EVALUATION PROPERTIES OF HIGH IMPACT AND MICROWAVE

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Abstract

Polymethyl methacrylate is the most widely used material for the construction of denture bases. Attempts have been made to improve the mechanical properties of this material. The purpose of this study was to evaluate some properties of the proprietary material known, commercially, as high impact resins, the microwave cured resin, and to compare them with the conventional heat- cured resins. The results showed that the high- impact denture base materials had higher impact strength, transverse strength, and deflection compared to the conventional and microwave cured resins. The tensile strength, modulus of elasticity were higher in the conventional and microwave cured resins but without statistically significant differences between the groups. Packing plasticity showed the highest values for the SR Ivoclar material (high impact resin), followed by the conventional heat-cured acrylic resins and the microwave cured acrylic resin. Within the high impact resins group, the SR Ivoclar material showed the best results in all properties studied. On the other, hand there was no significant difference between the properties of heat and microwave cured resins. All properties for the different studied materials complied with the ADA specification for the denture base polymers.

INTRODUCTION:

The acrylic resin (polymethyl methacrylate) denture base material has been available since 1937[1]. The advantages of acrylic resin denture base material are the ease of manipulation and pigmentation, good esthetics, well tolerance by tissues, the possibility of repair, and less expensive. However, the impact and fatigue properties of the acrylic resin are not ideal [2,3]. Attempts have been tried to improve the impact strength, transverse strength and fatigue strength of polymethyl methacrylate. The use of a copolymer of polymethyl methacrylate with other polymeric materials is the incorporation of carbon fibers or rubbery phase as butadiene-styrene rubber have been tried [4,5]. Many experiments [6-14] were carried out on modified polymethyl methacrylate's study their mechanical properties. In evaluation of the effect of cross linking agents on acrylic resin, some authors [6, 7,8] found that cross linking agents in high percentages decreased tensile and impact strength. Other [9, 10] found that tensile strength was increased slightly in cross linked specimens up to 25% concentration of the cross linking agents. Jagini et. al [9] found that the incorporation of ethylene glycol dimethacrylate cross linking agent to acrylic resin monomer, up to 100% concentration, did not affect its impact strength. Sharma et. al [11], John et. al [12], Joseph et. al [13], Ozdemir et. al [14] and Mansour et. al [15], found that the butadiene-styrene rubber reinforced polymethyl methacrylate had considerably higher impact strength than the conventional acrylic resin. Dalal et. al [16], found that these rubber contents increased significantly the tensile strength of polymethyl methacrylate.

The use of microwave energy to polymerize denture base materials was first reported in 1968[17, 18]. Uzun et al. [19], Ayaz [20] and Consani et al [21] compared the dimensional accuracy, density, transverse strength and, hardness of denture base resin polymerized by microwave irradiation and heat activation. These studies concluded that the two polymerization methods did not cause differences in the properties of the resins.

The purpose of the present study was to compare between denture base materials known, commercially, as high impact strength material, with the microwave cured resin and the conventionally heat cured resin. The comparison included the impact strength, as well as other properties, such as; transverse strength, deflection test, tensile strength, modulus of elasticity and packing plasticity.

MATERIALS AND METHODS

The materials used in this study are listed in Table (1).The DNA specification No 12[22] for denture base polymers was followed for the evaluation of the different tested materials. The different properties evaluated for each material were: Impact strength, tensile strength, modulus of elasticity, and packing plasticity. Preparation of samples was performed and cured, for each material, according to its manufacturer's directions. A plastic flask without any metal contents* and a 500-watt microwave oven** were used for the microwave type acrylic resin.

For these different tests, five samples of each material were prepared according to the dimensions mentioned in each test procedure.

*FRP Flask Gem Dent Ltd, Wellingborough, U. K.

**National S.G, Japan

All the specimens to be tested were finished and polished in the usual manner and immersed in distilled water in a calibrated incubator for 48 hours at 37 +/- 2°C prior to testing. The different tests were performed as follows:

Table (1): Materials used in the study

Material	Type	Manufacturer
Meliodont	Conventional cross-linked heat cured acrylic resin	Bayer, Germany
P.S.P.	Conventional cross-linked heat cured acrylic resin	P.S.P. Denture M.F.Q. Co.Ltd Dylan Road, Belvedere, Kent, Uk
Acron MC	Microwave cross-linked acrylic resin	GC Industrial Corporation. Tokyo, Japan
Titan	High impact cross-linked acrylic resin	Vernon, Benshoffco Inc. New York, USA
SR-Ivocap	Injection, high impact cross-linked acrylic resin	Deutsche Ivoclar Dental, Postfach, Germany
Optilon	High impact cross-linked acrylic resin	The hygienic Corporation, Ohio. , USA

Impact strength test:

Samples having the dimensions of 75 mm length 10 mm width and 10 mm thickness were prepared from each material. The specimens were notched from one side (Fig.1) in a notcher machine*.

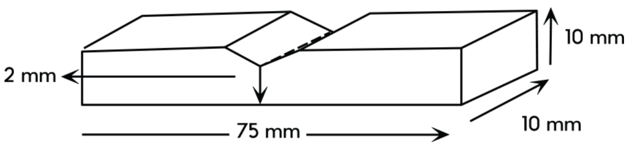

Fig.(1) Dimensions of The impact strength test specimen

The specimen to be tested was held in a Charpy's testing machine**. A load of 10 kg with a striking velocity of 5.5 meter/ sec was used. The impact strength value was expressed in terms of kg/cm of energy absorbed in breaking the specimen by measuring the swing reduction of the pendulum.

Transverse strength and deflection tests:

The test specimens were in the form of strips having the dimensions of 65 mm length, 10 mm width, and 2.5 mm thickness. An Instron testing machine*** was used for measuring the transverse strength of the specimens by applying a breaking load along a line at the center of the specimen (500 gm/ 30 sec). The deflection was measured by means of a deflectometer****

** Custom Scientific Instruments Inc, Model CS-93M, Whippany, New Jersy.*

***Charpoy'sTestingMachinin,WPMVEB, Werktoffprufmaschinen, Leipzig, Germany.*

****Instron Universal Testing Machine, Model 1128, USA*
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*****Carl Zeiss, Germany*.

Tensile strength and Modulus of Elasticity Tests:

Dumbbell shaped samples. (Figure 2) were prepared from each material. The specimens had the following dimensions: 6 mm width of narrow section (WC), 33 mm length of narrow section (L), 19 mm width of overall (LO), 25 mm gauge length (G), 64 mm distance between grips (D), 14 mm radius of the fillet (R), 25 mm of the outer radius (RO), and 3 mm thickness (T)

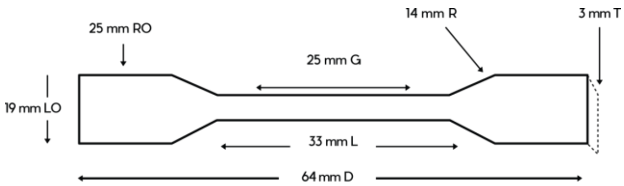

Fig (2) Dimensions of tensile strength test specimen

The specimen to be tested was placed in the grips of the Instron testing machine. A tensile load was performed with cross head speed of 0.5 mm/min and chart speed of 10 mm/min. The load and extension curves at the moment of rupture were recorded. The tensile strength at breakage was calculated by applying the following equation: Tensile strength = Maximum load/original minimum cross section. = kg/cm. The tensile modulus of elasticity was calculated by applying the following equation: Modulus of elasticity = Stress/Strain = Kg/cm.

Packing plasticity test:

A brass die was specially prepared, having dimensions of five cm square and one cm thick, the die is supported at each corner by a leg of 0.3 cm long and having 16 holes, 5 mm apart, 0.75 mm diameter, Fig. (3).

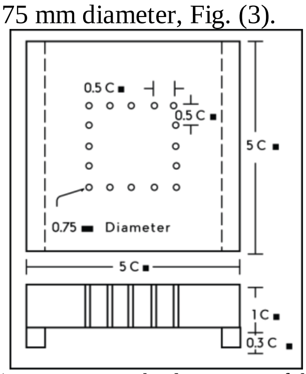

Fig (3) Demonstrates the dimensions of the die used for the packing plasticity test

Guided with ADA specification no. 12 for denture base polymers, 8 grams of the material to be tested were mixed according to manufacturer as

Table (2,A&B): The means and standard deviation of the different properties for all tested materials

A.

Materials/Properties		Meliodont Convent.	PSP Convent.
Impact strength (Kg/cm)	Mean S.D	1.95 .382	1.75 .380
Transverse strength (Kg/cm2)	Mean S.D	836 131.17	895 105.90
Deflection (m.m)	Mean S.D	3.1 0.310	3.65 0.240
Tensile strength (Kg/cm2)	Mean S.D	681 69.91	665 65.95
Modulus of elasticity (Kg/cm2)	Mean S.D	138.8 11.17	130.6 12.30
Packing plasticity (No of protruded material more than (0.5mm)	Mean S.D	8.2 1.4832	8.4 2.0736

B.

Acron Microwave	Titan high impact		Optilon High Impact
1.93 .321	3.65* .195	4.79* .236	3.48* .230
791 54.13	1079* 134.28	1291* 131.58	1040* 141.65
3.35 0.330	6.97* 1.020	8.89* 0.590	7.55* 0.190
598 74.69	503 81.4	540 157.81	521 66.34
138.84 13.41	122.90 36.55	129.71 19.91	123.89 14.1
8.6 1.1401	7.8 1.7888	13.8* .8366	8 1.2247

*Statistically Significant at $P < 0.05$

Instructions The packing test was stated 5 minutes after the proper plasticity of the material had been reached, it was placed on the perforated die to a thickness of approximately 5 mm., a sheet of polyethylene was used as separator between the specimen and a glass plate (5 mm thick and 50 mm square) which was loaded with 5000-gram weight. Ten minutes after loading, the material was stripped from the die. The depth of intrusion was measured with steel scale and magnifying glass.

Results:

Table (2) shows the means of the tested properties for the different acrylic resins evaluated. (Student test was made at 5% level of significance.)

From Table (2), there was significant difference between the impact strength of the high impact resins and that of the conventional and microwave cured acrylics at 5% level if significance. The impact strength of the SR Ivoclar injection resin, was highly significant.

The transverse strength and deflection of the SR Ivoclar, Optilon, and Titan were significantly higher than the other types of acrylic resin tested at 1% level (Table 2).

The tensile strength and modulus of elasticity of the conventional and microwave cured resins were higher than the high impact resin materials. However, there was no significant difference.

Table (2) show that the SR Ivoclar had the highest value of packing plasticity which was of significantly different from the other tested materials.

Discussion:

The purpose of this study was to compare between denture base materials known, commercially, as high impact strength materials, with the microwave curing resin and conventionally heat cured resin. The comparison was not limited to the impact strength, but also extended to find out whether the other properties such as: transverse strength, deflection, tensile strength, modulus of elasticity and packing plasticity are affected. The microwave curing resin was included in this study because the material is relatively new and was found in previous studies [22,23] to be superior to the conventionally heat cured resin regarding other properties.

The results of this study shows that the materials ranked commercially as high impact strength materials and had actually the highest values of impact strength among the tested materials. The lowest value of impact strength among this group (recorded for Optilon) was almost one and half the corresponding value of the conventional cross linked or microwave cured resins. The relative manufacturer's treatment of these materials was obviously successful in this respect. Despite the fact that the composition of each material is a secret formula for the manufacturer, the incorporation of rubber particles in the polymer matrix is known to enhance resistance of the material to impact failures as the rubber particles will act as stress absorbents [24].

The transverse strength and deflection were also higher in the high impact materials. This finding can be attributed to the positive effects of the added fillers.

On the other hand, the values of the tensile strength and modulus of elasticity shows no statistically significant differences between the different groups. This may be attributed to the nature of these tests that might depend mainly on the ground substance of the polymer rather than the phases of the resin. It is known that polymethyl methacrylate is the main ingredient among the tested materials. However, the manufacturer treatment and the possible presence of rubber filters could only improve the impact and transverse strength without having a significant effect on the other properties.

The ADA specification No. 12 for denture base resins indicates that the material when subjected to packing plasticity test shall intrude into at least 2 holes of the die to a depth of not less than 0,5 mm. In the present study, the packing plasticity ranged from 8(1.66 to 16)0.582. This relative differences in plasticity test could be attributed to the different viscosities of the tested materials. The incorporation of minute rubber filters, which act as impact restorers in the high impact materials could have an effect on the relative viscosity of the material which was natural by different proportions in the different materials with subsequent higher viscosities in the high impact group in comparison to the conventional and microwave resins. However, the SR Ivoclar material was an exception with a significantly higher packing plasticity. This could be attributed to the mechanical mix and vibration used with this material which led to a dough of higher flow.

Nevertheless, the present study showed that the SR Ivoclar material have better strength properties than the other two high impact materials as well as among all the other tested materials, except for the tensile strength and modulus of elasticity. The reason for this finding is attributed to the fact that the processing of the S.R Ivoclar material is well controlled. The material is provided in solitary vials contain the liquid and powder in separate compartments. Furthermore, the mixing process is carried out within the vial itself by means of a vibrator similar to that used for amalgam capsules. By this way, the exact (and minimum) ratio of monomer to polymer, which effects the properties of the cured material, are used. Furthermore, packing and curing are done under vacuum pressure, which provide a continuous source of the material to the mold as curing shrinkage might occur. All these factors helped to a great extent in the making of the material having the least shortcoming in its mechanical properties, as any slight error that could have arisen during manual handling was completely avoided. Finally, it appears that the properties of the tested materials lie within the range of the ADA Specification for acceptance.

CONCLUSION:

1. The denture base materials ranked commercially as high impact strength materials shows superior properties when compared with the microwave curing resin and conventionally heat cured resin regarding impact, transverse strength and deflection properties.
2. The tensile strength, modulus of elasticity, and packing plasticity, except for the SR Ivoclar, were higher in the conventional and microwave cured resins (statistically non-significant).
3. The SR Ivoclar material shows the best results in all properties studied compared with the other high impact resins. On the other hand, there was no significant difference between the properties of heat and microwave cured resins.

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