Supporting Information

$MLi_2Ti_6O_{14}$ (M= Sr, Ba, and Pb): new cathode materials for magnesium-lithium hybrid batteries

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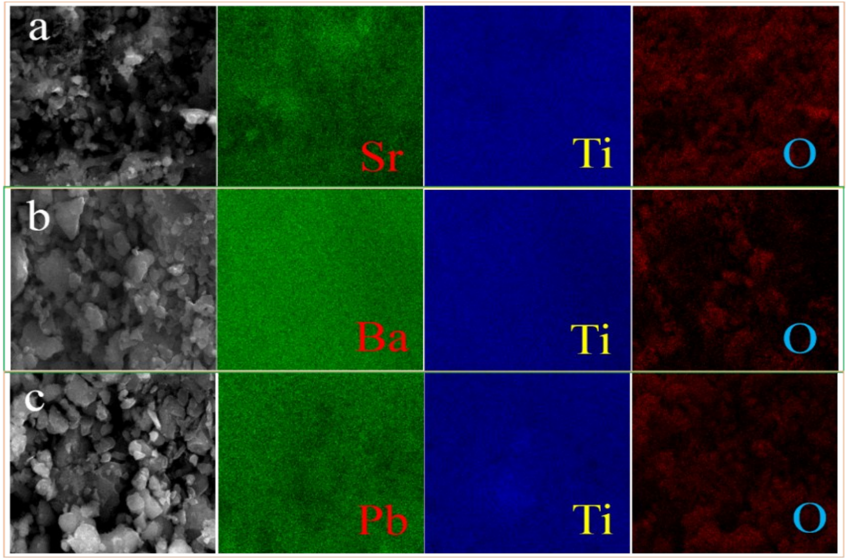

Fig. S1 SEM and element mapping images for

$SrLi_2Ti_6O_{14}$ (a), $BaLi_2Ti_6O_{14}$ (b) and $PbLi_2Ti_6O_{14}$ (c).

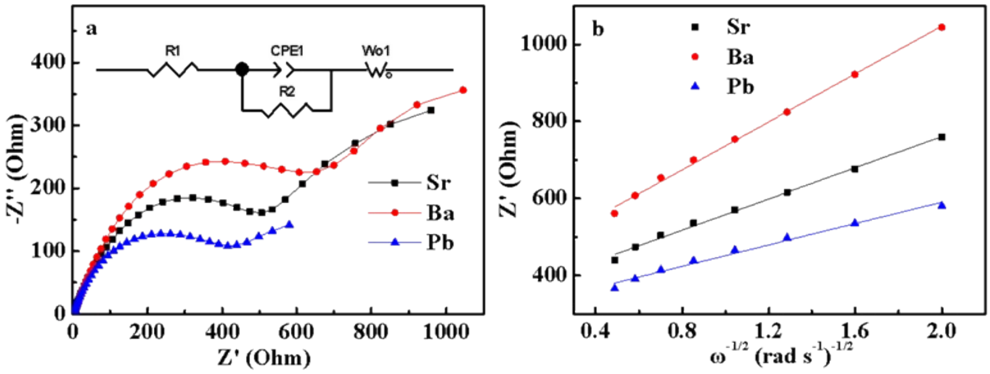

Fig. S2 (a) Electrochemical impedance spectra of $MLi_2Ti_6O_{14}$ (M= Sr, Ba, and Pb), (b) the relationship between the Z' and $\omega^{-0.5}$ in low frequency region.

The electrochemical impedance spectroscopy measurement is used to evaluate the Li^+ insertion/extraction kinetic process. All three samples display similar scatter curves with a semicircle in the high frequency region and a straight line in the low frequency region. All the curves can be fitted with the same equivalent circuit that presented in the insert pattern of Fig. S2a. In the equivalent circuit, R_1 expresses the ohmic resistance and R_2 indicates the charge transfer resistance between the active material and the electrolyte. It can be clearly observed that the charge transfer resistance for $PbLi_2Ti_6O_{14}$ is smallest among all the electrodes, meaning $PbLi_2Ti_6O_{14}$ has rapider charge transfer ability than $BaLi_2Ti_6O_{14}$ and $SrLi_2Ti_6O_{14}$ during cycles. Lithium ion diffusion coefficients are calculated according the following equations:

$$D_{Li+} = R^2T^2/2A^2n^4F^4C^2\sigma^2 \qquad (1\text{-}1)$$

$$Z_{re} = R_s + R_{ct} + \sigma\omega^{-0.5} \qquad (1\text{-}2)$$

In the two equations, R_S, R_{ct}, ω, R, T, n, A, F and C have fixed values, such as R (gas constant, 8.314 J mol^{-1} K^{-1}), T (absolute temperature, 298 K), A (surface area of the electrode, 1.13 cm^2), n (number of electrons transferred in the half-reaction for the redox couple), F (Faraday constant, 96500 C mol^{-1}) and C (concentration of lithium ions in solid), σ is the Warburg factor, which are obtained from the slope of the lines in Fig. S2b. The Li^+ diffusion coefficient of 2.02×10^{-13} cm^2 s^{-1} for $PbLi_2Ti_6O_{14}$ is higher than the values of 9.45×10^{-14} cm^2 s^{-1} and 4.0×10^{-14} cm^2 s^{-1} for $SrLi_2Ti_6O_{14}$ and $BaLi_2Ti_6O_{14}$, respectively.

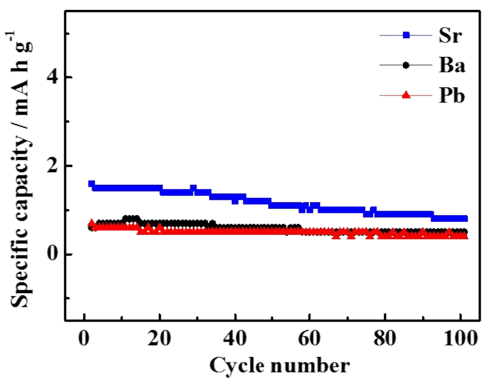

Fig. S3 Cycle performances of $MLi_2Ti_6O_{14}$ (M= Sr, Ba, and Pb) at the current density of 50 mA g^{-1} in the APC electrolyte.

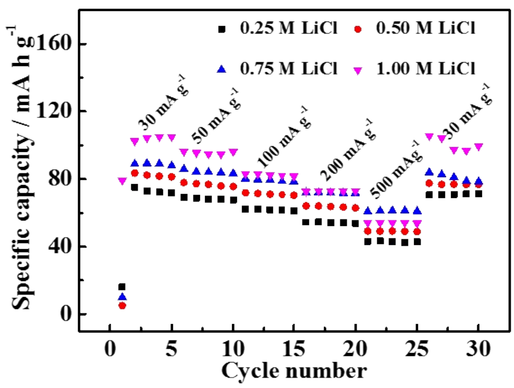

Fig. S4 Rate performances of $PbLi_2Ti_6O_{14}$ in different electrolytes.