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Synthesis, Characterization and Optimization of New Silicone Hydrogel Contact Lens Materials prepared by Free Radical Photopolymerization

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ABSTRACT

Silicone hydrogel contact lenses (SiHy) are modern and advanced lenses with distinctive properties compared to other lenses; The basis of their design is to have high oxygen permeability. In this paper, silicone-based contact hydrogel lenses were fabricated by polymerizing 3- (methacryloxypropyl TRIS (trimethylsiloxy) silane (TRIS) with N, 1-vinyl 2- pyrrolidone (NVP), Methacrylate (MA), 2-hydroxyethyl methacrylate, and 2-Hydroxyethyl acrylate (HEMA). A feature for silicone hydrogel lenses has been studied through several laboratory tests to ensure the validity of these lenses, including equilibrium water content, oxygen permeability, mechanical properties, optical transparency, protein absorption, contact angle, and bacterial attachment. The outcomesshowed which the TRIS component in each component raised oxygen permeability as well as reduced the equilibrium water component, whilst (NVP& HEMA) -co-TRIS and increased equilibrium water content (EWC)%. The highest oxygen penetration value was 140barrers, corresponding to a 86%equilibriumwater content. Overall, the silicon hydrogels in this work showed adequate oxygen permeability as well as optical transparency and anti-protein absorption. Therefore, polymers made of silicone hydrogel may have the potential to be among the polymers made of contact lenses.

KEYWORDS

Lenses, silicone, equilibrium, permeability, anti-protein absorption

INTRODUCTION

A silicone hydrogel contact lens has been launched at the end of the 1990s as well as their portion of the soft contact lens sales have gradually grown, presently representing for about one third among all modern contact lens provides at United Kingdom [1]. Made by flexible, water swollen hydrogel components, they seek to mix the beneficial properties of silicone materials with hydrophilic hydrogel components. Clinical problems found with traditional hydrogen materials push the creation of silicone hydrogel materials. Efforts to minimize a amount in corneal hypoxia encountered all through contact lens wear was only partially effective by increasing the water content and reducing lens material thickness (and thus increasing oxygen permeability). Accordingly, contact lens manufacturers worked to develop a material transition with better oxygen permeability. Lens surface requires to maintain a stabilized layer of the ocular tear film, as well as fail for attaining which can negatively impact vision [2], rise the Deposition of the lenses surface[3], as well as a comfortable reduction [4]. A steady preens tear film contains a greasing impact that allows comfy cover motion across a lens' frontal surface[5]. At low wettability of the lens appear to be non-comfortable, the surface desiccation through blinks may create a hydrophobic region that can disturb the cover as it passes on a surface of the lens [6]. A steady, orderly tear film should be protected on frontally surface for a contact lens to

achieve maximum visual efficiency with contact lenses. A lens that lacks will be wetting properties that can outcome in a fast break down for tear film as well as therefore a decrease to visual clarity [7].

Wetting the surface of the contact lenses may affect the on tear film deposits, lens surface dry at between twinkle cycle can create a wetting region on the surface lens, promoting the deposit of components of the hydrophobic tear film [6]. Where the deposition for tear film elements on the surface for the contact lens doesn't seem to has a reverse impact of wettability. It has been shown that an absorber coat of snotty glycoprotein on to contact lens makes a continual pre-lens tear film as well as better wettability [8]. Due to their hydrophobic nature, the premature silicone elastomers contact lens displayed thick deposit, poor comfy as well as decreased severity resulting among destabilized tear film [9], [10]. Makers of contact lenses have expend several years trying to develop a component containing silicone for enhance the penetrative of oxygen while having sufficient surface wetting as well as lens motion. Current silicon hydrogel components employ an area for manufacturing technology, including a plasma surface therapy [11], as well as the use for hydrophilic monomer [12]–[14], in extent materials that cover surface hydrophobicity as well as enhance eye dynamic compatibility [11], [15], [16]. In this paper is pointing to explore the outcome of those monomers on a contact lens that is silicone-dependent from TRIS,NVP, MA, and HEMA in relationfor oxygen as well as water absorbability, protein approval, as well as wettability. Hence, the resultant TRIS-HEMA,TRIS-HEMA-NVP as well as TRIS-MA-NVP-HEMA hydrogels are characterized by FTIR spectrum, equilibrium water content, oxygen penetrability, optical transparency, contact angle, mechanical properties, the adsorption process of protein, as well as bacterial attachment.

EXPERIMENTAL METHODS

Materials

1,6 hexandioldiacrylate, Purity (99.99%), (226.27) is the M.Wt. was purchased from ALDRICH , 2-hydroxyethyl methacrylate (HEMA), Purity (99%) , M.Wt(130.14),was purchased from MERCK, 1-vinyl 2-pyrolidone(NVP)Purity(99%) M.Wt(111.14) , was purchased from MERCK , Bovine serum albumin , Yellow granules , was purchased from HIMEDIA, Distilled water Purity(99%), Iraqi local product ,Methylacrylate (MA), Purity(99.99%) ,M.wt(85.12), was purchased from ALDRICH, Silicone (Si) 3-(methacryloyloxy) propyltris (trimethylsiloxy) silane, Purity(99.99%), was obtained from ALDRICH,1-hydroxycyclohexyl phenyl ketone (PI184), Photo initiator Bisphenol A dimethacrylate , Purity(99.99%), was bought from ALDRICH, Phosphate buffer saline (PBS), Purity (99.99%), was purchased from HIMEDIA, Ethanol Purity (99.99%) was purchased from MERCK.

Preparation of Silicone Hydrogels

Hydrogels that are made of silicone were underwent the process of polymerization from TRIS, MA, HEMA, and NVP monomers with different ratio (10%,20%) by polymerization process that is free-radical at the existence of crosslinking agent HDODA as well as photoinitiatorPI184, as shownat Table(1). The reaction mix were emptied from gas using nitrogen gasabout 30 min to eliminate the oxygen. Then the mix was moved at adark atmosphereat room heat for 30min. Afterward, pouring in apolypropylene molds, a mix was healed below 365 nm UV light to 40 min. Then, a lens component was cleaned by immersion in 50% ethanol to 24 hr in 50°C to eliminate the monomers that are un-reacted as well as photo initiator. After that, the lens was engrossed in refined water for 12 h at 50 °C to wash out the ethanol. eventually, the lens was conserved in PBS (pH 7.4) at chamber heat. To each constructions,the ratio of HDODA as well as PI184 were 0.625 wt % as well as 0.4 wt %, respectively.[17]

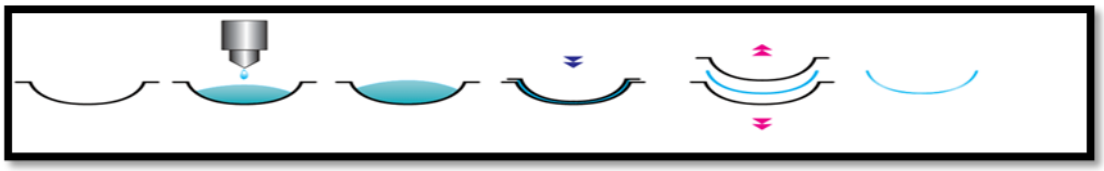

Figure 1. The process ofmaking contact lenses

Table 1. Formulations of silicone hydrogel through copolymerization of TRIS, DMA, AA, NVP.

Sample	Feed monomer				Time irradiation(min)	EWC%	DK	Contact angle^{o}	Modulus (MPa)
	TRIS	MA	HEMA	NVP					
A1	10	0	90	0	3.18	39	98	88	0.008
A2	20	0	80	0	3.47	36	88	84	0.0004
B1	10	0	45	45	5	80	90	109	0.002
B2	20	0	40	40	9	67	140	69	0.00012
C1	10	30	30	30	5	86	96	76	0.00075
C2	20	26.66	26.66	26.66	5	69	100	131	0.000275

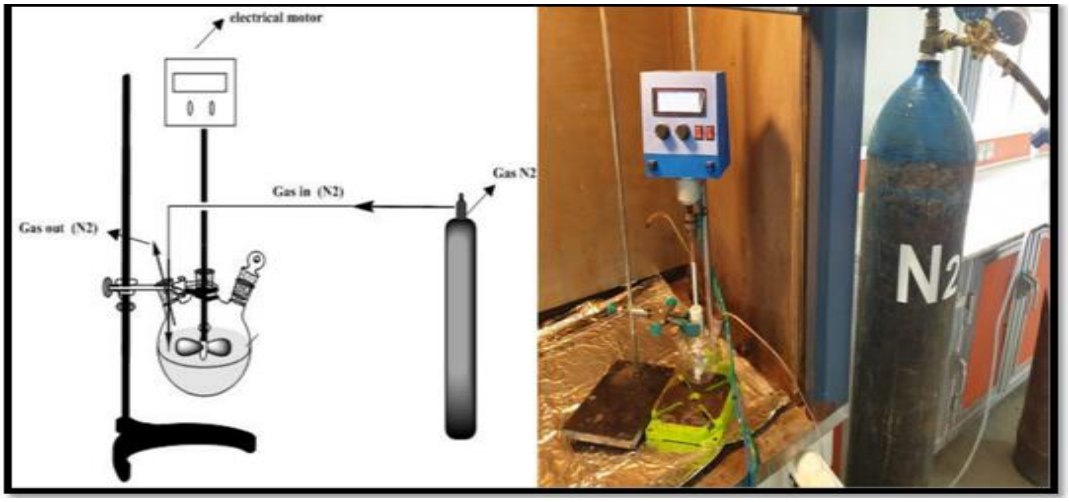

Figure 2. Experimental device

Equilibrium Water Content

Dried hydrogel pieces were implemented to control the water content, the water content was regulated by submerging the hydrogel (0.1gm) in 100 ml of distill water 24 hrs through a lengthy period of time. Excess water from the surface of a lens was elimination by drying with a lens cleaning tissue immediately prior to the weighing. The Equilibrium Water Content (EWC) at distillated water was regulated through the weight of water's ratio in the hydrogel to the entire hydrogel weight at equilibrium of hydration.EWC was measured through the usage the ensuing equation.

$$EWC = \frac{Ws-Wd}{Ws} \times 100\% \quad (1)$$

Where Ws as well as Wd correspond to the weight of the swollen example as well as dried sample, correspondingly[18].

Oxygen Permeability

Oxygen penetrability is fundamentally controlled through EWC in hydrogels that are conventional. Such happens as oxygen is capable of passing over the water more than over the substance itself. Oxygen penetrability is designated as the Dk, which D is a diffusivity of a substance as well as K is the solubility of the substance. The connection amid EWC as well as oxygen penetrability was established to be (Morgan & Efron equation).

$$Dk=1.67e^{0.0397EWC} \quad (2)$$

The 'EWC' is Equilibrium water content of a substance. where Dkare's units of identified being Barrer [19]:

$$\mathrm{DK(barrer)} = \frac{10^{-11}(\mathrm{cm}^2 \times \mathrm{ml}O_2)}{\mathrm{sec} \times \mathrm{ml} \times \mathrm{mmHg}} \quad (3)$$

Optical Transparency

The membrane's transparency was studied with the use of UV-visible spectrophotometer, sample were made through cutting to a slight piece (1 cm × 1 cm) after by solvent evaporation method as well as engrossed in refined water for 24 hrs to approaching equilibrium of swelling. The calculations were done from 200 to 700 nm wavelength at chamber heat[20].

Contact Angle

An estimation of a outward wettability for the lens made of silicone hydrogel substance depended on the test of contact angle. Calculations showed that with the use of a contact angle goniometer (DSA 100, Krüss GmbH, Hamburg, Germany) at room temperature, the contact angle assessment was an average to five measurements[21].

Mechanical Features

Afterswelling at distilled water, the sample 2cm × 3cm rectangular form. The specimens that are dry were acquiredthrough placing them into a furnace to 40ºC for one day. The tensile features of the specimen was calculated in rapidity of medium, in agreement with ASTM D1708 standard, using a tensile tester (transact, motorized force test stand ,Esm, Mark -10 , Eden Prairie, MN, USA).[22]

Protein Deposition

The membranes of the hydrogel were engrossed in solution of phosphate buffer (PBS, pH 7.4) 5ml about 24 hrs. Then, drenching the membranes of hydrogel in solution of protein of bovine serum albumin for 3 hrs in37 °C the usual temperature for a human eye's surface, an attentiveness for solution of the protein was 0.5mg/ml. Later, a membranes' adsorption of a hydrogel were located mildly in to PBS about 5 secfor eliminate extra solution adhering to the membranes of the hydrogel. The membranes were after that put in a tube made of glass having 1wt% aqueous sodium dodecyl sulfate's solution (SDS) for eliminate the adsorbed proteins found on a membranes. The sum for the adsorbed proteins on the surface of the membrane was measured from the attentiveness of proteins into a solution of SDS with use of Bradford evaluates reagent kit at the end, protein deposition of all specimens was calculated by a UV-Vis spectrophotometer [20].

Evaluation of bacterial adhesion

The lenses are made of different types of mixtures consisting of a mixture of silicon and hydrogel. The lenses are kept within a saline solution. The tasters were washed with 100 ml of sterile saline three times Tasters were saved in 3 ml of PBS solution. Adhesion examination was performed by the method of editing the adherent bacteria by ultrasound, where the lenses were exposed to bacterial isolates by dilution $10^{-4}$and 10^{-5}respectively and for each isolation for 30 minutes and 60 minutes, then lenses were put at sterile vials having 1 ml from PBS solution and then The super waves were shown at a rate of 75 kHz placed in a water bath with a depth of 1 cm at a temperature of 30ºC for a period of (15-15) minutes after which the vials were transferred to the vortex vibrator for 1-2 minutes .Then withdraw about 100 ml of the solution containing the free bacteria for the samples and spread on the dishes containers on TSA incubated the dishes for 24 hours at 37°C and the cell numbers were calculated with a value of cfu / mm^2[23].

RESULT AND DISSOCIATION

Synthesis and Characterization of (TRIS-co-HEMA)

TRIS is mercantile silicone monomer to preserve elevation oxygen penetration in contact lens, whilst (HEMA) was selected for its hydrophobic to supplyoxygen transmissibility. At first, only TRIS was copolymerized with(HEMA). The silicone hydrogels were polymerized from TRIS as well as (HEMA) monomers with existence of cross-linking factor 1-6 hexandioldiacrylate as well as photo initiator,1-hydroxycyclohexyl phenyl

ketone, using different percentages (10%,20%). The mix was stirred in a dimatmospherein room heatto 30 min. After the mixture was poured into polypropylene molds, the mixture was placed under a 365nm UV lightabout 3.18 minutes at 10% ,3.47 minutes at 20% of TRIS.

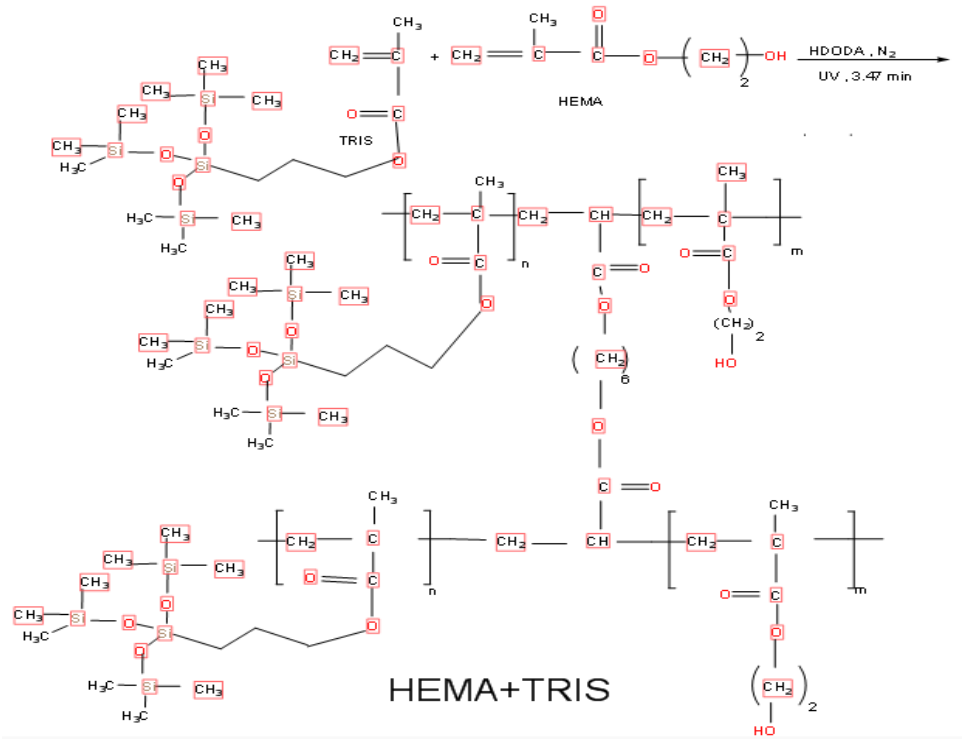

Figure 3. Copolymerization and Crosslinking with HDODA TRIS-co-HEMA

FTIR Spectrum

The FTIR Spectrum of (TRIS-co-HEMA),is shown in Figure(4); the hydrogel confined with silicone constituents might detect a robust group for –Si–O^3 extending at 636 cm^{-1}, two feeble group of –Si–$(CH_3)_3$ extending in 683 as well as 735 cm^{-1} , a feeble group of –CH_3 distortion at 1406 cm^{-1}as well as a robust groupfor –CH_3extendingin 2890 cm-1;which indicates absorption band at 3400-3420cm^{-1} due to (-OH str. group in polymer),2940cm^{-1},2830$cm^{-1}$to (C-H str. aliphatic polymer backbone), 1758cm^{-1}(C=Ostr. ester group), ,1152cm^{-1} to (C-O-C str.) as well as 1085 $cm^{-1}$to (-C-O of C-OH str.) .Furthermore Moreover, distinguishing bands at about 900 cm^{-1} and 3100 cm^{-1}agreeingwith the vinyl bands of monomers disappeared totally, that designated nonexistence of unreacted monomers.[25] ,[24] .

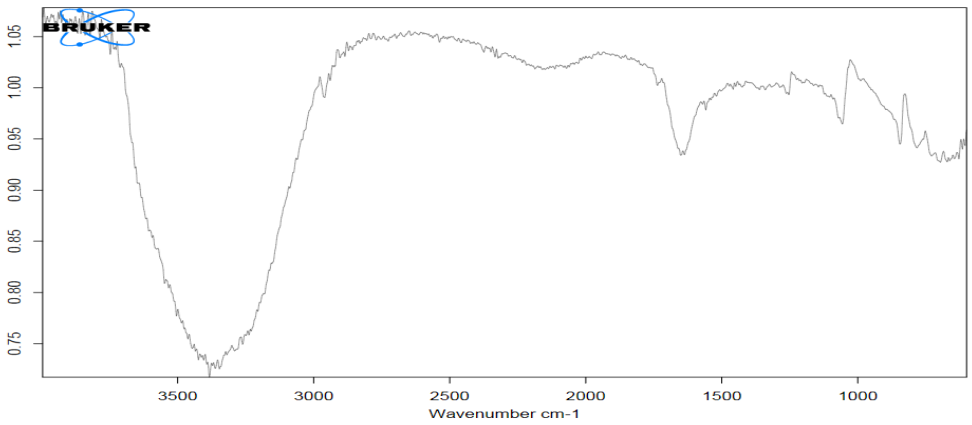

Figure 4. FTIR spectra for HEMA -co-TRIS

Synthesis and Characterization of (HEMA-co-NVP-co-TRIS)

TRIS is mercantile silicone monomer to preserveelevation oxygen penetration in contact lens, whilst(HEMA) was selected for its hydrophobic forsupply oxygen transmissibility. In the beginning, only TRIS was copolymerized with(NVP). The silicone hydrogels were polymerized from TRIS as well as (HEMA)&(NVP) monomers with existence of cross-linking factor 1-6 hexandioldiacrylate as well as photo initiator,1-hydroxycyclohexyl phenyl ketone, using different percentages (10%,20%). The mix was stirred in a dimatmosphere at room heatat 30 min. After the mixture was poured into polypropylene molds, the mixture was placed under a 365nm UV lightabout 4 minutes at 10% ,3 minutes at 20% of TRIS .

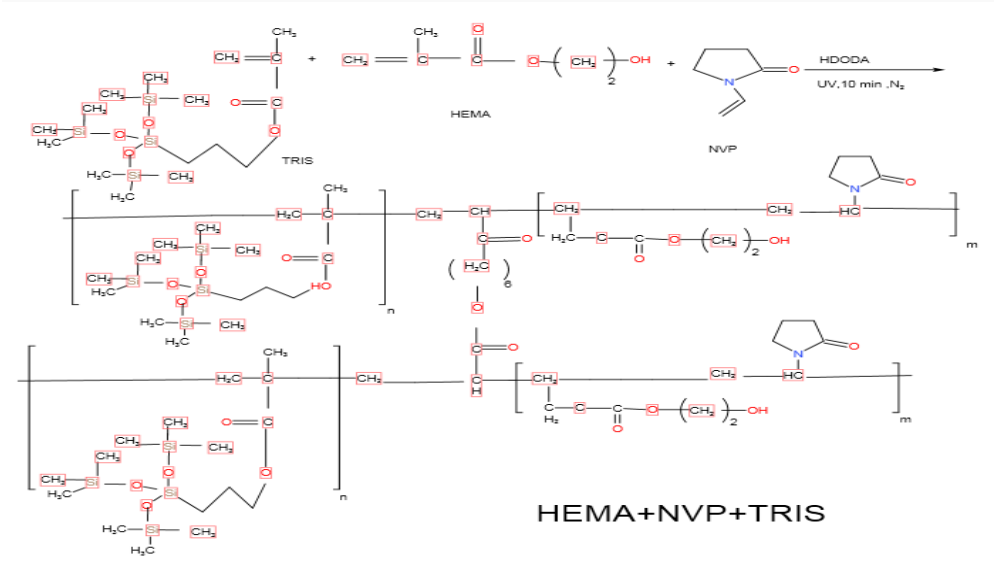

Figure 5. Copolymerization and Crosslinking with HDODA NVP-CO-TRIS-CO-HEMA

FTIR Spectrum

The FTIR Spectrum for (TRIS-co-HEMA-co-NVP),as shown at Fig(6); the hydrogel confined with silicone constituents might detect a robust groupof –Si–O3 extendingin 636 cm^{-1}, two weak band for –Si–(CH3)3 stretching at 683 and 735 cm^{-1} , a feeble group of –CH3 distortion at 1406 cm^{-1} and a robust groupfor –CH3 extending in 2890 cm^{-1}; which designates absorption band at 2947cm^{-1},2869cm^{-1} due to (C-H str of polymer backbone),1728 cm^{-1} to (C=O str ,ester group of EHMA), 1688 $cm^{-1}$for (C=O of the NVP),1450cm^{-1},1427 cm^{-1} and 1265 cm^{-1} were assigned to the characteristic vibration of the pyrrolidone ring ,and the peak at 1164 $cm^{-1}$for (C-O-C str).Moreover, distinguishing bands at about 900 cm^{-1} and 3100 cm^{-1}agreeingwith the vinyl bands of monomers disappeared totally, that designated nonexistence of unreacted monomers ..[25] ,[24]

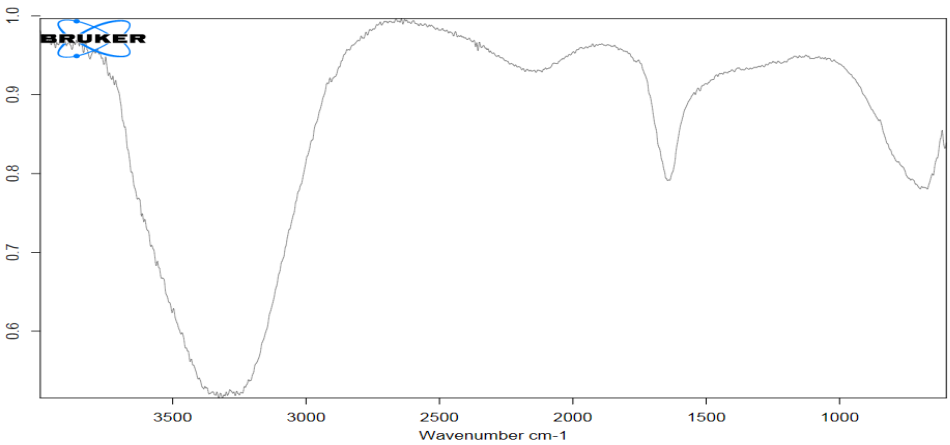

Figure 6. FTIR spectra for HEMA-co-NVP-co-TRIS

Synthesis and Characterization of (TRIS-co-NVP-co-HEMA-co-MA)

TRIS is mercantile silicone monomer forpreserveelevation oxygen penetration in contact lens, whilst (MA) &(HEMA)was chosen for its hydrophobic to supply oxygen transmissibility. In the beginning, only TRIS was copolymerized with(NVP). The silicone hydrogels were polymerized from TRIS and (HEMA),(NVP)&(MA) monomers with existence of cross-linking factor1-6 hexandioldiacrylateas well as photo initiator,1-hydroxycyclohexyl phenyl ketone, using different percentages (10%,20%). The mix was stirred in a dimatmospherein room heat for 30 min. After the mixture was poured into polypropylene molds, the mixture was placed under 365 nm UV light about 5 minutes at 10% , 5 minutes at 20% of TRIS.

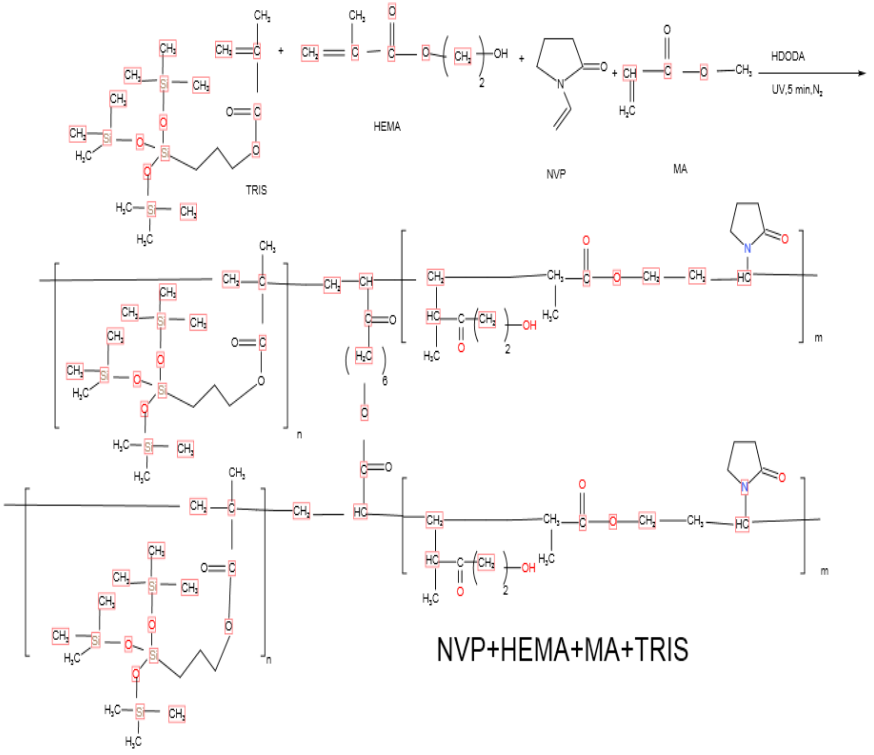

Figure 7. Copolymerization and Crosslinking with HDODA MA-co-TRIS-co-NVP-co-HEMA.

FTIR Spectrum

The FTIR Spectrum of (Si-co-NVP-co-HEMA-co-MA),as shown in Fig(8); the hydrogel confined with silicone components constituents might detect a robust group of –Si–O3 extendingin 636 cm^{-1}, two feeble group of –Si–$(CH_3)_3$ stretching at 683 and 735 cm^{-1} , a weak band for –CH_3 deformation in 1406 cm^{-1} as well as a robust group of –CH3 stretching at 2890 cm^{-1};which designates absorption band at; 2916 cm^{-1} to (C-H str. of polymer backbone),1720 $cm^{-1}$to (C=O str., ester group of MA) , 1157cm^{-1} ,1080 cm^{-1} to (C-O-C str.) , absorption band ; 3433 $cm^{-1}$to (-OH str.) , 3402 cm^{-1} to (-COOH str.), 1710cm-1 to (C=O str. ,carboxyl group), and 1072 $cm^{-1}$to (-C-O of C-OH str.),absorption band in 3400-3420cm^{-1} due to (-OH str. group in polymer), 1758cm^{-1}(C=Ostr,ester group), 1152cm^{-1} to (C-O-C str.) and 1085 $cm^{-1}$to (-C-O of C-OH str.), 1731cm^{-1} to(C=O str. ester group),1250 cm^{-1} , 1728 cm^{-1} to (C=O str. ,ester group of EHMA),1728 cm^{-1} to (C=O str. ,ester group), 1692 $cm^{-1}$to (C=O of NVP) the absorption band 1386 cm^{-1} to(C-N-C of the imide in the NVP) , 1164cm-1 to (C-O-C str.).Moreover, distinguishing bands at about 900 cm^{-1} as well as 3100 cm^{-1}agreeingwith the vinyl bands of monomers disappeared totally, that designated nonexistence of unreacted monomers .[25] ,[24] .

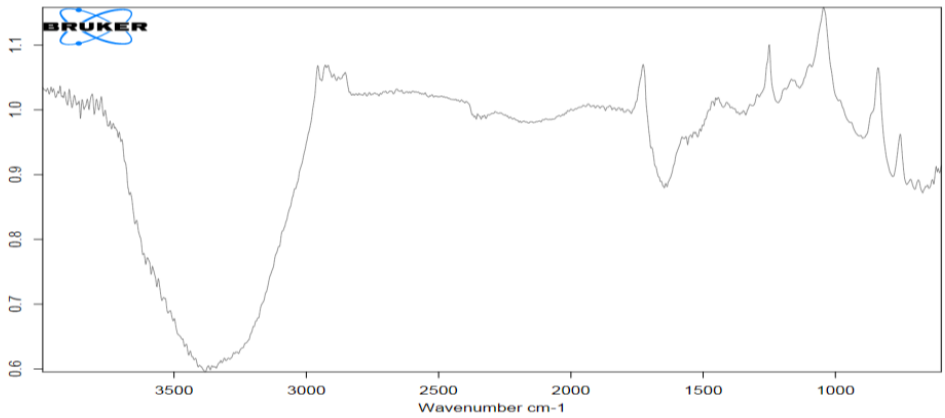

Figure 8. FTIR spectra for HEMA-co-NVP-co-MA-co-TRIS.

Effect of HEMA, NVP & MA on Water Content forSilicone hydrogel contact lenses

Figure (9) represents the equilibrium water content to time for different percentages of TRIS. It is obviously that HEMA, NVP are hydrophilic monomers, whilst TRIS and MA monomer are relatively hydrophobic. We fixed the silicone monomer content as well as complex hydrophilic monomer HEMA at a chain for the shape to produce silicone hydrogels. The EWC rises linearly with the rising HEMA content. NVP is more hydrophilic than HEMA, because ofThe polar lactam moiety of (NVP) cause these polymers to have high water content, an advantage of a nonionic monomers (NVP) bested water absorption, the existence of a polar lactam group at pyrrolidone moiety rising the hydrophilicity of the polymer the combination of NVP with HEMA to produce a high water contain is better than PHEMA alone , can absorb up to 86 of water because of NVP,HEMA can make hydrogen bonding together with water molecule and rise water content to 86%; clearly that the water content of a hydrogel component is associated with the number of hydrophilic sites in the polymer.This increases occurs, for the carbonyl group provides two sites to hydrogen bonding of water. And , rising content of NVP get better the constancy of the hydrogels[26] .Where provided a strong water affinity than HEMA.

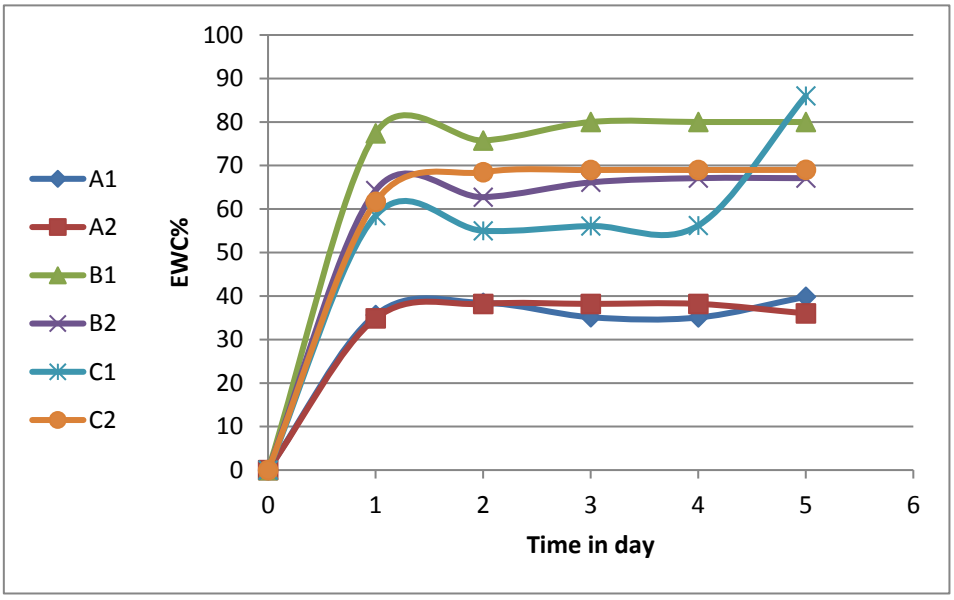

Figure 9. EWC% for different ratio of monomers

Figure 10. Immersion sample and dray it.

Oxygen Permeability

Conventional contact lenses depend on water to transmit oxygen over a lens. Dk bounds Unlike traditional hydrogels, oxygen can be transported. Through the silicon constituent in the silicone hydrogel substances, which leads to a great distance increased oxygen permeability. Investigate Dk as well as water component of diverse hydrogel made of silicone lenses on the market also establish an opposite connection amid Dk as well as water component equally, some preceding readings designated opposite association amid Dk as well as EWC due to silicon hydrogel lenses water is the preventive aspect in the permeability of oxygen [17]. Generally , the silicone–oxygen bonds as well as free water being two chief paths to oxygen transport within hydrogel made of silicone network. Due to the ability of oxygen to absorb siloxane band is 10 times higher other of that of free water, the ability of oxygen to transmit is mainly by the silicone of hydrophobic stage, that is controlled by means of TRIS in this paper. Away from the siloxane bands, oxygen could too carriage by free water presence in the phase of silicone. In matrix of silicone a of hydrogel, water is found as free water as well as well as water that is bound. The bound water is straightly linked to unceasing hydrophilic stage composed of non-freezable as well as formulas that can be freezable. Further, the water stuck in phase of hydrophobic silicone is generally free water. Being an outcome, in the silicone stage, pores that are small will look as if with too little water component , as well as oxygen could be absorbed over this channel[20].

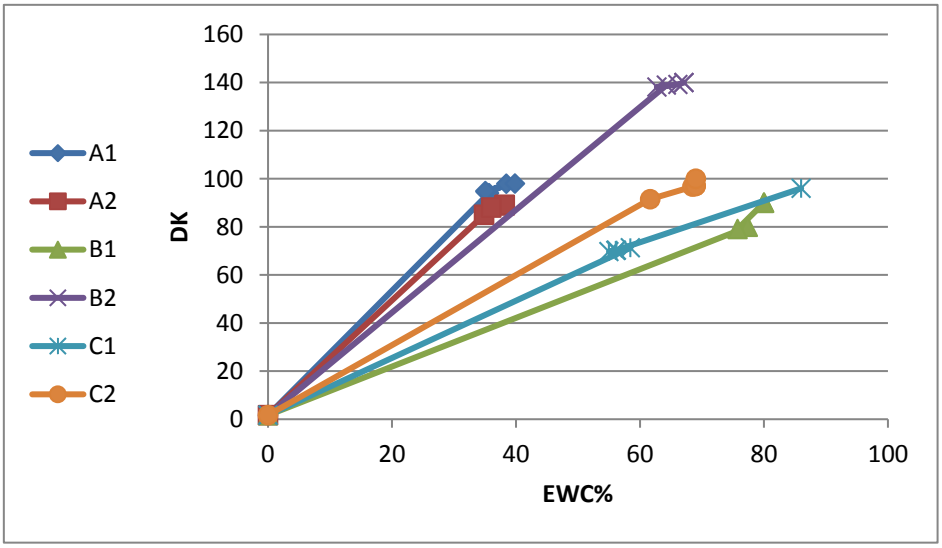

Figure 11. The correlation between Dk and EWC

Contact angle

As a significant element affecting, the surface's wettability aspect of the lenses was assessed via a contact angle for a drop of water onto the surface which is hard. Comparable to envisaging Dk, could too be manipulated to expect the contact angle from EWC. Surface's wettability is a significant to contact lens that affecting putting comfort and reducing happenings of an eye that is dry. The surface wettability aspect of lens made from hydrogel is assessed through calculating the contact angle. Nevertheless, this process is further sensitive to

ecological circumstances due to the reorientation of hydrophobic field, particularly silicone chains in the network of the silicone hydrogel. Principally, together with the innate elastic construction, Si-O bands in silicone seriescan rotate off from the surface of the lens net if it discloses to a wet atmosphere. On the contrary, the hydrophobic practical band will become major on the surface of the lens when opened to dry milieu. Briefly, the reasons for poor surface wettability are the original hydrophobic substance as well as migration of silicone bands in hydrogel made of silicone contact lens.[5]. Contact angle as well as EWC are connected to the hydrogel's hydrophilicity. Hydrophobic TRIS dropped the hydrophilicity of the hydrogel, as well as henceforth dropped the wettability of the surface of lens. Moreover, the monomer that is hydrophobic (TRIS) is subtle to ecological circumstances due to its reorientation aspect [27], [28]. Consequently, TRIS is the monomer which affects the contact angle worth of hydrogel made of silicone lens substantial in relation to a preceding study [29].

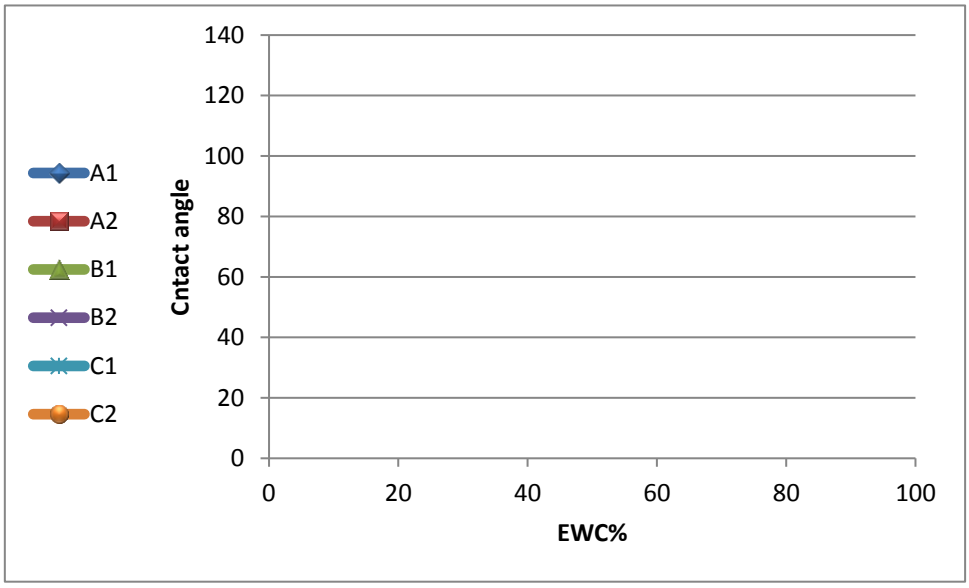

Figure 12. The correlation between EWC and contact angle for (TRIS-MA-NVP-HEMA)

TRIS component, the contact angle of 10 wt% was greater than 20 wt%. Furthermore, contact angle rose intensely in the presence of NVP, HEMA, and MA for the similar TRIS component. This indicates that hydrophilic monomers could rise the wettability for polymers of hydrogel made of silicone. In the literature, NVP was capable of continue worthy wettability of the surface through 4–6 h of putting on, whereas MA cause low wettabilityfor the alike wearing time [30]. To sum up, in this paper, nearly every contact angle for hydrated lens was below from 80which is analogous to that of other profitable contact lens like Lotrafilcon A(Air Optix Night& Day), as well as Balafilcon A (Pure vision) [28].

Transmittance

In the hydrogel contact lenses could efficiently decrease the light scattering as well as cause a great light transmittance. The absorbance for UV light is critical aimed at perfect artificial cornea in term of prevent damage of UV to inner eye tissue. [31]. The synthesized polymer should be transparent for the sake of being appropriate to contact lenses. the transmittance of monomers used in contact lenses must be as compatible as conceivable to escape stage of separation. There might be a serious problem with hybridization of theses organic substances due to the different in hydrophobic and hydrophilic monomers ,such compounds that are incompatible may lead to micro phase parting as well as form opaque substances .The solution to this problem a network that is interpenetrating (IPN) construction ,has been showed to be a hopeful method. [32] . The results showed that the whitest Cole contact lenses permitted comparatively uniform range of light transmission of about 95.8-98.5% ,at wavelengths between 400-700 nm and below at wave lengths 240 nm the transmittance less than 1% for all contact lenses .

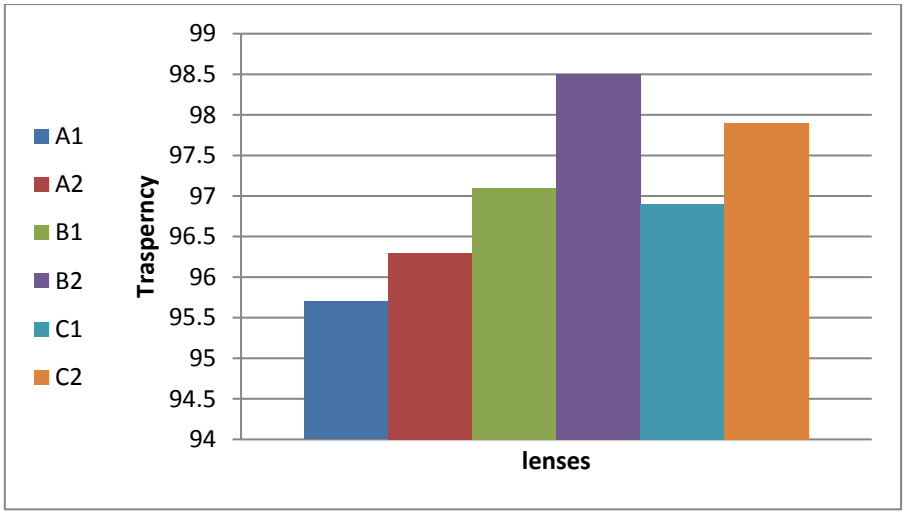

Figure 13. Light transmittance of hydrated modified silicone hydrogel examples

Protein Deposition

Contact lenses signify a great precise sort of interface that is biomaterial, in way of the substance is showing to equally the tear film as well as numerous ecological elements. Although the stage of protein deposition above contact lenses are powerfully affected thru the tear conformation, it's also altered according to a features that are chemical of the lens substance [33], [34] .It is shown that substantial on formation [35] as well as features like water content [36] and pore size [37] roughness of the surface [38] hydrophobicity [35] and charge [39], [40] all play a title role in adsorption of protein, in addition to tear film pH as well as ionic strong point. [41], [42].Lastly, protein features like size, charge, as well as time of material revelation to the protein are all significant elements to examine . [3]. In the present paper Bovine serum albumin was used because the BSA are very similar in the shape as well as physicochemical properties to human serum albumin, because of the resemblance of HSA as well as BSA, as well as the related availability as well as lesser cost of BSA, many vitro studies have be use BSA being a substitute to HSA. [43], [44] .

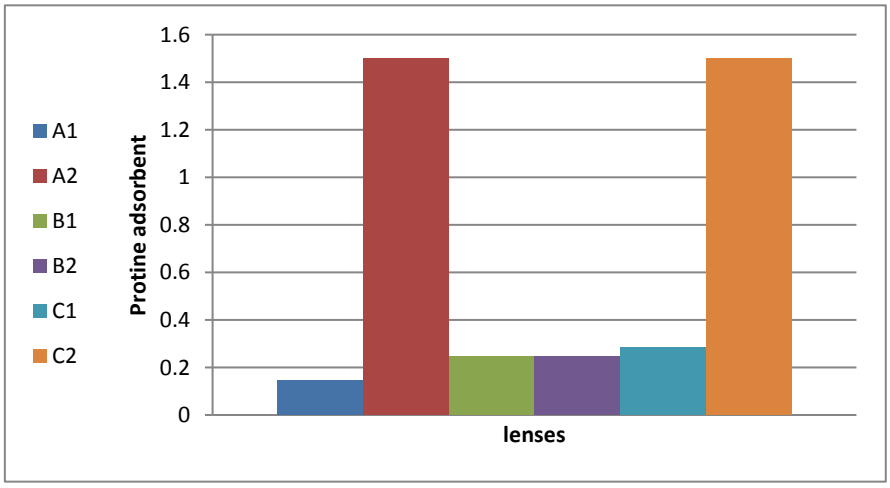

Figure 14. Effect of Albumin Deposition on Lens Material

Mechanical Properties

The Young's moduli were considered from the linear visco-elastic variety as well as shortened in Table (1). The existence of monomers made of silicone in hydrogels displays a greater Young's modulus and a lesser elongation at break. In the instance of 20% monomers content made of silicone, it's Young's modulus is extreme (MPa). Generally, lenient contact lenses by moduli vacillating from to MPa are cooler to content might manage mechanical features. For modulate the water component, we put a monomer that is hydrophilic,

HEMA,MA, and NVP, in the constructions to moderate the mechanical features of the hydrogels made of silicone. The existence of higher hydrophilic monomer might decrease Young's modulus an dim prove presence. Young's modulus fall together with rising hydrophilic monomer component.

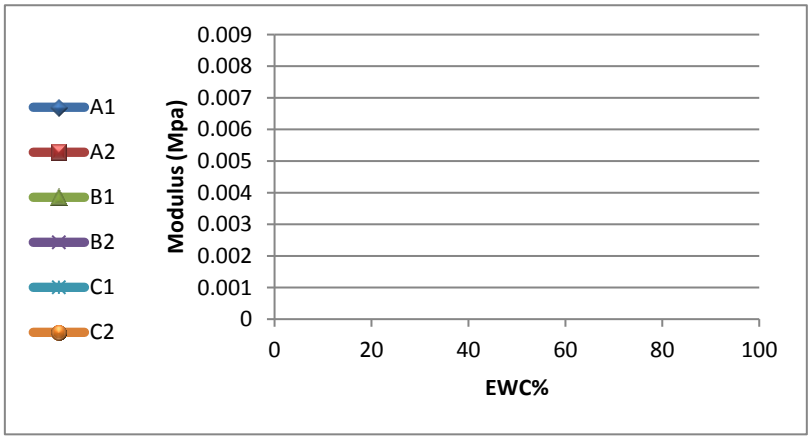

Figure 15. The correlation between the modulus and EWC for (TRIS-MA-NVP-HEMA)

Bacterial Attachment

Staphylococcus aurous is among the forms regularly found in the eyes and has also been spotted at people's contact lenses[45], below we used Staphylococcus aurous as a bacterial study to evaluate a bacterial adherence of lens components. The bacterial stuck in silicone hydrogels was tested for various mix-up parameters of NVP, MA and HEMA hydrophilic monomers. An addendum of hydrophilic monomers by over 35 percent reduced bacterial adhesion to approximately 10^{-3} CFU / mL, Which was determined by counting the number of bacteria with a bacterial counting device. After the lenses have been exposed to bacteria (Staphylococcus aurous) and incubated for 24 hours, we notice that the highest adhesion rate for bacteria on the lenses is after one and a half to two hours. As for the acceptable limits for the presence of bacteria on the lens. It is assumed to be a parameter, but of course it is present. Here the type of bacteria plays a role . There are dangerous bacteria as soon as they exist we refuse to use the lens . Of course there is no specific number. Here comes the role of the control group and we compare with it where we compared the results with a search [23]**.**

And it's well defined that a substance's bacterial adhesion will be mainly linked to the characteristics of the surface, like wettability and 3D microanatomy[46]–[48]**.**Bacterial adhesion on surfaces is really a dynamic process involving unspecific forces such as Brownian motion forces ,electrostatic forces&Vander Waals forces , etc.[49]**.**The roughest surface is typically vulnerable to much bacterial attachment because of shortcoming over a surface region in which deposits of pollution are possible to occur[50]. A positive result Giraldez et al. have shown which higher hydrophobic silicone contact lenses are much sensitive to Staphylococcus epidermidis adherence from traditional soft contact lenses[51]**.** Their analysis is compatible with our experience. We say that hydrophobicity from the lens surface among the deciding bacterial agent's attachment according to our findings.

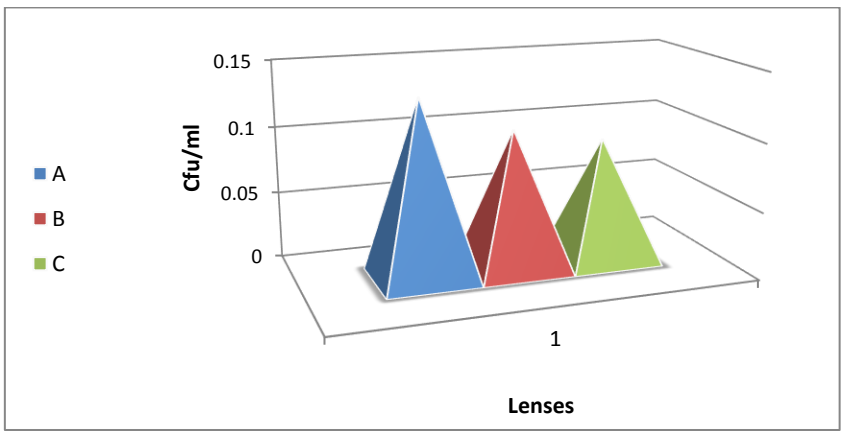

Figure 16. The value of adhered cells, A mono monomer, B di monomer tri monomer

CONCLUSION

Development of a series of silicone hydrogels manufactured from monomer-containing silicone co-polymerase (TRIS) for various quantities of hydrophilic monomers MA, NVP and HEMA. The ability to change the water content of silicone hydrogel lenses that have been produced by improving their chemical formulas by adjusting the concentrations of added monomers. High transparency of the silicone hydrogel. When EWC% increases, the transmittance of visible light increases, that is, the relationship between them is positive. The mechanical tensile properties are inversely related as it decreases with increasing EWC%. As for the relationship between the DK variable and EWC%, we got an average EWC% for all lenses between 36-80%. DK with increased EWC% as the drawing takes on the parabola. As for the biological properties, the number of bacteria bound to the hydrophilic silicon gels decreases. Since the amended mechanical properties as well as decreased bacterial adhesion the enhanced silicone hydrogels are very suitable for use in contact lenses.

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