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Evaluation Effect of Certain Denture Cleansers on Flexural Strength of Sustainable PMMA Biocomposite

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Abstract:
The purpose of the current study is to investigate the effect of adding eggshell (ES) as reinforcement on the flexural strength of PMMA polymer and evaluate the flexural strength of eggshell-PMMA composite when treated in certain denture cleansers . Different amounts of eggshell(1 %, 3%, 5% and 7% wt%) were used to synthesizecomposites also5% wtchitosan was add as antibacterial. Flexural strength of PMMA and the biocomposites was tested before and after treatment within certain denture cleansers (tap water, salty water and peroxide based cleanser).Laser Light Scattering was used to measure the particles size of eggshells powder.Scanning Electron Microscopy (SEM) was used to investigate the fracture surface after bending test.Results demonstrate that 15% improvement of PMMA flexural strength achieves at 1% ES filler content. After treating within the certain cleansers, the flexural strength of PMMA negatively affected whereas flexural strength of 1% ES containing composite improvesby 25%, 30% and 11% when treated within tap water, salty water and peroxide based cleansers respectively. Generally, for these composites, tap water and salty water denture cleansers are the more suitable compared with the costly peroxide based cleanser.
Keywords: *egg shell, chitosan, SEM,denture, biocomposite, cold cure PMMA.*

I. INTRODUCTION

The gradual increasing of production of chicken egg, due to worldwide using for industrial, cosmetics and domestic purposes, leads to consider that eggshells represent an environment problem as waste material[1].According to sustainability engineering, researchers have been attempting to reduce pollution by employing the by-products to be sources for new valuable useful materials[2, 3,4, 5]. Eggshell, as a by-product, was employed as bio-filler for polymeric composites and cement[6,7,8].

Chitosan can be defined as a copolymer of glucosamine and N-acetylglucosaminedeacetylated from nature chitin. Chitosan has inert nature, also is an inexpensive, biodegradable, biocompatible, hydrophilic support materialandnon-toxic[9]. Incorporation of Chitosan with PMMA polymer makes the resulted composites possess biological properties[10].Arun et.al confirmed by FTIR that chitosan grafted PMMA, therefore, chitosan-PMMA copolymer was obtained.

Polymethylmethacrylate (PMMA) is currently the most common denture base material due to its biocompatibility, satisfactory appearance, low cost, dimensional stability and easy manipulation [11,12, 13].

During chewing process, PMMA denture is subjected to shear and compression forces. This will be a reason for denture failure. However, PMMA has low flexural strength. Therefore, many researchers suggested several methods to reinforce PMMA polymer by either adding reinforcement materials or by polymerization process controlling. For, example, post-curing microwave irradiation was suggested to improve flexural strength of PMMA. So et al.reported that combination of post-curing and incorporation of glass fibers(2% wt. to resin) obtains a significant improvement in flexural strength[11]of PMMA.Pradhan and Sahoo studied the effect of eggshell (nano- CaO) as a bio-filler on the mechanical strength and thermal stability ofchitosan grafted PMMA, they concluded that adding of nano-CaO at different loads (from 0.1% to 0.9%) effects on tensile and compression strength of bionanocomposites (BNCs) and the sample with 0.35% of nano-CaO was found to be more suitable BNCs. Also, they found that this nanocomposites have higher thermal strength due to presence of eggshells into the structure [10].Waly studied effect of incorporating undoped or silver-doped titanium dioxide nanoparticles on the antifungal and dynamic viscoelastic properties of acrylic denture, it was found thatinsertion Ag-doped TiO2-NPs into acrylic imparts antifungal effect against Candida with a reduction in the impact strength[14]. However, rubber could be used as filler to improve flexural strength of PMMA. Alharebet al concluded that the impact and fracture resistance of PMMA denture were enhanced after reinforcement with nitrile butadiene rubber (NBR) particles and treated ceramic fillers[15].

Water and chemical solutions may have effects on polymer properties, when treated with it, depending on the environment nature, chemistry and structure of the polymer. As a result of mouth environment; bacteria, candida and plaque are created on denture material, therefore denture cleanliness is essential and patient is advised to clean denture by brushing and the treatment with certain denture cleansers[20]. This study deals with investigating the effect of adding eggshell as reinforcement on the flexural strength of PMMA polymer and evaluating the flexural strength of eggshells-PMMA biocomposites when treated with certain denture cleansers or various periods.

II. MATERIALS AND METHODS

2-1 Materials

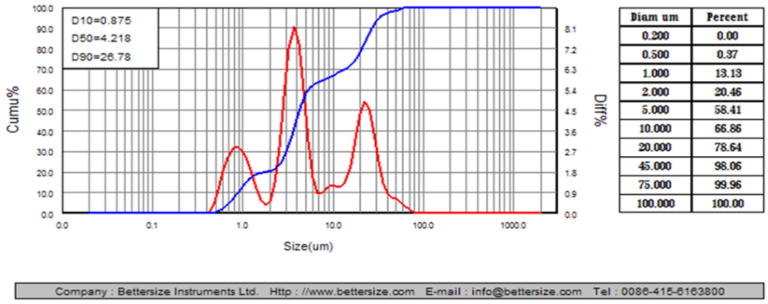
Cold cured PMMA was supplied from Shanghai New Century Dental Materials Co.Ltd, China. Eggshells were collected locally andthoroughly washed by a sponge with tab water and detergent to remove any undesired materials such as dust, solid soil, chicken wastes and internal membrane of eggshell. After that, rinsing with deionized water was necessary. The cleaned eggshells were dried at 120℃ for 1 hr.The powder of eggshells was prepared in laboratory by mechanical grinder for 15 minutes of grinding.

2-2 Synthesizing of sustainable PMMA Composites

The required weight of eggshell powder (as 0%, 1%, 3%, 5% and 7% by weight of resin) and 5% of Chitosan were added to PMMA powder. This materials mixture was well crushed by mortar and pestle. The recommended amount of MMA monomer was poured into beaker and the materials mixture was gradually added with continuous stirring until a dough-like mixture was formed. The preparing process was accomplished in ice bowl because of hot weather and the exothermic nature of the reaction. The final mixture was poured into greasy mold (75 x 50 x 3 mm) to prepare the composites sheets.

2-3 Characterization

Laser particle size analyzer (Bettersize2000, from Bettersize Instruments Ltd.) was used to determine the particle size of eggshells powder. Scanning electron microscopy (SEM) was used to examine thefracture morphology, adhesion and incorporation of eggshell particles into the PMMA matrix.



Diam um	Percent
0.200	0.00
0.500	0.37
1.000	13.13
2.000	20.46
5.000	58.41
10.000	66.86
20.000	78.64
45.000	98.06
75.000	99.96
100.000	100.00

Fig.1: Laser particle size analyzer chart.

2-4 Treatments within certain denture cleansers

Nine groups of specimens were classified according to medium of treatment and period of treatment. Each group was treated in certain medium for 7, 14 and 30 days. The first group G1 was treated with tap water. The second group G2 was treated with salty water. The third group G3 was treated with peroxide based medium (Polident, Stafford-Miller limited, Ireland) which prepared according to manufacturer directions. Treatments were performed at room temperature and the treatment mediums (denture cleansers) were daily changed to simulate the daily treatment by patients. Long immersion period procedures were followed according to durability of dentures (5-7 years)[16].

2-5 Testing of flexural strength

According to ISO 5833(2002), specimens were prepared of (75 x 5 x 3 mm) and universal testing machine (WDW-E Series, TIME-Shijin, China)operating at a crosshead speed of 5 mm/min, three points bending test to determine the bending strength of biocomposites of eggshell-Chitosan-PMMA. Flexural strength of specimens was tested before and after treatments with certain denture cleansers.

III. RESULTS AND DISCUSSION

The noteworthy issue of crushing eggshells, chitosan and PMMA powders together by mortar and pestle is to reduce segregation and aggregation of added materials so that good homogeneity is satisfied and no micro voids would be formed around eggshell particles dispersed within PMMA matrix. Another issue is: when such solid powdered materials were crushed, the surface area of particles increases so that the contact areas of particles increase and more incorporation is satisfied. Yatet.alreported that adding extra amount of monomer to achieve good wetting of reinforcement phase by pre-wetting and using injection molding for acrylic dental applications. Whereas, in current study the good impregnation of fillers achieved by crushing the powdered materials together before adding monomer and no extra monomer is needed to achieve good wetting.

From studying the results of adding eggshells (ES) particles (4.2 µm particle size) to PMMA (Fig.2), it can be noted that filler content 1% of ES achieves improvement of flexural strength (15% improvement of flexural strength of PMMA) where the ES particles carried part of applied load, therefore, material strength has improved.

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FromSEM micrograph offailure surface of the composite containing 1% ES content (Fig. 3b) it can be seen that homogeneous particles distribution, good adhesion between ES particles and PMMA matrixand no micro voids are formed. Therefore, ES can be considered to be good support to reinforce PMMA.

When filler content was increased up to 7%, filler content per unit volume increases, leading to weak adhesion between the ES particles and PMMA matrix.Therefore, ES particles present weak points within the matrix and concentrated stresses generate in those weak regions causing strength decreasing. Generally, from SEM micrographs, it's clear that the holes of pulled-out ES particles are rough which proved the good mechanical adhesion (due to the porous surface ofES particles [17]). Also, it can be noted that the fracture surface is non-smooth and serpentine where ES particles acted as obstacles against cracks propagation.

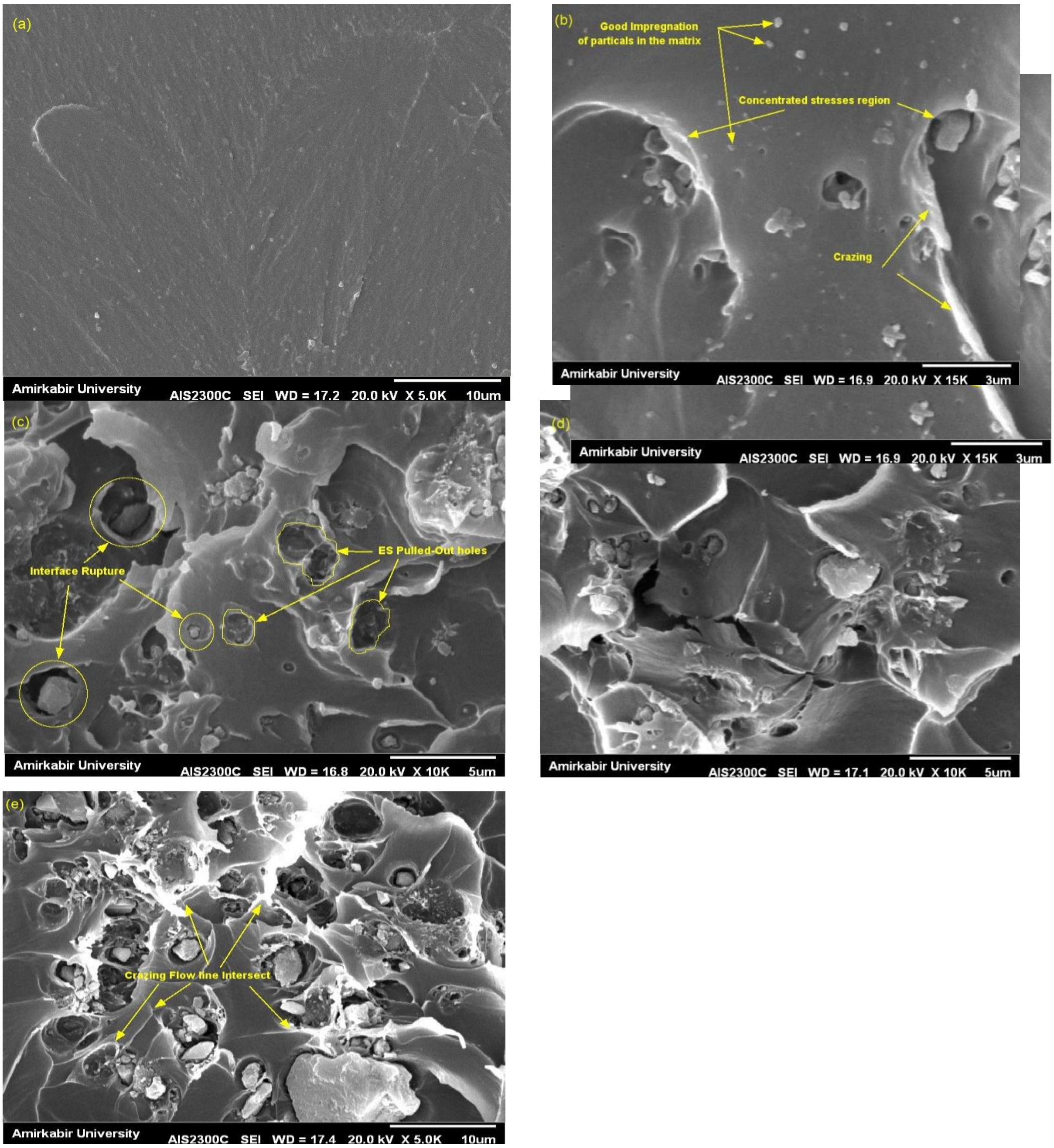

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Fig.3: SEM micrographs from the fracture surfaces of PMMA-chitosan copolymer (a), biocomposite containing 1% eggshell (b),biocomposite containing 3% eggshell (c), biocomposite containing 5% eggshell (d) and biocomposite containing 7% eggshell.

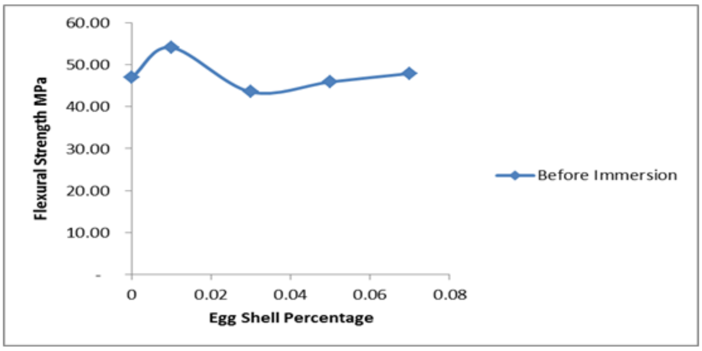


Fig.2 : effect of eggshell filler content on flexural strength of PMMA.

Fig.4 represents the effects of immersion period, filler content and immersion solutions on the flexural strength of PMMA composites. It can be seen from fig.4, that flexural strength of PMMA decreases when treated with the certain denture cleansers whereas1% ES containing composite has the highest flexural strength but when filler content increased up to 7% the flexural strength decreases.

After 7 days immersion period, it can noted thatflexural strength decreases. This can be related to the diffusing molecules of water and/or sodium chloride into PMMA which may strain or rupture the intermolecular bonds in the matrix and at the interface. Another major factor effected the flexural strength is ES particles dispersed within PMMA. When ES content higher than 1%, the reinforcement effect was shown to be negative. This may be due to the higherES content in the polymeric matrix; i.e. ES particles per unit area increased and became more vulnerable to water and it may be hydrolyzed leaving micro voids or became moisturized particles dispersed within the matrix.

when immersion period increased up to 14 days, the flexural strength slightly improved.This may be due to residual monomers releasing when PMMA immersed in aqueous solutions [18] and calcium calcification may be started.

Also, it is clear that the flexural strength of biocomposites increases (see fig.4c) this may be due to calcium calcification (egg shells contain~ 95% calcium).Generally, from fig.5, it can be seen that tap water and salty water treatment mediums are the more suitable compared with the costly peroxide based cleanser. This may be related to the peroxide based cleanser chemicals which affect the acrylic resin properties [19] and its mechanism which affect water molecules diffusion so affected calcium calcification.

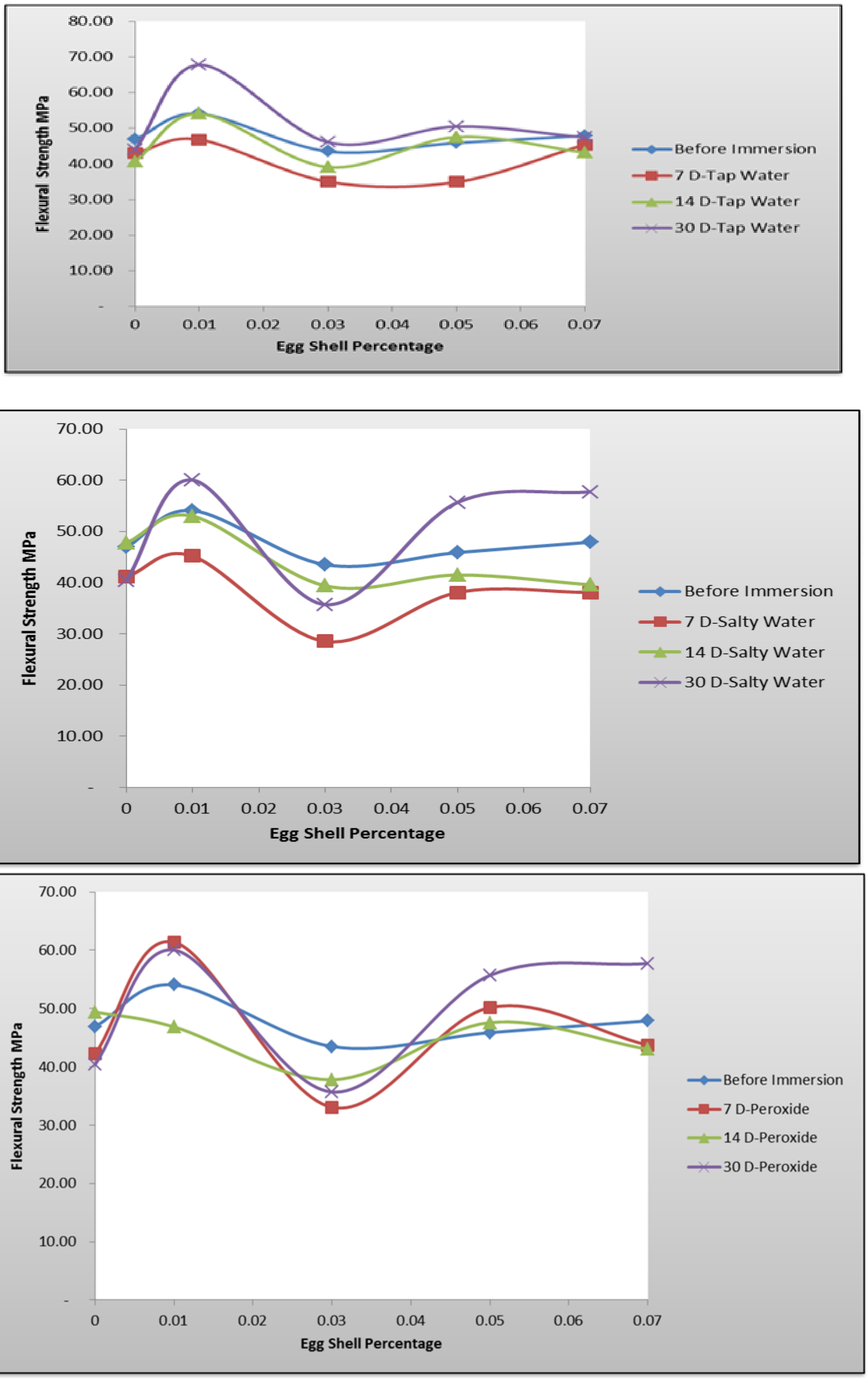
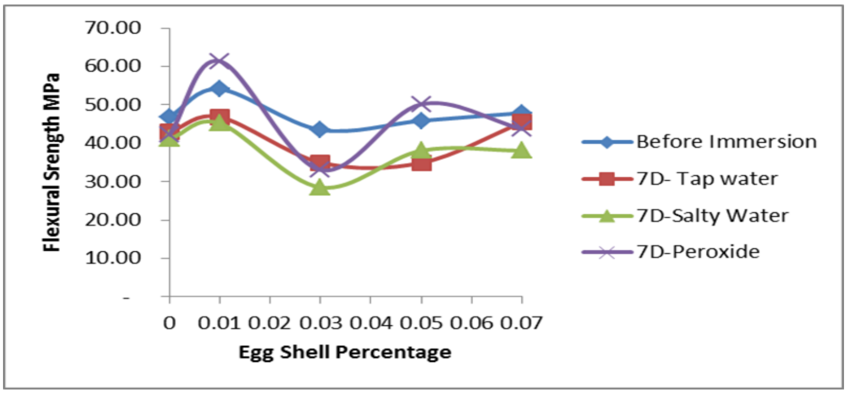
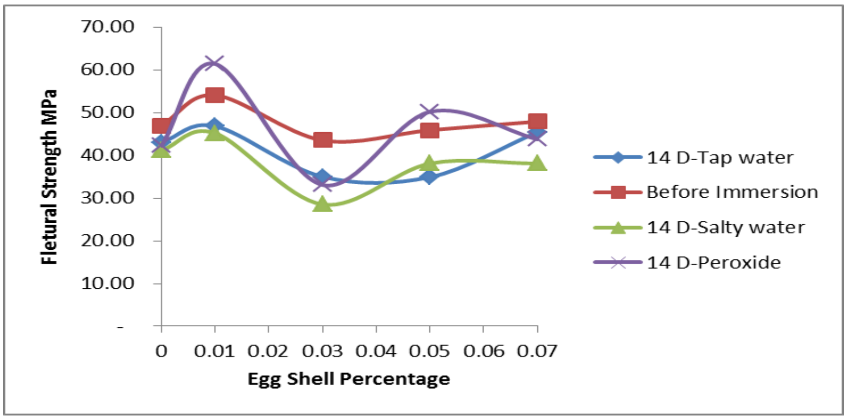


Fig.4 represents the effects of immersion period in different denture cleansers on the flexural strength of PMMA composites.





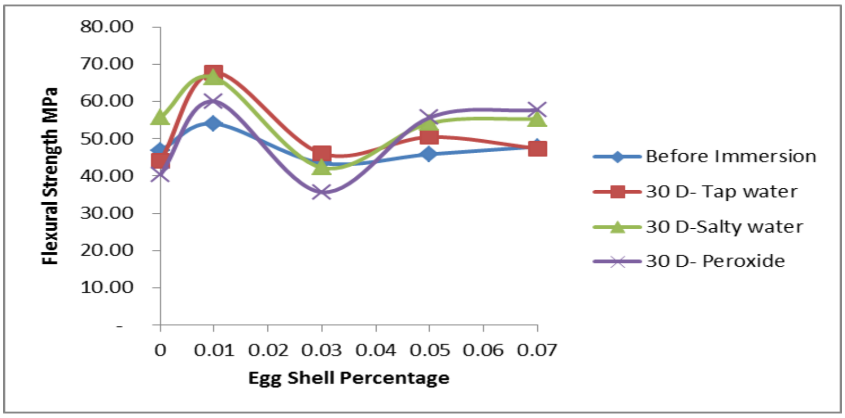


Figure 5 illustrates the denture cleanser type effect on the flexural strength of PMMA biocomposites.

IV. CONCLUSIONS

Within the limits of the current study, the following conclusions can be written: The most important results demonstrate that 15% improvement of PMMA flexural strength achieves at 1% ES filler content.The certain denture cleansers negatively affect the flexural strength of PMMA whereas flexural strength of 1% ES containing composite improvesby 25%, 30% and 11% when treated within tap water, salty water and peroxide based cleansers respectively. Generally, for these composites, tap water and salty water denture cleansers are the more suitable compared with the costly peroxide based cleanser.

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