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Wettability of three denture base materials to different forms of saliva substitute and distilled water – An Invitro study

[1]Dr. Soundaria Saravanan, Post Graduate Student, Department of Prosthoodontics, Crown and Bridge , K.S.R. Institute of Dental Science and Research, Thiruchengode, Namakkal-637215

[2]Dr. Chalakuzhiyil Abraham Mathew, Professor and Head, Department of Prosthoodontics, Crown and Bridge, K.S.R. Institute of Dental Science and Research, Thiruchengode, Namakkal-637215

[3]Dr. Dheepika Kittuchami, Senior Lecturer, Department of Prosthoodontics, Crown and Bridge, K.S.R. Institute of Dental Science and Research, Thiruchengode, Namakkal-637215

Corresponding Author: Dr. Soundaria Saravanan, Post Graduate Student, Department of Prosthoodontics, Crown and Bridge, K.S.R. Institute of Dental Science and Research, Thiruchengode, Namakkal-637215

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Abstract

Statement of Problem: Xerostomia causes compromised retention of removable prosthesis and may require the use of saliva substitutes. To aid in retention of prosthesis, artificial saliva substitutes should exhibit good wettability on the denture base. The degree of wetting will vary among the denture base resins.

Aim: The aim of this study was to evaluate the wettability of three denture base materials to different forms of saliva substitutes and distilled water.

Objective: To evaluate and compare the wetting ability of different forms of saliva substitutes and distilled water on three different denture base materials.

Materials and Methods: Group A: 30 specimens were fabricated with Acralyn-H heat cure denture base material; **Group B**: 30 specimens were fabricated with Acralyn high impact heat cure denture base material; **Group C**: 30 specimens were fabricated with Triplex SR denture base material. The saliva substitutes used in the study were zenwet saliva substitute, biotene oral balance gel and distilled water. The specimens were fabricated to an even measurement of 25*15*2 mm. advancing and receding contact angles were measured using contact angle analyzer (KYOWA) and FAMAS software.

Results: Advancing contact angle, receding contact angle, contact angle hysteresis and equilibrium contact angle were statistically analyzed using ANOVA and TUKEY'S post hoc test. There was statistically significant difference between different forms of saliva substitutes in terms of advancing contact angle, receding contact angle and

equilibrium contact angle. There was no statistically significant difference between different forms of saliva substitutes in terms of contact angle hysteresis.

Conclusion: With the evidence of results from this study, zenwet could be considered as a suitable saliva substitute and Triplex-SR could be considered as a suitable denture base material for improving denture retention and comfort, in patients suffering from xerostomia. Further clinical trials are required to prove the subjective and objective efficacy of different forms of saliva substitutes.

Keywords: Xerostomia, Advancing contact angle, Receding contact angle, Contact angle hysteresis and Equilibrium contact angle.

Introduction

The geriatric population seeking prosthetic treatment has been considerably increasing because of the awareness, especially in the last few decades. Retention of denture is based on the physical, mechanical, systemic and psychological condition of the patient. The physical factors of retention include adhesion, cohesion, capillarity, atmospheric pressure and interfacial surface tension. Optimum quantity and quality of saliva between the oral mucosa and the denture base is essential to attain sufficient retention and stability

Xerostomic patients experience a subjective sensation of dryness of oral mucous membranes along with the objective evidence of significantly decreased salivary flow[1]. Saliva substitutes are used by the xerostomic patients in whom the salivary stimulants are ineffective. It is available in liquid, gel and spray forms. Mode and frequency of application plays a major role in reducing the symptoms[2]. Commercially available salivary substitutes may be mucin based, carboxy methyl cellulose (CMC) based, mucopolysaccharide based and hydroxyethylcellulose-based salivary substitutes. Xerostomic patients showed preference for mucin based saliva substitute compared to CMC based saliva substitute [2]. Ideally, saliva substitutes should be non-toxic, pleasant in taste and odour, non-addictive, economical and must exhibit good wetting of the tissue surface of the denture [3]. Contact angle acts as an indicator of wettability, and as the contact angle decreases wettability increases and vice-versa. Thus good wetting of denture base materials with saliva substitutes is essential to improve the retention of denture and comfort of the patient. Thus the aim of this study is to evaluate the wettability of three denture base materials to different forms of saliva substitute and distilled water.

Materials and methods: the saliva substitutes used in the study were Distilled water, Zenwet saliva supplement (Ther Dose Pharma Private Limited) and Biotene Oral balance gel (Biotene dry mouth, GSK) (figure-4)

Group A: 30 specimens were fabricated with Acralyn-H (Asian Acrylates Maharastrra, India) heat cure denture base material (figure-1)

Group B: 30 specimens were fabricated with Acralyn high impact Asian Acrylates Maharastrra, India) heat cure denture base material(figure-2)

Group C: 30 specimens were fabricated with Triplex SR denture base material (figure-3)

Fabrication of wax pattern

Modelling wax(Maarc Dental, Maharastra , India) of thickness 1.5mm was folded into two to get a thickness of 3mm. The folded wax sheet was placed between two glass plates measuring 26*16 mm and cut along the sides of the glass plates (figure-5). Thus a wax pattern measuring 26*16*3mm (length*breadth*thickness) was obtained. Thirty number of wax patterns were prepared for each group [1].

Fabrication of specimens

The wax patterns were invested in a dental flask (figure-6) using dental plaster and Dewaxing was done (figure-7).

The mould space was created and it was packed with ACRALYN-H for group A(figure-8), Acralyn high impact for group B(figure-9) and Triplex SR for group C(figure-10). The powder and liquid were mixed in the ratio of 3:1 by weight. Bench curing was done for one hour and the dental flask was immersed in a curing unit and curing was done according to the manufacturer instructions. The specimens were retrieved from the flask and it was finished to an even measurement of 25*15*2 mm with flat cherry stone and sand paper. The specimens were not polished, in order to simulate the intraoral conditions[4]. In order to remove the contaminants from the surface of the specimens, the specimens from each group were cleaned with household soap and water for 1minute followed by cleaning with cotton dipped in alcohol. Later the specimens were cleaned using ultrasonic cleaner for 15 minutes and they were dried in an incubator at 44 degree Celsius for 30 minutes. The specimens were stored at room temperature in an air tight container. The specimens were viewed under scanning electron microscope at 2000X magnification to check whether there were any contaminants present on the surface of the specimen (figure-16, (figure-17), (figure-18).

Contact angle measurement[4]

Advancing and receding contact angles were measured using contact angle analyzer (KYOWA) (figure-11) and FAMAS software. An oven dried glass syringe was used as a dropper as it was titrated in microlitres. The specimens were held using tweezers only on the sides in order to prevent the contamination of the surface to be tested.

10 specimens from each group, [GROUP A (Acralyn-H), GROUP B (Acralyn - high impact), GROUP C (Triplex-SR)] were randomly selected using a computer generated random number generator (http://www.randomnumbergenerator.com). Each specimen was placed just beneath the glass syringe. The syringe was loaded with distilled water. A drop of distilled water was placed in a random area on the surface of the specimen (figure-12). After a waiting period of one minute, advancing contact angle was measured with the help of FAMAS software (figure-13). Likewise, advancing contact angle was measured in two other random areas. Then the droplets were wiped with tissue paper and the specimen was placed over an inclined plane of 24 degrees (figure-14). A Drop of distilled water was placed in three random areas and three different receding contact angles were measured with the help of FAMAS software (figure-15). After the contact angle values were obtained, the procedure was repeated for the new specimen in each group. Likewise the contact angles were measured for zenwet saliva substitute and biotene oral balance gel.

Results

The data obtained were statistically analyzed using analysis of variance. The confidence interval of 95% was used for statistical analysis, thus $P<0.05$ could be considered as statistically significant.

The mean and standard deviation values of advancing contact angle, receding contact angle, contact angle hysteresis and equilibrium contact angle for three different saliva substitutes are presented in Table 1. One way ANOVA test showed that there was statistically significant difference in advancing contact angle, receding contact angle, and equilibrium contact angle between the saliva substitutes and there was no statistically significant difference in contact angle hysteresis between the saliva substitutes(Table: 1). The minimum mean advancing contact angle, receding contact angle and minimum mean equilibrium contact angle was exhibited with the zenwet liquid (Table: 1). The highest mean contact angle hysteresis was exhibited with distilled water (Table: 1)

Discussion

Need for saliva substitutes: Saliva plays an important role in hydration, speech, mastication, deglutition, taste perception and protection of the oral health through its antimicrobial property. It also plays a crucial role in retaining a complete denture. Lubrication and viscoelastic character of saliva is contributed by O- and N- linked salivary glycoproteins[5,6]. Since the saliva functions are contributed by specific micromolecules, it can be suggested that any disturbance in protein synthesis or post- translational modification of proteins can lead to salivary dysfunction[7]. When salivary gland function is diminished, there will be changes in the oral mucosa like epithelial atrophy and inflammation sometimes leading to fissuring, ulceration and discomfort in wearing prosthesis[1].

The products evaluated in this study are distilled water, zenwet saliva substitute and Biotene oral balance gel. Zenwet saliva substitute is a CMC based saliva substitute. Olsson and axel in 1991 stated that both CMC based saliva substitute and mucin based saliva substitute were effective for same period of time and both were twice efficient as compared to water. Oral balance gel is a hydroxyl ethyl cellulose based saliva substitute. According to DYD Samarawickrama, oral balance gel containing polyglyceryl methacrylate, lactoperoxidase and glucose oxidase would be more effective in diminishing the sensation of oral dryness.

Denture base materials: Polymethyl methacrylate is most commonly used in dentistry to fabricate prosthesis because of its ease of fabrication[8]. The denture base materials used in this study are Acralyn-H, Acralyn- high impact and Triplex-SR. The specimens were fabricated according to the dimensions specified by Ramanna. The surface of the specimens were finished but not polished in order to simulate the intaglio surface of the denture[1].

Preparation of specimens: Wettability depends on the viscosity of the saliva substitute, purity of the denture base resin and the shape of irregularities of the denture base resins[9]. The presence of surface contaminant will alter surface tension of the saliva substitute and hence it will produce an error in the contact angle values[42]. The source of contamination may be chemical or microbial in nature [3]. The specimens were fabricated with utmost care to avoid contamination and cleaning procedure was done using house hold soap, alcohol and ultrasonic cleaning was performed as mentioned by Jaiswal and stored in an air tight container. The specimens were viewed under scanning electron microscope to verify the surface cleanliness (figure-19, (figure-20), (figure-21). Also the saliva substitute was left in contact with the specimen for less than two minutes to avoid contamination [10].

Contact angle measurement: Contact angle measurement replicates the wetting ability of saliva substitute on denture base resins[11]. Lower the contact angle greater will be the wettability and complete wetting occurs when the contact angle formed is zero degree[12]. The contact angle formed when a drop of liquid advances over a dry solid surface for the first time is called as advancing contact angle. The contact angle formed when a drop of liquid advances over a previously wet solid surface is called as receding contact angle. For a contact angle to be measured the liquid to be tested should not react chemically with the solid surface and the liquid and solid should be mutually insoluble[11].

Advancing contact angles were measured using contact angle analyzer at zero degree tilt[11]. The advancing contact angles were independent of time, when left in contact for less than 5 minutes. So in this study, the saliva substitute was placed over the specimen and advancing contact angle was measured after 1 minute. The results indicate that there is a statistically significant difference

between the saliva substitutes in terms of advancing contact angle (TABLE 1) and that Zenwet exhibited the minimum mean advancing contact angle (67.9degrees) followed by distilled water (84.1 degrees) and oral balance gel (88.7 degrees).

Receding contact angle is formed when the liquid recedes on the previously wet solid surface. Kilani et al in 1984 stated that receding contact angle measurement was most important because the film of saliva between a denture base and the tissues recedes over these surfaces during dislodgment of a denture. The specimens were placed at a tilt of 24 degrees, and the receding contact angle was measured [1,4,11]. The measurement of receding contact angle was lesser than the advancing contact angle. This could be due to the presence of pores on the denture base materials and entrapment of saliva/saliva substitute as it flowed over the solid surface. The results indicate that there is statistically significant difference between the saliva substitutes in terms of receding contact angle (TABLE 1) and that Zenwet exhibited the minimum mean receding contact angle (60.7 degrees) followed by distilled water (75.7 degrees) and oral balance gel (84.6 degrees).

Contact angle hysteresis: The difference between advancing and receding contact angle is termed as contact angle hysteresis [Contact angle hysteresis=ΘA−ΘR, ΘA is the advancing angle and ΘR is the receding angle]. Monsenego et al in 1989 stated that contact angle hysteresis should exist between the saliva and denture base in order to improve the retention of dentures. They found that sand abraded specimens showed high contact angle hysteresis. The reasons for the presence of contact angle hysteresis could be due to reorientation of polymer chains on the superficial layer, surface roughness and entrapment of water on the surface of acrylic resin. Contact angle hysteresis is related more to the denture retention; hence it was evaluated in this study.

Higher the contact angle hysteresis greater will be the retention of the denture [10]. According to Abdul Habeeb Bin Mohsin et al, contact angle hysteresis is influenced by surface roughness, surface heterogeneity, surface deformation and chemical contamination of water. Ramanna also stated that liquids having surface active agents, such as saliva substitutes, when placed in contact with the denture base materials lead to adsorption of these molecules and elicit a contact angle hysteresis. According to this study, there was no statistically significant difference between the different forms of saliva substitutes in terms of contact angle hysteresis (TABLE-1).

Equilibrium contact angle: Equilibrium contact angle has a role in improving the denture comfort. Equilibrium contact angle= (ΘA+ΘR)/2, where ΘA is the advancing angle and ΘR is the receding angle. Lower the equilibrium contact angle better will be the comfort. The results indicate that there is statistically significant difference between the saliva substitutes in terms of equilibrium contact angle (TABLE 1) and that Zenwet exhibited the minimum mean equilibrium contact angle (64.3 degrees) followed by distilled water (79.9 degrees) and oral balance gel (86.6 degrees).

Surface roughness of a solid surface is an important factor that alters the contact angle formed by a liquid. Busscher et al in 1984 stated that there was no difference in contact angle if the average surface roughness is less than 0.1 micrometer. Nishioka et al 2006 stated that as the surface roughness decreased, the contact angle decreased, thereby wettability was improved. Abdul Habeeb Bin Mohsin et al stated that, surface roughness of specimens within the same group is an uncontrollable variable.

Zenwet saliva substitute exhibited lower contact angle values compared to biotene oral balance gel. This could be

due to the difference in viscosities, composition of the saliva substitutes and interaction among the molecular entities. Hatton et al stated that viscosities of the solutions could be related to the lubricating property, and mucin based saliva substitute had better wetting property than CMC based saliva substitute. Park et al in 2007 stated that viscosity of the solution increased proportionately as the mucin concentration increased, whereas the contact angle was found to be decreasing. Contact angle of human saliva on acrylic resin were much lower than those of animal mucin solution.

In the present study the advancing contact angle was measured after one minute and receding contact angle was measured immediately after dispensing the test liquid on the specimen. Ayme et al in 1992 noted that adhesion between PMMA and saliva improved when it was previously kept in contact with water. The polarity will increase after contact with water. Thus contact with water was considered to be the best surface treatment. Farcasiu et al in 2015 reported that there was a significant decrease in contact angle on day 7 compared to day 1 with both natural and artificial saliva following its immersion in the saliva and saliva substitutes.

Surface tension and viscosity of saliva substitute values are highly variable from the natural saliva and no saliva substitute can exactly replicate the natural salivary constituents[22]. In order to improve the biophysical properties, constituents like xanthum gum, phosphatidylethanolamine and mucin could be added to alter surface activity and muco-adhesive property of saliva substitutes.

Limitation of the study

1) Viscosity of the saliva substitutes were not measured , to be co-related with the wetting ability
2) Surface roughness of specimens within the same group is an uncontrollable variable
3) Clinical situation cannot be exactly replicated in this Invitro study because; test specimens used in this study were flat, in contrast to the irregular tissue surface of the denture.

Summary and conclusion

The present in vitro study was conducted to evaluate the wettability of different forms of saliva substitutes like distilled water, zenwet saliva substitute and biotene oral balance gel with three different denture base materials. The difference between advancing and receding contact angle was calculated and it refers to contact angle hysteresis, which plays an important role in denture retention. The average of advancing and receding contact angle was calculated and it refers to equilibrium contact angle, which plays an important role in improving the denture comfort. From the results of the study, it was found that statistically significant difference was evident between the distilled water, liquid and gel form of saliva substitutes. It was concluded that the null hypothesis was rejected.

Within the limitations of the study, it was concluded that:

- ✓ There was statistically significant difference between different forms of saliva substitutes in terms of advancing contact angle, receding contact angle and equilibrium contact angle. Zenwet exhibited the minimum mean advancing contact angle, receding contact angle and equilibrium contact angle
- ✓ There was no statistically significant difference between different forms of saliva substitutes in terms of contact angle hysteresis.
- ✓ With the evidence of results from this study, zenwet could be considered as a suitable saliva substitute for improving denture retention and comfort, in patients suffering from xerostomia. Further clinical trials are required to prove the subjective and objective efficacy of different forms of saliva substitutes.

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Legends Tables and Figures

Table 1: Contact Angle Measurements For Three Different Saliva Substitutes

	Saliva substitutes	N	Mean	Std. Deviation	Sig.
Advancing contact angle	Distilled water	30	84.1120	6.50045	.000
	Zenwet	30	67.9867	5.26273	
	Oral balance gel	30	88.7333	4.17838	
	Total	90	80.2773	10.41444	
Receding contact angle	Distilled water	30	75.7100	9.78600	.000
	Zenwet	30	60.7300	8.91334	
	Oral balance gel	30	84.6333	7.34426	
	Total	90	73.6911	13.15395	
Contact angle Hysteresis	Distilled water	30	8.4020	9.13017	.091
	Zenwet	30	7.2567	7.43003	
	Oral balance gel	30	4.1000	6.53289	
	Total	90	6.5862	7.89959	
Equilibrium contact angle	Distilled water	30	79.9110	6.94052	.000
	Zenwet	30	64.3583	6.30640	
	Oral balance gel	30	86.6833	5.00288	
	Total	90	76.9842	11.18672	

Figure 1: Denture base material – Acralyn-H

Figure 2: Denture base materials – Acralyn-High impact

Figure 3: Denture base material – Triplex-SR

Figure 4: Media used – biotene oral balance gel, zenwet saliva substitute, and distilled water.

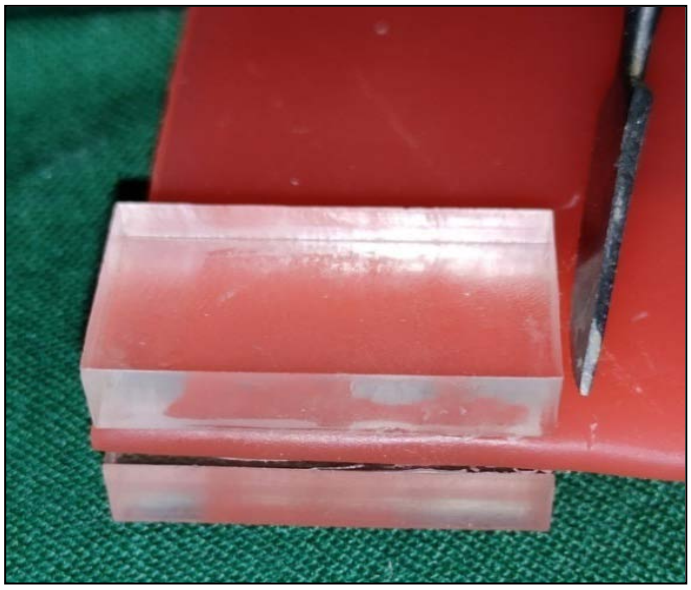

Figure 5: preparation of wax pattern

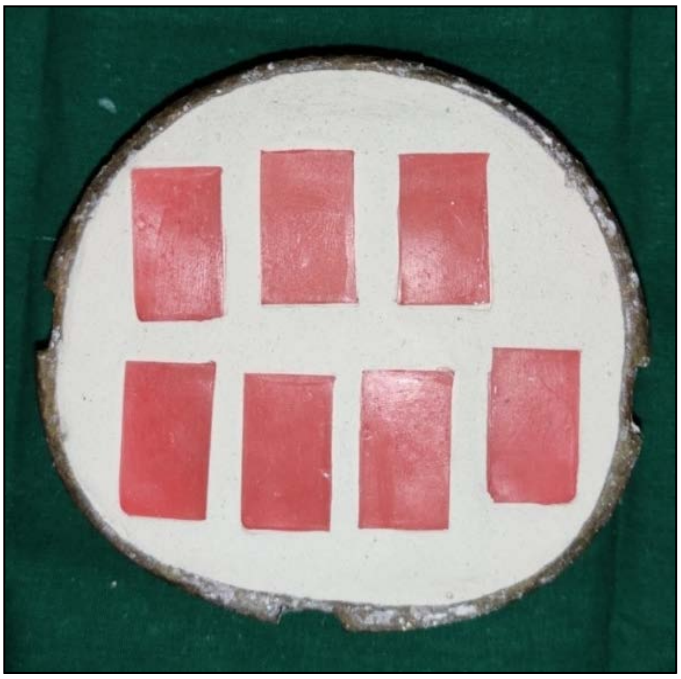

Figure 6: Invested wax patterns

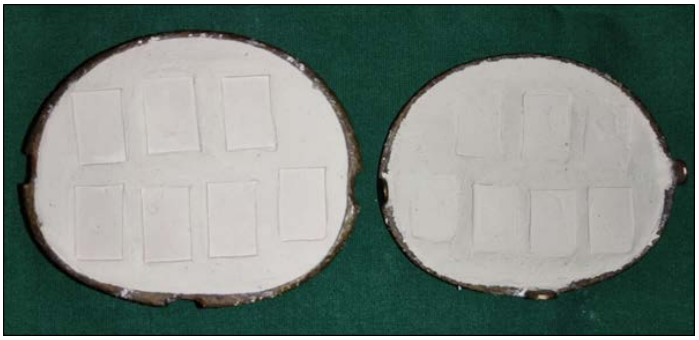

Figure 7: mould space preparation

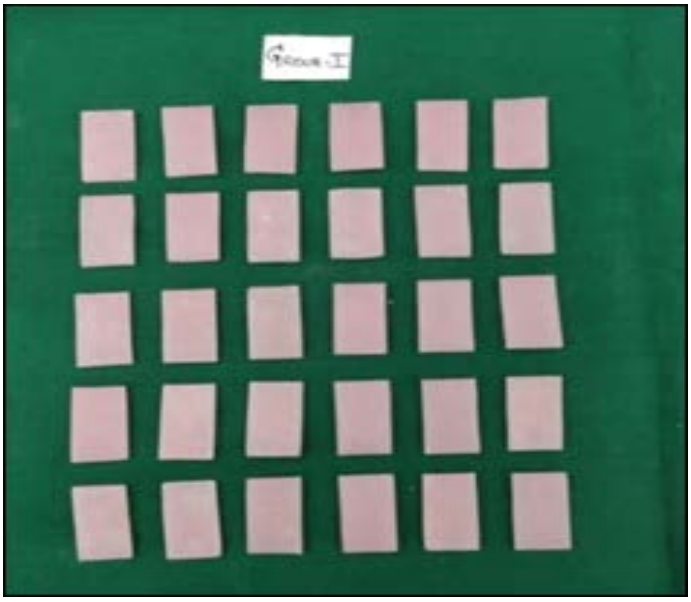

Figure8: Group-A denture base specimens

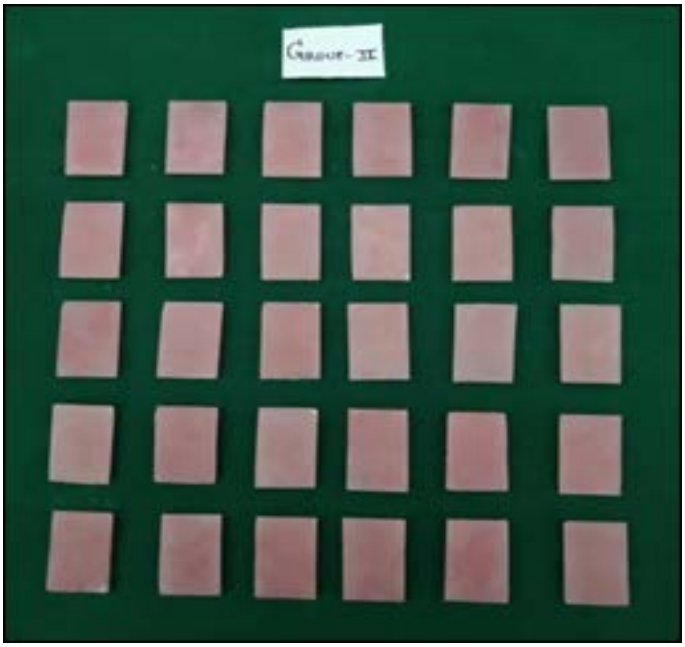

Figure 9: Group-B denture base specimens

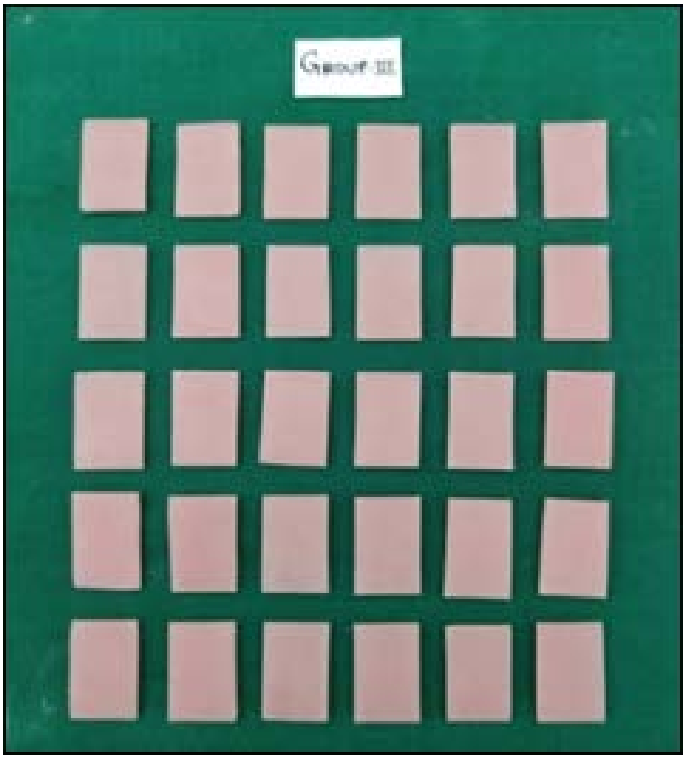

Figure10: Group-C denture base specimens

Figure11: contact angle analyzer

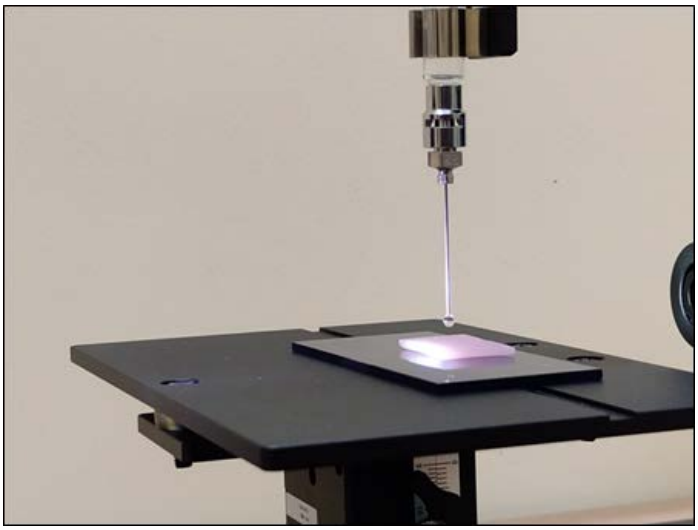

Figure 12: a drop of test liquid is dispensed to measure advancing contact angle

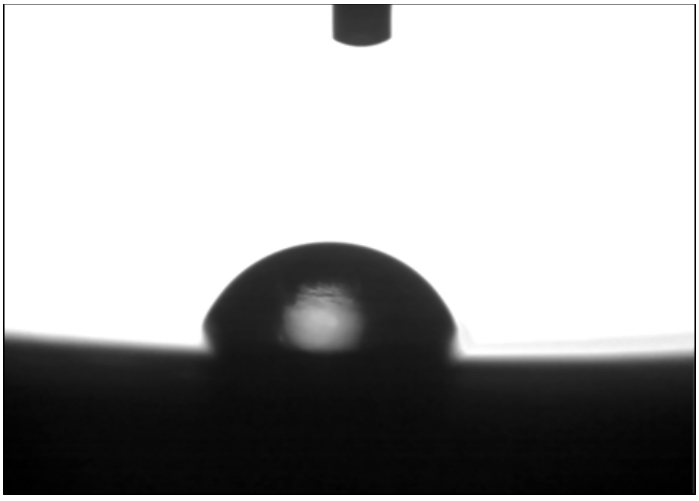

Figure13: measurement of advancing contact angle

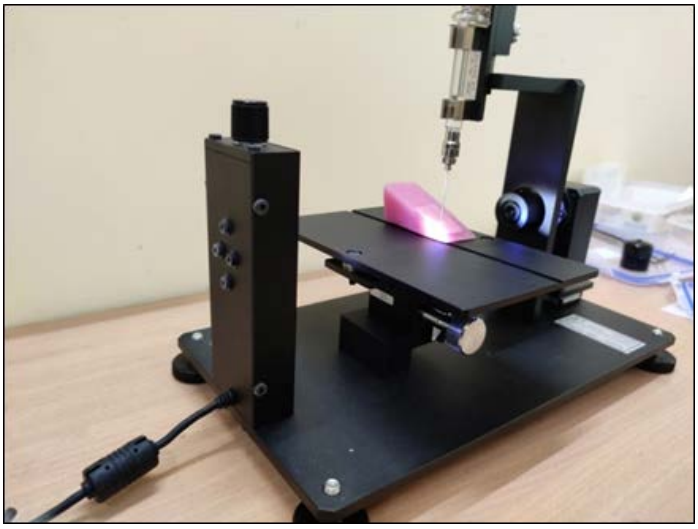

Figure14: a drop of test liquid is dispensed to measure receding contact angle

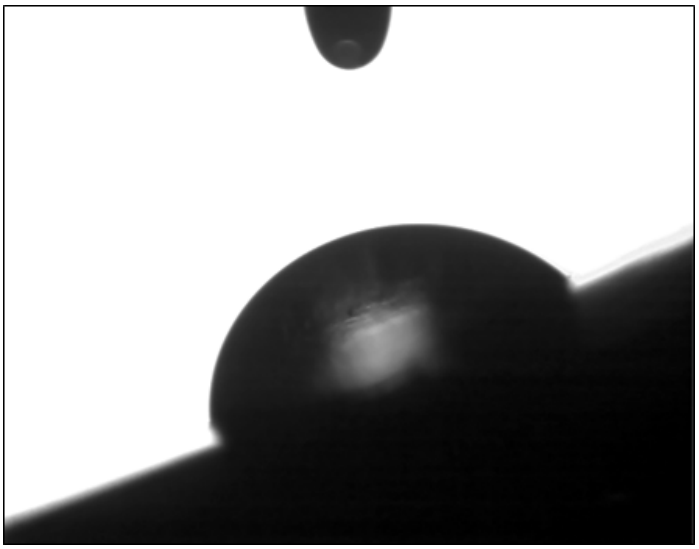

Figure15: measurement of receding contact angle

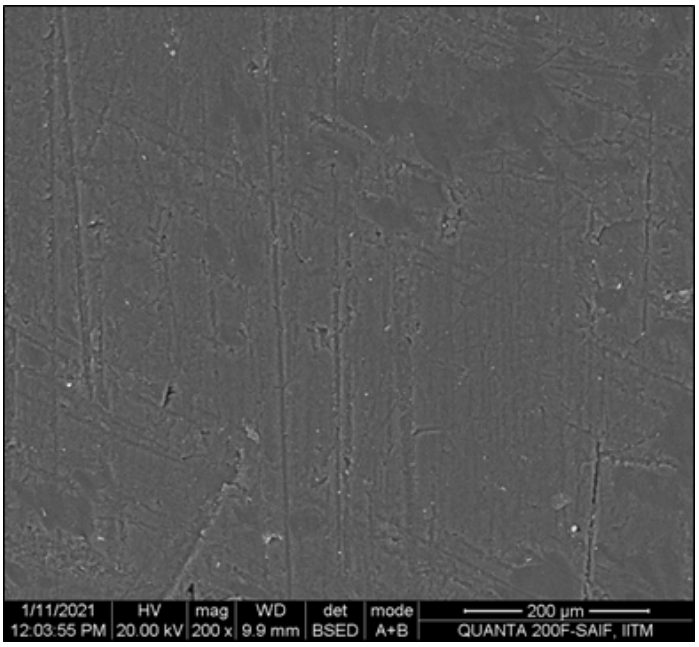

Figure 16: Image of Group-A specimen under magnification

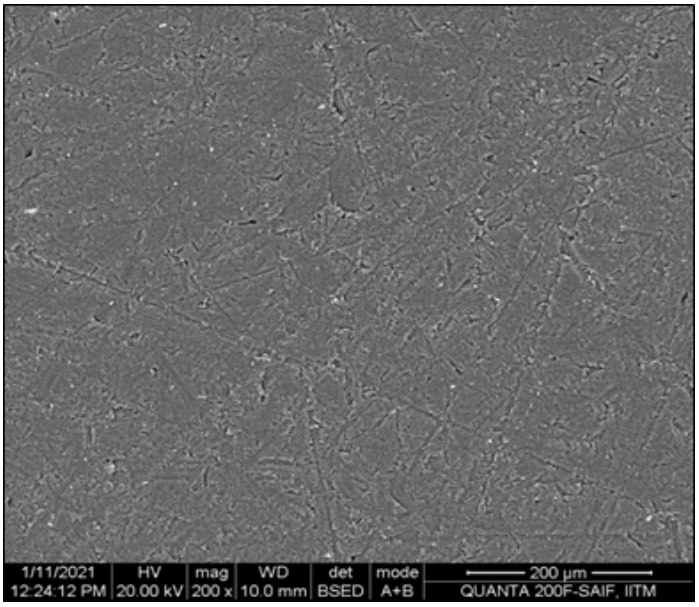

Figure17: Image of Group-B specimen under magnification

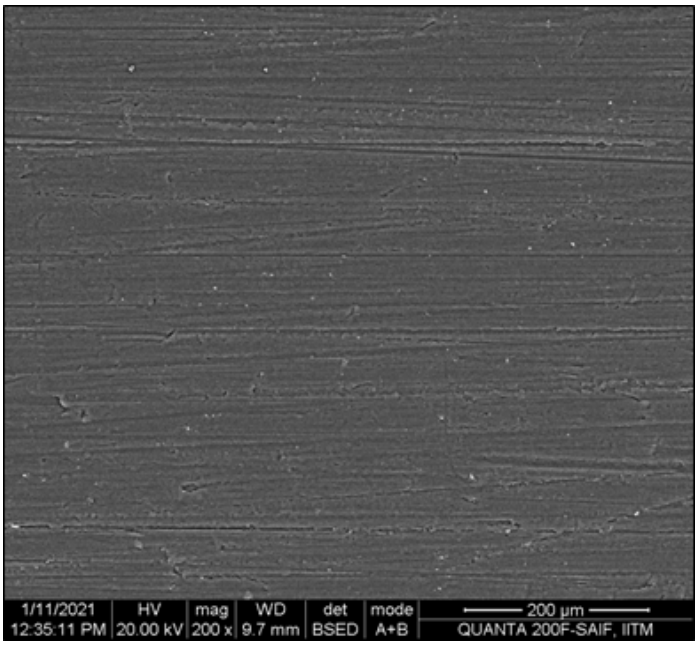

Figure 18: Image of Group-C specimen under magnification