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# Supplementary materials

## $V_2CT_x$-MXene Partially Derived Hybrid $VS_2/V_2CT_x$ Electrode for Capacitive Deionization with Exceptional Rate and Capacity

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The salt adsorption capacity (SAC, mg·g$^{-1}$) was obtained by the following equation:

$$\text{SAC} = \frac{(C_0 - C_t) \times V}{m} \tag{S1}$$

where $C_0$ and $C_t$ represent the concentrations of NaCl at the initial stage and t min (mg L$^{-1}$), respectively; V stands for the volume of the NaCl solution (L); and m is the overall mass of the active material (g).

In addition, the salt removal rate (SRR, mg·g$^{-1}$·min$^{-1}$) could be determined by the following equation:

$$\text{SRR} = \frac{SAC}{t} \tag{S2}$$

among them, t (s) refers to the Charging time.

The energy consumption (EC, kw·h·kg$^{-1}$-NaCl) could be calculated by the following equation:

$$EC = \frac{J \times m \times \int_{t_0}^{t_e} u\,dt}{3600 \times (C_0 - C_e) \times V} \tag{S3}$$

where J refers to the set current density (mA·g$^{-1}$), m refers to the mass of the electrode active material (g), $t_0$ is the time (s) at the start of a given cycle of desalination, $t_e$ is the time (s) at the end of a given cycle of desalination, u refers to the voltage (V), $C_e$ represents the NaCl concentration at the end of the desalination stage and dt is measured in seconds.

In the EQCM behavior, the variation of resonance width $\Delta W_n/n$ is obtained by converting the dissipation factor:

$$\frac{\Delta W_n}{n} = f_0 \times \frac{\Delta D_n}{n} \tag{S4}$$

among them, $f_0$ is the fundamental frequency of the quartz wafer (5 MHz) when the sample is not loaded, n = 1, 3, 5, 7, 9, 11, 13.

When the deposited film is rigid, the bandwidth of the standing wave does not increase, so the relationship between the film mass (Δm) and the corresponding resonant frequency can be expressed by the classical Sauerbrey equation[1]:

$$\Delta m = -C \times \frac{\Delta f}{n} \tag{S5}$$

where C is the mass sensitivity constant ($C = \sqrt{\mu_q \times \rho_q}$), $\mu_q$ and $\rho_q$ are the elastic shear modulus and density. For a crystal with $f_0$ = 5 MHz, C = 17.7 ng·cm$^{-2}$·Hz$^{-1}$.

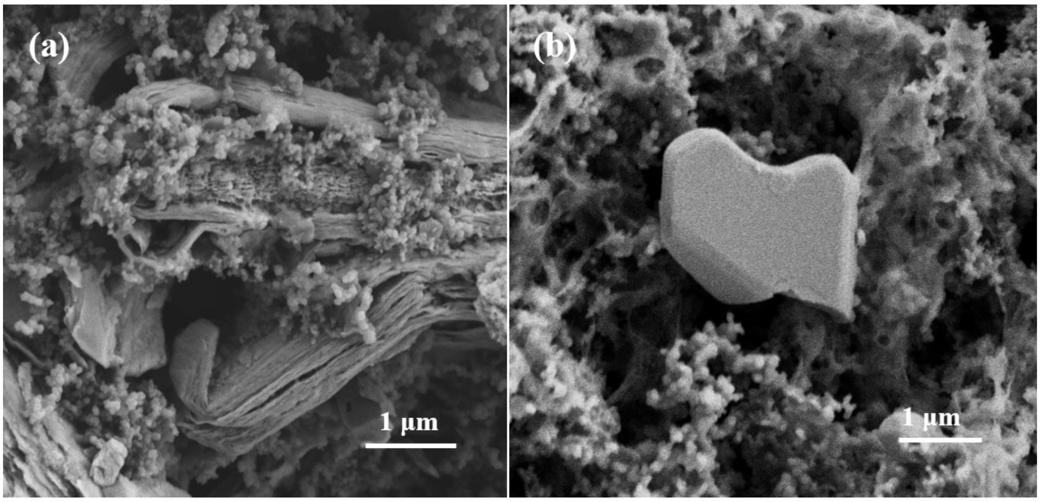


Figure S1. (a) SEM image of $VS_2/V_2CT_x$ film before 60-cycle of CDI desalination; (b) SEM image of $VS_2/V_2CT_x$ film after 60-cycle of CDI desalination.

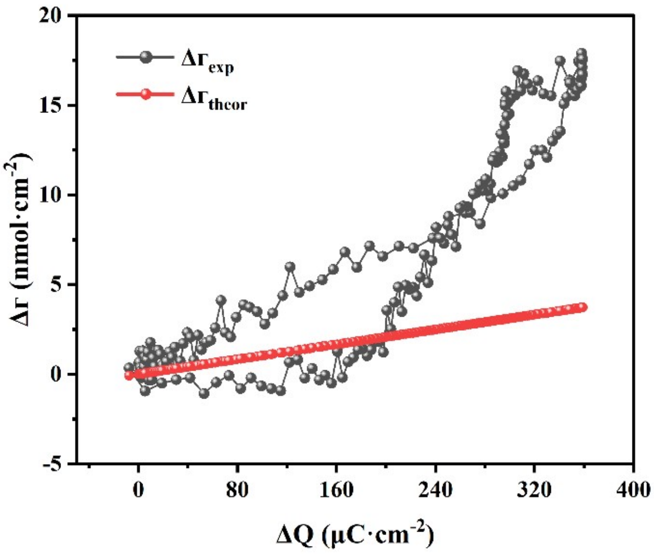


Figure S2. The theoretical and experimental ion population changes (ΔΓ) as a function of charge density (ΔQ) during charging and discharging process (n = 3, scan rate = 0.03 $V \cdot s^{-1}$).

The experimental ion population change ($\Delta\Gamma_{exp}$) can calculate by the following equation:

$$\Delta\Gamma_{exp} = \frac{\Delta m}{M_i} \tag{S6}$$

where Δm is the mass change, and the molecular mass $M_i$ of $Na^+$ is 23 $g \cdot mol^{-1}$. The theoretical ion population change ($\Delta\Gamma_{theor}$) can calculate with the adoption of Faraday's law:

$$\Delta\Gamma_{theor} = \frac{\Delta Q}{nF} \tag{S7}$$

where ΔQ is the charge passed through the electrode (C), n is the valence number of the ion (n=1), and F is the Faraday constant (96485 $C \cdot mol^{-1}$).

Table 1. Evaluation and ranking of the operating parameters using TOPSIS-Entropy weight model

| Parameters | $D^+$ | $D^-$ | Normalized score | Rank |
|---|---|---|---|---|
| IC-100 | 0.33 | 0 | 0 | 4 |
| IC-300 | 0.01 | 0.33 | 0.5221 | 1 |
| IC-500 | 0.24 | 0.12 | 0.1769 | 3 |
| IC-700 | 0.15 | 0.19 | 0.3009 | 2 |
| CD-40 | 0.12 | 0.15 | 0.2424 | 3 |
| CD-50 | 0.06 | 0.22 | 0.3398 | 2 |
| CD-60 | 0.05 | 0.20 | 0.3399 | 1 |
| CD-70 | 0.24 | 0.003 | 0.0778 | 4 |
| CFV-1.2 | 0.14 | 0.35 | 0.3895 | 2 |
| CFV-1.4 | 0.09 | 0.32 | 0.4306 | 1 |
| CFV-1.6 | 0.35 | 0.14 | 0.1799 | 3 |

**References**


[1] G. Sauerbrey, Use of a Quartz Vibrator for Weighing Thin Films on a Microbalance, Eur. Phys. J. A, 155 (2) (1959) 206−222.