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Dental adhesives effects in the total restoration

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ABSTRACT

This article discusses the dental adhesive mechanical properties and the effects on the total restoration, based on the manufactures specifications, experimental data, and mechanical -computer simulation test results. The optimal dentist's adhesive selection will be when he can be chosen for one specific restoration, avoiding wasted time, material and exposure to marginal infections.

The samples adhesives show an amorphous structure and they use the same bonding monopolymer, showing in the X-R Diffraction, SEM and EDS experiments. The mechanical test shows properties under tension and sheer rupture stress. Results will be in the conclusion.

Significance: The first conclusion is that the amorphous structure is present in all six adhesives experiments, showing strong possibilities of bonding with another neighbor's molecules. The discussion will be extended to the bonding advantages for this type of structure.

Findings: The bonding quality is related to the time delay of photopolymerization and it was controlled with the variable etching treatment water evaporation. In addition, it was found that the variable size of the wavelength of the curing light obtained better molecular organization, avoided internal stress and bonding defect. Lastly, the elements chemical composition was a variable that provided the opportunity to predict the bond type and strength.

1. INTRODUCTION

The goal of this study is to compare different types of restorative dental adhesives. The focus is on the mechanical properties effects on the overall restored tooth, using experiments, mechanical and simulation tests that are performed under technical specifications given by the manufacturer. Besides extending the findings of the previous research exposed below, some observation needs to be added as to the practical events of the restoration, based on the theory of the polymerization process. The dentist will benefit by saving time, avoiding exposure to marginal infections from a failed restoration.

The dentist selects the material for a specific restoration. This choice is based, primarily, on personal experiences, results, and familiar brand names. It may not be the best dental adhesive selection for the restorative tooth. This selection can be more specific, if the different dental adhesive mechanical properties can be clarified, allowing the dentist to select one for a specific class of cavity. The goal of dental adhesives is to create a strong bond against the residual tooth, as well as a white composite filling, which is, usually, some other polymer.

Normally, the selection is doubled or tripled, considering that a regular restoration the dentist selects the composite adhesive to create a layer bond between the real residual tooth and the composite filling. When the dentist prepares the cavities uses different types of etching and primer, the process for one restoration has more options to choose from.

This study will apply a direct restoration, in–vitro, randomly Class I to VI, with real tooth, extracted at the clinic of Dr. Michael Barnard, Fort Lauderdale, Florida. Others, like Amalgam, Glass Ionomers, and Resin Monomers exist, but they are not part of this study.

The clinician normally is not familiar with the polymers terms of the market dental adhesives. Specific selection can be clarified by knowing the mechanical properties of dental adhesives or quality to perform a strong bonding . The dental polymers material classification sometimes, adds a bit of confusion to the dentist selection, because the terms, like "universal", "all-purpose composite filled", do not give specific- technical data to inform the dentist about the best composite resin or adhesive to be used in a specific restoration.

The “Effective Health Dental”, published by D2 Composite Restoration Direct Methods, comments on the study of filling composite, rarely showing resistance load differences, especially about potential health problems on the back teeth. Weak conditions for restoration can break the coronal residual tooth, which has only the crown or post solution. In the meantime, patients can get infections in the blood stream due to the tooth environment.

The compatibility with hard tooth tissue, the environment, and the load applied to the tooth define the bordering condition. The type of adhesive structure defines the bonding quality performing. The amorphous structure of the dental adhesives presented in the experiments creates an ideal molecular bonding environment. There is a thermodynamic relationship between the degree of atomic disorder given by the entropy and the Gibbs’s free energy of the amorphous adhesive. This free energy governs the spontaneous chemical reaction of photo-polymerization process, not related to the bonding quality. The strength of the restoration will depend on the bonding between the adhesive and the enamel- dentin surfaces; the strong ionic bond of the hybrid layer is at the level of dentine

Carvalho[1] studied bond strength, with the ability of the primer to maintain expansion of the collapsed desmineralized dentine. This is an environment where the amorphous structure adhesive shows the capacity of diffusion in the interfibril collagen spaces without polymerization. The control of the polymerization process is a function of water presence. To obtain the maximum diffusion in the intertubular and peritubular dentine, surfaces are required to be wet. When the water is removed, the amorphous adhesive promotes the spontaneous polymerization. The material diffusion process is called self-expansion. The key to control the bonding process is the amorphous structure.

Another bonding variable that will be discussed is the control of water evaporation, which is directly proportional to the time delay before the photo-polymerization process. This variable is related to the etching pretreatment.

Bouillaguet[2] studied the mechanism of polymerization. It depends on the water evaporation in the intertubular and peritubular dentine with the hybrid layer; which is a function of the solvent presence. One goal of the dental bonding adhesive is to create a sealer layer under the polymerization process. The dental adhesive structure provides an opportunity to manipulate the bonding process. The best sealer represents a perfect bonding chemical reaction system with minimum structural defect. These requirements are directly related to the atomic disorder entropy and time delay, which can promote the control of photopolymerization, manipulating the bonding process. In this article the polymerization, process describes the control of the presence of water. When the water is removed, the amorphous adhesive promotes the spontaneous polymerization.

J-T. Cheng[3] studied the efficiency of one-step dental adhesive. This article explains the bonding mechanism into the intertubular dentine, specifically, the hybrid layer formation. The study relates the dental bonding dentine to the chemical or physical interaction between the amorphous adhesive and the desmineralized collagen fibril. The results are in favor of the old-fashioned three-step adhesive with the etching acid application. Using the three-step adhesive, water-air removal by evaporation is the best way to manipulate the polymerization process. The one-step adhesive has no control over the polymerization process with water. It creates bonding very quickly with a

higher contraction gap and no time for the structure to be organized. The one-step production of decalcification dentine fibril is very low, creating a weak hybrid layer; therefore, it creates a weak-bonding link with very low concentration. The three-step adhesive produces more desmineralized dentine with etching acid than the "all-in-one-step" adhesive.

Some dental adhesives use the stress absorber, adding nanosized filler particles into the matrix to improve strength. The fillers are very small; they need time to flow through the interfibril collagen spaces to create the hybrid layer. The fillers' density is not uniform; each area has different mechanical properties. This distribution causes a weakness on the bonding link. The fast polymerization process affects atomic organization and is responsible for internal stress, leakage, or failure of restoration. The effects of the polymerization time delay on the dental bonding quality gives the chance for the hybrid layer to obtain better organization and deeper diffusion. It creates more uniform bonding against the tooth, avoiding internal defects, like gaps, voids and potential leakage.

The dentine has a complex bonding due to the different substrate nature. It is very complicated to form a smear layer and to prepare the surface. The dentine quality and the adhesive resin define the bonding, creating a sealer with a very complex chemical reaction.

The material test and evaluation are done to obtain the best result for adhesives, selected for each specific restoration. This study is about a restoration adhesive interface as the main variable. Six different market adhesives, with a common white filling composite resin will be applied on all tooth specimens.

The adhesive creates an interface layer between the residual tooth and the white composite filling with the chemical bond and mechanical interlocking. That is why the restoration depends on the bond quality of the interface adhesive. The effects of the polymerization time delay variable on the dental bonding quality. It allows the hybrid layer to obtain better organization and deeper diffusion, creating more uniform bonding against the tooth and avoiding internal defects and potential leakage. The variables that will be discussed are the control of water evaporation and the wavelength size of the curing light before the photopolymerization process (implies time delay*).*

2. EXPERIMENTS, MATERIALS AND METHODS

Six pure bonding adhesive samples were prepared at the clinic of Dr. Michael Barnard, DDS, Ft. Lauderdale,FL, the X-R Diffraction was performed at the X-R Diffraction Lab of Florida Atlantic University, Boca Raton, FL, under the supervision of Professor Dr. Th. Leventtori, Physics Department. The SEM- EDS experiments were performed at the University of Central of Florida, Orlando, FL. The same composite filling Spectrum TPH (L.D. Caulk Division, Dentsply Canada Ltd, Woodbridge, ON), was used .All details about the experiments results as amorphous structure were explained in the publication Structure Dental Adhesives, Laccei 2008. This article will be focused on the results of the mechanical and computer test simulation.

This material was selected from the clinical history requested by the office of Dr. Michael Barnard. Manufacturer brand and assigned names are listed in Table 1

Table 1 Market adhesives

Assignment	**Adhesive Names**	**Manufacturer**
R1	1) One Coat Self-Etching	Coltene Whaledent
R2	2) Optibond Solo Plus	Csds Kerr Sybrom Dental specialist

R3	3) Prime and Bond	Dentply De Trey
R4	4) Adper Single Bond Plus	3M ESPE
R5	5) 1Bond Gluma inside	Heraeus
R6	6) Heliobond	Kulzer,GmbH,Wehrheim Germany

Research Stages

The first stage is the tooth morphological study, followed by the chemical composition background, environmental boundary condition, and state of decay. Next, there are the adhesive, composite filling, and manufacturer's specifications. Lastly, all the dental restoration treatment variables were revised.

The second stage identifies the structure type and the six pure different adhesive composite fillings chemical composition. The X-R Diffraction, Energy Disperse Spectroscopy (EDS), Scanning Electron Microscopy (SEM) experiments were performed. Under the control of certain variables, the evaluation of these results was given a practical manipulation approach to the polymerization process. The third stage involves the mechanical test results. The fourth stage is the computer simulation .The sixth stage was the discussion and conclusion of the results of the Analysis of Variance (ANOVA)

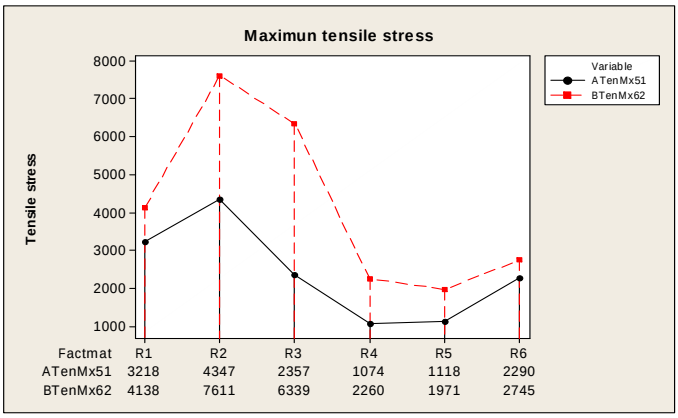
Mechanical test

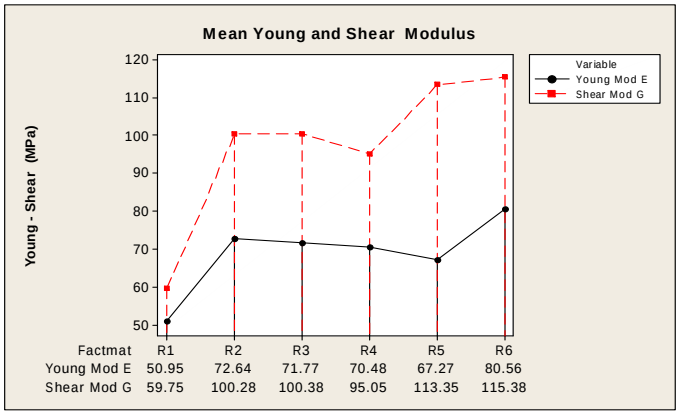
The Mechanical Test Traction and Pure Shear was performed on a real tooth specimen at the Ocean Engineering Lab, Florida Atlantic University. There were seventy-two real teeth divided into two groups of 36 teeth: one group of teeth for the Tension Test and another for the Shear Test. The test was done on six different adhesive samples with six specimens of each one, under time delay and water evaporation variable.

The restoration will be successful if the chemical bond is strong enough to resist the load applied over the bonding surfaces. The objective is to create a maximum adhesion force in the interface filling between the composite and the natural tooth. This will improve and make great changes in the mechanical properties, like modulus elasticity, hardness, and strength on the fracture. The new cavity geometry, created by the dentist, is directly related to the decrease in strength of the new tooth structure, considering that part of the tooth has been removed.

The mechanical test shows the real mean bond mechanical properties. It gives real data about maximum tensile and shear stress, obtaining the Young modulus, Shear modulus, Poisson Ratio, Strain, and Strain Energy for different adhesives, as shown Fig. 2. The direct impact test is very weak.

The mechanical properties result will be discussed in more details on the conclusion and discussion.





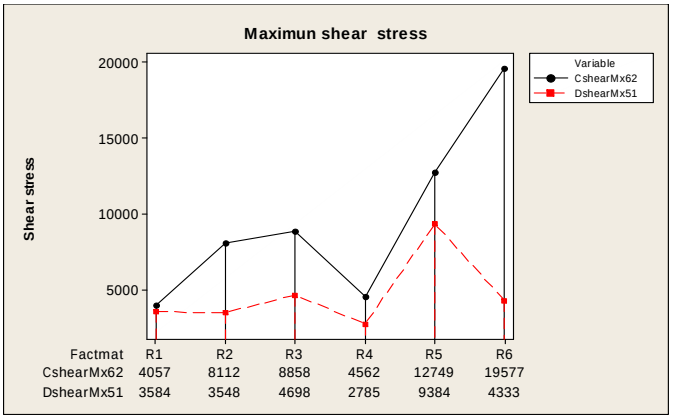


Figure 2 Tensile Stress, Young modulus Rupture Stresses

The above graphics represents the maximum stress results obtained from the mechanical test data and the mean Young and shear modulus. This data represents an adhesive materials interaction without the Analysis of Variance with test of Significance Design experiment, giving result of the interaction of the factors, producing different response. The maximum stress shows the adhesive R6 perform high shear resistance and the R2 the maximum tensile stress from the mechanical test using the mean data.

Computer Simulation

The forth stage is the computer simulation. It starts with a CT tomography of the real tooth at the CT- MRI Well Center, Lantana.Fl.The data image used in the Ansys computer simulation will be obtained from the Computer Tomography Scanner Image. This type of 3-D image works with DICOM medical files. These files need to be converted into engineering files using the Mimics and Magics program. as shown in the Fig 3.

Mimic and Magics, create the geometry .To obtain this simple geometry it is necessary to pass for all kinds of different ones. It tries to find the most critical geometry that represents the maximum stress and create the maximum risk to break the bond. Any volume that uses 90-degree angle in the geometry creates maximum stress concentration in boundary of this angle surfaces.

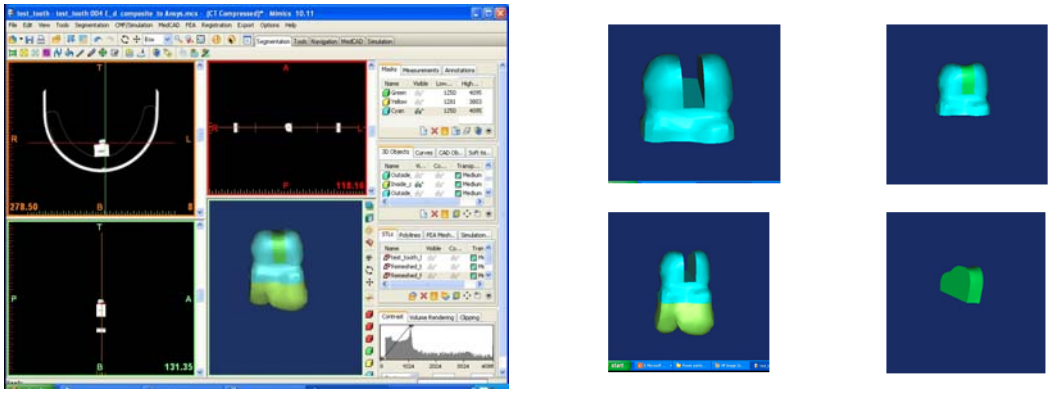


Fig 3 Mimics geometry ready to export to Ansys simulation

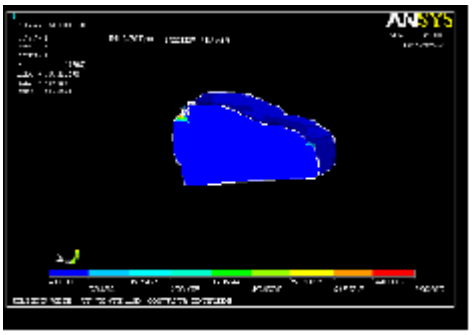


Figure 5 R1 First principal stress filling

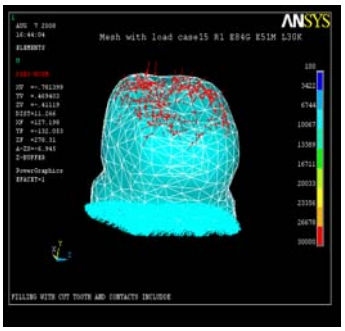


Figure 4 Tooth Model loaded

They will be exported to the ANSYS program using Finite Elements Analysis to perform a general stress analysis. Computer simulation information will be obtained with the Finite Elements Analysis using the experimental data obtained from the mechanical test. This Ansys program can give a complete stress and strain analysis under specific boundary conditions. This analysis using the mechanical properties like of Young, Shear Modulus and the Poisson ratio, it will be significant base for a selection of the dental adhesive. The Computer Simulation test results give the possibility to observe the internal stresses behavior in 3-D of the dental material behavior, Fig 5.

The failure theory requires defining an upper limit stress with the sudden fracture of the brittle dental material given for $\sigma_{ultimate}$ in the uniaxial stress mechanical test data. The maximum normal stress theory says: "a brittle material will fail when the maximum principal stress σ_1 reaches over the ultimate normal stress".If, $|\sigma_1| <= \sigma_{ultimate,}$ there is no failure. The applied load mastication pressure was 30 kPa, distributed over the tooth, using the residual tooth Young Modulus E_{RT} 84 Gpa and Poisson Ratio 0.3[S.Habelitza][26]. The bonding Young Modulus $E_{filling}$ was obtained from the Mechanical test for different dental material, then if the maximum principal stress σ_1 reaches over the ultimate normal stress, the material fail. If, $|\sigma_1| <= \sigma_{ultimate,}$ there is no failure.

The maximum normal stress theory was applied to the R1 bonding dental material with Young Modulus E_1=50.95 Mpa. The upper limit stress is $\sigma_{ultimate}$ =2675.23Kpa., It was obtained from the uniaxial stress mechanical test for all six adhesives. The principal stress σ1= 896 Kpa, is less than $\sigma_{ultimate}$, therefore, the material will no fail.

By applying a bigger mastication load on all six dental materials, the stress will increase until the material breaks. We can compare the material's principal stress to find out the strength of each one. In this case, the principal stress of R1 is σ1= 4830 Kpa, more than $\sigma_{ultimate}$, therefore the material will fail when applied 150 Kpa .

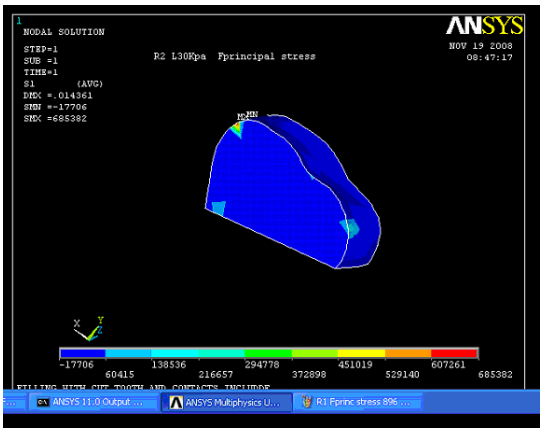


Figure 6 R2 First principal stress, filling.

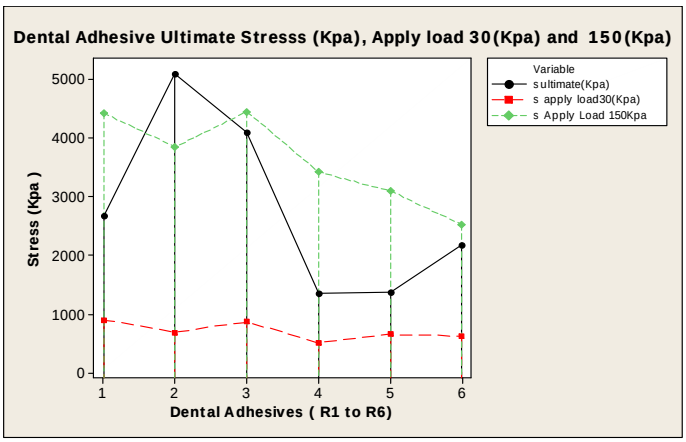


Figure 7 Ultimate stress

The R2 Young Modulus E_2=75.643Mpa was used on this test. The upper limit normal stress failure is $\sigma_{ultimate}$ 5092 Kpa and the maximum principal stress is σ_1 (σ_1= 685Kpa), as shown in Figure 6. Therefore, there is no failure, because σ1 is less than the ultimate stress. When applying 150 Kpa a bigger mastication load, the principal stress of R2 is σ1= 3850 Kpa, less than $\sigma_{ultimate}$, therefore the material will not fail .

By applying a bigger mastication load on all six dental materials, the stress will increase until the material breaks. We can compare the material's First Principal stress to find out the strength of each one. When a bigger mastication load of 150 Kpa is applied, the principal stress σ_1 of the dental material R1, R3, R4, R5, R6, is more than $\sigma_{ultimate}$, respectively. Therefore, those materials will fail. as shown in graph of the Fig 7

At this point, R2 dental materials did not fail, showing more strength. According to the maximum normal stress theory, R2 and R3 have the higher $\sigma_{ultimate}$ and the First principal stresses are closer to the $\sigma_{ultimate}$. The both have a lower chance to failure; they are candidate to the best dental adhesive. Therefore, represents a minimum potential micro-crack failure. The final decision will be to apply the experiment design (ANOVA) statistic test and interaction factor.

Finally, the mechanical test data will give the adhesive results on the basis of variables effects and computer simulation give valuable internal view points of observation. It will be interesting to observe both test data and see how the stresses are related with the amorphous structure behavior, filler distribution, density, rupture failure, voids/bubbles, elastic, and plastic stresses.

This discussion also is focused on the Analysis of Variance and Multiple Factorial Model. The factors were classified by name and arranged in an easy way to analyze when the MINITAB computer program is applied.

The result obtained by the Mechanical Test is the response defined by the tensile and shear stress. They can be different when the factor variable is applied with Minitab program.

The mechanical test variables factors are: The cure light wavelength (λ), etching water evaporation time (t) and the type of adhesive material R1 to R6. The Minitab first check for the mean significance value of responses .In addition compares the interaction results between the variable and the response. The result can be shown on the graphs interaction. Therefore, we have a model with three factors. The first two factors, wavelength(λ) and the time (t) have two levels, and the type of material factor has six levels (R1 to R6) Fig 8 . This is the reason why the Multilevel Factor Model or Full Factorial Model Minitab computer program was used.

The full factorial design, response all combination of the factors levels, normally have more than two levels. Each experiment called run and the response is the observation. General full factor design has a combination of all

factor levels. The factors can have any number of levels and "runs". Full Factorial model Design 2^2x 6 two factor with two level and one factor with six levels.

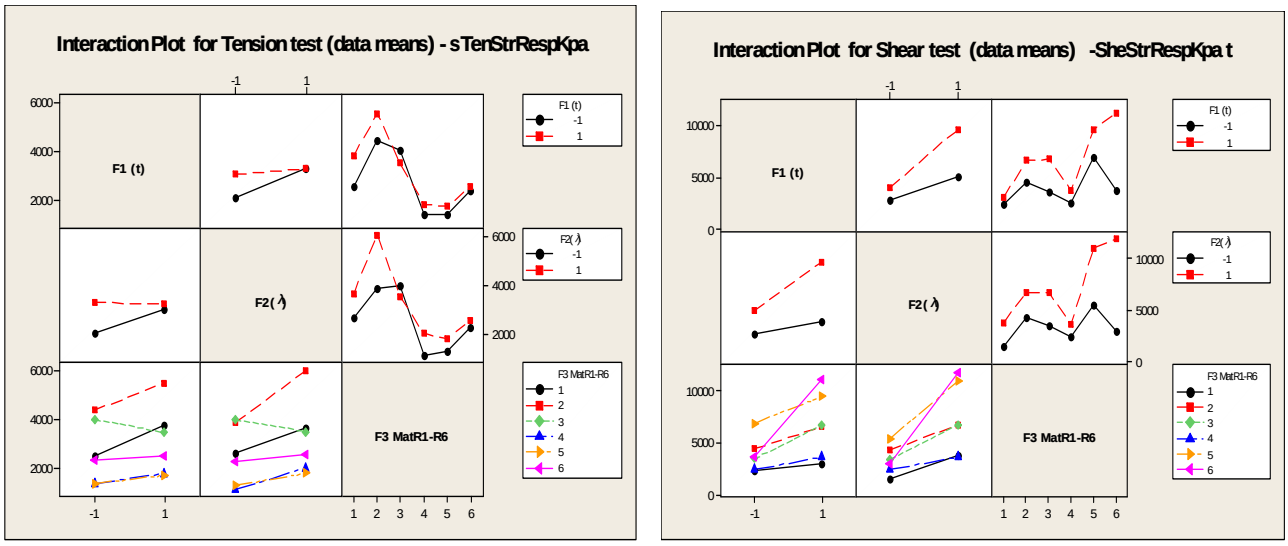


Figure 8 Interaction Plot for Tension and Shear (data means)

Interpretation of the Interaction Plots

The above interaction plot shows the interrelation effects of three different factors or treatments given by the data mean obtained from the tensile and shear stresses mechanical test. The graph shows a clear response from the variability of different types of material and treatments when prepare the specimen, giving specific stress responses. The tensile stress graph shows the wavelength of 600 nm of material R2 that can withstand a higher elastic tensile stress. In addition, the same graph will look for the evaporation time factor, and for maximum stress that can stand the same material R2, with 2 min etching treatments. Therefore, the material R2 has the best result on the tension mechanical test. The shear interaction plot, using the same criterion, shows that the R6 dental adhesive supports the maximum shear stress. Summarizing R2 and R6 material support the maximum tensile and shear stresses; respectively with 600nm, wavelength and two minutes etching water evaporation time.

Discussion

Reviewing the laboratory experiment main results appears some interesting observations .The experiment EDS and SEM are performed simultaneously. The EDS experiment can determine and plot the chemical composition results of the dental adhesive. The X-ray pattern can identify the six samples as amorphous type of structure. The X-R Diffraction and EDS chemical composition elements results were matched, based on the manufacturer's monomer elements specification, like methacrylate derivatives elements.

The calculation of reaction rate K (reactants concentration or products change per unit time), given in the thermodynamic topic, it shows a possible manipulation of the reaction process as a function of the reactants entropy. Considering the monomers, components of dental adhesive have methacrylate derivatives and they are in the same phase. Therefore, all of them have Carbon, Hydrogen, and Oxygen, combined between them like CH_2 and CH_3 monomers. With EDS and X-R experimental data, we can know the weight percentage of the elements belonging to the monomers. Using the transformation mole – molecules, the atomic weight and the percentage of the monomers elements can get the specific monomer (Mo). Morality/sec is the change of the concentration given the units for reaction rate. Identifying the monomers percentage of each adhesive, we can discern which adhesive has more possibility to create a cross-link bonding with the neighbor's molecules. The manipulation on the rate of formation of the initiation free radical is a function of the energy absorption per unit volume. It is proportional to the intensity of the incident light and the monomers-photosentizers concentration. The incident light absorption can be controlled (manipulated) with the curing light wavelength size. Longer wavelength response slows

photopolymerization process. At this point, a better result in the dental bonding and in total restoration can be obtained. The idea is to obtain the best uniform bonding with amorphous material presently existing in the market, rather than having to create an entirely new adhesive, trying to achieve the best bonding results, considering almost all of them, which have the same monomers to create the free radical chain reaction.

The statistic study results with Minitab programs shows the real factors interaction of the of different wavelength of the curing light with another factors like type of material and time of etching water evaporation. The manipulation of wavelength and evaporation time were tested with the same objective, minimize the rapid or high rate of photo-polymerization, considering it has no time for the molecules to organize in order to create crystalline structure.. The combined results will be show on above graphs Figure 8 .

X-R Diffraction. The result of the X-R Diffraction experiments of dental bonding samples shows the pattern of amorphous structure. In the six curves profiled, there are no relevant intensity peaks or absorption counts nor non-intensity periodicity. There is a minor non-linearity of the background. The physical meaning is that the atomic arrangement present is not crystalline nor without particular structure. While in atomic disorder with a continuously changing pattern, they are closely packed with beneficial elastic mechanical property, especially the sheer stress. The atomic disorder interferences destroy any pattern. This is the reason the adhesive samples' X-Ray Diffraction curves pattern has no linearity, these phenomena occur when a short electromagnetic wavelength interacts with the atoms and responds like intensity peaks. The density molecular distribution affects the X-R diffraction patterns too, the electromagnetic waves diffracted continuously, changing the pattern when hitting the disordered atoms .The ATOMS computer program cannot create a symmetric crystal lattice with the experimental PDF cards; the program cannot give physical meaning with this continuing pattern change created by the atomic disorder. The crystalline material has different profile lines with clear periodicity and high intensity absorption, stable, chemical equilibrium. The atomic disorder interferences destroy any pattern. This is the reason the adhesive samples' X- Ray Diffraction curves pattern has no linearity.

The six dental adhesives exhibit a rapid photopolymerization, avoiding crystallization in photochemical reaction. The adhesives' photopolymerization process is promoted by adding adequate photosynthesizers and the camthoquinone photoinitiators. These promoters do not allow time for the monomers to organize before the cure light. The rate of photo-polymerization is rapid; it has no time for the molecules to organize in order to create crystalline structure

The dental amorphous material looks like liquid structure and the diffraction patterns are like liquid but are really a solid. When entering into the solid state with light curing, the liquid's physical properties are changed under the photopolymerization.

Relevant results of experiments appear in the plot of X R Diffraction R1 and R6. The patterns are typical of amorphous materials: we can see the constantly changing patterns, and therefore structure is not symmetric crystal lattice. Other relevant information is that the chemical composition obtained by the X-R and EDS experiments are close to the manufacturer's specification monomer elements, which are methacrylate derivatives. The constant of polymerization K of the experiment, all the values were greater than one, meaning that the products polymerized of dental bonding are more than the reactants at the equilibrium.

The final concentration of the hybrid layer is not uniform because it is affected by gravity; therefore the bond will be weak in direct relation to the lower density of the filler particles present in the hybrid layer. The density distribution affects the entropy and the negative free Gibbs's energy of the hybrid layer before the polymerization. Both benefit the spontaneous dental bonding by layer.

From the thermodynamics-energy viewpoint, the kinetics of spontaneous polymerization or constant polymerization K, is governed by standard Gibbs' free energy equation, $\mathbf{K=e^{-\Delta G/RT}}$, must be a positive value greater than one in order to get strong bonding. Positive value of K means that there is more polymerized adhesive than reactant monomers. The photopolymerization is a synthesis chemical reaction. In polymerization, chemical reaction constant K represents the rate forward (polymerization) and in reverse (depolymerization). In the dental adhesives, the depolymerization is not applied. The chemical reaction is only forward, one way only with the K greater than one. If we manipulate the value of K, we must to observe the monomers weight and the wavelength

size of the curing light. . The constant of photopolymerization K with the entropy represented by the monomers concentration in the dental bonding. The results are the chain cross-links networks with the structure of the amorphous material and can reach high strength with high elastic limits. The real numerical value of strength for each dental adhesive will be obtained through mechanical tests.

The photoinitiator absorbs light energy, disassociating the free radical monomer or energizes and then starts the photpolymerization initiation. The monomers absorb the light producing ions or free radical, only affecting the initiation step; the propagation and termination steps are not affected. Sometimes monomers need photo-sensitizers for initiation.

This discussion of photopolymerization concerns to the intertubular and peritubular dentine location. At this point, the photopolymerization can take advantage of a wet environment manipulating the process. The photochemical reaction waits for water to be evaporated; the polymerization is very fast and starts after the water evaporates; normally the molecules have no time to be organized into a uniform mix, presenting different concentrations, contraction gaps, internal stress, leakage and therefore infections. The water manipulation is located in the hybrid layer and is obtained from the etching treatment.

The photopolymerization control of dental adhesives statistic discussion uses the Minitab program, giving an amazing relationship between the factors variables and the effects producing in the dental restoration. The main factors are the wavelength size of curing light, the etching treatment evaporated water and the type of dental adhesive materials. The effects were measured and quantified with maximum tensile and shear stress applied to the six different samples on the mechanical test.

The best way to minimize discussion is referring to the interaction graphs of the statistic results for Mechanical test for design experiment.

These graphs were obtained from the Full Factorial and different Analysis of Variances (ANOVA). The statistic interactions plot, Fig. 8 shows the interrelationship-combined effects of the three different factors levels under tension and shears stresses. Considering the main objective of this study is define the best dental adhesive material on a total restoration, theses graphs plot show on the column –row material type factor F3 Mat R1-R6 the response variability of the different type of materials, from R1 to R6, affected with the wavelength and evaporation time treatment factors, giving a specific stresses responses. The most important information from the tensile stress is showing that the wavelength 600 nm of the material R2 can support the higher elastic tensile stress. In addition, the same graph shows the results for the factor water evaporation time F1 (t). The maximum tensile stress is supported by material, R2, with 2 min treatments. Therefore, the material R2 has the best result on Tension Mechanical experiment with 600 nm curing-light wavelength and two minutes of water evaporation on the etching treatments. Using the same technique we obtain the material results that can support the maximum shear stress on the plot interaction graph. R6 dental adhesive supports the maximum Shear Mechanical experiment with 600 nm curing-light wavelength and two minutes of water evaporation on the etching treatments.

Conclusion

The results from the EDS-SEM and X-R Diffraction patterns of different dental adhesives have almost the same profile curves as the amorphous structure. Concluding, in fact all six dental market adhesives do have amorphous structure. Normally the rate of photopolymerization is high; it allows no time for the molecules to organize and to create crystalline structure. For this reason, the amorphous structure has a high atomic disorder with high entropy in the glassy structure, as well as a negative Gibbs's free energy. This amorphous structure provides the energy necessary to create the spontaneous photopolymerization of dental bonding adhesive expressed in chain-cross-link polymer, controlled by the absorption of the photon light energy.

The manipulation of the time delay is an advantage of photopolymerization initiation process. Another conclusion obtained from the amorphous structure results from the SEM and X-R Diffraction experiments is that there exists the possibility to control the photo-polymerization process, giving more time for the dental bonding to obtain the maximum molecular organization thereby avoiding the internal defects like shrinkage, internal stress etc. As we

control the rate of water vaporization of the hybrid layer in intertubular and peritubular dentine, all photochemical reaction waits for the water to be evaporated. This event occurs before applying the curing light, and the restoration remains wet with dental adhesive and the bonding surfaces with water from the etching treatment. There is time delay obtained by the natural water evaporation, which the dentist can use in controlling the photopolymerization.

The energy photopolymerization is a variable, which can be manipulated by the curing light wavelength: the longer the wavelength, the slower the photopolymerization will be. That means now we have another conclusion at the atomic level that was tested with mechanical test data and ANOVA statistic experiments. Now we have another way to add more time delay for better atomic organization and avoid defects by using different wavelength size in the initiation of the photopolymerization. The curing light with a shorter wavelength close to the border of UV produces a fast and weak dental bonding, compared to the longer wavelength like visible light spectrum ~600 nm obtaining a uniform mix, and avoiding defects. Thus, dentist can use specific wavelengths of curing light for different layers of a specific type of the restoration.

The R2 and R6 with 600nm wavelengths and two minutes water evaporation time obtained the best results in total restoration test. Therefore, the dentist ca use the R2 for molar restoration and R2 and R6 can use for canine and incisor front teeth.

The EDS and X-R Diffraction elements chemical composition of the samples play an important role in the manipulation of the process. Some calculations explained in the discussion can determine an approximate value of the adhesive's monomers. These results reflect their possible bonding and rate of polymerization, based the polymers is a chain of monomers and the interconnection between monomers or chain can form a 3-D network. In addition, there is a possibility to predict the type of polymers bonding, based on competition of the electronegativity-affinity, atoms' radii and hybridation of the monomers elements. Thus, for different levels of electronegativities, we can predict the type of bonding that should be applied. This example of atomic radii sizes can clarify this conclusion; the atoms' radii of reactants can take a part in numerical evaluation of the photon energy that needs to remove or to add valence electrons from different energy orbital, creating the ions. Thus, these ions are the free radical initiators created and take a part in the ionic bond. When the atomic radii of the adhesive elements is known, we can obtain the lattice energy or strength of ionic bond that is directly proportional to the charge of the ions divided by sum of two radii. In addition, the radii size affects inversely proportional to the flow in the hybrid layer, which promotes a uniform, mix avoiding bonding defects.

The idea is to obtain the best uniform bonding with amorphous material existing in the market today, trying to achieve the best bonding result rather than having to create new adhesives, considering almost all of them, which have the same monomers to create the free radical chain reaction.

The amorphous adhesive is an energy-loaded material with a disposition to create the free radical photopolymerization .It attempts to be more stable at a lower energy level, especially with the covalent, ionic and Van der Wall's bonds, adhering to residual tooth and the composite filling. Future research can perform experiment's structure, with more factor effects of variability such as material, type of teeth, post type, crown and class of restoration. Showing a deeper relationship between the experiment's parameters and the real numerical value of mechanical properties reflected by tension-shear rupture stress, controlling with one interactive program, it wil be help to the dentist performance.

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