

**Figure S4 | Component-resolved Bode decomposition of the MXene equivalent-circuit response.**

(a) Bode magnitude  $|Z(\omega)|$  and (b) Bode phase for the measured impedance (symbols) and the total fitted response (solid line), together with the individual circuit contributions decomposed into  $R_s$  (series resistance),  $j\omega L$  (lead inductance), the interfacial branch ( $R_{ct} \parallel CPE_1$ ), and  $CPE_2$ . This decomposition illustrates how different physical elements dominate distinct frequency regimes:  $R_s$  sets the high-frequency real-axis offset,  $j\omega L$  produces the high-frequency inductive phase lead, ( $R_{ct} \parallel CPE_1$ ) governs the mid-frequency dispersive arc associated with non-ideal interfacial charge transfer/double-layer behavior, and  $CPE_2$  captures the low-frequency distributed capacitive/pseudocapacitive response. The panel-wise breakdown provides an interpretable link between the fitted parameters and the observed magnitude/phase evolution across the full measurement window.

