

Evaluation of Titanium di oxide Nano-fillers Incorporation on Mechanical Properties of Heat Cured Acrylic Resin

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Abstract

The persistence of this revision was to assess the outcome of adding of surface cured titanium dioxide Nano stuffing (TiO_2) on Impact strength, Transvers strength and tensile strength. Titanium oxide Nano fillers were merged into (PMMA) denture base by allowed essential majority. The nanoparticles were coated by a film of trimethoxysilypropylmethacrylate (TMSPM). A controlled group and three different percentages 3%, 5% and 7%, of TiO_2 dust was added to PMMA powder by weigh up and mixed by probe sonication appliance. 120 samples were built and distributed into 3 clusters rendering to the test (40 specimens for each group) and each cluster was split into 4 sub-groups conferring to the ratio of auxiliary TiO_2 (10 specimens for each subgroup). The tests piloted were impact strength (charpy tester), transverse strength test and tensile strength test. Extremely significant rise in charpy tester and transverse strength was detected associated with the increase of the addition of TiO_2 powder to (PMMA) at the ratio of 3% and 5%; despite the fact a significant drop happened in both tests at the ratio of 7%. Alternatively, there were non-significant progresses in the tensile strength through the enforcement of (TiO_2).

Conclusion: the result of this revision presented that treated TiO_2 Nano-fillers is nominal in altering impact strength and Transvers strength while it was non nominal in successful altering the tensile strength, the extreme rise in impact strength and Transvers strength pragmatic in denture base containing 5% wt. of treated TiO_2 Nano-particles.

Keywords: heat cures acrylic, Titanium dioxide Nano-filler (TiO_2), Nano technology.

Introduction

Till now a day acrylic still used widely whatever the poor mechanical properties of it because it considered as material of choice for denture base [1]. To solve this problem acrylic might be treated by different enforced materials in order to enhance its properties these enforcement materials include metallic strengtheners, carbon-graphite fiber, aramid fiber and glass fibers [2].

One of the best materials used to altering the properties of acrylic is the use of Nano particles through the Nano technology [3]. In the chemical engineering, during the past 10 years, study has been enthusiastic to the advance of a new manufacturing procedure that includes nanoparticles into acrylic resin given that a new class of acrylic resin that proposals the strength of the Nano-oxides, with the elasticity of PMMA [4].

Metal Nano oxide as TiO_2 , and SiO_2 are branded by their minor extent, great surface area and strong interfacial contact with the polymer matrix [5]. So that, they can advance the physical, thermal and optical properties of the polymer matrix denture base [6].

Augmented bond strength by operation of silanes is a consequence of a multipart set of issues such as wet out, surface energy, border layer captivation, polar adsorption, acid-base communication, interpenetrating grid development and covalent response [7]. Titanium oxide Nano-particles mechanically underline the polymers and allow for high impact strength, breakage toughness, rigidity and solidity of the armored PMMA matrix [8].

External surface alteration of a mineral particle with an organic substance is a valuable method to decrease its superficial energy and raise its compatibility with

polymer matrix and dispersalsameness and thus recover the assets of the polymer-inorganic subdivisions [9].

The non-competitive Nanoparticles were experiencedsuperficialconduct with saline link agent and entrenched into PMMA [10].

Handling the superficial aspect ofTiO2 nanoparticles using trimethoxysilypropyl methacrylate (TMSPM) could reducecombination of TiO2 particles and improve its compatibility with organic polymer [11].

Materials and Method

Titanium dioxide already coated with trimethoxysilypropylmethacrylate (TMSPM), heat cured resin polymer and monomer, yellow dental stone (III) and could mold seal were prepared to be used. (120) samples were organized for this revision. The samples were distributed to three groups according to the type of the examination. Each group involved 40 samples and these were segmented according to the attentiveness of Titanium di oxide Nano particles into four sub groups as follow:

- a. Group (A) control group (0% TiO2) 30 samples
- b. Group (B) 3% modified group (3% weight TiO2) 30 samples
- c. Group (C) 5%modified group of (5% TiO2) 30 samples
- d. Group (D) 7% modified group of (7% TiO2). samples

Table (1): Involvement Proportion of TiO₂ with PMMA according to the manufacturer instruction

cod	TiO ₂	Polymer	monomer
0%	0	100g	40ml
3%	3g	97g	40ml
5%	5g	95g	40ml
7%	7g	93g	40ml

Plastic model preparation:

By using of CNC laser cutting machine plastic models were made on deferent plastic sheet: .a. for Compressive or Transverse strength test bar designedsample with

measurement of (65mm x 10 mm x 2.5 ± 0.1 mm) length, width, thickness respectively.

b. for charpy or Impact strength test: bar designedsample with measurement of (80 mm x10 mm x 4 mm) length, width and thickness respectively.

c. Tensile strength test: Dumbbell- Shaped samples with measurement of (75mm × 12.75mm × 2.5mm) length, width, thickness respectively. As shown in Fig (1)

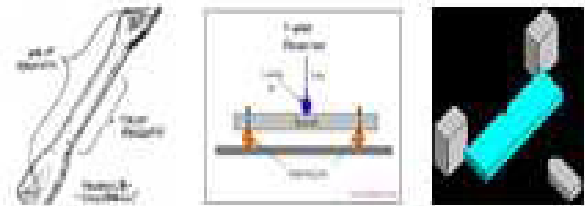


Fig (1) Tensile strength specimen (A), Transverse strength specimen (B) and Impact strength specimen(C)

Preparation of the mold

By using metal dental flask, denture processing method were used to prepared the samples, at the beginning paint the flask by separating medium allowed to dry then paint the samples by separating medium weight to be dry mix the stone according to manufacturer instruction then filed the first half of the flask by the stone put the samples in which half of it appeared to be removed easily after the set of the stone put the other half of the flask on the first one fill the flask by dental stoneweighted to the dry and open the tow half of the flask paint them by separating medium and pack the acrylic and cure

Titanium di oxide Nano fillers incorporation

TiO₂ Nano filler powder was added by weightiness in four clutches; 0%, 3%, 5%, and 7% to acrylic monomer. digital automaticweighing scale with exactness of (0.001g) was used, Next the totaling mixed by probe ultra-sonicater (140W, 65KHz) for several min to destroy the coated particles intospecific crystals of Nano TiO₂.The postponement of monomer with TiO₂ Nano crystals was instantlydiverse with polymer to decrease the opportunity of crystals accumulation and segmentparting.

1. Charpy test (Impact strength test)

A- Test samples

The samples were equipped with measurement (8cm

x 1cm x 0.4 cm) for unnotched Charpy Impact test. For each concentration ten samples were equipped make an overall of (40) samples. PMMA samples were kept in distilled water at 37°C for 48 hours on the incubator before the test.

B-Testing equipment and procedure

The test was assessed subsequent the technique recommended by the use of Charpy device. The samples were sustained horizontally at each end and hit by free fluctuating pendulum of two Joules and digital paradigm to show the impact energy fig (5). The measurement analysis provides the impact energy in Joules. The amount of the strength at unnotched specimens was intended in kilo Joules per square meter (KJ/M²)



Fig (2) impact testing device

2. Transverse strength test

A- Specimen design:

The samples were equipped with measurements of (6.5cm x 1cm x 0.25cm) for each concentration. Ten samples were equipped make an overall of (40) samples. Samples were kept in distilled water at 37°C for 48 hours on the incubator before the test.

B-Testing equipment procedure:

The test was assessed subsequent the technique recommended by the use of universal Instron testing machine, the sample was situated on the bending fixture which consists of two parallel supports 5cm apart, the full scale was 50 Kg, and the weight was pragmatic with a cross head quickness of 1mm/min by a rod placed centrally between the supports making bend until break happens.

3. Tensile strength testing:

A- Specimen design:

The specimens used were Dumbbell- Shaped specimens with dimension of (75mm x 12.75mm x 2.5mm). Ten specimens for each concentration plus the control will make a total of (40) specimen for the measurement of transverse strength. All the specimens were immersed in distilled water on the incubator at 37°C for (48) hours before testing.

B-Testing procedure:

Tensile strength was assessed via Jian Qiao testing apparatus for determining tensile strength. (Fig7). The sample was detained at each two ends and the force at the disappointment was recorded in Newton (N) and the tensile strength standards were intended from the following equation:

$$TS = A/F$$

Where

TS: Tensile Strength.

F: The Force

A: Minimum cross sectional area

Revision results

1. Impact strength

Statistical values listed in the table 2 appears the effect of adding different concentration of

TiO₂ Nano particles to heat cured acrylic on the impact strength of PMMA

Table (2) distractive data of Impact strength parameters analysis (Kj/m²)

	Group A	Group B	Group C	Group D	
N	10	10	10	10	
Mean	8.22	9.111	9.625	7.19	
SD	0.254	0.111	0.145	0.32	
SE	0.822	0.334	0.544	0.11	
range	Min.	8.133	9.001	9.321	7.222
	Max.	8.945	9.422	9.934	8.133

Maximum mean value seemed in group C with a mean of 9.617 KJ/m² and the last mean was in group D which was 7.77 KJ/m².

Rise of impact strength because of interfacial crop strength between Nano filler and matrix was high because of creation of cross-links or supra molecular attachments which shelter the Nano plaster and avoid crashes. Also the crash broadcast can be altered by good attachment

between Nano filler and matrix.

2. Transverse Strength

Statistical values listed in the table 3 appears the effect of adding different concentration of TiO₂Nano particles to heat cured acrylic on the transverse strength of PMMA

Table (3) descriptive data of Transverse strength parameters (N/mm²)

		Group A	Group B	Group C	Group D
N		10	10	10	10
Mean		114.945	120.135	124.533	111.633
SD		1.423	0.845	1.566	0.50
SE		0.834	0.367	0.587	0.111
range	Min.	112.433	118.992	121.996	110.994
	Max.	116.686	122.122	127.111	112.082

Maximum mean seemed in group C which was 124.562 compared to group D with mean of 111.6 which presented the last mean.

Rise in transverse strength that happen with adding of 3%TiO₂ Nano particles because of decent spreading of the greater than 150nm size of Nano subdivisions allow them to entomb between lining macromolecules chains. Segmental motion of the macromolecular chains were limited and prime to rise strength and firmness of the risen so this enhanced the fractural confrontation and lead to progress transverse strength.

3. Tensile strength test:

Statistical values listed in the table 4 appears the effect of adding different concentration of TiO₂Nano particles to heat cured acrylic on the tensile strength of PMMA

Table-4 Show that the same mean appeared in-group A, B, C and D, which was between 43.220 to 43.261

		Group A	Group B	Group C	Group D
No.		10	10	10	10
Mean		43.222	43.233	43.224	43.226
SD		1.656	1.356	1.378	1.343
SE		0.533	0.555	0.555	0.555
range	min	39.77	39.24	39.53	39.89
	max	45.16	45.25	45.15	45.16

Discussion

The adding of coated TiO₂ Nano-filler powder to PMMA amplified the value of impact strength related to 0% concentration group, 5% group has the peak impact strength and 7% group has the last impact strength.

The increase of impact strength due to interfacial shear strength between Nano filler and matrix was high due to formation of cross-links or supra molecular bonding which cover the Nano filler and prevent sudden cracks. Also the crack propagation can be changed by good bonding between Nano filler and matrix [12].

Increase the concentration of smaller size Nano particles increase inter facial surface area so that the force need to destroy the samples also increased, adding TiO₂ Nano filler will form a network of 3D dimension of PMMA and TiO₂ Nano particles. PMMA, matrix powder chain shifted in to 3D-network like chains at 5% of Nano filler accordingly lead to decrease the segment motion and rise the impact strength [13].

At the 7%, the drop in impact strength as compared with 5% may be due to high external expanse of the collected Nano filler which may reach to micro filler TiO₂ within the matrix causing stress concentration around the collection of the Nano material which lead to fissure spread. The increase in transverse strength that occur with addition of 3% TiO₂ Nano particles due to good distribution of the <100nm size of Nano particles enable them to inter between liner macromolecules chains. Segmental motion of the macromolecular chains was restricted and lead to increase strength and rigidity of the risen so this improved the fractural resistance and lead to improve transverse strength [13&14].

Rise clarified on the roots of alteration strengthening when adequate stress progresses and fissure instigates to spread, an alteration of TiO₂ from the steady crystal phase to the steady monocyclic phase happens which reduces the energy of fissure spread, at this procedure growth of TiO₂ crystals happens and seats the fissure under a state of compressive stress and fissure spread was blocked [15].

At the 7%, drop in transverse strength may be because of spaces between the acrylic cuffs were occupied with Nano filler produced filler among this cuffs and because of frail attachments between them producing drop on transverse strength, as well as because it was stop stress transformation [16].

Conclusion

Within the limits of this study, the following conclusion was drawn:

1- Incorporating Nano titanium di oxide Nano filler into conventional heat-cured denture base resin results in an increase in impact strength and transverse strength. The magnitude of the increase is depending on the percentage of TiO₂ added into the resin (3%,5%). However, as the percentage increased to 7% there was significant decreased in impact and transverse strength.

2- No significant change in tensile strength was seen when acrylic resin was mixed with TiO₂ percentages 3% and 5% but there was highly significant decrease in tensile strength with 7% TiO₂.

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Ethical Clearance – Not required

Conflict of Interest: None

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