The Influence of Accelerated Aging on Mechanical Properties and Microstructure of Fiber-reinforced Resin Posts

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(Abstract)

Objective: The aim of this study was to determine the effects of accelerated aging on shear strength, micro-tensile strength and microstructure of different fiber-reinforced resin posts.

Method: five brands of fiber posts were selected for this study (Macro-lock Post/ML, Luxa Post/LP, ParaPost Taper Lux/PA, FRC Postec Plus/VI, Nordin Glassix+plus/NO. 20 specimens of each brands of posts were divided randomly into 2 groups. One for aging test, the other one not (ineach group 10 specimens were used for shear strength test, 10 for tensile strength). The group of aging was accelerated aged for 200 h, and the other one was stored in opaque box. Then the specimens of these groups were used for tests in shear strength and tensile strength, and processed for ESEM analysis to assess their microstructural characteristics, namely fiber diameter, fiber density, fiber/matrix ratio. FTIR was used to assess the inner chemical bonds. The statistical analysis of shear strength and tensile strength before and after aging was carried out with two-way ANOVA for the 5 different brands of posts. The correlation between mechanical properties and microstructural variances of the posts was measured by calculating Peason's correlation coefficients (_=0.05).

Results: The posts of different brands showed statistically significant differences in shear strength ($P<0.005$). The shear strength showed a significant correlation to fiber diameter ($r=0.740$, $P=0.000$), and to fiber density ($r=-0.822$, $P=0.000$); the tensile strengths showed a significant correlation to fiber diameter($r=0.776$, $P=0.000$), and to fiber density ($r=-0.860$, $P=0.000$). The shear strength and tensile strength of the samples before and after aging were significantly different ($P<0.05$). The shear strength declined after aging, of which the reduction of NORDIN was the lowest (4.73±12.02%) and VI the highest(30.53±6.96%). The tensile strength of the of ML/PA inclined, LP/VI declined after aging, of which the reduction of VI was the highest (50.29±2.53%). ESEM observatioins showed that most of the matrix separated from the surface of the fiber, and FTIR observations showed that the absorbance of ester increased after aging.

Conclusion: The shear strength of the different brands were significantly different. Both the shear strength and tensile strength were influenced by fiber diameter and density. Physical aging and oxidation tool place in matrix, which influence the interfacial bond and mechanical properties after aging. The shear strength declined after aging, and the aging resistance of NORDIN was the strongest, VI the weakest. The tensile strength changed variously and the aging resistance of VI was the weakest.

Introduction

1. Composition and pattern of fiber post

Fiber-reinforced resin post (FRC-post) adopts organic polymer (such as ethoxyline resin, etc.) as the base, and finally polymerized by adding various inorganic or organic fibers.

The posts are divided into conical, cylinder and straight posts based on the basic patterns of fiber posts; of these posts, the rigidity of conical post gradually decreases, root fracture can be avoided, but concentrated stress may be produced at the tip because conical post wedge into the root canal. [1]

According to the different fibers added, fiber posts can be divided into carbon fiber-reinforced post (CFR), glass fiber reinforced post (GFR), quartz fiber-reinforced post (QFR) and resin post directly reinforced by polythene fiber. These posts are introduced as follows:

CFR: CFR is the fiber post earliest released and adopted. In 1990, Duret [2] et al firstly introduced a non metal material based on fiber reinforcement theory, the prepared post based on carbon fiber is introduced into the mouth restoration field in Europe and Canada. Carbon fiber post is composed by sticking numberless carbon fibers with a diameter of 8 onto ethoxyline resin, where the carbon fibers are lined with the same direction, all the fibers are granted with the same tension, thus to realize the high strength of the carbon fiber[3]. However, the early carbon post contains many black carbon fibers, which are not matched with tooth color, and they are not transparent; modern carbon fibers are generally white, milky white, but still have a relatively thin block axis, and can not meet the requirements for aesthetics restoration.

GFR: glass fibers are mostly E-glass fiber, an amorphous mixture composed of Si02, CaO, B203, A1203 and other base metal oxides; S-glass fiber is also common. GFR has properties including low thermal expansion, high sintering point, strong corrosion resistance and high electric resistance, etc. As indicated by related experiments, elastic modulus will increase with the content of GFR. [4]

QFR: QFR is composed of pure crystal Si02, a inertia material with relatively low coefficient of thermal expansion. A study on GFR reinforced compound materials indicated that, after the plywood is stretched and cut off, GFR can significantly improve the tensile strength, bending strength and shearing strength of the compound materials [5]. The tensile modulus of GFR post is close to dentin, so as compared to casting metal post, it can transfer and disperse bite force better, and will not concentrate stress at root tip, can effectively prevent root fracture, and is beneficial for preservation of residual root and corona [6, 7]. This greatly prolong the survival of tooth root, thus to provide better conditions for mouth restoration.

Resin post directly reinforced by polythene fiber: it is prepared by weaving the polythene fibers onto light-cured resin. This post can be prepared direclty in clinics, the operation is simple, with better adaptation; but its bending strenght is not good enough. Because this root canal post can not guarantee sufficient solidification of resin at root tip, and can not be applied to tiny root canal, so it is rarely applied in clinics.

2. Study method and direction fiber post property

A lot of systemic studies on fiber post property and clinical application indicate that, fiber post demonstrates many advantages and restoration possibility. There are two categories of study methods on mechanical properties of fiber posts in China and at abroad: in vivo study and in vitro study. Most the the studies are in vitro, including finite elemet method, in vitro model method and photoelastic model, etc.

The finite elemet method can provide the distribution of stress when homogeneous mass is weighted, but the finite elemet method is established on the prothesis that, the imitated materials are isothopous homogeneous mass, which is not consistent with mouth tissues.

In vitro model is currently the most extensively applied method, and it can be divided according to the mode loaded stress: static stress method and circular stress method, and the circular stress method imitates the bearing conditions in mouth as possible.

Bending strength: Torbjomer [8] et al compared the bending strength of fiber post, casting post and stainless steel post after water aging or hot circulation by using in vitro 3-point bending experiment, and the resutls indicate that, the bending strength is decreased after water aging or hot circulation. Lassia [9] et al have used 3-point bending experiment to compare the bending properties of several fiber posts, and find that, E-glass fiber post has the highest bending strength. Ottl [6] et al have found in the study that, the clinical need is met when 3-point flexing strength reaches 400 Mpa. deflexion [10] et al have found in the studies on Shidelong glass fiber post, Shidelong carbon fiber post, QFR, Tenax glass fiber post, and the flexing strength all reached more than 2 times of the clinical demand.

Rupture strength: Isidor [11] et al have confirmed in their studies that, tooth repaired by carbon fiber post has higher rupture strength compared to tooth repaired by Parapost metal post or conical casting post under circular loading conditions. by loading constant stress, Ottl [6] et al have compared the rupture strength of tooth repaired by carbon fiber post and metal post, ceramic post, and found that rupture strength of tooth is highest for tooth repaired by carbon fiber post. Purton [12] also confirmed that, under high loading force, tooth repaired by casting metal post firstly ruptured, and the percentage is as high as 91% of the sample.
Elastic modulus: the core of the post should have certain rigidity. Though the size and rigidity of the post are closely correlated, the shape of root canal is limited by the post size, so when selecting core materials of the post, the elastic modulus must be considered. People believed in that past that, post materials with high elastic modulus should be chosen, and the strength requirement can be satisfied even the diameter is small [13]. Assif [14] et al have appointed out that, when system composed of materials with varied rigidity are stressed by external force, the hard part can resist to greater power, and can transfer the stress to materials with lower rigidity, and release stress by rupturing the materials. Therefore, if the elastic modulus is too high, when root canal post is impacted by great loading force, the tooth body tissues with low strength will be ruptured first. Therefore, materials for manufacturing post should have proper elastic moduls. Mannocci et al [15] have confirmed in their experiments that, non metal core materials similar to dentin could greatly lower the risk of tooth rupture. Torbjomer et al [18] compared the root rupture conditions for fiber post, casting post and stainless steel post by using in vitro 3-point bending test, and the results indicate that, the rupture type of fiber post is beneficial for preservation of tooth root.

Shear viscosity: fiber post must be adhered by using resin adhesives, thus to realize high splicing strength between fiber post and root canal. Nissan [16] has compared resin adhesives and traditional cement, and found that, no statistically significant difference has been observed for fixing power when resin adhesives are used to adhere 5 mm short post and 10 mm long post.

Besides of jogging with root canal post, resin adhesives mainly binds chemically to root canal [17], thus to significantly promote the adhesion strenght. When root canal is only adhered to the root canal, but not bind to the dentin chemically, root canal post can not promote the rupture resistance of tooth, but the adhesion may be weakened. Under electron microscope, the surface of fiber post is porous, which provide great adhering area for resin adhesives [16]. Meanwhile, the epoxy resin in fiber post and BIS-GMA in adhesives have not only similar chemical structure, but similar elastic modulus, its surface has good surface moisture property to adhesives, resin can permeate into micropores to form resin process, and reinforce the mechanical fixation [18].

3. Reasons for fiber post aging

Environments in mouth is complicated, which is not only affected by temperature, humidity, acidity or alkalinity, but also ultraviolet radiation, ozone in the air and biological factors, etc. Saliva is continuously secreted in mouth, and body fluid circulation exists in dentin; oral temperature changes greatly, the bacteria and metabolites can degrade and retrograde the materials in mouth; in addition, the stress produced durign chewing and clinical procedures, etc. can affect the using life of fibers [19]. Fiber post is aging from manufacture, processing, store and oram environmental application.

There are mainly two categories of methods to predict aging life of compound materials, one is the aging kinetics of compound materials. The study on aging mechanism can predict the property change of compound materials from the structural parameter changes, and construct physical and math model by correlation between structure and property; another is on the properties of compound materials, which discuss the correlation between accelerated aging and natural aging values, thus to formulate semi-experience formula for use life prediction; moreover, moderl testing analysis techniques including FTIR, XPS, XRD, DMA, etc can perform structural analysis, and predict the aging life of compound materials by constructing math model or through the correlation between median aging life and remaining strength. [20]

4. Aging experiment

There are two main categories of experimental methods for materials aging: aging experiments under natural climate conditions and artificial aging conditions. Under natural climate conditions, aging experiment is conducted strictly following the G7-83.14 by American Society for Testing and Materials (ASTM) [21]. However, because the climate is significantly different, the experiment is long, and the application is limited. While artificial method is not limited by district, climate, and season, etc., and can imitate environmental factors including sunlight, oxygen, humidity, Young 's modulus, and the experiment can obtain the results in a short period. The artificial aging experimental methods include: ozone aging, steam aging, humid heat aging by alternating high and low temperatures, salt mist corrosion aging, etc.; the commonly applied methods in aging experiments on oral materials include: humid heat aging by alternating high and low temperatures, photoaging, chewing aging,

etc. [22]. L Muhanad et al [23] studied the bending strength of photoaging fiber on maxillofacial region, and found that after photoaging and humid aging for 200 hours, the bending strength reached the opitmal value. Lee et al [24] conducted accelerated photoaging (150 kJ/m2) on compound resin materials, and the aging process would not significantly affect the opalescence and fluorescence of compound resin materials, while semi-translucence and chromaticity will have significant changes. Douglas [25] adopted Ci-35 weather-o-meter to determine the chromaticity change of ceramic polymer was between 0.62 and 3.40 after 150 h and 300 h acelerated aging experiment, and the changes of chromatic aberration was acceptable in clinics. Goto et al [26] compared the chewing resistance of three post core systems, when the frequency was 260/min, the fatigue resistance of fiber post core was higher than those of metal post and titanium alloy post.

5. Testing method of surface microstructure

At present, there are two main categories of techniques to determine microstructures: qualitative technique and quantitative technique. The qualitative technique is the mostly adopted in two patterns: optical microscope and scanning electron microscopy (SEM), both of the two can provide qualitative references for the surface. Of the two methods, natural light microscope has a poor observation effects, but with good effects on refracted light, phase contrast, differential interference contrast, and calculus phase contrast microscope. SEM is the most common measure to observe microstructure, and structure of 10 nm can be observed. SEM has great superiority to light microscope in resolution, depth of field and micro analysis, etc., so it is developed quickly and extensively applied. When SEM is gradually improved, its application range is expanding. But SEM has some defects in working theory and structure, and its using performance and applicable range are greatly affected, mainly including: (1) The sample must be clean and dry, because dirty and moist samples will decrease the vacuum; (2) The sample must has electroconductivity. (3) Illuminating or high temperature samples can not be observed. For the defects of SEM, people have proposed various methods, of which Environmental scanning electron microscopy (ESEM) is the most noticeable. The biggest advantage of ESEM is that, it permits changes of pressure, temperature and air components for microscope samples. ESEM does not only preserve the advantages of SEM, but also eliminate the limits of sample room, especially high vacuum. Damp, dirty, greasy samples or sample with no electroconductivity can all be tested under natural conditions, with no need for pretreatment. When air pressure is as high as 5000 Pa, temperature is as high as 1500 °C, ESEM can provide high resolution secondaryary electron images in an environment with any air components, thus to greatly improve the using property of SEM and applicable range. The quantitative instruments include: Profilometer, atomic force microscope (AFM), scanning interomiter, scanning tunneling microscope (STM), and optical noncontact profilometer.

6. Fourier transform infrared spectroscopy

In recent ten years, Fourier transform infrared spectroscopy (FTIR) is the optimal technique to analyze various polymers, and it is greatly developed with the continuous improvement of computer techniques. FTIR is the important tool to analyze the structure of chemicals, with high sensitivity and high precision (0.01 cm-1), high resolution (0.1-0.005 cm-1), quick scanning speed (1 s), low stray light (<0.3%) and wide spectral range (1000-10 cm-1), less beam section (approximately 1mm). Therefore, it becomes the most common and necessary tool for modern structural chemistry and analytical chemistry. The location and strength of infrared absorption peak reflect the properties of molecular structure, and can be used to identify the structural composition of unknown

substance or determine the chemical group: while the absorption strength of absorption spectra is correlated with content of chemical group, which can be used to perform quantitative analysis and purity identification. In addition, in studies on mechanism of chemical reactions, infrared spectra also have certain effects. However, the most extensively application is the structural identification of unknown substance. FTIR has been extensively applied to organic chemistry, metal organic chemistry, mineral chemistry, catalyst, petrochemical industry, materials science, biology, medicine and environment, etc.

A lot of studies and clinical applications have confirmed that, compared to metal post, fiber post has various advantages, reflecting good repairing possibility. Many studies also investigated the adhering property, bending property and clinical applications of fiber post, with certain achievements obtained mainly from macroscopic studies. Secondarily, store and application of fiber posts are affected by many environmental factors, such as sunshine (ultraviolet), humidity, mechanical chewing, etc.; similarly, dust and pollutes in the air can also affect its properties [23]. Experiments and reports are rare on effects of aging on mechanical properties and components of fiber posts, and by ESEM and FTIR, differences in internal microstructures and components are evaluated to predict the aging resistance of fiber post, thus to provide an approach for further improving fiber post properties and the clinical use life of fiber post.

Materials and methods

1. Experimetnal materials

This experiment had chosen 5 brands of fiber reinforced resin posts. These fiber posts were Macro-lock™ Post(ML), Luxa Post (LP), Para Post Taper Lux(PA), Ivoclar Vivadent FRC Postec Plus (VI) and Nordin Glassix + plus (NO), with diameters of 0.6-1.0 mm (Table 1, Fig. 1-3).

Table 1: properties of five fiber posts

Product name	Abbreviation	Manufacturer	Composition
macro-lock post	ML	RTD, France	Quartz fiber, ethoxyline resin
Luxa Post	LP	DMG, Germany	Glass fiber, Bis-GMA containing quartz particles
Para Post Taper Lux	PA	Coltene, Switzerland	Glass fiber, ethoxyline resin
FRC Postec Plus	VI	Ivoclar vivadent, Liechtenstein	Glass fiber, ethoxyline resin, polyurethane di(meth)acrylates containing silicon oxide particles
Nordin Glassix + plus	NO	Harald Nordin S.A, Switzerland	Glass fiber, ethoxyline resin

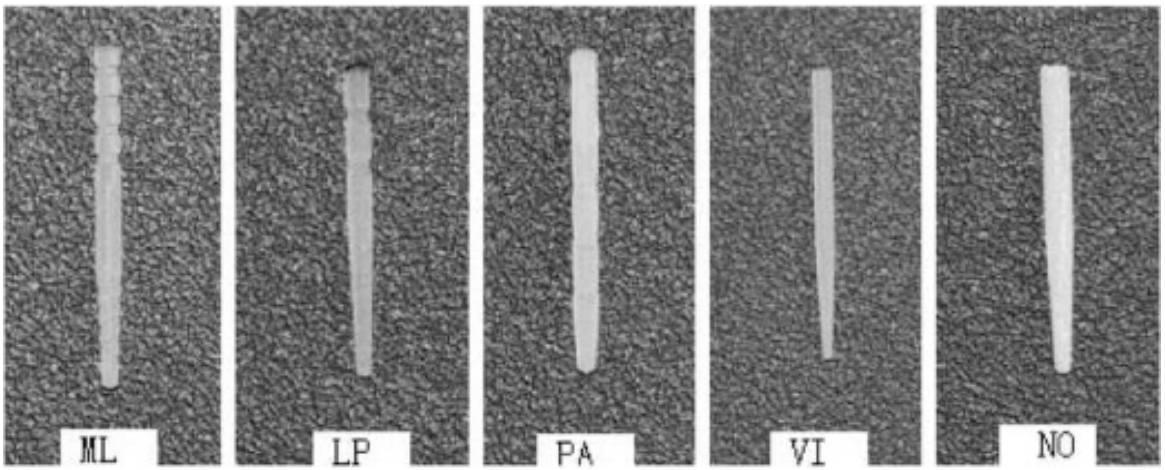


Fig. 1: fiber post figs of five brands

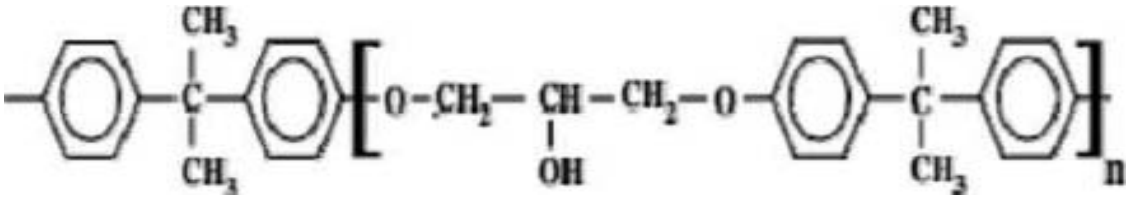


Fig. 2: chemical structure of ethoxyline resin

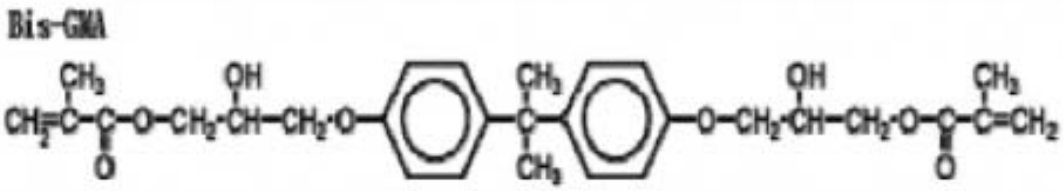


Fig. 3: chemical structure of Bis-GMA

2. Experimental instruments

2.1 Aging instrument: Suntest CPS + Atlas Material Testing Technology BV, Gelnhausen, Germany (Fig. 4). Technical parameters: (1) Light source: 1100 W, aircooling arc lamp; (2) Irradiance control: automatic computer control; (3) Humidity range: 10%-95%; (4) Black board temperature range: 35-100 °C; (5) Total exposure area: 560 cm2. Standards: ASTM and ISO.

2.2 Pattern number of pull and push dynamometer, SH-500 (Sundoo, Wenzhou Sundoo Instrument) (Fig. 5). Technical parameter: (1) maximal test load: 500 N; (5) Division value: 0.1 N; (3) Installment mode of sensor: 10%-95%; (4) Black board temperature range: 35-100 °C; (5) Total exposure area: 560 cm2.

2.3 Environmental scanning electron microscopy XL-30 (ESEM-TMP, Philips Instruments Co., Holland) (Fig. 6). Technical parameters: resolution: at 30 kv, high vacuum mode, low vacuum mode and environmental vacuum mode, all 3.5 nm resolution; at 3 kv, resolution of low vacuum mode < 1.5 nm; at 1 kv, resolution of E-T secondary electronic probe 25 nm. Accelerated voltage: 0.2-30 kv, adjustable continuously; magnification: 6°¡-100°¡, automatically marked with pm, providing screen test function; molecular pump vacuum system:

molecular pump + 2 mechanical pump, no need for cooling water or air pump, with three modes including high vacuum, low vacuum and environmental vacuum, the vacuity is 0.1-1 Torr at low vacuum mode, 0.1-20 Torr at environmental vacuum mode; sample table: motor system, software control + manual control, location coordinates automatically tracked; sample moving range: x, y=50mm, z=motor driven 25 mm, continuously rotating, slant angle -15°-+75°. Basic testing measure: secondary electronic probe at all vacuum mode, E-T secondary electronic probe at high vacuum mode, air secondary electronic probe to investigate real secondary electronic signal under environmental mode, LFGSED at low vacuum mode to test secondary electron; backscattered electron probe to test backscattered electron at accelerated voltage lower than 4 kv; image export: store and print.

2.4 Fourier transform infrared spectroscopy Thermo NicoletiS 10 (USA) (Fig. 7). Technical parameters: applicable for quality control to guarantee the most reliable material confirmation and identification results. System performance verification (SPV) was a powerful tool to guarantee the long term stable operation of spectroscopy; SPV included the software and hardware of testing instrument for ASTME1421 method. Nicolet Smart AccessoryTM technique simplified the accessory change and installment under experimental conditions, with material confirmation routine package of related algorithm with high standard and sensitivity, which could satisfy various requirements of materials to be tested. Sealed dry photonic components protected the instruments from dampness and corrosion of chemical solvents. An automatic supplementary and dynamic collimated interferometer could correct the inclination, cut off scanning error, automatically adjust instrument to the optimal luminous flux, and provided the necessary scanning rate for real time investigation and scanning.

Fig. 4: Suntest CPS+aging instrument

Fig. 5: SH-500 pull and push dynamometer

Fig. 6: Environmental scanning electron microscopy

Fig. 6: Fourier transform infrared spectroscopy (FTIR)

3. Experimental method

3.1 Sample grouping and preparation

Each brand contains 40 samples, which were randomized into aging group and non aging group. In aging and non agining group, each brand contains 20 samples, 10 samples were performed shearing strength test, and 10 pull and push test. According to ISO 527-4:1997, exquisite dental laboratory lathe was used to preapre samples for pull and push strength experiment, and formed plane a and b vertical to long axis of fiber post; the diameter of bb segment was 0.5 mm, 2 mm in length; ab segment has a 0.8 mm diameter and 2 mm length (as shown in Fig. 8).

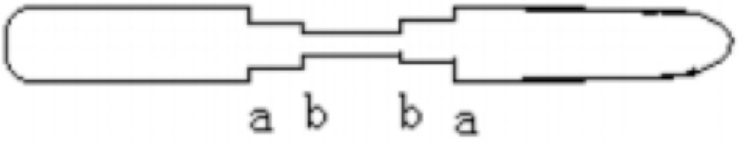


Fig. 8: pull and push model of fiber post

3.2 Experimental steps (as shown in Fig. 9)

3.2.1 Aging test

Samples of aging group were acceleratedly aged for 200 h in Suntest CPS+ aging instrument (total exposure 540 000 kJ/m2). Xenon lamp passed special ultraviolet plated quartz glass, with a radiation spectrum similar to room illumination (irradiance 760 W/m2). Each aging cycle was 2 h, including 102 min dry aging (temperature 37°C) and 18 min damp aging (temperature 37°C, pure water). Adjust the sample angle for every 20 h to guarantee the even aging of all parts of sample. Dry the sample after aging, place into a room (temperature 23°C) for 24 h for later test [23, 27]. Samples of non aging group were standed and place into a dry and non transparent sealing box (room temperature 23 °C).

Mark at 5 mm from the top of fiber post, determine the diameter, fix the marked site onto the clamp of pull and push dynamometer, load head onto the hold of fiber post, cast pressure at a loading rate of 1.0 mm/s (as shown in Fig. 10). Experimental end is defined that this sample can not bear larger load, or fiber post would be broken or ruptured. Record the data at fiber post rupture, and calculate shearing strength according to formula (1). The experiment was conducted at room temperature 23°C.

$$\tau = \frac{F_\varrho}{A} \qquad (1)$$

Whereas:

τ —— shearing strength (N/mm^2),

F_ϱ — load at shearing rupture (N),

A —— transverse section area of the sample (mm^2).

3.2.3 Pull and push strength test

Fix the a plane of the two ends of the test piece into the sink of clamp, align the central line of the test piece to the central line of superior and inferior clamps, and cast axial pull force continuously and evenly to the test sample at a loading rate of 1.0 mm/s (as shown in Fig. 8 and 11). The experimental end was defined that, this sample could not bear large load, or the fiber post would be broken, then record the data when fiber post was ruptured, and calcualte tensile strength according to forumula (2). The experiment was conducted at room temperature 23°C.

$$\sigma = \frac{P}{F_0} \qquad (2)$$

Whereas:

_—— tensile strength (N/mm2),

P—— load when sample was pulled and broken (N),

F_0—— transverse section area of the sample (mm2).

3.2.4 Scanning by environmental scanning electron microscopy (ESEM)

Cut the samples into 3mm intact transverse sections vertical to the long axis by using separating carborundum disc (thin, SHOFU, Japan); similarly, cut the shearing and tensile rupture sections of various brands, 3 mm in thickness.

All samples were fixed onto the sample table of scanning electron microscope by using electric conduction paste, dry on heating plate, and spray gold 50s on the transverse section and rupture section by using getter ion pump (BAL-TEC,SCD 005, Germany), and scan and observe by using ESEM. All samples were observed comprehensively under a 200°¡ len, then collect l000°¡∫Õ2000°¡ images at two representative sites, and analyze the microstructures of transverse section and rupture section of the fiber post: determining the diameter, density and content ratio of fibers.

3.2.5 Analyzed by Fourier transform infrared spectroscopy (FTIS)

Grind the samples of all brands into powder, 1-2 mg powder was added 100-200 mg potassium bromide, grind into fine powder in an agate mortar, press tablets, the pressure of oil press is usually 8000-15000 g/cm2, pressing time was maintained for 1 min to obtain transparent troche. Then place under an infrared spectrometer, scan for 32 times at the resolution of 4 cm -1, scanning range of 400-4000 cm -1, and then determine and collect the infrared spectral images before and after aging.

4. Statistical method

SPSS statistical software 19.0 (IBM SPSS Statistics, USA) was used to treat the data. Dual factor analysis of variance was used to analyze the differences in shearing strength and tensile strength before and after aging. Pearson correlation analysis was used to compare the correlation between shearing strength, tensile strength and microstructure parameters of the fiber post. _= 0.05 was adopted as the statistically significant level.

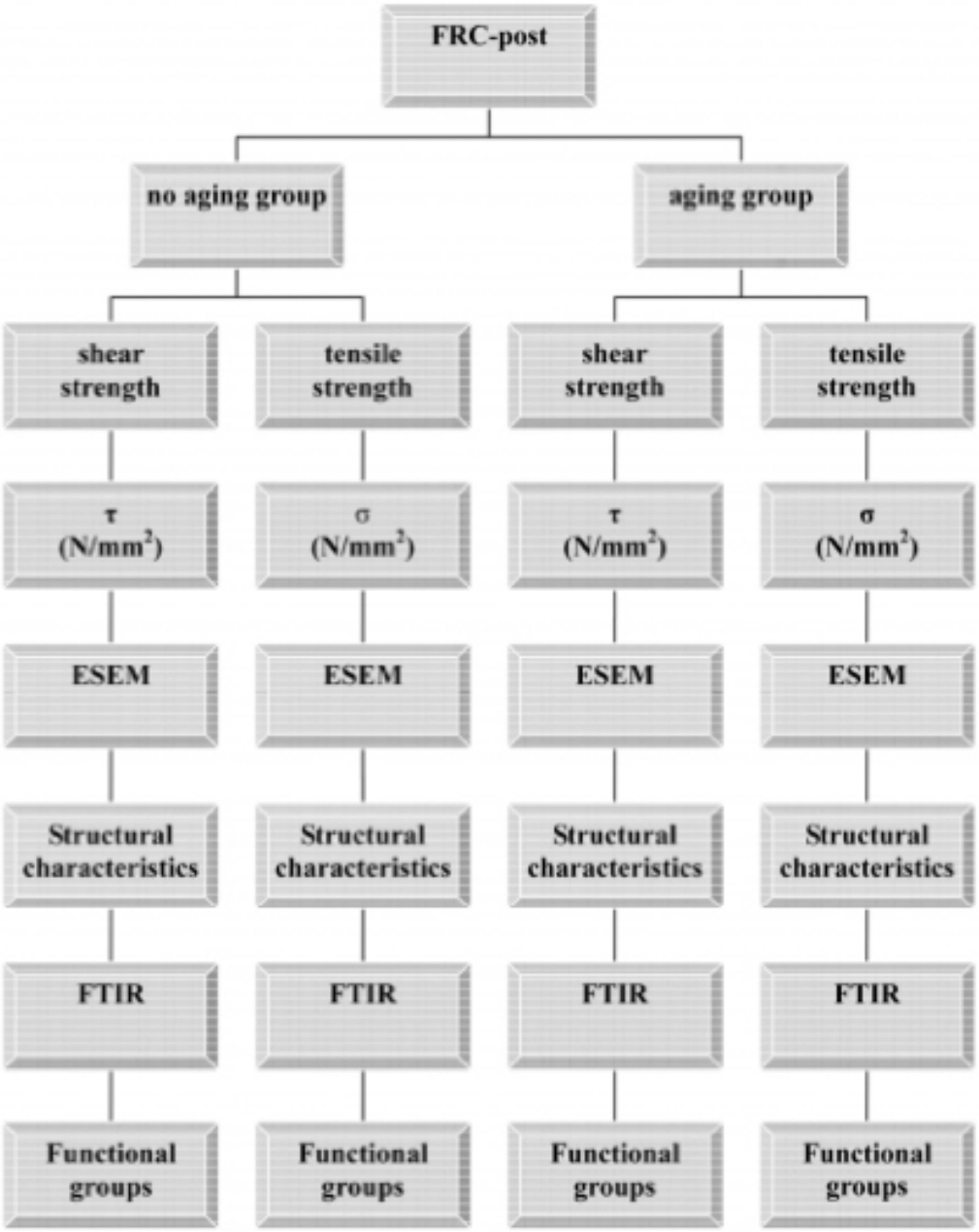


Fig. 9: flow chart

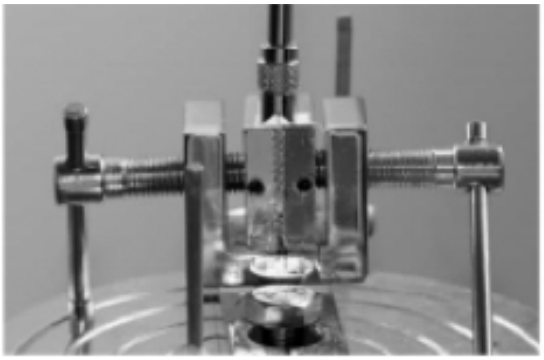


Fig. 10: experimental model of shearing strength

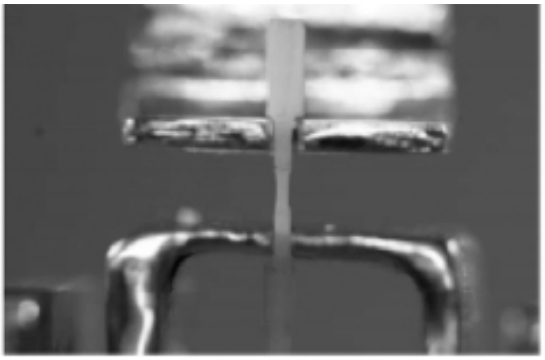


Fig. 11: experimental model of tensile strength

Results

1. Measurements of shearing and tensile strength experiments

The results of shearing (_) and tensile strength (_) of samples in aging group and non aging group were shown in Table 2.

Table 2 The results of shear strength

Groups s	Number r	_(MPa)				
		ML	LP	PA	VI	NO
Non aging group	1	58.7649	67.2270	70.1555	42.1847	66.2807
	2	61.0315	64.1713	79.0140	52.0755	61.2418
	3	57.2466	65.8522	71.8107	51.0961	55.6406
	4	59.8014	64.6806	75.2485	47.8764	57.0409
	5	61.7885	65.4445	68.6276	46.3318	60.5673
	6	62.5454	67.7363	69.1369	52.1370	63.4515
	7	59.0444	63.2800	77.0310	53.7864	64.3986
	8	57.6251	68.8823	77.9223	54.5065	60.6104
	9	56.8681	62.1341	76.0124	54.5073	62.0836
	10	58.8552	69.5189	73.5932	51.7660	59.7686
Aging group	1	42.9586	58.2705	61.9242	41.7623	58.5059
	2	44.4725	55.0182	66.0218	33.2316	57.1122
	3	46.4596	59.8738	63.2199	33.2826	58.7989
	4	41.9177	63.0254	65.4445	36.0327	60.6928
	5	41.5393	56.5318	63.4073	34.8868	53.6706
	6	45.5134	57.2958	62.0068	34.2501	57.0906
	7	44.6618	56.1499	61.1155	38.1972	59.8738
	8	43.9994	57.0411	66.5904	32.0856	55.7806
	9	42.4855	58.8237	65.6992	31.4490	57.5655
	10	42.5801	59.7149	64.2986	32.5949	61.4347

Table 3 The results of tensile strength

Groups	Number	_(MPa)				
		ML	LP	PA	VI	NO
Non aging group	1	1017.9043	737.9696	1206.1577	601.1059	839.3200
	2	849.7032	745.6091	1263.3268	621.4935	813.5320
	3	813.9868	882.7505	1039.8867	614.2108	827.9670
	4	909.8582	780.5379	1130.6389	610.5427	815.6539
	5	884.0956	800.5862	1228.5429	618.7548	831.6327
	6	902.4628	811.7351	1107.6421	615.6325	820.4803
	7	935.6926	753.6462	1121.6493	606.8426	831.3906
	8	858.2460	808.3216	1075.6573	609.5258	822.5429
	9	847.7427	740.5974	1149.9866	614.7564	834.6793
	10	917.7428	827.7324	1131.7425	612.5428	826.8537
Aging group	1	967.1528	545.4558	1437.6973	272.4733	807.7432
	2	980.5725	486.3775	1649.7219	337.1538	741.5347
	3	1132.5858	597.9133	1523.7643	304.6235	852.5612
	4	1003.7436	548.8539	1604.9733	289.6556	934.0485
	5	998.6529	517.5357	1584.8636	310.6469	833.6547
	6	1121.8548	559.3691	1536.8646	315.3457	810.1346
	7	1006.6490	499.7446	1499.7535	296.6894	862.3472
	8	1035.3689	567.2675	1617.7224	320.2146	843.7654
	9	989.8536	538.8642	1526.5114	301.3467	825.8526
	10	1113.8536	576.0853	1502.6547	297.8996	819.5923

2. Statistical analysis of shearing strength

2.1 Comparison of shearing strength before and after aging process

The results of statistical analysis were shown in Table 4 and Figure 12. Statistical significance was observed in shearing strength of various brands before and after aging process (P<0.05). Shearing strengths of all brands were not consistent before aging process (P<0.05), PA> LP>ML and NO > VI; shearing strengths of various brands were not consistent after aging process (P<0.05), PA> LP and NO >ML>VL. The average changes and statistics of shearing strengths of various brands after aging process were shown in Fig. 13: after accelerated aging process, shearing strengths of various brands had significant but varied decrease; VI group had the maximal decrease (30.53±6. 96%), while No group had the minimal decrease (4.73±12. 02%).

Table 4 Two-way ANOVA results of the shear strength before and after aging

Brands	Non aging group (MPa)	Aging group (MPa)	P value
ML	59.3571±1.9272A	43.6588±1.6201a	.000
LP	65.8927±2.4234B	58.1745±2.3103b	.000
PA	73.0903±3.8385c	63.9728±1.9269c	.000
VI	50.6268±3.9899D	34.7773±3.1633d	.000
NO	61.1084±3.2113A	58.0526±2.3309b	.036

Note: the same letter with superscript indicated no statistical significance (P>0.05); or with statistical significance vice versa (P<0.05).

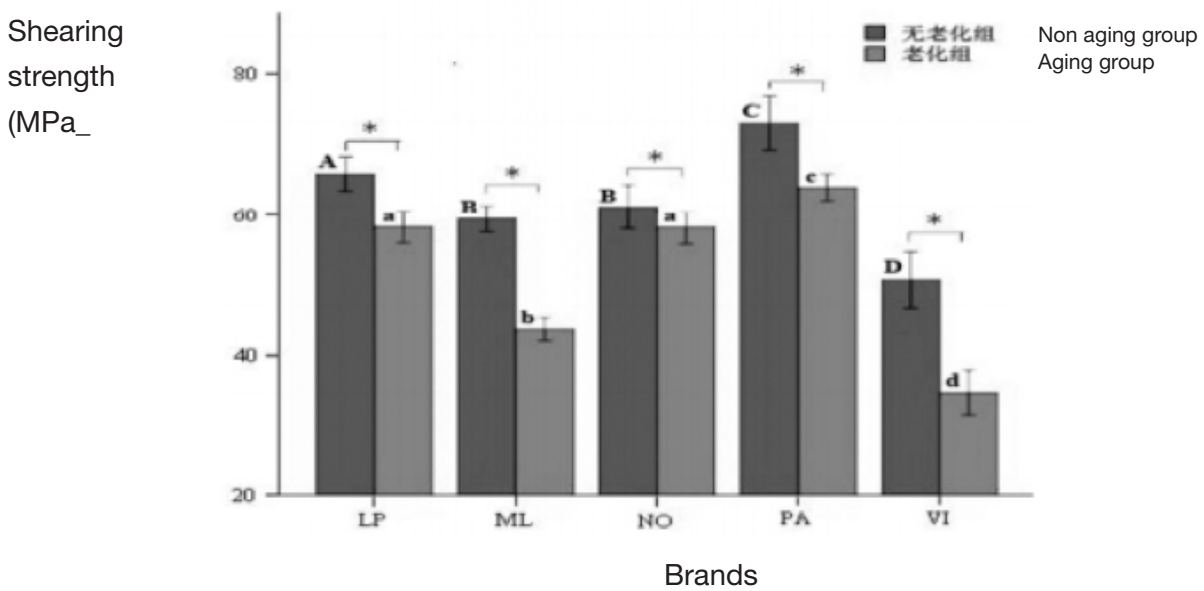


Fig.12 The shear strength of each group specimens with asterisk and different letters are significantly different (P<0.05).

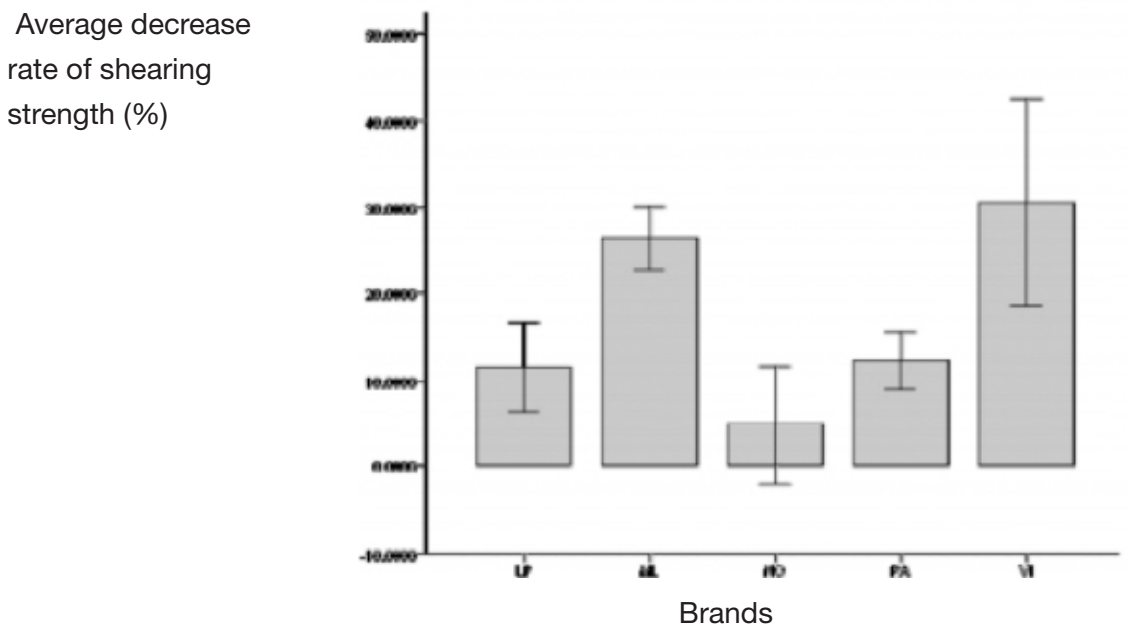


Fig. 13 Reduction in shear strength of fiber posts after aging, of which VI was the highest (30.53±6.96%) and NO the lowest (4.73± 12.02%).

2.2 ESEM scanning results of microstructure of shearing rupture before and after aging process

ESEM images of shearing rupture sections before (Fig. 14 A-E) and after (Fig. 14 a-e) before aging process showed that, (A) thick fiber had coarse surface and cohered many resin particles, (a) thick fiber had less cohered many resin particles; (B) thick fiber adhered to resin matrix closely, with no significant isolation, (b) resin matrix was chalked, with less resin particles on the surface; (C) thick fiber surface was adhered many resin particles, (c) resin matrix was fallen off in large blocks, the fiber surface was smooth, with no significant resin adherence; (D) resin matrix and fibers integrated together closely, with no large blocks of resins fallen off; (d) resin matrix had large blocks fallen off, the fiber surface was smooth, with distinctive borders; (E) thick fiber and resin matrix integrated together closely, with no obvious isolation, (e) large blocks of resin matrix fallen off, and the fiber surface had smooth surface.

3. Statistical analysis of tensile strength

3.1 Comparison of tensile strength before and after aging process

The statistical results were shown in Table 5 and Figure 15. The differences of tensile strengths of ML, LP, PA and VI were statistically significant before and after aging process ($P<0.05$), and No had no statistical significance ($P>0.05$). The tensile strengths of all brands were incompletely consistent ($P<0.05$), PA>ML>LP and NO > VI; tensile strengths of various brands were incompletely consistent after aging ($P<0.05$), PA>ML>NO>LP>VI. The average changes of tensile strengths and statistics of various fiber posts before and after aging process were shown in Fig. 16: after accelerated aging process, ML group and PA group had increased values, LP group and VI group had decreased tensile strengths, and VI group had the biggest decreased value (50.29%±2. 53%).

Table 5 Two-way ANOVA results of the tensile strength before and after aging

Brands	Non aging group (MPa)	Aging group (MPa)	P value
ML	893.7435±57.5975A	1035.0288±63.2371a	.002
LP	788.9486±46.5056B	543.7467±34.5517b	.000
PA	1145.523 l±69.0597C	1548.4527±64.5799c	.000
VI	612.5408±5.8909D	304.6049±17.7298d	.000
NO	826.4052±8.3093 D	833.1234±48.6808e	1.000

Note: the same letter with superscript indicated no statistical significance (P>0.05); or with statistical significance vice versa (P<0.05).

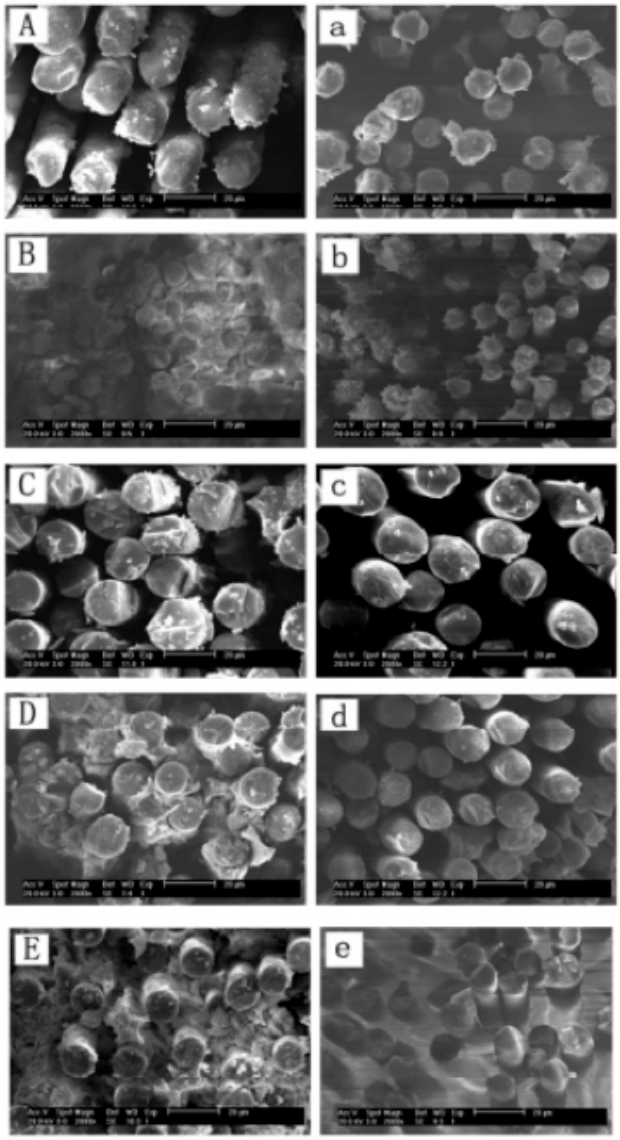
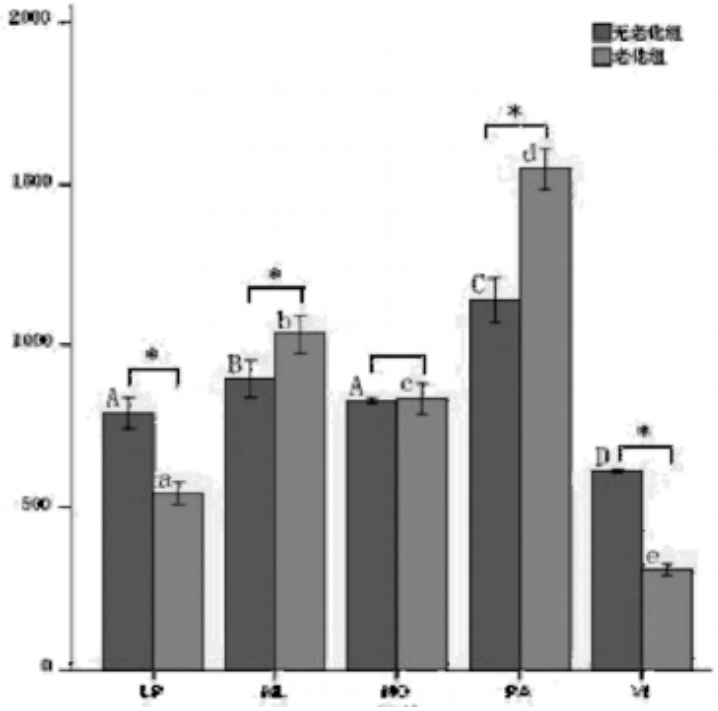


Fig. 14: ESEM-micrographs of fractured surfaces of fiber posts before (A to E) and after aging (a to e). A/a: ML; B/b: LP; C/c: PA; D/d: VI; E/e: NO.

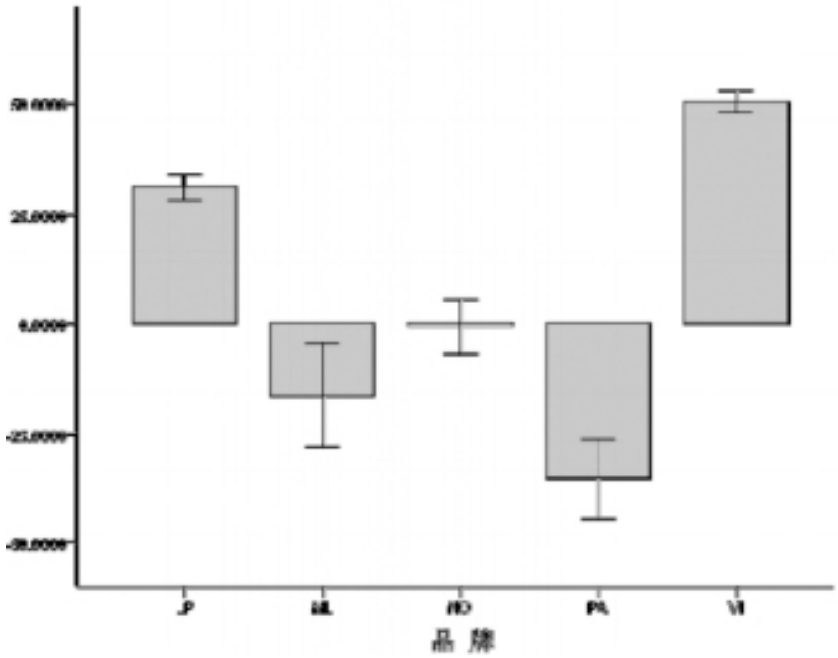
Tensile strength (MPa)



Brands

Fig. 15 The tensile strength of each group specimens with asterisk and different letters are significantly different ($P < 0.05$)

Average decrease rate of shearing strength (%)



Brands

Fig. 16: Reduction in tensile strength of fiber post specimens after aging. The tensile strengths of ML/PA significantly inclined, LP/VI declined after the accelerated aging, the highest reduction was that of VI (50.29±2.53%).

3.2 ESEM scanning results of microstructures of tensile sections before and after aging process

ESEM images of tensile ruptures before (Fig. 17 A-E) and after aging process (Fig. 17 a-e) showed: (A) group, the section was regular, fiber and matrix were isolated partially, and large matrix blocks still linked to fibers, (a) group, fibers were isolated from the matrix, with a little resin particles attached to the surface, matrix were broken; (B) group, thick fibers were partially isolated from the matrix, large matrix blocks were still linked to fibers, (b) thick fibers were extracted from the matrix, the surface was relatively smooth; (C) the section was relatively regular, fibers were partially isolated from the matrix, some large matrix blocks were still linked to the fibers, (c) the sections were irregular, fiber surface was smooth, with no obviously attached resin particles, and ruptured matrix could be observed; (D) the sections were irregular, matrix was chalked, fiber surface was attached with large resin blocks, (d) matrix blocks were peeled off, fiber surface was relatively smooth, with a little resin particles attached; (E) sections were relatively regular, fiber and matrix were partially isolated, some matrix were linked with the fibers, (e) matrix were chalked, the exposed fiber surface was relatively smooth.

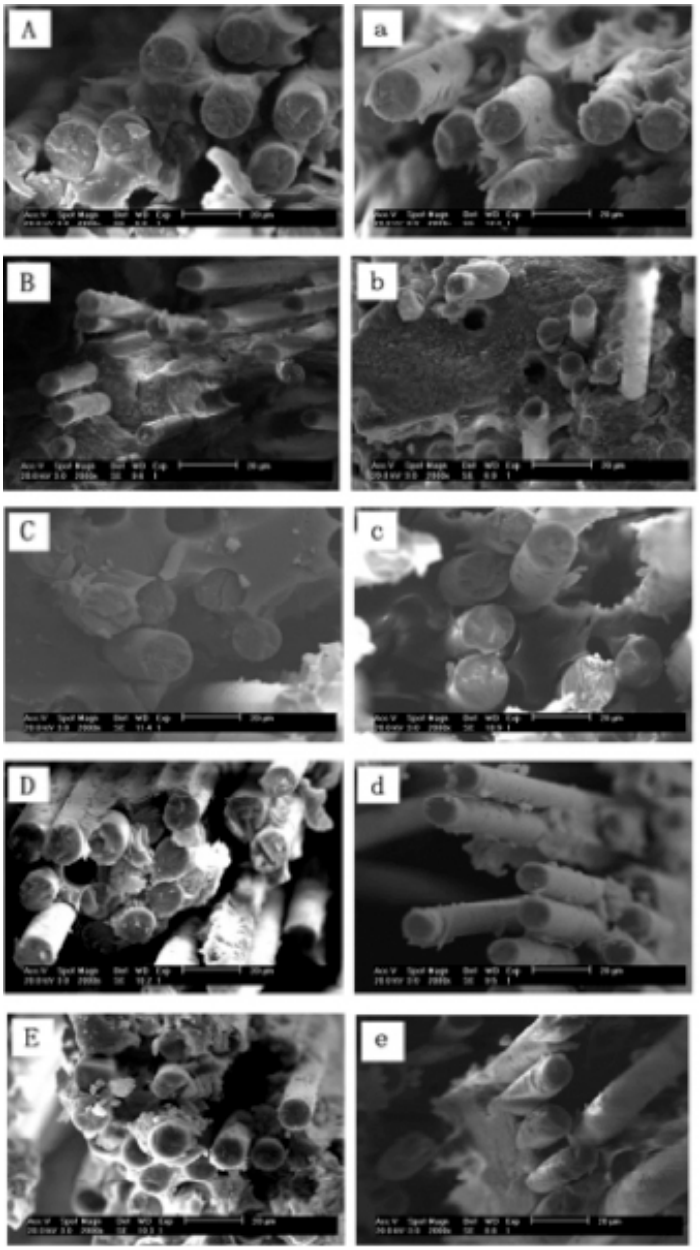


Fig. 17 ESEM-micrographs of tensile fracture-surfaces of fiber posts before (A to E) and after aging (a to e). A/a: ML; B/b: LP; C/c: PA; D/d: VI; E/e: NO.

4. ESEM observation and statistics of transverse section microstructure of various fiber posts

4.1 ESEM and measurements of transverse section of fiber post

The ESEM scanning images of transverse sections of various fiber posts were shown in Fig. 18: fibers were evenly distributed in the matrix. Table 6-8 showed the measured values of diameter (pm), density (/mm2) and content ratio (%) of various fiber brands.

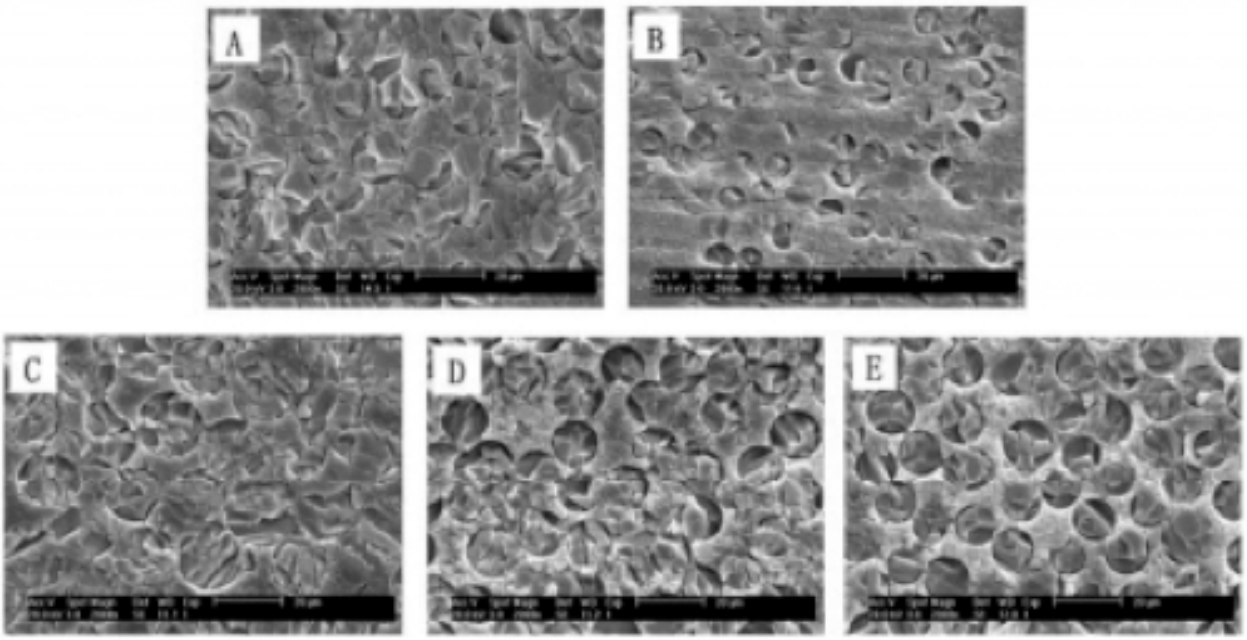


Fig. 18 ESEM-micrographs of cross sections of each fiber post. A: ML; B: LP; C: PA; D: VI; E: NO.

Table 6 The results of fiber diameter (pm)

	Diameter of fibers (am)				
Number	ML	LP	PA	VI	NO
1	14.00	8.41	20.60	14.00	12.90
2	14.00	8.41	17.60	13.50	13.50
3	12.90	8.41	18.80	13.20	12.40
4	12.90	8.08	19.10	14.00	12.00
5	15.30	8.08	18.50	13.50	12.70
6	13.90	8.08	18.70	13.50	12.60
7	13.20	8.41	19.60	13.70	12.30
8	13.40	8.61	18.30	15.30	13.50
9	14.40	8.61	19.20	13.90	12.80
10	14.70	8.71	19.70	13.80	12.60

Table 7 The results of fiber density(/mm2)

	Density of fibers (xl03/mm2)				
Number	ML	LP	PA	VI	NO
1	4.7048	6.9452	2.4191	4.5928	4.5851
2	3.9944	6.2447	2.5765	4.4808	4.5928
3	4.4808	6.7212	2.5879	4.7048	4.7257
4	4.0788	6.3010	2.2404	4.6132	4.7048
5	4.3688	6.9452	2.4754	4.8168	4.6414
6	4.0225	6.3291	2.3524	4.8383	4.9289
7	4.5928	6.4971	2.5316	4.7048	4.6695
8	4.1069	6.1885	2.6885	4.9508	4.4808
9	4.4808	6.6092	2.4473	4.9289	4.7539
10	4.2475	6.2729	2.5598	4.9226	4.8168

Table 8 The results of fiber/matrix radio(%)

	Content ratio of fibers (£•)				
Number	ML	LP	PA	VI	NO
1	71.09	38.31	68.66	69.09	58.36
2	60.35	34.45	73.13	67.41	58.46
3	67.70	37.08	73.45	70.78	60.15
4	61.63	34.76	63.59	69.40	59.88
5	66.01	38.31	70.26	72.46	59.07
6	60.78	34.92	66.77	72.79	62.73
7	69.39	35.84	71.86	70.78	59.43
8	62.05	34.14	76.31	74.48	57.03
9	67.70	36.46	69.46	74.15	60.51
10	64.18	34.61	72.65	74.06	61.31

4.2 Statistical analysis of microstructure parameters of fiber post

4.2.1 Results of statistical analysis for fiber diameter

Statistical results were shown in Table 9, the single factor variance analysis results indicated that, the fiber diameters of various brands were incompletely consistent (P<0.05); as indicated by Games-Howell test method, there was statistical significance between different brands (P<0.05); fiber diameter: PA>ML> VI>NO>LP.

Table 9 One-way AN OVA results of the fiber diameter

Brands	n	Fiber diameter (pm)	F value	P value
ML	10	13.8700±0.78888a		
LP	10	8.3810±0. 23293b		
PA	10	19.0100±0.83593c	1.73932	.000
VI	10	13.8400±0.57388d		
NO	10	12.7300±0.48086e		

Note: the same letter with superscript indicated no statistical significance (P>0.05); or with statistical significance vice versa (P<0.05).

4.2.2 Results of statistical analysis for fiber density

The resutls of statistical analysis were shown in Table 10, the single factor variance analysis results indicated that, the fiber density of various brands were incompletely consistent (P<0.05); as indicated by Games-Howell test method, there was no statistical significance between VI and NO (P>0.5); and statistical significance between other brands (P<0.05); fiber density: LP>VI and NO>ML>PA.

Table 10 One-way ANOVA results of the fiber density

Brands	n	Fiber density (x l0 Vmm2)	F value	P value
ML	10	4.3078±0.25353a		
LP	10	6.5054±0.28667b		
PA	10	2.4879±0.12966c	498.638	.000
VI	10	4.7554±0.16126d		
NO	10	4.6900±0.12725d		

Note: the same letter with superscript indicated no statistical significance (P>0.05); or with statistical significance vice versa (P<0.05).

4.2.3 Results of statistical analysis for fiber content

The resutls of statistical analysis were shown in Table 11, the single factor variance analysis results indicated that, the fiber content of various brands were incompletely consistent (P<0.05); as indicated by Games-Howell test method, there was no statistical significance between PA and VI (P>0.5); and statistical significance between other brands (P<0.05); fiber content ratio: PA and VI>ML NO>LP.

Table 11 One-way ANOVA results of the fiber/matrix radio

Brands	Groups	n	Fiber content ratio (£•)	F value	P value
ML	1	10	65.89±3.831a		
LP	2	10	35.89±1.581b		
PA	4	10	70.61±3.680c	271.352	.000
VI	5	10	71.54±2.426 c		
NO	6	10	59.69±1.620d		

Note: the same letter with superscript indicated no statistical significance (P>0.05); or with statistical significance vice versa (P<0.05).

4.2.4 Correlation analysis of shearing strength and microstructure parameters

Pearson correlation analysis was conducted for shearing strength and microstructure parameters for non aging group (table 12), and the results indicated statistical significance in shearing strength and fiber diameters for 5 fiber brands (P<0.05); and with fiber density (P<0.05); but not correlated with fiber content ratio (P>0.05).

Table 12 Strength and statistical significance of the correlation between shear strength and the structural characteristics

Shearing strength	Structure parameters		
	Fiber diameter	Fiber density	Fiber content ratio
Pearson correlation analysis	r=0.740*	r=-0.822*	r=-0.008
	P=0.000	P=0.000	P=0.962

* Statistical significance.

4.2.5 Correlation analysis of tensile strength and microstructure parameters

Pearson correlation analysis was conducted for tensile strength and microstructure parameters for non aging group (table 13), and the results indicated statistical significance in tensile strength and fiber diameters for 5 fiber brands (P<0.05); and with fiber density (P<0.05); but not correlated with fiber content ratio (P>0.05).

Table 13 Strength and statistical significance of the correlation between tensile strength and the structural characteristics.

Tensile strength	Parameters		
	Fiber diameter	Fiber density	Fiber content ratio
Pearson correlation analysis	r=0.776*	r=-0.860*	r=-0.033
	P =0.000	P=0.000	P=0.841

* Statistical significance.

5. FTIR test results of samples of various brands

Fig. 19 indicated FTIR difference before and after aging of various samples. 2964 cm-1, 1728 cm-1 and 1510 cm-1 were respectively the absorption peaks of methyl (methylene), carboxide and benzene ring, 1079, 1037 and 1010 cm-1 were the absorption peaks of ester groups. In general, after sample was aged, the absorption values of the above functional groups were upward, indicating the peak values were improved to different degrees. The absorption peaks of all functional groups in ML group were minimal, and absorption peak values of all groups were close to each other.

Absorption difference

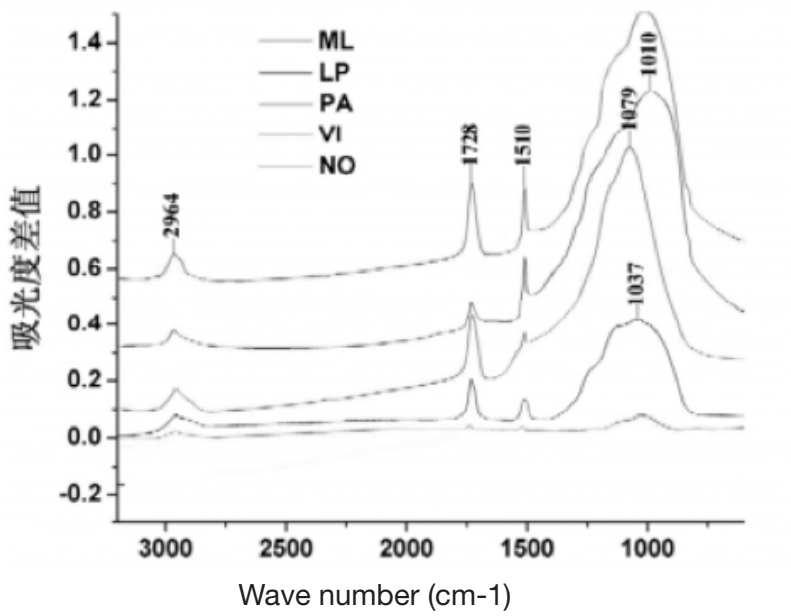


Fig. 19 FTIR subtraction results of each fiber post before and after aging

Discussion

1. Aging conditions

At present, there are mainly two methods to study the aging of compound materials: one is the natural aging method, a relatively real method to evaluate the aging properties of polymer compound materials, but the method has some defects including long cycle, uncontrolled environmental factors, and poor reproducibility of test results; another method is artificial aging method, which utilizes artificial method to imitate almost climate conditions or some special environmental conditions in room or equipment, and reinforce some factors, thus to obtain results in a short period. Artificial aging experiment will not affected by areas, seasons and climates [20].

From manufacture, processing, storing to oral application of fiber posts, it will be affected by various factors including heat aging, light aging, water aging and chemical cleavage, etc. Oral environment is extremely complicated and changeable, saliva is continuously secreted, dentin also has body fluid circulation; oral temperature changes greatly, and there are many bacteria and metabolites which can easily degrade and age the materials; moreover, chewing stress and clinical operation can also affect the oral materials [19]. In this experiment, the chosen Suntest CPS+ aging instrument (xenon lamp) provides controllable conditions including temperature, humidity and ultraviolet to accelerate aging process, and the total radiance volume in 24 h can reach 56160 ld/m2. In 2006, in the aging laboratory under natural climate conditions in Miami, Florida, USA, the 45° daily radiance can produce total energy of 6199.8 MJ/m2, and mean daily radiance energy is 16.98575 MJ/m2. Therefore, 200h radiance energy of Suntest CPS+ aging instrument equals radiance energy of 27.583d in the aging laboratory under natural conditions in Miami [28]. Though the aging conditions and oral environmental conditions are not same completely, but can mostly imitate the aging process under oral conditions.

2. Nature of fiber post

Fiber post is the fiber reinforced compound material, and fibers imbedded into matrix reinforce the systemic mechanical properties of fiber posts. However, the specific materials and manufacturing methods of different fiber posts were not completely the same. E-glass fiber is the most common in glass fiber, a mixture composed of SiO2, CaO, B2O3, A12O3 and some other base metal oxides; quartz fiber is composed of pure crystal SiO2, with high tensile strength and elastic modulus and restoration, its elastic modulus is similar to glass fiber, but it is an inertia material with low coefficient of thermal expansion, so under complicated environment with changeable temperatures, it may be an advantage in its internal microstructure [9]. In this study, fiber posts have been studied, ML group is quartz fiber, and the left LP, PA, VI and NO groups are all glass fibers. There are many factors affecting the mechanical properties of fiber posts, besides of diameter and shape of fiber posts, fiber diameter, density, alignment direction, organic matrix and interface viscosity of matrix and fiber are also the factors [29]. Resin matrix imbedded into fibers can obviously reinforce the rigidity and fatigue strength of compound materials [30].

Normal occlusion and chewing have stress to various directions on natural teeth and dental prosthetic restorations, so shearing strength and tensile strength are important parameters as considered from clinical aspect. The matrix in fiber post, diameter of fibers in filling materials and matrix density has direct effects on shearing

sand tensile strengths. Good interface viscosity can effectively transfer the load from matrix to fiber reinforced posts, and this parameter is one of the important factors for reinforced compound materials. When fibers closely bind to matrix, the stress transporting capacity on fiber-matrix interface is stronger [31].

3. Shearing and tensile strengths of fiber posts

The shearing strength, tensile strength and microstructure parameters are different between brands. When the stress is vertical or parallel to the long axis of fiber post, the stress is mainly concentrated onto the interface between fibers and matrix, which will induce isolation of interface plasticity.

In this experiment, the matrix was bisphenol A-glycidyl methacrylate (Bis-GMA) in LP group, and epoxide resin (ER) in the other four groups. Because the elastic modulus of Bis-GMA is higher than that of ER [32], the strength is greater, so when the fiber post is loaded, the matrix will be ruptured earlier than fibers, so the shearing and tensile strengths of fiber post (LP group) with Bis-GMA as the matrix are greater.

As seen from the analysis and statistics of ESEM figures of fiber posts, for the five fiber posts evaluated in this study, the shearing and tensile strengths are directly correlated with fiber diameter, and negatively correlated with fiber density. Compared to matrix, fiber is the main reason for reinforcement of systemic mechanical properties of fiber posts; however, if fiber density is too high, matrix coating between fibers will be affected, interface viscosity will have a decreased strength or even small ruptures or trachoma, and the stress transferring efficiency will be affected [29]. In this experiment, fiber diameter in PA group is greater than those of the other groups, with will a smaller density; while in VI group, fiber diameter is smaller compared to other groups, but with a greater density, so it is presumed that diameter and density of fibers are the reasons for biggest and smallest shearing and tensile strengths in PA group and VI group, respectively. However, it is found in this experiment that, shearing and tensile strengths of fibers posts are correlated with fiber content, suggesting that fiber diameter and density are only parts of the influencing factors for mechanical strength of fiber posts, the viscosity between fibers and matrix interface is also the important parameter. Tezvergil et al [9] have proposed that, good interface viscosity strength can effectively transfer the loading force to reinforced fiber posts, the stress transferring capacity is better when fibers bind to the matrix interface closer. In tensile experiment, when stress is higher than the adhering force between fibers and matrix, tensile model of fibers is established, and the fibers are distributed along the interface; when viscosity disappears, fibers will be ruptured, and fiber posts are broken [33]. Fiber posts in ML group are prepared by preload stress, which are composed of quartz fibers, the latter is made of silicon dioxide crystal, with high tensile strength, elastic modulus and restoration, which can effectively resist external force, so it can protect deformation of resin materials; secondly, fiber posts are manufactured by using pre-tensile technique, fibers are pre-stretched and imbedded into resin, and then polymerized. When resin is polymerized, fibers will recover to the original length, when resin is at a compressing state, by using this technique, when fiber posts are broken by stress, especially by tensile stress, preloading stress fiber will quickly retract to reduce or eliminate the ruptures at weak site, prevent continuously dilation of ruptures [30], protect resin matrix, and fiber posts in ML group have higher tensile strength.

4. Effects of accelerated aging on fiber-matrix interface

Shearing strength of various fiber posts reduces after accelerated aging process, ESEM figures of shearing sections (Fig. 14) indicate that, accelerated aged resin matrix are chalked or peeled off in large blocks, resins

attached to fiber surface are reduced, some fiber surface is smooth, which suggests the viscosity between fibers and resins significantly reduces. While in LP and VI group, tensile strength of fibers after accelerated aging process decreases, ESEM figures of tensile sections (Fig. 17) indicate that, resin matrix chalks or ruptures after accelerated aging process, the interface is isolated, fibers are pulled out when the posts are ruptured, and the resin matrix attached are reduced around the fibers. This is similar to the conclusion from the study by TanakA et al [34], wet heat aged fiber surface is smoother than the non aged surface, ethoxyline resin is attached onto non aged fiber surface, and matrix damage is mainly observed in the single-fiber pull-out test.

Therefore, after accelerated aging process, fiber reinforced compound materials transfer from “strong interface combination” to “weak interface combination”. The reasons for decreased interface combination are that, resin matrix absorbs water and swell to produce internal stress on the interface, and then slight rupture is induced to lower the interface bonding force [35]. Fibers and ethoxyline resins contain a lot of hydrogen bonds, water molecules permeate into the materials during aging process, and attach onto the adjacent areas of polar group (-OH, -CO), hydrogen bonds in the molecular chain are damaged, thus to damage the reticulate structures between fibers and; ethoxyline resins, induce lytic response, and break down the binding properties of the interface [36, 37]. The longer the duration, the more water will be absorbed and permeated, moreover, heat produced in aging process will accelerate permeation of water molecule, and interface damage will be aggravated. FTIR indicates that, after aging process, methyl and methylene at 2964 cm-1, carboxide at 1728 cm-1, ester group at 1079, 1037 and 1010cm-1, the absorbance increases, suggesting oxidation occurs during aging process of fiber posts, and oxidation increases the cross linking density of resin matrix [38]. Cross linking density increases, elasticity decreases [23, 39, 40], this conclusion is similar to that in the literature [4], i.e. after long term accelerated photonic aging (or increased radiance time), elasticity of organic polymer reduces, viscosity at the interface between fibers and matrix weakens or isolates, rupture strength decreases, and hardness increases. Elenil et al [41] also have pointed out that, with aging process (increased radiance), elastic modulus of resin decreases, hardness increases, interface viscosity between fibers and resin matrix weakens, and the strength decreases.

In this experiment, fibers of NO group align in axial direction and weave into plait, which prevent permeation of water molecule during aging process, hydrolysis degree is low, so shearing strength decreases minimally in NO group. While in ML group and PA group, tensile strength increases. There may be two reasons: one, accelerated aging materials cause secondary solidification effects, resin matrix and fibers polymerize, and this solidification eliminates partial residual stress [20], thus to increase the binding strength at the interface of fibers, and tensile strength also increases. This is similar to the conclusion from Muhanad et al [23], who have pointed out that, fibers are not completely polymerized during sample preparation, accelerated aging process for 200 h can induce further polymerization of samples, the binding strength at sample interface will be reinforced, and tensile strength also increases. Second, water molecules during aging process enter into fibers as lubricators, thus to improve the locomotor activity of fibers, tenacity will be increased, and will be quickly ruptured under certain load, but prevent rupture by deformation, and improve tensile strength in macroscopic aspect [42].

Therefore, resin matrix after accelerated aging process are chemically damaged and degenerated, the binding force between matrix and fibers are weakened [28]. When the loading force is vertical to fiber posts, the interface between fibers and resin will be separated with only small strength applied, and the isolation will spread

along the long axis, fibers and resin matrix begin to deform and rupture. After fibers are ruptured, stress will quickly be spread to the surrounding fibers [33]. Therefore, with the development of aging process, fiber/matrix interface is gradually damaged, the load transferring force is weakened, and shearing and tensile strengths of the fibers are decreased.

Matrix in fiber posts, diameter of filling fibers and matrix density, alignment measures will produce direct effects on shearing and tensile strengths. Shearing and tensile stress is mainly applied to the interface between fibers and matrix. Therefore, fibers should have sufficient elastic modulus, the interface should have good viscosity, and then it can effectively resist external force, and protect the materials from deformation.

Conclusion

The shearing and tensile strengths of different brands were significantly different. The matrix in fiber post, diameter of filling fiber, the matrix density and alignment measures have direct effects on shearing and tensile strengths.

Before and after aging process, the shearing and tensile strengths of fibers posts of different brands are statistically significant. After accelerated aging process, matrix has physical aging, hydrolysis and oxidation, which can affect the viscosity at interface between fibers and matrix, shearing and tensile strengths will change: shearing strength significantly decreases, the decrease is minimal in NO group with stronger anti-aging capacity, and maximal in VI group with weaker anti-aging capacity; the tensile strengths of various brands change differently, VI group has the maximal decrease, with weaker anti-aging capacity.

In this experiment, only 5 brands of fiber posts are accelerated aged for 200 h, the changes of mechanical properties of fibers posts should be analyzed at different aging times in the aspect of aging kinetics, thus to investigate the aging mechanism, the differences and reasons for different fibers posts and the related reasons, and provide a possible approach to improve properties of fiber posts.