

# Adsorption of polymer-surfactant complexes as studied with in-situ ellipsometry and QCM-D

*Using QCM-D and ellipsometry it is possible to study the deposition of surfactant-polymer complexes to model surfaces. This can be used to investigate the effect of parameters such as water hardness on hair conditioning efficacy (as in the presented example), but also other product parameters such as molecular weight, ionic strength, charge distribution, concentration and the fundamental choice of surfactants and polymers.*

## Polymer-surfactant complexes in Personal Care products

Personal care products often contain oppositely charged polymers and surfactants. The surfactant concentration is often at least one magnitude higher compared to the concentration of the polymer, and thus any surfactant polymer complex formed would carry a net negative charge, yielding a high solubility. However, as the formulation is diluted and the surfactants are rinsed out in the shower, the negative overcharge is rapidly decreased, until a point is reached where neutral or charged-matched complexes are formed. The solubility of these charged matched complexes are in most cases exceedingly low, and thus the complex deposits on surfaces such as the hair.

For a conditioner, this is a desired effect and it is thus crucial to know how the deposition can be maximized or tailored by changing the polymer used or the other parameters such as pH, and ionic strength.

## Comparative study of product-in-use with QCM and Ellipsometry

In this example, the deposition from a model shampoo formulation was investigated and its effects from usage in various tap water conditions were discovered.



*With QCM and Ellipsometry we can study the deposition during dilution. In the present example we showed that the adsorbed mass is stable for all concentrations and that the same amount stays attached even after the final rinsing in pure water. We also found that the effect of water hardness was significant.*

As can be seen both with QCM (Fig. 1), and ellipsometry (Fig. 2), the adsorption is greatly increased when the shampoo is diluted using tap water. This effect was not seen when corresponding concentrations of sodium chloride was added, and thus this is attributed to a sensitivity towards ions such as Ca and Mg. Using tap water with two different hardness values we even measured a difference in the adsorbed amount.

Thus, with QCM and Ellipsometry, we can make comparative studies to

- show one formulation's superiority over another,
- determine which polymer or surfactant to choose
- learn about the behavior in various environments

### QCM-D AND ELLIPSOMETRY

QCM-D, Quartz Crystal Microbalance with Dissipation monitoring, is just as its name claims: a balance. It operates with an oscillating piezoelectric quartz crystal with a certain resonance frequency which changes with variations on the surface. With QCM, changes in the frequency and energy dissipation is registered and can through data analysis both the total adsorbed mass (hydration water included) as well as the viscoelastic properties of the adsorbed layer can be determined.

Ellipsometry is an optical technique that measures changes in the polarization of light and through a subsequent data analysis give data on the thickness, dry mass and refractive index of an adsorbed layer. The applications are plentyfold when studying polymers, proteins, biofilms, surface modifications etc. Ellipsometry is often combined with Atomic Force Microscopy and QCM.

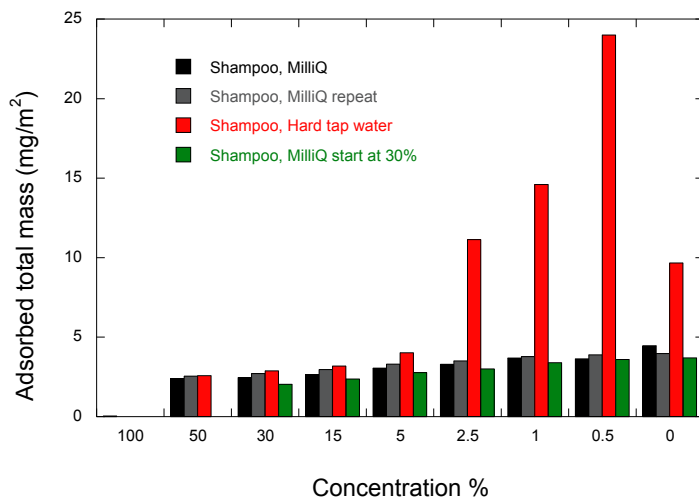


Figure 1. Total adsorbed mass, calculated from QCM data, for a shampoo formulation stepwise diluted (from 100% shampoo to rinsing) in MilliQ or hard tap water.

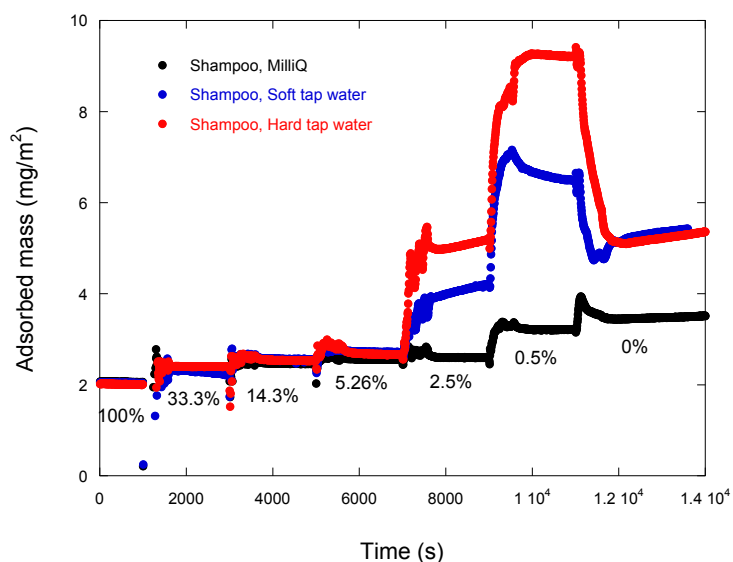


Figure 2. Real time adsorbed "dry" mass calculated from ellipsometry data. The same shampoo formulation was stepwise diluted from 100% shampoo to rinsing, using MilliQ and tap water with two different hardness values.