

A different approach of the manufacturing method used to demonstrate the effect of halogenated organic compounds and aromatic hydrocarbons to the composite teeth denture base resin tensile strength.

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Abstract:- The evaluation of the efficiency of the organic compounds used in this study, to the composite teeth denture base resin tensile strength represents the main purpose of this study. For this reason 50 large size artificial composite molars (Ivoclar-Vivadent) were used to mill 50 composite cylinders. The cylinders were randomly assigned in five experimental groups, so that 10(ten) cylinders were part of the each one of the 5 experimental groups. The flat milled surfaces of the cylinders, representing the bonding areas were submitted to a different treatment.

Group 1:(control group), Group 2: Methylene chloride, Group 3: Ethylene chloride, Group 4: Benzene Group 5: Toluene. The chemical treatment procedures were realized using organic solvents with 98, 9% chemical purity. Self-cured denture base repair resin (Duracryl – Spofa Dental) was used for the bonding test specimens manufacturing, according to the ADA specification No. 15. Each specimen was stored for 30 days in distilled water and tensile tested at a speed of 1 mm/min. The mean values of the tensile bond strength test registered were statistically significant among groups, ranging from 13, 41 MPa (group 2) to 25,70 MPa (group 1). The results of this study suggest the fact that the chemical treatment with the organic solvents mentioned above generates not a statistically significant improvement to the adhesion of the composite teeth to the denture base resin.

Key-Words: - benzene, composite teeth, denture base resin, ethylene chloride, metylene chloride, polymers, tensile strength, toluene.

1 Introduction

The main reason that was behind this study is represented by the desire to assess the efficiency of organic solvents on adhesion of composite teeth to self cured denture base resin. Basically, this paper aim is to investigate and to realize a comparison between the effect of halogenated organic compounds and aromatic hydrocarbons to the composite teeth denture base resin tensile strength, in order to be able to understand better the influence of these solvents to the composite teeth denture base bond strength trough tensile tests. So, in order to realize our goal, we focused on a few organic solvents that are used at a low frequency in this type of conditioning. One of the most important reasons

of this low frequency conditioning rate is represented, perhaps, by the high level of toxicity of some of the solvents used in this study, toxicity manifested in case of chronic poisoning by negative effects that are affecting the normal functionality of human body. This is also the reason why in the literature it is not very often found a large variety of studies focused on the chemical treatment with organic solvents such as benzene and toluene or ethylene chloride. Supposing that the use of the mentioned organic solvents proves their efficiency in terms of improving the adhesion of composite teeth to denture base resin and taking into account the local and systemic adverse effects caused by the high toxicity of these solvents, the present study

does not suggest the mainly clinical use of these organic solvents in order to avoid the problems caused by the detachment of composite teeth from the denture base resin. It is well known the fact that the elderly group of patients seeks dental treatment especially for replacing the entirely or partially missing acrylic teeth and also composite teeth detached from denture base resins, especially of those pertaining to anterior region, that are reaching 20% -33% from all complete denture repair clinical cases [1],[2]. This clinical situation requires often fast solutions such as the repair of the complete denture, technique that consists in the realization of an adequate bond at the denture teeth–acrylic resin interface, essential for the success of the prosthetic treatment. Debonding of denture teeth from the acrylic resin denture base still remains a frequent problem in prosthodontic clinical practice, as it can be seen in Fig. No. 1., and Fig. No 2. and is a common cause of failures regarding dentures repairs [3], [4].



Fig. No 1. Detachment of artificial tooth from the denture base.

A dislodged denture tooth is an inconvenience to both, patient and dentist, and numerous attempts have been made to improve the bond strength of denture teeth [5], [6], [7]. Several studies have been conducted to evaluate the influence of mechanical and chemical preparation of the denture teeth, of different polymerization methods and types of acrylic resins and denture teeth on the adhesion between denture teeth and acrylic resins [8],[9]. Composite denture teeth are widely used than porcelain teeth in fabrication of complete and removable dentures [10],[11],[12]. However, the acrylic resin layer of a composite denture tooth is removed when resin-retaining components (struts, beads or meshwork) interfere with placement. New artificial teeth (composite resin) have been developed in order to improve their mechanical

properties and wear resistance. Composite with filler particles and cross-linked polymers is used as the material for artificial teeth [13], [14].



Fig.No 2. Vestibular aspect of the artificial teeth detachment: detail

Debonding of composite denture teeth from the denture base is also therefore, a common clinical problem [15]. One of the important properties of artificial teeth is to absorb some of the energy during function [16].

It was proved that in dentures subjected to bending deformations, tensile stresses are encountered with at lingual area as to the most heavily stressed. The failure at the tooth denture base resin interface will eventually occur when cracks are originating from the high stress areas. This type of problems may be the result of a heavy and uneven masticatory forces, unbalanced occlusion, and parafunctional habits. In this cases the increased force is directed to prosthetic components.[17]. According to Kawara et al. studies, the failures are probably caused by gap and crack propagation in load concentration areas [18].

Knowing the fact that plastics are the main part of artificial teeth, acrylic or composite, and part of the denture base, it is a necessity, from our point of view, to present in the next lines of the text, a few aspects regarding the type, structure, physical and chemical properties of the plastics, practically the features of the polymers that are the main structural components of the plastic materials, even though the present paper does not aim to become a review regarding the plastics. The one and only reason of the following text lines is generated by the need to find a pertinent explanation to the results of this study, according to and based on the information related to the structure and properties of the polymers.

The plastics industry is relatively young because its main growth began in 1950, when the first

polymeric materials based on natural products were used industrially. Plastics are organic, man-made materials. The polymers are the components that determine their technological and physical behaviour, which are characterized by long chains of repeated monomeric units, derived from the petrochemical industry. Plastics contain polymers, but also additives, used in order to enhance the processing or the physicochemical or mechanical properties of plastics.

Chemical and technological behaviour of plastics divides them into the following main groups: thermoplastics and thermosets. [19].

Polymer composites are macromultiphase plastics materials with a polymer resin matrix as continuous phase.

Compounded plastics can contain as a disperse phase specific property-improving additives. Plastic denture teeth are made essentially of polymethylmethacrylate copolymerized with a cross linking agent as, for example, glycol dimethacrylate [20]. Cross-linked polymers are insoluble and normally must be bonded with adhesives, rather than with solvent cements. [21] However, authors such as [22] and [23] found solvent cementing increased the bond strength between plastic teeth and cold-curing denture-base acrylic up to 80% of the strength of the resin. The amount of cross-linking of acrylic teeth is apparently not so great as to prevent diffusion of solvents into the acrylic [24]. No polymer can be volatilized without chemical decomposition. Polymers do not behave as ideal elastic materials in the solid state. The extent of relaxation or creep under a given stress is dependent to the time and temperature. At higher temperatures polymers relax or creep faster than at lower temperatures.

2 Material and Methods

Why should we try to test the efficiency of adhesion, practically the bond strength between artificial teeth and denture base resin, and rely not on experience, because testing costs money and practically every test has its limitations? In the case of an established material and application, there would ideally be a reason to continue testing because all machines are fallible and liable to vary in performance for a variety of reasons. Plastics, artificial teeth (acrylic or composite) and denture base resin also, are no exception in this matter, and being complex materials they require particularly careful control to ensure a consistent product. There is currently a growing trend towards greater

demands for quality assurance which is resulting in more testing rather than less.

At the design stage, physical property data is necessary to be correlated with the calculated stresses, the expected environment and so on. Without such data one would be reduced to a few guesses with its uncertainty of possible failure.

In the case of plastics these needs are particularly great because the plastics in use today are very often not precisely the same as those available years ago, even if the polymer is basically the same.

Plastics are not like other materials they need their own careful formulated test procedures, so it is not satisfactory to transfer methods taken from other technologies if meaningful results are to be obtained, in other words the same procedure cannot sensibly be applied to all of them. If test results on any materials are to be comparable, they must be obtained on mouldings produced under the same temperature, cycle time and so on. It is important when materials are being compared. Ideally results are obtained on mouldings produced under conditions comparable to those to be used in production aspect that needs to be considered also in the case of composite teeth denture base resin tensile test samples.

In order to establish the bond strength between artificial teeth, acrylic or composite and denture base resin the tensile test was elected. Since the most properties are reduced to units of length, area or volume to yield the basic data for the material, the precise size of test pieces cannot be lacked of importance. The statement of results, as per unit thickness, implies that the property is proportional to thickness, but this fact is very misleading because the properties of a given material moulded in thin sections and those moulded in very thick sections may be quite different.

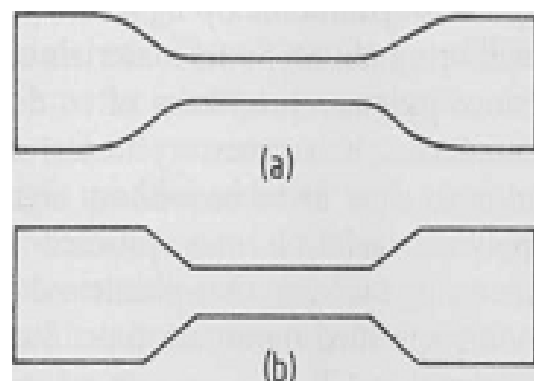


Fig. No. 3. Shapes (a), (b) for tensile test pieces

In other words the size or shape will influence the final result. It is not difficult to realize that the two

dumb-bell shapes shown in Fig. No. 3. will generate different results because the shape has undesirable stress raisers at the sharp so called shoulders which would result in a lower breaking load [25].

This may be an extreme shape, but a variety of tensile test pieces are used and they do not all yield identical results. Apart from shape, they vary in actual size and may be produced from different thicknesses of material.

So, many parameters have to be specified and controlled if the final results are to be comparable. It is necessary for all to measure each property in exactly the same way and the first step in order to achieve this is to use standards, and test method standards. A test method standard aims to specify all the device parameters, the test piece details, the steps in the procedure, the presentation of the results which are all important and allow us to obtain comparable data.

Many of the test methods use arbitrary conditions and procedures. The data obtained from these routine type tests, will rarely give the designer the values upon which to base his calculations. The more nearly a test approaches the real conditions of service, the more relevant or significant results will be obtained. If there were no standardized test methods the progress would be severely impaired. Because of increased demand for product reliability standards have become more important in recent years. To avoid misunderstanding over terminology the British Standards Institution elaborates documents standards and the word specification is reserved for those standards which specify minimum requirements for materials or products. Other types of standard are Methods of Test, Codes of Practice. In other words the specification may refer to several methods of test. For all the above mentioned reasons, the samples were made so that their material, size and design subscribe ADA specification No. 15.

2.1 Sample preparation

In order to realize the samples according to ADA Specification Nr. 15, the division of the manufacturing stages of the samples, in different steps, was necessary.

The first step involved the milling of the 50 artificial composite large molars (Ivoclar Vivadent, Lichtenstein) so that 50 cylinders with 5 mm height and 6 mm diameter should result from the milling procedure. A milling keys device, a trepan bur with 6 mm internal diameter and a diamond disc, both, mounted in the mandrels milling machine, were used.

Aspects of the lateral surface milling of the cylinder are captured in Fig. No 4. The procedure through which the mucosal and the occlusal surface of the composite teeth was milled to flat is presented in Fig. No 5 and Fig. No.7.



Fig. No 4. Mucosal view of the cylinder milled with the trepan bur inside the composite tooth.

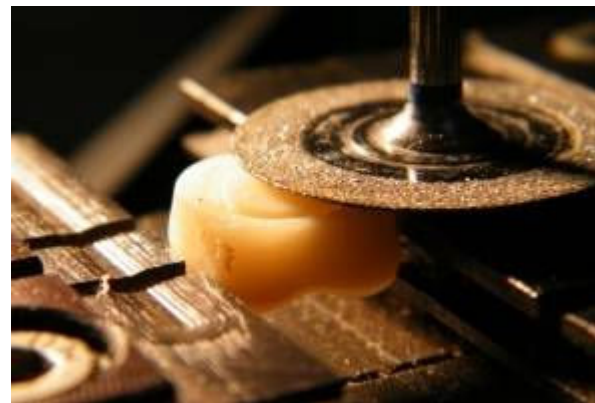


Fig. No. 5. The first milled flat surface of the composite cylinder.

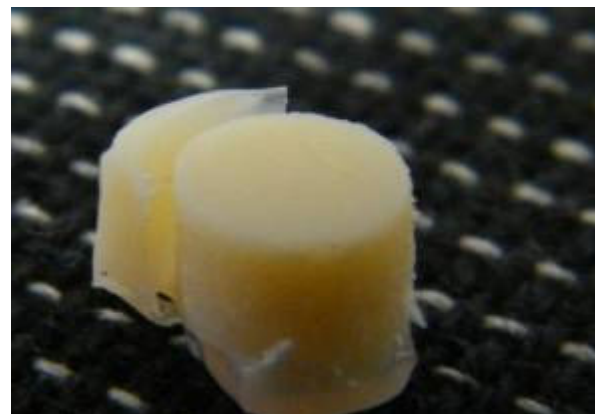


Fig. No 6. Capture of the evidenced lateral surface of the composite cylinder.



Fig. No.7. Aspect regarding the milling of the second base of the composite cylinder



Fig. No. 10 The shape of the metallic object

The composite cylinders are representing only the central part of the entire tensile test sample. For this reason the two self cured denture base extremities of the tensile test samples must be manufactured.

The lateral surface of the cylinder was evidenced as a consequence of the removal of the composite tooth 4 axial surfaces, aspect characterizing the Fig. No. 6, the final shape being the shape of a cylinder with 6 mm diameter and 5 mm height. The tensile test specimen should have the shape and size stipulated by the ADA. Specification Nr. 15.

In order to realize the tensile test samples a metallic object (Fig. No 10.) with the shape and sizes of half of the tensile specimen was impressed.

The impression of the metallic object served to obtain the wax model representing half (Fig. No. 11) of the future tensile test sample.

Attaching two wax halves samples one to each other at the 6 mm diameter base allowed us to obtain a wax model corresponding to the entire tensile test sample as it can be observed in Fig. No. 12.

The wax samples for the patterns of the future tensile test samples are realized and already have the

shape and size stipulated by the ADA Specification Nr.15, as in the Fig. No.13 it is showed



Fig. No. 11 The wax models of the metallic object.



Fig. No. 12. The two wax halves ready to be attached



Fig. No. 13. The final shape of the wax samples

For the patterns of the future tensile test samples realization, 10 mould patterns suitable as size and design for the proper alignment of the 5 wax samples and class IV gypsum were used. In Fig. No. 14, five of the ten pattern moulds are captured, and

it can be observed that the wax samples were placed in a horizontal position, parallel one to each other and only with half of their thickness immersed in the gypsum paste, five wax samples per each pastern mould.

Filling the containers with class IV gypsum paste allowed us to obtain the patterns for the tensile test samples.

Once the sample patterns were realized, the chemical treatment of the two bases of the composite cylinders followed. The composite cylinders were divided into five groups, so that 10 cylinders are part of each one of the five groups. The two flat bases of the cylinders were considered bonding areas.



Fig. No. 14. Part of the wax samples in the plaster moulds

The surface treatment regimens were different from one group to the other: Group 1: control group (without chemical treatment); Group 2: methylene chloride; Group 3: ethylene chloride; Group 4: benzene; Group 5: toluene.

Methylene chloride is a colorless, volatile liquid with a light sweet aroma, pertaining to the halogenated organic compounds class, widely used as a solvent for many chemical processes because he has the ability to dissolve a wide range of organic compounds. It is not miscible with water, but it is miscible with many other organic solvents. It is also a volatile organic compound, reason for which it is used as an aerosol spray. Regarding his toxicity level, it is known that from all the simple chloro hydrocarbons is the least toxic. Its high volatility makes an acute inhalation possible so that optic neuropathy and hepatitis may result afterwards. Long time skin contact can be followed by the dissolution of some fatty tissues in skin, generating skin irritation, chemical burns.

It may be carcinogenic, as it has been associated with animal cancer of the lungs, liver, and pancreas.

Dichloromethane crosses the placenta but fetal toxicity at women exposed to it during pregnancy, was not proved. The animal experiments have proved that it was fetotoxic at doses that were maternally toxic but was not teratogenic.

Ethylene chloride (1, 2-dichloroethane), is a colorless liquid, has a chloroform-like odor and is used as an intermediate for other organic chemical compounds and also as a solvent. It forms azeotropes with a large variety of solvents, including with water and other chlorocarbons. It is a good apolar aprotic solvent used as degreaser and paint remover. It is highly flammable, carcinogenic and toxic by inhalation, because of his high vapor pressure. It is also a perennial pollutant and health risk compound, because of his high solubility and 50 year half life in anoxic aquifers, requiring expensive bioremediation methods. Therefore substitutes are recommended: 1, 3-dioxolane and toluene are possible substitutes as solvents.

Benzene is an aromatic hydrocarbon related to the functional group arene, which is a generalized structure of benzene. It is a natural constituent of crude oil, and one of the most basic petrochemicals, it is a colorless and highly flammable liquid with a sweet smell and an important industrial solvent and precursor to basic industrial chemicals including drugs, plastics. It was used as an additive in gasoline but because of his carcinogenic effect his use is now limited. Prior to 1920, benzene was frequently used as an industrial solvent. As its toxicity became obvious, benzene was replaced by other solvents, especially toluene (methyl benzene), which has similar physical properties but it is not as carcinogenic. Benzene increases the octane rating and reduces knocking. The United States Environmental Protection Agency has new regulations that will lower the benzene content in gasoline to 0.62% in 2011. Today, toluene is often used as a substitute for benzene. The solvent properties of the two are similar, but toluene has a lower toxicity and has a wider liquid range. Benzene could be oxidized by both bacteria and eukaryotes. Benzene exposure has serious health effects. The American Petroleum Institute (API) stated in 1948 that it is generally considered that the only absolutely safe concentration for benzene is zero. The US Department of Health and Human Services (DHHS) classifies benzene as a human carcinogen. Long time exposure to excessive levels of benzene in the air causes leukemia, a potentially fatal cancer of the blood-forming organs, in individuals. The major effects of benzene are manifested through chronic exposure through the blood. Benzene damages the bone marrow and can cause a decrease

in red blood cells generating anemia, causes excessive bleeding and depress the immune system, increasing the chance of infection. Benzene causes also leukemia and is associated with other cancers and pre-cancers of the blood.

Human exposure to benzene is a global health problem because causes cancer in both animals and humans, being first reported to induce cancer in humans in 1920. Benzene damages the liver, the kidney, the lungs, the heart and the brain and can cause DNA strand breaks and chromosomal damage. Benzene exposure has been directly associated to the neural birth defects spina bifida and anencephaly and to a rare form of kidney cancer. The exposure of men to high levels of benzene is more susceptible to produce sperm with an abnormal amount of chromosomes, which impacts fertility and fetal development. The exposure of the general population to benzene occurs especially through breathing, the major sources of benzene being represented by tobacco smoke (approximately 50%), exhaust from motor vehicles and industrial emissions, altogether, those last three sources reaching almost 20%. The vapors from products that contain benzene, such as glues, paints, detergents, also are a source of exposure. The average smoker (32 cigarettes per day) takes in about 1.8 milligrams (mg) of benzene per day. The United States Environmental Protection Agency has set a maximum contaminant level (MCL) for benzene in drinking water at 0.005 mg/L promulgated via the National Primary Drinking Water Regulations, in order to prevent benzene leukemogenesis. The US Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit of 1 part of benzene per million parts of air (1 ppm) at the workplace during an 8-hour workday, 40-hour workweek. The short term exposure limit for airborne benzene is 5 ppm for 15 minutes. Benzene can be measured in breath, blood or urine, but this type of testing is limited to the first 24 hours post-exposure due to the rapid removal of the chemical by exhalation or biotransformation. In the body, benzene is enzymatically converted to oxidation products such as phenol, hydroquinone. Most of these metabolites have biomarker values of human exposure, because they accumulate in the urine in levels directly associated to the extent and duration of exposure, and they may still be present for some days after exposure has ceased. Inhaled benzene is primarily expelled unchanged through exhalation, 30% of absorbed dermal applied benzene, is primarily metabolized in the liver, and excreted as phenol in the urine.

Toluene is an aromatic hydrocarbon, a mono-substituted benzene derivative in which a single hydrogen atom from the benzene molecule has been replaced by CH_3 . Toluene is an important organic solvent, also capable of dissolving a number of notable inorganic chemicals, it is a clear, water-insoluble liquid, able to dissolve paints, paint thinners, many chemical reactants, printing ink, adhesives, lacquers. Toluene should not be inhaled because of his health effects.



Fig. No 15. Composite cylinders aligned in the mould each of the mould patterns

Low and even moderate levels can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, hearing and color vision loss. These symptoms usually disappear when exposure is stopped.



Fig. No 16. Composite cylinder placed in each mould patterns.

Inhaling high levels of toluene in a short time can also cause unconsciousness, and even death. Toluene is, much less toxic than benzene, and has consequently largely replaced benzene as an aromatic solvent in chemical preparation.

We mentioned in the above lines of the text in detail the toxicity effects of the organic solvents used in this study in order just to highlight the fact that even if the results obtained after testing the tensile strength samples will be higher than 31 MPa, the limit stipulated by the ADA. Nr. 15, the high toxicity of the solvents used in this study on the human body, does not allow us to recommend their use in dental laboratories in order to improve the adhesion of composite resin teeth to denture base.

After the chemical treatment of all the 100 flat bases of the 50 composite cylinders, pertaining to the 5 groups of this study, each cylinder was aligned in the mould patterns, in a manner that allowed that the cylinder flat bases to be placed parallel and at equal distances between the two 8 mm bases of the pattern tensile test samples extremities, as it can be seen in both Fig. No. 15. and also in Fig. No. 16.



Fig. No. 17. Mould patterns acrylic resin dough stage tamping



Fig. No 18. Unpacking of the tensile test samples

It is also necessary to note that the time elapsed since the application of organic solvents droplets on the two bases of the composite cylinders until the

dough stage denture base resin paste application in to the patterns was 5 minutes.

During this time it could also be observed that at normal temperature and pressure the organic solvents droplets evaporated from the flat base of the cylinders.

The preparation and mould stamping of self cured acrylic denture base resin in the dough stage phase (Duracryl SPOFA Plus Dental, Kerr Company) followed by the polymerization process in accordance with the manufacturer's directions (Fig. No.17) was succeeded by the unpacking of the samples (Fig. No 18).

All the samples (Fig. No. 19), (Fig. No. 20) were kept in distilled water for 30 days at a temperature of 37 degrees Celsius.

All the samples were tensile tested, using Multitest 5i (Mecmesin) at 1 mm/min speed.

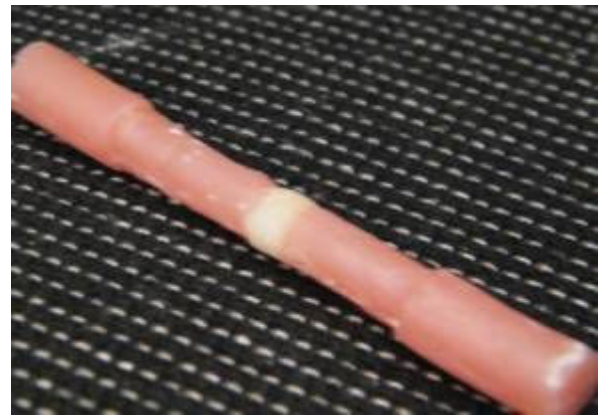


Fig. No. 19. The shape and size of the sample corresponding to specification ADA/ANSI No.15.



Fig. No.20. Tensile test samples: details
Nine test speeds are given in ISO 527 among which we mention:

- Speed A 1 mm/min $\pm 50\%$
- Speed A₁ 2mm/min + 20%
- Speed B 5mm/min + 20%
- Speed D 20 or 25 mm/min $\pm 10\%$

Speed G 200 or 250 mm/min \pm 10%

The two D and G speeds are allowed because both are widespread used throughout the world.

The most frequently used stress-strain measurement is that made in tension, which is by stretching the material.

Taking the stressing operation to the ultimate, measuring the force until the material breaks, tensile strength (ultimate tensile stress) is $\sigma = F/A$ where F = failure force and A = area of cross-section at failure. For experimental convenience most tensile strengths are based on the original cross-section (A_0) since this is easily measured before the test is started. As the material stretches, its dimensions orthogonal to the axis of applied force decreases and thus the area of cross-section decreases. Even so, for experimental convenience the tensile strengths are based on the original cross-section (A_0) because is easily measured before the test is started. Hooke's law says that for an ideal elastic solid stress is proportional to strain, but even so, no plastics material comes very close to this ideal. Ultimate elongation, elongation at break, equals $l - l_0$ where l is the length at failure. This is usually expressed as a percentage of the original length: elongation at break = $(l - l_0)/l_0 \times 100$ per cent.

Four basic types of the shape and size of pieces on which the measurements will be performed are found in the standards literature: among which the narrow-wasted dumb-bell, the 'dog-bone' dumb-bell. The successful completion of a tensile test is associated also to the grip system used to hold the test piece so that the specimen is held firmly in order to minimize, or prevent slippage without crushing the tab ends. For this reason the design of the grips or chucks and their mode of attachment to the testing machine must be such as to ensure alignment of the test piece in the direction of strain, without any bending or shearing component. Some control over the friction between the test specimen and the gripping faces of the wedges can be obtained by having different surface patterns on the wedge faces, varying from serrated patterns (Fig. No. 22) to perfectly smooth.

There are a large variety of terms used in tensile testing, tensile strength is usually known to be the maximum tensile stress exhibited during a test, but occasionally is taken as the stress at break; these two physical processes not always are the same. The following are those that are most commonly found in literature.

Tensile stress (nominal) is the tensile force per unit area of the original cross-section within the gauge length carried by the test piece at any given

moment. The standard unit is Mega Pascal (MPa) = $MN/m^2 = N/mm^2$

Tensile strength (nominal) is the maximum tensile stress (nominal) sustained by a test piece during a tension test.

Tensile stress at break Yield stress is the tensile stress which occurs at break of the test specimen

3 Results

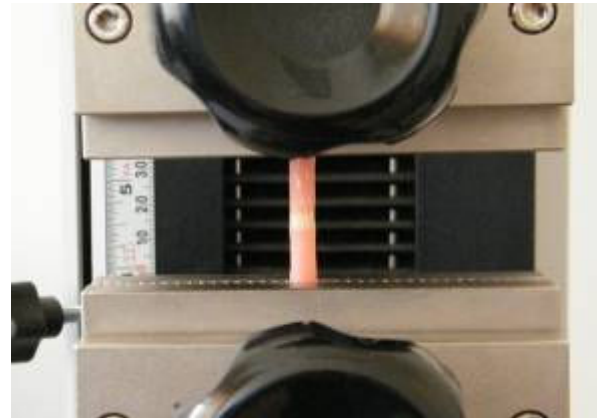


Fig. No.21. Sample clamped in Mecmesin holding device before tensile test development

The tensile test strength values at which the acrylic tooth denture base resin adhesive interface cracked as it can be seen in Fig. No 21 and Fig. No 22, were one by one captured as graphics as it can be seen in Fig. No 23, Fig. No 24, Fig. No.25, Fig. No. 26 and afterwards also registered in tables (Table.1) , (Table.2).

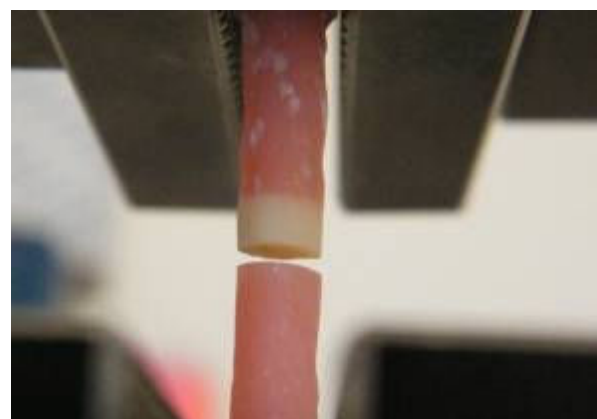


Fig. No. 22. Detaille of the tensile sample after the adhesive fracture

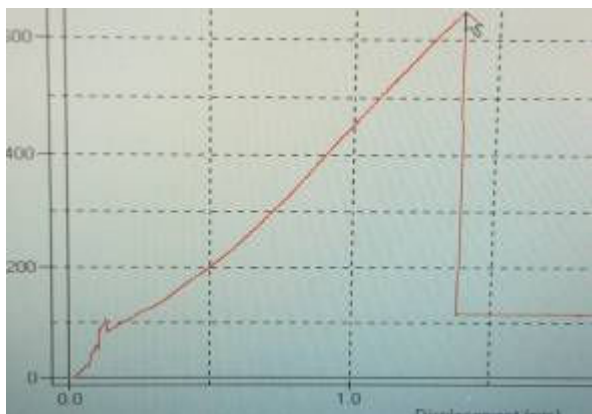


Fig. No. 23 Capture of the graphic depicting a 600 N force responsible for adhesive fracture of methylene chloride treated specimens

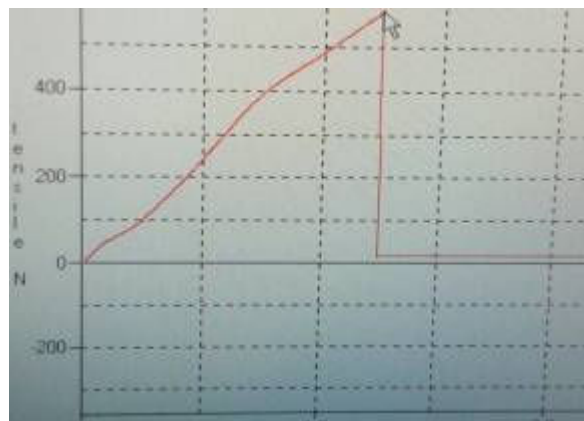


Fig. 26. Capture of the graphic depicting a 500 N force responsible for adhesive fracture of toluene treated tensile specimens.

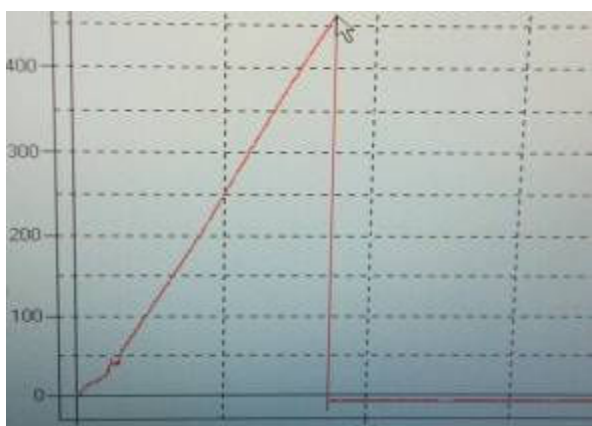


Fig. 24. Capture of the graphic depicting a 500 N force responsible for adhesive fracture of benzene treated tensile specimens

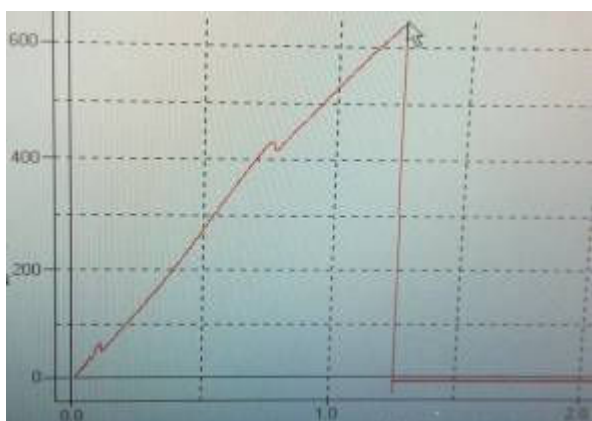


Fig. 26. Capture of the graphic depicting a 600 N force responsible for adhesive fracture of ethylene chloride treated tensile specimens.

Table. 1. The registered composite tensile strength values (in Newton).

control	methylne chloride	ethylene chloride	benzene	toluene
F=683,0 N	F=365,2 N	F=457,8 N	F=594,8 N	F=576,4 N
F=731,5 N	F=402,9 N	F=638,9 N	F=470,2 N	F=521,3 N
F=799,0 N	F=402,5 N	F=441,5 N	F=539,5 N	F=527,3 N
F=793,8 N	F=269,0 N	F=572,6 N	F=457,6 N	F=506,7 N
F=633,2 N	F=438,8 N	F=539,6 N	F=645,5 N	F=497,0 N
F=694,3 N	F=378,7 N	F=461,7 N	F=590,4 N	F=567,7 N
F=741,1 N	F=410,8 N	F=653,8 N	F=481,2 N	F=575,6 N
F=800,0 N	F=400,2 N	F=456,1 N	F=559,8 N	F=533,5 N
F=791,9 N	F=281,2 N	F=581,8 N	F=467,5 N	F=542,0 N
F=625,4 N	F=420,2 N	F=561,3 N	F=638,8 N	F=501,8 N

Table.2. Comparisons between the values obtained after composite teeth denture base resin tensile strength test.

Group	N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
1	10	25.70	2.31	0.73	24.04	27.35	22.13	28.30
2	10	13.41	1.90	0.60	12.05	14.77	9.51	15.52
3	10	18.98	2.78	0.88	16.99	20.97	15.62	23.13
4	10	19.46	2.61	0.83	17.59	21.32	16.19	22.84
5	10	18.93	1.06	0.33	18.17	19.69	17.59	20.39
Total	50	19.29	4.47	0.63	18.02	20.57	9.51	28.30

Table. 3. Composite tensile strength values in MegaPascals

Control 1	methylene chloride 2	ethylene chloride 3	benzene 4	toluene 5
F=24.6 MPa	F=12.92 MPa	F=16.19 MPa	F=21.04 MPa	F=20.39 MPa
F=25.8 MPa	F=14.25 MPa	F=22.60 MPa	F=16.63 MPa	F=18.45 MPa
F=28.27 MPa	F=14.25 MPa	F=15.62 MPa	F=21.00 MPa	F=18.66 MPa
F=28.08 MPa	F= 9.51 MPa	F=20.26 MPa	F=16.19 MPa	F=17.93 MPa
F=22.40 MPa	F=15.52 MPa	F=19.09 MPa	F=22.84 MPa	F=17.59 MPa
F=24.56 MPa	F=13.40 MPa	F=16.34 MPa	F=20.89 MPa	F=20.09 MPa
F=26.22 MPa	F=14.53 MPa	F=23.13 MPa	F=17.02 MPa	F=20.37 MPa
F=28.30 MPa	F=14.15 MPa	F=16.14 MPa	F=19.80 MPa	F=18.88 MPa
F=26.96 MPa	F=10.70 MPa	F=20.58 MPa	F=16.54 MPa	F=19.18 MPa
F=22.13 MPa	F= 14.86 MPa	F=19.86 MPa	F=22.60 MPa	F=17.76 MPa

The MegaPascals tensile strength values from the Table 3. are obtained with the formula:

$$R = F / S, \text{ where } F = \text{force and } S = \text{surface}$$

Table. 4. Two (2) by two (2) comparisons of groups (Scheffe post-hoc test)

(I) Group	(J) Group	Sig.	Sig. level (α)
1	2	<0.001 ^s	0.001
	3	<0.001 ^s	0.001
	4	<0.001 ^s	0.001
2	3	<0.001 ^s	0.001
	4	<0.001 ^s	0.001
	5	<0.001 ^s	0.001
3	4	0.994 ^{ns}	0.05
	5	0.997 ^{ns}	0.05
4	5	0.994 ^{ns}	0.05

^s – significant differences

^{ns} – not significant differences

After a simple analysis of the Table.2 it can be observed that comparing the mean values of the 5 groups submitted to this study, the lower mean values were those of Group 2 (methylene chloride)(13.41MPa) and the higher were those pertaining to Control group (without chemical treatment) (25,70 MPa)

In order to compare two by two the five groups, the option Post Hoc multiple comparisons, ANOVA test, was chosen.

Table. 4 reveals the fact that according to Scheffe post-hocTest, significant differences, (p <0.001), were found between the five groups submitted to tensile strength test as it follows: Between Control Group (no treatment) and Group 2 (methylene chloride treated composite teeth), significant differences were registered so that control group registered values were significant higher compared to those pertaining to Group 2. Comparing the values of the Control group with those pertaining to Group 3(ethylene chloride) significant differences were registered also in favour of Control group. Higher values and statistically significant differences were registered comparing the control group with Group 4 (benzene) and Group 5 (toluene), and non significant differences (significance level of 0, 05) were registered between Group 4 and Group 5. Also statistically non

significant differences were registered comparing Group 3 with Group 4 and also with Group 5.

4 Discussion

It is known the fact that the solvents mechanism regarding the adhesion of plastics involves softening or swelling of the substrate by the solvent. Also the solvent must have a solubility parameter similar to that of the substrate in order to be effective. Secondary forces between interwoven polymer chains bond the materials together. The diffusion theory of adhesion of polymeric materials was developed by authors such as Voyutskii [26]. It is also well known the fact that the solvents that can produce the highest bond strengths between two adherents that have a chemical structure based and developed from poly(methylmethacrylate) must have a solubility parameter similar to that of poly(methylmethacrylate), meaning 9,3 H (Hildebrand) [27]. According to those affirmations and reporting the fact that the solubility parameters of methylene chloride, reaching 9,93 H is close to solubility parameter of polymethylmethacrylate (9,3 H) [28], the tensile strength test values obtained after chemical treatment of acrylic teeth with methylene chloride are significantly higher (35,9 MPa) than those pertaining to Control group or to the groups submitted to microsanblasting with methylmethacrylate (28,69 MPa) or to the groups treated with methylmethacrylate (29,81 MPa) [29], but according to the results of this study the bond strength effect of methylene chloride to the composite complete denture teeth denture base resin bond is lower (a mean of 13.41 MPa) compared to the bond strength effect of methylene chloride treatment to acrylic teeth (a mean of 39,5 MPa) [30], probably because the chemical structure of composite complete denture teeth (in this study Ivoclar Vivadent composite teeth) involves not only poly(methylmethacrylate) derivatives but also different additives, among which even inorganic elements, that may have a different solubility parameter compared to the solubility parameter of polymethylmethacrylate. In 1936 Joel H. Hildebrand the founder of solubility theory in his classic work on the solubility of nonelectrolytes in 1916, proposed the square root of the cohesive energy density as a numerical value indicating the solvency behavior of a specific solvent. In other words the total van der Waals force, reflected in the simplest solubility value: is the Hildebrand solubility parameter. The solubility parameter is a numerical value that indicates the relative solvency behaviour of a specific solvent. It is derived from

the cohesive energy density of the solvent, which in turn is derived from the heat of vaporization.

The solubility parameter of ethylene chloride reaches 9,76 H, a value close to the Hildebrand value of poly(methylmethacrylate) (PMMA) and also to the Hildebrand s value of methylene chloride. Even so the Group 3 (ethylene chloride) tensile strength recorded values, are reaching a statistical significant difference compared both to the Control group but also to the Group 2 (methylene chloride), the mean values of the Group 3 being lower (18,98 MPa) than the ones of the Control Group (25,7 MPa) and higher than the values of the Group 2 (13,41 MPa). Practically the Hildebrand s value of both methylene chloride and ethylene chloride are close to the H value of poly(methylmethacrylate), but the tensile strength test values of those two groups were significant different statistically.

The Hildebrand value of benzene is 9,15 H, also close to the H value of PMMA (9,3 H), but lower than the H values of methylene chloride (9,93 H) and ethylene chloride (9,76 H), so that between the tensile strength test values of Group 4 and Group 2, statistically significant differences were registered, but not significant between Group 4 and Group 3. Toluene's Hildebrand value is 8,91 H, the lowest of the values of the four solvents used in the study, with almost one measure unit lower than the PMMA H value, so in this case the lower statistically significant differences registered between Group 5, on one side and Group 1 on the other side, could perhaps be explained by the H value scale.

So probably the results of this study were influenced by a group of factors among which we could remember on one side, the chemical composition of the composite teeth, characterized by the presence of different monomer types, additives, and inorganic elements which perhaps have not the same or not even a close H (Hildebrand) value with the PMMA, and on the other side another factor could be represented by the time elapsed from the solvents drops application on the composite cylinder flat surfaces until the moment on which the resin base dough paste was immersed in to the mould patterns, time interval in which the solvents have evaporate. The evaporation time is not the same for all the solvents used in this study. It is known that methylene chloride evaporates in 5 seconds; ethylene chloride benzene and toluene have an evaporation time between 60 and 180 seconds. Also, two-tree drops (2-3 ml) of solvent were applied on each one of the flat surfaces of the composite cylinders of each sample from each of the groups submitted to chemical treatment. The flat surfaces of the composite milled cylinders are practically

perfect circular surfaces with a 6 mm diameter and an area equal to 28.26 mm^2 , because if the diameter is 6 mm, then r will be $D/2 = 6\text{mm}/2 = 3\text{mm}$. The area is calculated with the formula $A = \pi r^2$, so $A = 3,14 \cdot 3^2 = 3,14 \cdot 9 = 28,26 \text{ mm}^2$. It is known that the use of too much quantities of solvent is considered to be a real common mistake made in making solvent bonds [31], and perhaps those two, tree drops (2-3 ml) of solvent have represented increased quantities of solvent for the $28,26 \text{ mm}^2$ area of the circular flat surfaces of the composite cylinders chemically treated in order to achieve a enhanced composite teeth denture base bonding. Only the minimum amount of solvent required to wet a surface area should be used. Excessive solvent quantities can generate bubbling and squeeze-out, fact which decreases the strength of the bond. So the quantities of solvent, probably too much in this case, are the third factor that could generate also the lower values of the tensile tests of this study. Taking into account the above specified aspects regarding the limitations of this study which refer to the exact quantification of the applied organic solvent volume in order to be appropriate for the calculated surface area of the composite cylinders, further investigations and studies must follow this direction.

5 Conclusion

Within limitations of this study related to the research methodology and considering the fact that the tensile test values of the groups 2, 3, 4 and 5 submitted to the treatment with organic solvents are lower than the amount stipulated by the ANSI/ADA specification Nr 15, value of 31 MPa, it could be considered that the organic solvents used in this study are not indicated for the chemical treatment of composite denture teeth in order to improve their bond strength to the denture base resin, and also further investigations regarding the effect of those solvents on composite teeth must be persuaded .

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