Supporting Information for *Journal of Materials Chemistry A*

Graphene Coupled Ti$_3$C$_2$ MXenes-Derived TiO$_2$ Mesostructure: Promising Sodium-ion Capacitor Anode with Fast Ion Storage and Long-Term Cycling

Rutao Wang,$^a$ Shijie Wang,$^a$ Yabin Zhang,$^a$ Dongdong Jin,$^a$ Xinyong Tao,$^b$ Li Zhang$^*$

$^a$Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Shatin NT, Hong Kong SAR 999077, P. R. China.

$^b$College of Materials Science and Engineering, Zhejiang University of Technology, Hangzhou 310014, P. R. China.

*Email: lizhang@mae.cuhk.edu.hk
Fig. S1 Optical images showing the violently oxidized process of MXenes-Ti$_3$C$_2$ with 30 wt% H$_2$O$_2$.

Fig. S2 Optical images showing the reaction process of MXenes-Ti$_3$C$_2$ with H$_2$O$_2$ with the different concentrations.
Fig. S3 Optical images showing Ti-peroxo complex gels obtained by the oxidation of H$_2$O$_2$ with different concentrations: (a1) and (a2)-1 wt% H$_2$O$_2$, (b1) and (b2)-3 wt% H$_2$O$_2$, (c1) and (c2)-6 wt% H$_2$O$_2$, (d1) and (d2)-15 wt% H$_2$O$_2$, (e1) and (e2)-30 wt% H$_2$O$_2$. All the gels in the glass bottles can be inverted. Some unreacted raw materials are observed at the bottom of the gels, as the dilute H$_2$O$_2$ was used.

Fig. S4 (a) Optical image and (b) XRD pattern of freeze-dried Ti-peroxo complex gel (from 30 wt% H$_2$O$_2$).
Fig. S5 (a) UV-vis spectrum, (b) XRD pattern, (c) and (d) TEM images of Ti-peroxo complex after aged for two months.

Fig. S6 Optical images for (left) Ti-peroxo complex-GO and (right) M-TiO$_2$-RGO samples.
Fig. S7 (a) SEM and (b) HRTEM image of M-TiO$_2$-RGO. Blue arrows show mesoporous structure in M-TiO$_2$-RGO.
Fig. S8 EDS spectrum of M-TiO$_2$.

Fig. S9 TGA curves of M-TiO$_2$ and M-TiO$_2$-RGO samples in air with an elevated temperature rate of 10° min$^{-1}$. The weight loss of M-TiO$_2$ might be related to the decomposition and oxidation of the residual carbon in air atmosphere. Assuming M-TiO$_2$ with and without RGO experiences the same weight loss, the content of M-TiO$_2$ in M-TiO$_2$-RGO can be calculated as 73.7/98.4=74.9 wt%. The weight retention value here is obtained at 700 °C. As we know, RGO can be completely decomposed at 700 °C in air. Then the percentage of RGO in M-TiO$_2$-RGO is (100-74.9) wt%=25.1 wt%.
**Fig. S10** (a) Full and (b) C1s XPS spectrum of MXenes-Ti$_3$C$_2$, M-TiO$_2$, and M-TiO$_2$-RGO samples.

**Fig. S11** Rate capability of Ti$_3$C$_2$ MXenes and M-TiO$_2$ at various current densities ranging from 50 to 2000 mA g$^{-1}$. 
Fig. S12 CV curves from 10 to 100 mV s\(^{-1}\) of M-TiO\(_2\)-RGO electrode.

Fig. S13 Contribution ratio of the capacitive and diffusion-controlled charge versus scan rate of M-TiO\(_2\)-RGO electrode.
**Fig. S14** (a) Galvanostatic charge-discharge curves (current density of 0.5 A g$^{-1}$) of M-TiO$_2$-RGO//PDPC SIC measured at different anode/cathode mass ratios. (b) Ragone plot (power density vs. energy density) of this M-TiO$_2$-RGO//PDPC SIC with different anode/cathode mass ratios.