https://africanjournalofbiomedicalresearch.com/index.php/AJBR
Afr. J. Biomed. Res. Vol. 28(2s) (February 2025); 1274 - 1284
Research Article

Evaluate Bioactive Orthodontic Adhesive with Fluorescence Property.

Mohammed Thanoon Younis[1*], Prof. Dr. Ne'am F. Agha[2]

[1*]Assist lecturer, BDS, MSc, Department of Orthodontics, Pedodontics, and Preventive Dentistry, College of Dentistry, University of Mosul, Iraq. Mohammedthanoon@uomosul.edu.iq / ORCID No. 0000-0001-8140-8697

[2]Full Professor, BDS, MSc, PhD, Department of Orthodontics, Pedodontics and Preventive Dentistry, College of Dentistry, Al -Noor University, Mosul, Iraq. neamagha@uomosul.edu.iq /ORCID NO. 0000-0002-0439-9464

Abstract:
Objectives: This study aimed to assess the effect of adding fluorescent dyes to bioactive orthodontic adhesive by measure the degree of conversion & the shear bond strength.
Materials and Methods: Bioactive BEAUTIFIL Injectable XSL (S-PRG), from (GIOMER, SHOFU, JAPAN) mixed with Flourcence dye (Strontium aluminate), White Glow in the Dark Powder from (Techno Glow Inc., USA) which glows up for long time. using in 5%, 10% & 15% of weight concentrations. For degree of conversion (DC) we prepared 40 disc-shaped sample for 4 groups (with 10 sample for each) as following: Group1: BEAUTIFIL Injectable XSL (control group), Group2: BEAUTIFIL Injectable XSL with 5% flourcence dye, Group3: BEAUTIFIL Injectable XSL with 10% flourcence dye & Group4: BEAUTIFIL Injectable XSL with 15% flourcence dye. The DC was determined by using Fourier Transform Infrared spectrophotometer FTIR (ALPHAII PLATINUM-ATR. Bruker. GERMANY). For shear bond strength (SBS) 40 samples prepared & divided into 4 groups with 10 samples as following: Group1: BEAUTIFIL Injectable XSL (control group), Group2: BEAUTIFIL Injectable XSL with 5% flourcence dye, Group3: BEAUTIFIL Injectable XSL with 10% flourcence dye & Group4: BEAUTIFIL Injectable XSL with 15% flourcence dye. The shear strength measured by Instron Testing Machine (Gester international. CHINA).
Results: The use of fluorescent with bioactive adhesive show statistically no significant difference between groups. but there was decreasing in both DC & SBS with increase flourcence concentration.
Conclusions: add fluorescence dye produce acceptable fluorescence-bioactive adhesive & with increase its concentration will increase time of plowing which in turn simplified the removal of remnant after complete treatment with decrease enamel damage.

KEY WORDS: orthodontic; bioactive; fluorescent; degree of conversion; shear bond strength.

Received 18/01/2025, Acceptance 03/02/2025

DOI:https://doi.org/10.53555/AJBR.v28i2S.6663

INTRODUCTION

Orthodontic treatment involves using fixed or removable appliances to correct the positions of teeth. Orthodontic fixed device used to fixes occlusion discrepancies and tooth malpositions [(1,2)]

During treatment, wires are changed as the treatment advances but the brackets stay connected to enamel until treatment finish. A wide assortment of orthodontic adhesive available for the bonding brackets & orthodontic attachments. Light curing adhesives have a great choice for orthodontic holding as they

have great aesthetic & mechanical properties and little failure degrees [3,4]. Orthodontic Adhesive should be balance between providing sufficient strength to retain the appliance during the course of treatment, and allowing its easy removal at the end [5].

Patients with fixed orthodontic appliances show increase in the risk of white spot lesions and caries due to increased bacterial plaque accumulation [6]. These bacteria metabolize fermentable carbohydrates and produce acids which dissolve the mineral of the enamel resulting in enamel demineralization which observed as white spot lesions [7,8].

Efforts were made to decrease demineralization of enamel by presenting fluoride delivering adhesives e.g. amorphous calcium phosphate (ACP) containing adhesives [9. Light Bond from Reliance company, Transbond Plus Adhesive from 3M Unitek cmopany [10], glass ionomer & resin modified glass ionomer [11]. Another technique offered

by investigate groups is invention of bioactive glass (BAG) into the structure of orthodontic cements [12].

Bioactive glass material included the GIOMERS, as a surface pre-reacted glass core (S-prg). In the field of orthodontics, it helps prevent and treatment of white spots lesions [13]. Various ions release from S-prg include: fluoride, sodium, silicate, aluminium, borate and strontium ions which offer multiple biological roles, containing anti-plaque, pH modulation that providing protection against caries, the anti-biofilm effects & release & recharge of fluoride [14].

Another problem associated with orthodontic treatment are, after completion of orthodontic treatment (e.g. bracket failure), there are great troubles in eliminating the residual adhesive from the enamel surface [15] it represents critical activities that affect the enamel integrity. leaving adhesive remnant on the surface of enamel initiate formation of plaque and caries [16]. Also using rotating instruments to remove the remaining white or transparent adhesive cause damage to enamel [17].

To overcome this problem, orthodontic adhesive with fluorescent property has been industrialized to improve the brightness of the adhesive remenat after debonding [15]. Fluorescent additives will make it easier to distinguish between the enamel and adhesive residue after the debonding process, this adjustment can optimize the preservation of tooth structure [18].

Statement of problem: there is no orthodontic adhesive have both fluorescent and bioactive properties together, so that can provide excellent method to remove remnant of adhesive after complete treatment.

The aim of this study is to evaluate the effect of adding fluorescent materials to bioactive composite to be used as an orthodontic adhesive by evaluate the degree of conversion & the shear bond strength of the new bioactive adhesive after addition of fluorescent dye.

Materials & Methods

Materials:

1. BEAUTIFIL Injectable XSL (Self-Leveling) (Surface Pre-Reacted Glass/Pre-Activated Surface Ionomer (S-PRG), patented and exclusive technology. GIOMER, SHOFU Inc., Kyoto. JAPAN)
2. Flourcence dye material, White Glow in the Dark Powder (Techno Glow Inc, USA) (Strontium aluminate) which glows up for long time.

For flourcence dye material use the following concentrations according to company instruction 5%, 10% & 15%.

Mixing method:

The components were weighed by using a precision scale (Kern ABS analytic balance 120-4N, Kern Corporation, Germany). To achieve homogeneous distribution of the flourcence material within the giomer structure, mixing was done by using the electro-mechanical stirrer (Krafit ki-20 dental implant motor, Saeyang Company, Korea) they mixed for 90sec (45sec clockwise & 45sec counter-clockwise) at 2,500 rpm and at room temperature until the mixture becomes homogeneous. During mixing of a material, the material is continuously pushed into the corner between bottom and cup wall, whereas the additional rotation forces move the material towards the center of mixing cup. After that, the mixture extracted from the cup and kept at room temperature until a day of preparing the samples by stored it in lightproof containers to prevent the exposure to ambient light and to allowed it to grow freely until used it [19, 20].

Methods:

This study was conducted at Mosul university, Dentistry College, Dental Hospital Central laboratory. And was approved by the Ethics Committee of College of Dentistry/ Mosul University/ IRAQ (under the code UoM.Dent.23/49).

Degree of Conversion:

We prepared 40 disc-shaped sample for 4 groups (with 10 sample for each) as following groups:

Group1: BEAUTIFIL Injectable XSL (Self-Leveling) Adhesive (control group)

Group2: BEAUTIFIL Injectable XSL (Self-Leveling) with 5% flourcence material.

Group3: BEAUTIFIL Injectable XSL (Self-Leveling) with 10% flourcence material.

Group4: BEAUTIFIL Injectable XSL (Self-Leveling) with 15% flourcence material.

Specimen Preparation for Test Degree of Conversion:

To prepare the disc-shaped specimens for testing degree of conversion (DC), we poured uncured testing materials into plastic molds of 5 mm in diameter and 2 mm in thickness, which was confined from both side by transparent strip and a 1mm in thickness laboratory glass slide. i.e; mold was sandwiched between transparent strips & glass slides, which was pressed on top of the plastic mold. then specimen polymerized using a LED light-curing Curing Pen (Eighteeth. Version:03. Changzhou Sifary Medical Technology Co., Led. CHINA) with 380-515nm wavelength & with at 1500 mw/cm^2. The LED tip positioned on the top surface of

the disc for photo-activation with 20sec curing time as prescribed by the producer. A glass slide was applied to standardize the distance between the specimen and light source, also to create sample with a flat smooth surface & to prevent oxygen inhibition layer. after curing specimen removed from mold then remove any excess edges from it by scalpel blade. This process was made at room temperature & repeated for all testing groups, after that specimens were coded & to prevent additional exposure to light exposure it kept in dry & dark container containing deionized water at room temperature for 24hr prior to testing [21,22,23].

Measuring the degree of conversion:

The DC was inspected for each spacemen using Fourier Transform Infrared spectrophotometer FTIR (ALPHA II PLATINUM-ATR. Bruker OPTIK GmbH & Co. GERMANY). FTIR spectroscopy has been demonstrated to be an effective strategy and has been utilized as are obligated strategy because it identifies the C = C stretching vibrations directly before and after curing of composite resins. Each specimen was placed directly in the center of the crystal of the ATR detector's crystal for prompt analysis see shape (1). As non-cured references, non-cured resin specimens were also exposed to FTIR spectroscopy. Between each measurement, Ethyl alcohol and soft absorbent paper were used to clean the crystal plate, and an air blower was used to dry it. The measuring done in the 1st Central laboratory in the College of Sciences-Mosul University [24,25,26].

To measure the degree of conversion (DC) The aliphatic carbon = carbon of each sample was compared to the aromatic component for both cured and uncured resins. each sample was determined by comparison of the aliphatic carbon = carbon with that of the aromatic component for the cured and uncured resins. The aliphatic carbon = carbon (C = C) double bond group has a characteristic infrared absorption peak around 1,636 cm^{-1} to 1,608 cm^{-1}. The aromatic carbon - carbon (C..C) single bond peaks due to the aromatic bonds of the monomer molecules. The DC was calculated by the following equation: [27,28].

$$DC\% = 1 - \left[\frac{C_{aliphatic} / C_{aromatic}}{U_{aliphatic} / U_{aromatic}} \right] . 100$$

DC% = 1 – [Cured aliphatic (C = C)/Cured aromatic (C..C)] / [Uncured Aliphatic (C = C)/Uncured Aromatic (C..C)] × 100.

Cured aliphatic (C = C) = Absorption peak at 1,636 cm^{-1} of the cured specimen. Cured aromatic (C..C) = Absorption peak at 1,608 cm^{-1} of the cured specimen. Uncured aliphatic (C = C) = Absorption peak at 1,636 cm^{-1} of the uncured specimen. Uncured aromatic (C..C) = Absorption peak at 1,608 cm^{-1} of the uncured specimen.

Shear Bond Strength Test:

A total of 40 human maxillary premolars extracted for orthodontic purpose were collected and then washed thoroughly with plain water to remove any tissue debris or blood and cleaned it from calculus using an ultrasonic scaler. Then it stored at $37^{O}C$ for no longer than three months in dark jars having distilled water to prevent them from drying up which was altered at regular intervals to avoid deterioration [29,39,31]. The following requirements must be met in order for the teeth to be assessed in this study: extracted for orthodontic purpose, undamaged labial tooth surface, teeth with a distinct morphology and anatomy & absence of any structural or developmental defect, teeth intact buccal enamel & with non-caries & with absence of cracks caused by the extraction procedures while exclusion criteria for the sample are as follows: Fracture of tooth surface, teeth with caries or restorations or previous orthodontic history. Sample stored improperly after tooth removal. Variations in crown morphology & enamel defects, hypo-calcifications, or fluorosis on the buccal surface & gross enamel hypoplasia. Teeth treated with chemical agents [29,32]

Sample preparation

Method of mounting teeth: Each tooth was placed & aligned vertically in the center of a standardized PVC mounting ring with dimension (height 20.55 mm & diameter 21.25 mm) & then this ring filled with cold cure acrylic resin, so that the buccal surface of the crown was perpendicular to the block's base and the roots were fully implanted in the acrylic to the cementoenamel junction [24,33]. The mounting jig was utilized for alignment of buccal surfaces of the teeth parallel with the applied force during the shear test this done by using a dental surveyor. See shape (2). Until the bonding time all of these block put in deionized water at room temperature [34, 35].

Enamel Surface Conditioning: The teeth's buccal surface was delicately polished with non-fluoridate pumice powder (PD Company, Switzerland) slurry using rubber cup (TPC, CHINA) mounted on a slow speed contra angle hand piece (10,000) rpm (Apple. CHINA for 10 seconds. Subsequently, after polishing, the teeth washing with water for 10 seconds and dried with oil free air from a 3-way syringe (Delma. CHINA). A 37% phosphoric acid (Scotchbond Universal Etchant Gel, 3M ESPE, GERMANY) was applied for a 15 sec to the buccal surface then it washed away with water for 10 sec. After that, the tooth surface was dried using oil free air 3-way syringe (Delma. CHINA) until chalky white appearance, on the enamel was noted, then by using disposable microbrush (TPC, CHINA) apply a thin film of bonding agent (Shofu. JAPAN) was applied on the center of etched tooth surface & gently thinned with air directed perpendicular to the labial surface then light cured it for 10 seconds by LED [36,37] after that all samples isolate to avoid contamination of the treatment area. The above procedure was done for all the test specimens, to be bonded with adhesives to be evaluated [24,38].

Bonding procedure: After that, samples are randomly coded by numbers for easy identification & to differentiate. Then these prepared samples were randomly divided into 4 groups with 10 samples in each group according to the material used for bonding. So they divided as following:

Group1: BEAUTIFIL Injectable XSL (Self-Leveling) Adhesive (control group)
Group2: BEAUTIFIL Injectable XSL (Self-Leveling) with 5% flourcence material.
Group3: BEAUTIFIL Injectable XSL (Self-Leveling) with 10% flourcence material.
Group4: BEAUTIFIL Injectable XSL (Self-Leveling) with 15% flourcence material.

All the materials used in this study were applied according to manufacturing instructions. The bracket used are upper 1st premolar stainless steel bracket Equilibrium® roth system with a 0.022-inch slot and torque: -7°/ Angulation: 0° with a mesh base surface area of 12.25mm^2 (Dentaurum GmbH & Co., Germany) [35].

Each sample positioned in the table of dental surveyor then After that, adhesive was directly applied to the bracket's base. A bracket holder (Dentaurum GmbH & Co. Germany) held the bracket and carried it straight & positioned along the midline of buccal surface at a distance of 4 mm from the occlusal surface this achieved by using bracket positioner (DENTAURUM GmbH & Co. Germany). After applying the adhesive, we pressed the brackets gently & firmly on the enamel surface by pressed the reverse end of the bracket holder after that the specimen placed under a load of 200 gr to ensure a complete seating. A dental probe was used to smoothly remove the extra bonding resin from the bracket base's edge [39-40].

The curing was carried out by LED with at 1500 mw/cm^2 and it was done for 10sec on each bracket face (mesial, distal, cervical and occlusal). After polymerization, the samples were incubated in deionized water at 37^{o}C for 24hr. This period simulated oral conditions [35,41].

Debonding procedure: Debonding was done at room temperature [35] & in central laboratory in the Dentistry College Mosul university. The shear bond strength of the specimens carried out by Instron Testing Machine (Gester international Co. LTD- model GT - K03B). The specimen-mounted acrylic block was secured to the machine's lower grip (fixed head), in a manner that blocks were placed with the long axis parallel to the direction of the load application, and a blade-shaped steel rod was fixed in the upper grip (movable head) connected to the load level. The cervico-incisal dimension of the buccal surface was parallel with the vertical plane. The blade was positioned in such a way that it touched the bracket-tooth interface as possible to determine the force required to detach the brackets see shape [3]. So as to record the force at which the bracket debonded, the crosshead speed was set to 1 mm/min. The highest load for debonding reported in Newtons (N) and then altered into Megapascal (Mpa). by using formula: [33,39,42].

$$\text{Force in Newton} = \frac{\text{Bond strength MPa}}{\text{Surface area of the bracket in mm}^2}$$

Statistical analysis:

A one-way analysis of variance (ANOVA) was used for the statistical analysis. with significance level =0.05.

Result:

The (DC) values, are represented in units of (percent %), which mean the degree of percent of converting resin from monomer to polymer. The descriptive statistics that includes the minimum, maximum, mean & standard deviation, are given in the table (1). The results indicate that the control group's mean DC value produced the highest mean, which was followed by groups F5% & F10% respectively, while the groups F15% of give rise to the lowest one. See figure (1).

Table (1): Descriptive Analysis of Degree of conversion in (%)

Groups	N.	1	2	3	4	5	6	7	8	9	10	Mini.	Maxi.	Mean	Std. Deviation
control	10	71	68	71	66	73	67	69	72	69	68	66	73	69.4	2.27
Adhesive + 5% flourcence dye	10	71	69	69	67	71	69	69	70	69	69	67	71	69.3	1.15
Adhesive + 10% flourcence dye	10	71	69	68	69	71	69	68	70	69	66	66	71	69.0	1.49
Adhesive + 15% flourcence dye	10	70	69	67	67	70	69	67	69	69	65	65	70	68.2	1.61

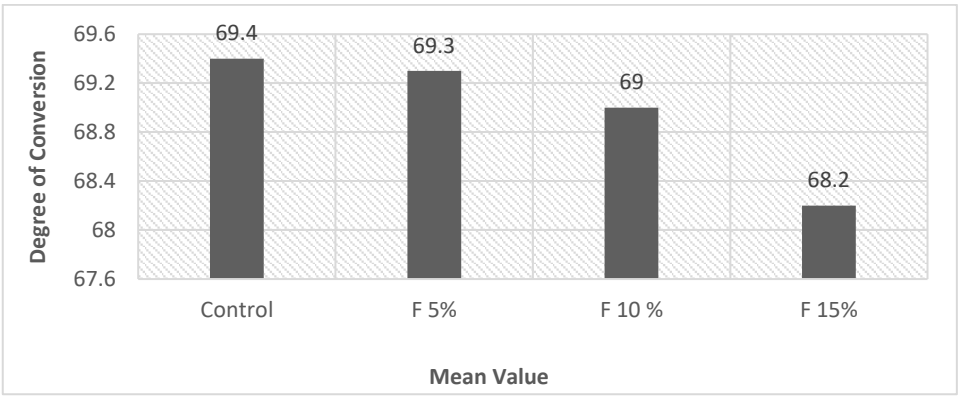


Figure (1): The Histogram for the Degree of conversion in (%)

For every group, the analysis of variance of one way (ANOVA) test reveals no significant difference ($p \leq 0.05$) between them as illustrated in table (2).

Table (2): Difference Between Degree of Conversion of groups by using ANOVA (one way)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.875	3	2.958	1.043	0.385
Within Groups	102.100	36	2.836		
Total	110.975	39			

$P \leq 0.05$

The Duncan's multiple range test result in table (3) show no significant difference within groups a significant difference ($p \leq 0.05$).

Table (3): The Duncan's Analysis for Determining the Significant Difference Between the Groups

Groups	N	Mean	Std. Deviation	DMRT groups
control	10	69.4000	2.27058	A
F 5%	10	69.3000	1.15950	A
F 10 %	10	69.0000	1.49071	A
F 15%	10	68.2000	1.61933	A
Total	40	68.9750	1.68686	No significant difference

DMRT groups = Duncan Multiple Range Test

The same letters have no significant difference and different letters have significant difference

The shear bond strength (SBS) values, are signified in units of (MPa). The descriptive statistics includes the minimum, maximum, mean & standard deviation, are given in the table (4). The results of this study show that the control group's mean SBS value produces the highest mean followed with the groups F5% & F10% respectively, while the groups F15% of give rise to the lowest one. See figure (2)

Table (4): Descriptive Analysis of Shear Bond Strength in (MPa)

Groups	N.	1	2	3	4	5	6	7	8	9	10	Mini.	Maxi.	Mean	Std. Deviation
control	10	20.91	13.41	16.8	14.48	12.3	20.59	13.64	15.69	13.43	12.66	12.30	20.91	15.39	3.13
Adhesive + 5% flourcence dye	10	16.81	17.77	16.18	15.61	12.57	12.77	14.47	13.13	14.37	18.05	12.57	18.05	15.17	2.02
Adhesive + 10% flourcence dye	10	15.22	12.44	14.47	14.36	14.91	13.14	15.67	16.25	13.02	16.35	12.44	16.35	14.58	1.36
Adhesive + 15% flourcence dye	10	11.97	20.51	13.84	13.62	13.52	11.57	13.66	13.11	11.3	16.11	11.30	20.51	13.92	2.69

* MPa = Megapascal

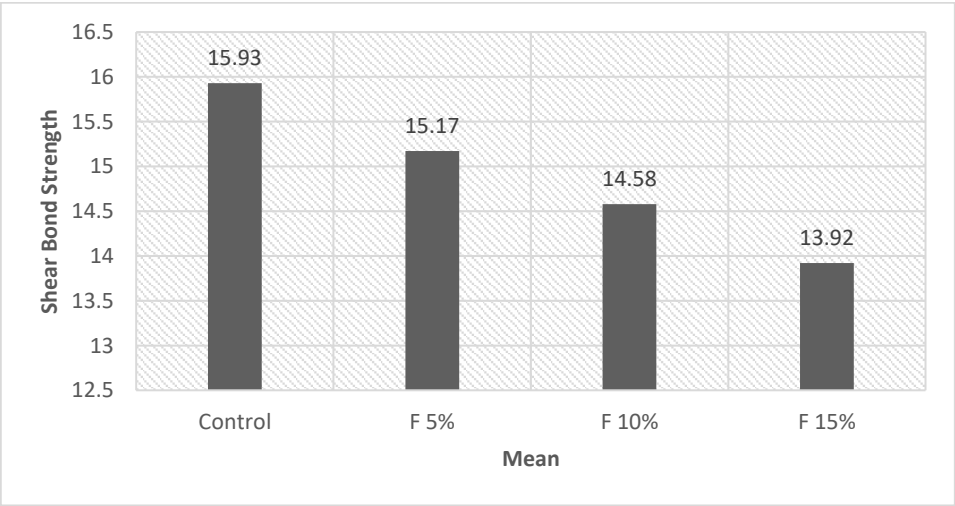


Figure (2): The Histogram for the Shear Bond Strength

As shown in table (5), the analysis of variance of one way (ANOVA) test for each group reveals no significant difference ($p \leq 0.05$) between them.

Table (5): Difference Between Shear bond strength of groups by using ANOVA (one way)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.038	3	4.346	.755	.527
Within Groups	207.181	36	5.755		
Total	220.218	39			

$P \leq 0.05$

The Duncan's multiple range test result in table (6) show no significant difference within groups a significant difference ($p \leq 0.05$).

Table (6): The Duncan's Analysis for Determining the Significant Difference Between the Groups

Groups	N	Mean	Std. Deviation	DMRT groups
control	10	15.39	3.13	A
F 5%	10	15.17	2.02	A
F 10 %	10	14.58	1.36	A
F 15%	10	13.92	2.69	A
Total	40	14.76	2.37	No significant difference

DMRT groups = Duncan Multiple Range Test

The same letters have no significant difference and different letters have significant difference

Discussion

the Degree of Conversion (DC) known as the amount of double carbon bonds (C=C) in the monomers that are changed into single bonds (C−C) to create the polymeric chain throughout the polymerization process [43].

The DC of the aliphatic C=C in orthodontic adhesive resins is an essential feature that affect the mechanical and physical properties such as flexural modulus of compressive strength, elasticity, tensile strength, hardness, color stability, degradation, solubility and biocompatibility. Generally, mechanical strength increases with double bond conversion while the unreacted double bonds may either be present in free monomer or on the network. Therefore, One desirable property of a polymerization system is the reduction of the remaining double bonds to the lowest level feasible [44].

FTIR analysis provides a straightforward, trustworthy, and more accurate method of assessing the DC [45].

There are different factors that could affect the DC of composite resin such as the transmission of light through the material & properties of the matrix [46], the initiator/inhibitor concentration & type in the resin [47], chemical structure & composition of the resin, [48], viscosity of the monomers [49 time & duration of exposure, light intensity, and the energy absorbed by the resin [50]. Additionally, the filler volume fraction that can cause light to be reflected by the tooth structure and filler particles placed between the composite and the light source [51].

In the current study, the findings clearly show that DC have little difference between variable groups and the control group which have the highest DC one with 69.4 % while the adhesive with 15% flourcent have the lowest one with 65.8 % DC. Anyway all DCs are within range for composite resins that has been documented in the literature: 55-75% [52]. These differences among groups related to many factors:

First, we find there was a relation between DC & viscosity, as when add dyes it will affect the viscosity of adhesive which later affect the DC %. The low viscosity samples, like the control group, had the highest DC mean values, as Because of their reduced viscosity, resins can better distribute free radicals and facilitate monomeric mobility, which can speed up the polymerization process and increase monomer conversion. This principle also states that low viscosity groups facilitate the curing reaction and allow for greater diffusion of reactive groups, which raises the DC. whereas when the viscosity increase the remaining reactive species are totally immobilized. As a result, the polymerization stops before all of the reactants have been consumed. These explain why the control group have the high DC as it don't have dye so it's have low viscosity while other groups have adding dye fillers with different percent. These agree with [53-56].

Furthermore, increasing filler proportion, increase the scattered light that will reduce overall light transmittance through the resin material & the more hard for the light to pass through the resin and consequently cause reduction the DC. This explain way the DC decrease when the percent of fluorescent or color change within group increase. This agree with Arikawa *et al.* (2007). & da Silva *et al.* (2008) [57-58].

In SBS, Reynolds in (1975) [59] suggest that 5.9 MPa recognizes as the minimum accepted bond strength value. In this study all results values which obtained are higher than that Reynold's value, but they are different in each mean group. These differences related to many reasons as will explained as following:

Firstly, This study discovered a strong positive correlation between SBS and DC, similar to what was proposed by Chidipothu & Chandrasekhar (2012) [60]. So, we suggest that increasing the degree of conversion (DC) will results in increasing the shear bond strength. Therefore, this would lead to a stiffer and a more durable resin. As, when the DC increase, it will increase the

monomer to polymer conversion, so the SBS will increase. this in turn agree with Yoshida (2012) [61] & Abdul Majid & Elbadry (2016) [62].

Other reason related to the add filler which affect the shear bond strength which lead to decrease bond strength this is may be due to correlating between the DC values and the material's viscosity that investigated, the highest DC mean values were discovered in the samples with low viscosity. The filler content affects the resin's viscosity, monomers and spread of the polymerization reaction this phenomenon agree with Francescantonio et al (2013) [55]. Additionally, resins' reduced viscosity promotes better monomeric mobility and free radical distribution within the material, which can speed up polymerization and increase monomer conversion. Low viscosity composites may therefore enable improved diffusion of reactive groups and encourage the curing reaction due to this principle, which would raise the DC which agree Ferracane & Greener (1984) [53] & Uysal et al. (2010)[63]. In addition, from present study we suggest that The viscosity and flow characteristics of the adhesive are crucial. Due to their ability to better penetrate the adhesive into the bracket base's mesh and the etched enamel surface's microporosities, lower viscosity composites enhance handling characteristics and bond strength which agree with Pradeep et al (2013) [64], Sari et al. (2014) [65], Nobre et al. (2020) [66] & Inatomi et al (2021) [67].

Also adding filler particle cause increase porosities within the resin matrix, resultant in dropping the SBS and other mechanical properties which agree with Santos *et al*. (2002) [68]. Also agree with Altmann *et al*. (2017) [69] who discovered that nanoparticles decreased DC, indicating that this decrease might have resulted from reactive groups' restricted mobility brought on by the quick creation of a cross-linked polymeric network. Furthermore, Elsharkawy in 2018 [70] statements that adding more fillers will effect on the viscosity of adhesive, which may lead to inadequate penetration into the tubule. This is because agglomeration of the nanoparticles is the primary cause of the decreases in DC and SBS because it prevents light from passing through the adhesive layer, which obviously slows down the photopolymerization process. Barylyak *et al*. in 2024[71] suggest that adding up to 1% of filler to orthodontic adhesive is acceptable, because exceeding this limit cause the decreasing the values of shear bond strength.

While Faltermeier *et al* in 2007[72] and Memarpour *et al*. in 2019[73] claimed that increasing the amount of filler enhanced the mechanical qualities of the adhesive and revealed a stronger bond between the enamel and the stainless steel brackets. This may be due to type of filler & its bond with adhesive.

While AlSamak *et al* in 2023[74] said that the fluorescent orthodontic adhesives demonstrated higher SBS than traditional ones.

While from 3rd view, Dastjerdi *et al* in 2018[35] & Al Shehab *et al* in 2022[75] suggest that filler does not significantly affect the shear bond strength of orthodontic adhesive. Rossato *et al* in 2020 [18] said that the addition of fluorescent elements does not alter the in vitro and clinical mechanical strength of the orthodontic adhesive

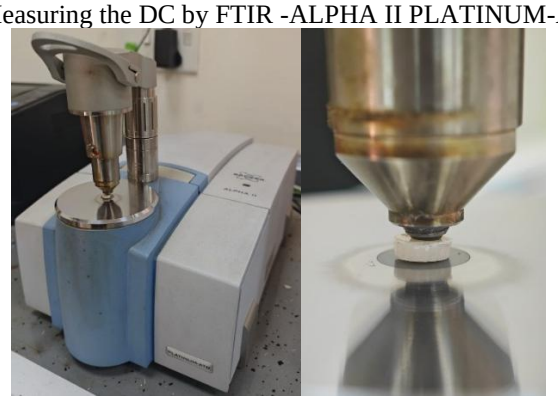
Other 4th view like Hasan in 2021 [22] supposed that adding 2% weight nanoparticle to Heliosit adhesive increased the adhesive's SBS, but adding 4% weight caused a noticeable decrease in SBS. While Mohammed et al. in 2024 concluded that incorporating colored resin into fluoride releasing restorative material particularly 10% can produce acceptable bite riser with regards to SBS [76].

Also in this study the we suggest that the color of adhesive affects the degree of polymerization. As, the dark color cause decrease in DC and then decrease in SBS this result approves with Koupis *et al*. (2006) [77] who found that shade A4 offers lower curing degree values than shade A2. We hypothesize that this is because darker pigments absorb more light, which makes it harder for light to penetrate the resin deeply this agree with Jafari and Mirzakochaki (2015) [78]. While on the other hand, Other research found that darker materials produced better polymerization than lighter ones as Rizzante *et al*, 2019 & Contreras *et al*, 2021 [79,80].

Conclusion:

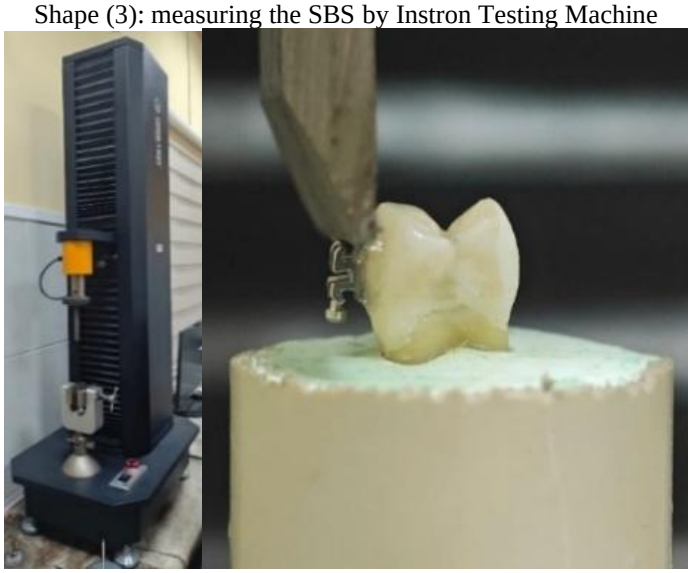
Adding fluorescence dye produce acceptable fluorescence-bioactive adhesive and with increase fluorescence dye concentration will cause increase time of plowing which in turn facilitated the removal of remnant of adhesive after complete orthodontic treatment with decrease enamel damage.

Shape (1): Measuring the DC by FTIR -ALPHA II PLATINUM-ATR. Bruker



Shape (2): The mounting jig was utilized for alignment of buccal surfaces of the teeth parallel with the applied force during the shear test this done by using a dental surveyor

Shape (3): measuring the SBS by Instron Testing Machine



Refferences:

1. Tsichlaki A., Chin S.Y., Pandis N., and Fleming P.S. (2016). How Long does Treatment with Fixed Orthodontic Appliances Last? A Systematic Review. American Journal of Orthodontics and Dentofacial Orthopedics, 149(3): 308–318.
2. Stasinopoulos D., Papageorgiou S.N., Kirsch F., Daratsianos N., Jäger A., and Bourauel C. (2018). Failure Patterns of Different Bracket Systems and their Influence on Treatment Duration: A Retrospective Cohort Study. The Angle Orthodontist, 88(3): 338–347.
3. Millett, D. T., Glenny, A. M., Mattick, R. C., Hickman, J., & Mandall, N. A. (2016). Adhesives for fixed orthodontic bands. *Cochrane Database of Systematic Reviews*, Issue 10. Art. No.: CD004485.Pp:1-19
4. Kilponen, L. (2020) Orthodontic Brackets to Enamel. Studies on the Clinical Outcome of Bracket Bonding and Approaches to Increase the Bond Strength of the Adhesive Interface Annales Universitatis Turkuensis. Sarja - Ser. D Osa – Tom. 1497 | Medica – Odontologica | Turku :1-88
5. Littlewood, S. J., & Mitchell, L. (2019). *An introduction to orthodontics*. Oxford university press. 5th ed, P:232
6. Tufekci E, Dixon JS, Gunsolley JC, Lindauer SJ. Prevalence of white spot lesions during orthodontic treatment with fixed appliances. Angle Orthod 2011;81:206-10.
7. Naidu, S., & Suresh, A. (2019). Bond failure rate of amorphous calcium phosphate containing (aegis ortho) and fluoride releasing (transbond plus colour change) orthodontic adhesives–a randomized clinical trial. *J. Indian Dent. Assoc.*, *13*, 18-26.
8. Spatafora, G., Li, Y., He, X., Cowan, A., & Tanner, A. C. (2024). The evolving microbiome of dental caries. *Microorganisms*, *12*(1), 121.
9. Skrtic D, Hailer AW, Antonucci JM, Takagi S, Eanes ED. Quantitative assessment of the efficacy of amorphous calcium phosphate/methacrylate composites in remineralizing caries-like lesions artificially produced in bovine enamel. J Dent Res. 1996;75:1679–1686.
10. Pseiner, B. C., Freudenthaler, J., Jonke, E., & Bantleon, H. P. (2010). Shear bond strength of fluoride-releasing orthodontic bonding and composite materials. The European Journal of Orthodontics, 32(3), 268-273.
11. Kohda, N., Iijima, M., Brantley, W., Muguruma, T., Yuasa, T., Nakagaki, S., & Mizoguchi, I. (2012). Effects of bonding materials on the mechanical

properties of enamel around orthodontic brackets. *The Angle Orthodontist*, *82*(2), 187-195.
12. Kuśmierczyk, D., & Małkiewicz, K. (2019). Orthodontic adhesive systems–over half a century of research and experience. *Journal of Stomatology*, *72*(4), 179-183.
13. Takahashi Y, Okamoto M, Komichi S, Imazato S, Nakatsuka T, Sakamoto S, *et al*. Application of a direct pulp capping cement containing S-PRG filler. Clin Oral Investig 2019;23(4):1723-1731.
14. Kaga, N., Nagano-Takebe, F., Nezu, T., Matsuura, T., Endo, K., & Kaga, M. (2020). Protective effects of GIC and S-PRG filler restoratives on demineralization of bovine enamel in lactic acid solution. *Materials*, *13*(9), 2140.
15. Salomão FM, Rocha RS, Franco LM, Sundfeld RH, Bresciani E, Fagundes TC. (2019) Auxiliary UV light devices for removal of fluorescent resin residues after bracket debonding. J Esthet Restor Dent.;31(1):58–63.
16. Patcas, R., & Eliades, T. (2017). Enamel alterations due to orthodontic treatment. In *Orthodontic Applications of Biomaterials* Woodhead Publishing ch:14;pp. 221-239
17. Sfondrini MF, Scribante A, Fraticelli D, Roncallo S, Gandini P. Epidemiological survey of different clinical techniques of orthodontic bracket debonding and enamel polishing. J Orthod Sci 2015; 4: 123-127
18. Rossato, P. H., Kaneshima, E. N., Domingues, F., Fernandes, T. M. F., Berger, S. B., & Oltramari, P. V. P. (2020). Do fluorescent agents alter the mechanical strength of orthodontic adhesives? An in vitro and clinical study. *Progress in Orthodontics*, *21*, 1-6.
19. Amin, O. A., Hassan, S. A., Sadek, M. A., Radwan, M. A., & Elazab, H. A. (2021). Mechanical characteristics for composite materials using commercial epoxy resins and different fillers. *Journal of Southwest Jiaotong University*, *56*(5).
20. de Resende, L. F. M., Catelan, A., Baroudi, K., Palialol, A. R. M., de Resende, A. M., Andreucci, A. C., ... & Liporoni, P. C. S. (2022). Mechanical Properties of Experimental Composites with Different Photoinitiator. *European Journal of Dentistry*, *16*(01), 167-172.
21. Lacerda-Santos, R., de Meneses, I. H. C., de Morais Sampaio, G. A., Pithon, M. M., & Alves, P. M. (2016). Effect of degree of conversion on in vivo biocompatibility of flowable resin used for bioprotection of mini-implants. The Angle Orthodontist, 86(1), 157-163.
22. Hasan, L. A. (2021). Evaluation the properties of orthodontic adhesive incorporated with nano-hydroxyapatite particles. Saudi Dent J 33 (8): 1190–1196.
23. Hassan, S. S., Al-Jadwaa, F. T., & Ashou, W. M. O. (2022). Evaluation of degree of conversion of different types of bulk-fill resin composites. J Glob Sci Res, 7, 2104-16.
24. Nimcharoensuk, K., Anuwongnukroh, N., Dechkunakorn, S., Sattabanasuk, V., Sunintaboon, P., & Wichai, W. (2019). Cytotoxicity of an experimental light-cured orthodontic adhesive. Solid State Phenomena, 294, 65-70.
25. Kilponen, L. (2020) Orthodontic Brackets to Enamel. Studies on the Clinical Outcome of Bracket Bonding and Approaches to Increase the Bond Strength of the Adhesive Interface Annales Universitatis Turkuensis. Sarja - Ser. D Osa – Tom. 1497 | Medica – Odontologica | Turku :1-88
26. Yılmaz, B., Bakkal, M., & Zengin Kurt, B. (2020). Structural and mechanical analysis of three orthodontic adhesive composites cured with different light units. Journal of applied biomaterials & functional materials, 18;1-8; 2280800020901716
27. Mäkinen, E., Lassila, L., Varrela, J., & Vallittu, P. (2019). Light-curing of orthodontic bracket adhesive by transillumination through dentine and enamel. Biomaterial investigations in dentistry, 6(1), 6-12.
28. Aung, S. Z., Takagaki, T., Ikeda, M., Nozaki, K., Burrow, M. F., Abdou, A., Nikaido T, & Tagami, J. (2021). The effect of different light curing units on Vickers microhardness and degree of conversion of flowable resin composites. Dental materials journal, 40(1), 44-51
29. Hijazi A. H. (2019) Evaluation of Shear Strength of The Bracepaste Adhesive In Comparison With 3m Transbond Xt Adhesive Material. Master Thesis. Istanbul Yeni Yüzyil University .Health Sciences Institute Department of Orthodontics
30. Kethavath, T., Surender, B., & Shailaja, J. T. (2023). Evaluation of enamel colour changes with orthodontic bonding an in vitro study. *IP Indian Journal of Orthodontics and Dentofacial Research*, *8*(1), 28-33.
31. Kumar, P. (2024) Evaluation of enamel colour changes with orthodontic bonding an in vitro study. Afr.J.Bio.Sc.6(15)
32. Sanjay Prasad Gupta & Basanta Kumar Shrestha (2018) Shear bond strength of a bracket-bonding system cured with a light-emitting diode or halogen-based light-curing unit at various polymerization times Clinical, Cosmetic and Investigational Dentistry:10 61–67
33. Rameez, M., Kiran, H., Alle, R. S., Bharathi, V. S., & Dharmesh, H. S. (2020). Comparison of SBS of colour changing adhesives-Transbond Plus, Blugloo, Grengloo. *Journal of Advanced Medical and Dental Sciences Research*, *8*(1), 1-8.
34. Althagafi, N. M. (2022). Impact of fluoride-releasing orthodontic adhesives on the shear bond strength of orthodontic brackets to eroded enamel following different surface treatment protocols. *Journal of Orthodontic Science*, *11*(1), 3.
35. Dastjerdi, E. V., Nahvi, G., Amdjadi, P., & Aghdashi, F. (2018). Bond strength of an orthodontic adhesive containing an antibiofilm agent (octafluoropentyl methacrylate). *Contemporary clinical dentistry*, *9*(Supp 1), S39-S44
36. Sfondrini MF, Gandini P, Gioiella A, Zhou FX, Scribante A. Orthodontic metallic lingual brackets:

the dark side of the moon of bond failures? J Funct Biomater. 2017;8:27.
37. Rameez, M., Kiran, H., Alle, R. S., Bharathi, V. S., & Dharmesh, H. S. (2020). Comparison of SBS of colour changing adhesives-Transbond Plus, Blugloo, Grengloo. *Journal of Advanced Medical and Dental Sciences Research*, *8*(1), 1-8.
38. Fonseca-Silva, T., Otoni, R. P., Magalhães, A. A. M., Ramos, G. M., Gomes, T. R., Rego, T. M., ... & Santos, C. C. D. O. (2020). Comparative analysis of shear bond strength of steel and ceramic orthodontic brackets bonded with six different orthodontic adhesives. *Int. J. Odontostom*, *14*(4), 658-663.
39. Bucur, S. M., Cocoș, D., & Saghin, A. (2020). Bond strength of three adhesive systems used for bonding orthodontic brackets. *Romanian Journal of Oral Rehabilitation*, *12*(1), 162-7
40. Fonseca-Silva, T., Otoni, R. P., Magalhães, A. A. M., Ramos, G. M., Gomes, T. R., Rego, T. M., ... & Santos, C. C. D. O. (2020). Comparative analysis of shear bond strength of steel and ceramic orthodontic brackets bonded with six different orthodontic adhesives. *Int. J. Odontostom*, *14*(4), 658-663.
41. Guravaiah, D., Prudhvi, K., Kiran, S. S. M., Kavya, K. S., & Ram, R. R. (2023). An In-Vitro Comparison of Shear Bond Strength and Adhesive Remnant Score Between Two Color Change Adhesives in Orthodontic Bonding With Reduced Curing Time Using Different High-Intensity Light Emitting Diode Units. *Cureus*, *15*(6).
42. Bud, E. S., Bucur, S. I., Cocoș, D. I., Bucur, S. M., Bud, A., & Vlasa, A. (2021). Challenges of using transbond plus in orthodontic treatment. *Romanian Journal of Oral Rehabilitation*, *13*(1).
43. Masood, T. M., Abbassy, M. A., Bakry, A. S., Matar, N. Y., & Hassan, A. H. (2018). Fourier-transform infrared spectroscopy/attenuated total reflectance analysis for the degree of conversion and shear bond strength of Transbond XT adhesive system. Clinical, cosmetic and investigational dentistry, 275-280.
44.]. Tanthanuch S and Kukiattrakoon B. Degree of conversion and hardness of resin composite using various light curing units. Songklanakarin Dent. J, 6:28-47. 2018.
45. Atai M, Watts DC, Atai Z. Shrinkage strain-rates of dental resin-monomer and composite systems. Biomaterials 2005;26(24):5015-20.
46. Correr AB, Sinhoreti MA, Sobrinho LC, Tango RN, Schneider LF, Consani S. Effect of the increase of energy density on Knoop hardness of dental composites light-cured by conventional QTH, LED and xenon plasma arc. Braz Dent J 2005; 16(3):218-24.
47. Musanje L, Ferracane JL, Sakaguchi RL. Determination of the optimal photoinitiator concentration in dental composites based on essential material properties. Dent Mater 2009;25(8):994-1000.
48. Leprince JG, Hadis M, Shortall AC, et al. Photoinitiator type and applicability of exposure reciprocity law in filled and unfilled photoactive resins. Dent Mater 2011;27(2):157-64.
49. Sideridou I, Tserki V, Papanastasiou G. Effect of chemical structure on degree of conversion in light-cured dimethacrylate- based dental resins. Biomaterials. 2002 Apr;23(8):1819-29.
50. Gioka C, Bourauel C, Hiskia A, et al. Light-cured or chemically cured orthodontic adhesive resins? A selection based on the degree of cure, monomer leaching, and cytotoxicity. Am J Orthod Dentofacial Orthop 2005;127(4):413-9; quiz 516.
51. Anusavice KJ, Philips'science of dental materials (11th ed). Saunders 2003.
52. Brantely WA, Eliades T. Orthodontic materials: Scientific and clinical aspects Thieme; 2001
53. Ferracane JL, Greener EH. Fourier transform infrared analysis of degree of polymerization in unfilled resins – method comparisons. J Dent Res 1984; 63(8):1093-95.
54. Tarle Z, Knezevic A, Demoli N, et al. Comparison of composite curing parameters: effects of light source and curing mode on conversion, temperature rise and polymerization shrinkage. Oper Dent 2006;31(2):219-26.
55. Francescantonio M Di, Cavalcanti AN, Davanzo CU. Influence of viscosity and curing mode on degree of conversion of dual-cured resin cements. Eur J Dent. 2013;7:81–5.
56. de Araujo, L. O. F., Barreto, O., de Mendonça, A. A. M., & França, R. (2015). Assessment of the degree of conversion in light-curing orthodontic resins with various viscosities. Applied Adhesion Science, 3, 1-7
57. Arikawa H, Kanie T, Fujii K, Takahashi H, Ban S. Effect of filler properties in composite resins on light transmittance characteristics and color. Dent Mater J. , 26:38–44. 2007.
58. Da Silva EM, Poskus LT, Guimarães JG, de Araújo Lima, Barcellos A, Fellows CE. Influence of light polymerization modes on the degree of conversion and crosslink density of dental composites. J Mater Sci Mater Med 2008; 19: 1027-1032.
59. Reynolds IR. A review of direct orthodontic bonding. Br J Orthod 1975;2(3):171–8
60. Chidipothu, H. R., & Chandrasekhar, S. (2012). Evaluation of degree of cure and shear bond strength of a color changing light cure adhesive. Journal of Indian Orthodontic Society, 46(4_suppl2), 334-339.
61. Yoshida S, Namura Y, Matsuda M, Saito A, & Shimizu N (2012). Influence of light dose on bond strength of orthodontic light-cured adhesives. Eur J Orthod; 34:493-7.
62. Abdul Majid, Z.S., and Elbadry, A. (2016). A Literature Review on the Correlation Between Shear Bond Strength and the Degree of Conversion of Orthodontic Adhesive Systems. European Scientific Journal. 12(13):411-21.
63. Uysal, T., Yagci, A., Uysal, B., Akdogan, G., 2010. Are nanocomposites and nano-ionomers suitable for orthodontic bracket bonding?. Eur. J. Orthod. 32 (1), 78–82
64. Pradeep, S., Shanthraj, R., Kiran, H. J., & Shivalinga, B. M. (2013). Comparative evaluation of the shear bond strength and debonding properties of

a conventional composite and flowable composites used for orthodontic bracket bonding. *World J Dent*, *4*, 6-16.
65. Sari, M.N., Tabaii, E.S., Vaziri, A.S., Ghaffari, H., Araghbidi, M., Amirabadi, G.E., Sari, N., 2014. Effect of Nano-Hydroxyapatite Incorporation into Resin Modified Glass Ionomer Cement on Ceramic Bracket Debonding. J. Islamic Dental LOCAL Jidai MES Fall. 26 (3), 208–213.
66. Nobre, C.M.G., Pu¨ tz, N., Hannig, M., 2020. Adhesion of Hydroxyapatite Nanoparticles to Dental Materials under Oral Conditions. Scanning. https://doi.org/10.1155/2020/6065739
67. Inatomi, K., Saito, H., & Endo, T. (2021). Bond strength of indirect bonded brackets in orthodontic adhesives with different viscosities. Dental Materials Journal, 40(2), 439-445.
68. Santos, C., Clarke, R.L., Braden, M., Guitian, F., Davy, K.W.M., 2002. Water absorption characteristics of dental composites incorporating hydroxyapatite filler. Biomaterials 23 (8), 1897–1904.
69. Altmann, A.S.P., Collares, F.M., Balbinot, G.S., Leitune, V.C.B., Takimi, A.S., Samuel, S.M.W., 2017. Niobium pentoxide phosphate invert glass as a mineralizing agent in an experimental orthodontic adhesive. Angle Orthod. 87 (5), 759–765
70. Elsharkawy, D.A., 2018. Effect of Incorporation of Bioactive Glass Nano Particles in Adhesive Resin On Microtensile Bond Strength to Dentin in Self Etch and Etch and Rinse Mode. AL-AZHAR Dental J. 5 (4), 399–404
71. Barylyak, A., Kisała, J., Fornal, P., Bobitski, Y., Dziedzic, A., & Kus-Liśkiewicz, M. (2024). Physical, mechanical and antibacterial properties of the orthodontic adhesive doped with S-TiO2. Scientific Reports, 14(1), 17862.
72. Faltermeier A, Rosentritt M, Faltermeier R, Reicheneder C, Müssig D. Influence of filler level on the bond strength of orthodontic adhesives. Angle Orthod 2007; 77: 494-498.
73. Memarpour, M., Shafiei, F., Rafiee, A., Soltani, M., Dashti, M.H., 2019. Effect of hydroxyapatite nanoparticles on enamel remineralization and estimation of fissure sealant bond strength to remineralized tooth surfaces: an in vitro study. BMC Oral Health. 19, 92.
74. AlSamak, S., Alsaleem, N. R., & Ahmed, M. K. (2023). Evaluation of the shear bond strength and adhesive remnant index of color change, fluorescent, and conventional orthodontic adhesives: An in vitro study. International Orthodontics, 21(1), 100712
75. Al Shehab, A., Bakry, A. S., Hill, R., Alsulaimani, F. F., & Abbassy, M. A. (2022). Evaluation of bioactive glass and low viscosity resin as orthodontic enamel sealer: An in vitro study. Journal of Functional Biomaterials, 13(4), 191.
76. Mohammed T. Younis, Omar K. Mohammed, Ali R. Al-Khatib .2024. Effects of color incorporation into bite rising material: an in-vitro study. 92(6): 486-494.
77. Koupis NS, Martens LC and Verbeeck RM. Relative curing degree of polyacid-modified and conventional resin composites determined by surface Knoop hardness. Dent Mater 2006; 22: 1045–1050
78. Jafari Z JS and Mirzakochaki P. Evaluation of colored compomer micro-hardness with different colors in various time curing. Daneshvar Medicine 2015; 22: 17–24.
79. Rizzante, F.A.P.; Mondelli, R.F.L.; Furuse, A.Y.; Borges, A.F.S.; Mendonça, G.; Ishikiriama, S.K. Shrinkage stress and elastic modulus assessment of bulk-fill composites. J. Appl. Oral Sci. 2019, 27, e20180132.
80. Contreras, S.C.M.; Jurema, A.L.B.; Claudino, E.S.; Bresciani, E.; Caneppele, T.M.F. Monowave and polywave light-curing of bulk-fill resin composites: Degree of conversion and marginal adaptation following thermomechanical aging. Biomater. Investig. Dent. 2021, 8, 72–78.