EQCM-D-Based Surface-Acoustic-Wave Spectroscopy: Emerging Innovations in Material Characterizations for Energy Storage and Conversion

Mikhael D. Levi

Department of Chemistry, Bar-Ilan University, Ramat-Gan 52900, Israel

Depending on stiffness/softness of the electrode coatings (attached with no-slip to quartz crystal surface), their thickness and morphology, the quartz crystal resonator can operate in either gravimetric or beyond-gravimetric modes providing important information about the mechanical properties of the electrodes. [1,2] Starting from a simple gravimetric monitoring of dynamics of ions adsorption into nanoporous carbon supercapacitors, [3] we have demonstrated a couple of years ago that the use of multiharmonic Electrochemical Quartz Crystal Microbalance with Dissipation Monitoring (EQCM-D) constitutes the basis of a new powerful *in situ* method of highly sensitive tracking intercalation-induced dimensional and porous structure changes in operating battery [4] and supercapacitor [5] electrodes. The resonance frequency and dissipation changes caused by contact of a porous solid electrode with electrolyte solutions are recorded on multiple harmonics and fitted to a suitable hydrodynamic impedance model returning the structural parameters of the electrode. Later on this new methodology was extended to a continuous monitoring of viscoelastic changes in binder-free 2D electrodes such as Mxene ($Ti_3C_2(OH)_x$) caused by insertion of water molecules modulated by intercalation-deintercalation of Li-ions in aqueous solutions. [6] Monitoring viscoelastic properties of solid-electrolyte interface (SEI) on a high-voltage anode such as LTO was shown to be an extremely effective means for fast optimization of cycling behavior of this electrode. [7] Our recent paper makes focus on in situ acoustic diagnostics of particle-binder interactions in battery electrodes: accommodation of intercalation-induced volume changes significantly depend on the stiffness/softness of the binder used, [8] on one hand, and on the extent to which the size of the guest cation matches the size of the host sites in which the cations are accommodated. [9] The different worked examples of the successful use of EQCM-D-based surface-acoustic-wave spectroscopy for material characterization of energy storage electrodes have been summarized in a recent review. [10]

References

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