Study to determine and estimate residual monomer leached out in heat cure polymethylmethacrylate Resins of commonly used brands using different polymerization cycles: (An invitro study)

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Abstract
Introduction: To study the residual monomer leached out in heat cure poly methylmethacrylate Resins of commonly used brands using different polymerization cycles
Aims and Objectives: To compare the amount of leachable residual monomer in Poly methylmethacrylate of heat cure brands available in market at different time interval that are polymerized by short and long curing cycle.
Results: Results from the study shows that following short curing cycle denture has to be kept in water for 48 hours whereas following long curing cycle denture has to be kept in water for minimum for 24 hours in order to deliver denture with least leachable residual monomer
Conclusion: From the results of this study it was concluded higher level of residual methylmethacrylate was leached from short curing cycle than long curing cycle, suggesting that long curing cycle causes greater degree of polymerization as compared to the short curing cycle, resulting in the reduction of amount of residual monomer in long curing cycle. It was observed that by keeping immersed regular resin denture of short curing cycle for 48 hours duration, the leaching of monomer has significantly decreased, whereas long curing cycle requires resin denture to be immersed for 24 hours duration only which showed significant reduction in leaching of monomer

Keywords: Short curing cycle, long curing cycle, Heat cure acrylic resin.

Introduction
In dental profession, acrylic resin is used extensively as a denture base material, for repairing and relining of dentures and for fabrication of artificial teeth. Polymethyl methacrylate denture base material cures by addition polymerization reaction. Despite the various commercially available polymerization activators, the conversion of methyl methacrylate to Polymethyl methacrylate is not, however, complete and some amount of residual monomer is left.

Since the introduction of dough moulding technique by Kullodent in 1935[1], acrylic resins have become the most commonly used denture base material, even though there have been reports of allergic reactions to prosthesis fabricated from these materials like commonly occurring allergic eczematous contact type dermatitis, or allergic stomatitis. Causes of oral reactions to acrylic resins include trauma from ill fitting denture, local chemical reaction caused by acrylic resin or leaching of residual monomer. In clinical trials, traumatic factors have masked the adverse effects of leachable components from the denture .Several bioactive leachable components from acrylic resins are responsible for reactions of these kinds, of these most common is methyl methacrylate leachable component.

A study conducted by Austin and Basker[2] showed that inadvertent use of curing time and failure to adhere to the recommended curing temperature may result in the production of resins containing very high levels of residual monomer, which not only induce mucosal reaction but also has more serious effect on the mechanical properties of the resin. There are several other studies conducted by an author which shows similar results.

Aims and Objective
The study was designed
1. To estimate residual monomer and compare residual monomer in heat cure Polymethylmethacrylate resin following short and long curing cycle.
2. To analyze the level of residual monomer content in four commonly used brands of heat cure acrylic resin at different time interval that are polymerized by short curing and long curing cycle.

The objectives of the study
1. To compare the amount of leachable residual monomer in Polymethylmethacrylate of heat cure brands available in market at different time interval that are polymerized by short and long curing cycle.
2. To determine curing cycle and time interval after polymerization, to deliver denture with least leachable residual monomer

Materials and Methods
A comparative in vitro study to evaluate and estimate residual monomer leached out from heat cure Polymethylmethacrylate resins of commonly used brands using different polymerization cycles was undertaken at the Department of Prosthodontics, A.B.Shetty Memorial Institute of Dental Sciences, Mangalore in collaboration with the Nitte Institute of Pharmaceutical Science, Mangalore.

Standardized mould for fabrication of the resin samples was made from brass. The brass mould was milled precisely

with precautions taken to maintain the dimensions with a close tolerance to produce five circles of 10mm in dimensions and 3 mm in thickness, equidistant from each other. Mixing was performed according to the manufacture's instructions; the acrylic dough packed into the Brass mould to get the resin disk of 10 mm diameter and 3mm thickness. The Polymerization was carried out for group I according to manufacturer instruction and for group II following long curing cycle. The polymerized resin disk specimen of each subgroup of Group I and Group II was immersed in screw capped vials containing 3 ml distilled water at room temperature. The amount of monomer leached from each disk at different time intervals (2 hours, 24 hours, 48 hours and 72 hours) has been estimated by using UV Visible spectrophotometer at 210 nm. Based on the method suggested by Reeta Jain et al to evaluate leaching of monomer from acrylic resin, a brass mould was fabricated to prepare the resin discs. Four brands of heat cure acrylic resin were used to make the resin disc samples using the curing cycles suggested by the manufacturer. These samples were immersed to different time intervals in distilled water and leaching of methyl methacrylate were determined by using UV visible spectrophotometer.

Fabrication of brass mould: :Standardized mould for fabrication of the resin samples was made from brass using precise milling devices at the Hebich Technical Training Institute, Mangalore. The brass mould was milled precisely with precautions taken to maintain the dimensions with a close tolerance to produce five circle of 10mm in dimensions and 3 mm in thickness, equidistant from each other.

Result

Table 2 Shows the comparison of residual methyl methacrylate leached into water among four brands of acrylic resin at various time interval between 0 to 24 hours, 2 to 24 hours, 24 to 48 hours and 48 to 72 hours following short curing cycle. Brand I leached minimum amount of residual monomer (16.51±2.48) followed by brand III (17.06 ± 3.18) and brand II (36.60±3.10) whereas brand 4 showed maximum amount of (41.65±2.12) residual monomer leached out at the end of 2 hours. Similar results were seen at interval between 2 to 24 hours, 24 to 48 hours, 48 to 72 hours among the various brands of acrylic resin. Variations in residual methyl methacrylate leached out among all the four brands of acrylic resin at various time interval were found statistically very highly significant ($p<0.001$) following short curing cycle. Table 3 Shows the comparison of residual methyl methacrylate acrylic resin leached in to water among four brands of acrylic resin at various time interval between 0 to 24 hours, 2 to 24 hour, 24 to 48 hours and 48 to 72 hours following long curing cycle. Brand I leached minimum amount of residual monomer (12.28±0.66) followed by brand III (13.91±10.55) and brand II (15.55±1.95) whereas brand 4 showed maximum amount of (16.19± 2.02) residual monomer leached out at the end of 2 hour. Similar results were seen at interval between 2 to 24 hours, 24 to 48 hours, 48 to 72 hours among the various brands of acrylic resin. Variations in residual methyl methacrylate leached out among all the four brands of acrylic resin at 2 hours,2 to 24 hours after long curing cycle was statistically significant and at time interval between 24 to 48 hours and 48 to 72 hours were statistically highly significant Table 4 Shows the comparison of concentration of residual methyl methacrylate leached out in water between short and long curing cycle at different time interval of brand 1.At the end of 2 hour residual monomer leached out in brand I acrylic resin having undergone long curing cycle was (12.29± 0.66) , whereas short curing cycle showed significantly increased amount of (16.51± 2.48) residual monomer leached out. Similar results were seen at time interval between 2 to 24 hours. Acrylic resin samples after time interval 24 to 48 hours following long curing showed very minimum amount of (1.52± 2.41) residual monomer being leached out whereas following short curing cycle samples showed (12.28± 2.27) residual monomer being leached out . This change was statistically very highly significant ($p=.009$). Similar results were also seen between 48to 72 hours. Table 5 Shows the comparison of concentration of residual methyl methacrylate leached out in water between short and long curing cycle at different time interval of brand II. At the end of 2 hours residual monomer leached out in acrylic resin of brand II having undergone long curing cycle was (15.55±1.95) whereas short curing cycle showed significantly increased amount of (36.60±3.10) residual monomer leached out. .Similar results were seen between time interval of 2 to 24 hours, 24 to 48 hours, and 48 to 72 hours. Increased leaching of residual methyl methacrylate following short curing cycle in comparison with long curing cycle was statistically very high significant at all time intervals. Table 6: Shows the comparison of concentration of residual methyl methacrylate leached out in water between short and long curing cycle at different time interval of brand III. At the end of 2 hours, residual monomer leached out in acrylic resin of brand III having undergone long curing cycle was (10.66±4.06) whereas short curing cycle showed significantly increased amount of (17.60±3.18) residual monomer leached out ($p=0.028$) Between 24 to 48 hours acrylic resin have undergone long curing cycle showed very minimum amount of(4.90± 2.60) residual monomer leached out whereas following short curing cycle acrylic resin showed (13.29± 2.62) residual monomer leached out between the same time interval. This change was statistically highly significant ($p=0.009$). Similar results were seen between 2 to 24 hours, 24 to 48 hours and 48to 72 hours. Table 7: Shows the comparison of concentration of residual methyl methacrylate leached out in water between short and long curing cycle at different time interval of brand IV. At the end of 2 hours residual monomer leached out in acrylic resin of brand IV having undergone long curing cycle was (16.19±2.02) whereas short curing cycle showed significantly increased amount of (41.64±2.12) residual monomer leached out. This change was statistically highly significant ($p=0.009$). Similar results were seen between 2 to 24 hours, 24 to 48 hours and 48to 72 hours.

Table 8: Compares the concentration of residual methyl methacrylate leached out in water between different time interval of all the brands after undergoing short curing cycle. The Bonferroni test for repeated measure for brand I shows residual monomer leached out after 2 hours and between 2 to 24 hours is not statistically significant (P=0.697), whereas when as it reaches to 48 hours the decrease in residual methyl methacrylate leached out compared with after 2 hours and between 24 to 48 hours following short curing cycle is statistically significant (P=0.019). These results indicate amount of residual monomer leached after 2 hours, and between 2 to 24 hours is almost same, but whereas between 24 to 48 hours there is significant reduction in leaching of residual monomer .Similar results were seen for time interval between 48 to 72 hours. The difference of residual monomer leached out after 24 hours and 24 to 48 hours is statistically significant (P=0.049). Similar results were seen between 48 to 72 hours. Whereas amount of residual monomer leached out between 24 to 48 hours is compared with 48 to 72 hours the difference is not significant. When Boneferonni test was applied for brand II, difference in residual monomer leached out after 2 hours is compared with residual monomer leached leached out between 2 to 24 hours, no statistically difference was seen. In other words significant amount of residual monomer leached upto 24 hours. Whereas amount of residual monomer leached out between 24 to 48 hours is significantly less, when compared with leaching of residual monomer after 2 hours following short curing cycle. Whereas difference in leaching of residual monomer after 48 hours is compared with after 2 hours, the difference was very highly significant. This result shows amount of residual monomer leached after 48 hours is minimum. When Boneferonni test was applied for brand III, difference of residual monomer leached out after 2 hours is compared with residual monomer leached out between 2 to 24 hours, no statistically difference was seen. In other words significant amount of residual monomer leached upto 24 hours. Whereas amount of residual monomer leached out between 24 to 48 hours is significantly less, when compared with leaching of residual monomer 2 hours following short curing cycle. Difference in leaching of residual monomer after 48 hours is compared with after 2 hours following short curing cycle the difference was significant This result shows that amount of residual monomer leached after 48 hours is minimum. When Boneferonni test was applied for brand IV, difference of residual monomer leached out after 2 hours is compared with residual monomer leached out between 2 to 24 hours, no statistically difference was seen. In other words significant amount of residual monomer leached upto 24 hours. Whereas amount of residual monomer leached out between 24 to 48 hours is significantly less, when compared with leaching of residual monomer at 2 hours following short curing cycle. Difference in leaching of residual monomer after 48 hours is compared with after 2 hours; the difference was highly significant .This result shows that amount of residual monomer leached after 48 hours is minimum. Table 9: Compares concentration of residual methyl methacrylate leached out in water between different time intervals of all the brands after undergoing long curing cycle The Bonferroni test for repeated measure of brand I shows the difference in residual monomer leached out after 2 hours is compared with amount leached out between 2 to 24 hours, a highly significant change was noticed, whereas very high significant decrease in residual methyl methacrylate leaching was noticed at time interval between 24 to 48 hours. Similar results were seen when residual methyl methacrylate leached out after 2 hours when compared with amount leached between 48 to 72 hours. When amount of residual monomer leached out after 24 hours is compared with after 48 hours and 72 hours, no statistically significant difference was noticed. The Bonferroni test for repeated measure of brand II shows the difference in residual monomer leached out after 2 hours is compared with amount leached out between 2 to 24 hours is highly significant change was noticed, Whereas very high significant decrease in residual methyl methacrylate leaching was noticed at time interval between 24 to 48 hours Similar results were seen when residual methyl methacrylate leached out after 2 hours when compared with amount leached between 48 to 72 hours. When amount of residual monomer leached out after 24 hours is compared with after 48 hours and 72 hours, no statistically significant difference was noticed. 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Table 1: The data and standard plot are given in Table 1

Conc.	Absorbence *	SD
($\times 10^{-3}$%V/V)		
0.5	0.009	± 0.0052
1.0	0.1614	±0.0012
2.0	0.3281	±0.0046
4.0	0.6853	±0.0073
6.0	1.0074	±0.0066
8.0	1.3187	±0.0072

*Average of 6 replication

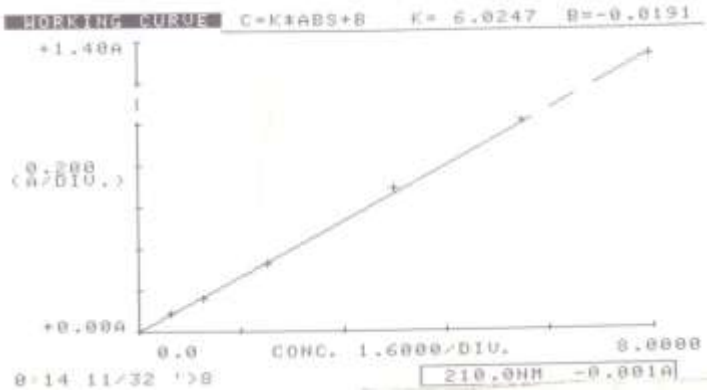

Fig 1: Standard plot of MMA in water at 210 nm.

Table 2: comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water among four brands at different time interval for short curing cycle

Group I	N	MEAN	Standard Deviation	H	P
C 2 HOUR					
1	5	16.50	2.48		
2	5	36.60	3.10	15.59	.001 Vhs
3	5	17.60	3.18		
4	5	41.65	2.12		
C 24					
HOUR	5	14.03	1.44		
1	5	32.68	2.53	16.14	.001 Vhs
2	5	15.80	3.55		
3	5	4O.47	2.97		
4					
C 48					
HOUR					
	5	11.28	2.27		
1	5	29.88	0.42	16.09	.001 Vhs
2	5	12.89	2.62		
3	5	39.03	3.01		
4					
C 72					
HOUR					
	5	11.24	2.98		
1	5	28.26	3.24	15.10	.002 hs
2	5	12.12	0.42		
3	5	31.33	1.41		
4					

Group –I –Short curing cycle. N-Number of Samples

TABLE 3: Comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water among four brands at different time interval for long curing cycle

Group II	N	Mean	Standard Deviation	H	P
C 2 Hour					
1	5	12.28	0.66		
2	5	15.55	1.95	7.42	.05 sig
3	5	13.91	10.55		
4	5	16.19	2.02		
C 24					
Hour	5	4.05	5.26		
1	5	5.78	3.48		
2	5	5.26	2.59	10.90	.012 sig
3	5	14.24	2.06		
4					
C 48					
Hour					
	5	1.52	2.41		
1	5	5.28	3.25	14.00	.003 hs
2	5	4.90	2.60		
3	5	14.18	1.90		
4					
C 72					
Hour					
	5	1.51	2.42		
1	5	5.12	3.32	14.14	.003 hs
2	5	4.59	2.64		
3	5	13.59	1.58		
4					

Table 4: Comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water short and long curing cycle at different time interval of brand 1

Brands		**Group**	**N**	**Mean**	**Std Deviation**	**Z**
1	C 2 HOURS	Shortcuring	5	16.51	2.48	2.402
		Longcuring	5	12.29	0 .66	P=.016sig
	C 24 HOURS	Shortcuring	5	14.03	1.44	2.402
		Longcuring	5	4.05	5.26	P=.016sig
	C 48 HOURS	shortcuring longcuring	5	12.28	2.27	2.402
			5	1.52	2.41	P=.016hsig
	C 72 HOURS	Shortcuring	5	11.24	2.98	2.402
		Longcuring	5	1.51	2.42	P=.016hsig

Table 5: Comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water between short and long curing cycle at different time interval of brand II

Brand		**Group**	**N**	**Mean**	**Std deviation**	**Z**
II	C 2	Shortcuring	5	36.60	3.10	2.611
	HOURS	longcuring	5	15.55	1.95	P=.009hsig
	C 24	Shortcuring	5	32.68	2.53	2.611
	HOURS	longcuring	5	5.78	3.48	P=.009 hsig
	C 48	Shortcuring	5	29.88	0.42	2.619
	HOURS	longcuring	5	5.28	3.25	P=.009 hsig
	C 72	Shortcuring	5	28.26	3.23	2.611
	HOURS	Longcuring	5	5.12	3.32	P=.009 hsig

Table 6: Comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water between short and long curing cycle at different time interval of brand III

Brand		Group	N	Mean	Std Deviation	Z
III	C 2 Hours	Shortcuring	5	17.60	3.18	2.402
		longcuring	5	10.66	4.06	P= .028 sig
	C 24 Hours	Shortcuring	5	15.80	3.55	2.611
		longcuring	5	5.26	2.59	P=.009 hsig
	C 48 Hours	Shortcuring	5	13.29	2.62	2.611
		longcuring	5	4.90	2.60	P=.009 sig
	C 72 Hours	Shortcuring	5	12.12	0.42	2.619
		Longcuring	5	4.59	2.64	P=.009hsg

Table 7: Comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water between short and long curing cycle at different time interval of brand IV

Brand		Both Group	N	Mean	Std Deviation	Z
IV	C 2 Hours	Shortcuring	5	41.65	2.12	2.619
		Longcuring	5	16.19	2.02	P=.009 hsig
	C 24 ours	Shortcuring	5	40.47	2.97	2.611
		Longcuring	5	15.49	2.06	P= .009 hsig
	C 48 Hours	Shortcuring	5	39.03	3.01	2.402
		Longcuring	5	15.17	1.90	P= .009 hsig
	C 72 Hours	Shortcuring	5	31.33	1.41	2.611
		Longcuring	5	13.59	1.58	P= .009 hsig

Table 8: comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water between different time intervals of four brand of short curing cycle

Group i brands	(i) time	(j)time	Mean difference (i-j)	P
	2 Hours	24 Hour	2.48	.697
1	2 Hours	48 Hours	4.23	0.019 sig
	2 Hours	72 Hours	5.27	0.016 sig
	24Hours	48 Hours	2.75	0.049 sig
		72 Hours	2.79	0.045 sig
	48 Hours	72 Hours	1.04	1.000
	2 Hours	24 Hour	3.92	.173
2	2 Hours	48 Hours	5.72	0.017 sig
	2 Hours	72 Hours	8.34	0.001 vhs
	24Hours	48 Hours	2.80	0.045 sig
		72 Hours	4.42	0.011 sig
	48 Hours	72 Hours	2.62	.766
	2 Hours	24 Hour	1.80	1.000
3	2 Hours	48 Hours	4.31	0.039 sig
	2 Hours	72 Hours	5.48	0.035 sig
	24Hours	48 Hours	2.91	0.047 sig
		72 Hours	3.68	0.028 sig
	48 Hours	72 Hours	1.17	
				1.000
	2 Hours	24 Hour	1.18	1.000
4	2 Hours	48 Hours	6.62	0.002 hs
	2 Hours	72 Hours	9.46	0.001 vhs
	24Hours	48 Hours	5.44	0.009 vhs
		72 Hours	8.29	.001 vhs
	48 Hours	72 Hours	2.84	
				0.375

Table 9: Comparison of concentration of residual methylmethacrylate ($x10^{-3}$ V/V %) leached out in water between different time intervals of four brand of short curing cycle

Group ii brands	(i) time	(j)time	Mean difference (i-j)	P
	2 Hours	24 Hour	8.24	0.005 HS
1	2 Hours	48 Hours	10.76	.001 VHS
	2 Hours	72 Hours	10.77	.001 VHS
	24Hours	48 Hours	2.52	1.000
		72 Hours	2.54	1.000
	48 Hours	72 Hours	0.01	1.000
	2 Hours	24 Hour	9.77	.001 VHS
2	2 Hours	48 Hours	10.27	.001 VHS
	2 Hours	72 Hours	10.43	.001 VHS
	24hours	48 Hours	0.50	1.000
		72 Hours	0.66	1.000
	48 Hours	72 Hours	0.16	1.000
	2 Hours	24 Hour	8.65	0.003 HS
3	2 Hours	48 Hours	9.02	0.005 HS
	2 Hours	72 Hours	9.32	0.005 HS
	24Hours	48 Hours	0.37	1.000
		72 Hours	0.67	1.000
	48 Hours	72 Hours	0.30	1.000
	2 Hours	24 Hour	1.85	0.049 SIG
4	2 Hours	48 Hours	2.01	0.045 SIG
	2 Hours	72 Hours	2.60	0.042 SIG
	24Hours	48 Hours	0.32	1.000
		72 Hours	1.91	.792
	48 Hours	72 Hours	1.59	1.000

Discussion

Methacrylate resins are found in a variety of dental materials including denture base polymers, synthetic teeth, provisional and definitive fixed prosthesis, sealants, dentin adhesives, luting agents for crowns and fixed partial dentures, and tooth colored restorative materials. As reported by Jerolimov[3] that choice of curing has much greater influence than mixing ratio with regard to the level of residual monomer, and flexural property of heat cure denture base material which improves with decreasing the amount of residual monomer. In a study by Honorez [4] three processing methods were used: two processing cycles recommended by the manufactures and one quick violent boiling. They stated that denture should not be polymerized by placing the flask in boiling water for quick cure as it may have a clinical significance for those patients who may be sensitive to acrylic resin monomer A Harrison and R. Hugget[5] in their study determined the effect of curing cycles on residual monomer levels of acrylic denture base polymers, they showed that high level of residual monomer has a deleterious effect on the properties of denture base polymers and further concluded that short curing cycles were undesirable and result in significantly raised levels of residual monomer. A Dogan[6] reported that for heat cured resins, the longer curing time improved the tensile strength and decreased the level of residual monomer. He stated that the tolerable level of residual monomer for tissue sensitivity for each individual was hard to predict. Pekke K Villittu[7] studied the effect of polymerization temperature and time on residual monomer content of denture base polymers and concluded that polymerization temperature and polymerization time significantly affects the residual monomer of denture base polymers Alezander A Fisher [3] concluded that Methyl methacrylate, liquid monomer is a sensitizer and a cause of allergic contact type of eczematous reaction on the skin and oral mucosa. Tsuchiya H [8] studied that under oral and artificial conditions significant amounts of Methyl methacrylate are leachable from acrylic denture base materials. Pre-leaching in water reduces the subsequent leaching of methyl methacrylate. Reeta Jain[9] concluded that significant amount of methyl methacrylate is leachable both in saliva and water which decreased with time. Nicolas Martin[10] showed unusual response of acute gingivostomatitis caused by contact sensitivity to the methacrylate constituents of dental material. In the present study four brands of heat cure acrylic rein Travelon HI, DPI Heat Cure, Meliodent and Acralyn-H were used to determine and estimate residual monomer leached out following various polymerization cycle and to propose the brand and curing cycle which would leach out minimum amount of residual monomer were analyzed by ultraviolet spectroscopy .This method was used here because of its procedural simplicity. On analyzing the results in table 2 Trevalon–HI showed least amount (16.51±2.48) of residual monomer leached out at the end of two hours followed by DPI HeatCure (17.60±3.18), Meliodent (36.60±3.10) and Acralyn-H showed maximum (41.65±2.12) amount of

leaching following short curing cycle .Similar results were seen after 24 ,48 and 72 hours. On analyzing the results in table 3 Trevalon –HI showed least amount (12.28±0.66) of residual monomer leached out at the end of two hours followed by DPI HeatCure (13.91±10.55), Meliodent (15.55±1.95) and Acralyn-H showed maximum (16.19±2.02) amount of leaching following long curing cycle. Similar results were seen after 24 ,48 and 72 hours.From the above result it is evident that variation in concentration of residual monomer by various brands of acrylic resin following short and long curing cycle at different time intervals was very highly significant. On analyzing the results from table 4 amount of residual monomer leached out by Travelon-HI acrylic resin following short curing was 16.51 and long curing was 12.29 after 2 hours. This difference was statistically significant. Similar results were observed between 2 to 24 hours. On comparison of amount of residual monomer leached out between 24 to 48 hours and 48 to 72 hors after short and long curing cycle was very highly significant. The samples having undergone short curing cycle after 24 to 48 hours leached 12.28. Whereas following long curing cycle amount of residual monomer leached was only 1.52.Similar results were seen between the time intervals of 48 to 72 hours. On analyzing the result of table 5 Meliodent acrylic resin at 2 hours after undergoing short curing cycle leached (36.60±3.10) residual monomer. Following long curing cycle (15.55±1.95) residual monomer leached out. This variation was statistically very highly significant. Similar results were seen between the time interval of 2 to 24 hours but following long curing cycle samples showed only (5.78±3.48) residual monomer being leached out .After time interval of 24 to 48 hours and 48 to 72 hours, samples having undergone short curing cycle leached out residual monomer in a range of 28 to 30×10^{-3} V/V% whereas following long curing cycle residual monomer leached is only 5×10^{-3} V/V%. This difference was statistically very highly significant. These results show that after48 hours following long curing cycle amount of residual monomer was minimum whereas following short curing cycle significant amount of leaching was observed. On analyzing the result of Table -6 DPI Heat Cure, Acralyn-H acrylic resin following long curing cycle, acrylic resin samples showed significant amount of residual monomer being leached up to 24 hours whereas samples continue to leach significant amount of residual monomer even up to 72 hours following short curing cycle. On observing the result of Table-7 samples of Acralyn-H showed large amount of residual monomer being leached out even after 72 hours following short curing cycle. On comparison even though samples of Acralyn –H following long curing cycle exhibited significant less amount of residual monomer leaching. Earlier literature has supported the fact that longer curing time improved the tensile strength and decreased the level of residual monomer.[11,12,8] Similarly studies done by Pekke K Villittu[7] showed that polymerizing heat cure denture base resin at long curing cycle significantly reduced the residual monomer content of the polymer when compared to short curing cycle. This might be due to the following reasons ,the initiator used in heat cure methyl methacrylate resin is benzoyl peroxide which decomposes when the temperature is increased (above 60˚c), giving free radical which start and propagate further polymerization[13].The decomposition of benzoylperoxide initiator is temperature dependant , in the long curing cycle greater decomposition of benzoylperoxide results in a greater number of polymer chains .In addition to this the conversion of monomer to polymer is time dependendent and the rate of conversion is greatly increased by raising the temperature from 74˚ c to100˚ c .This finding is in agreement with the result of other worker Matthews and Tyldesley 1950,Axelsson,1955:Smith 1958[2] .Table-8 Shows Bonferonni test for repeated measures of residual methyl methacrylate leached out in water at different time intervals for four brands of acrylic resin following short curing cycle. Amount of residual methyl methacrylate leached out after 2 hours and during the time interval between 2 to 24 hours did not show any significant difference. When residual methyl methacrylate leached out at the end of 48 hours and 72 hours is compared with amount leached after 24 hours a significant difference was noticed in the form of decrease in leaching of residual methyl methacrylate with increase time interval from completion of short curing cycle. Brand II,III and IV namely Meloident, DPI Heat Cure and Acralyn H also established similar result.

These results can be interpreted as, it is necessary to immerse acrylic resin for 48 hours in water in order to reduce the amount of leachable residual methyl methacrylate following short curing cycle. This could be because of incomplete polymerization of resins leaving free residual monomer (MMA) existing in the polymerized resin which leaches out in to the water .[10] Table-9 Shows Bonferonni test for repeated measures of residual methyl methacrylate leached out in water at different time intervals for four brands of acrylic resin following ling curing cycle. On analyzing the results Brand-I (Travelon-HI) acrylic resin shows highly significant difference in leaching of residual monomer content after 2 hours and between 2 to 24 hours following long curing cycle. When leaching of residual methyl methacrylate after 24 hours upto 72 hours is compared with amount leached after 2 hours following long curing cycle a very highly significant difference was noticed .But no significant increase in leaching was recorded when the study samples were immersed in water for more than 24 hours. That is to say the long curing cycle causes greater degree of polymerization as compared to the short curing cycle, resulting in the reduction of amount of residual monomer. The leaching of methyl methacrylate was found to be significant for the first 2 to 24 hours, following which a drop in the concentration of methyl methacrylate in a aqueous solution was noted. The release of methyl methacrylate into the water proceed somewhat rapidly for the first few hours and then declined at progressively lower rate, The decrease may be due to the hydrolysis of methyl methacrylate to Methacrylic acid and methanol and also due to continued polymerization of the resin.[12] These result

indicate following long curing cycle the prosthesis made with acrylic resin has to be kept in water for a minimum of 24 hours in order to reduce the amount of leachable residual monomer in the prosthesis .Similar results were also noticed for brand Brand II,III and IV. From the analysis of tables and graphs it is evident that Travelon-HI has the least monomer among the entire brand, followed by DPI Heat Cure, Meliodent and Acralyn H has maximum residual monomer. Results from the above study shows that following short curing cycle denture has to be kept in water for 48 hours whereas following long curing cycle denture has to be kept in water for minimum for 24 hours in order to deliver denture with least leachable residual monomer.

Conclusion

Conclusion can be drawn from this study which evaluated the residual methyl methacrylate leached out in water by four brands of acrylic resin at various time intervals having undergone short and long curing cycle Trevalon HI had the least amount of residual monomer leached out among all other brand followed by DPI Heat Cure, Meliodent. Acralyn H. Acralyn H had the maximum amount of residual methyl methacrylate leached out among all other brand. Higher level of residual methyl methacrylate was leached following short curing cycle than long curing cycle, suggesting that long curing cycle causes greater degree of polymerization as compared to the short curing cycle, resulting in the reduction in amount of residual monomer. It was observed 48 hours following short curing cycle acrylic resin samples showed significant reduction in leaching of residual methylmethacrylate, inferring that the acrylic resin prosthesis should be immersed for at least 48 hours following short curing cycle in order to deliver prosthesis with least amount of residual monomer Acrylic resin following long curing cycle should be immersed in water for at least 24 hours in order to have least amount of residual monomer in acrylic denture prosthesis.

Conflict of Interest: None.

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