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Improvement of the mechanical properties of pores silicone rubber/chitosan/sodium bicarbonate composites using for burn dressings

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Abstract

The present idea is aimed to prepare porous composites of silicone rubber (SR) and sodium bicarbonate ($NaHCO_3$/SR/Chitosan) composites by mixing the medical grade liquid silicone rubber LSR with different ratios of both $NaHCO_3$ and Chitosan (prepared from fish shells) by hand and studied their physical and mechanical properties such as tensile tests, tear resistance, hardness and compression. Results confirmed that $NaHCO_3$/SR/Chitosan blend mechanical properties of the composites were influenced significantly by the blowing effect of sodium bicarbonate.

Key words: Medical grade silicone rubber; Chitosan; Nano-composite; Sodium bicarbonate; Mechanical properties

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Introduction

Chitosan is a naturally renewable polymer to have excellent unique properties such as biocompatibility, non-toxicity, and adsorption and due to this reason, it has wide applications in various industries such as waste water treatment, pharmacy, cosmetics and medicine [1]. This substance is antibacterial and antifungal; it can prevent from bacteria growth which causes infection. The antimicrobial properties of Chitosan and $NaHCO_3$ involve a wide range of microorganisms as fungi, bacteria and viruses. With its antibacterial activity, chitosan is applied in medical applications such as wound dressing and suturing thread [2]. In some studies, Chitosan absorbing of harmful UV radiation or different dyes can be easily covalently bound to Chitosan amino groups. Hence, utilizing this substance as new dressing is important in medicine, so that many researches, either academically or in the industry have focused on it. This substance is usually used in the form of gel and film for treating wounds and burns, but one of the main problems of this substance as a dressing is weak mechanical properties in the sheets phase [3]. Therefore, various methods are provided to overcome the shortcoming of Chitosan based polymeric sheets, such as combining with other polymers like SR, cellulose and poly (ethylene oxide) (PEO), synthesis of Chitosan copolymers, and applying physical and mechanical crosslinking agents [2, 3]. SR is inert biological, resistant against chemicals and heat. It has a biological compatibility with human tissues. Combination of SR and Chitosan was prepared to provide new materials with biological functions and unique physical and mechanical properties [4]. Sodium bicarbonate is capable to improve breathability and antibacterial properties of silicone sheets, and to progress the polymer composites efficiency as dressings [5]. Although there are no literatures about the combination of Chitosan/SR/$NaHCO_3$, there are less valid reports about the mechanical and antibacterial properties of composites as a dressing. In this work, the effect of sodium bicarbonate and Chitosan were investigated on physical, mechanical and antibacterial properties of the SR composite sheets.

Experimental and Materials

Chitosan (prepared in a lab from fish, shells), liquid silicone rubber (LSR), and $NaHCO_3$ obtained commercially.

Preparing of Chitosan using fish shell

Firstly, we collect (100 g) of fish, shells to prepare chitin by washing the shells with water, then drying it in the atmospheric air after that milling in electric mill, treating the results shells powder by NaOH with concentration of 3.5% for 3 hours at 65C˚ to remove protein (Deproteinization). Demineralization done by mixing with 1molary HCl in 1:15 (w/v) for 30 minutes at room temperature. As final steps, remove the dyes by acetone for 10 minutes at room temperature, finally washing the results white powder with distilled water and drying with oven 60C˚ for 24 hours. Mixing the result chitin prepared in the lab with 50 % NaOH by the ratio 5:7 (w/v) annealed at 100C˚ for 20 hours and washing by deionized water then drying at an oven 60 C˚ for 24 hours to produce Chitosan.

Chitosan/SR/ sodium bicarbonate composite preparation

The Chitosan, $NaHCO_3$ and LSR of different proportions were then mixed to obtain the mixtures with weight ratios of LSR/Chitosan/ $NaHCO_3$ at room temperature and then poured in lubricated glass molds with (10×10×0.2) cm^3 dimensions, the obtained composites was kept for 10 hours, and the resultant composite sheets obtained were separated from glass molds after drying and tested mechanically (tensile strength, tear resistance, hardness, compression and water uptake).

Mechanical test results and discussion

The thickness of prepared sheets was measured using a micrometer at three different places and mean values were calculated. Tensile test shows SR sheets strength and elasticity which are determined according to strength at break. A clear advantage of the prepared composite in comparison with common composites was the improvement of strength by adding natural polymer (Chitosan). These results are mainly due to high compatible interactions with SR matrix. Addition of different percent of the Chitosan and $NaHCO_3$ to the LSR to determine the right addition for manufacturing high-performance composites silicone sheets using with burn patients to remove burn scars or scar management. The optimum result shows 6 % of Chitosan because this ratio gives the highest mechanical properties as shown in **Fig. 1**.

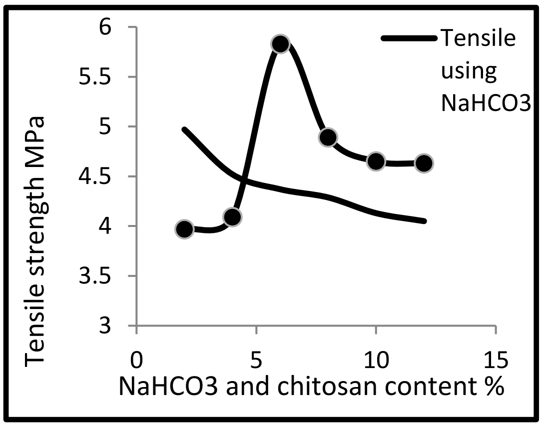

Figure 1
The effect of $NaHCO_3$ and Chitosan content on the tensile strength of the prepared sheets.

From **Fig.1**, rubber compounds (with $NaHCO_3$) show a low tensile strength. The increase in the tensile strength occurs when we add chitosan because of the reinforcing effect of chitosan. Then decreases continuously when increasing the chitosan load because of aggregation. pores rubber composites(breathable) show comparatively lower tensile properties than normal composites in stress-strain behavior and this behavior agree with [6]. **Fig. 2**, shows significant increment in tear resistance by adding Chitosan could be attributed to the formation of hydrogen bonds during manufacturing and drying processes [7, 8].

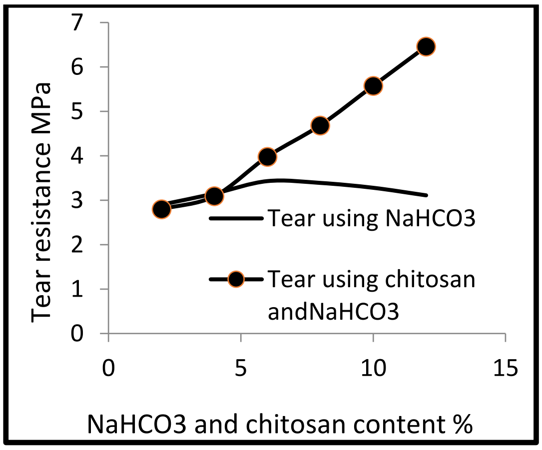

Figure 2
The effect of $NaHCO_3$ and Chitosan content on the tear resistance of the prepared sheets

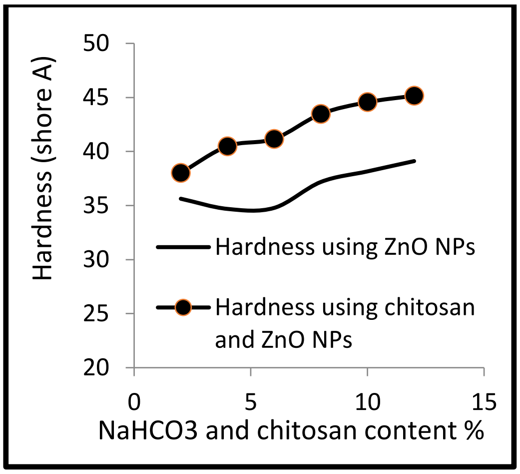

Figure 3
The effect of $NaHCO_3$ and Chitosan content on the hardness of the prepared sheets

The **Fig. 3** shows the increase in the hardness of prepared composites because of the positive effects of chitosan may be masked if the chitosan molecules are entrapped within the volume of the surrounding material (LSR) argued that an increase in the surface-to-mass ratio of chitosan structures leads to increase the hardness. To increase the efficiency of LSR and maintain mechanical integrity [9].

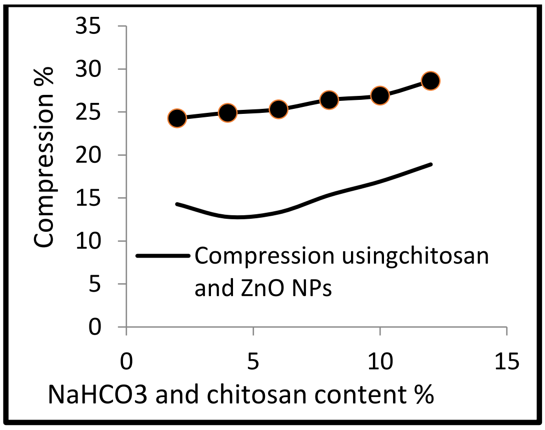

Figure 4
The effect of $NaHCO_3$ and Chitosan content on the compression of the prepared sheets.

The composites sheets with chitosan have the ability to withstand high compression with little deformation in dimensions than the sheets prepared with sodium bicarbonate only as shown in **Fig 4**.
Inevitably the presence of a $NaHCO_3$ material is going to affect the antibacterial and breathable properties of the samples produced. While the Chitosan play a good role in raising the mechanical properties represented by tensile strength, tear resistance, hardness and compression [10].

Degree of swelling
In this study, water uptake was measured as an important characteristic in burner dressings. This feature shows the capacity of a dressing in absorbing exudates from wounds. As it was seen in figure 5, water

uptake in SR/ Chitosan /$NaHCO_3$ was higher than SR/chitosan sheets in salty water media, because of blowing effect of sodium bicarbonate that produced cellular sheets that prevent the accumulation of exudates at the skin surface, which would result in delayed healing process and hence an increase in bacterial growth risk [11].

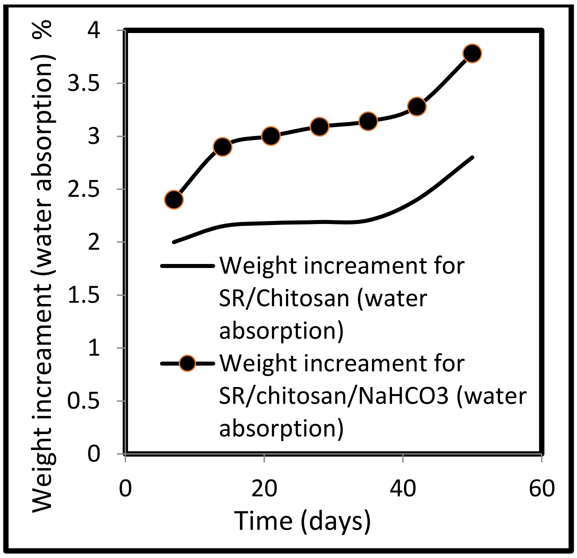

Figure 5

The water absorption of the prepared composites sheets during different time.

The applied Chitosan had a low molecular weight, and this resulted in an easier diffusion of water molecules in Chitosan chains. Thus, the addition of sodium bicarbonate to SR led to increment of water uptake. This factor confined polymer chain movements, limited water molecule dispersion and therefore water uptake decreased this is because of hydrophobic acetyl groups in Chitosan molecule. Addition of sodium bicarbonate to Chitosan led to increase in water uptake in comparison with pure Chitosan as reported by [12].

Conclusion

Chitosan based liquid silicone rubber nanocomposite sheets were produced successfully. The product contained nano-chitosan particles have sufficiently good mechanical properties compared to composite sheets without nano-chitosan. The prepared nanocomposite sheets made a remarkable improvement in water uptake activity properties by using sodium bicarbonate that it can be used as burning dressing to absorb exudates and prevent bacterial growth. Besides that, it prevents to increase the scar tissue size.

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