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Effect of Montmorillonite Incorporation on Wettability of Heat-Cured Soft-Denture Lining Material

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Abstract

Relining is the process of resurfacing the intaglio of a removable dental prosthesis with an entirely fresh base material, generating a precise adaptation to the denture base area. The wetting ability of a denture material gives an indication of the extent to which the lubricating effect of saliva will be enhanced, that promoting retention of denture and patient comfort . The purpose of this research was to evaluate how adding montmorillonite nanoparticles(MMTNPs) would affect the soft lining material's wettability. **Materials and Methods:** (MMTNPs) with 0.25 and 0.5 wt. of % were incorporated into the heat-cured acrylic-based soft lining. A total of thirty specimens were prepared for wettability test ,ten for each concentration (0%,0.25%,0.5% wt.MMTNPs) .Also specimens for atomic force microscope (AFM). The data were analyzed using one-way ANOVA test and the Bonferroni multiple comparison test. **Result**: The wettability was not significantly decreased as a result. **Conclusion:** The present study showed that MMTNPs decrease the wettability of soft lining materials.

Keywords: AFM, montmorillonite, nanoparticles,soft liner,wettability .

Introduction

Soft liners are used to produce a pleasant connection between the denture and oral tissues, thus minimizing the traumatic transfer of occlusal pressures to areas of healing from surgical procedures and those with excessively resorbed alveolar ridges (Alamen and Naji,2018).

The soft liner is used to enhance the denture's fitting to the underlying supporting tissues. The denture should be relined when the underlying residual ridge resorbs since the denture will lose its accurate adaptation to this resorbed ridge (Abdulmajeed and Abdulbaqi,2021).

The degree to which saliva lubricates the lining material aids retention of the dentures and patient comfort .We measured surface energy and tension resulting from moisture by measuring contact angles .Changes in wetting ability occur in the opposite direction of the contactangle (Feldom,1978) .

(MMTNPs), which is part of the 2:1 phyllosilicatefamily, is the layered silicate mineral used mo st often in nanocomposites. The formula is $(OH)_4Si_8Al_4O_20nH_2O$. Due to its low cost, large surface area (750m2/g), and clear intercalation/exfoliation chemistry, it is utilized in a wide range of applications. Montmorillonite's chemical properties enable it to intercalate physiologically active compounds, thereby facilitating the development of effective systems for topical or oral drug delivery.The focus nowadays towards the incorporation of various materials like rubber ,fiber, nanofiller so these particles were therefore chosen to improve the properties of polyethylmethacrylate (PEMA) (Joseph.,2019)(Balakrishman.,2012)(Hussein and, Al-Judy, 2023) .

Nanoclay's effectiveness in improving the properties of nanocomposite materials is dependent on its chemical composition, dispersion, polymer compatibility, and process conditions (Hooriabad and Safajou ,2022) .

Materials and Methods

The nanocomposite of heat-cured acrylic-based soft-lining materials (Moon Star, Turkey) and MMTNPs (SIGMA-ALDRICH, USA) (shown in figure 1)were made by mixing the measured MMTNPs concentrations with monomers.

Figure 1 : A, Soft lining material . B, MMTNPs

The MMTNPs were evenly dispersed within the monomer by ultrasound mixture for a period of three minutes using a laboratory sonication system (120W, 60KHz) in order to separate them into isolated nanocrystals to reduce the likelihood of molecule aggregation and stage separation (Janigh et al.,2021). Keep in mind to subtract the weight of MMTNPs from the weight of soft liner powder (Mohad and Fatalla,2019) . Rectangular shaped specimens were prepared for wettability test has a length, breadth, and depth of 30 × 10 × 1 mm. Laboratory silicon (LABOSIL, Spain) was used to invest in the plastic design . Soft lining materials was mixed as directed by the producer (P/L ratio: 10g of polymer to 7.8ml of monomer). When the acrylic resin reaches the dough stage, it is loaded into a mold, packed and cured in a digital water bath(Lab. tech, Korea). After flask cooling , specimens were removed and ready for testing (Qanber and Hamad ,2021) as showed in figure 2

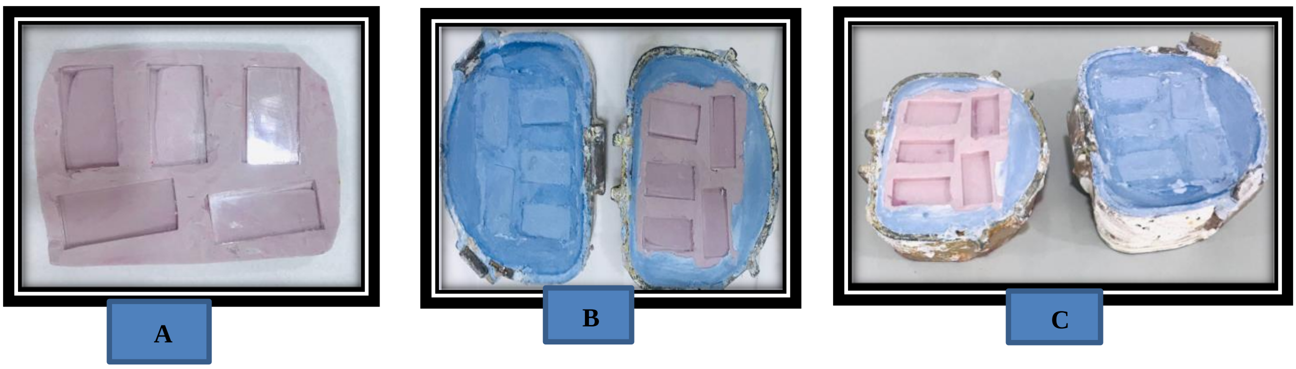

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Figure 2. : Wettability specimens preparation .A, plastic blocks invested in silicon. B, silicon mold invested in stone. C, Removing blocks for making a space for soft liner material. D,A specimen after curin

In this work, the static sessile drop technique was used ; an optical subsystem was utilized to take a lateral picture of a water droplet on a steady base that was set on a horizontally straight plane and evaluate it .An optical tensiometer (TL 1000, Theta Lite, OneAttention, Biolin Scientific, Lichfield, UK) figure 3 was used to determine the contact angle, which refers to the angle formed between the air , sample surface and water. A drop was utilized at room temperature. In this method, a drop is deposited using a graded syringe with a hydrophobic needle after five seconds, and the contact angle is computed using 60 photos taken per second for ten seconds. The microscope's specialized software was used to evaluate the pictures that were collected. This program automatically drew a tangential, and the angle between the drop's bas eline and the tangential at the solid/liquid/air was calculated. As the contact angle increased the wettability decreased and vice versa (Al-Shaikhli and Khamas,2012) .

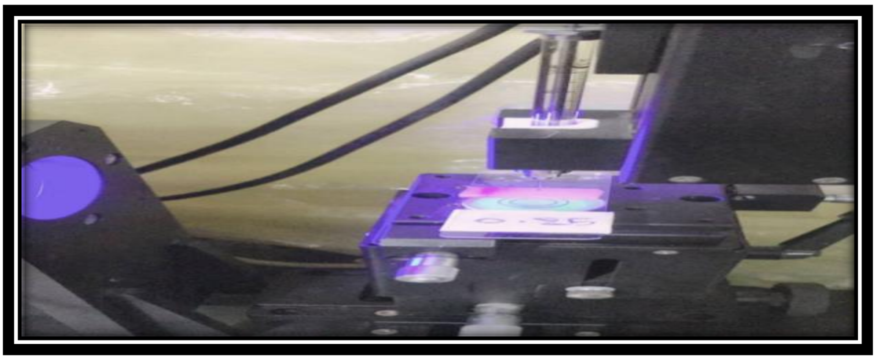

Figure 3: Optical tensiometer

Atomic Microscope or AFM Investigation

Atomic force microscopy was used to examine and compare the surface texture or geometry of the soft liners . (AA 3000 Angstrom Advanced Inc. USA). The specimens surface with a probe that had a tiny cantilever and a pointed tip. In AFM contact mode imaging, the tip apex was in constant contact with the surface; in tapping mode, it was only in touch with the specimen at specific intervals. A tiny piezoelectric device was responsible for setting the probe into oscillation at its resonance frequency in this mode. Cantilever deflection (contact mode) or dampening of the oscillation's amplitude (tapping mode) were used to manipulate the position of the microscope's tip, optical lever measurements of the sample's displacement and the tip's attraction to or resistance from the sample(Qanber and Hamad ,2021) .

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Result

Wettability test

Static contact angles of specimens containing 0.5% wt. MMTNPs exhibited the highest mean value of 56.7, followed by specimens containing 0.25% wt. MMTNPs with 55.3, while lowest mean value of 53 was obtained in control group as presented in figure (4).

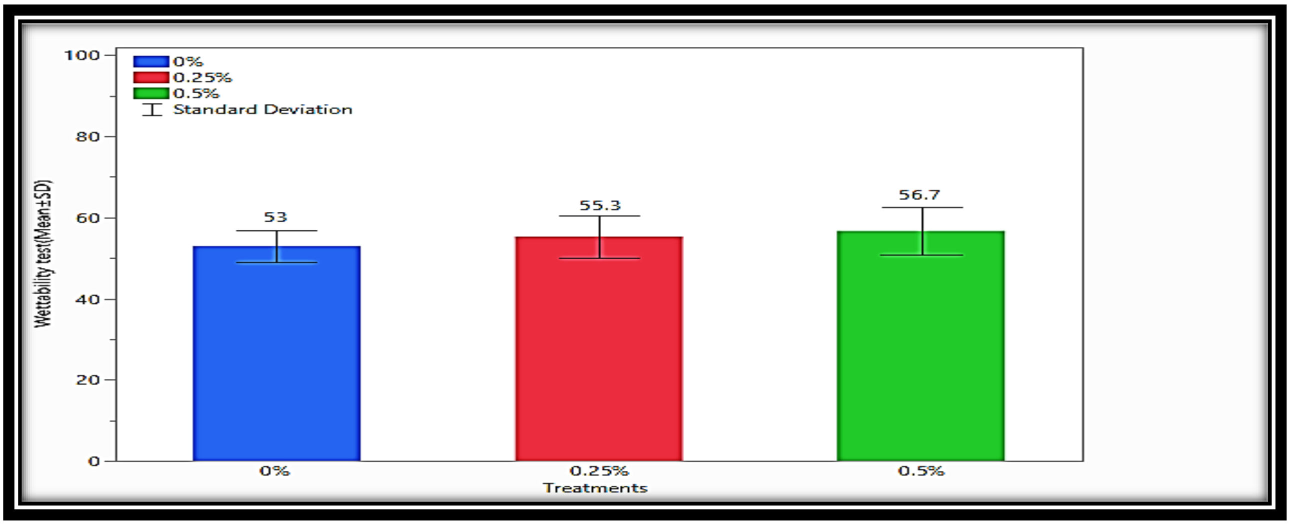

Figure 4: Bar chart representation the mean values of surface wettability test resulamong the studied groups.

One-way ANOVA Table for wettability test results showed non significant difference between all tested groups table (1).

Table 1: One-way ANOVA Table for wettability test results.

Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F	Significant
Between Groups	2	69.80000	34.9000	1.3535	0.2753	NS
Within Groups	27	696.20000	25.7852			
C. Total	29	766.00000				

Static contact angles of wettability test shown in figure 5.

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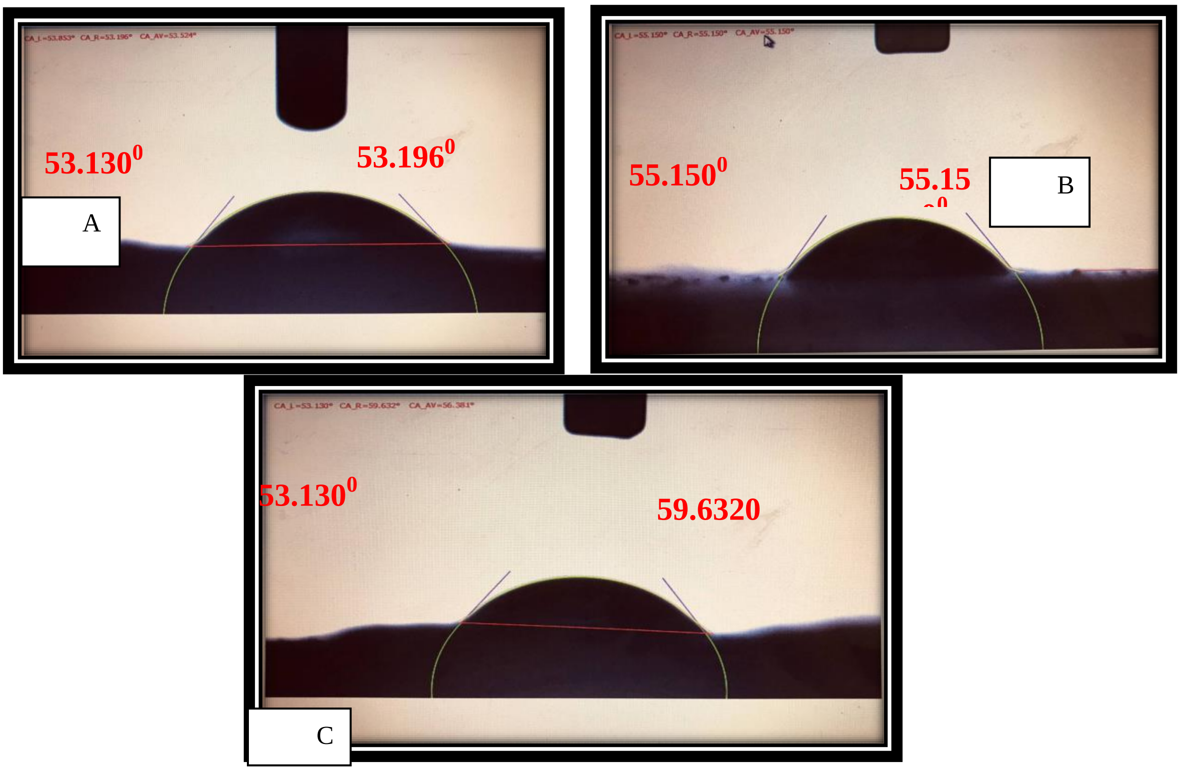

Figure 5 :static contact angles of wettability test.A,control specimen B,0.25% MMTNPs specimen C,0.5% MMTNPs specimen.

Atomic Force Microscopy Analysis

The two- and three-dimensional images obtained by the AFM analysis and bar chart illustrating granularity cumulation distribution of nanograins are presented in **figure (6,7,8)**

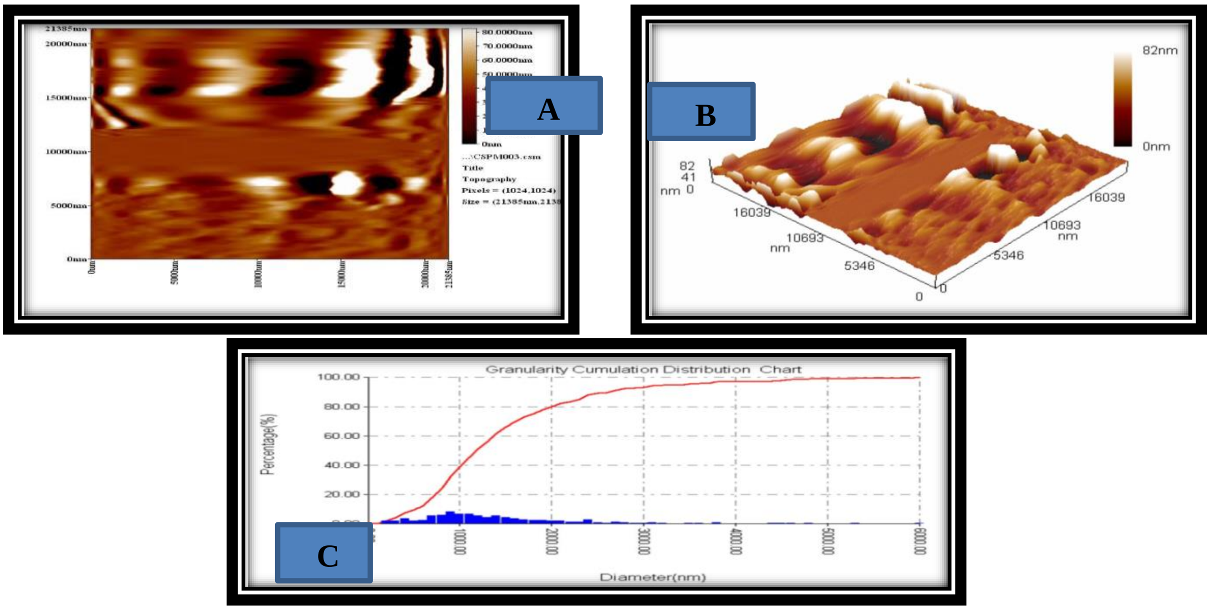

Figure 6: A,B ; AFM analysis of the of control soft liner.
C, Bar chart illustrating granularity cumulation distribution of nanograins of control soft liner

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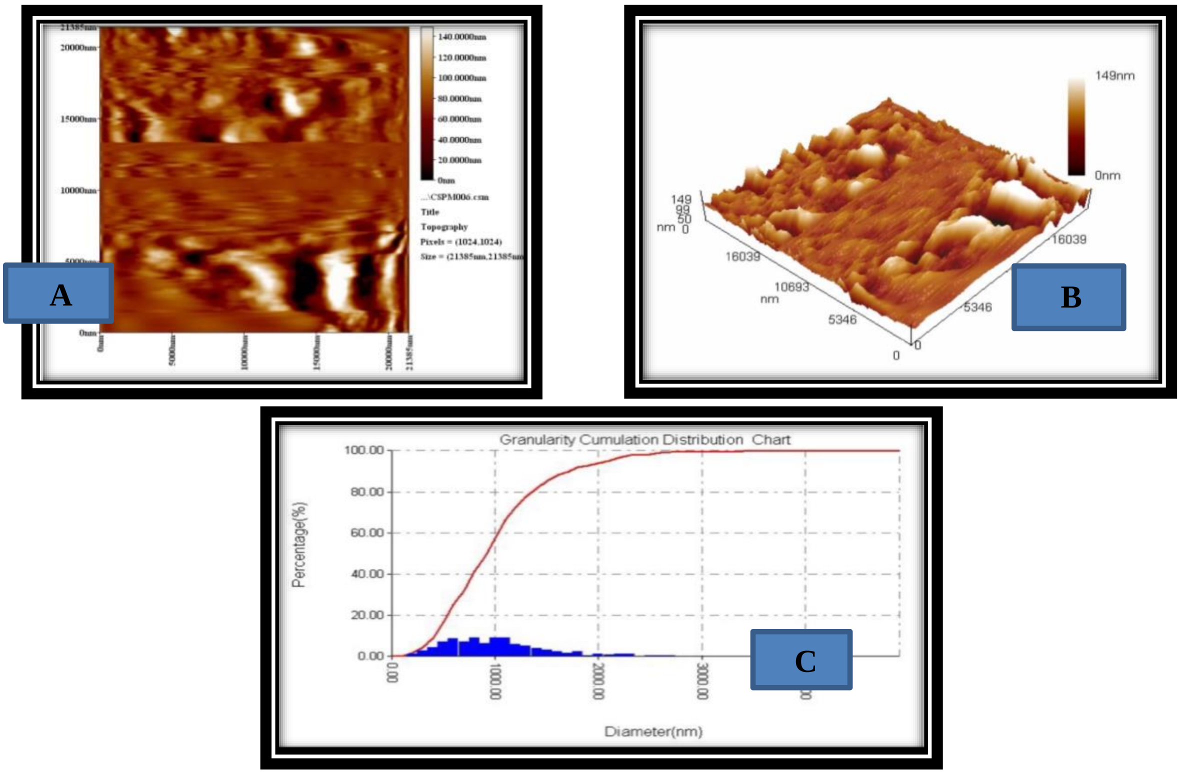
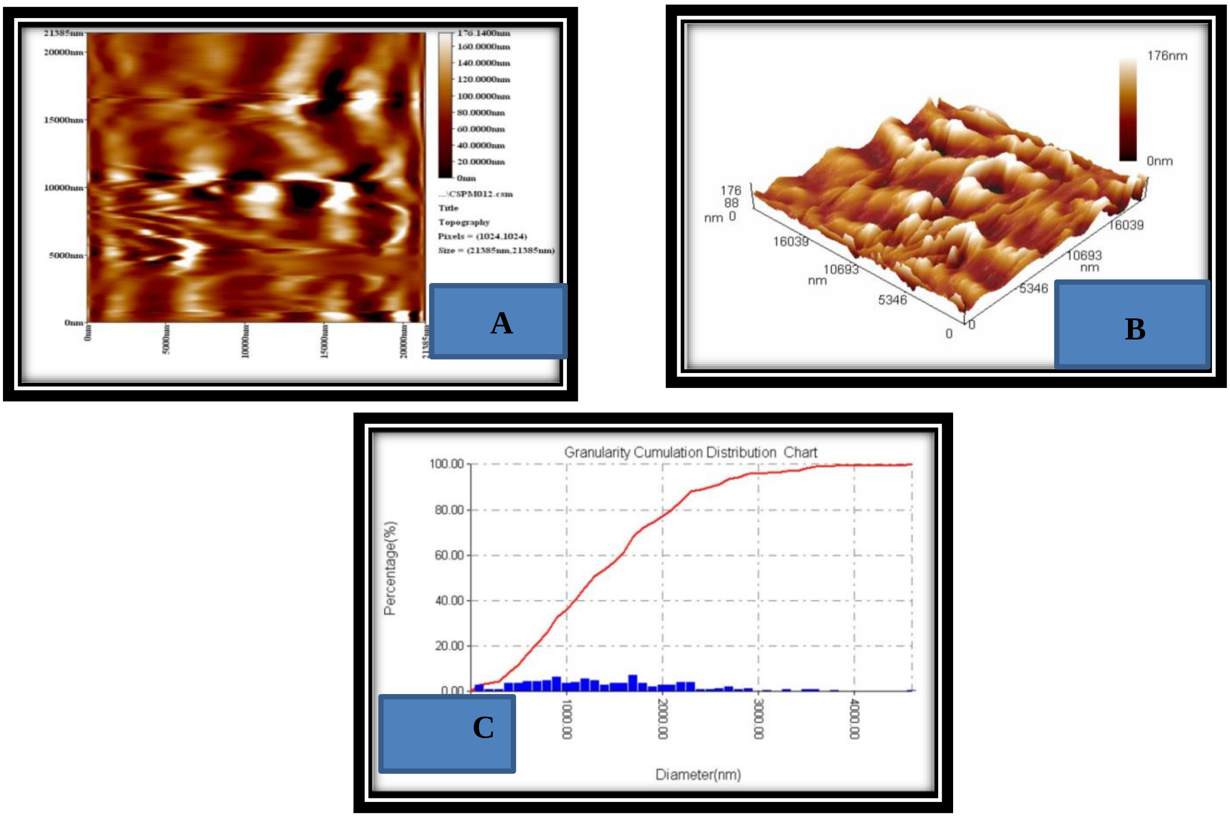


Figure 7 :A,B: AFM analysis of soft liner with 0.25% MMTNPs. C,Bar chart illustrating granularity accumulation distribution of nanograins.



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igure 8 :A,B: AFM analysis of soft liner with 0.5% MMTNPs. C,Bar chart illustrating granularity accumulation distribution of nanograins.

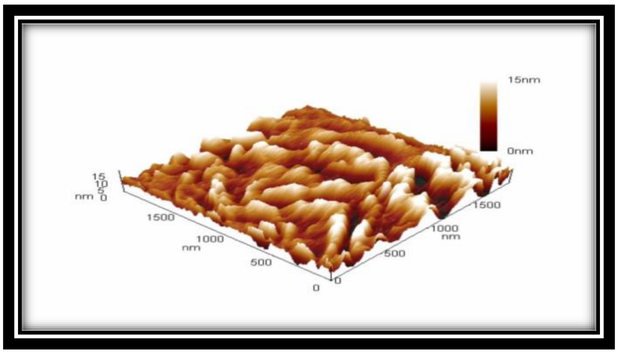

Figure 9 : AFM analysis of MMTNPs powder

The AFM analysis showed increased in average roughness and in reduced valley depth as presented in table(2) .

Table 2: Granular cumulation distribution report .

Groups	Average roughness (nm)	Reduced valley depth(nm)	Grains no.	Average diameter(nm)
control	10.6	35	195	**1424.29**
0.25% MMT	15.5	41.5	439	**999.17**
0.5% MMT	28	48.1	218	**1404.37**
MMT powder	/	/	497	**88.8**

DISCUSSION

Soft lining materials play an important role in prosthetic dentistry due to the viscoelastic pro perties of denture liners, which reduce and distribute functional stress across the denture supporting area(Naser and Abdul-Ameer,2023).

Although a complete denture has a mean life span of 4-5 years, the actual duration depends on the level of alveolar bone resorption. A relining material can be used for replacing a denture's intaglio surface in order to improve the fitting of the denture (Mohammed and Fatalla ,2020).

The topography and physiochemistry of a specific surface affect its wettability and surface free energy(Noro et al.,2013) .

In this study, a non-significant decrease in wettability was seen in study groups with various percentages. This is related to the incorporation of MMTNPs, which were hydrophilic in nature but because of their natural cation exchanging behavior, Some organic ions may substitute for inorganic

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cations, giving hydrophilic nanoclay a hydrophobic property that makes it compatible with polymer matrices (Pavlidou and Papaspyrides ,2008)

The incorporation of hydrophobic organically modified clay with hydrophilic polymer lead to a well-dispersed/exfoliated clay structure. organophilic MMT Clays with decreased surface energy and greater compatibility with Organic polymers display hydrophobic properties when exposed to water (Savas,and Savas,2013) .

In addition the acid activation of MMT, known as K-MMT, which is the type that was used in this study, this activation reduces the cation exchange capacity and makes the spacing between interlayers bigger by partially removing aluminum from the tetrahedral sheets and atoms from the octahedral sheets and putting them in the interlayers (Gubernat and Zambrzycki ,2021). Frequently, the contact angle rises as the interlayer space(d-spacing) increases(Savas,and Savas,2013) .

CONCLUSION

In this study , the effects f MMTNPs on soft lining materials are little decrease in surface wettability and this decrease was non significant , while AFM analysis presented some increase in roughness and valleys depth.

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