Technology Note

QCMD in Lipid Research

Quartz Crystal Microbalance with Dissipation (QCMD) in Lipid Research

QCMD is a label-free surface-analytical technique based on a quartz resonator excited to oscillate at its resonance frequency on one or more overtones. Resonators can have various coatings: gold (Au), silica (SiO_2), titania (TiO_2), etc. It works in aqueous media or organic solvents and is therefore widely used for studying solid/liquid interfaces.[1,2] At each overtone, QCMD measures changes in the resonance frequency and energy dissipation due to the processes occurring at the resonator surface (Figure 1). Examples of such processes include formation of a film or changes in the geometrical or physical properties of the film.

The key feature that makes QCMD useful in lipid research is its ability to distinguish between different geometries and topologies of lipidic assemblies at interfaces, for example, homogenous solid-supported bilayers or monolayers vs. adsorbed liposomes (Figure 2),[3] or other structures (such as cubosomes)[4] without relying on fluorescent or deuterated labels but by relying on the combination of the frequency and dissipation.

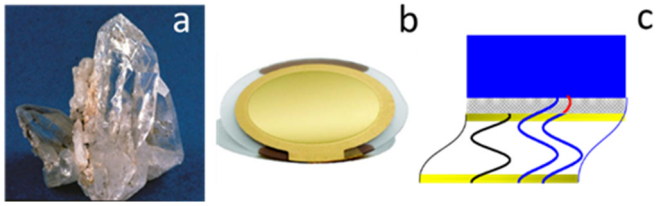

Figure 1. *QCMD.*
(a) Mineral quartz. (b) A 14 mm 5 MHz QCMD sensor consisting of a quartz disc with gold electrodes. (c) A side view of the sensor depicting its shear motion. Gold electrodes are shown in yellow, sample film in grey, and liquid above in light blue. Thin waves depict the fundamental, thick ones depict the 3rd overtone. Comparing black and blue lines, one sees how the wavelength increases (frequency decreases) in the (sensor + film) case (blue) as compared to the sensor alone (black). The effect of energy dissipation in the film on the attenuation of the amplitude of the wave is shown in red for the 3rd overtone.

Lipid-related QCMD work can be grouped into several topics, with a total of more than a thousand publications:

- Studies focusing on the interactions between lipids and surfaces.[2, 5, 6, 7, 8]
- Studies focusing on the properties of the lipids, such as their phase behavior,[9,10,11] adsorbed liposome deformation,[12] etc.
- Studies examining interactions between lipids and membrane-binding proteins, [13, 14, 15] peptides, [16, 17, 18] or viruses. [19] Particularly interesting is that QCMD offers a way to study clustering of membrane-bound proteins.[20]
- Studies focusing on the interactions of lipids with polymers[21] or with nanoparticles.[22]

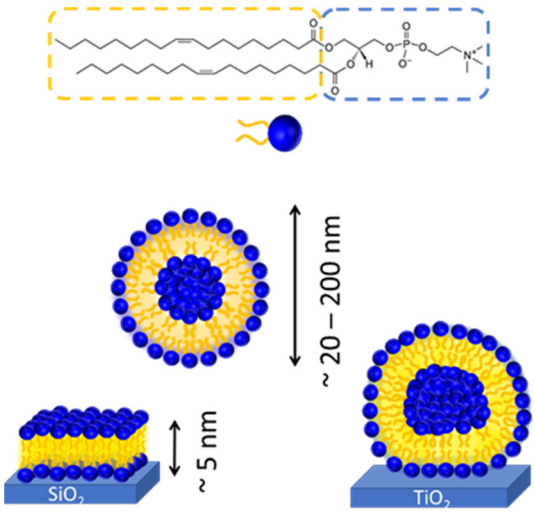

Figure 2. *Chemical structure of a lipid (top) with its schematic representation (below), a liposome in solution (middle), and surface-supported lipidic structures with low and high dissipation: lipid bilayers (left) and adsorbed liposomes (right). Note the approximate sizes of the structures.*

It is worth highlighting the studies where QCMD was combined with other techniques, such as neutron reflectometry (NR).[3, 23, 24, 25] QCMD and NR provide complementary information but

QCMD is much faster and simpler. It can therefore be used to rapidly screen many conditions while NR is typically performed on select few. Combinations of QCMD with other techniques, such as surface plasmon resonance,[26] ellipsometry,[17] atomic force microscopy,[27,28] and optical reflectometry,[29] have also been reported.

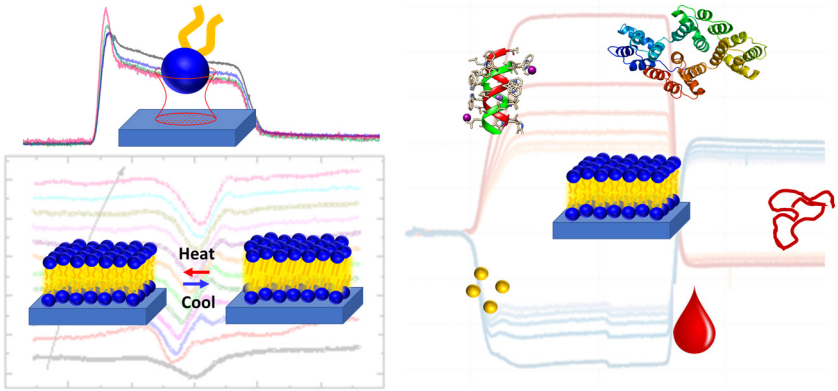

Figure 3: *Examples of QCMD applications related to lipid work. Top left: lipid-surface interactions; bottom left: lipid phase behavior; right: interactions with nanoparticles, peptides, proteins, polymers, and complex biological samples such as blood or blood plasma.*

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[2] Technology Note: AWSensors QCMD (www.awsensors.com)

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