Biomaterials

MIM.5.068
Evaluation of nanocoated polymeric biomaterials in term of surface properties

S. Gümüş[1], S. Polat[1], J. Lackner[2], W. Waldhauser[2]

[1]Kocaeli University, Metallurgical & Materials Engineering, Kocaeli, Turkey
[2]JOANNEUM RESEARCH Forschungsgesellschaft mbH, Funktionelle Oberflächen, Leoben, Austria

gumus.serap@gmail.com
Keywords: biomaterials, biocompatibility, polymeric materials, nanosized topography, roughness

Biomaterials are natural or artificial based materials that are used to support or replace a part of the function of living tissue of human body. Biocompatibility is the major property of a material to evaluate it as biomaterial and depends on a series of biological responses occurring at the interface of the material's surface and biological system [1]. It is of great importance to know the cell/biomaterial interaction mechanism in designing biomaterial surfaces with improved biocontact properties.

Surface properties of a biomaterial such as composition, roughness, topography, wettability play a major role in the events occurring at material interface. When the biomaterial comes in contact with the biological system containing different types of proteins e.g. blood, cell culture media, interstitial fluid etc., proteins will adsorb on the surface of the material, rapidly [2]. The type and amount of the adsorbed proteins determine the bioactive sites for cell interactions. Therefore, influence of the surface properties such as chemistry, roughness, topography to adsorption of the protein should be understood for controlling the cellular response. Polymeric materials provide most of the requirements for biomedical applications [3]. However, polymeric materials are inadequate in many cases in terms of biocontact. Surface engineering offers a multi-purpose approach for solving this problem by creating nanosized layer to control the chemical composition, topography and roughness, hydrophilic /hydrophobic balance on the surface. Pulsed laser coating (PLC) is a method to produce such surfaces at room temperature which is appropriate for coating polymers. One of the major effects of the surface properties on the protein adsorption is the characteristics of the surface topography including shape and size of features, roughness parameters etc. Also, the surface wettability and energy which will further influence the behavior of biological molecules are significantly affected by roughness. It has recently been revealed that cell adhesion is also influenced by surface features as small as 10 nm [4, 5]. Recently, atomic force microscopy (AFM) is widely used for imaging of nanometer-sized surface structures due to its ability of providing high-resolution images in atomic scale. Three dimensional (3D) images of the surface are obtained by AFM, providing information about the surface morphology, roughness, features formed at the surface, their shape and distribution.

In this study, surface properties like topography, roughness, surface energy, hydrophobicity and hydrophilicity are determined for nanocoated polymers to be evaluated as biomaterials. Polyurethane (PU) and polycarbonate (PC) based polymeric materials are coated with titanium (Ti), titanium nitride (TiN) and diamond like carbon (DLC) nanosized layer by PLC.

The AFM images taken in tapping mode of Ti, TiN and DLC coated PC and PU are given in Figure 1, respectively. As it is seen, the surface morphology of stiff polymer, PC differs from the surface of the soft polymer, PU. Dome-shaped topographic features are dominant at the surface of PC whereas wrinkle structures are seen at the surface of PU. Stiff materials overcome the deformation that occurs near the surface under high stress if the adhesion of the coating on the substrate is very strong, while the soft materials start to wrinkle [6]. Roughness parameters such as average roughness (R_a), root mean square (R_q), skewness (R_{sk}) and kurtosis (R_{ku}) are determined from AFM analysis.

1. W. Song, H. Chen, Chinese Science Bulletin, 52, (2007), pp. 3169-3173.
2. R. A. Latour, Jr., in “Encyclopedia of Biomaterials and Biomedical Engineering”, 2nd. Edition, vol.1, G. E. Wnek, G. L. Bowlin (eds.), pp. 270-284, Informa, NY (2008).
3. Y. X. Wang, J. L. Robertson, W. B. Spillman, Jr., R. O. Claus, Pharmaceutical Research, 21, (2004), pp. 1362-1373.
4. M. S. Lord, M. Foss, F. Besenbacher, Nano Today, 5, (2010), pp.66-78.
5. M. J. Dalby, M. O. Riehle, H. Johnstone, S. Affrossman, A. S. G. Curtis, Cell Biology International, 28, (2004), pp. 229-236.
6. J. M. Lackner, W. Waldhauser, P. Hartmann, O. Miskovics, F. Schmied, C. Teichert, T. Schöberl, Thin Solid Films, 520, (2012), pp. 2833-2840.

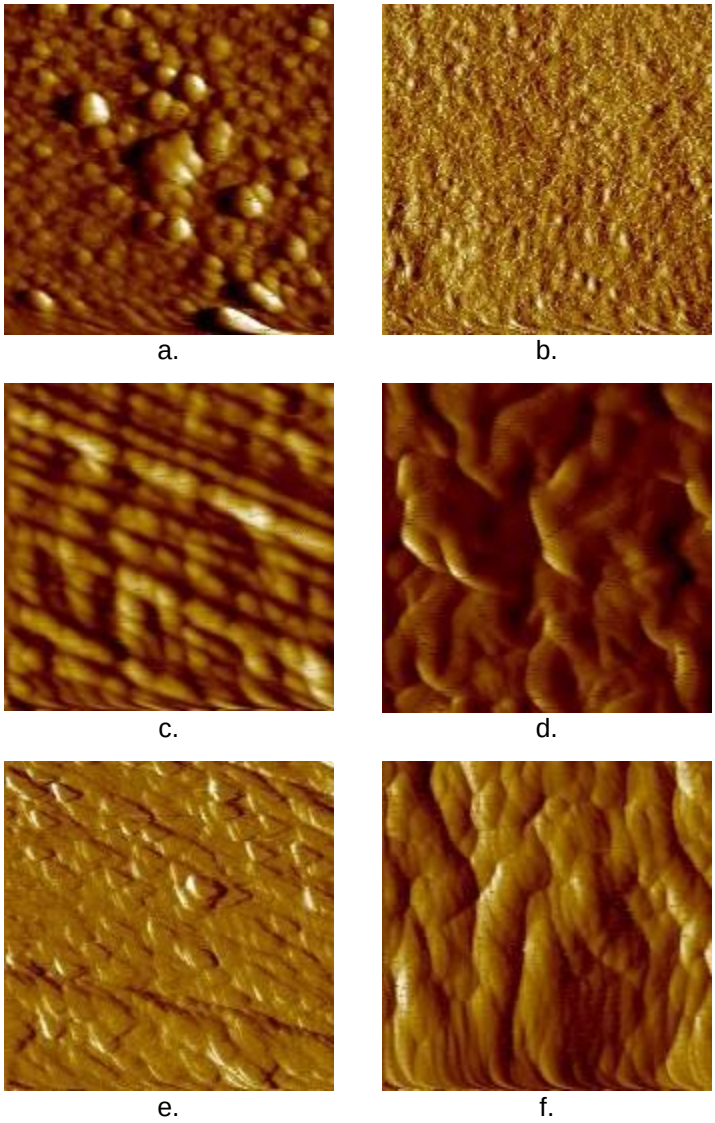

Figure 1. AFM images of PC coated with a) Ti, c) TiN, e) DLC and PU coated with b) Ti, d) TiN, f) DLC.