International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 7 Issue 5, May-2018, Impact Factor: 4.059

The effect of recycled polymethylmethacrylate on some physical and chemical properties of acrylic resin denture base

Amrah Y. Al-Jmmal[1], Nada Z[2], Amer A Taqa[3*]

[1,2]University of Mosul, College of Dentistry, Department of Prosthodontics
[3]*University of Mosul, College of Dentistry, Department of DBS

ABSTRACT

Introduction: Addition of filler to poly methylmethacrylate (PMMA) matrix may enhancethe mechanical properties of the polymerized resin, but there is a great concern about the stability of PMMA in aqueous environments, this is mainly because the filler matrix interface provides paths of facilitated diffusion similar to grain bound diffusion.

Aim of present study: To evaluated the effect of incorporation of recycled poly methyl methacrylate with different present conventional heat cured acrylic resin on physical and chemical of PMMA denture base material.

Materials and Methods: A total of 60 specimens were fabricated in the current study. They were divided into all groups with each group consists of 20 specimens: Group1: conventional heat cured acrylic resin, was considered as control. control. Group2: conventional heat cured acrylic resin with1% of recycled polymethyl methacrylate. Group3: conventional heat cured acrylic resin with2% of recycled polymethyl methacrylate. Group4: conventional heat cured acrylic resin with3% of recycled poly methylmethacrylate. Such groups were subdivided into physical tests: water solubility test,water sorption test, residual monomer test, and Fourier transform infrared spectroscopy (FTIR).

Results: The results of value of mean of solubility test, water sorption test and residual monomershowed as decreased in waterSolubility, water sorption andresidual monomer of acrylic specimen with the increased in concentration of added of recycled poly methylmethacrylate.

Conclusion: The addition of recycled poly methylmethacrylate to heat acrylic resins change chemical and physical proprietress of heat acrylic resins.

HOW TO CITE THIS ARTICLE

Amrah Y. Al-Jmmal1, Nada Z2, Amer A Taqa3*, "The effect of recycled polymethylmethacrylate on some physical and chemical properties of acrylic resin denture base", International Journal of Enhanced Research in Science, Technology & Engineering, ISSN: 2319-7463, Vol. 7 Issue 3, March -2018.

INTRODUCTION

Poly(methylmethacrylate) still the most predominantly used denture basematerial because of its excellent esthetics, ease of processing and repair and being economical. However, this material is not ideal in every respect, especially when meeting with mechanical requirements of prosthesis. Fracture of acrylic resin denture base happens frequently because of the fatigue and chemical degradation of base material, to overcome these drawbacks, there has been much new advancement in the field ofacrylics. Resins have been reinforced using different materials to improve strength. Other physical properties have also been improved by usingdifferent additives in resins. Several modified poly (methyl methacrylate) materials have been used for denture base applications [1,2]. During clinical use, the denture base materials are immersed in saliva and when not in use may be soaked in water. When immersed in such solutions, plasticizers and other soluble components may leach out over extended periods, while water or saliva is absorbed. The loss of plasticizer may cause brittleness and increased hardness values. Several investigators have evaluated the effect of water on the bond strength of acrylic materials and demonstrated that absorbed water can have a detrimental effect on bond strength to acrylic resin. Furthermore, material aging can dramatically affect the physical and mechanical properties [3].

Water sorption is a feature of acrylic resins that significantly affects their mechanical and dimensional properties. The water pools among the polymers of the acrylic resin by diffusion, and pulls them apart, slightly expanding the resin. This small volume expansion, of approximately 1%, causeslinear expansion of 0.3%, which practically overrides the contraction caused by polymerization of the resin. The microspores that form in the resin, in turn, may lodge bacteria and fungi, favoring plaque formation and hindering proper cleaning of the prosthesis[4].

Addition of filler to poly methylmethacrylate (PMMA) matrix may enhancethe mechanical properties of the polymerized resin but there is a great concern about the stability of PMMA in aqueous environments. This is mainly because the filler matrix interface provides paths of facilitated diffusion similar to grain diffusion[5,6].

Fourier transform infrared spectroscopy(FTIR), is one of the most common spectroscopic techniques used by organic and inorganic chemists. Simply, it is the absorption measurement of different IR frequencies by a sample positioned in the path of an IR beam. The main goal of spectroscopy can analyses to determine the chemical functional groups in thesample[7].

Previous study was carried for showed the effect of recycled poly methylmethacrylate Additive on the physical properties of Dental Modelling Wax[8]. The aim of the present study was to evaluated the effect of incorporation of recycled poly methylmethacrylate with different present conventional heat cured acrylic resin on physical and chemical of PMMA denture base material.

MATERIALS AND METHODS

In this study, recycled poly methylmethacrylate (Chaini HKG) additive material was used to assess the physical and chemical properties of heat cured acrylic resin (Spofadental, Czech Republic). A total of 60 specimens were fabricated in the current study. They were divided into all groups with each group consists of 20 specimens:

Group1: conventional heat cured acrylic resin, was considered as control.

Group2: conventional heat cured acrylic resin with1% of recycled polymethyl methacrylate.

Group3: conventional heat cured acrylic resin with2% of recycled polymethyl methacrylate.

Group4: conventional heat cured acrylic resin with3% of recycled polymethyl methacrylate.

Such groups were subdivided into physical tests: water solubility test, water sorption test and residual monomer test, and chemical: Fourier transform infrared spectroscopy (FTIR). A wax pattern with dimension of 30mm diameter and 2 mm thickness was used to fabricate acrylic according (ADA. American Dental Association,1999) Initially, the upper and lower parts of a metal flask are separated using Vaseline. The dental stone was mixed with water according to manufacturer instructions (40g/100ml) at creamy mix and poured into lower half of the flask. Then, the wax pattern was placed gently into middle of flask with taking into consideration half of pattern must be exposed as shown in the (Figure 1). The flask was left to set for one hour.

The surface of dental stone was lubricated with the separating medium and left to dry for15 min. The second layer was applied and the upper part of the flask was placed into position. Once drying, the wax pattern was fully invested and left to set for one hour. The mould was then placed into a boiling out machine for five minutes and then removed and opened. The upper and lower part of the mould was cleaned using detergent. The upper and lower parts of the mould are separated using separating medium. Heat cure clear acrylic resin polymer and monomer with a ratio of 3:1 was mixed. When the mixture reached dough, it was then packed into the mould and cured in water bath. After curing, the flask was removed from water bath and left to cool. The samples were removed from the flask, finished and polished. The specimens were kept in distilled water for 2 days before testing.

For recycled poly methylmethacrylate additive material (1%,2%,3%) was added to monomer, and the polymer and monomer with a ratio of 3:1 were mixed. When the mixture reached dough, it was then packed into the mold and cured in water bath. Once curing, the specimens were removed, finished and polished. All acrylic specimens were dried in desiccators containing freshly dried silica, which placed in an Incubator at 37±2°C for 24 hours.

Figure 1: Specimen for water sorption Solubility

Sorption test:
The cured disks were dried in a desiccator containing silica gel at 37± 2°C for 24 hours then removed to a similar analytical room temperature for 1 hour, then weighed with an analytical balance of (0.0001 gm) accuracy. The specimens were weighed every 24 hours until a constant weight was attained, it considered as (W_1). The specimens then immersed in distilled water at 37±1°C inside an oven. Every 24 hours the specimens were removed from the water, wiped with a clean, dry hand towel, until free from visible moisture, waved in the air for 15 seconds, and after minute removal from the water and weight until constant weight was obtained, this represents as (W_2). The water sorption calculated according to this equation: Sorption (mg/cm^2) = W_2 -W_1 /SA (surface area of the disc).

Solubility test:
After the final weight obtained in water sorption test, the disks were reconditioned to constant weight by returning to the desiccator which containing silica gel at 37± 2°C as was done in previous sections, this value represents (W_3). The soluble matter lost during immersion was determined to the nearest 0.01 mg/cm^2. The water sorption was calculated according to the following equation: Solubility(mg/cm^2) = W_1 - W_3/ SA (surfaceareaofthedisk).

Residual monomer test:
HPLC was used to quantify the residual methyl methacrylate (MMA) content in the sample of heat-cure and heat-cure with additive material. The specimens were placed in amber-glass bottles filled with 10 mL of deionized water, sealed with plastic film, and kept in a sterilizer at 37°C. Different samples of the solutions in which the specimens were kept were collected every 24 hours. After the samples were collected, the specimens were rinsed in distilled water for one second and the remaining solution was discarded.

The specimens were then placed in the bottles again, and another10 mL of deionized water was added. This procedure was repeated for 11 days. The spectrophotometer used for our analysis was calibrated with a solution of known concentration of monomer. The wavelength used at260 nm. A standard dilution curve was constructed to be compared with the values obtained by the spectrophotometer and to determine the correct concentrations of residual monomer in the samples collected. In order to do this, the stored solutions were transferred to crystal cuvettes which were then used in the spectrophotometer to measure residual monomer concentration.

Fourier transform infrared spectroscopy(FTIR):
To determine the chemical change in the sample, the conventional heat cured acrylic resin and resin with additive was detected by (FTIR) to determine if there is any chemical change occurs as showed in (Figure 5), the measurements were done by using the Alfa Bruker instrument. Mosul University, College of Dentistry.

RESULTS

The results ofvalue of mean ofsolubility test, water sorption test and residual monomer (Table1) showed as the decreased in water Solubility, water sorption and residual monomer of acrylic specimen with the increased in concentration of added of recycled poly methylmethacrylate. In the present study there is decreased in water solubility of acrylic specimen after addition of recycled poly methylmethacrylate (Table 1), the lowest value of Solubility, was achieved group4 (3%). Statistical analysis, (Tables 2,3), revealed that there were statistical significant, decreased in sorption test, water Solubility of acrylic at (1%,2%,3%) as compared with control group, the decreased in water Solubility, water sorption directly related to concentration of added of recycled poly methylmethacrylate (Figures2,3). For residual monomer release (Table1), demonstrated that there are decreased in residual monomer of acrylic specimen with the increased in concentration of added of recycled poly methylmethacrylate, there were statistical significant, as showed in (Table 4).

Table 1: The value of mean of all groups of tests

	Group1(control)	Group2(1%)	Group3 (2%)	Group4(3%)
Water solubility test	1.6	1.4	1.3	1.2
Water sorption test	3.3	3.11	2.92	2.79
Monomer release test	2.5	2.2	2	1.9

Table 2: Dependent Samples Test for Solubility test:

Dependent Variable: test

	(I) code	(J) code	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Dunnett t (2-sided)[a]	2.00	1.00	-.36000-*	.08832	.002	-.5889-	-.1311-
	3.00	1.00	-.70000-*	.08832	.000	-.9289-	-.4711-
	4.00	1.00	-.80000-*	.08832	.000	-1.0289-	-.5711-

*. The mean difference is significant at the 0.05 level.

a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table 3: Dependent Samples Test for Sorption test:

Dependent Variable: test

	(I) code	(J) code	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Dunnett t (2-sided)[a]	2.00	1.00	-.36000-*	.08832	.002	-.5889-	-.1311-
	3.00	1.00	-.70000-*	.08832	.000	-.9289-	-.4711-
	4.00	1.00	-.80000-*	.08832	.000	-1.0289-	-.5711-

*. The mean difference is significant at the 0.05 level.

a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

Table 4: Dependent Samples Test for residual monomer:

Dependent Variable: teste

Dunnett t (2-sided)[a]

(I) code	(J) code	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2.00	1.00	-.30000-*	.00000	.000	-.3000-	-.3000-
3.00	1.00	-.50000-*	.00000	.000	-.5000-	-.5000-
4.00	1.00	-.60000-*	.00000	.000	-.6000-	-.6000-

*. The mean difference is significant at the 0.05 level.

a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

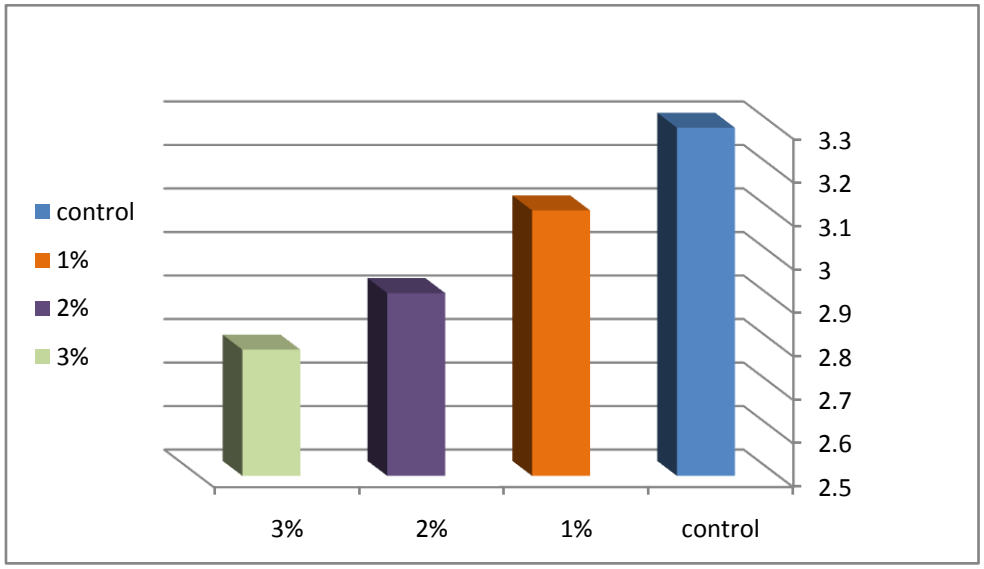

Figure 2: Solubility test of control andconventional heat cured acrylic resin with (1,2,3)% of recycled poly methylmethacrylate and

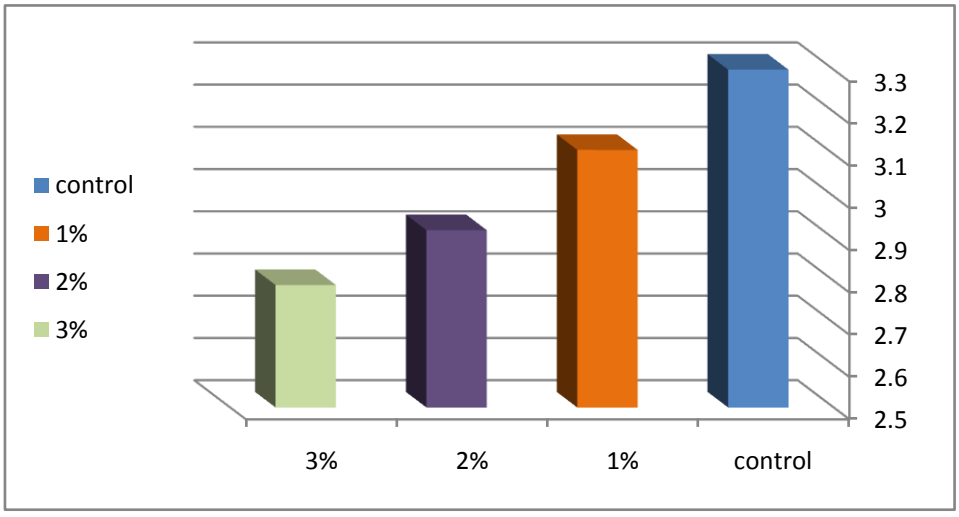

Figure 3: Sorption test of control and conventional heat cured acrylic resin with (1,2,3)% of recycled poly methylmethacrylate .

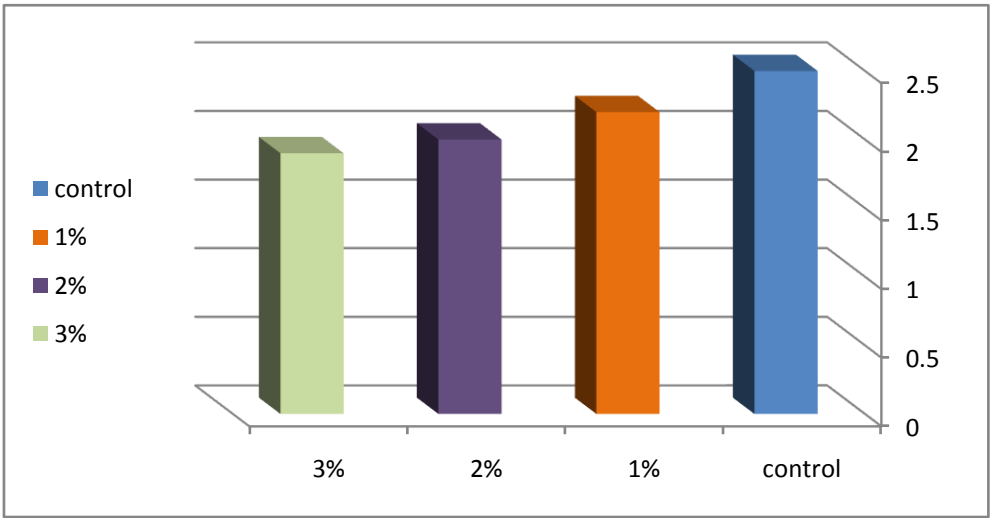

Figure 4: Residual monomer release of control and conventional heat cured acrylic resin with(1,2,3)% of recycled poly methylmethacrylate.

Fourier transform infrared spectroscopy (FTIR):

The FT-IR spectrum of PMMA (Figure 5) indicates the details of functional groups present in the synthesized PMMA. A sharp intense peak at 1731cm^{-1} appeared due to the presence of ester carbonyl group stretching vibration. The broad peak rang in rang from1260-1000 cm^{-1}can be explained owing to the C-O (esterbond) stretching vibration. The broad band from 950-650 cm^{-1} is due to the bending of C-H. The broad peak ranging from 3100-2900 cm^{-1} is due to the presence of stretching vibration of C-H bond[9]

The peaks at 1625 cm^{-1} and 1635 cm^{-1} in the spectra of MMA monomers were –C=C– stretching peaks of double bonds and they were invisible in the spectra PMMA, which means that polymerization was occur and completed.

DISCUSSION

Numerous studies have been reported in dental pertaining to the reinforcement of poly methylmethacrylate with various types of fibers and fillers in order to improve its mechanical properties, relatively few studies are present in literature where emphasis of research is also widened to include improvement in other physical properties such as water absorption, solubility and monomer release with the same reinforcements. It is, however, important to remember that the methodologies that improve the mechanical properties of a denture base material should not affect its physical and thermal properties[10,11].

According the result of this study there were decreased in water solubility, water sorption of group 2,3,4 as compared to control group (Table1). Actual no. of poly methyl methacrylate molecular available on surface of water sorption disk decreased as compared with contro[112,13,14]., studied the water sorption and dimensional changes of denture base acrylic resin reinforced with woven, highly drawn linear poly ethylene fibers. The high fiber loading, namely, fiber content, reduced the water sorption of the resin by about 25% this agree with our study. Poly methylmethacrylate (PMMA) absorbs water slowly over a period of time when placed in an aqueous environment. Though relatively moderate, this water exerts significant effects on the mechanical and dimensional properties of the polymer. It causes plasticization and lowers mechanical properties[15].

In the present study, a decrease in water sorption of the samples upon addition of fillers was noted. This was because by the addition of filler particles, the actual number of PMMA molecules available on the surface of the disk for water sorption to occur decreases as compared to the control samples; This result is decreased potential site of water exchange to occur, agree with our studied {16,17].

The sapphire fillers were smaller than the silver fillers and we had incorporated similar percentages of the two fillers individually by volume, the numbers of sapphire fillers were more, fewer and larger silver filler particles decreased the potential sites of water exchange to occur. On the other hand, because of the larger number of sapphire fillers, more sites were present on the surface of cured polymer (PMMA with sapphire fillers) for water molecule diffusion to occur by capillary action, so the water absorption and solubility of PMMA resin decreased with the increase in the percentage of silver powder (5-20%)[18] , agree with results. Since glass fibers and silver fillers resulted in significant decreased linear dimensional changes and significant decrease in water sorption, modification of heat-cured acrylic resins with certain amounts of glass fibers and silver particles, may be useful in preventing undesirable physical changes of dentures resulting from oral fluids clinically[19].

The results of this study showed residual monomer release, decreased with increase of in concentration of added of recycled poly methylmethacrylate, as compared with control. Residual monomer releaserelated to type of resin used so the additional of recycled poly methylmethacrylate cause alteration in molecular resin. [20].

Ihab et.al[21]were studied the incorporation of zinc oxide powder into acrylic denture base reduces its ' porosity. In term of water sorption, there was a slight reduction following adding zinc oxide filler. The amount of such residual monomers are known to be influenced by the type, curing method, and thickness of denture base resins addition filler; therefore, the tissue irritation induced by the denture base resin can be reduced by addressing these influential factors. The majority of studies on the cytotoxicity of the resins currently used as denture base materials reported that these resins are not toxic and do not suppress cell growth. The three types of denture base resin materials tested in our study revealed that they have a negligible influence on cell viability and adhesion; hence ,these materials are not believed to be cytotoxic[22,23,24].

The results of water solubility, watersorption and residualmonomer release decreased with increase of in concentration of added of recycled poly methylmethacrylate, this due to change of the matrix of polymer lattice during polymerization process which can obeyed analytical of FTIR chart:

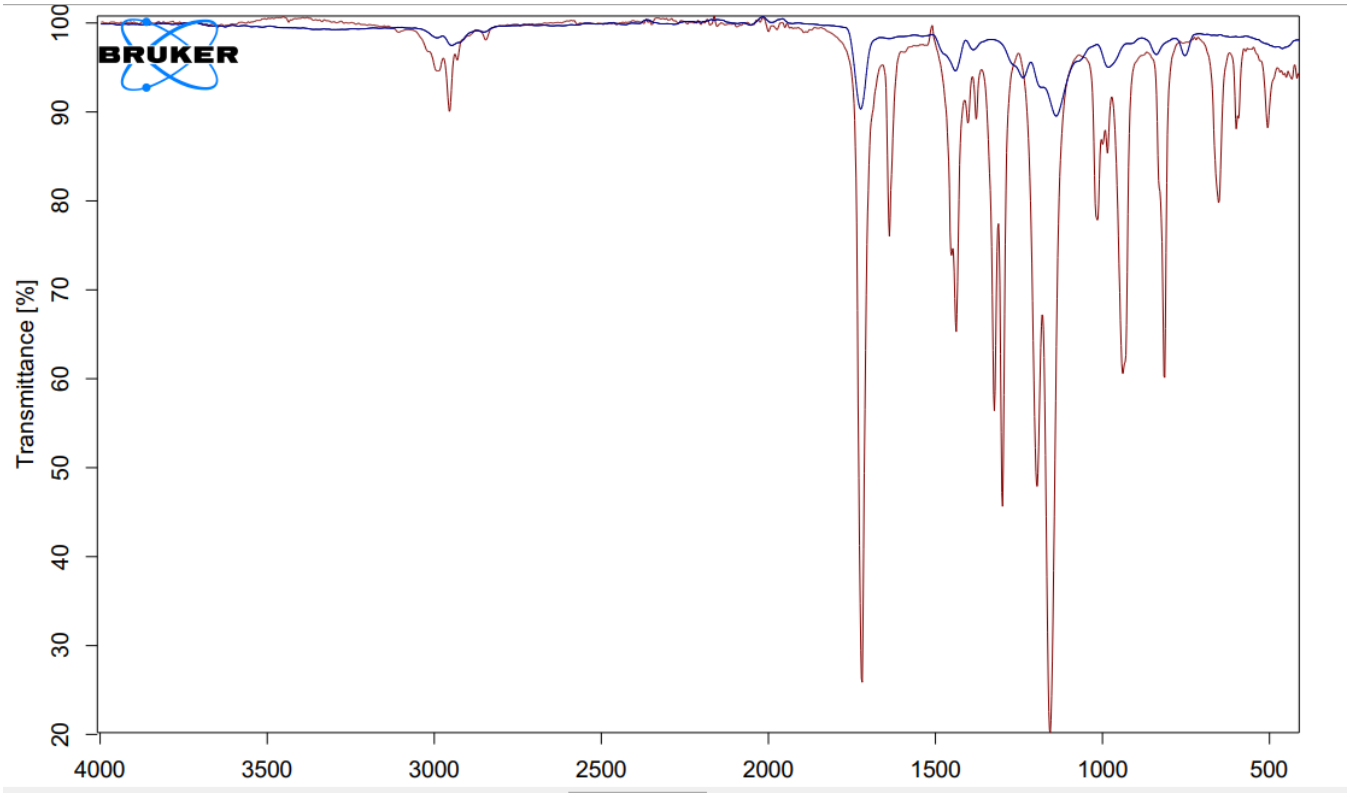

Figure 5: The FTIR for methyl acrylate and recycle PMMA

CONCLUSION

The addition of recycled polymethylmethacrylate to heat acrylic resins change chemical and physical proprietress of heat acrylic resins.

REFERENCES

[1]. Amer A. Taqa , Nadira A. Hatim, Sufian A. Yassin, Modification of heat cured acrylic resin by using additivesto make a flexible acrylic resin denture base material:A pilot study, Edorium J. Dent 2016;Vol.3:1–11.

[2]. Amer A. Taqa ,Nadira A. Hatim Ammar K. Al- Noori, Biocompatibility of Nano-Sized Additives on Flexible Denture Base Material, International Journal of Enhanced Research in Science Technology & Engineering, Vol. 4 Issue 4, April-2015, pp: (93-100)

[3]. Pfeiffer, P. and Rosenbauer, E. (2004)., Residual methyl methacrylate monomer, water sorption, and water solubility of hypo allergic denture base materials. *J. Prosthetic Dentistry*, 92(1), 72–78.

[4]. Salim N, S. JD, Rautemaa R, Silikas N., Impregnation with antimicrobials challenge bonding properties and water sorption behavior of an acrylic three liner. J.Dent.2012:40(8):693-9.

[5]. Noort RV, Nejatian T, Johnson A, (2006) Reinforcement for denture base resin. Advanced Sciences and Technologies 4: 124–129.

[6]. Noort Van R: *Chemical Properties* in*:* Introduction to Dental Materials. 2nd ed. London: Mosby, 2002; p. 62.

[7]. Swann I, Patwardhan S., Application of Fourier Transform Infrared Spectroscopy (FTIR) forassessing biogenic silica sample purity in geochemical analyses and palaeoenv iron mental research. Copernicus Publications on behalf of the European GeosciencesUnionClim.Past2011,7,65–74

[8]. Amer A Taqa1, Luma M. Al-Nema, Amrah Y. Al-Jmmal, The Effect of recycled poly methylmethacrylate Additive on the physical properties of Dental Modelling Wax International Journal of Enhanced Research in Science Technology & Engineering, Vol. 4 Issue 5, May-2015, pp: (183-189).

[9]. Cemil Alkan ,Sennur Alay Aksoy ,Ruhan Altun Anayurt, Synthesis of poly(methyl methacrylateco-acrylic acid)/n-eicosane microcapsules for thermal comfort in textiles, Textile Research Journal 2015, Vol. 85(19) 2051–2058

[10]. Mahdy H, Idris A, El-Gheriani E, Saad A., Effect of coupling agents on the important physico-mechanical properties of acrylic resin reinforced with ceramic filler. Ainshams Dental Journal 2005;8:243-53.

[11]. Ellakwa E, Morsy A, El-Sheikh M., Effect of aluminum oxide addition on the flexural strength and thermal diffusivity of heat-polymerized acrylic resin. J Prosthodontic2008;12:1-6.

[12]. Rama Krishna Alla1, Suresh Sajjan, Venkata Ramaraju Alluri, Kishore Ginjupalli, Nagaraj Upadhya, Influence of Fiber Reinforcement on the Properties of Denture Base Resins, *Journal of Biomaterials and Nanobiotechnology*, 2013, 4, 91-97

[13]. Mohammed M Gad,Shaimaa M. Fouda, Fahad A Al-Harbi1 Ritva Näpänkangas Aune, Raustia., PMMA denture base material enhancement: a review of fiber, filler, and Nano filler addition International Journal of Nano medicine 2017:12 3801–3812.

[14]. Polat T, Karacaer Ö, Tezvergil A, Lassila L, Vallittu P (2003) Water sorption, solubility and dimensional changes of denture base polymers reinforced with short glass fibers. J Biomater Appl 17(4): 321-335.

[15]. Al- Nori A.Kh, Ali AA, Rejab LT. Water sorption of heat-cured acrylic resin. Al–Rafidain. Dent J 2007;7(2):186-94.
[16]. Özlem G., Fatma Ünalan, Pinar Kursoglu,Water sorption and solubility of denture teeth acrylic resin reinforced with milled glass fiber, OHDMBSC - Vol. IV - No. 4 - December, 2005
[17]. Alla RK, Sajjan S, Alluri VR, GinjupalliK, Upadhya N (2013) Influence of Fiber Reinforcement on the Properties of Denture Base Resins. Journal of Biomaterials and Nano biotechnology 4(1): 91-97.
[18]. Neelu A,VeenaJ ,AnoopC,VijayP., Effect of Addition of Sapphire (Aluminum Oxide) or Silver Fillers on the Flexural Strength Thermal Diffusivity and Water Sorption of Heat Polymerized Acrylic Resins, International Journal of Prosthodontics and Restorative Dentistry, April-June2011;1(1):21-27.
[19]. Beyari MM (2015) Effect of Glass Fibers or Metallic Filler on the Linear Dimensional Changes and Water Sorption of Acrylic Resin Denture Base Material. *Int J Dentistry Oral Sci*. S2:005, 26-29.
[20]. Mohammed Nz., The Effect of Thickness of Heat Cure Acrylic Resin with Additives on Water Sorption and Solubility.AL-Rafidain Dent J.2010;10(1):167-174.
[21]. Ihab N. Yassin ,Alaa A. Abdulmajeed, Firas Abd Kati Al-Shammari, The effect of adding micro zinc oxide filler to heat-polymerizing acrylic resin on somephysical properties,Muthanna Medical Journal2016; 3(2):80-86**,**
[22]. Mohamed S.H, Alb. M. Al-Jadi and. Ajaal T, Using of HPLC Analysis for Evaluation of Residual Monomer Content in Denture Base Material and Their Effect on Mechanical Properties,Journal of Physical Science, Vol. 19(2), 127–135, 2008
[23]. Dae-Eun Jang, Ji-Young Lee1, Hyun-Seon Jang, Jang-Jae Lee, Mee-Kyoung Son, Color stability, water sorption and cytotoxicity of thermoplastic acrylic resin for non-metal clasp denture, J Adv. Prosthodontic 2015;7:278-87
[24]. Rodrigo O., Porosity, residual monomer and wayer sorption of conventional heat-cured, microwave-cured and cross-linked acrylic resins, Clin Lab Dent 2014:20(3):137-44.