Poly(L-lactic)acid as stimulator of bone growth: Piezo-force microscopy study of the local piezoelectric properties.

N. B. Barroca [a], *A. Wu* [a], *A. L. Daniel-da-Silva* [a], *M. H. Fernandes* [a], *P. M. Vilarinho* [a]
[a] *Department of Ceramics and Glass Engineering, CICECO, University of Aveiro, Aveiro, Portugal*
nbarroca@ua.pt

Poly-L-lactic acid (PLLA) is a biodegradable semi-crystalline polymer, widely investigated in biomedical field because it is also biocompatible and its properties can be tailored to match the properties of living tissues. For instance, PLLA degradability and mechanical performance can be altered by varying the content and the characteristics of the crystalline phase through the processing conditions [1]. More recently, PLLA has attracted attention due to one of its less-known properties: the piezoelectricity, which is also related to the crystalline phase characteristics. When implanted in bone, piezoelectric active PLLA has shown to promote bone growth [2].

As piezoelectricity and poling phenomena have been implicated in physiological mechanisms of bone growth and remodelling [3], there is the need to investigate the piezoelectric properties of PLLA at a local scale. These studies will allow to understand how to manipulate the piezoelectric activity of PLLA in order to control the physiological phenomena that take place at a local scale, such as protein adsorption. Indeed our previous studies, using scanning probe microscopy, clearly indicated the superior affinity of poled PLLA samples to human fibronectin compared to non-poled samples [4].

The present study aims to systematically investigate the local piezoelectric properties of PLLA thin films with different crystallinity degrees using piezoresponse force microscopy. With this purpose, spin-coated PLLA thin films were submitted to different post-melting heat treatments near the glass transition temperature and crystallization temperature (as indicated by DSC) to induce both nucleation and crystallization to obtain different microstructures.

The possibility to manipulate dipoles at micro and nanoscale by the application of a dc field through the tip was demonstrated. Piezoelectric activity was detected in the different films. Different piezoelectric hysteresis curves were measured locally on crystalline (Figure 1) and amorphous regions. The effect of poling on piezoelectric behaviour was also studied and the possible correlation between local and macroscopic properties is presented and discussed.

References:

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[2] E. Fukada, Jpn. J. Appl. Phys., **37** (1998) 2775-2780
[3] A.A. Marino, R.O. Becker, Nature, **228(5270)** (1970) 473-474
[4] N. Barroca, A.L. Daniel-da-Silva, A.Wu, M.H.V. Fernandes, P.M.Vilarinho, A. Gruverman, Poly (L-lactic) acid for biomedical application - assessment of polarization phenomena and their effect on human protein adsorption by scanning probe microscopy, to be submitted

Figures:

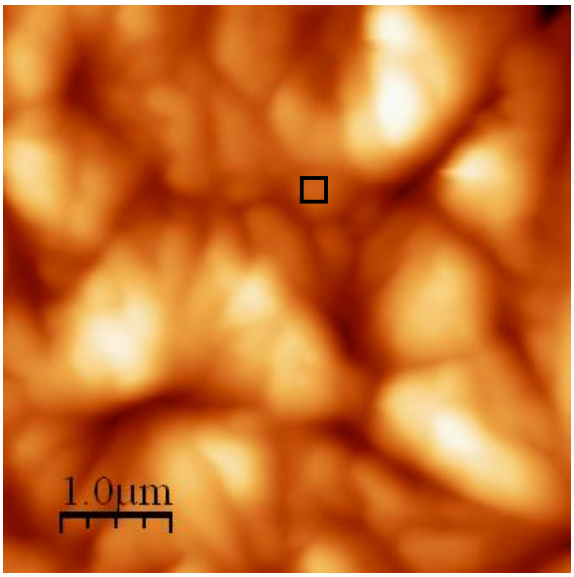

Figure 1a. Morphology of 500 nm x 500 nm area of semi-crystalline PLLA thin film observed with AFM contact mode in air

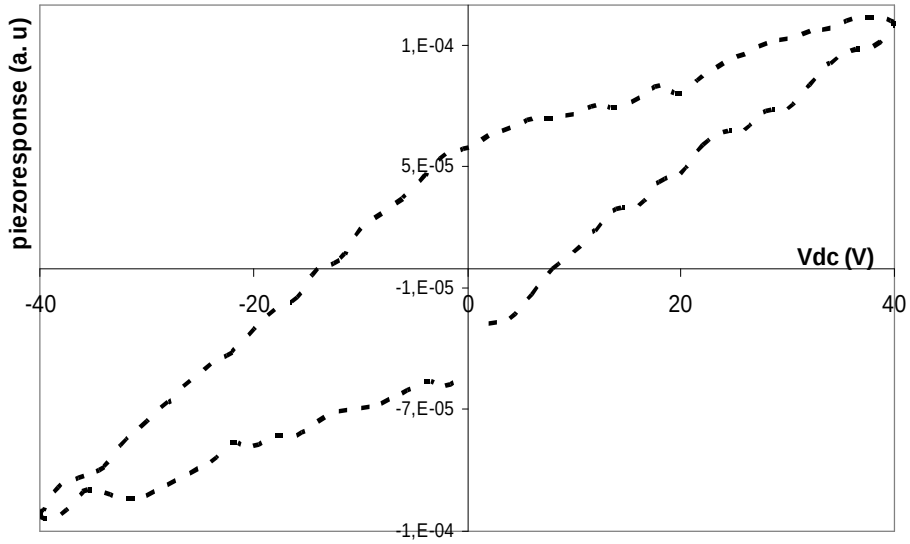

Figure 1b. Piezoelectric hysteresis curve measured on 25 nm x 25 nm area (black square in Figure 1a.) in semi-crystalline PLLA