Supporting Information

MXene/CNTs@P nanohybrid with stable Ti-O-P bonds for enhanced lithium ion storage

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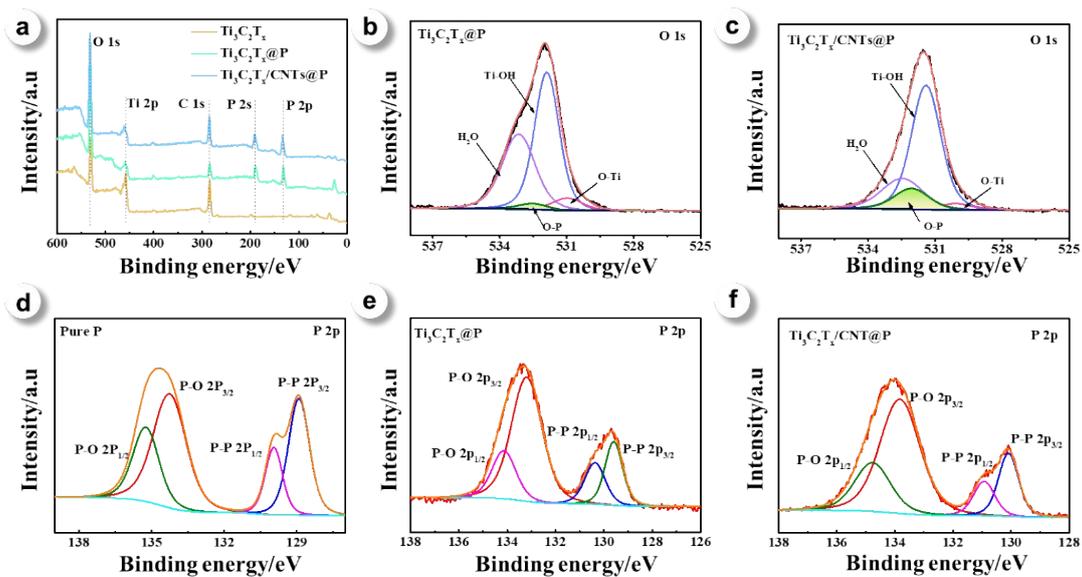[1] Shixue Zhang and Huan Liu contributed equally to this work.

Fig. S1 XPS survey spectra of the samples (a). The O 1s spectra of $Ti_3C_2T_x@P$ (b) and $Ti_3C_2T_x/CNTs@P$ (c). The P 2p spectra of pure red P (d), $Ti_3C_2T_x@P$ (e) and $Ti_3C_2T_x/CNTs@P$ (f).
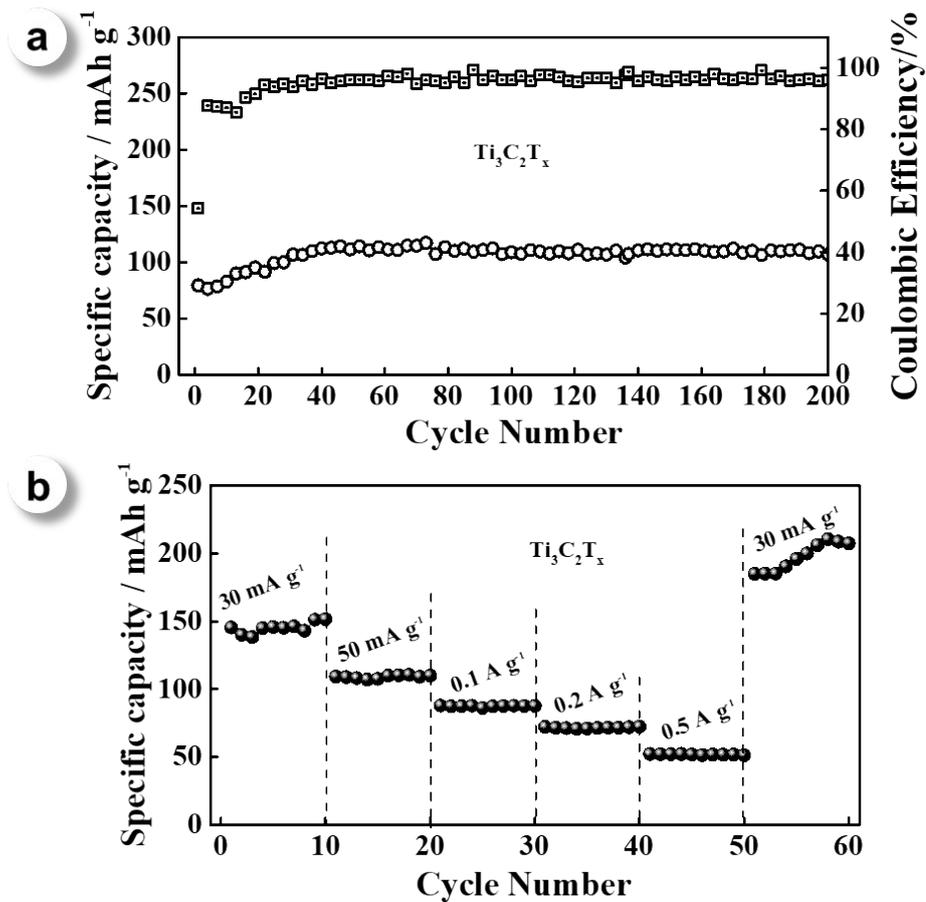
Fig. S2 Cycle performance and their columbic efficiencies of $Ti_3C_2T_x$ at a current density of 50 mA g^{-1}(a). Rate performance of $Ti_3C_2T_x$ at different current density (b).
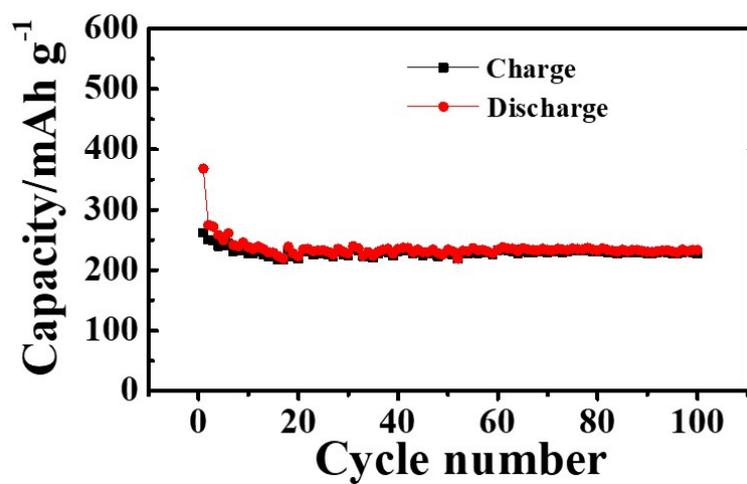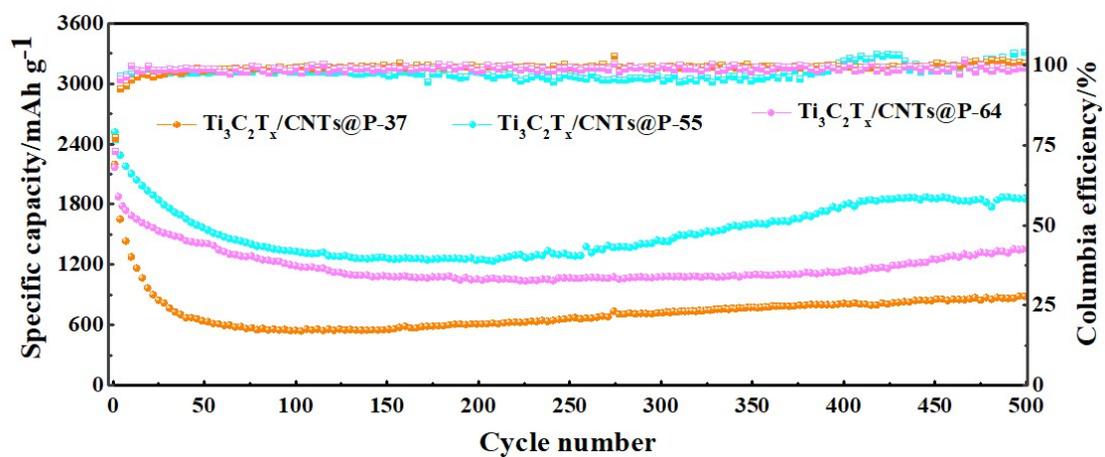
Fig. S3 The cyclability of the pure CNTs anode.

Fig. S4 Cycle performances of $Ti_3C_2T_x$/CNTs@P hybrids with different mass ratio of $Ti_3C_2T_x$/CNT to P. The mass ratios of $Ti_3C_2T_x$/CNTs to P for $Ti_3C_2T_x$/CNTs@P-37, $Ti_3C_2T_x$/CNTs@P-55 and $Ti_3C_2T_x$/CNTs@P-64 are 3:7, 5:5 and 6:4, respectively.
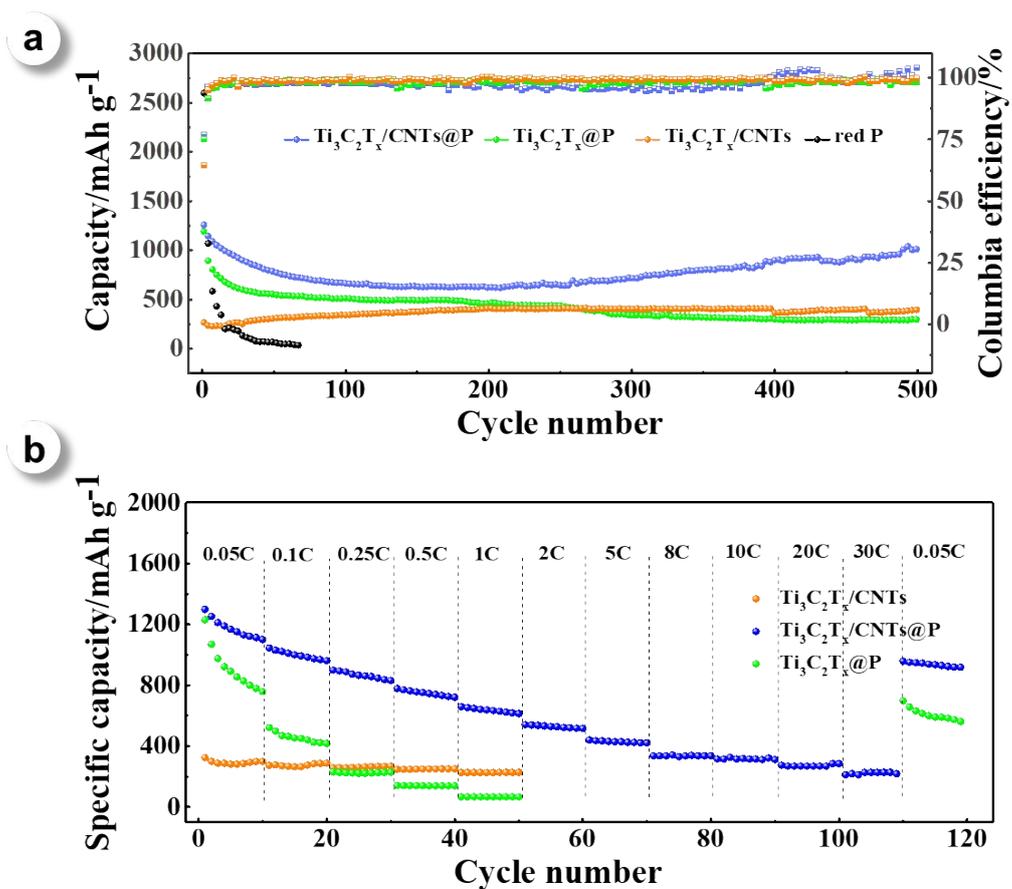
Fig. S5 Cycle performance and their columbic efficiencies of all composites at a current density of 0.05 C (a). Rate performance of all composites at different current density (b). The specific capacity is calculated based on the mass of composite.
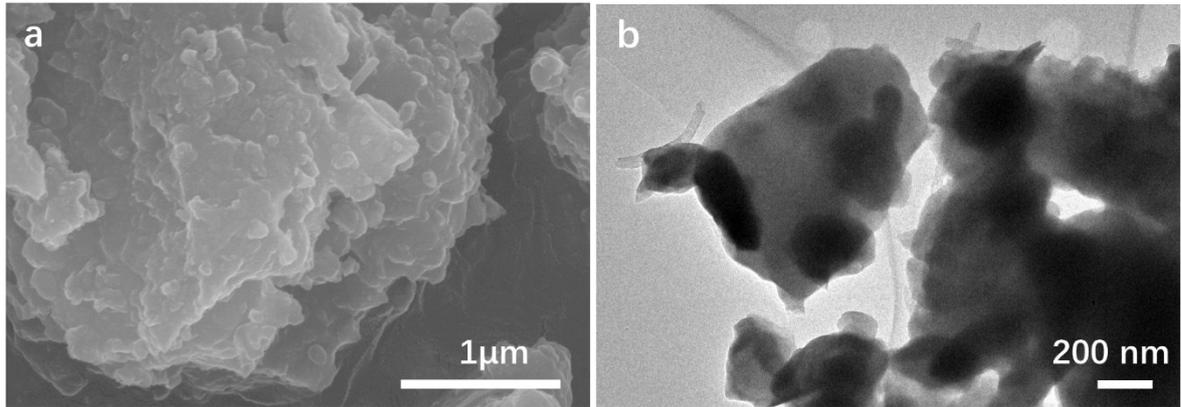
Fig. S6 SEM (a) and TEM (b) images of $Ti_3C_2T_x$/CNTs@P electrodes after 500th cycle.

The cell voltage is linearly proportional to $\sqrt{\tau}$, as shown in Fig. S6a. The diffusion coefficient (D) can be calculated from the GITT potential profiles by Fick's second law, as the following equation:

$$D = \frac{4}{\pi\tau}\left(\frac{m_B V_M}{M_B S}\right)^2 \left(\frac{\Delta E_s}{\Delta E_\tau}\right)^2$$

(equation S1)

The τ is the titration time, m_B is the electrode active material mass, S is the geometric area of the Cu foil electrode, ΔE_s is the quasi-thermodynamic equilibrium potential difference before and after the current pulse, ΔE_τ is the potential difference during current pulse, V_M is the molar volume, M_B is the molar mass.
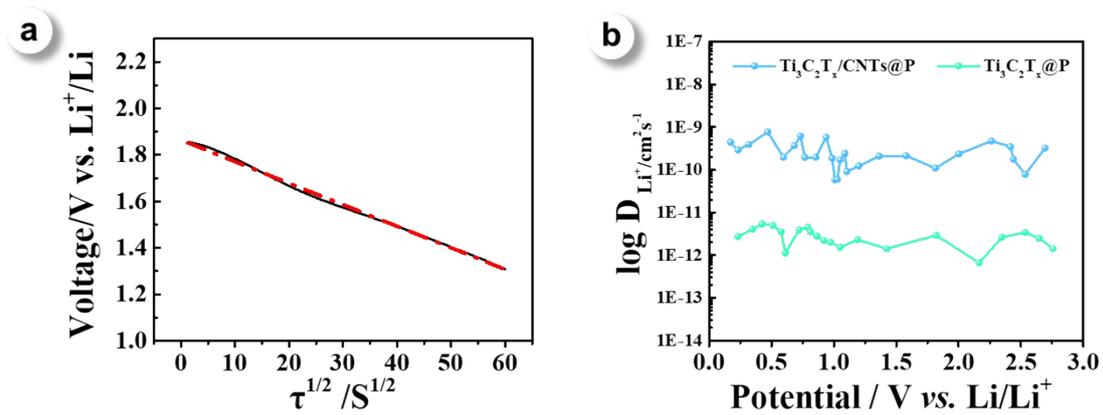
Fig. S7 Linear behavior of the potential $vs\cdot \sqrt{\tau}$ relationship in GITT at 1.824 V vs. Li$^+$/Li of forth lithiation process of Ti$_3$C$_2$T$_x$/CNTs@P for LIBs (a). Chemical diffusion coefficients of Li$^+$ as a parameter of voltage calculated by GITT for lithiation (b).