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Evaluation of some properties of recycled polymethylmethacrylate incorporated to the acrylic resin

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ABSTRACT

Many attempts have been made enhancing properties of PMMA denture base material. Adding fillers to PMMA was a commonly used method to improve physical and mechanical properties. To estimate the effects of incorporating recycled polymethylmethacrylate with a different percentage with conventional heat-cured acrylic resin on some properties of heat-cured denture base resin. The recycled polymethylmethacrylate (Chaini-HK G) particles dissolved at (5%,10%,15%) was added to heat-cured polymethylmethacrylate (Spofadental, Czech Republic) polymer and mixed with a ratio of 2:1 with the polymethylmethacrylate monomer. A total number of specimens were 80, which divided into three experimental groups (5%, 10%, 15%) and control group. Each group have 20specimens. The surface hardness, water sorption, solubility and residual monomer of test groups measured as well as compared to that of control groups. Fourier transform infrared spectroscopy test (FTIR) was done for three experimental and control group. This study shows a statistically significant difference at ($p<0.01$) in the hardness of recycled polymethylmethacrylate incorporate material (10 %,15%) groups when compared with a control group; while recycled polymethylmethacrylate incorporated (5%) group show no significant difference, group with 15% shows the highest Vickers hardness value. The mean values of water sorption test solubility test and residual monomer were decreased with the increase of incorporating a percentage of recycled polymethylmethacrylate as compared to the mean value of the control group. The incorporation of recycled polymethylmethacrylate to heat acrylic resin at different percentage improves some of its properties.

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INTRODUCTION

The acceptance of PPMA resin was accredited to easy processing, low cost, perfect aesthetic properties hardness, lightweight, low solubility and water sorption, and ability to easy repair (Meng and Latta, 2005).

Polymethylmethacrylate absorbs moderate amounts of water if place in an aqueous environment, water exerts a significant effect on the mechanical and dimensional properties of polymer (Al-Nori *et al.*, 2007).

Numerous studies showed with goal of enhancing the properties of PMMA by adding fillers inside the

composition. Addition of fillers and fibers to PMMA is a commonly used technique to develop physical and mechanical properties (Alla *et al.*, 2015; Hamouda and Beyari, 2014).

Hardness is the main physical property of PPMA resin. It is used for manufacturing denture bases, that get up from occlusion that growing durability of dental prostheses (Pinto *et al.*, 2010).

The addition of inorganic filler in acrylic resin alter properties of end product depend on the kind, sizes, shape, concentration and interaction among polymer matrix itself (Hameed and Rahman, 2015).

Fourier transform infrared spectroscopy, mainly common spectroscopic technique used for an organic and inorganic chemist, used to detect any chemical modify- cation occurs (Swann and Patwardhan, 2011).

Aim of our study

Estimate effect of higher amount incorporation of recycled polymethylmethacrylate with a different percentage to heat-cured acrylic resin on more than property of PMMA resin.

MATERIALS AND METHODS

Experimental Part

Preparation of incorporate material

Five, ten and fifteen gram of recycled polymethylmethacrylate (Chaini-HKG) particles dissolved in 10 ml of monomer separately, then mixed until all particles completely dissolved to obtain 5 %,10% and 15% of the additive of recycled polymethylmethacrylate. Incorporate material (5%,10%,15%) were added to heat-cured acrylic resin (Spofa dental, Czech Republic) amount of mixing (2:1). A wax pattern measurement was (30mm diameter * 2mm width). After curing, finishing and polishing for all specimens. Freshly dried silica used to dry acrylic specimens, which found in an Incubator at 37±2°C at 24 hours. A total number of specimens were 80, were divided into three experimental groups (5%,10%,15%) and control group, each group have 20specimens. The surface hardness, water sorption, solubility and residual monomer of test groups measured and compared to that of the control group. Fourier transform infrared spectroscopy test (FTIR) were recorded for experimental groups (5%, 10%, 15%) and control group.

Hardness test (Vickers hardness)

Hardness tested (Microhardness tester- Shimadzu, Japan), to determine Vickers value, a specimen was measured by applying a load under 25g load at 30s

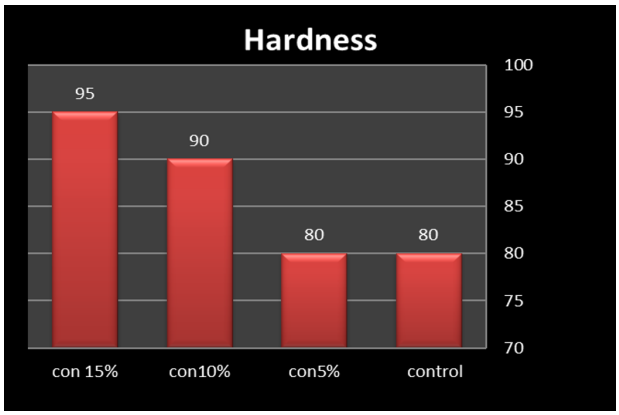

Figure 1: Mean value of hardness test of three experimental groups (5%, 10%, 15%) and control group.

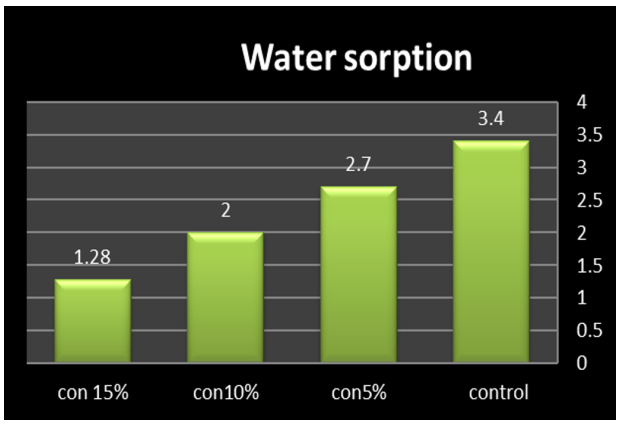

Figure 2: Mean value of water sorption of three experimental groups (5%, 10%, 15%) and control group.

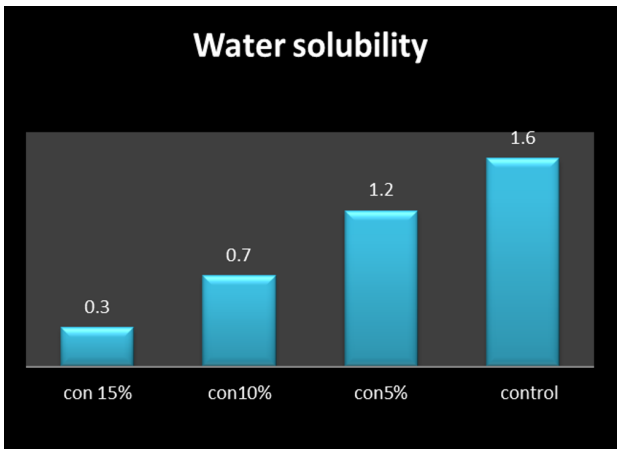

Figure 3: Mean value of water solubility of three experimental groups (5%, 10%, 15%) and control group.

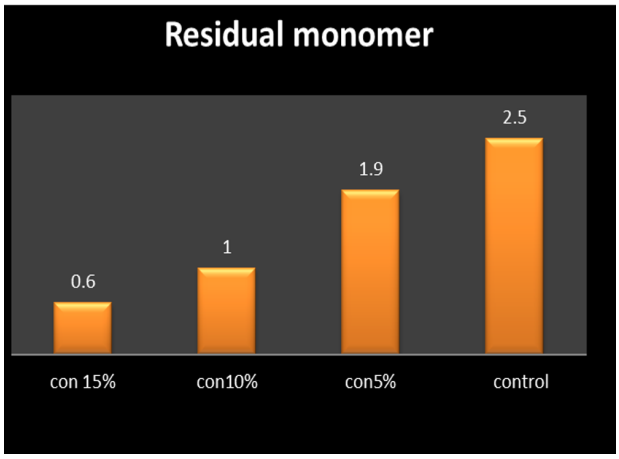

Figure 4: Mean value of residual monomer of three experimental groups (5%, 10%, 15%) and control group

penetration. Three readings were recorded for each specimen (one on the middle and two on the boundary) the mean value was calculated for each specimen.

Water Sorption and solubility test

The specimens were dipped in water seven day at 37±1̊C. After specimens removed from the water, specimens dried in desiccators contain dry silica gel (37 ± 2°C for 24 hrs.) weighed with 0.1 mg in a weighing balance. This sequence repeated until the weight of each disk stabilized. Water sorption for specimen taken by using this equation: -(mass of specimen after immersion (mg) conditioned mass(mg) W1) /surface area. final weight obtained in the water sorption test; this value signifies (W_3). Formula of solubility(mg/cm^2) = (W_1 - W_3/ SA).

Residual monomer test

The spectrophotometer used measure a residual monomer concentration. Should be construct a standard dilution curve to comparison with reading values taken from spectrophotometer and decide the exact concentrations of residual monomer in all group's samples collected.

Fourier Transform Infrared Spectroscopy

Establish changing in chemical of specimens of three experimental groups (5%,10%,15%) and control group recorded by (FTIR). The measurements are taken by (Alfa Burke instrument) University of Mosul, Dentistry College.

RESULTS

Hardness test

Figure 1 displayed the average mean value of hardness of the three experimental groups (5%,10%,15%) and the control group. Statistically significant difference at($p<0.01$) detect in recycled polymethylmethacrylate incorporate material (10%,15%) groups, when compare with control, while recycled polymethyl- methacrylate incorporated (5%) group show no significant difference, group with 15% show the highest Vickers hardness value, as display in Table 1.

Water sorption and solubility

Figures 2 and 3 displayed the average mean value of water sorption and solubility, respectively of control and recycled polymethylmethacrylate incorporated material (5%,10%,15%) groups. Statistically significant difference at ($p<0.01$) detected in recycled polymethylmethacrylate incorporated material (5%,10%,15%) groups, when compared with control for water sorption and solubility respectively as display in Tables 2 and 3. A group with 15% of incorporated material show the lowest value of water sorption and solubility when compare with control.

Residual monomer test

For residual monomer release Figure 4, displayed the average mean value of residual monomer of three experimental groups (5%,10%,15%) and control group, decreasing in the residual monomer of acrylic specimens with increasing incorporated of recycled polymethylmethacrylate. There is statistically significant, as shown in Table 4.

FTIR test

Shift bands at 1196,1156 which as singed to c=c bond after polymerization. The FTAR chart showed in Figure 5 dispensed this band or moved to the lower frequency in all three concentration groups, especially to the c=c bands. This confirms the polymerization process.

Discussion

Hardness

Vickers microhardness test is very effective method to evaluate the stiff polymers and capability of material that resist the diffusion of load (Anusavice, 2003).

According to the result in the current study, the hardness value was increased with increase filler material (recycled polymethylmethacrylate incorporated material). This due the insertion and linkage of filler to heat cure resin, create polymerization of acrylic resin and appeared more stiff and lower deformation. Increase of hardness is a result of cross-linking agent occurred to neutralize by result of residual monomer substance.

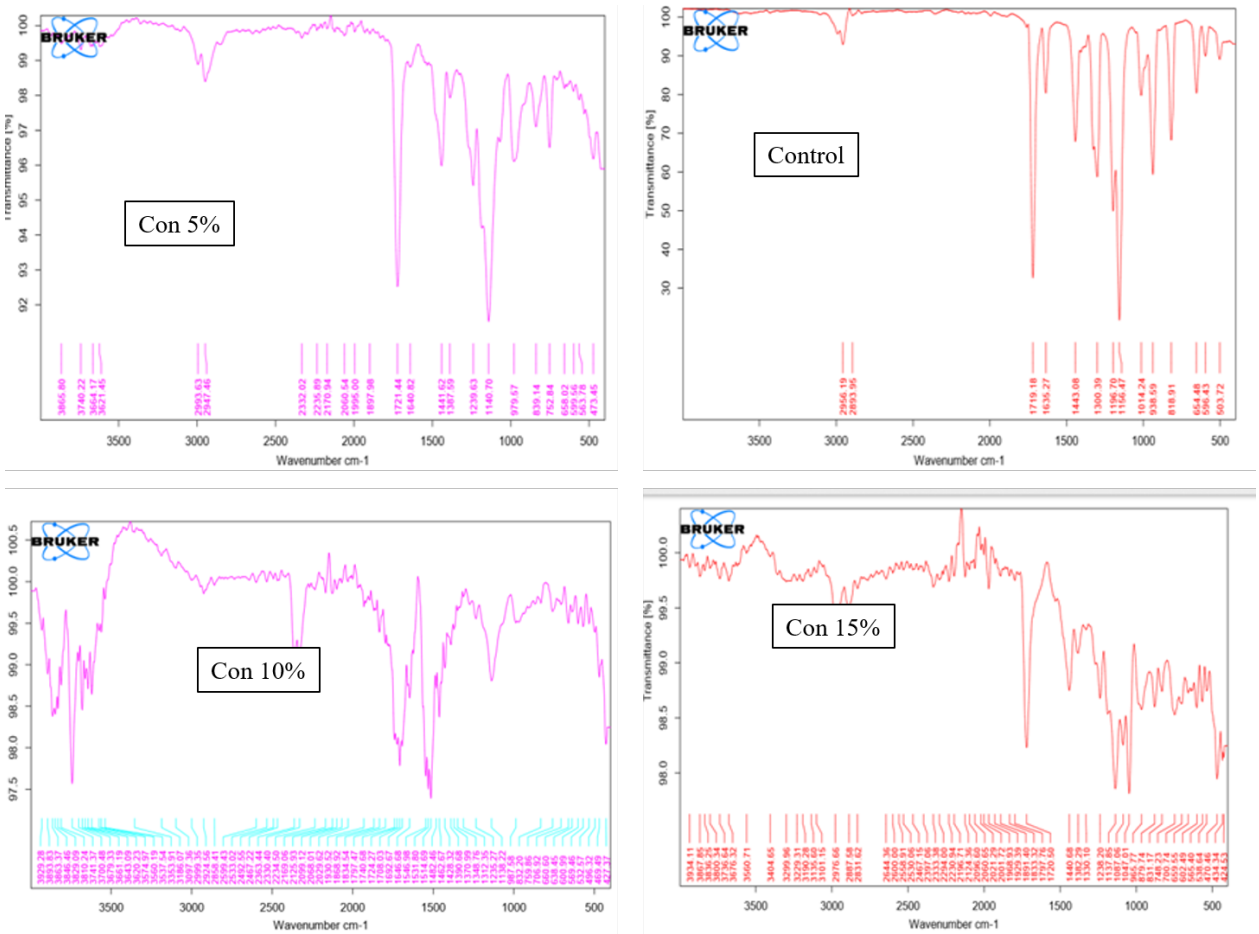

Figure 5: FTAR of three experimental groups (5%, 10%, 15%) and control group.

Table 1: Dunnett test for hardness

Upper Bound	Lower Bound	Sig	Std Error	Mean Difference (I-J)	Dunnett(2-sided) (J)code	(I)code
7.3190	-3.3190	.651	2.05183	2.00000	1.00	2.00
12.9190	2.2810	.005	2.05183	7.60000	1.00	3.00
15.7190	5.0810	.000	2.05183	10.40000	1.00	4.00

Table 2: Dunnett test for (water sorption).

Upper Bound	Lower Bound	Sig	Std Error	Mean Difference (I-J)	Dunnett(2-sided) (J)code	(I)code
-.1311	-.5889	.002	.08832	-.36000	1.00	2.00
-.4711	-.9289	.000	.08832	-.70000	1.00	3.00
-.5711	-1.0289	.000	.08832	-.80000	1.00	4.00

Table 3: Dennett test for (water solubility).

Upper Bound	Lower Bound	Sig	Std Error	Mean Difference (I-J)	Dunnett(2-sided)	
					(J)code	(I)code
-.5693	-.7467	.000	.03423	-.65800	1.00	2.00
-1.3113	-1.4887	.000	.03423	-1.40000	1.00	3.00
-1.9113	-2.0887	.000	.03423	-2.00000	1.00	4.00

Table 4: Dunnett test for (residual monomer).

Upper Bound	Lower Bound	Sig	Std Error	Mean Difference (I-J)	Dunnett(2-sided)	
					(J)code	(I)code
-.6000	-.6000	.000	.00000	-.6000	1.00	2.00
-1.5000	-1.5000	.000	.00000	-1.50000	1.00	3.00
-1.9000	-1.9000	.000	.00000	-1.90000	1.00	4.00

(Ana *et al.*, 2012) showed that the acrylic resin displayed higher hardness values with glass fiber reinforcement (GFR). This agrees with my study·

(Shirkavand and Moslehifard, 2014) demonstrated that increasing in filler amount leads these particles to agglomerate and presentation at stress directed in the center of matrix hence negatively influence the mechanical properties after polymerization.

(Hasratiningsih *et al.*, 2017) said that "13% reinforced ZrO_2-Al_2O_3-SiO_2 filler system at 700°C showed the highest hardness increased about 25% comparison to calcinationtemperature550 -700°C".

(Asopa *et al.*, 2015) "said that a greater filler content reducing the strength and the resin cannot adding more filler particles. This leads to a disturbance in the resin matrix that leads to reduce the strength of the reinforced specimens. Addition fillers with different percentages may decrease the hardness value compared to the control group; a decrease of hardness was found when the filler added more than eleven per cent of filler".

Water sorption and water solubility

PMMA will remain the favourite material of select for the construction of acrylic denture. Try to improve the strength features of the material that lead in lengthening the durability of acrylic dentures. Reinforcement of acrylic resin with any type of fillers have revealed a significant improvement in mechanical properties (Rama *et al.*, 2013; Mohammed *et al.*, 2017).

The procedure employed for the incorporation of a higher percentage of filler to PPMA resin affected the water sorption and water solubility, with the increase ratio of incorporated material, water sorption and water solubility decrease, this agrees with my study (Amrah *et al.*, 2018).

Our result shows that water (sorption, solubility) decrease as compared to control group, incorporated material with15% of recycled polymethylmethacrylate material have lowest mean value for water (sorption, solubility, this due to water destroyed the fiber polymer matrix bond and polymer matrix by water molecules and lead to plasticization.

(Ozlem *et al.*, 2006) studied the strengthening of a denture (PMMA) with milled glass fiber, which leads to reduce water sorption and generally unaltered solubility. This agrees with our result.

(Al-Nori *et al.*, 2007) Demonstrated that (PMMA) absorbs water little by little over a period of time when located inside an aqueous environment. That lead to mechanical characteristics of the resin and becomes more low.

Since silver fillers and glass fibers cause decreasing in value of water sorption and alteration of heat cure acrylic resin with adequate amounts of silver particles and glass fibers, can useful into avoiding an unwanted physical change of dentures resultant from oral fluids (Hamouda and Beyari, 2015; Polat *et al.*, 2003).

(Neelu *et al.*, 2011), said that "silver fillers, sapphire fillers are purported to be better fillers for the reinforcement of polymethylmethacrylate resin. This is because they have potential as added components in denture bases to provide increased flexural strength, thermal diffusivity and decreased water sorption".

Study of copolymerization via incorporated

monomer in dental materials makes available reinforcement method, Heat cure acrylic resin material exhibit lesser residual monomer content than of self-cure material (Elif and Rukiye, 2013; Long G, Hilde M. Kopperud & MaritOil., 2017).

Residual monomer

Results of the study show residual monomer release decreased with increase of incorporated recycled polymethylmethacrylate in comparison with the control group. Residual monomer release associated with a type of resin used. Added recycled polymethylmethacrylate causes alteration of a molecular matrix of heat cure acrylic resin.

(Rodrigo and Oliveira, 2014) "said that residual monomer release is relative to the type of resin employed rather than the polymerization cycle".

(Ihab *et al.*, 2016) studied the addition of zinc oxide powder to heat cure acrylic reduces its water sorption and porosity.

(Vojdani *et al.*, 2010) said that "quantity residual monomers are influenced by the kind, curing method, and thickness of acrylic resins, adding filler'.

While (Mohammed *et al.*, 2008), demonstrated that different method of polymerization affects the residual monomer. Heat cure material depicts a higher tensile strain, tensile strength than self-cure.

FTAR test

The FTAR result indicate that the polymerization process leads to a decrease in monomer release; this was confirmed by an increase of the degree of conversions (Amrah *et al.*, 2018).

CONCLUSIONS

The incorporation of recycled polymethylmethacrylate to heat acrylic resin with different percentages decrease the water sorption and solubility while hardness means value increase, this leads to improving some properties of heat acrylic resins.

Conflict of Interest

None.

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None.

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