INTRODUCTION

For dental restorative applications, resin-based composites are well known for their great esthetics, light weight and biocompatibility\(^1\)\(^,\)\(^2\). Alongside the fact that computer-aided design/computer-aided manufacturing (CAD/CAM) technique is gaining rapid popularity, indirect restorative materials are welcomed by dentists because it may enable shorter fabrication process and better properties in comparison with those direct restorative procedures and materials\(^3\)\(^-\)\(^5\). Traditional composite resins, which contain heavily filled ceramic particles, display only one continuous phase, i.e. the resin matrix phase. Thus, they raise the challenges in mechanical properties, hardness and wear resistance\(\ldots\), which demand the use of high-temperature/ high-pressure polymerization to ameliorate these disadvantages, normally, 250–300 MPa and 180°C being required\(^6\)\(^,\)\(^7\). The commercially available products for such materials include Lava Ultimate (3M, St. Paul, MN, USA) and Cerasmart\(^\text{TM}\) (GC, Tokyo, Japan)\(^8\)\(^,\)\(^9\). Since the release of Vita Enamic (Vita, Bad Säckingen, Germany) in 2013, however, the concept of polymer-infiltrated ceramic network (PICN) has been widely spread and well accepted by all walks of life in relation to dental restoration in the past few years\(^10\)\(^-\)\(^12\). Different from those traditional composite resins, PICN composites are a kind of ceramic based resin interpenetrating network (IPN) material, possessing interconnected networks of both continuous ceramic and resin phases\(^13\). The combination of the brittle ceramic network and the ductile polymer network exhibits enhanced properties not only over that of each constituent phase, but also over those of conventional ceramic-resin composites\(^14\)\(^,\)\(^15\). And comparative studies are found on characterizations such as flexural strength, fracture stress, hardness and fatigue mechanical behaviors of various CAD/ CAM materials including Vita Enamic (Vita) and Lava Ultimate (3M)\(^8\).

In surveying publications, PICN composites usually consist of 70–85 wt% inorganic phase and 15–30 wt% organic phase\(^6\). The inorganic phase has a wide choice such as sodium aluminum silicate, zirconia and feldspathic powders, etc.\(^16\)\(^-\)\(^18\). The organic phase has been reported including UDMA (urethane dimethacrylate), Bis-GMA (bisphenol A-glycidyl methacrylate), TEGDMA (triethylenglycol dimethacrylate) and even poly(methyl methacrylate) resins\(^19\)\(^-\)\(^22\). The organic phase of the PICN Enamic materials is composed of UDMA and TEGDMA, while many others apply Bis-GMA/TEGDMA\(^23\). Judging from the molecular structures of these dimethacrylates, it is readily to notice that the viscosity of their mixtures will vary in dependent on the types of the dimethacrylates and their ratios in the mixtures. Therefore, it raises an uncertainty in producing PICN composites because the infiltration of resin mixtures into the porous inorganic phase is closely in relation to the composition of the organic phase. At the meantime, the properties of the resulting PICN composites are also dependent on the resin mixtures if the inorganic phase is kept the same, because the rigidity is different among these dimethacrylates\(^24\).

To the best of our knowledge, however, it can not find a systematically comparative study in concerning...
Preparation and sintering of feldspar inorganic preform
The feldspar ceramic powder (VITAVM®9, VITA Zahnfabrik, Bad Säckingen, Germany) was screened through 200 meshes to obtain the feldspar ceramic powder with an average diameter of 15.8 μm PVA (polyvinyl alcohol) (MW=22,000, Sigma-Aldrich, St. Louis, MO, USA) was dissolved in deionized water to get an 3 wt% solution. Then, 1.5 g feldspar ceramic powder was weighed and wetted with the PVA solution (~0.3 mL). The feldspar paste was transferred in a stainless steel mold (ϕ=25 mm, h=40 mm) and pressed (6 MPa, 1 min) to obtain preforms without visible defects, and then dried at 60°C for 24 h. The prepared preforms were placed in an oven thermostat at 500°C for 1 h to remove the organic component. Five temperatures (650, 700, 750, 755 and 800°C) were selected to sinter the preforms by putting them in the oven and being heated at a rate of 3°C/min, followed by being kept at the selected temperature for 0, 15, 30, 45 or 60 min. Porous feldspathic ceramic preforms were readily obtained after cooling down naturally in the oven.

Analysis of porosity and shrinkage
The porosities of the ceramic preforms prepared under different sintering conditions were quantified by applying the Archimedes principle. Briefly, the precisely weighed sample (m) was completely soaked in boiled water for 15 min. After cooling down, the buoyant weight (m2) and the wet weight (m1) of the sample were weighed, respectively. And the sample porosity (P) was calculated using Equation (1).

\[ P = \frac{m_1 - m_2}{m_1 - m} \times 100\% \]  

(1)

The shrinkage referred to the change in the volumes of the ceramic preforms before and after the sintering. Briefly, the diameters and the heights of both as-pressed and as-sintered feldspathic preforms were precisely measured. Accordingly, the sample volumes were calculated, termed as \( V_1 \) for the as-pressed sample and \( V_2 \) for its sintered counterpart. Then, the sample shrinking percentage (\( \psi \)) was calculated using Equation (2).

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(2)

For both porosity and shrinkage analysis, five measurements for one set of preparation parameters were conducted for averaging, and the results were expressed as mean±SD (standard deviation).

Dimethacrylate mixtures and viscosity measurement
Bis-GMA (Aldrich, St. Louis, MO, USA) and TEGDMA (Aldrich) were mixed at the mass ratios of 3:7, 4:6, 5:5, 6:4 and 7:3, respectively, followed by benzoyl peroxide (BPO) (Aldrich) being added at 0.5 wt% in relation to the total weight of Bis-GMA and TEGDMA. In parallel, the mixture of UDMA (Aldrich) and TEGDMA was prepared at the mass ratio of 6:4. These dimethacrylate mixtures were submitted to viscosity measurement by applying Brookfield DV-II+Pro digital viscometer (Middleboro, MA, USA) at room temperature.

Preparation of polymer-infiltrated feldspar ceramics
The silane coupling agent KH570 (Aladdin, Shanghai, China) was dissolved in mixed ethanol/H₂O (1:1 in volume), followed by soaking the aforementioned porous feldspathic preforms into the solution and being kept for 6 h at room temperature. The silanized preforms were then vacuum-dried under 60°C and ready for resin infiltration.

To optimize the infiltration time, at first, the Bis-GMA/TEGDMA resin mixture (6:4) was selected to infiltrate the porous feldspathic preforms, which were sintered under 755°C with no keeping time, during which, the vacuum degree for the infiltration was controlled below 0.1 MPa and the duration for the system staying in the vacuum state was controlled at 1, 2, 5, 10, 15, 20, 25, 30 or 40 min. For another group of porous preforms, the vacuuming operation was repeated 1–4 times by fixing the vacuumizing duration at 30 min. At each preset point, two samples were retrieved for photo-taking to evaluate the extent of resin infiltration. Subsequently, Bis-GMA/TEGDMA resin mixtures with different weight ratios and UDMA/TEGDMA resin mixture (6:4) were tested to infiltrate the porous feldspathic preforms under controlled parameters (vacuum degree: <0.1 MPa; remaining time: 30 min; vacuumizing times: 2). Finally, all these resin infiltrated feldspathic composites were thermocured at 110°C for 12 h.

Characterizations
Morphology observations were conducted on scanning electron microscope (SEM, S-4800, Hitachi, Tokyo, Japan) at an accelerating voltage of 15 kV. The samples submitted to SEM observations were sputtered with gold (30 mA, 60 s) using a sputter coater (JFC-1100, JEOL, Louis, MO, USA). Zahnfrabrik, Bad Säckingen, Germany) was screened through 200 meshes to obtain the feldspar ceramic powder with an average diameter of 15.8 μm PVA (polyvinyl alcohol) (MW=22,000, Sigma-Aldrich, St. Louis, MO, USA) was dissolved in deionized water to get an 3 wt% solution. Then, 1.5 g feldspar ceramic powder was weighed and wetted with the PVA solution (~0.3 mL). The feldspar paste was transferred in a stainless steel mold (ϕ=25 mm, h=40 mm) and pressed (6 MPa, 1 min) to obtain preforms without visible defects, and then dried at 60°C for 24 h. The prepared preforms were placed in an oven thermostat at 500°C for 1 h to remove the organic component. Five temperatures (650, 700, 750, 755 and 800°C) were selected to sinter the preforms by putting them in the oven and being heated at a rate of 3°C/min, followed by being kept at the selected temperature for 0, 15, 30, 45 or 60 min. Porous feldspathic ceramic preforms were readily obtained after cooling down naturally in the oven.

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To determine the content of infiltrated organic component in the prepared PICN composites. The samples were ground and 3–5 mg powder was placed in a small crucible, which was put into the TGA equipment (TA Instruments, Newcastle, DE, USA) and heated from room temperature to 800°C in air at a heating rate of 5°C/min.

**Flexural properties**

A universal test instrument (EZ-100, Shimadzu, Kyoto, Japan) was employed to measure the flexural strength, the flexural modulus and the fracture toughness of samples. Three-point bending method with a loading rate of 1 mm/min was used for the flexural strength and the flexural modulus. The single edge-notched beam method with a loading rate of 0.5 mm/min was used for the fracture toughness. For the flexural strength and flexural modulus test, ten polished specimens (3×4×16 mm³) were prepared for each kind of PICN composites by cutting bars from corresponding PICN blocks according to standard ISO-4049. For the fracture toughness test, a notch (1 mm in depth) was created in the middle part of the polished bars at one edge. The notch was carefully checked to ensure the radius of the notch tip being <0.2 mm. The characteristic strength (MPa), \( \sigma_0 \) - the characteristic strength (MPa), \( m \) - the Weibull modulus, \( P_n \) - the failure probability estimator, \( n \) - the ranking and \( N \) - the number of specimens being tested.

\[
\sigma = \frac{3Pl}{2Wb^2} \quad (3)
\]

\[
E = \frac{Pl^4}{4Wwb^3} \quad (4)
\]

\[
K_{IC} = \frac{Px}{BW_w} f_1 \left( \frac{a}{W} \right) \quad (5)
\]

\[
f_1 \left( \frac{a}{W} \right) = 2.94 \left( \frac{a}{W} \right)^{1.2} - 4.6 \left( \frac{a}{W} \right)^{0.2} + 21.8 \left( \frac{a}{W} \right)^{0.2} - 37.6 \left( \frac{a}{W} \right)^{0.2} + 38.7 \left( \frac{a}{W} \right)^{0.2} \quad (6)
\]

**Hardness and wear resistance test**

The Vickers hardness was tested by nano indenter (MTS, XP, Eden, MN, USA). Specific method refers to Oliver-Pharr method. Each sample was randomly selected for 10 indentation tests, with a maximum load of 0.980 N and a load duration of 15 s.

For wear resistance test, samples were processed into cylindrical shape with the diameter of 10 mm and the height of 6 mm. Wear resistance of the samples was then tested by CW3-1 wear machine (Peking University, Beijing, China) in referring to the operational details reported by Stober et al. Then the wear volume loss was calculated by Equation (9):

\[
V = \frac{m_1 - m_2}{\rho} \quad (9)
\]

where: \( V \) - the wear volume loss (mm³); \( m_1 \) - the original weight of the sample before the wearing (g); \( m_2 \) - the residual weight of the sample after the wearing (g) and \( \rho \) - the density of the sample (g/mm³).

**Statistical analysis**

For the results of flexural properties, Vickers hardness and wear resistance, Statistical analysis was conducted using one-way analysis of variance (ANOVA) with Tukey’s test. Differences between any two groups were considered as significant for \( p \leq 0.05 \).

**RESULTS**

**Optimizing the preparation of porous feldspathic preforms**

Sintering temperature and time are critical parameters to influence the porosity and the volume stability of the obtained porous feldspathic preforms for polymer infiltration. In one set of experiments, those as-pressed feldspathic preforms were put in oven and heated up to different sintering temperatures. As reaching the target temperature, the samples were cooled down immediately without being kept at the temperature for a period. Changes of porosity and shrinking percentage were measured for these sintered preforms, and the results are presented in Fig. 1A. As shown in the figure, the porosity of the sintered feldspathic preforms decreased alongside the sintering temperature being increased, at the meantime, the shrinking percentage became larger at higher sintering temperature. In particular, drastic shrinkage occurred when the sintering temperature was raised above 750°C, which caused the porosity of the resulting ceramic preforms beginning to decrease, at the same time, the porosity of the materials decreases violently. And 800°C was already too high to obtain porous feldspathic preforms. It was tried and found that sintering temperature of 755°C was possible to obtain feldspathic preforms with porosity of 20–25%.

Then, 750°C was settled for the sintering, while the duration time of feldspathic preforms at the sintering temperature was changed from 0 min to 60 min. By prolonging the duration time, as shown in Fig. 1B,
the changes in the porosity and the shrinkage of the resulting sintered samples displayed similar trends to those presented in Fig. 1A, along with the increased sintering temperatures. It turned out that no duration was likely allowed if the porosity of the prepared feldspathic preform intended to be ~20% to facilitate polymer infiltration.

Figure 2 shows the microstructure of the feldspathic ceramic preforms prepared under different sintering processes. It could be found that the preforms sintered at 650 and 750°C for 0 min duration at the temperature displayed loose structure, without apparent hint of coalescence between feldspar particles (Figs. 2a and b). When the sintering temperature reached 755°C, the feldspathic ceramic powder melted and fused together to form a kind of porous-structured block (Fig. 2c). If the sintering time was 750°C with the duration time at the sintering temperature being prolonged, the feldspathic ceramic powder would also melt and fuse together to form a similar porous-structured block (Fig. 2d), showing larger voids than those presented in Fig. 2c. These observations were consistent with the shrinkage and porosity results shown in Fig. 1. In considering the results of both Figs. 1 and 2, thus, it was determined that the feldspathic preform prepared by being sintered at 755°C with 0 min duration was proper for the following resin infiltration study for its ~20% porosity and well-connected porous structure.

Optimizing the resin infiltration into porous feldspathic preforms

To ensure the complete infiltration of viscous resin mixtures into the porous feldspathic preforms, extending the soaking time and applying the aid of vacuuming are quite helpful. Under vacuum condition, from Fig. 3A, it could be seen that the resin (Bis-GMA/TEGDMA in 6:4 ratio as the representative) contents in the prepared PICN composites increased initially when the soaking time was prolonged from 1 to 30 min. However, it was found the amount of the infiltrated resin leveled off even if the soaking time was further prolonged. Illustrated by those photos shown in Fig. 3C, resin infiltration occurred gradually alongside longer soaking time, however, unwetted domains still could be seen after 30 min. It revealed that fully resin infiltration was unlikely to be achieved if only one round of vacuumizing operation was conducted. It was no great help to extend the keeping time under vacuum because the infiltrated resin had leveled off after 30 min (Fig. 3A). However, homogeneous blocks with fully infiltrated resin were obtained when the vacuumizing operation was repeated (Figs. 3B and C). At the present block height (3 mm), two repetitive rounds of 30 min soaking under vacuum condition was sufficient to ensure the resin infiltration into the porous feldspathic preforms.

PICN composites prepared from different resin mixtures

With the previous approaches, all the following PICN composites were prepared using the same conditions, that the porous feldspathic preforms were sintered under 755°C with no duration at the temperature, and the resin infiltration was conducted by soaking the preforms in different resin mixtures 30 min under vacuum for two
At first, comparative study by using Bis-GMA/TEGDMA and UDMA/TEGDMA mixtures (both at mixing ratio 6:4) as the infiltration resin was conducted. Flexural strengths and moduli of resulting PICN composites were measured and provided as Fig. 4. The results displayed clearly that the flexural properties of the UDMA/TEGDMA case were significantly inferior to those of the Bis-GMA/TEGDMA case.

Subsequently, Bis-GMA/TEGDMA mixtures with different blending ratios were applied to infiltrate the porous feldspathic preforms. These resin mixtures showed different viscosity, i.e., the viscosity increased gradually as the content of Bis-GMA in the mixtures increasing, particularly when the ratio of Bis-GMA to TEGDMA was higher than 6:4 (Fig. 5). The difference in resins’ viscosity led to difference in their infiltration. As shown in the figure, the infiltration contents of Bis-GMA/TEGDMA resin mixtures into the final PICN composites were measured increasing when the ratio of Bis-GMA to TEGDMA was raised from 3:7 to 6:4, while it decreased as the ratio of Bis-GMA to TEGDMA was further raised to 7:3. It turned out that the Bis-GMA/TEGDMA (6:4) could achieve the highest extent of resin infiltration (17.1±0.3%), while the value for the Bis-GMA/TEGDMA (7:3) was reduced to 10.5±0.05%.
Fig. 5  Viscosity of Bis-GMA/TEGDMA mixture showing dependence on their ratio and influencing the infiltrated resin contents into the porous ceramic preforms.

Fig. 7  Vickers hardness of Bis-GMA/TEGDMA infiltrated feldspathic ceramic composites as a function of the mass ratio of Bis-GMA to TEGDMA.

**Flexural properties assay**

Flexural properties of all these Bis-GMA/TEGDMA infiltrated PICN composites were evaluated. From the data presented in Figs. 6A and C, both the flexural strength and the fracture toughness displayed a clear trend in relation to the compositions of the Bis-GMA/TEGDMA ratios. It could be seen they gradually increased as the content of Bis-GMA increasing, reaching the highest values in the case of Bis-GMA/TEGDMA (6:4) infiltrated PINC composite, whose flexural strength and fracture toughness were 145±10 MPa and 1.64±0.12 MPa*m^{1/2}, respectively. Further increase in the content of Bis-GMA would cause remarkably decrease in flexural properties. This trend was in accordance to the change...
in the infiltration content of various Bis-GMA/TEGDMA resin mixtures into the porous feldspathic preforms. The difference of flexural modulus was found not so significant between samples, all close to 27–30 MPa (Fig. 6B). The flexural strength data were statistically analyzed using Weibull distribution and the results are plotted in Fig. 6D. It exhibited the Weibull modulus of materials' flexural strength being relatively high, about 22.1, which indicated that the data of flexural strength obtained in this study were uniform and centralized.

**Hardness and wear resistance assays**

The Vickers hardness of the Bis-GMA/TEGDMA infiltrated feldspathic ceramic composites were evaluated and shown in Fig. 7. The values were seen descending in the order of Bis-GMA contents in resin mixtures being increased. As for the Bis-GMA/TEGDMA (6:4) case, a moderate hardness of 5.2±1.3 was detected, close to that of natural enamel, which was reported 3–6 [27].

The results of the wear resistance assay for these PICN composites are shown in Fig. 8, presenting the volume losses and the worn surfaces after the testing. The wear resistance varied from case to case in relation to the composite compositions. The minimum volume loss (8.21±0.04 mm³) was found for the Bis-GMA/TEGDMA (6:4) case, indicating its best wear resistance among the tested materials (Fig. 8a). The surfaces of the tested specimens were observed using SEM. From the images, the worn surface of the PICN composite prepared with Bis-GMA/TEGDMA (6:4) was quite smooth (Fig. 8e), while the worn surfaces of other specimens were rough.

**DISCUSSION**

To emulate the properties of a natural tooth, the PICN composites developed for CAD/CAM systems have been strongly recommended as promising dental restorative materials [25]. Their dual interlocking phases are a rational combination, with the elastic modulus of organic-inorganic composites being similar to that of dentin, which is essential to achieve long-term success in clinical restoration [28,29]. One of the interlocking phases is the sintered ceramic phase, and the other is the infiltrated polymeric phase. The mechanical properties of the resulting PICN composites are greatly dependent on both the phases [17]. In addition to the type of the ceramic being used, thus, the composition of the polymer being applied is also quite critical.

Although dimethacrylates are the common choices for dental materials including PICN composites, there are different dimethacrylates (e.g. Bis-GMA, UDMA, TEGDMA) available for the purpose [20]. In preparing composite resins, mixtures of dimethacrylates at different ratios are often applied, in which, TEGDMA is usually used as the diluent to adjust the viscosity of the Bis-GMA and/or UDMA for easy operation [21]. Accordingly, resin mixtures are also an important tool to control the properties of PICN composites. In view of the fact that the PICN Enamic materials are composed of the feldspathic ceramic and the UDMA/TEGDMA infiltrating polymer, it is interesting to know if the replacement of Bis-GMA/TEGDMA for UDMA/TEGDMA can result in suitable PICN composites for dental applications, at the meantime, by adjusting the mixing ratios of Bis-GMA/TEGDMA.

To carry out the study, firstly, the sintering parameters for fabricating the porous feldspathic preforms were optimized by sintering the pressed powders at different temperatures for different duration. It was found sintering temperatures above 750°C would cause significant coalescence between particles to vanish porous structure. A proper sintering process was to raise the temperature from room temperature to 755°C and immediately cool down without a duration at the sintering temperature. In doing so, the surface of feldspathic particles would fuse together to form...
the stable porous structure, while it would not lead to significantly damaged and coalesced morphology. To ensure the complete infiltration of resin mixtures into the obtained porous feldspathic preforms, repeated vacuuming operation was required and the soaking time under vacuum should be longer than 30 min.

Under these optimized parameters, PICN composites were then prepared by infiltrating the feldspathic preforms with different resin mixtures. In comparing the UDMA/TEGDMA and the Bis-GMA/TEGDMA cases, both at the mixing ratio of 6:4, it was found that the PICN composites made from the latter resin mixture possessed higher mechanical properties than those of PICN composites prepared from the former resin mixture. It was reported the photocuring activity of UDMA being higher than that of Bis-GMA, which commonly led to higher double bond conversion and better performance of UDMA-based composite resins than that of Bis-GMA-based composite resins. In preparing the PICN composites, however, thermal curing was applied instead of the photocuring, which was thought able to achieve enough high double bond conversion in both the cases. Therefore, the mechanical properties of resulting PICN composites mainly relied on the molecular structures of UDMA and Bis-GMA. Due to the presence of the two rigid benzene rings in Bis-GMA, reasonably, the Bis-GMA/TEGDMA-based PICN composites demonstrated higher mechanical properties than the UDMA/TEGDMA-based ones.

Accordingly, the mechanical properties of PICN composites were also significantly dependent on the ratio of Bis-GMA to TEGDMA. Theoretically, the mechanical properties should increase alongside the increase of the rigid Bis-GMA content in the resin mixtures. When the mixing ratio of Bis-GMA/TEGDMA changed from 3:7 to 6:4, the flexural strength and modulus, and the Weibull modulus indeed gradually increased. When the mixing ratio of Bis-GMA/TEGDMA was further raised to 7:3, however, the mechanical properties began to decline. The reason to cause this phenomenon was thought due to the increasing viscosity of Bis-GMA/TEGDMA mixtures with higher content of Bis-GMA, because the viscous resin mixture would be hard to infiltrate into the porous feldspathic preforms, which was confirmed by the TGA analysis (Fig. 5). The dependence of the composite fracture roughness on the Bis-GMA/TEGDMA mass ratio was similar to that of the flexural strength and modulus. The value of fracture toughness would reflect the ability of a composite in resisting the damage caused by external force, which is related to the brittleness of the composite and influenced by defects within the composite. It had been proposed that the PICN composite made from Bis-GMA/TEGDMA in the mass ratio of 7:3 would have the most significant defect inside the composite, because the viscosity of this resin mixture was the highest among all the resin mixtures, which brought difficulty for it to fully infiltrate into the porous feldspathic preforms and generated voids. However, its fracture toughness was still significantly higher than those of the PICN composites made from Bis-GMA/TEGDMA in the mass ratios of 3:7, 4:6, and 5:5. The explanation for this phenomenon went to the fact that a higher content of the rigid Bis-GMA in the resin mixture would lead to higher mechanical strength after it being hardened. In the present study, therefore, it was determined that the PICN composite made from Bis-GMA/TEGDMA in the mass ratio of 6:4 displayed the highest fracture toughness under the combined influence of both the intrinsic strength and viscosity of the resin mixture if the porous ceramic preforms applied were identically prepared.

Promisingly, the volume loss upon wearing test was also found the smallest for the PICN composites prepared from Bis-GMA/TEGDMA (6:4) among all the samples. Those PICN composites made from with lower contents of Bis-GMA did not show improved wear resistance although they displayed higher hardness. The explanation was thought to be the liable outflow of infiltrated resin from the porous preforms when the viscosity of the resin mixture was low. This would lead to defects in final PICN composites, thus, it resulted in lower mechanical properties and poorer wear resistance in comparison with the Bis-GMA/TEGDMA (6:4) case.

With all these data and discussions, it was summarized that the Bis-GMA/TEGDMA (6:4) infiltrated feldspathic ceramic network, demonstrating flexural strength, flexural modulus, hardness, fracture toughness and wear volume values of 145±10 MPa, 31±4 GPa, 5.2±1.3, 1.6±0.12 MPa*m1/2, and 8.21±1.33 mm3, respectively, could be an proper choice to meet the requirements for dental restoration. And these values were apparently higher than those of the commercial Vita Enamic composed of UDMA/TEGDMA and feldspathic ceramic, i.e., 137±10 MPa (flexural strength), 22.1±2 GPa (flexural modulus)9, 1.7±0.12 (hardness)10, 1.09±0.05 MPa*m1/2 (fracture toughness)10. In comparison with the UDMA/TEGDMA resin mixture, therefore, it was suggested that the Bis-GMA/TEGDMA resin mixture was preferred for the preparation of PICN composites.

**CONCLUSIONS**

Although the UDMA/TEGDMA resin is a well known polymeric phase for PICN composites, such as in the commercial Vita Enamic products, there still was room for improvement. Due to the rigid feature of Bis-GMA than UDMA, at the same mixing ratio with TEGDMA, the Bis-GMA/TEGDMA based PICN composites would achieve higher mechanical properties than the UDMA/TEGDMA based PICN composites. Additionally, the optimized Bis-GMA/TEGDMA ratio was found 6:4 to obtain the PICN composites with the most promising properties among the groups in flexural strength, flexural modulus, fracture toughness and wear resistance, as well as moderate hardness. These data are close to those of natural enamel, suggesting the potential use of Bis-GMA/TEGDMA (6:4) infiltrated feldspathic ceramic network for dental restoration.
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