

Studies on the Effect of Molecular Weight on the Degradation Rate of Biodegradable Polymer Membrane

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Abstract. Membrane fabricated from poly (L-lactic acid) (PLLA) and poly (L-lactic-co-glycolic acid, 85/15) (PLLGA) are performed at a wide temperature range (35°C to 65°C) and compare the degradation characteristics. Samples were fabricated using a solvent-casting method and subjected to degradation in phosphate-buffered saline at the different test temperatures for different periods of time. At the end of each test period, the samples were examined for changes in mass. The pH of the degradation media was also measured. And degradation of membrane was characterized by different scanning calorimetry (DSC), scanning electron microscopy (SEM) and Brunauer Emmett Teller equation (BET).

Keywords: Degradation, Degradation Rate, Molecular Weight, Membrane, Phase inversion

1 Introduction

Biodegradable polymers have been the most attractive device for tissue engineering applications over the past decades. Biodegradable polymers are natural or synthetic and are degraded in vivo, to produce biocompatible, toxicologically safe by-products by the normal metabolic pathways. The biomedical applications of enzymatically degradable nature polymers such as collagen dates back thousands of years, but the biomedical applications of synthetic polymers started only for decades. Poly lactic acid (PLA) and Poly lactic-co-glycolic acid (PLGA) have shown immense potential as drug delivery carriers and scaffolds. Because they are physically strong and highly biocompatible and have long clinical experience, favorable degradation characteristics. [1-3] The degradation mechanisms and molecular weight change over time of PLGA copolymers have been reported. [4-7] And faster degradation of PLA and PLGA at elevated temperature has been reported. [8-10]

In this study the effect of molecular weight on the degradation rate of PLLA and PLLGA at different temperature.

2 Materials and methods

2.1 Materials

Different molecular weight PLLA (Poly (L-lactic acid)) and PLLGA (Poly (L-lactic-co-glycolic acid, 85/15) was purchased from Purac co. (Netherland) as listed in table 1. Chloroform (GR grade), ethanol (GR grade) were purchased from Daijung chem, (Korea). Phosphate buffered saline (PBS, pH 7.4) was purchased from Biosesang Lnc, (Korea).

Table 1. The inherent viscosity (IV) and molecular weight (Mw) of PLLA and PLLGA.

No. Sample	IV(dl/g)	M _w (g/mol)
Poly(L-lactide)18	1.8	221,000
Poly(L -lactide)24	2.4	339,000
Poly(L -lactide)32	3.2	521,000
Poly(L -lactide)38	3.8	647,000
Poly(L -lactide)49	4.9	954,000
85/15L-lactide/Glycolide copolymer23	2.3	363,000
85/15L-lactide/Glycolide copolymer31	3.1	560,000

2.2 Preparation of membrane

All membrane were prepared by a solvent-casting method. PLLA and PLLGA was dissolved at room temperature in a chloroform. The PLLA and PLLGA solutions (3w/v) were casted into the mold, and then it was placed in ethanol. After complete of phase inversion, the membranes were dried in a fume hood overnight, followed by a vacuum oven for 24 hours at room temperature. The resulting membranes had a thickness of about 150-300µm and were cut into a square shape with dimensions of 10mm*30mm.

2.3 In vitro degradation of membranes

The membranes were each weighed and then immersed in 10ml of phosphate buffered saline (pH 7.4) in individual vials. Then the samples were incubated at test temperatures of 35°C, 45°C, 55°C and 65°C. At different time intervals, 4 parallel samples were tested for each type of membrane. The membranes were removed, washed three-fold with water, and weighed after removal of surface water. The samples were then dried in a vacuum for 48 h, and analyzed for changes in mass. The pH of the degradation media was also measured at each time point. And then used for DSC, SEM and BET studies.

3 Results

Figure 1 is the glass transition temperature of different molecular weight PLLA and PLLGA membrane. A is the glass transition temperature of PLG23, PLG31 and PLG60 membrane. B is the glass transition temperature of PL10, PL18, PL32, PL49 membrane. A and B shows that the glass transition temperature is higher when the molecular weight is higher.

Figure 2 is SEM image of the membrane prepared from different PLLA and PLLGA. (A) PL18, (B) PL32, (C) PL49, (D) PLG23, (E) PLG31, (F) PLG60. SEM image shows the morphology of blank membranes before in vitro degradation. The higher molecular weight, the smaller pore size.

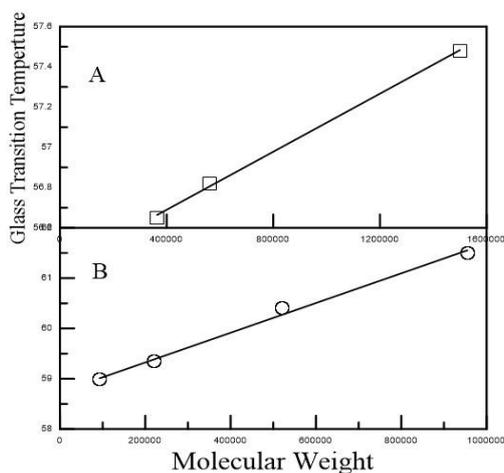


Fig. 1. The glass transition temperature of different molecular weight PLLA and PLLGA membrane.

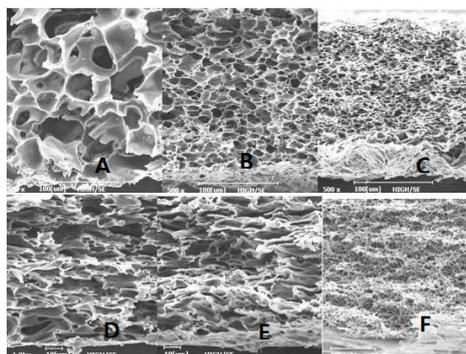


Fig. 2. SEM image of the membrane prepared from different PLLA and PLLGA. (A) PL18, (B) PL32, (C) PL49, (D) PLG23, (E) PLG31, (F) PLG60.

Figure. 3 showed that the degradation ratio of PLG23 membrane and PLG31 membrane with degradation time at 45 °C, 55 °C, 65 °C. The weight loss of PLG23 membrane was faster than the weight loss of PLG31 in the same temperature. And it could be observed that the first stage of the degradation of all the PLG membrane was shorter than those of their corresponding hydrolytic degradation. And the weight loss at 65 °C more rapidly than the weight loss at 55 °C. The results indicated that the degradation ratio of membrane increased with increasing test temperature.

Figure. 4 showed that the pH of the degradation media decreased degradation time. The rate of pH change increased with increasing temperature, and this rate was the lowest at 45 °C. The pH of the degradation media surrounding PLG23 membrane was faster than the pH of the degradation media surrounding PLG31 membrane in the same temperature.

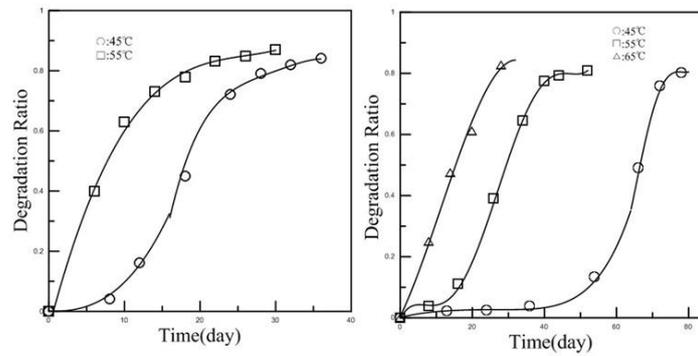


Fig. 3. The degradation ratio of PLG23 membrane and PLG31 membrane at 45 °C, 55 °C, 65 °C.

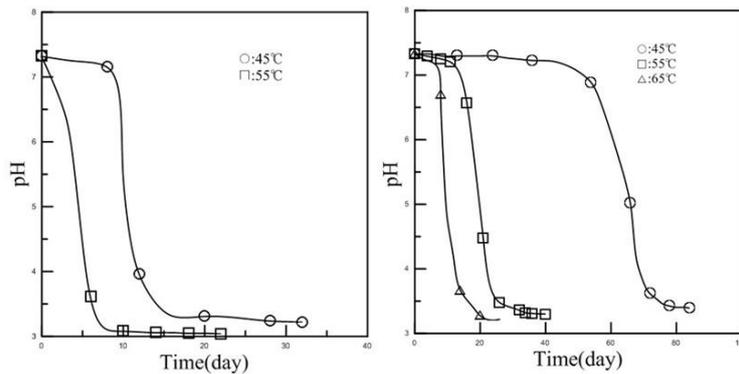


Fig. 4. The pH value change of media during the degradation of PLG23 membrane, PLG31 membrane..

4 Conclusions

Faster degradation of the membranes, at higher temperatures, and when acidic degradation products were allowed to accumulate in the media. The higher molecular weight, the higher glass transition temperature and the smaller pore size. The degradation ratio of membrane increased with increasing test temperature. And as the molecular weight increase, hydrolysis rate was decrease in geometrical progression. And the first stage of the degradation of all the membrane was shorter than those of their corresponding hydrolytic degradation.

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