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Studying The Mechanical Properties of Silicone Rubber-Alum Composites using in Manufacturing of Prosthetic Liners

Noor Hadi Aysa Mohamed Hamza Al-Maamori
College of pharmacy, College of material engineering, Babylon university

Nehad Abdul Ameer Al-Maamori
College of Science/Babylon university

Abstract
Silicone liners protect the stump and also act as protection mechanisms against stress, weight loading, and bacteria growth. In this work we used alum, which is a compound of potassium- aluminum sulfate salt ($K_2SO_4.Al_2$ $(SO_4)_3.12H_2O$ as bifunction filler that help in producing closed cell composites and to get the more sterilization product. The addition of alum to the silicone rubber is for different percent (1,2,3,4,5) %. At all levels of alum powder have lower mechanical values with the increase of alum percent. The alum powder is not having much reinforcing action. The addition of alum reduces all mechanical properties (tensile strength, tear resistance, modulus, compression, hardness, elongation and specific gravity) due to the formation of gaps in the material and weakening the cohesion of the recipe components.

Introduction
As changes occur in prosthesis design and fabrication, prosthetic liners must adapt to be compatible with these developments. When Iraqi amputee patients wear the liner in summer season (temperature to more than 50 C°), the thermal environment inside prosthetic liner, in addition to decreased quality of life and prosthesis use, comfort, and satisfaction, could put people with amputation at high risk for skin irritations [1]. The current review explores the importance of sterilization by providing an insight into the prevalence of the problem leading to the accumulation of sweat within the liner producing a good medium for bacteria growth [2]. The major function of a prosthetic liner is to give comfort and enhance the efficiency of the prosthesis by providing protection to the residual limb and slide with respect to the socket wall. This has been accomplished efficiently by using a silicone rubber liner. Introducing alum-silicone composites, have afforded the resiliency that provides comfort between the socket and the residual limb, and have supported the distal tissue within the closed sock [3]. New liners are being fitted more closely, wearers are becoming more active, and the skin condition is being given more attention. To answer these needs, a new prosthetic liner has been developed in a lightweight construction. Pure silicone gel padding provides an excellent weight-bearing support. When used to fabricate soft insert liners, it can help absorb external forces by allowing movement between the skin and the socket or liner [4].

Material and experiment:
The composite materials are commericially silicone rubber (HY-Y810) and alum. The tensile, modulus, and elongation properties were evaluated on an Instron using ASTM D-412 [5]. Tear tests were performed on an Instron according to ASTM D-624 [6]. Hardness measurements were carried out on a shore A durometer, following the procedure of ASTM D-2240 [7] and water absorption performed according to ASTMD-570-98 [8]. Each point information reported on the plots presented in this research is the average of 3 specimens from the same sample.

Results and discussions
Testing the mechanical properties against alum contents shows the decrease in tensile strength with the increase of alum contents due to the formation of micro gaps that it acts as a defect that the rubber will not withstands the high tensile force as shown in figure (1).

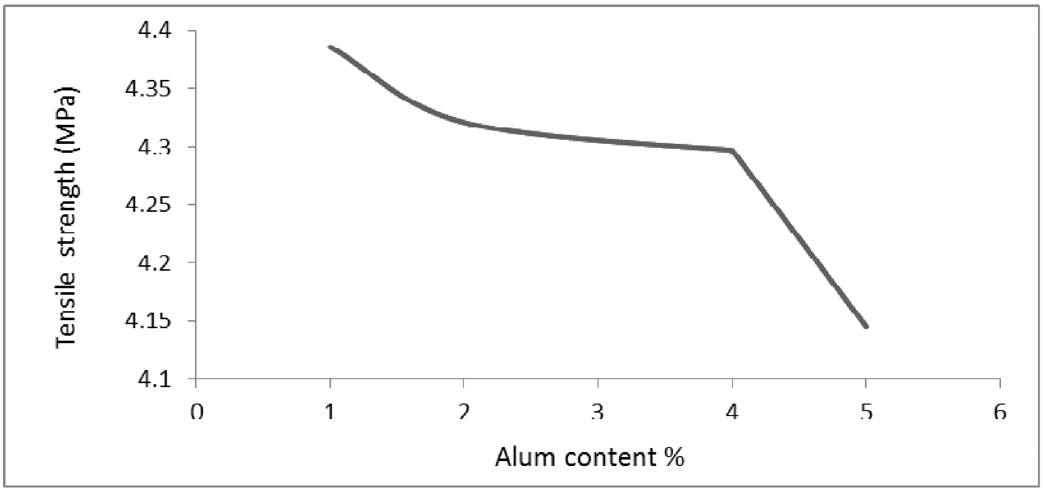

Figure (1) Effect of alum loading on the tensile strength of the recipe

Tear resistance properties illustrate in figure (2) indicate that more alum content impart low tear resistance, because alum molecules creates poorly bonding with the composites network producing microgaps which initiate composites rupture agreeing with [9]. The extent of decrease still within the acceptable range of standard mechanical properties.

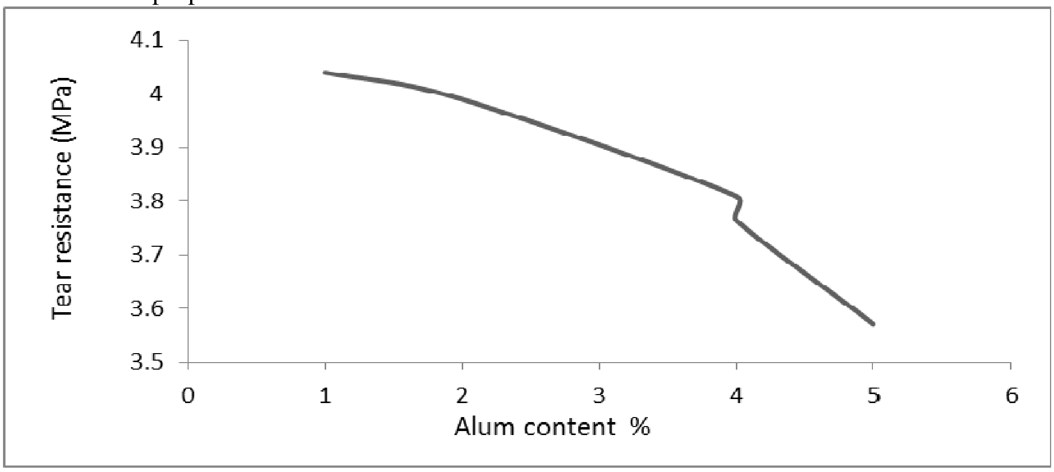

Figure (2) Effect of alum loading on the tear resistance of the recipe

According to the figure (3); The elongation decreases when we add alum compared with that when we add ZnO and starch that's mean alum giving boardy and brittle composites with poor elongation at high alum loading. Such a reduction in elongation at break of a composite with increases in filler content has been reported by [10].

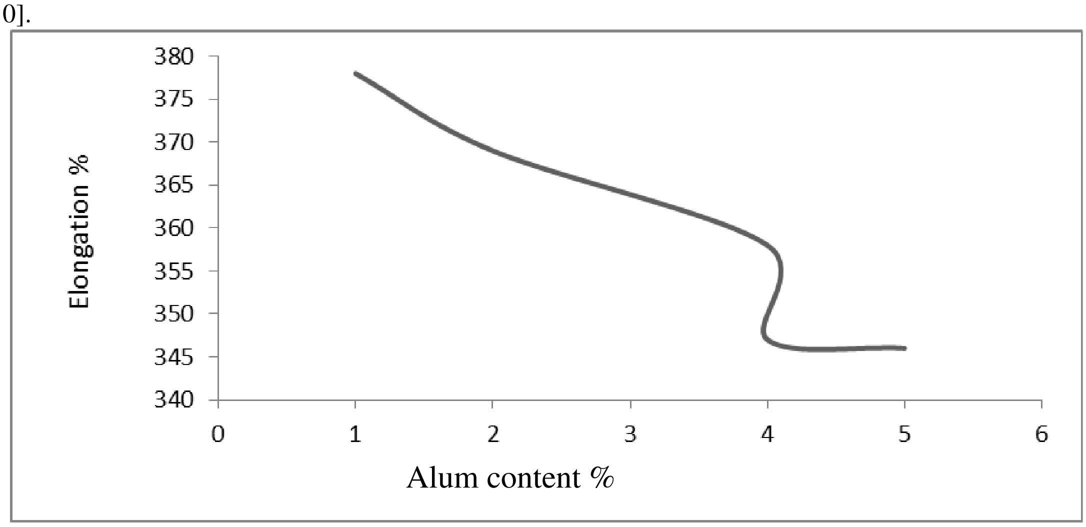

Figure (3) Effect of alum loading on the elongation of the recipe

According to the Figure (4) its shown the hardness decreases with alum loading. This can be related to the interfacial and physical bonding between the filler and silicone rubber matrix. On the other hand, hardness, depends on the allocation of the alum molecules in the SR composites. It is well known that incorporation of the alum molecules in the soft matrix increases the elasticity of the polymer chains resulting in less rigid composites [11]. These interactions reduce the hardness of the SR matrix-fillers under investigation. A further increase in alum content deteriorates the mechanical properties of the composites that's agreed with [12].

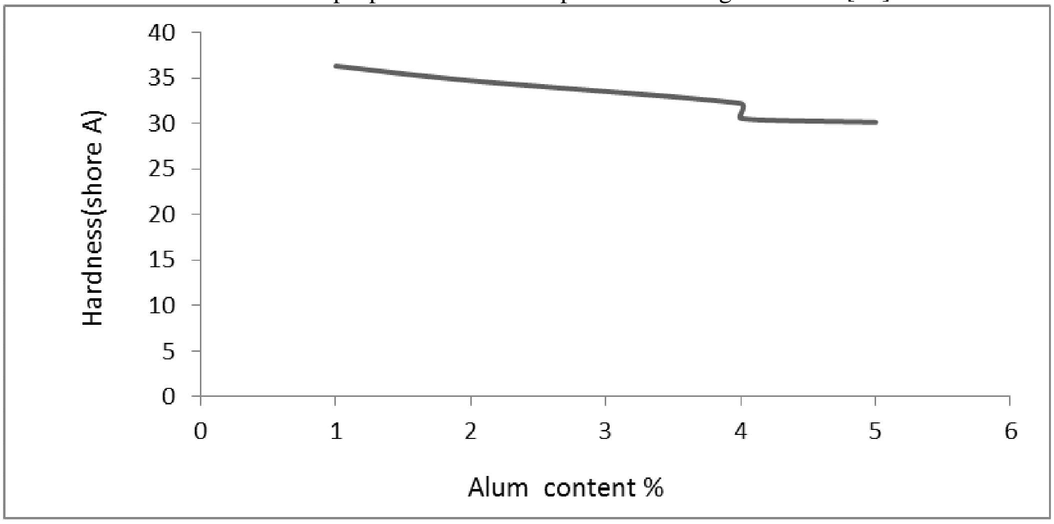

Figure (4) Effect of alum loading on the hardness of the recipe

At lower loadings, the contribution towards an increase in resilience is mainly from poor extents of crosslinking. As the quantity of alum is increased creates such an obstacle to elastomer chain extension in proportion to the strength of the particle-polymer interaction therefore decreasing the resilience that agrees with [13].

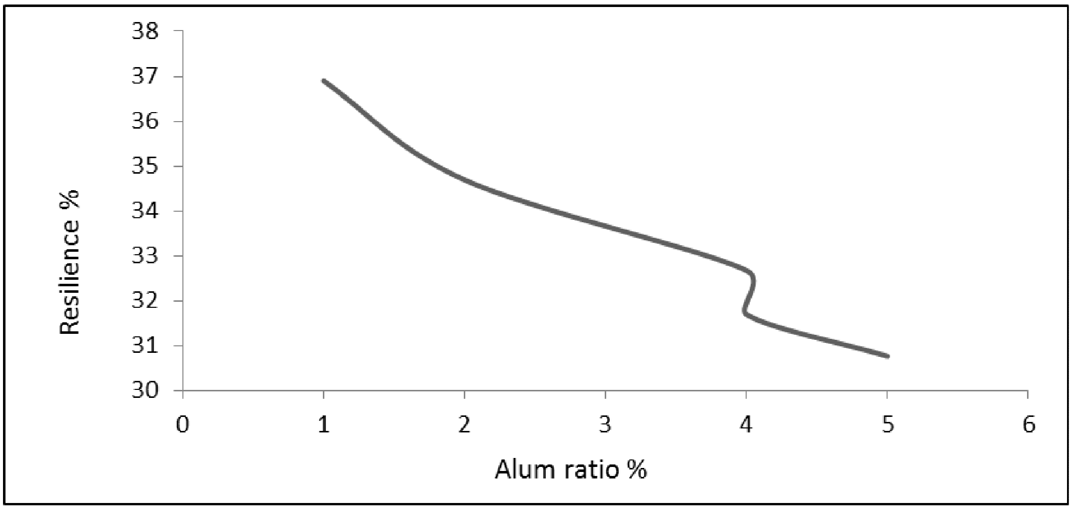

Figure (5) Effect of alum loading on the rebound resilience of the recipe

Compression sets increased with alum loading this could be due to the presence of alum molecules within the network structure which tend to increase the dimensional deformation as stated by [14, 15]

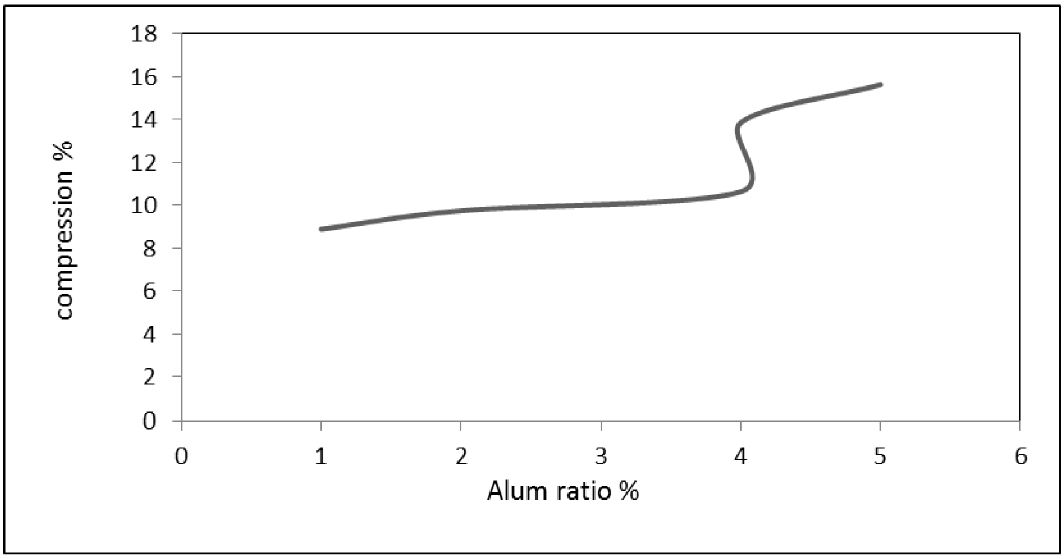

Figure (6) Effect of alum loading on the compression of the recipe

The modulus decreases with the increase of alum that increase (strain) as mention above increasing the change in the recipe dimension containing alum and as a results the composites will not have the ability to withstand high stress approach to that of [16] as shown in figure (7).

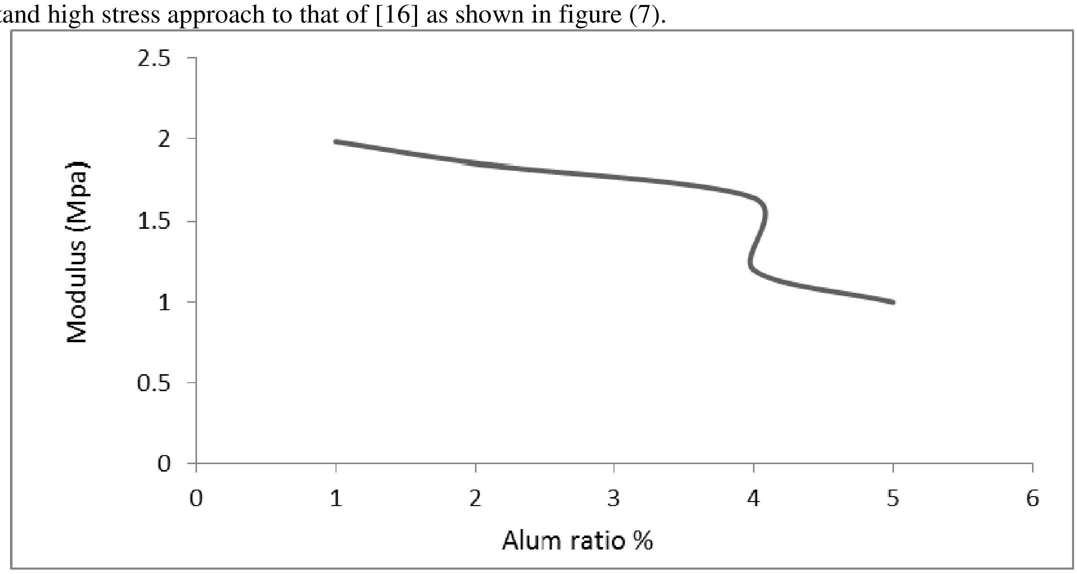

Figure (7) Effect of alum loading on the modulus of the recipe

Figure (8) shows the decrease in specific gravity with increasing of alum content that's the air will diffuse through the open cell in the recipe increasing volume and reducing the specific gravity that's also reported by [15].

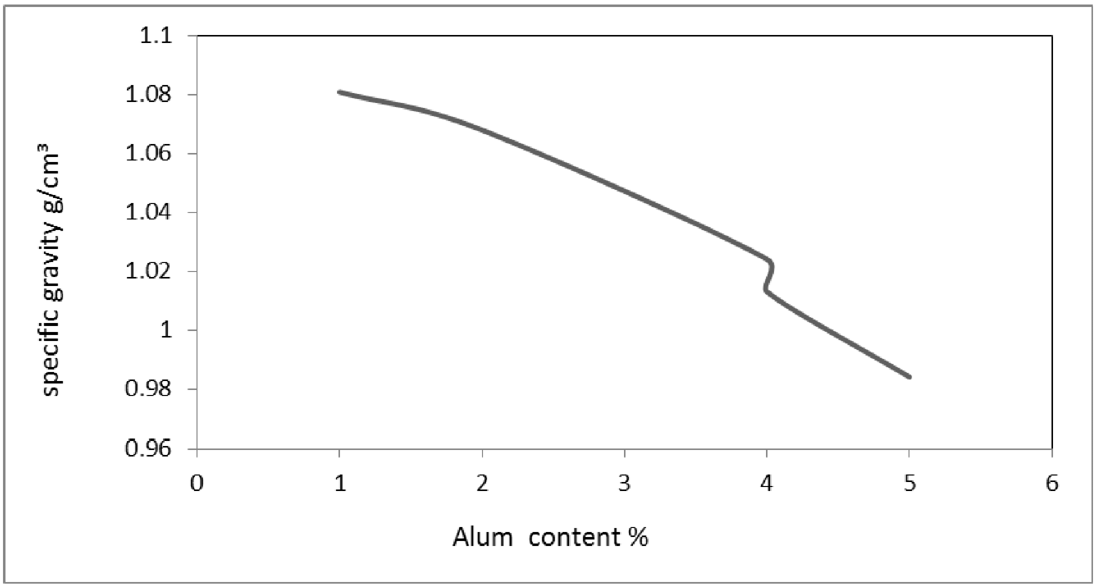

Figure (8) Effect of alum loading on the specific gravity of the recipe

Conclusions

1. Alum can be used as difunctional filler produced sterilization and form cellular silicone rubber has permability to skin to breathe through it.
2. Increasing the alum content deteriorate the mechanical properties of the product.
3. Forming cellular silicone product lead to reduce the weight, which is preferred in medical application such of artificial limbs

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