ORIGINAL ARTICLE

Hybrid Nanocoating Waterproof of Silicon Si and Nano-aluminum Oxide Al_2O_3 for Medical Lenses Applications

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ABSTRACT

Introduction: This article specifies on manufacturing hybrid nano-coating waterproof that focused on the medical field of eyeglass lenses application by regular material such as silicon rubber - room temperature vulcanizing (R.T.V.) that approved by (Gelareh et. Al 2011) due to the problem of humidity and wetting that stick on glasses leads to guide for inclusive seek for production of hybrid nanocoating. This type of nanocoating helps to prevents condensation of water droplets on the surface of the glass lenses. **Methods:** Material used was silicon rubber - room temperature vulcanizing (R.T.V.) dissolved with its solution (thinner) in various wt% (10%, 15% and 20%) in addition of Al_2O_3 nanoparticles. Eyeglass lens that coated with Si have reveal a low response to the incidence and also acuity for eyeglass lenses because of pollution of water drop remains and mini dust. **Results:** Material used was silicon rubber - room temperature vulcanizing (R.T.V.) dissolved with its solution (thinner) in various wt% (10%, 15% and 20%) in addition of Al_2O_3 nanoparticles. Eyeglass lens that coated with Si have reveal a low response to the incidence and also acuity for eyeglass lenses because of pollution of water drop remains and mini dust. **Conclusion:** new process for fabricating hydrophobic hybrid nanocoating, using raw material with hydrophobicity, anti-dust properties and shows 100% reduction to adhesion at the eyeglass lens surface for both water and dust.

Keywords: Hybrid nanocoating, Al_2O_3 Nanoparticles, Th thinner, Silicone rubber and Contact angle (CA).

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INTRODUCTION

The issue of wetting and humidity in common, also specifically for medical lenses guide to inclusive seek for production of hybrid nanocoating. Nanotechnology owns the ability to divide material into particles with very small size to enhance its properties (1). (Gelareh et. Al 2011) approved a good candidate to wettability behavior of RTV silicone rubber coated on nanostructured aluminum surface. Some advanced research was made by (Balkees et. al 2017) for fabrication of superhydrophobic nanocomposites coating by E-spin method that lead this article to expand the scope of work on different substrate such as glasses. Materials with nano volume will owns different properties than raw materials, authorize these unique uses in various fields such as medical, biomaterials, electronics and produce of energy (2). Nanotechnology improve the anti-wetting efficiency of known surfaces or provide a new hydrophobic efficiency to apply in medical field. Eyeglass lenses consider as medical tool and can be used either to correct eye vision or for therapeutic cases or cosmetology (3). Eyeglass lenses and their physical characteristics have been examined widely during the years, by increase the clarity of vision along-side and comfortable with anti-scratch lenses (4). Other advanced research made to study the mechanical of hydrophobic properties by same technique E-spin that effect on parameters of morphological by (sigi H et. al 2015).

Contact angle test is very important in this study to knowledge of surface behavior also by the results we can define the surface if its own a hydrophobic or a hydrophilic properties (5). Another complexity of eyeglass lens is scratches. Coating lenses by silicone rubber totally abolish scratches on eyeglass because of their hydrophobicity granted with properties of anti-dust

(6). Silicone rubber provides good qualification stand for pollution of mini dust than traditional lens. Fabrication hybrid nanocoating for eyeglass lenses decrease the amount of dust aggregate, also cases which chained to pollution adherence for eyeglass lenses. Different wt% of Si solution have been studied (7). The contact angle instrument used was optical system with automatic unit and software for contact angle estimation (static and dynamic). It is also suitable to calculate surface interfacial tension. This type of device can measure contact angle with static and dynamic which can have base angle from (0-90o) to measure contact angle hysteresis and also roll off angle.

Nanocoating can be fabricated by electrospinning technique which consider as best process for the fabrication on nanocoating. Last few years the interested of researcher rise for nanotechnology due to the nanofibers production with diameter of nanometer (3nm). Common electrospinning instrument owns 3 major tool that come with electrospinning device which are (syringe, voltage and collector) (8). Roughness of the surface is tested in this article to all coated specimen to define the changes alteration over concerned substrate and how interact to the ambient situation, high amount of roughness is unwanted and would be hard and expensively to control the production. Also give undesirable properties for the manufacturing of hydrophobic nanocoating which known in general having very smooth surface characteristics (9). The objective of this article is to advance the surface functionality and application of new hybrid nanocoating in eyeglass lens that related to ophthalmology and also to the surface engineering as well.

MATERIALS AND METHODS

Material and sample preparation

Material used was silicon rubber R.T.V (room-temperature-vulcanizing silicone) dissolved with its solution (thinner) in various wt% (10%, 15% and 20%) in addition of Al_2O_3 nanoparticles for fabrication of hybrid nanocoating (Si/thinner/Al_2O_3). The resultant solution will be in percentages of (90%thinner+10%Si), (85%thinner+15%Si) and (80% thinner +20%Si), a 0.1%wt of nanoparticles were added to all previous ratios.

Nano alumina (Al_2O_3) is a fine nanoparticle, with diameter (20nm-30nm) and 99.99% purity is a product of Hongwn Co., Al_2O_3 was added to the Si solutions that prepared in known percent %wt.

When Si prepared with its solution Th, and after applying coating to the lens by electrospinning process, Si nanocoating will adhesion on the eyeglass lens surface and only Si/Al_2O_3 will remains on the lens substrate while the solution Th will evaporate due to the mechanism of electrospinning process. Eyeglass lens that coated with Si have reveal a low response to the incidence and also acuity for eyeglass lenses because of pollution of water drop remains and mini dust (10). Al_2O_3 nanoparticles also added to the coated lens surface to prevent adherence of water to eyeglass lens (11–13).

Electrospinning for Nanocoating manufacturing

The synthesis of nanocoating was made by electrospinning process that used a moderate voltage (about 6KV) for range of time (1-2 hours) and the eyeglass lens was installed on metal plate for conductivity mechanism to evaporate Th solution that put in syringe of 3ml and attract the Si/Al_2O_3 nanocoating on eyeglass lens surface which resultant with only Si/Al_2O_3 nanocoating will remain on the lens substrate.

Contact angle measurement

This test consider as basic for the glass lens substates to show the surface if become hydrophobic after coating, this test is a common experiment to reveal the properties of the surface (hydrophobic of hydrophilic), the coated specimen were submitted to the instrument by a droplet water and taking a record image for the calculation of angles for both (left and right) sides of droplet on surface as average, as mentioned in the experimental part in material and method the highest magnitude of contact angle results was obtained from 20%Si and this will be described in details in the results section.

Accelerated weathering measurement

This test made to show the wreathing factors on the coated surface, the principle of the instrument of this test is to expedite the weathering conditions, in other words, the days of the week can be counted with the equivalent of one month in return, instead of waiting for an actual 6 months, the test is done in this test for only 6 weeks. The possibility of this test is that its results are completely identical to the weathering conditions in nature for the factors of (temperature, UV, and humidity) in cycle. The specimens were submitted in this test and show very little effect on the surface without change the hydrophobicity properties that obtained from hybrid nanocoating. That leads to the perfect result on the success of nanocoating on the glass, also can be made as self-cleaning applications in future work as in advanced research.

RESULT

Contact Angle

All coated specimens was tested to contact angle before and after exposed to accelerated weathering test (15). First of all the test made for the eyeglass lens before coating and shows hydrophilic properties to the surface about (40.368^{O}) as showed in the Fig. (1). Highest magnitude of contact angle results was obtained from 20%Si solution as shown in Fig.(2) which shows about (99.850^{o}) contact angle as compared to the rest solutions (10% and 15% of Si). After addition of Al_2O_3 nanoparticles to the highest result of contact angle that been obtained from 20%Si in which the applying nanocoating become 20%Si/Al_2O_3, the coated eyeglass lens shows different result which differ from (99.850°) to (110.173°) as shown in the Fig. (3) that shows eyeglass lens specimen after applying of nanocoating with best ratio of 20%Si/Al_2O_3.

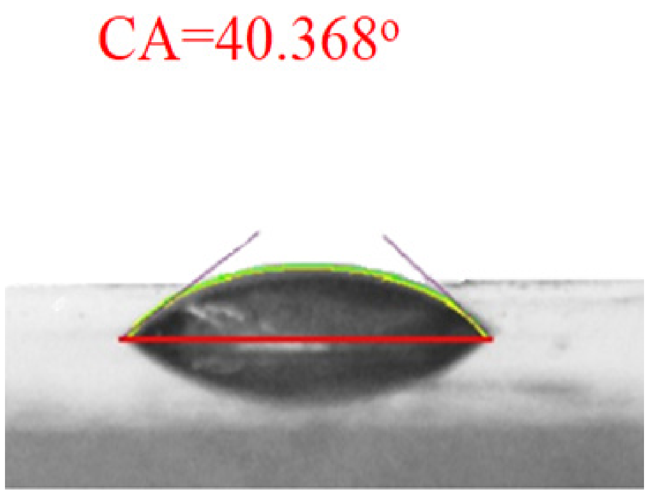

Fig 1: First of all the test made for the eyeglass lens before coating and shows hydrophilic properties to the surface about (40.368°)

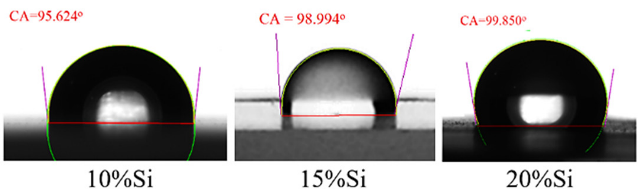

Fig 2: Highest magnitude of contact angle results was obtained from 20%Si solution

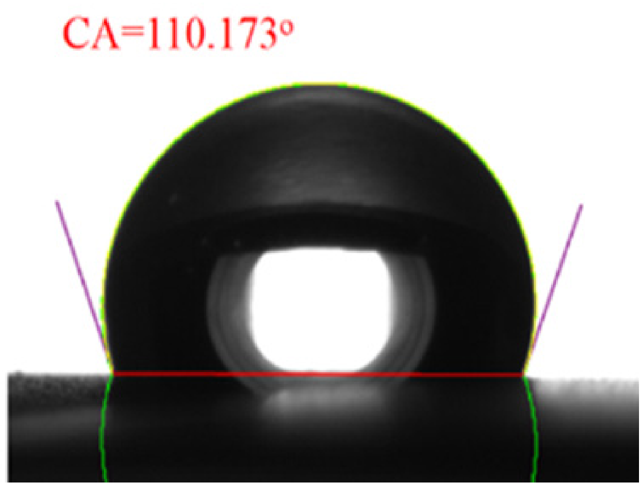

Fig 3: Eyeglass lens specimen after applying of nanocoating with best ratio of 20%Si/Al_2O_3.

Contact Angle Hysteresis

Hysteresis contact angle was tested to 20%Si/Al_2O_3 eyeglass lens substrate to determine the nature of the surface if it was slippy or sticky. High hysteresis gives slippy characteristics and low hysteresis gives sticky properties. Eyeglass lens substrate before nanocoating was stick and owns very low hysteresis of contact angle about (6.021°). And the angle position of the base was measured in two situation 45° and 90°. The results shows slippy properties after nanocoating as in the Fig. (4) that shows hysteresis contact angle results for eyeglass lens before and after nanocoating. The results were obtained by calculating the receiving and advancing of contact angle(16).

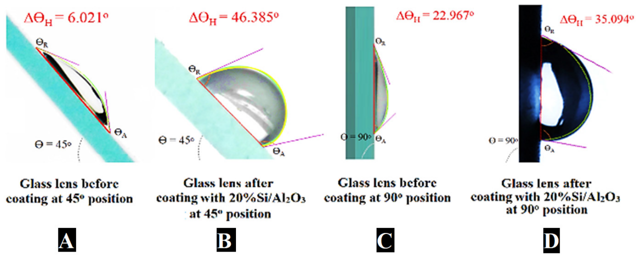

Fig 4: Slippy properties after nanocoating

Accelrated Weathering Condtions

Accelerated weathering system was carried out on Q-lab of spray type. The specimens were subjected for six months in cycle runs of (UV ultraviolet radiation, 50°C temperature and rain) to see weatherizing situation that happened at the surface. The results shows minimum decreacse in conatct angle test and still saved the advanced properties much longer (17).

Surface Roughness

Surface roughness test was examined for the coated eyeglass lens. The surface roughness result depends on the use of surface in nature. However, the specimen with highest value of roughness is not necessarily the best, it depends on its use such as for wear test, where surface with higher roughness gives better performance than lower roughness. Obviously and very important to know that surface roughness results estimated from the lowest value considered as the smoother ones in general. Eyeglass lens substrate is known to have smoothest surface roughness as compared to other materials also the lowest value of it. After coating with Si/Al2O3 nanocoating glass gave surface roughness values of (0.010μm) (18). Coated eyeglass lens owns roughness result lower than eyeglass before coating which was of (0.115μm) of roughness. Fig. (5) shows (SR) results for eyeglass lenses.

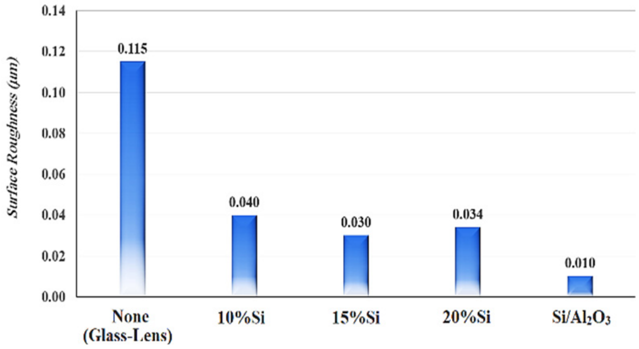

Fig 5: (SR) results for eyeglass lenses.

Scanning Electron Microscope

SEM images were taken to see the optimum beads that achieved from solution prepared. Also, the SEM images in Fig. (6) were recorded before and after addition of nano particles of Al_2O_3. SEM test help to see surface alteration changes happened and surface morphology after nanocoating (19). The SEM images show the morphology of the coated surfaces and show that (20%Si/Th) coated specimen appearing have higher amount of beads and (Si) coated specimen having little amount of beads and defect as compared to specimen before coating and (Si/Al_2O_3) coated specimen has less amount of beads and defect and pure percent of contaminations at the surface as compared to other coated specimen.

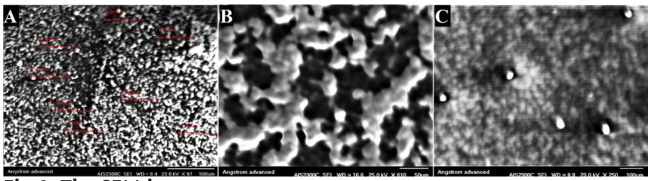

Fig 6: The SEM images

DISCUSSION

Contact angle has been calculated using sessile drop process and from Fig.(2) showed that wettability characteristic for coated samples of (10%, 15% and 20% of Si) is much higher than sample before coating (None sample or as it is) as compression. The higher value of contact angle was for 20%Si about (99.850°) and depending on this ratio, Al_2O_3 nanoparticles were added to improve its wettability and surface roughness properties. There is a straight relationship between the surface roughness and contact angle results and according to sessile drop test shows that nanocoating of 20%Si/Al_2O_3 owns higher hydrophobic properties than 20%Si without nanoparticles as shown in Fig.(3), which is devour from (99.850°) to (110.173°). the major factor that control the surface properties for its wettability is roughness, hydrophobic surface can be obtained by reducing the amount of surface roughness.

Contact angle hysteresis also been measured to know if the surface owns sticky oy slippy properties. contact angle hysteresis deals with the difference between advancing and receding angles that produced or formed by sessile drop on the substrate, High amount of hysteresis represent to huge slippy of the surface while low hysteresis is demand for hydrophilic substrate that grant the ability for sticky characteristics, this phenomenon is derived Lotus effect and been depended upon generations. However, it was difficult to move the water drop even by tilting the surface, to get exact photo because of slippy properties in which can't be inverted upside down of it due to high hysteresis of contact angle. First of all before making the test, the positions were taken for calculating contact angle hysteresis, two places considered for the positions from the base is (45° and 90°). For 45° angle position from the base, Fig.(4)-A shows the result for lens sample that not been coated owns ΔθH about (6.021°) with sticky properties and Fig.(4)-B shows the result for lens sample that been coated with 20%Si/Al_2O_3 owns ΔθH about (46.385°), which shows great improvement with slippy properties and deals with surface as hydrophobic substrate. For 90° angle position from the base, Fig.(4)-C also show the result for lens sample that not been coated owns ΔθH about (22.967°) with sticky and little slippy properties and Fig.(4)-D shows the result for lens sample that been coated with 20%Si/Al_2O_3 owns ΔθH about (35.094°), also shows good improvement with slippy properties before coating that could lead to future work as self-cleaning application.

Accelerated weathering system was measued to see the various changes that happened upon period of time (6 months) and during (UV ultraviolet radiation, 50°C temperature and rain) to see weatherizing situation that happened at the surface form and result of wettability to the coated lens. The results shows minimum decrease in contact angle test and still saved the advanced properties much longer.

Surface roughness test was examined for the coated eyeglass lens. Fig.(6) shows the results for surface roughness after test to different samples before and after coating. The results shows that coated eyeglass lens owns roughness result lower than eyeglass before coating which was of (0.115µm) of roughness, while after coating with 20%Si in addition of nanoparticles Al_2O_3 ¬the surface roughness results shows greater value transformation from (0.115µm) to (0.010µm) which the lower magnitude is considered as the best roughness properties as mentioned above in results section.

The SEM images show the morphology of the coated surfaces and show that (20%Si/Th) coated specimen appearing have higher amount of beads and (Si) coated specimen having little amount of beads and defect as compared to specimen before coating and (Si/Al_2O_3) coated specimen has less amount of beads and defect and pure percent of contaminations at the surface as compared to other coated specimen. The observation from SEM images is that the substrates comes with noncontinuous layer of Al_2O_3 deposition and appear to be widely homogenous and for the topographies that are various in nanometric only, as a result of Al_2O_3 nanoparticle for layer deposition, the topographies of the substrates that coated by E-spin process still similar before coating.

CONCLUSION

This article shows a unique and efficient process for acquaint anti-wetting characteristics to eyeglass lenses. Identical acquaint of fabricated nanocoating might be used to various medical instruments. This study shows enhancement process for fabricating hydrophobic hybrid nanocoating, using raw material with hydrophobicity, anti-dust properties. The results show that fabricated nanocoating owns excellent properties of waterproof which shows 100% reduction to adhesion at the eyeglass lens surface for both water and dust. Hysteresis contact angle recognize the major problem of slippy and sticky properties that still remains with pollution in the eyeglass lens surface, the test determined the good enhancement to the lens and make it repels water droplets in much more amount as before which prevent humidity to the eyeglass lenses surface. Surface roughness show good improvement after application of nanocoating. Finally, this article can be consider as a good step for production of nanocoating that use for self-cleaning applications.

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