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ENVIRONMENT FRIENDLY CAPACITORS OPERATING AT HIGH VOLTAGE DOWN TO -40°C IN SALT AQUEOUS ELECTROLYTE

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Commercially available supercapacitors are generally based either on organic electrolyte ($TEABF_4$ in acetonitrile or propylene carbonate) or aqueous electrolytes (KOH and H_2SO_4). Both organic and KOH based symmetric capacitors are able to deliver power down to low temperature, e.g., -40°C [1-2]. However, due to the relatively high cost and environmental unfriendly character of organic electrolytes, and the limited operating cell potential of 0.7-0.8 V for basic (KOH) solutions, alternative electrolytes able to operate at low temperature and up to high cell potentials are desirable. Recently, aqueous lithium sulfate (Li_2SO_4) has been used in AC/AC capacitors allowing cell potentials up to 1.8 - 2.0 V to be reached. Such high cell potential is possible owing to the high over-potential for di-hydrogen evolution at the negative AC electrode [3]. However, the low temperature performance of capacitors based on these electrolytes has not been investigated yet and could be a hindrance in their practical viability.
In this work, we demonstrate that by using 0.7 mol L^{-1} aqueous Li_2SO_4 with an appropriate additive, an AC/AC capacitor can operate down to -40°C without freezing of the electrolyte while keeping good performance. Three-electrode cell investigations show that at such low temperature, the pseudocapacitive contribution related with hydrogen storage at the negative AC electrode is negligible. At -40°C, the AC/AC capacitor exhibits 99% efficiency up to a cell potential of 1.6 V. During prolonged potentiostatic floating for 120 h at 1.6 V and -40°C, the capacitance and resistance remain constant, indicating no ageing of the system under these harsh conditions. Upon returning back to 24°C after prolonged operations at -40°C, the capacitor behaves like a freshly prepared one (Fig. 1a). Electrochemical impedance spectroscopy measurements demonstrate that despite increased ESR, EDR and Rct values at -40°C, the low frequency region does not exhibit any deviation from linearity (Fig. 1b) suggesting nearly pure EDL behaviour at all cell potentials up to 1.6 V, which is in sharp contrast to the capacitor at 24°C (Fig. 1c).

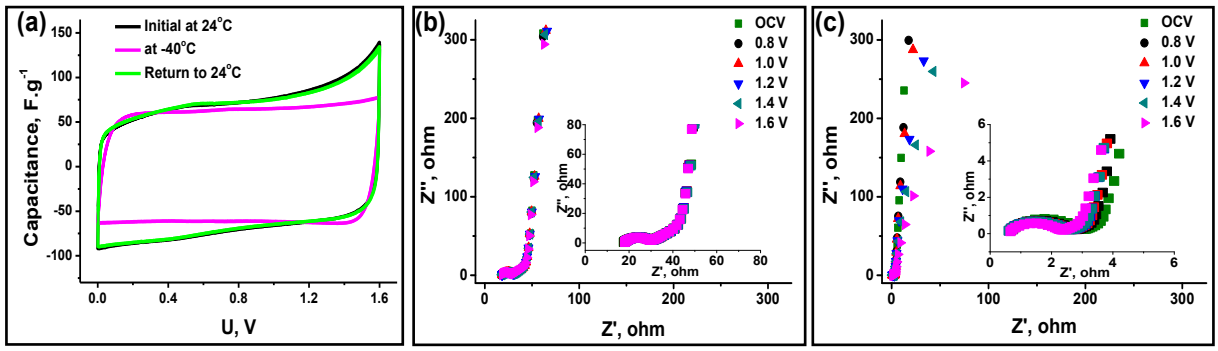

Figure 1: (a) Cyclic voltammograms (2 mV s^{-1}) of AC/AC capacitors at different temperatures, (b) Nyquist plots at -40°C, (c) Nyquist plots at 24°C. The Insets in (b) and (c) show the high frequency region.

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