

Structure Property Relationship of L-tyrosine based Polyurethanes for Tissue Engineering

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Statement of Purpose: The uses of biodegradable polyurethanes for tissue engineering applications are increasing. Due to structural flexibility and wide range of physico-mechanical properties, polyurethanes are emerging as viable candidates for tissue engineering. The polyurethanes have structures consisting of macrodiol, which constitutes the soft segment, and the polyfunctional isocyanate (mainly diisocyanate) and the chain extender (or crosslinker), which constitute the hard segment. The structure of the polyurethanes can be varied by changing the components and thus the properties of the polymer.

The development of amino acid based polymers including polyurethanes for tissue engineering biomaterial is known. Understanding structure property relationship of polymers for biomaterial application is important. Several studies show a distinct correlation between structure and the property of different polymers for biomaterial purposes and therefore the property of the polymer can be changed by varying the structure. Several L-tyrosine based polymers have also been studied for structure property relationships².

The study of structure property relationship for L-tyrosine based polyurethanes is reported in this research. L-tyrosine based diphenolic compound, desaminotyrosyl hexyl ester (DTH), is used as the chain extender for the synthesis of seven different polyurethanes with different macrodiols and diisocyanates, as shown in Table 1.

Macrodiol		Diisocyanate	Chain extender
Polyethylene glycol (PEG) different molecular weight	PEG(400)	Hexamethylene Diisocyanate (HDI)	Desaminotyrosyl hexyl ester (DTH)
	PEG(600)		
	PEG(1000)	Methylene dicyclohexyl diisocyanate (CHMDI)	
PCL(530)			
Polycaprolactone diol (PCL) different molecular weight	PCL(530)	Methylene dicyclohexyl diisocyanate (CHMDI)	Desaminotyrosyl hexyl ester (DTH)
	PCL(1250)		

Table 1. Combination of macrodiol and diisocyanate

The structure/property relationships of these polyurethanes are studied for tensile strength, water contact angle, and hydrolytic degradation and the effect structural variation is investigated in terms of change in the property.

Materials, Method and Analytical Procedures

• **Materials.** DTH was synthesized according to literature from L-tyrosine and desaminotyrosine². PEG (M_w 400, 600, & 1000), PCL (M_w 530 & 1250), HDI, CHMDI, Stannous Octoate ($\text{Sn}(\text{Oct})_2$), Dimethyl formamide (99%), Chloroform (99%), Sodium chloride (NaCl) were used. All the solvents and materials were dried before use.

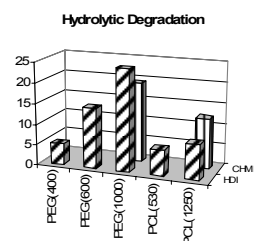
• **Method.** The polyurethanes were synthesized by standard two step method under inert N_2 atmosphere. In the first step, the diol is reacted with diisocyanate in DMF (solvent) in 1:2 molar ratios at 110°C for 3 hours with $\text{Sn}(\text{Oct})_2$ as catalyst. After this step, the reaction was cooled down to room temperature and the DTH was as the proportion of the diol

and the temperature was raised to 80°C . After 12 hours, the reaction was quenched in cold saturated NaCl solution. The polymer precipitated out was either filtered or centrifuged depending on the physical characteristics of the polymer and dried in vacuum.

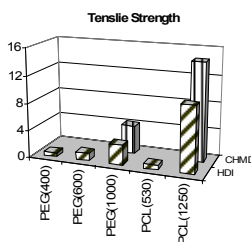
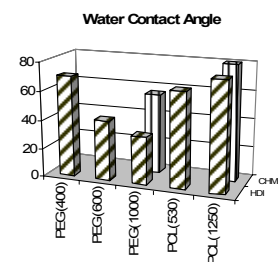
• **Characterization and Analytical Procedures.** Hydrolytic degradation of the polymers was studied by measuring mass loss over 4 weeks stored in PBS solution (37°C , $\text{pH}\sim 7.4$). Surface characteristics were assessed by water contact angle. Mechanical (tensile) properties were tested with sample dimension 20 mm (free length = 10 mm) \times 6 mm \times 0.3 mm with 100N load and 25°C .

Results: The effects of structural variation on the properties of the polyurethanes are shown in the histograms, which show the property of polymers can be altered over a wide range by changing both the macrodiol and diisocyanate component.

Hydrolytic degradation (% mass loss) in PEG based polymers is higher than PCL based and increases with increase in molecular weight of the PEG. Ring structured diisocyanate (CHMDI) absorbs more water and degrades faster.



Water contact angle (degree, $^\circ$) values decreases with increase in molecular weight of PEG, but opposite in PCL. Ring structured diisocyanate leads to hydrophobicity and thus higher contact angle.



Tensile strength (MPa) is dependent on both the macrodiol and diisocyanate. Increase in molecular weight of macrodiol increases the mechanical property. In general, PCL based

polyurethanes have higher tensile strength. Diisocyanate with ring structure increases the mechanical properties.

Conclusion: The results indicate that the property of the polyurethanes can be varied widely by changing the structure of the polymer. Changes in both or either component can change the property. This combinatorial method is useful for building a library of polyurethanes.

References

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2. Brocchini, S.; et. al. *J Biomed Mater Res*, 42, 66-75, 1998