Novel Method of In-Situ Tracking of Mechanical Changes in Composite Electrodes during Charging-Discharging by QCM-D

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Abstract : We have developed an in-situ method for tracking ions adsorption into composite nanoporous carbon electrodes based on quartz-crystal microbalance (QCM). In these first papers QCM was used as a simple gravimetric probe of compositional changes in carbon porous composite electrodes during their charging since variation of the electrode potential did not change significantly width of the resonance. In contrast, when we passed from nanoporous carbons to a composite Li-ion battery material such as $LiFePO_4$ olivine, the change in the resonance width was comparable with change of the resonance frequency (polymeric binder PVdF was shown to be completely rigid when used in aqueous solutions). We have provided a quantitative hydrodynamic admittance model of ion-insertion processes into electrode host accompanied by intercalation-induced dimensional changes of electrode particles, and hence the entire electrode coating. The change in electrode deformation and the related porosity modify hydrodynamic solid-liquid interactions tracked by QCM with dissipation monitoring. Using admittance modeling, we are able to evaluate the changes of effective thickness and permeability/porosity of composite electrode caused by applied potential and as a function of cycle number. This unique non-destructive technique may have great advantage in early diagnostics of cycling life durability of batteries and supercapacitors.

Keywords : Li-ion batteries, particles deformations, QCM-D, viscoelasticity
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