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Effect of the Modified and Unmodified ZnO Nanoparticle on the different Properties of Silicon Elastomer

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Abstract. The aim of the present study is to establish the synthesis of the antibacterial prosthetic liner with artificial limb mediated ZnO nanoparticle and the evaluation of their different properties and antibacterial activity. So thatwe used both modified and unmodified ZnO nanoparticle prepared silicone rubber nanocomposite using in the production of prosthetic liner that being antibacterial and prevent may occur.With the addition of 1,2,3,4,and 5 pphr (part per hundred rubber) of modified and unmodified ZnO nanoparticle it was noted that as, the concentration of both type ZnO nanoparticle compression, hardness, modulus, elongation, tear resistance, tensile strength, and specify gravity decrease. Composite contain modified ZnO nanoparticle still has higher mechanical properties than that contain unmodified nanoparticle the work suggested to use little amount of nanoparticle to get better mechanical and antibacterial properties because the propagation of nanoparticle near the surface of the nanocomposite prepared.
Keywords: Modulus, Elongation, Nanocomposite, Unmodified and modified.

1. Introduction

Nanomaterials are of great scientific interest as they are effectively a bridge between the bulk material and atomic or molecular structure. The properties of materials change as the percentage of atom at the surface of a material become significant [1]. In order to reach a homogenous dispersion of the nanoparticle within silicone rubber, use of coupling agent is necessary to modify the surface of the nanoparticle to get the better mechanical properties and antimicrobial efficiency also to avoid aggregation of the particle during the preparation and production of composite this lead to the increase of the particle due to the aggregation which in turn influence the diffusion and the antimicrobial and mechanical properties [2],these properties is based on the diffusion of the particle from the bulk of the rubber to the surface where the antimicrobial agent interact with the mechanism cell[3].filling polymer with nanoparticle lead to significant improvements in their mechanical properties. Such improvement depends strongly on the type of the filler and the way in which the filling is conducted[4]. So that this work used modified ZnO and unmodified ZnO nanoparticle that prevent any agglomeration can occur within the matrix and then produced better mechanical and antibacterial properties.

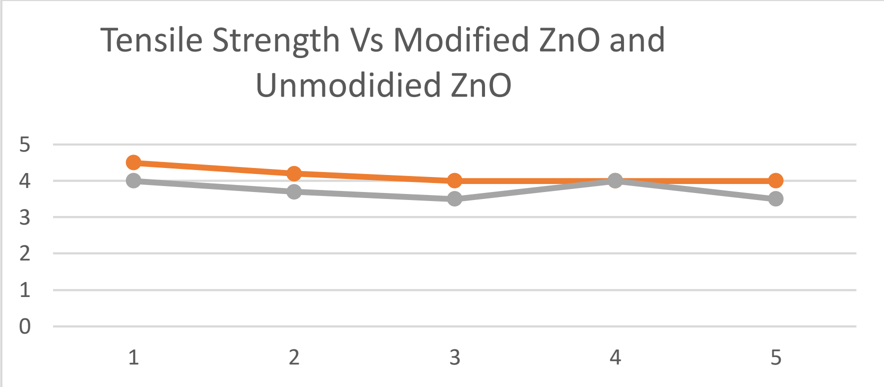
2. Material and Methodology

1 g of starch (as nutrient medium) was weighed correctly and mixed with 20 g of liquid rubber 4305, the second step that is adding unmodified and modified ZnO nanoparticle at different ratio (1,2,3,4,5) % for different sample then poured in circular templet has the diameter of 20 mm and thickness of 3 mm. After the sample be ready for testing the mechanical properties according to the ASTM mentioned beside each test (tensile strength ASTM D412 Die C[5],tear resistance ASTM 624 Die B[6], elongation ASTM 412 Die C[5],modulus ASMT D412 Die C[5],Hardness ASTM 2240[7],compression ASTMD395[8],andresilience ASTM1054[9]).Than two bacteria which cause skin infection was implanted on the sample prepared previously. The kinetic of bacteria growth rate was determined by a method that is based on the culturing bacteria with sample by using the loop and put it on the surface of the samples containing the best characteristics studied and containing a small proportion of the modified ZnO nanoparticle. Covering the disposable dates using para film to prevent pollution. The media were incubated at 37C for one week. Staphylococcus aureus and Pseudomonas areoginosa were used to test the sample prepared against the bacteria growth. The result were taken by considering the zone of growth of the bacteria. Antibacterial activity was evaluated by measuring the diameter of the growth zone around the sample.

3. Result and Discussion

With the addition of both modified and unmodified ZnO nanoparticle it was noted that as, concentration of both type of ZnO nanoparticle modified and unmodified increase, tensile strength decrease. Addition of modified ZnO still has high mechanical properties such behavior can explain that modified ZnO nanoparticle will increase the contact surface area between rubber chain, thus will give a rigid structure with better tensile strength (4.5 MPa). While in high quantities of both type of ZnO will happen aggregate in rubber matrix. This result in poor dispersion that weakens the bond between chains and decrease the tensile strength. This result agrees with reference [10-12] as shown in the figure 1:

Tensile Strength



ZnO NPs %

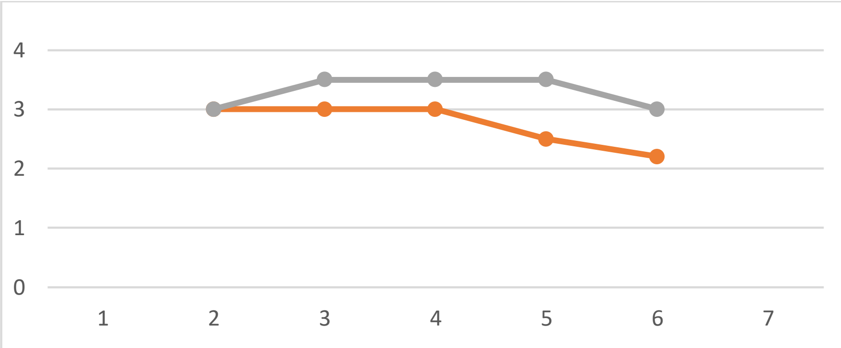
Tensile Using modified ZnO Nps Series 1

Tensile Using unmodified ZnO Nps Series 2

FIGURE 1. Effect of ZnO modified and unmodified nanoparticles on the tensile strength of recipe.

Tear property is related to the tensile property. So that tear resistance increases with small quantities of both of the ZnO modified and unmodified nanoparticle, as shown in figure 2.

Tear Resistance



ZnO NPs %

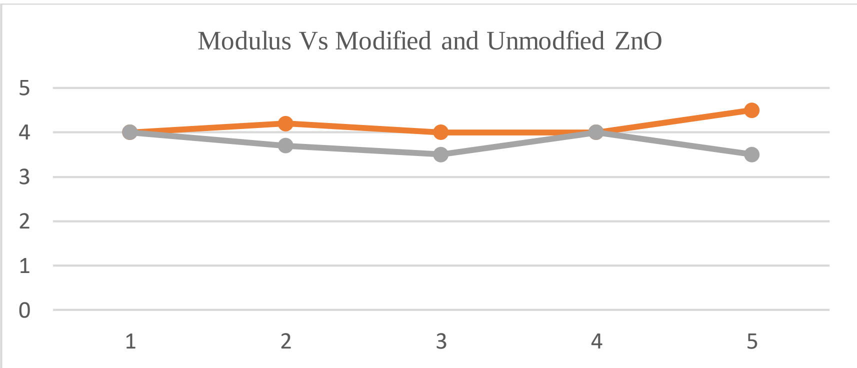
Series 1 Modified ZnO NPs

Series 2 Unmodified ZnO NPs

FIGURE 2. Effect of ZnO modified and unmodified nanoparticles on the tear resistance of the recipe.

For the same reason as previously mentioned in the case of tensile property that the particle will uniformly distributed between rubber chains and increase the mechanical bond between them. This lead to better tear resistance. In case of increasing the quantity of both type of nano ZnO, tear resistance decrease due to irregular distribution of nano ZnO nanoparticle in rubber matrix and aggregate between chains. This is in agreement with previously reported by Jorgen and Mary [11].

Modulus (Mpa)



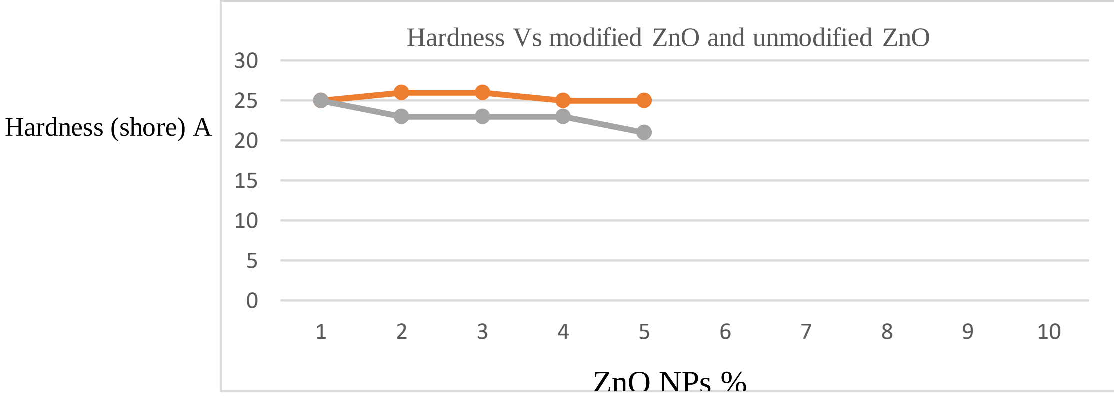
ZnO Nps %

Series 1 Modified ZnO NPs

Series 2 Unmodified ZnO NPs

FIGURE 3. Effect of ZnO unmodified and modified nanoparticle on the Modulus of the recipe.

According to the figure 3 Its show that ZnO nanoparticles does show resistance to metrix molecule orientation in the direction of applied force results in slipping od rubber chian in the direction of applied force and lowering modules of elasticity. This result agrees with that of [6]. From figure 3, it can be seen that the Young modulus decreased with the increase of ZnO modified and unmodified nanoparticle that's belong to a high ZnO loading, means that the composite will not be able to withstand greater loads and the recipe tends to brittle as ZnO increase this behaviour is similar to a result reported by [12].

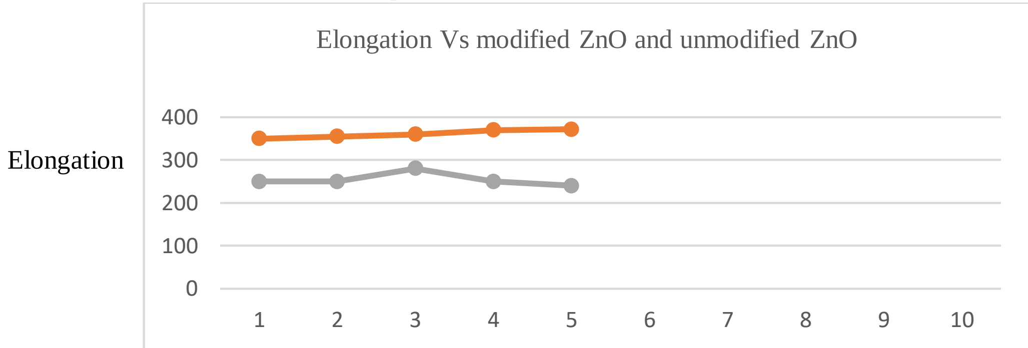


Series 1 Modified ZnO NPs

Series 2 Unmodified ZnO NPs

FIGURE 4. Effect of ZnO modified and unmodified nanoparticles on the hardness of recipe.

Figure(4) shows hardness property increase with small quantities of both of the ZnO modified and unmodified nanoparticles. Because ZnO acts as a filler that it strengthen recipe and make it resistant to the applied forces. The filler can be Physically be entrapped in the rubber and share in the load bearing progress in the matrix lead to higher hardness which is considered to be due to the overall effect of crosslinking of polymer network. Polymer filler interactions which may be physical and chemical and formation of occluded rubber give high hardness value and this agrees with that reported by Ahmed et-al [13]. It was noted that for both of the ZnO modified and unmodified nanoparticle have the same behavior that both tend to increase the hardness of the recipe.



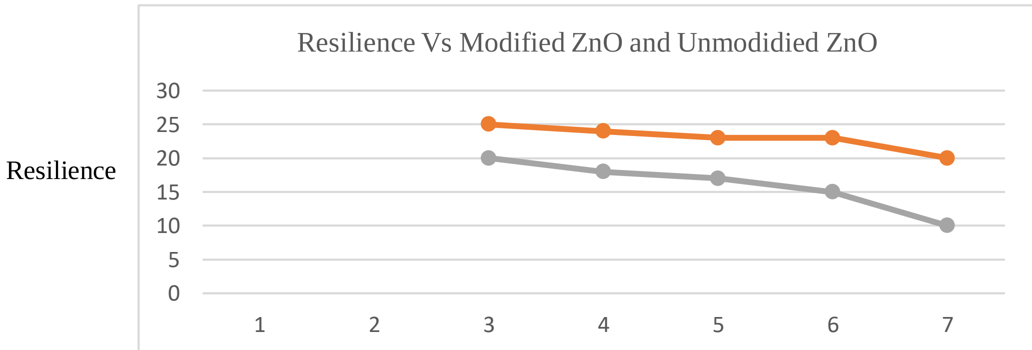
ZnO Nps %

Series 1 Modified ZnO NPs

Series 2 Unmodified ZnO NPs

FIGURE 5. Effect of ZnO modified and unmodified nanoparticle on the elongation of the recipe.

Figure 5 shows that The elongation property decrease with addition of nano ZnO as figure 5,Due the rubber is highly stretching so that when the very fine particle fill the spaces, it will restrict the movement of chains due to the diffusion of very fine ZnO nanoparticles through the rubber chains which are responsible for riveting the rubber chain and then decrease elongation property and this agree with research [14-15].



ZnO Nps %

Modified ZnO NPs (Series 1)

Unmodified ZnO NPs (Series 2)

FIGURE 6. Effect of ZnO modified and unmodified nanoparticles on the resilience of the recipe.

Figure (6) shows decrease in the rebound resilience with the addition of zinc oxide modified and unmodified nanoparticle. The deterioration in resilience is most probably related to the presence of agglomerates at higher filler concentration. As expected, the addition of the ZnO increased the stiffness of the the silicone rubber SR gradually with increasing filler content forming exess material work on decrease resilience force increased ZnO content result in reduction in crosslink density of silicone rubber composites due to the dominant of the filler-matrix interaction and this may be the cause of lower compression set properties shown in the figure 8, such increased in deformation after load removal is similar to that reported by [16].

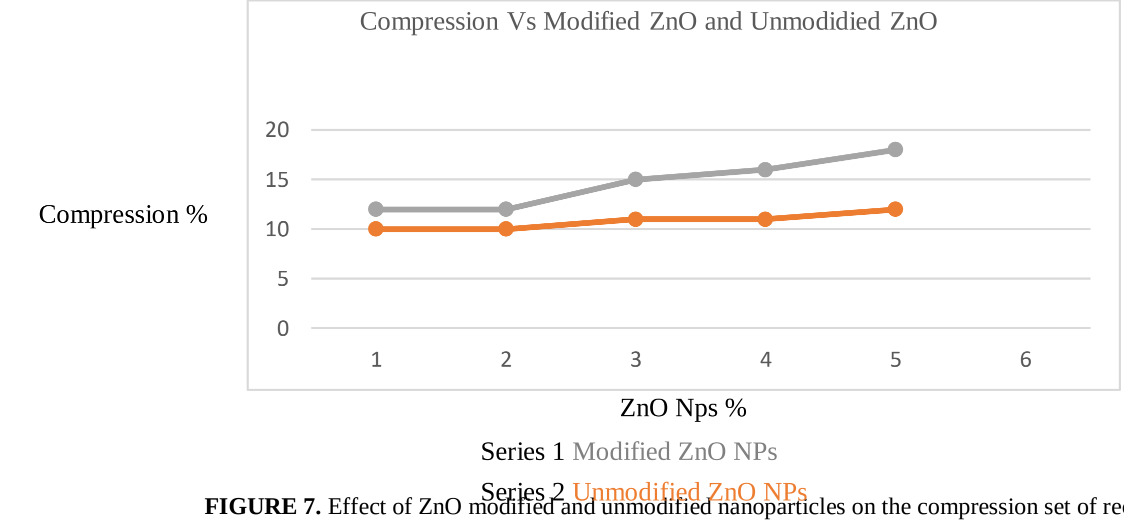


FIGURE 7. Effect of ZnO modified and unmodified nanoparticles on the compression set of recipe

Figure (7) Due to the dominant of the filler-matrix interaction and this may be the cause of lower compression set properties shown in the figure 7, such increased in deformation after load removal is similar to that reported by [16].

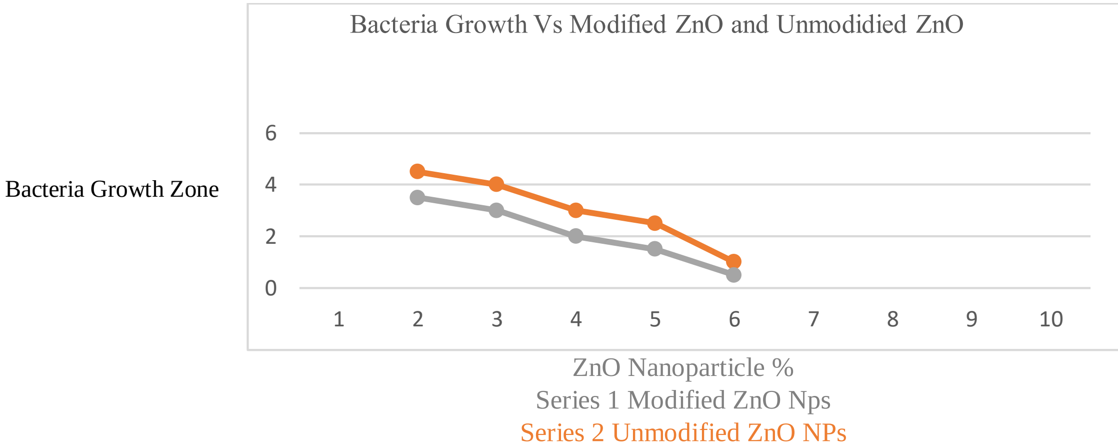


Figure (8) by increasing ZnO nanoparticle content the bacteria growth zone, decrease that is ZnO nanoparticle has the ability to penetrate the bacteria cell wall and cause damage to its cytoplasm leading to bacteria inhibition. This ability increase by increasing the nanoparticle content the same is reported by [8].

FIGURE 8. The Test of Bacteria growth on the surface of the final recipe.

Figure Effect of ZnO unmodified and modified nanoparticle on the bacteria growth zone. The Bacterial growth after incubation for week at 37 C according to the procedure stated by [17] shows negative result which reflect the ability of zinc oxide to prevent the bacteria growth, in the best knowledge of presenting author, these result are reported for the best time.

4. Conclusion

Adding modified ZnONPs produced higher mechanical properties than that of using unmodified nanoparticles. Using small amount of both modified and unmodified is preferred in preparing nanocomposite to avoid nanoparticle aggregation. Silicone rubber-Zinc oxide nanoparticle composite shows a resistance to a bacterial growth that is used safely in medical application.

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