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Research Article

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Synthesis of copolymer hydrogel P(Hema-MMA)

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ABSTRACT

In the field of biomedical application the biocompatible and biomedical materials are essential to develop the characterize the artificial materials which are spare parts for use in human body to measure, restore and improve physiologic function. The use of the polymer for medical application is determined by the chemical and physical properties if the polymeric materials and its stability of its life time depend on its chemical structure and conditions under which it is utilized. Hydrogels with tunable hydrophilic polymer and its mechanical properties were synthesized by the free radical polymerization of hydroxyethylmethacrylate with various co-monomers like methylmethacrylate. In this paper the resulting Hydrogels were investigated for their equilibrium water content, thermal stability and mechanical properties such as tensile strength, elongation at break and its hardness.

Keywords: Hydrogels, Comonomers, PHEMA-MMA,

INTRODUCTION

We are living in the global village trekking the Himalayan peak with great aspiration. On one side as we have started climbing the ladder of scientific and technological development; but on the other side we are being dilapidated by various new kinds of diseases which were unknown to our ancestors. The pressure of modern life style imposed on the mankind has brought with it various undesirable, yet unavoidable health problems and risks, which most often lead to physiological malfunctions. Ironically, we are forced to search for the remedy for the physiological disabilities and malfunctions only with the help of the ever advancing science and technology. In this context, developing biocompatible materials to help mankind tread over the congenital and / or accidental disabilities will be a challenge worth every effort and hence, this project aims specifically at developing polymer-based biomaterials. Biocompatible and biodegradable materials for biomedical applications are essential to develop and characterize artificial materials which are spare parts for use in human body to measure, restore and improve physiologic function. They will enhance the survival and quality of life. The inorganic materials or polymeric materials can be used to make artificial heart valve, synthetic blood vessel, artificial hip, medical adhesive, sutures, dental composite, polymers for controlled slow drug delivery, etc.

The use of polymers as materials for health care dates back to the early 1950s. In earlier days they were used in surgery as suture materials to close the wounds. Starting from linen, the suture materials used moved to natural fiber from bark of trees, plaited horsehair, cotton, and silk then turned to nylon, polyesters, polyolefins. The use of polymers for medical applications is mainly determined by the chemical and physical properties of the polymeric materials. Sujata.V.Bhat states that the stability and life time of polymers in long term implantation depends upon chemical structure and conditions under which it is utilized.

Biomedical polymers are classified as Elastomers and Plastics. Elastomers withstand large deformations and return to their original dimensions after releasing the stretching force whereas plastics are more rigid materials. Some of the elastomers used as biomaterials include butyl rubber, chlorosulfonated polyethylene, epichlorohydrin rubber, polyurethane, natural rubber and silicone rubber. Plastics can be classified into thermoplastic and thermosetting. Thermoplastic polymers can be melted, reshaped and reformed. The thermosetting plastics cannot be melted and reused, since the chemical reactions that have taken place are irreversible. The thermoplastic polymers used as biomaterials include polyolefin's, Teflon, poly (methylmethacrylate) (PMMA), poly(hydroxyethylmethacrylate) (PHEMA, hydron), polyvinyl chloride (PVC), polycarbonate, nylon, and polyester.

Swelling properties are influenced by the changes in the environment such as the pH, temperature, ionic strength, solvent composition, pressure and electrical potential. It can be biodegradable, bioerodible and bioabsorbable and it can degrade in a controlled fashion. Sathish et.al states that these properties depend upon the pore size, fabrication techniques, shape and surface/volume ratio, water content, strength and swelling activation

2. SYNTHESIS OF PHEMA HYDROGELS

An aqueous solution of pure distilled HEMA with a varying concentration of TEGDMA, with respect to the monomer, which acts as the cross linker was degassed with an argon flow for 15 min. The hydrogel was prepared by bulk polymerization. Initially the monomer hydroxyethylmethacrylate was mixed with triethyleneglycoldimethacrylate and stirred well. APS and SBS were added as initiators of the free radical polymerization in a varying concentration with respect to HEMA and water was used as the diluents to dissolve the initiators. The mixture was poured in a plastic mould and kept in oven at 45°C for 2h. The resulting Hydrogels were extensively washed in distilled water to eliminate the unreacted species and then dried in oven at 80°C for 24h.

$$\text{HEMA + TEGDMA} \xrightarrow[\text{SBS}]{\text{APS}} \text{Poly (HEMA) hydrogel}$$

2.1 PROPERTIES OF HYDROXYETHYLMETHACRYLATE ($C_6H_{10}O_3$)

Clear, mobile liquid

Density	- 1.064
Freezing point	- −12°C
Refractive index	- 1.4505(25°C)

Miscible with water and soluble are in common organic solvents.

METHYLMETHACRYLATE (MMA)

The chemical formula is given by, CH2=C (CH_3) COOCH3

Physical state and appearance	- Liquid
Molecular Weight	- 100.12 g/mole
Boiling Point	- 100°C
Melting Point	- -48°C
Specific Gravity	- 0.936
Solubility	- Partially soluble in cold water.

2.2 SWELLING DETERMINATION

Circular samples were dried overnight in an oven at 80°C. After cooling, they are weighed and placed in distilled water at room temperature. At selected time points, the samples were removed from water, and any excess water was removed by blotting on a tissue and the samples were weighed. The water uptake has been calculated according the equation,

$$\Delta Wu = (W_s - W_d) \div W_d$$

Where, W_s - Weight of swollen sample
W_d - Weight of dry sample

2.3 SYNTHESIS OF COPOLYMER HYDROGEL P(HEMA-MMA)

To the specified concentration of HEMA monomer, methylmethacrylate was incorporated. Four different Hydrogels in total were synthesized with varying HEMA/MMA molar ratios, ranging from 95:5 to 80:20. Samples are referenced using the following nomenclature; 90:10 refers to a hydrogel containing 90 parts HEMA and 10 parts MMA

$$\text{HEMA + MMA+ TEGDMA} \xrightarrow[\text{SBS}]{\text{APS}} \text{Poly (HEMA-MMA) hydrogel}$$

2.4 CHARACTERIZATION FT-IR ANALYSIS

A FT-IR analysis was performed on the homopolymer and copolymer Hydrogels using Perkin Elmer spectrum one FT IR to assess the extent of reaction and the purity of the hydrogel synthesized. Entire region of 450-4000 cm^{-1} was covered by this instrument. This instrument has a typical resolution of 1.0 cm^{-1}. The sample required was about 50 mg of solid or liquid. Infrared spectrum was used to identify the functional groups like -OH, -CN, -CO, -CH, $-NH_2$.

2.4. COPOLYMER HYDROGELS

The poly (hydroxyethylmethacrylate-methylmethacrylate), P (HEMA-MMA) hydrogel was prepared as per the composition given in Table.1.The incorporation of 5% to 20% of methylmethacrylate was done with the HEMA monomer. The yields of all the varying compositions of hydrogels were above 94%.

Table 1: The Feed Compositions, Swelling Ratios and Yields for Synthesized Hydrogels

Sample code		Feed composition (g)								Equilibrium swelling (%)	Yield (%)
		Hema	H_2o	Mma	Ua	Aua	Tegdma	Aps	Sbs		
PHEMA	100%	31.2	70	-	-	-	0.15	0.225	0.225	243	98.20
P(HEMA-MMA)	95%	29.64	70	1.56	-	-	0.15	0.225	0.225	185.41	99.20
	90%	28.08	70	3.12	-	-	0.15	0.225	0.225	188.33	97.73
	85%	26.52	70	4.68	-	-	0.15	0.225	0.225	161.32	94.58
	80%	24.96	70	6.24	-	-	0.15	0.225	0.225	152.19	94.26

The samples were transparent when dry and remain opaque in the swollen state. Copolymerization of various monomers allows the physical and chemical properties such as water content, hardness and oxygen permeability to be controlled. The swelling values were tabulated in table 2.

Table 2: Incorporation of MMA, Swelling values

% COMPOSITION OF P(HEMA-MMA)	% SWELLING AT					
	1 DAY	2 DAY	3 DAY	4 DAY	5 DAY	EQUILIBRIUM
95%	157.46	161.25	171.43	164.77	185.16	185.41(15days)
90%	176.40	182.94	178.95	180.82	188.33	188.33(15days)
85%	129.53	144.50	155.35	160.41	154.99	161.32(14days)
80%	113.78	123.35	139.24	147.09	145.50	152.19(14days)

As the content of MMA was increased in the copolymer hydrogel, swelling values were decreased. Since MMA is a hydrophobic monomer it reduces the hydrophilicity of the hydrogel to some extent than the pure PHEMA hydrogel.

2.5 YIELD OF POLYMERISATION

The yield of polymerization was calculated by the formula,(Qing Liu,2000)

$Y= (W_p / W_m) \times 100\%$,

where W_p= weight of dry PHEMA gel
W_m**=** weight of starting HEMA monomer

RESULTS AND DISCUSSION

The tabulation represent the percentage yield of PHEMA in comparison with the PHEMA-MMA polymer and its graphical representation was given in figure 1. Its mechanical Properties of Homopolymer and Copolymer Hydrogel is tabulated in table 3 and its tenstile strength is shown in figure 2.

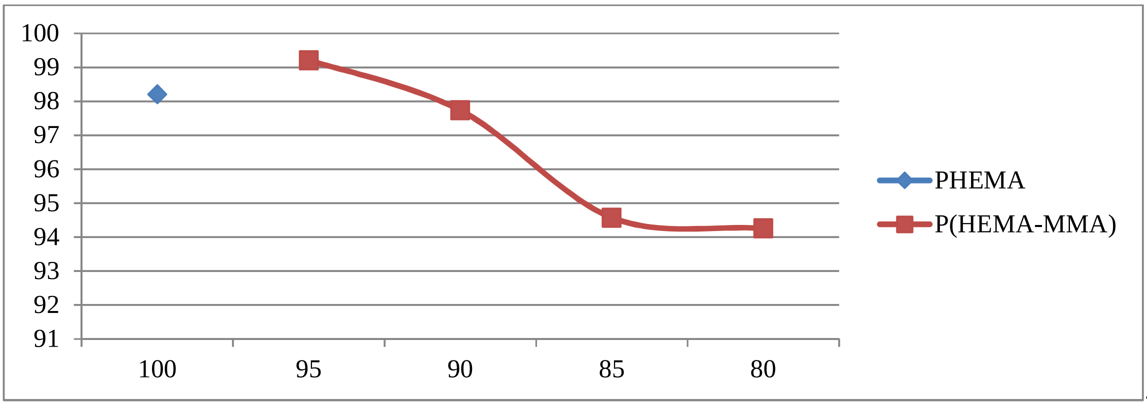

Figure 1: Determination of Yield

SAMPLE CODE		TENSILE STRENGTH(kg/cm^2)	HARDNESS
PHEMA	100%	0.52	10
P(HEMA-MMA)	95%	0.38	8
	90%	0.49	10
	85%	5.91	15
	80%	9.03	20

Table 3. The Mechanical Properties of Homopolymer and Copolymer Hydrogel

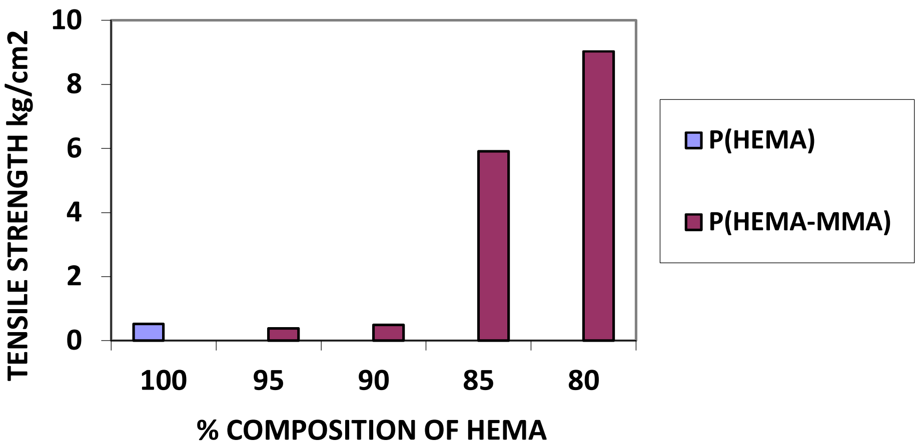

Figure.2. Tensile Strength

CONCLUSION

The objective is to synthesize PHEMA based Hydrogels with reasonable mechanical properties without compromising the swelling behavior. The potential use of PHEMA hydrogel is limited in biomedical applications because of its low mechanical strength and hence attempts were made to increase it with the incorporation of comonomers.

In the present study, the various properties, characteristic features, classification and applications of PHEMA Hydrogels in the biomedical fields were discussed. The polyhydroxyethylmethacryalte(PHEMA) hydrogel and the copolymer hydrogel such as poly [hydroxyethylmethacrylate-methylmethacrylate] hydrogel P (HEMA-MMA). The FT-IR analyses were carried out to determine the product obtained and its thermal stability. The swelling behavior was studied by allowing the sample to swell in distilled water and it was measured at definite time intervals. The mechanical properties such as tensile strength and hardness were determined.

The yields of polymerization of the homopolymer and copolymer hydrogels were found to be above 90%.The swelling values were determined at appropriate time intervals. For pure PHEMA hydrogel, the water uptake is 243% which was 6 times than that reported in the literature review. And it was decreased for P(HEMA-MMA) hydrogel due to hydrophobicity of MMA to about 1.27 times from that of PHEMA The mechanical properties such as tensile strength and hardness were studied on the homopolymer and copolymer hydrogels. The pure PHEMA hydrogel showed the tensile strength of 0.52 kg/cm^2 which is very low. The tensile strength of P(HEMA-MMA) hydrogel increased from 0.38 kg/cm^2 to 9.03 kg/cm^2 with the increase in contents of MMA from 5% to 20% in which MMA was a conventional strengthening monomer. Incorporation of MMA upto 10% in HEMA monomer decreased the strength one fold and further incorporation of higher concentrations of MMA alone increased the strength upto 17 times.

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