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Q-Sense | [Application Note] 19

QCM-D for analyzing the cleaning of hard surfaces using model and standardized stains

Quartz Crystal Microbalance with Dissipation monitoring (QCM-D) can be used to analyze the cleaning efficiency of detergent formulations in real-time. Parameters that can be obtained from such studies include real-time removal rates, structural changes of the stain and final overall efficiency of the formulations analyzed.

Introduction

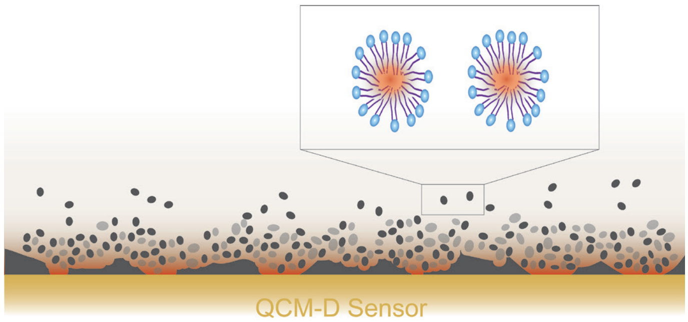
In this application note QCM-D is used to study the efficiency of different detergent formulations on two different fat stains: a fat model stain consisting of a single lipid molecule (triolein) and an industry standard used cooking fat obtained from the Center For Testmaterials BV.

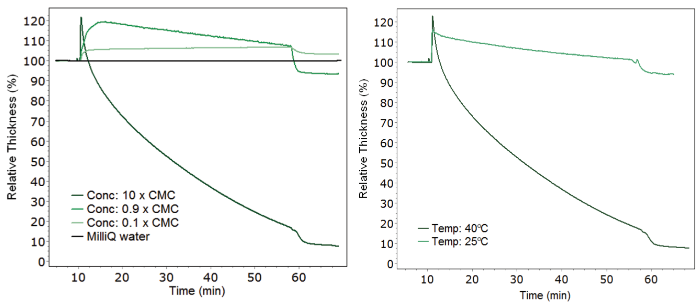
Experimental

In the first study, a single lipid (triolein) was spin-coated onto a gold QCM-D sensor to produce a model stain. The interaction and removal efficiency using the non-ionic surfactant TritonX was subsequently analyzed. Parameters such as surfactant concentration and different temperatures were also assayed in this first study.

In order to achieve a more realistic stain than the single lipid model stain, standardized used cooking fat (SUCF) obtained from the Center for Testmaterials BV was spin-coated onto a silica QCM-D sensor (a mimic for glass surfaces). In comparison to the single lipid model stain previously used, this stain is a highly complex mixture of fat and proteins. To assay cleaning efficiency and stain behavior upon formulation addition, two commercial dishwashing powders at identical concentrations were injected over the coated sensors.

All measurements were performed on the Q-Sense E4 system. Experiments were carried out in flow mode, starting in MQ water, followed by sample solutions and subsequent MQ water rinse. Unless stated otherwise the measurements were performed at 25°C.





[Figure 1A]: Changes in 30-40 nm thick lipid film upon injection of TritonX-100 (10 min) and subsequent rinse with water (58 min) at 40 °C. TritonX-100 at 0.1xCMC (light green), 0.9xCMC (green) and 10xCMC (dark green), MQ water reference (black). 100% refers to the initial thickness of the triolein film.

[Figure 1B]: Thickness changes of 30-40 nm of lipid film upon injection of TritonX (10 min) at concentration well above CMC (10xCMC), and subsequent rinse with water (58 min) at 25 °C (light green) and 40 °C (dark). 100% refers to the initial thickness of the triolein film.

Results and discussion

Both triolein and SUCF were successfully spin-coated onto gold and silica QCM-D sensors respectively. This is judged by optical inspection and by having a stable baseline in MQ water (Figs. 1A, 1B and 2). The approximate thicknesses of the films were in the range of 30-40 nm. Since triolein is a liquid at room temperature, it was necessary to use these sensors immediately after preparing them. On the other hand, the SUCF had a significant shelf-life (data not shown).

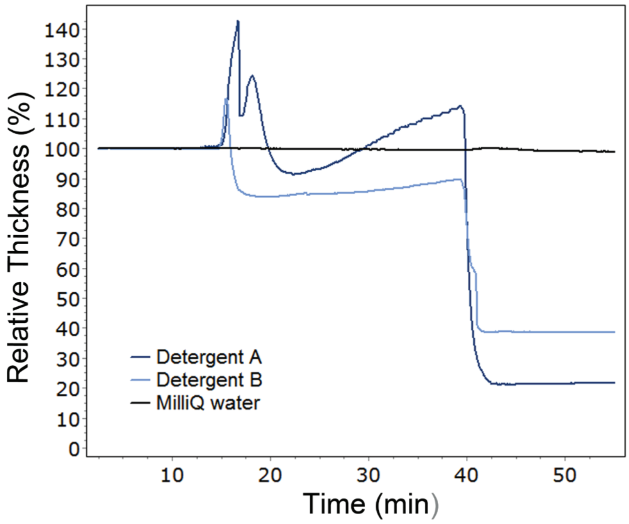
At all concentrations TritonX initially caused swelling of the triolein stain. A likely explanation for this is that the surfactant penetrates the stain and brings in coupled water causing a thickness increase (Fig. 1 A). At concentrations below the CMC TritonX either adsorbed to 0.1 x CMC or partially removed the stain (0.9 x CMC). However, at concentrations above the CMC (10 x CMC) almost all of the stain was removed (Fig. 1 A). In the first experiment the effect of temperature on removal rate was also investigated. As seen in Fig. 1 B the higher temperature the faster the removal rates of the triolein stain.

In the second study the effect of two commerically available dishwashing solutions (detergent A and detergent B) on a SUCF stain was tested. Similar to the triolein-TritonX study both detergents bound to the stain and initially caused swelling, with detergent A causing significantly more swelling than did detergent B (Fig. 2).

The removal rates and cleaning efficiency of the two formulations were significantly different with detergent B partially removing the stain before rinsing whereas detergent A swelled before rinsing. (Fig. 1 A). After rinse with MQ water the removal rate of detergent A significantly increased leading to a greater removal overall than detergent B.

Conclusions

QCM-D can provide real-time information about adsorption of formulation solutions, cleaning efficiency and stain removal rates during the measurement. The ability of coating complex and industry standardized stains onto the QCM-D sensor enables direct comparison between the data obtained at the nanoscale level with the more traditional test performed on the macroscale in for example dishwashing machines. The QCM-D measurements gives valuable insights about the behavior of different detergents under different conditions.



[Figure 2]: Thickness changes of 30-40 nm of SUCF stain upon injection of detergent A (dark blue) and B (light blue), and subsequent rinse with MQ water (38 min). MQ water reference represented in black. 100% refers to the initial thickness of the stain film.

References:

Measurements performed by Biolin Scientific / Q-Sense Application Scientists.

Standardized fat provided by Center For Testmaterials BV, the Netherlands.

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