Poly-DL-Lactic Acid (PDLLA) Nanosheet Thin Films for Biomedical, Bioengineering and Energy Saving Applications

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PDLLA nanosheet thin films with different thickness of from 50nm to 150nm were investigated. Contact angle, profilometry and Fourier Transform InfraRed (FTIR) spectroscopy measurements were performed. It is shown that thinner PDLLA nanosheets could be more relevant for biomedical applications. Meanwhile, thicker nanosheets could be more suitable for bioengineering applications. Potential energy saving through bioinspired surfaces will also be presented through biomimicry patterning of the nanosheets surface.

Keywords: PDLLA, nanosheet, surface profiling, biomimicry

1. Introduction

The surface properties of polymers are significant in numerous applications, in bioengineering such as interfacial adhesion, friction and wear. In the biomedical field, the biocompatibility of polymers is fundamentally reliant on surface properties [1]. This study aims to develop an understanding of the capability of the tribological properties and surface characterization of the PDLLA nanosheet thin films with different thicknesses.

2. Methods

2.1 Samples Preparation

Poly (D, L-Lactic Acid (PDLLA) nanosheet thin films were produced by a roll-to-roll mass production process in which PolyVinyl Alcohol (PVA) and Polyethylene Terephthalate (PET) layers sandwich the PDDLA samples. The concentration of the PVA is 20mg/ml, coated on a Polyethylene Terephthalate (PET) substrate and then dried. Next, 5, 10, 20, 30 mg/ml concentration of PDLLA is further coated on the PVA film on the PET substrate and then dried [2]. PVA & PET are used as sacrificial membranes. The PDLLA nanosheets are peeled off from those membranes using water as solvent. The PDLLA nanosheets were then deposited on Silicon substrate for analysis.

2.2 Profilometry, Contact Angle Measurements and Fourier-Transform InfraRed Spectroscopy

A DektakXT profilometer was used in order to measure the actual thickness and surface roughness of the various nanosheet thin films.

A Drop Shape Analyzer – DSA25 from Krüss was used for contact angle measurements with three different liquids (water, glycerol, and cyclohexane). Fowke's theory, Owens and Wendt (OWRK) theory and the Wu theory were compared and agreed for those samples. The surface free energies of various thickness of PDLLA nanosheet were hence determined.

A Nicolet iS50 FTIR Spectrometer was used in Attenuated Total Reflectance (ATR) mode and in Transmission mode on Intrinsic silicon substrates.

3. Results and Discussion

This study shows that the PDLLA nanosheets have hydrophilic nature surface. The hydrophilicity of these surfaces increases as the thickness of the nanosheet decreases. This is due to its increasing contact angle values as shown in Fig. 1(a). The surface roughness of the sample significantly influences the wetting properties.

The highest value of the surface free energy for PDLLA sample was at 47 mJ/m^2, with the lowest water contact angle at 41° for the 50nm thickness. It has higher surface free energy compared to the 150nm thickness due to its higher adhesion properties.

The characteristic absorption of PDLLA nanosheet deposited are shown in Fig. 1(b). The most dominant peak at 1759 cm^{-1} belongs to the vibration of C=O with strong absorption band. Peak at 1091 cm^{-1} represents the CO symmetric deformation. 1262 cm^{-1} refer to the vibration of -CO-O-, which is the stretching modes of ester group. These peaks show the significant functional group of PDLLA molecular structure. The absorption decreases by reducing the thickness of the nanosheets.

3. References

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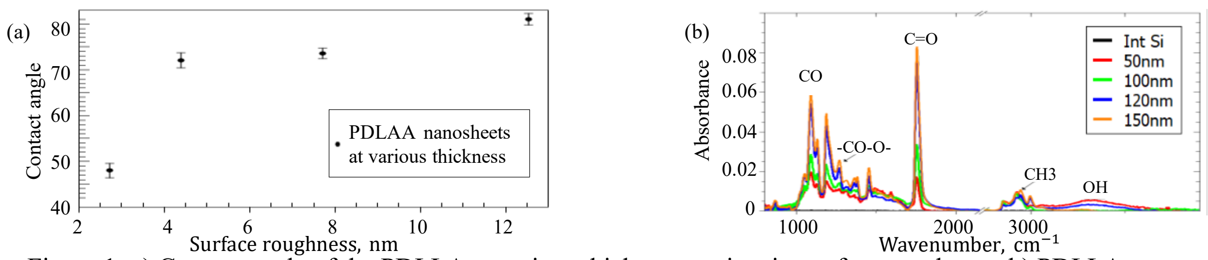

Figure 1: a) Contact angle of the PDLLA at various thickness against its surface roughness. b) PDLLA spectrum