

Denture base polymers, poly methyl methacrylate improved using free radical copolymerization

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Abstract

Poly methyl methacrylate (PMMA) is the most common material used in Prosthodontics. Several studies indicate a breakdown of the number of very high resin bases after 2 to 3 years to avoid breaking bass, and several attempts have been made such as altering the chemical structure of resin by adding causes cross linking or copolymerization. As an innovative method for improving the physical properties of the prosthesis and increasing its strength, a copolymer of styrene-methyl methacrylate was proposed. Tensile strength was increased with the increase of styrene with methyl methacrylate in an amount determined to be the most resistant. Polystyrene and poly methyl methacrylate and copolymers characterized by FTIR, CNMR and T_g and tensile strength were measured according to ISO1567 standard.

Keywords: Copolymer; poly methyl methacrylate (PMMA); poly styrene(PSt); tensile strength.

Introduction

Until about 60 years ago, despite rapid advances in technology, polymers, polymethyl methacrylate (PMMA) is still the most basic and most common material used in Prosthodontics. Polished and easy to use functionality, aesthetics, ease of maintenance

and color stability, which led to the construction of denture bases, a PMMA for an artificial prosthesis is used [1-3].

In addition to these advantages, it also has disadvantages such as low impact strength and low resistance to fatigue. Several studies indicate that a very large

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number of resin bases breaks down after 2 to 3 years [4-7]. The main reason for this failure of the prosthesis is falling on a hard surface and bending fatigue failure of the prosthesis under its affect [8-12]. Various attempts have been made to avoid breaking the bass like changing the chemical structure of the resin with the addition of cross linking agents or copolymerization [13-16]. As an innovative method for improving the physical properties of the prosthesis and increasing its strength, the copolymer of styrene - methylmethacrylate was proposed. Styrene monomer is used to determine the composition of copolymer in the radical copolymerization methylmethacrylate-styrene copolymer. It is, in some ways, more favorable than physical properties of the polymerization [17-20].

Experimental

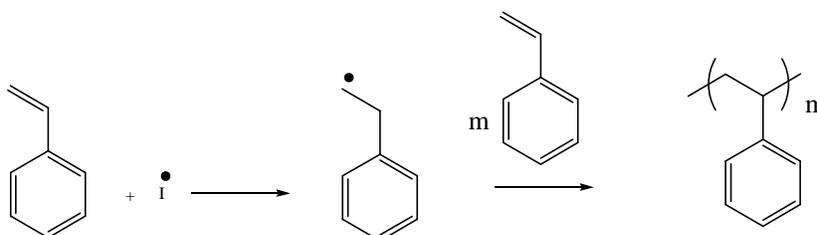
General

Styrene (St) methylmethacrylate (MMA), methanol, benzoyl peroxide, and all the other chemicals and solvents were purchased and used as it was supplied from Merck

(Germany). IR spectra of the compounds were obtained on a Shimadzu FTIR-8400s spectrometer using a KBr disk. The ^1H nuclear magnetic resonance (^1H NMR) spectra were recorded on a Bruker AC 400 advanced instrument at 400 MHz in dimethyl sulfoxide (DMSO-d₆) using tetramethylsilane as an internal standard. The glass transition temperature (T_g) was measured using thermal glass analysis (TGA).

Synthesis of polystyrene (PS) by free radical polymerization method

Styrene monomer (26 mmol) is slowly added to the reaction flask. Benzoyl peroxide 0.107 g, as a radical initiator reaction, was added to the flask; the reaction temperature was controlled at 60 ° C for 2 h. PS was cooled down to room temperature for 12 hours. The obtained product was a clear crystal in weighted 1.3449 g (Yield: 71.3%). The synthesis of PS was shown in Scheme 1. PS was characterized by FTIR, NMR, T_g and tensile strength physical test.

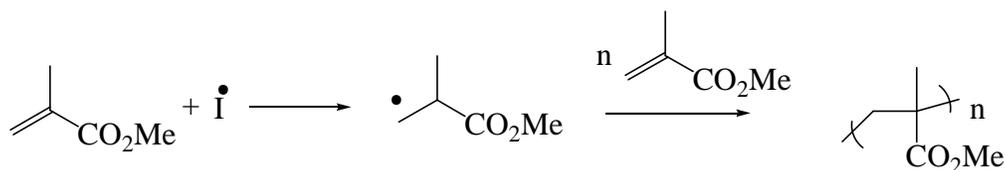


Scheme 1. Polystyrene polymerization process by free radical polymerization, benzoyl peroxide radical initiator symbolized by I

Synthesis of poly methyl methacrylate (PMMA) by radical polymerization method

Methyl methacrylate (MMA) monomer 28.17 (mmol) is removed slowly and added to the reaction flask. We added benzoyl peroxide 0.107 g to the flask as a radical initiator reaction, the reaction temperature that is

controlled at 60 ° C for 60 minutes was performed. PMMA was cooled down to room temperature for 24 hours. The obtained product was a clear crystal weighted 2.147 g (Yield: 72.4%). The synthesis of PMMA was shown in Scheme 2. The PMMA was characterized by FTIR, NMR, T_g and tensile strength physical test.



Scheme 2. Poly methyl methacrylate polymerization by free radical polymerization, benzoyl peroxide radical initiator symbolized by I

Synthesis of styrene / methyl methacrylate copolymer (St-Co-MMA) by radical copolymerization method

Styrene and methyl methacrylate monomer are used with volume percent different amounts at radical copolymerization in the five syntheses which are given below.

Synthesis of (St-Co-MMA) (20-80) using radical copolymerization

MMA (8 mmol) (80 wv. %) was added to St (9 mmol) (20 wv. %) in the reaction flask slowly. Benzoyl peroxide 0.134 g was added to a warm bath with a controlled temperature of 60 ° C for one hour and then was gently stirred. The copolymer was cooled down to room temperature for 24 hours in a desiccator. The obtained copolymer was a

clear crystal weighted 3.6885 g (Yield: 79.0%).

Synthesis of (St-Co-MMA) (40-60) using radical copolymerization

MMA (28 mmol) (60 wv. %) was added to St (17 mmol) (40 wv. %) in the reaction flask slowly. Benzoyl peroxide 0.161 g benzoyl peroxide was added to the hot water bath controlled at 70 ° C was stirred gently for 45 minutes. The copolymer to cool down to room temperature for 24hr. Obtained copolymer was a clear crystal weighted 3.5249 g (Yield: 76.0%).

Synthesis of (St-Co-MMA) (50-50) using radical copolymerization

MMA (19 mmol) (50 wv. %) was added to St (17 mmol) (50 wv. %) in the reaction flask

slowly. Benzoyl peroxide 0.215 g benzoyl peroxide was added to the hot water bath controlled at 60 ° C and was stirred gently for 1 h. The copolymer was cooled down to room temperature for 24 h. The obtained copolymer was a clear crystal in weighted 2.2928 g (Yield: 62.0%).

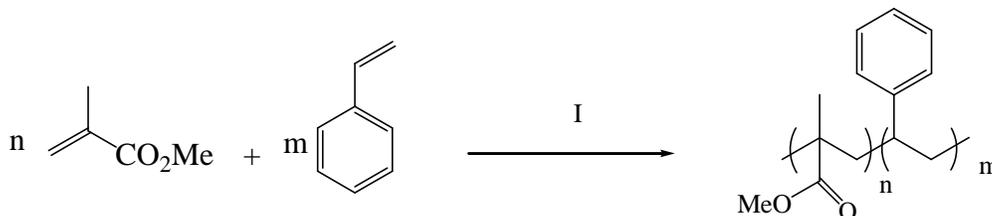
Synthesis of (St-Co-MMA) (60-40) using radical copolymerization

MMA (19 mmol) (40 wv. %) was added to St (26 mmol) (60 wv. %) in the reaction flask slowly. Benzoyl peroxide 0.161 g benzoyl peroxide was added to the hot water bath controlled at 60 ° C and was stirred gently for 1 h. The copolymer was cooled down to room temperature for 24 h. The obtained

copolymer was a clear crystal weighted 3.5704 g (Yield: 77.5%).

Synthesis of (St-Co-MMA) (80-20) using radical copolymerization

MMA (9 mmol) (20 wv. %) was added to St (35 mmol) (80 wv. %) in the reaction flask slowly. Benzoyl peroxide 0.134 g benzoyl peroxide was added to a warm bath with temperature control at 60 ° C for 70 min and was gently stirred. The copolymer was cooled down to room temperature for 24 h. Obtained copolymer was a clear crystal weighted 2.9010 g (Yield: 63.4%). Styrene/methyl methacrylate copolymerization was shown in Scheme 3.



Scheme 3. Styrene / methyl methacrylate copolymerization

Selected spectral data and physical tests polystyrene (PS)

Clear crystal, FT-IR (KBr): 2847 cm^{-1} (stretching CH_2), 1600 cm^{-1} (stretching $\text{C}=\text{C}$); $T_g = 368 \text{ }^\circ\text{K}$; $F=70.3 \text{ N}$, $S=55.10 \text{ Mpa}$.

Selected spectral data and physical tests polymethylmethacrylate (PMMA)

Clear crystal, FT-IR (KBr): 1245 cm^{-1} (stretching $\text{C}-\text{O}$), 1725 cm^{-1} (stretching $\text{C}=\text{O}$); $T_g = 388 \text{ }^\circ\text{K}$; $F=82.64 \text{ N}$, $S=64.80 \text{ Mpa}$.

Selected spectral data and physical tests (St-Co-MMA)

Clear crystal, FT-IR (KBr): 2856 cm^{-1} (stretching CH_2), 720 cm^{-1} (bendind,op

CH), 1728 cm^{-1} (stretching C=O); ^1H NMR (FT-400 MHz, DMSO): ; 3.60(s, a, 3H), 0.88 (s, b, 3H), 1.82 (d, c, 2H), 1.10(d, e, 2H), 2.94(m, d, 1H), 7.10 (d, f, 2H), 7.12 (t, g, 2H), 7.01 (t, h, H); ^{13}C NMR(400 MHz, DMSO): ; 65.5 (a), 177.5 (b), 45.3 (c), 19.3 (d), 20.2 (e), 49.3 (f), 23.1 (g), 145.7 (h), 129 (i), 129.1 (j), 127.1 (k),.

Scheme of St-Co-MMA for ^1H NMR and ^{13}C NMR were shown in figure 4(a, b) respectively.

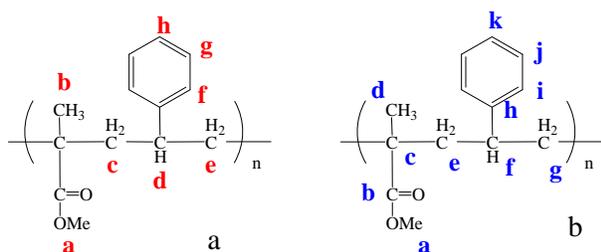


Figure 4. a, b, Scheme of St-Co-MMA for ^1H -NMR and ^{13}C NMR

Results and discussion

Values T_g for St-Co-MMA samples 2 - 6 in table (1) is given.

Table 1. St-Co-MMA samples 2 – 6 , T_g Values

Samples	St-Co-MMA		T_g °K
	%St	%MMA	
2	20	80	384
3	40	60	380
4	50	50	378
5	60	40	376
6	80	20	372

Increasing styrene in St-Co-MMA from 20% to 40%, 50%, 60% and 80%, T_g

changed to 384, 380, 378, 376 and 372 °K respectively. In other hand, it can be concluded that the increase of wv% styrene in the copolymer is to reduce the T_g .

The innovative methods to improve the physical properties of the implant and strength of the St-Co-MMA was proposed.

Styrene monomer was used to the composition of copolymer in the radical copolymerization methylmethacrylate-styrene copolymer.

According to the standard tests for compressive strength, specimens were tested synthetic copolymers. Figure (4) is a synthetic one on the tensile strength test based on the standard 1567 DIS / ISO studied. Synthetic samples before testing tensile strength, were inputed for two days in water 37 °C. Three points were tested with a speed of 5 mm per minute for each of the samples 1-7. The maximum force fractures samples were recorded. The tensile strength of the samples by Equation (1) was calculated.

$$S = \frac{l \times f \times 3}{h^2 \times b \times 2} \quad \text{Eq. 1}$$

In this equation, S tensile strength (MPa), f max force (N), l distance between reliance, b is the width of the sample and the sample thickness h . In Eq. (1) are the values of l , h , b , 65, 3.5 and 10 mm.

Table (2), maximum force fracture, tensile strength St-Co-MMA copolymers 1-7 were shown in Table (2).

Table 2. Tensile strength samples 1-7

St-Co-MMA				
Sample	St %	MMA%	F (N)	S (MPa)
1	0	100	82.64	64.80
2	20	80	90.72	71.10
3	40	60	85.76	67.21
4	50	50	79.24	62.10
5	60	40	75.70	58.50
6	80	20	72.35	56.70
7	100	0	70.31	55.10

The tensile strength (MPa) has been reported in table (2). Sample (1) only methyl methacrylate polymer formed from the value of 64.80 MPa. The copolymer styrene-methyl methacrylate (20 %- 80% wv) was tensile strength of the 71.10 (MPa) with increasing amounts of styrene to 40 wv. %; the amount of 3.9 MPa flexural strength decreased as the number of samples 67.21 (MPa) hit. Further increase to styrene 50 wv% in copolymer, tensile strength again fell to the 62.10 (MPa) were reported. With the increased weight of the copolymer of styrene at 60 and 80 wv. %, tensile strength 58.50 and 56.70 (MPa) was obtained respectively. The styrene homopolymer (7) is used to measure the tensile strength and the lowest 55.10 (MPa).

The tensile strength 71.10 (MPa) Sample (2) has shown the highest strength and it combines a St -Co- MMA (20-80) wv %.

Conclusion

We can say that sample, (2) is the best of the above samples, in which the tensile strength 71.10 (MPa) has shown the highest tensile and it combines a St -Co- MMA (20-80) wv %.

Acknowledgments

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