

Ultrasonic Force Microscopy characterization of a new scaffold formed of polyelectrolyte complexes

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Ultrasonic Force Microscopy (UFM) belongs to a novel family of Scanning Probe Microscopy techniques based on the use of Atomic Force Microscopy (AFM) with ultrasound excitation, initially developed to implement a near-field probe to emulate the Acoustic Microscope with nanoscale resolution [1]. The UFM procedure is based on the mechanical-diode effect [1, 2] which occurs due to the net force acting upon the AFM cantilever tip during each ultrasonic cycle because of the non-linearity of the tip-sample interaction force. A mechanical-diode response can also be detected in liquid environments [3]. UFM has been successfully applied to investigate the nanoscale distribution of elastic phases in polymer gels in ambient conditions [4], and in lipid bilayers in aqueous solution [3]. A unique advantage of the ultrasonic-AFM techniques is their ability to map nanoscale subsurface elastic inhomogeneities [1, 5].

Here, we apply UFM to image the elasticity of a biopolymer network within polyelectrolyte complexes [6]. Poly(acryloxyethyl-trimethylammonium chloride-co-2-hydroxyethyl methacrylate) [poly(Q-co-H)] / sodium alginate gel (Ca²⁺) [AlgNa] / poly-L-lysine [PLL] films were prepared on a mica surface. AFM / UFM allows us to study the structural arrangement and elasticity of the polyelectrolyte complexes with nanoscale resolution.

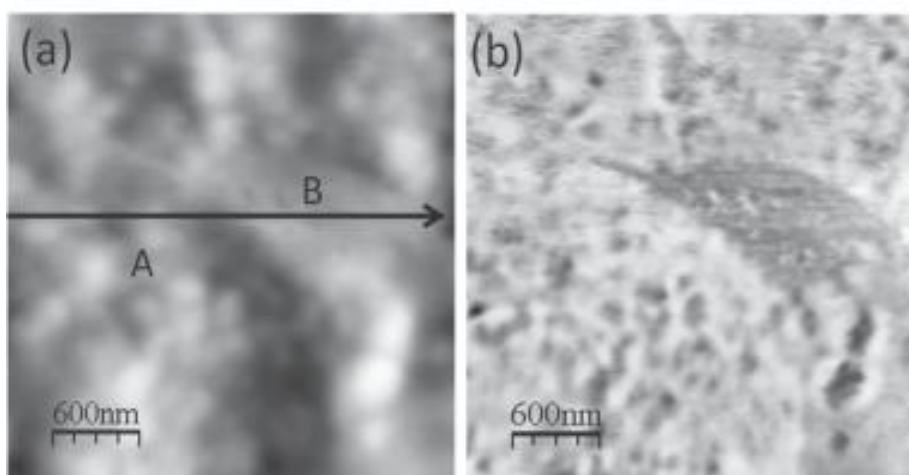
Fig. 1 shows the topography (a) and the UFM image (b) on the surface of the AlgNa gel/PLL/mica system. The elastic contrast on the AlgNa surface is indicative of the formation of a biopolymer network. On the AlgNa film, the surface morphology is mostly characterized by areas with rounded beads (≈ 150 nm in diameter) and polymer strands. Alginate is obtained from the Phaeophyceae brown seaweeds as a linear non-branched polymer containing 1, 4 - β - D-mannuronic acid (M) and 1, 4 - α - L - guluronic acid (G) residues. It gelifies in the presence of bivalent ions such as Ca²⁺. In the UFM contrast, guluronic residues with Ca²⁺ crosslinks in the alginate gel are identified as stiffer regions than the adjacent polymer formed by mannuronic or unreacted guluronic parts. Flatter, more homogenous surface regions are also present, presumably related to outdiffused PLL.

Incorporation of the poly (Q-co-H) layer results in an increased compactness of the film, and an enhancement of the previous AlgNa topographic features. Fig. 2 corresponds to the topography and UFM image recorded on the surface of the Poly(Q-co-H)/AlgNa gel/PLL/mica. The unique subsurface sensitivity provided by UFM reveals the elastic bonding distribution in the buried biopolymer network by imaging from the poly(Q-co-H) overlayer.

Provided the biocompatibility of the resulting polyelectrolyte complex film, we propose this system as a novel scaffold for bioengineering applications. The results we present demonstrate the potential of UFM to get insight in the elastic behavior of encapsulated bionetworks.

References:

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Figure 1:**Figure2:**