An antibacterial coating based on silver loaded in a polymer/sol-gel hybrid matrix

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In this work it is proposed a novel antibacterial surface composed of an organic-inorganic hybrid matrix of tetraethoxysilane (TEOS) and a weak polyelectrolyte like *Poly(acrylic acid sodium salt)* (PAA) which are deposited on glass slides by sol-gel method using the dip-coating technique [1]. This work is focused in the *in situ* synthesis of Ag nanoparticles (NPs) which are responsible of the antibacterial activity.

The weak polyelectrolyte PAA is used to create ion-binding sites in the starting solution by pH manipulation. This polyelectrolyte has been used earlier to bind Ag^+ via ion exchange (using $AgNO_3$ 10mM) [2, 3]. The silver cations (Ag^+) formed electrostatic pairs with the carboxylate groups from PAA. The carboxylate-bounded Ag^+ ions were reduced *in situ* to produce zero-valent silver (Ag^0) with dimethylaminoborane (DMAB 10mM) which acted as reduction agent. The UV-VIS absorbance spectrum confirms the existence of silver nanoparticles inside the coating due to the existence of an absorption peak near 410 nm (see Figure 1a). Such narrow absorption bands are typical of silver nanoparticles and they are originated by the Surface Plasmon Resonance (SPR) phenomenon [4, 5].

In this work the impact of the organic-inorganic ratio and the number of dip/reduction cycles on the total amount of synthesized silver nanoparticles has been studied. Figure 1a shows a direct relation between the number of dip/reduction cycles and the total amount of Ag nanoparticles. Moreover if the organic/inorganic molar ratio is increased, this also results into a rise of the number of nanoparticles, as it is shown in Figure 1b. The morphology of such surfaces was studied by Atomic Force Microscopy (AFM). The resultant coating was uniform and homogeneous, showing a smooth surface with a roughness of 7,5 nm (RMS). The topography and phase AFM images of the coating reveal is shown in Figure 2, and reveals the presence of a slight phase separation at the microscale, with the appearance of slightly different phase domains, which suggest different mechanical properties of each region.

The coated surfaces were tested in bacterial cultures of genus *Lactobacillus plantarum* to observe their antibacterial activities. Thus, *L. plantarum* were inoculated in a "MRS Broth" aqueous medium and incubated at 37º C for 24hours. The antibacterial activity was carefully measured by optical method. Figure 3 shows the results in two substrates placed on agar slabs after 24 h. The first one, Figure 3a, shows one reference substrate (uncoated) where it is obvious to observe a high number of *Lactobacillus plantarum* colonies that grow up randomly in the whole agar slab. The second one, Figure 3b, shows the coated substrate where it is easy to differentiate between the coated area (where there is no growth of colonies) and the un-coated area and the rest of the slab (where the growth of colonies is high as it was expected). These results confirm the high antibacterial property of the coatings based on silver loaded in a polymer/sol-gel hybrid matrix.

References:

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Figures:

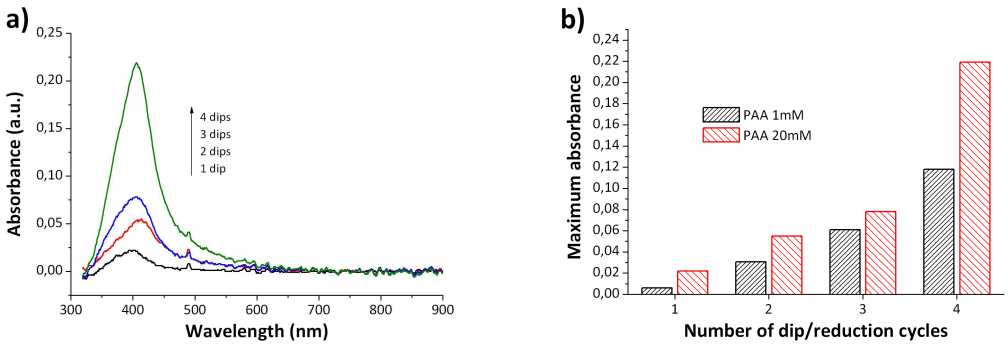

Figure 1: UV-VIS absorption spectra of the coating film (a) with different number of dip/reduction cycles (PAA 20mM), (b) with different ratio molar of organic/inorganic

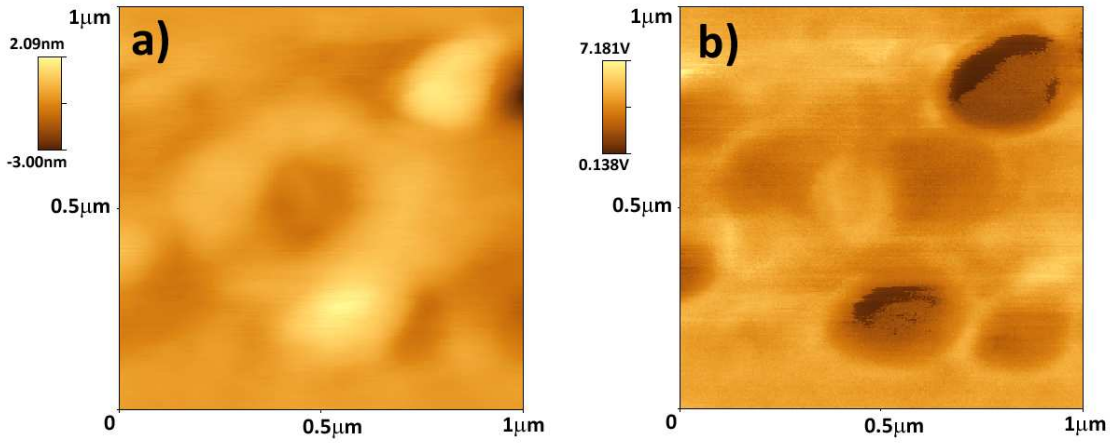

Figure 2: AFM images of the coating substrate: (a) height; (b) phase

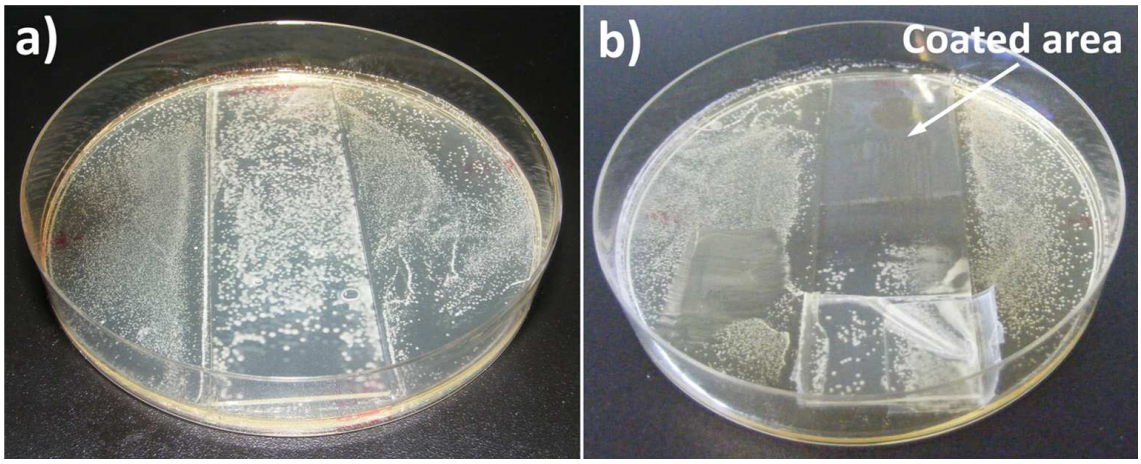

Figure 3: Bacteria growth on culture plates after 24 hours: (a) uncoated substrate;(b) coated substrate