Structural Changes in Interfacial Water Layers Induced by Electric Field.

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Resume: Water is the medium through which most of the processes in nature occur. All organelles of living organisms in the Earth are immersed in aqueous solutions where interfacial local electrical fields in the order of 10^6 V/m are easily found[1]. Fuchs et al. reported an unusual effect of liquid water exposed to a similar dc electric field: when a high voltage is applied to pure water filling two beakers kept close to each other a floating water bridge forms between them[2]. In a recent work, Pollack observed unexpected long distance water molecules organization at room temperature near hydrophilic surfaces[3]. To give some insight in this subject, we studied this effect by applying an electrical field of the same magnitude to the first water layers contacting the gold surface electrodes of a electrochemical quartz crystal microbalance, QCM, immersed in a in a 4mM HCl solution. The difference between the applied and the potential of zero charge, PZC, divided by the Debye length defined the electric field of the interfacial region. The field was changed by potential sweep between -0.45 and 1.05V at a rate of 20mV/s. From 0.1V to 0.6V the potential sweep caused frequency and resistance changes, Figure 1. A small part of the $\Delta f \cong -5.0Hz$ can be attributed to an oxide layer formation on the electrode surface[4]. A correspondent mass increase of 3.2 ng (0.6Hz) was calculated by integrating the current-potential curve from 0.1 V to 0.7 V (not shown). On the other hand, most of the frequency shift (4.4Hz) has to be related to the applied electric field in the Debye region, which at 0.7V is about $1.5 \times 10^6 \mathrm{V/m}$. This field also causes an unexpected resistance change of $\Delta R \cong 0.4\Omega$. The frequency and resistance changes should be attributed to a process induced by the electrical field occurring in the Debye layer at the electrode in the pre-oxide region of the electrode, which stops to grow at 0.7V, see Figure 1. In the cathodic direction, from 0.1 to -0.4V a symmetric change $\Delta R \cong 0.4\Omega$ was observed. The total frequency decrease measured was Δf≅-3Hz at the potential of -0.4V. The applied electric field in the Debye region at -0.4V is about $1.25 \times 10^6 \mathrm{V/m}$.
Concluding: Electric field Intensities greater than $10^6 \mathrm{V/m}$, induced mass increase in the interfaced layer, such intensities also cause the water film to increase its viscosity-density product.

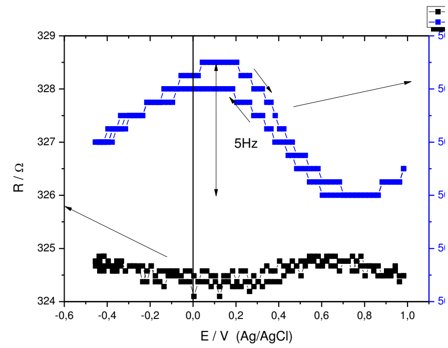

Figure 1. QCM resonant frequency and resistance changes corresponding to the potential sweep.

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