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Q-Sense [Application Note] 9

The QCM-D Technology To Study Surfactant/Surface Interactions

This Application Note illustrates how the QCM-D Technology can be used to study surfactant interactions with surfaces in real time with nanoscale sensitivity.

Introduction

Surfactants are surface active molecules that modulate the surface tension at air/liquid interfaces as well as phenomena and interactions at liquid/solid interfaces. Surfactants are widely used as important components in detergents and other cleaning agents, in oil processing and recovery, pharmaceutical formations as well as in many other products. It is therefore critical to be able to study the effects of surfactants in real-time and at the nanoscale. The Quartz Crystal Microbalance with Dissipation Monitoring technology (QCM-D) offers this possibility by enabling the analysis of surfactant interactions with surfaces including the kinetics, mass and stability of the surfactant/surface interactions

Experimental

Two different surfactants were analyzed:
1. Triton X-100: non-ionic detergent with a relatively low Critical Micelle Concentration (CMC) (0.24mM), Mw=645Da.
2. Octyl-ß-D-glucoside (ßOG): a non-ionic detergent with a relatively high CMC (20.25mM), Mw=292Da.

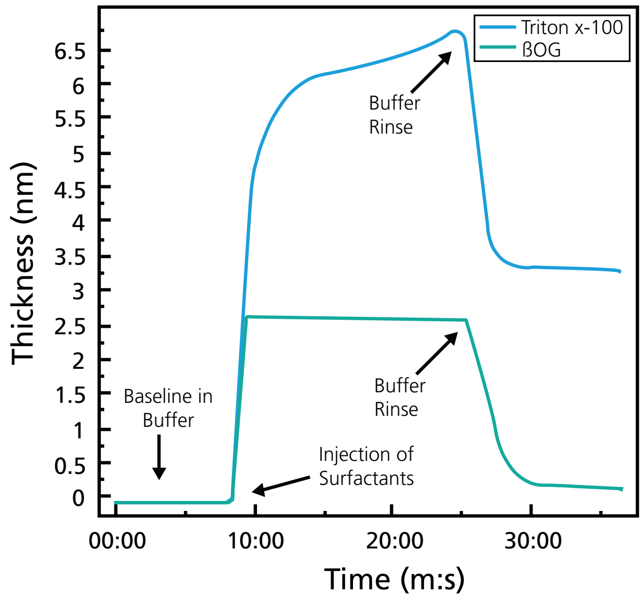
The buffer solution was PBS, pH 7.4.

QCM-D sensors with a gold surface were treated with UV ozone prior to the measurement, mounted in the QCM-D flow modules and the modules were filled with buffer solution. The sensors were then exposed to a Triton X-100 solution (0.24 mM) and a ßOG solution (20 mM), respectively, followed by rinsing with buffer.

Results

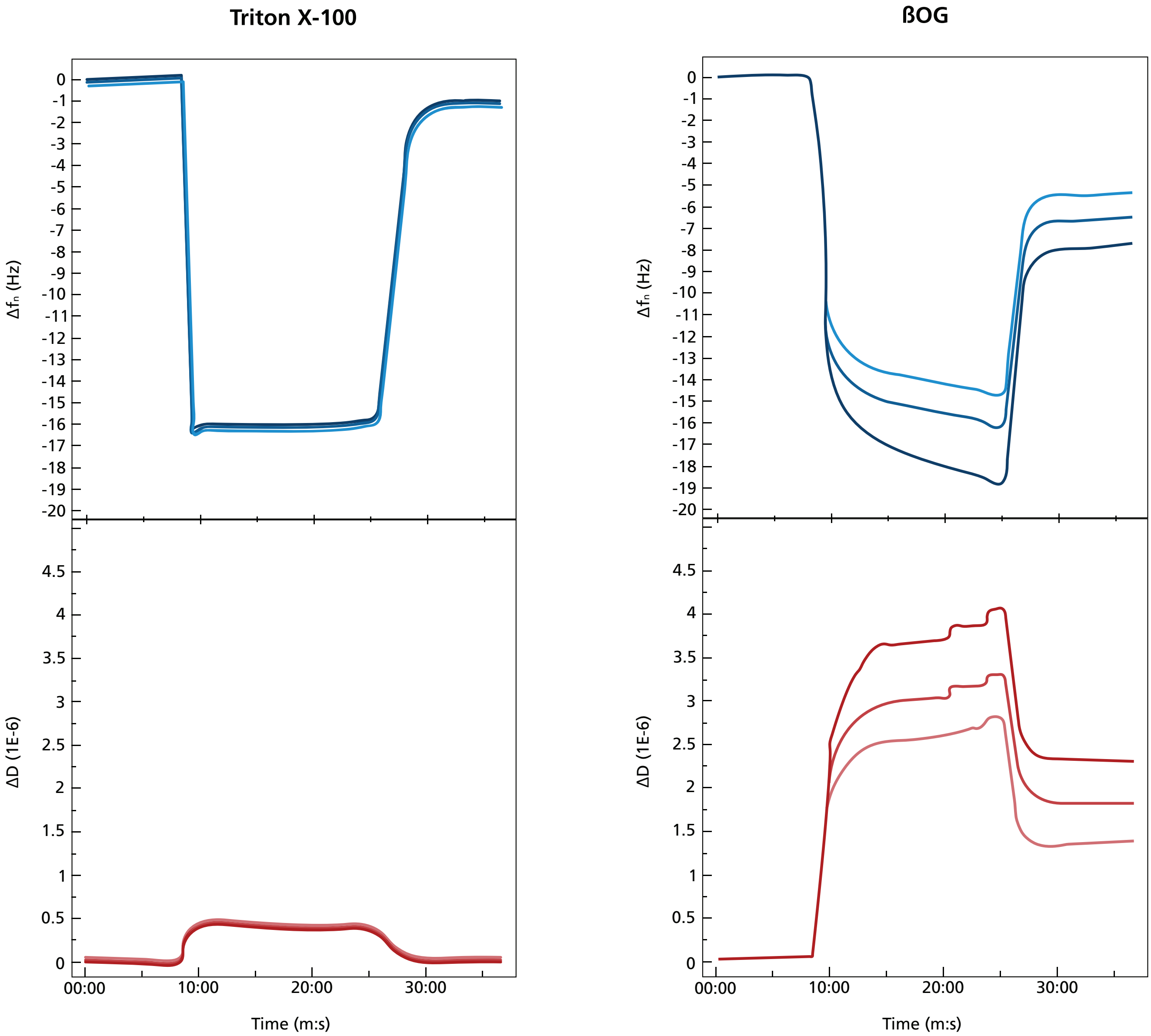
The adsorption behavior of surfactants on a gold surface was analyzed in real time. Figure 1 illustrates the areal mass/thickness as a function of time for the two surfactants. The adsorption of Triton X occurs faster but results in a thinner film than the slower adsorption of ßOG which yields a thicker film. The effective mass (thickness) of the formed molecular layers are 280 ng/cm^2 (25 Å) for Triton X and 740 ng/cm^2 (68 Å) for ßOG. Upon rinsing with buffer, a fraction of the bound surfactant de-sorbed. Particularly for ßOG, considerable amount of surfactant remains on the surface.

Final masses of 15 ng/cm^2 for Triton X and 360 ng/cm2 for ßOG were measured after the rinsing step. This corresponds to average molecular layer thicknesses of 1 Å for Triton X and 33 Å for ßOG.



Surfactant	Mass Before Rinse	Mass After Rinse	Film Thickness Before Rinse	Film Thickness After Rinse
Triton X-100	280 ng/cm^2	14 ng/cm^2	2.5 nm	0.1 nm
ßOG	740 ng/cm^2	360 ng/cm^2	6.8 nm	3.3 nm

[Fig. 1]: The blue plot shows the aerial mass density for the adsorption of Triton X-100 and ßOG , while the green plot shows the corresponding effective film thickness. It is clear that ßOG forms a thicker layer than the Triton X-100. Also the binding rate is different; saturation takes place quicker for the Triton X-100, even if the concentration was much lower.



[Fig. 2]: The left panel shows the frequency and dissipation responses for the adsorption of Triton X-100, while the right panel shows the responses for the adsorption of ßOG. The frequency and energy dissipation responses indicate that the ßOG forms a somewhat thicker and much softer layer than the Triton X-100. Overtone number 5, 7 and 9 are displayed (dark to light blue/gold).

Raw Data

In Figure 2 the changes in frequency (Δf) and energy dissipation (ΔD) are plotted as a function of time for Triton X (left) and ßOG (right). The total shifts in dissipation and spreading of overtones during the adsorption indicates that ßOG is resulting in a softer film (likely to have a considerable amount of coupled water) than that obtained with Triton X.

Conclusions

This application note shows that the QCM-D technology can detect adsorption of small molecules with Mw < 1000 Da. The binding rate, mass and structural properties of formed molecular layers are analyzed. Conclusions regarding the suitability of surfactants in different applications can be drawn based on such studies. The surface based QCM-D technology offers the possibility to study interaction processes under a variety of different substrates and experimental conditions.

References:

Measurements conducted at Biolin Scientific in Gothenburg, Sweden.

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