

Evaluation of viscoelasticity of water layers on model solid surfaces by quartz crystal microbalance with energy dissipation monitoring (QCM-D)

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Water at interfaces plays critical roles in various interfacial phenomena, such as chemical reaction, friction, corrosion. Many analyses by non-linear optical spectroscopy, atomic force microscopy, X-ray reflectivity measurements, etc., have been carried out to investigate molecular orientation, structuring, density profiles of the interfacial water at the interface to reveal the mechanisms underlying these phenomena.⁽¹⁾ Among many properties of interfacial water, mechanical properties have been speculated to govern friction and adsorption of molecules by affecting the interfacial interaction. However, compared with the orientation, structuring and density profiles, the mechanical properties of the interfacial water are lacking in the analytical method.

In this work, we attempted to evaluate the viscoelasticity of the water layer formed on self-assembled monolayers (SAMs) using quartz crystal microbalance with energy dissipation monitoring (QCM-D). We fabricated hydrophilic (OH), hydrophobic (CH₃ and CF₃), and protein-resistant [sulfobetaine and oligo(ethylene glycol)] SAMs on gold QCM sensors. First, dry nitrogen gas was flowed into the chambers for 1 h to remove the remaining water vapor. Then, the wet nitrogen gas was introduced with a constant flow. Fig. 1 shows the shifts in the resonance frequency due to the adsorption of water from vapor to the QCM sensor. These results exhibited that adsorption kinetics critically depends on the physicochemical properties of the SAMs. Fig. 2 indicates that viscoelastic properties also depend on the properties of SAMs. Especially, protein-resistant SAMs have larger $\Delta D/\Delta f$ values, indicating the formation of stiffer interfacial water layers. In this presentation, we discuss the correlation among the physicochemical properties of SAMs, the mechanical properties of the water layer, and interfacial phenomena.

Reference: (1) T. Hayashi, Chemistry Letters **50** (6), 1173 (2021).

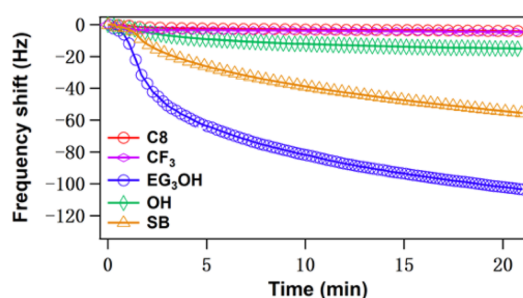


Fig. 1 Shift in the resonant frequency of the QCM-D sensors after the injection (Time = 0) of wet nitrogen as a function of time.

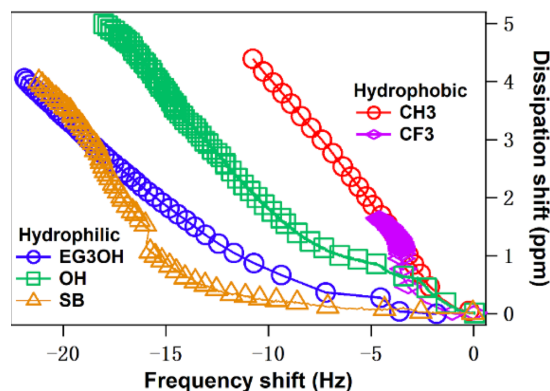


Fig. 2 Energy dissipation shift as a function of shift in resonant frequency of the QCM-D sensors.