Supplementary data

- **Determination of bulk Li^+ ion diffusion coefficient by Cyclic voltammetry**

From Randles Sevcik Equation

Diffusion coefficient, $$D = \left[\frac{slope}{26800 \times n^{3/2} \times A \times C}\right]^2$$

$$Anodic\ slope = 0.00249 \frac{A}{(Vs^{-1})^{1/2}}$$ [figure S4(b)]

$$Cathodic\ slope = 0.00264 \frac{A}{(Vs^{-1})^{1/2}}$$ [figure S4(b)]

$n \rightarrow number\ of\ electrons\ trensferred\ in\ the\ redox\ event = 3$

$A \rightarrow electrode\ area\ in\ cm^2 = 1.5\ cm^2$

$C \rightarrow Concentration\ of\ electrolyte, 1M\ LiPF_6 = 10^{-3} mol\ cm^{-3}$

$D_{Li^+}\ lithiation = 1.5 \times 10^{-10}\ cm^2\ s^{-1}$

$D_{Li^+}\ delithiation = 1.42 \times 10^{-10}\ cm^2\ s^{-1}$

- **Determination of bulk Li^+ ion diffusion coefficient from Warburg tail of EIS Nyquist plot**

$$D_{Li^+} = \frac{R^2 T^2}{2A^2 n^4 F^4 C^2 \sigma^2}$$

$R \rightarrow gas\ constant = 8.314\ J\ mol^{-1} K^{-1}$

$T \rightarrow absolute\ temperature = 298.16\ K$

$A \rightarrow electrode\ area\ in\ cm^2 = 1.5\ cm^2$

$C \rightarrow Concentration\ of\ electrolyte, 1M\ LiPF_6 = 10^{-3} mol\ cm^{-3}$

$n \rightarrow number\ of\ electrons\ trensferred\ in\ the\ redox\ event = 3$

$F \rightarrow Faraday\ constant = 96{,}485\ Cmol^{-1}$

$\sigma \rightarrow Warburg\ coefficient$
$= slope\ of\ the\ graph\ between the\ real\ impedance\ and\ the\ inverse\ square\ root\ of\ \omega$
$= 76.947 \Omega s^{-1}$

[figure S4(d)]

$D_{Li^+} = 3.28 \times 10^{-14}\ cm^2\ s^{-1}$

- **Solid-state diffusion coefficient of Li within the particle at different levels of prelithiation**

$$D_{Li^+} = \frac{R^2T^2}{2A^2n^4F^4C_{Li^+}^2\sigma^2}$$

$C_{Li^+} \rightarrow Concentration\ of\ Li^+\ in\ the\ solid\ phase\ of\ electrode$

$$C_{Li^+} = \frac{4 + 3x}{459.08\ gmol^{-1}} \times 3.38\ gcm^{-3}$$

$459.08\ gmol^{-1} \rightarrow Molecular\ weight\ of\ LTO$

$3.38\ gcm^{-3} \rightarrow Density\ of\ LTO$

$x \rightarrow stoichiometric\ amount\ of\ Li\ inserted\ in\ LTO\ corresponding\ to\ \%\ DOD$

Prelithiation level	**Value of x**	C_{Li^+} **(mols cm^{-3})**	D_{Li^+} **(cm^2 s^{-1})** [figure S5(b)]
No prelithiation ($Li_4Ti_5O_{12}$)	0	0.0294	1.74×10^{-17}
30 min ($Li_5Ti_5O_{12}$)	0.33	0.0368	7.7×10^{-18}
60 min ($Li_6Ti_5O_{12}$)	0.66	0.044	7.04×10^{-18}
Complete Prelithiation ($Li_7Ti_5O_{12}$)	1	0.515	1.7×10^{-17}

Formulas used for the assembly of AC/LTO LICs

- **Preparation of the AC electrode:**
    - According to the Mass loading formula

$$Q = q_{positive} * m_{positive} = q_{negative} * m_{negative}$$

Where Q=Discharge (mAh)

q=Specific capacity in second discharge cycle (mAh g^{-1})

m=mass of active material in the electrode

- **Energy and Power Density calculation:**
    - Charge Q, (mAh) = Current (mA) * time (h)
    - Capacity C, (mAh g^{-1}) =Q/m
        - m= total mass of active material in both the electrodes
    - The energy density (Wh kg^{-1}) = C*V
        - V= Intersecting voltage of the second charge-discharge curve.
    - Power Density= Energy density/time (h)

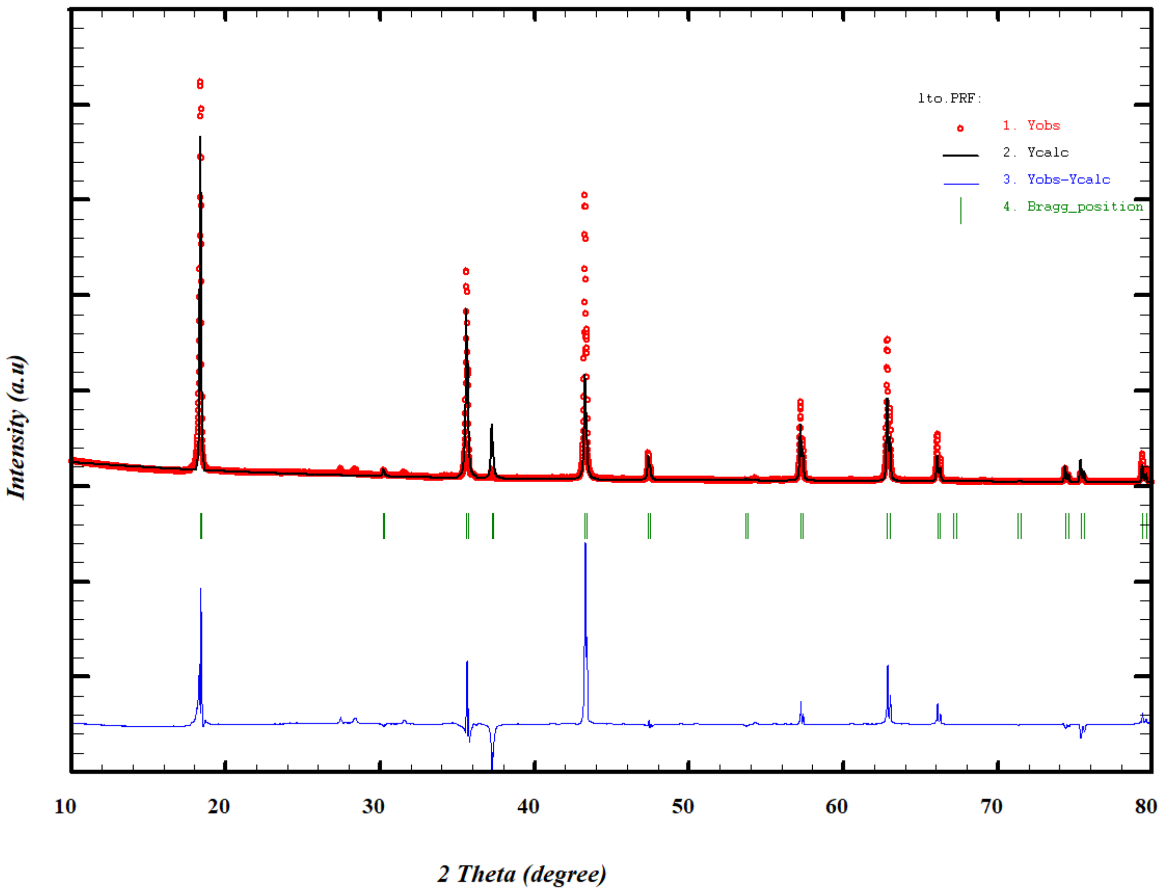

Figure S1: The XRD pattern of commercial LTO material along with Rietveld refinement.

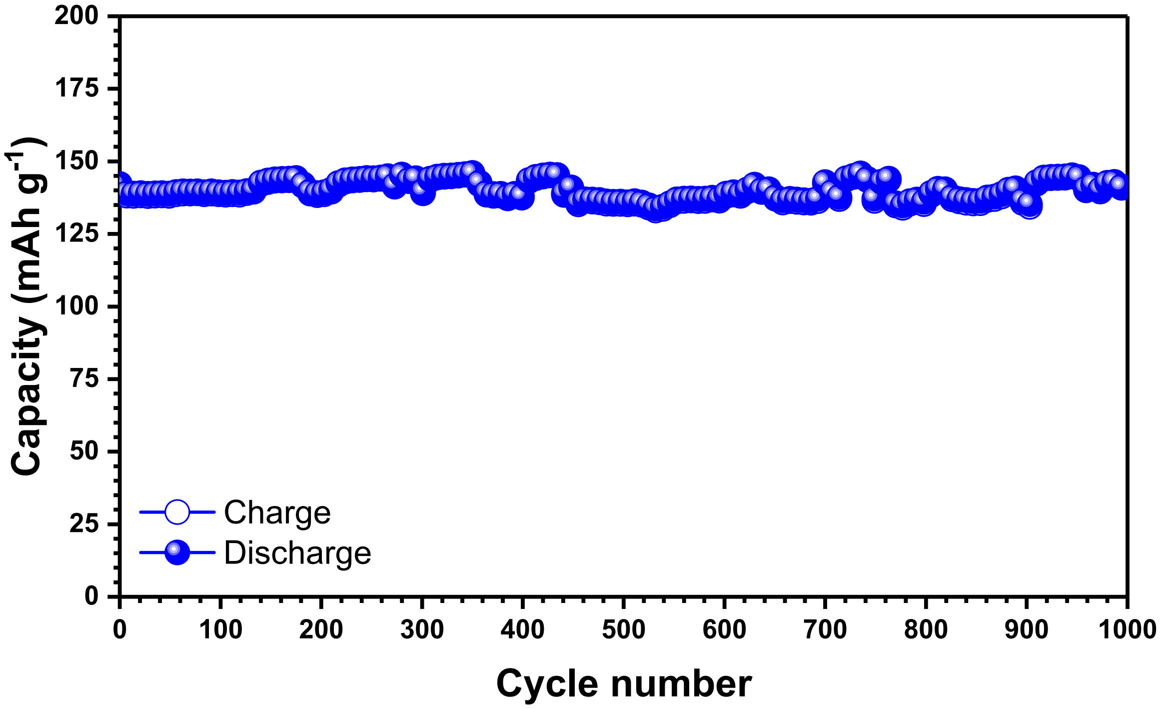

Figure S2: Cyclic stability of Li/LTO half-cells at a current density of 1 A g^{-1}.

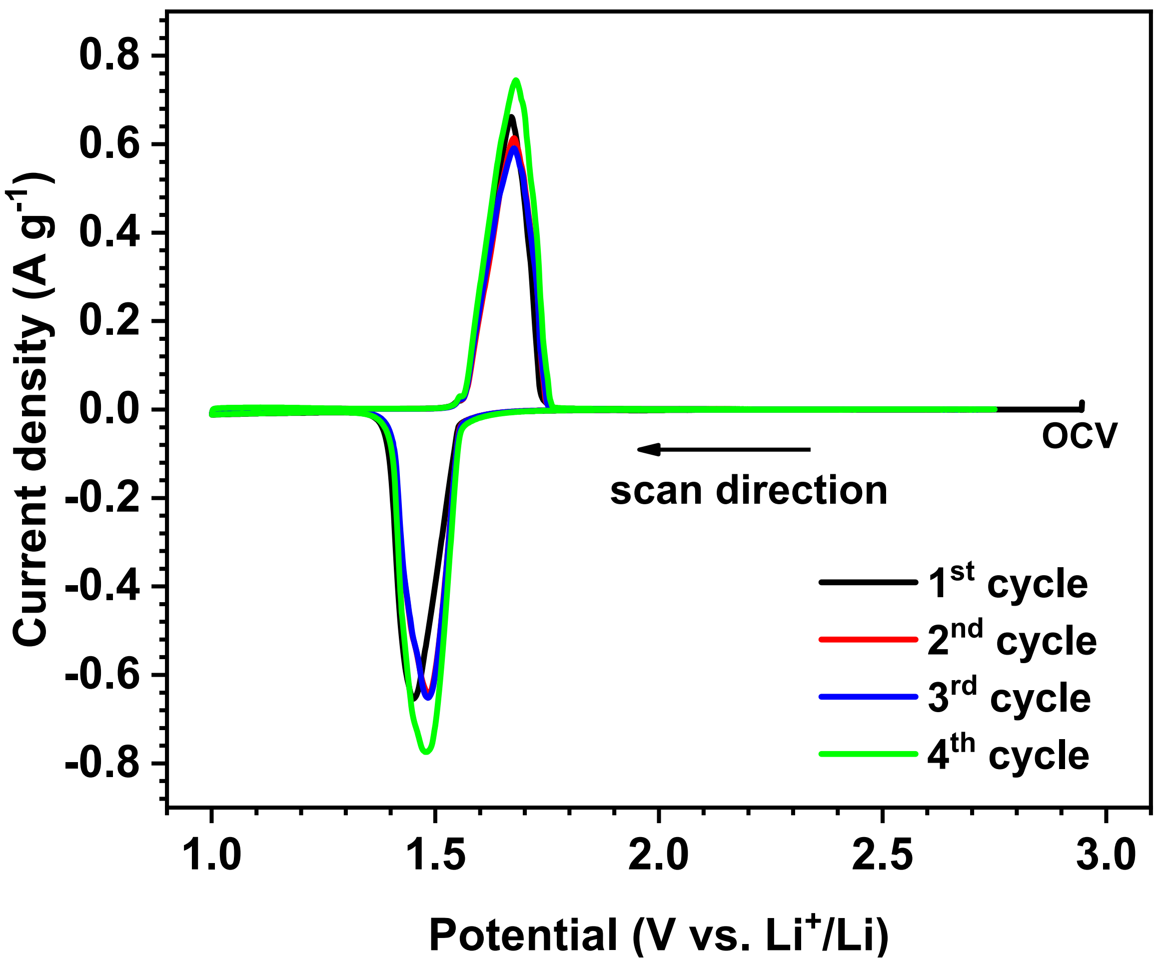

Figure S3: CV profile of Li/LTO half-cell within the potential window of 1-2.75 V *vs*. Li^+/Li at 0.1 mV s^{-1} (first four cycles).

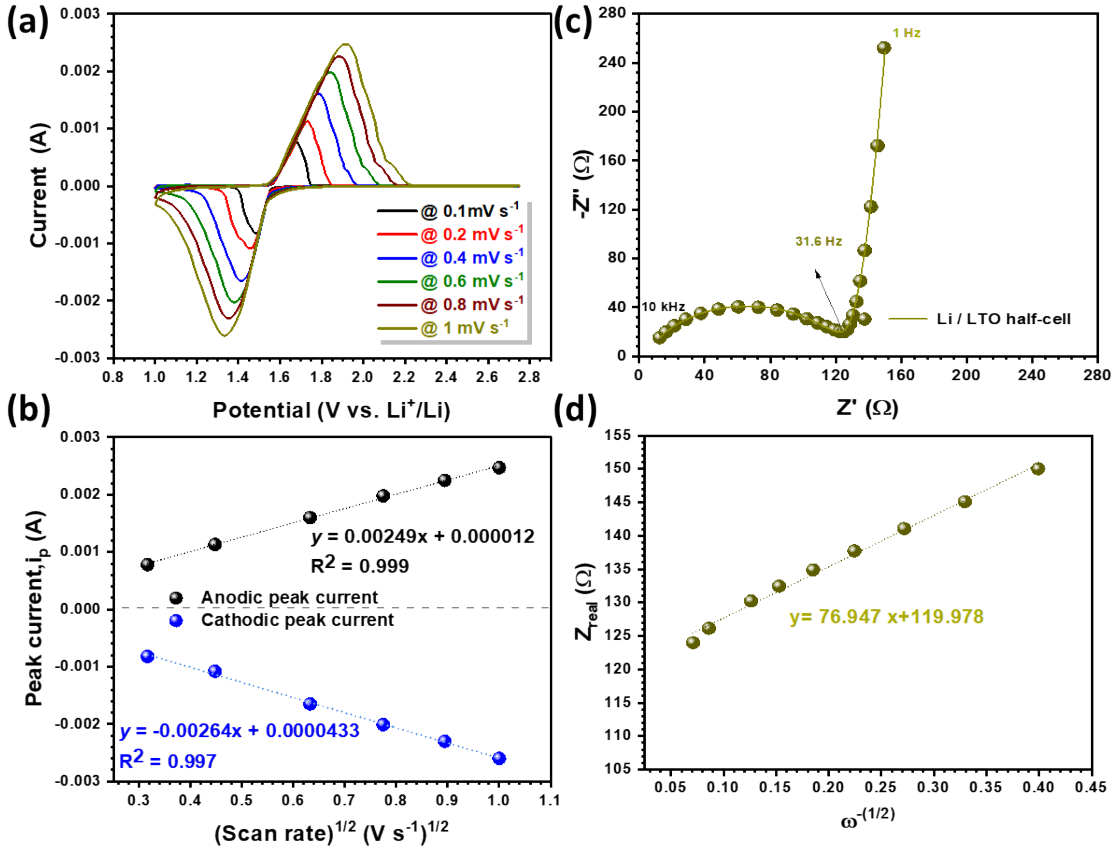

Figure S4: (a) CV profile of Li/LTO half-cell at different scan rates (0.1-1 mV s^{-1}), (b) plot of anodic and cathodic peak current (i_p)versus square root of scan rate($\sqrt{v}$), (c) EIS Nyquist plot of Li/LTO half-cell within the frequency range of 10 kHz to 1 Hz, and (d) Real impedance versus inverse square root of angular frequency in the Warburg tail region.

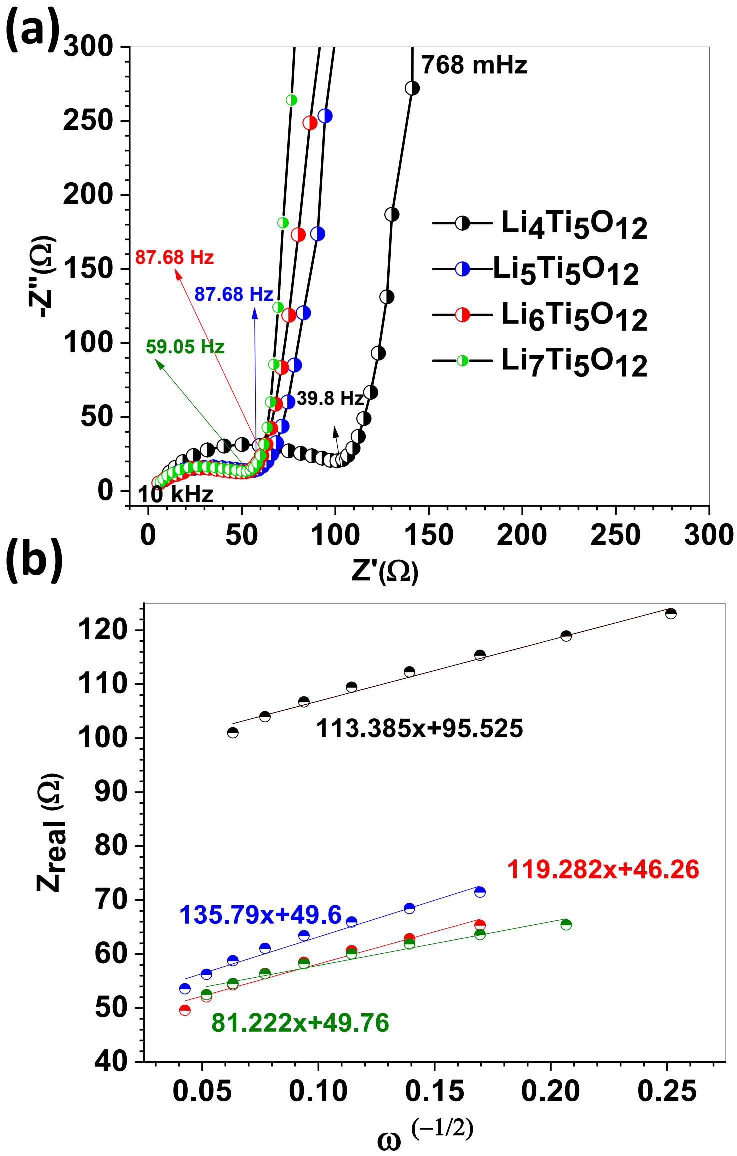

Figure S5: (a) EIS Nyquist plot of Li/LTO half-cell with different levels of prelithiation (0, 30, 60 & 90 min) within the frequency range of 10 kHz to 10mHz, and (b) Real impedance versus inverse square root of angular frequency in the Warburg tail region.

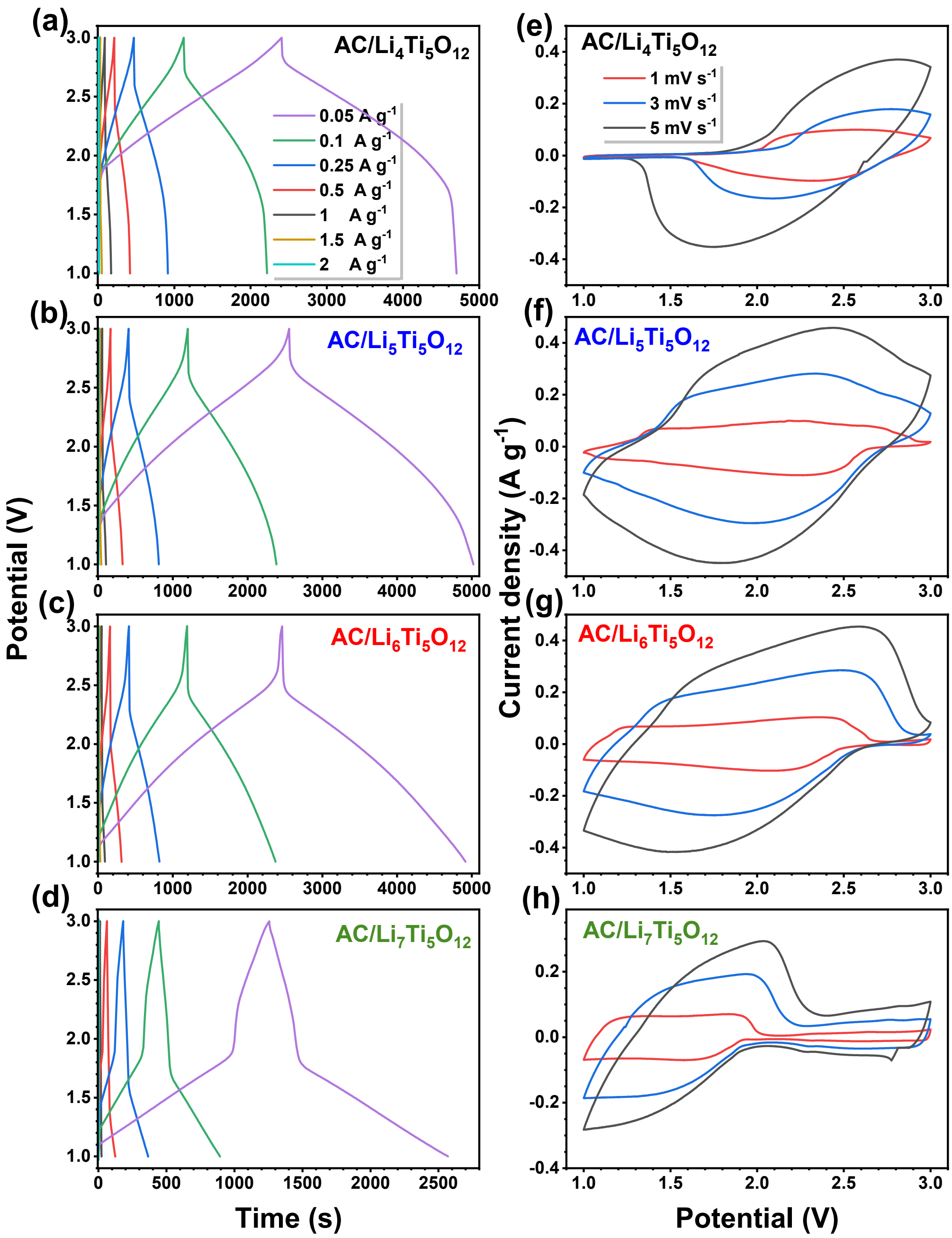

Figure S6: (a, b, c & d) Potential *vs*. time graph of the assembled LICs at different current rates (0.05-2 A g^{-1}), and (e, f, g, h) the CV profile of assembled LICs at different scan rates (1, 3 & 5 mV s^{-1}).

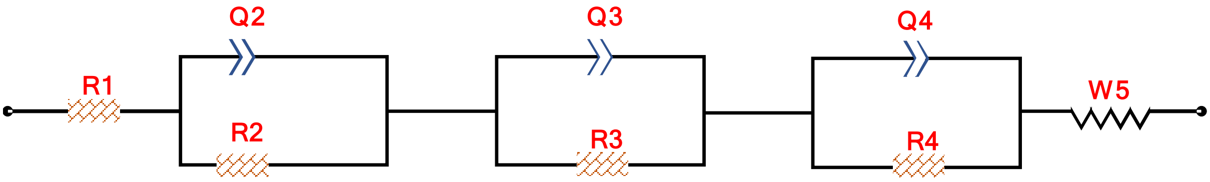

Figure S7: Equivalent circuit model used to fit EIS Nyquist plots recorded for the assembled LIC configurations within the frequency limit of 10 kHz to 10 mHz