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Machine learning to predict electrochemical impedance spectra (EIS): Can EIS be replaced by constant current techniques?

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Abstract

Electrochemical impedance spectra (EIS) have been widely used to diagnose the battery state of health (SOH), because the battery SOH is influenced by resistance-induced overvoltage (polarizations), i.e., ohmic (R_{Ω}), activation (charge transfer; R_{ct}), and concentration polarization (mass transport; R_{mt})[1]. However, the implementation of onboard EIS measurement is hindered, due to the high cost of the measurement equipment, test results subject to SOC, and time-demanding measurements. Here, we predicted impedance spectrum by battery charging voltage curve based on electrochemical mechanistic analysis and machine learning.

As reported, both EIS and charging curves can be used to predict battery SOH[2]. This indicates that the DC charging curve can also demonstrate the dynamic behaviors inside a battery (e.g., charge transfer and mass transfer). Besides, in constant current charging process, it has been found that the voltage change in the first few milliseconds corresponds to R_{Ω}, and the voltage change of first several seconds corresponds to R_{ct}, and the voltage change of first 100 seconds corresponds to R_{ct}[1]. It further confirms that both the EIS and constant current technique can express same electrochemical information.

Battery charging curves as input were used to predict EIS, as shown in **Fig. 1**. The experimental results show that the proper partial voltage range has high accuracy for EIS prediction. The predicted errors for impedance spectrum are less than 1.9 mΩ. This provides a new perspective and means for EIS interpretation.

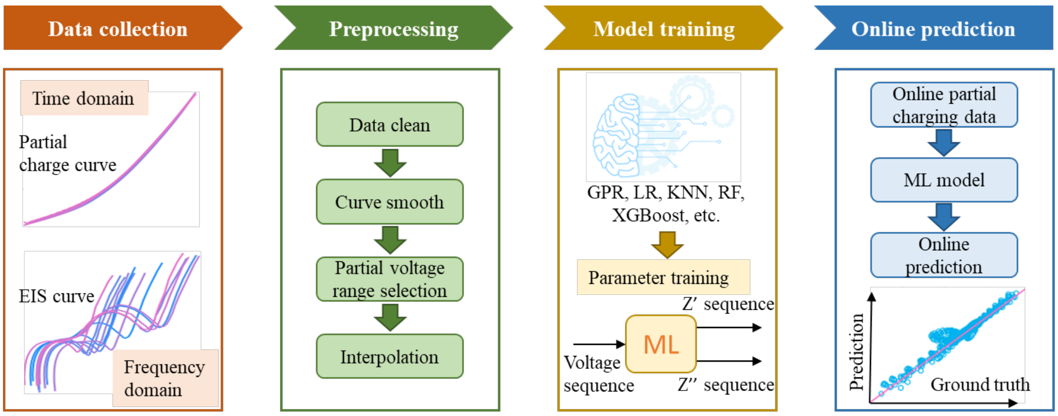

Fig. 1 Charging voltage curve were used to predict electrochemical impedance spectra.

Reference

[1] M. Winter, J. Kasnatscheew, L. Stolz, M. Gabers, **2022**.

[2] K. Uddin, G. H. Chouchelamane, C. Pastor-fern, W. D. Widanage, J. Marco, **2017**, *360*.