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Editorial

# On Knowing the Surface of a Material before Targeting its Application

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## Editorial

In the interface science, the outermost layer of each surface plays the most vital role in interaction of the surface with surrounding environment [1,2]. In the area of biomaterials and biosensors, the surface characteristics are of a great importance as such properties would determine how the surface responds to the living organs, cells or blood samples. There are different characterization techniques that provide essential information regarding the formation of the materials, their molecular weights and structural analysis. Among diverse range of existing analytical techniques, only a few numbers of them are dedicated to the surface analysis such as Scanning Electron Microscopy (SEM), Water-In-Air Contact angle Analysis (WCA), Atomic Force Microscopy (AFM) and X-ray Photoelectron Spectroscopy (XPS). Individually or in close cooperation with each other, the aforementioned analytical techniques provide valuable information regarding morphology, wettability, topography and chemistry of the surfaces that help to understand the nature of materials before targeting the possible applications. Herein, brief remarks on the essentiality of these characterization techniques in surface and material analysis are provided.

Morphology of the surface can be recorded by SEM. This technique provides the information on how the sample, from the frontal and cross section views, looks like; weather its surface is flat and smooth or rough and irregular. SEM also gives information regarding important dimensions such as overall size distribution and thickness of the surface in the case of coated platforms. Furthermore, SEM can be a method for confirmation of the changes that intentionally or unintentionally occurred on the surface of the materials [3]. Figure 1 depicts the SEM images of electrospun fibers before and after coating with a copolymer composition (Figure 1a and Figure 1b, respectively) [4]. An obvious change in the surface morphology of the analyzed samples can be observed in the recorded images.

Water contact angle analysis is rather a simple and straightforward surface analytical technique yet interesting information can be extracted from the recorded angles for the deposited water droplets deposited on different surfaces. Figure 2 schematizes the WCA on different surfaces that correlated to the wettability of these surfaces. As can be seen in the Figure 2, the WCA of above 90° shows a relatively hydrophobic material. Conversely, WCA of less than 90° corresponds to ahydrophilic surface, while the contact angle of 90° can be considered as neutral. Another two categories of materials are also reported in the literature, which are known as the superhydrophobic (WCA above 150°) and superhydrophilic (WCA of few degrees) materials [5]. The wettability of each surface is related to the shape and the morphology of the analyzed platforms. In that regard, SEM analysis can assist WCA analysis in predicting the characteristics of the examined surfaces. For example, it is expected that the electrospun fibers before coating (Figure 1a) result in lower WCA than the coated fibers (Figure 1b) as there is a higher chance of water penetration into the matrix of uncoated fibers [6]. Since most of the interstitial spaces among the fibers are covered by the coated segments (Figure 1b), logically, electrospun fibers after coating possess higher hydrophobicity than the uncoated fibers [7]. Moreover, the behavior of the surface towards deposited water droplets highly corresponds to the chemical structure of the materials and their available functional groups that can impose the hydrophilic or hydrophobic nature of themselves onto the surface of the material as well. In that perspective, XPS analysis can be of a great assistance to WCA and SEM analyses in knowing the surface of the material in a better detail [8].

As anultra-sensitive analytical technique, XPS provides with essential information regarding the top nano-layers of the surface and the chemical composition of the analyzed platform. XPS operates based upon the principles of ejecting electrons from the inner layers of the atoms attacked by a strong X-ray beam. Recorded energy levels of the ejected electrons can be translated into the valuable information in respect to the chemical composition of the surface. Some of the chemical functional groups are known to carry their natural hydrophobicity while some others are known as hydrophobic functionalities [8]. As expected, the presence of hydrophobic functional groups detected by XPS can influence the wettability of the surface and subsequently result in higher degrees of WCA. In contrast, if XPS detects more of the naturally hydrophilic functional groups on the surface, as a result, the WCA is expected to be lower.

In the path to understand the surface of the materials, AFM plays a great role as one of the known surface analytical techniques. By the aim of a tip that moves above the surface (in a contact or a non-contact mode), AFM records the changes on the surface and translate this information into the topographical images. Figure 3 shows representative AFM images of the surfaces with different roughness levels. As can be observed, Figure 3a depicts the topography of a flat surface with relatively low degree of roughness [4]. In contrast, Figure 3b and Figure 3c show the increasing roughness for the analyzed surfaces. Surface roughness, in turn, is the function of surface morphology and chemistry. It is in a direct correlation with the morphological properties of the surface that can be analyzed

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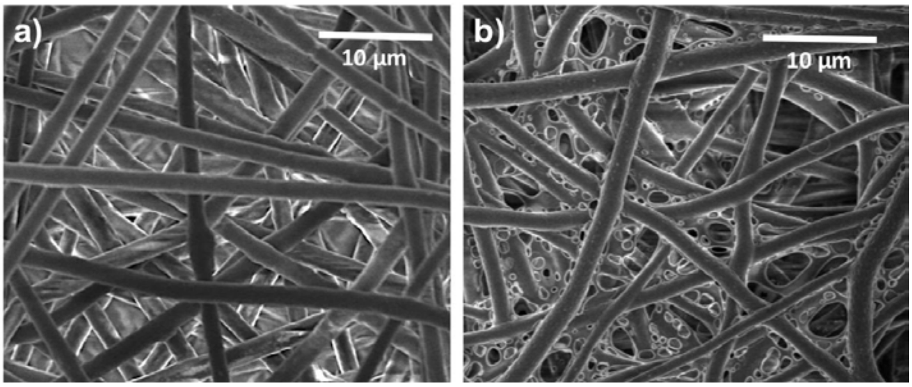

**Figure 1:** Morphology analysis performed by SEM shows the surface of electrospun fibers before (a) and after (b) polymer coating.

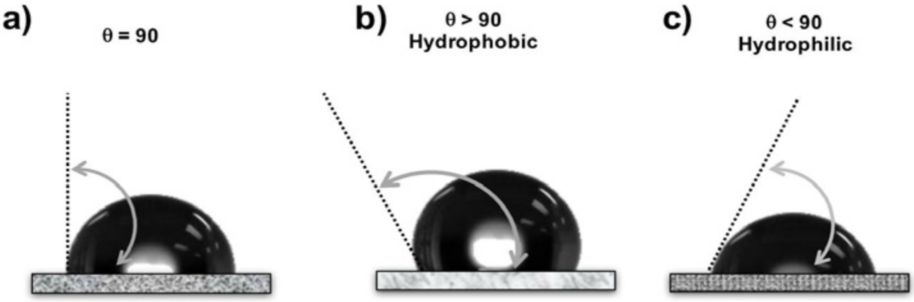

**Figure 2:** The angle of the water droplet on different surfaces corresponds to the wettability of the analyzed surfaces.

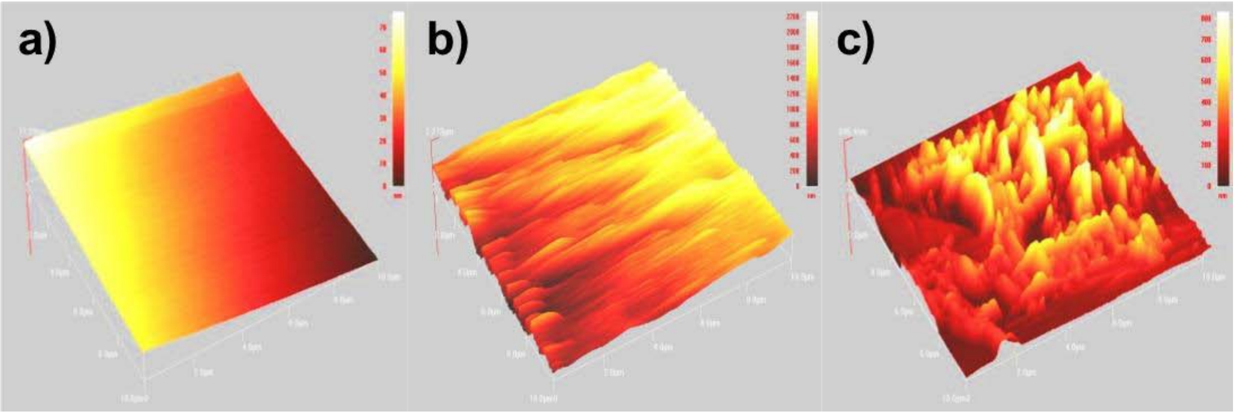

**Figure 3:** Topography analysis of different surfaces by AFM reveals corresponding surface roughness recorded for each platform.

by SEM analysis. However, the roughness of the surface is also the function of chemical characteristics of the examined platforms. In particular, the most commonly coupled technique with AFM is WCA analysis. Presence of hydrophilic functional groups that introduces lower WCA also results in the higher roughness of the surface, while flat and smooth surfaces with lower surface roughness often possess higher levels of hydrophobicity [4]. Presence of either group of functionalities can be accurately confirmed by XPS analysis.

In conclusion, the importance of the surface and its finely tuned characteristics has to be emphasized again. In particular, when the developed materials are intended to be used for biomaterial and/or biosensor applications, there would be a close contact between the proteins (existing in the blood or on the cells' surface) and the surface of the developed platform. The response of the surface to the surrounding environment is a direct function of the surface properties. In that regard, developed materials can be carefully designed to possess all the necessary characteristics that promote desirable interactions with blood and/or living organs. In any case, a thorough understanding of the surface properties and chemistry plays the most significant role in finding a suitable application for the developed material. Such understanding can only be achieved by thorough analysis of the surface with aforementioned techniques that provides with the certainty about the developed platform and its capabilities for the intended application.

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