometer

Abstract *Purpose:* The aim of present study was to evaluate extended curing times on the degree of conversion (DC) of filled and unfilled resin-based materials used as pit and fissure sealants.

Materials and methods: The materials examined were a flowable composite (Filtek™ Z350 XT Flowable) and a pit and fissure sealant (Clinpro™ Sealant). Thirty disks of each material were prepared. The 30 made of the flowable composite were divided into three groups ($n = 10$ each) according to the three different curing times studied: 20 s (group 1), 40 s (group 2), and 60 s (group 3). Similarly, the 30 disks made of the pit and fissure sealant were divided into three groups ($n = 10$ each) according to the three different curing times: 20 s (group 4), 40 s (group 5), and 60 s (group 6). After polymerization, the disks were removed from the mold and stored in dry, lightproof containers in an incubator at 37 °C for 24 h. The DC was obtained using an Avatar 320 FTIR spectrometer. Then the data were analyzed using the Kruskal–Wallis test and the Fisher's least significant difference post hoc test for multiple comparisons (alpha = 0.05).

Results: DC values for the flowable composite (Filtek™ Z350 XT) were higher ($p = 0.002$) than those for the pit and fissure sealant (Clinpro™ Sealant). Group 2 and group 5 showed significantly higher DC values than group 1 and group 4, respectively. There was no difference between groups 2 and 3 or between groups 5 and 6 ($p = 2.93$).

Conclusion: An extended curing time improves the DC to some extent for both materials.

1. Introduction

In the recent era of preventive dentistry, pit and fissure sealants are considered an ideal method to prevent caries (Brown et al., 1996). Sealants prevent the initiation and progression of caries by creating a physical barrier that inhibits the entry of food particles into pits and fissures and the propagation of microorganisms (Beauchamp et al., 2009). In general, pit and fissure

* Cell: +92 03218278361.
E-mail address: nazish_fawad@yahoo.com
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.sdentj.2014.05.002
1013-9052

sealants are used in pediatric dentistry (Warnock and Rueggeberg, 2004).

Today, daylight-activated, low viscosity, resin-based materials such as sealants and flowable composites are generally used as pit and fissure sealants (Aguilar et al., 2007). The mechanical and physical properties of these materials are very important for maximizing their clinical longevity because the efficacy of these materials is directly linked to their retention (Nalcaci et al., 2004; Rode et al., 2009).

Polymerization is a process by which monomer molecules are converted into a polymer chain (Costa et al., 2009). Polymerization of the common composite monomer bis-glycidyl methacrylate (bis-GMA) takes place when a carbon–carbon double bond (C═C) forms between two methacrylate groups (Calheiros et al., 2008). During the polymerization process, the degree of conversion (DC) directly affects the mechanical and physical properties of the composite (Luciene et al., 2008). The DC is the magnitude to which the monomer is converted into a polymer (Boniek et al., 2011). It is calculated as the fraction of the amount of remaining aliphatic C═C in a cured material compared to the total number of C═C in the uncured material (Luciene et al., 2008). The DC depends upon many factors, including the composition of the composite material, the length of the curing time, the amount and type of photo initiator, the intensity of curing light, and the opacity of the material (Lohbauer et al., 2005; Obici et al., 2004). A sufficient DC is one of the most desirable physical properties of resinous materials because it has been shown that an insufficient DC is associated with increased solubility, and it facilitates the proliferation of cariogenic bacteria (Calheiros et al., 2008; Schneider et al., 2008).

It is assumed that the DC of a composite is directly proportional to the length of light exposure (Rastelli et al., 2008). Therefore, it is rational to investigate the shortest curing time that provides the highest DC without deleteriously affecting the physical properties of the composite (Beauchamp et al., 2009). In the literature, there are limited studies on this subject (Papagiannoulis and Eliades, 1989). Therefore, the present study evaluates the DC of filled and unfilled sealant materials cured for different lengths of time. The hypothesis of the present study is that extended light exposure will increase the DC of resinous materials used as pit and fissure sealants.

2. Materials and methods

The materials tested in this study included the filled sealant Filtek™ Z350 XT Flowable Restorative (3M™ ESPE™ St. Paul, USA) and the unfilled Clinpro™ Sealant (3M™ ESPE™ St. Paul, USA). Detailed descriptions of the materials are presented in Table 1.

2.1. Specimen preparation

Filtek™ Z350 XT and Clinpro™ Sealant were supplied in a unset paste form. A polytetrafluoroethylene mold, which was 5 mm in diameter and 1 mm thick, was placed on a substrate consisting of a glass slide covered with a polyethylene sheet. The mold was filled with low viscosity uncured paste. After the mold was filled, it was covered with another polyethylene sheet and glass slide, and light pressure was applied.

Both materials were cured with a Mectron Starlight Pro light-emitting diode (LED) curing lamp (Mectron, Italy) at an intensity of 1.000 mW/cm^2 and at a distance of 3 mm. The distance was standardized by using three 1-mm glass slides (Borges et al., 2010). After polymerization, the disks were removed from the molds and stored in dry, lightproof containers in an incubator at 37 °C for 24 h.

In total, 60 disks were prepared, with 30 disks of each restorative material. The 30 disks of each restorative material were further divided into three groups ($n = 10$) according to the three different curing times examined: 20 s, 40 s, and 60 s. The disks in groups 1, 2, and 3 were made of Filtek™ Z350 XT Flowable Restorative, and the disks in groups 4, 5, and 6 were made of Clinpro™ Sealant. Groups 1 and 4 were cured for 20 s (as recommended by the manufacturer), groups 3 and 5 were cured for 40 s, and groups 3 and 6 were cured for 60 s.

2.2. Degree of conversion

To determine the DC (%) of the materials, the number of C═C converted into single bonds was measured with an AVATAR 320 FTIR Spectrometer (Thermo Nicolet Inc., USA). Measurements were made using an attenuated total reflectance (ATR) accessory, and 16 scans were performed at 4 cm^{-1} resolution with a wave number range from 500 to 4000 cm^{-1}. The percentage of unreacted carbon–carbon double bonds (% C═C) was determined from the ratio of the absorbance intensities of aliphatic C═C (peak at 1638 cm^{-1}) against an internal standard (aromatic C─C, peak at 1608 cm^{-1}) before and after the specimen was cured. After the sample preparation, the background spectrum was taken by collecting an interferogram. Data were subsequently converted to frequency data by inverse Fourier transform. Then, we collected a single-beam spectrum of the sample, which contained absorption bands from the sample as well as the background. The ratio between the single-beam sample spectrum and the single-beam background spectrum gave the sample spectrum. Data analysis was performed by assigning the observed absorption frequency bands in the sample spectrum to appropriate normal modes of vibrations in the molecules (Smith, 1996). The DC was determined by subtracting the % C═C from 100%, according to the following equation (Arikawa et al., 1998):

Table 1 Materials used in this study.

Material	Manufacturer	Shade	Composition	Batch
Flowable composite	Filtek™ Z350 XT 3M™ ESPE™ St. Paul, USA	A_2	BIS-GMA/TEGDMA, BisEMA Zirconia/silica and silica; nanoparticle	7018A3D
Pit & fissure sealants	Clinpro™ Sealant 3M™ ESPE™ St. Paul, USA	Opaque white	BIS-GMA/TEGDMA	12637