Quartz Crystal Microbalance with Dissipation Monitoring (QCM-D) Cleaning profile

Clever Characterisation for Smarter Formulation
Royal Society of Chemistry, Burlington House, Piccadilly, London

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WHO WE ARE...

- >70 employees globally (~30% PhDs).
- Head office in Gothenburg, Sweden.
- R&D and manufacturing in Sweden and Finland.
- Direct sales in USA, UK and China, distributors in >70 countries
- Part of Add Life

MORE ABOUT WHO WE ARE...

- Surface science experts
- Widely adopted and accepted techniques and methods
- Thousands of publications
- Work with companies including Henkel, AkzoNobel, Clariant, BASF...
QSense QCM-D technology

- Sensor can be coated with a suitable soil for your experiment
- QSense enables analysis of molecular interactions and surface properties.

Illustration of cleaning steps to obtain the cleaning profile.
What are your main challenges for cleaning efficiency?

- Constant development of more efficient and eco-friendly detergents and formulations
- Slow R&D test methods

**Basic, analogue** techniques, e.g.
- Visual inspection
- Foam height (Ross Miles test)
- Wettability (Draves method)

**One point measures**
- Need to do several analysis methods/tests
- Non-automated, manual methods
A fast lane to the future

QSense offers a method for efficient screening and ranking of surfactant / formulation candidates

- Know HOW FAST your candidates clean.
- Know HOW CLEAN your candidates clean.
- Speed up the development of more efficient and ENVIRONMENTALLY-FRIENDLY products.

So that you can be FASTER. CLEANER. GREENER.
What makes QCM-D unique?

- Follow molecular events in **REAL TIME**
  - in liquid or in air

- **Label free** technique
- Measures frequency and dissipation changes
- \( \Delta F \propto \text{mass} \)
  - Sauerbrey equation (uniform, rigid film)
  - Thickness
- Dissipation measurements – viscoelastic properties of the layer
  - How soft? How rigid?

- Measure mass 0.5 ng/cm² and thickness of molecular layers (resolution: 1Å - 1µM)
- Frequency range of 1-70MHz and time resolution of 200 data points per second

- Analyse **structural properties of molecular layers, reproducible data**

- Wide array of sensor coatings for specific applications

- **Understand how QCM-D is a valuable technique for your formulation research**
Soil removal is a chemical process

Sinners circle
Application Areas

- Absorption/Desorption/binding
- Degradation
- Cross-linking
- Swelling/collapse
- Conformational changes
The QSense cleaning profile

The chemical cleaning process in real-time

- How fast?
- How much soil is removed?
- Good or bad? Fast or slow?

![Diagram showing the cleaning process over time](image)

- Nano scale soil
- Compound flown over sensor swells soil
- Soil dissolves and leaves surface
- Final cleaning result
Comparing different cleaning profiles

Cleaning profile A: SLOW
- 15% of the soil remains
- Cleaning process still ongoing
- Longer wash cycle required

Cleaning profile B: BAD
- 15% of the soil remains
- Cleaning process inactive
- Bad final result

Cleaning profile B: FAST
- 100% of the soil removed
- Cleaning process inactive
- Shorter wash cycle or less efficient candidate possible
Comparing candidates in varying conditions

- Composition
- Concentration
- Temperature dependence
- Water quality
- Wash cycle time

- Pre-program and run up to 8 samples in one go
- Get high precision, real-time reproducible data
Three key values

1. **Swelling time**
   What is the ability to remove the soil?

2. **Mass removal rate**
   How much soil is removed per second?

3. **Total mass removal**
   How much soil is removed overall?
Data derived from changes in frequency and dissipation

1. **Removal rate**
   How much material is removed per second?

2. **Total removal**
   How much soil is removed overall?

3. **$t_D$ Swell Max**
   How quickly does the soil swell?

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Evidence-based ranking of surfactants/formulations

Study by Biolin Scientific in collaboration with Center for Testmaterials BV (Netherlands)

- Swell time, mass removal rate and total mass removal tested for 9 commercially available formulations

- **Rapid screening and ranking of the formulations was easily achieved**

- Significant correlation found when comparing to Center for Testmaterials ‘macro scale’ set-up

Evidence-based ranking of surfactants/formulations

1. Commercial detergents used in study
   - A, B, F, G: EXPENSIVE
   - D, E: MID-PRICE
   - C, H, I: CHEAP

2. Wash cycle
   - Fixed concentration of detergents at 4 g/L and measured at 21°C. The cleaning cycle as outlined below was programmed into the QSoft Pro software.
   - 1. Baseline with tap water
   - 2. Injection of detergent
   - 3. Wash with tap water

3. Sample data was collected
   Data was collected as triplicates and run in a fully automated mode to maximize efficiency and reproducibility and analyze:
   1. Swelling time
   2. Mass removal rate
   3. Total mass removal

4. Ranking result
   - Chart showing total ranking score for different detergents:
     - Reference
     - CHEAP
     - MID-PRICE
     - EXPENSIVE
     - Detergents: A, B, C, D, E, F, G, H, I
     - Scores range from 30 to 0

Biolin Scientific
[Progress Together]
AkzoNobel – an application example

In Q2 2017 AkzoNobel revealed new results for their ELFAN AT 84 G surfactant based on QSense Cleaning Profile

- Significantly better cleaning rate than competitor product
- Helps differentiate products
- Used both during and after the development phase
- QSense Cleaning Profile added to the ELFAN product data sheet
QSense Dfind analysis software

• A complete analysis toolbox in one intuitive software application
• Explore the full potential of your data
• Analyse all data in one go

QuickView and AutoPlotting to review and compare results
Material library and Model fit traffic lights
SmartTools analysis method toolbox
Batch mode and template tool
Report tool

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