Supporting Information

Fast Li\textsuperscript{+} Diffusion in Interlayer-Expanded Vanadium Disulfide Nanosheets for Li\textsuperscript{+}/Mg\textsuperscript{2+} Hybrid-Ion Batteries

Yuan Meng\textsuperscript{a}, Yingying Zhao\textsuperscript{a}, Dashuai Wang\textsuperscript{a}, Di Yang\textsuperscript{a}, Yu Gao\textsuperscript{a}, Ruqian Lian\textsuperscript{a}, Gang Chen\textsuperscript{a,b}, Yingjin Wei\textsuperscript{a,*}

\textsuperscript{a}Key Laboratory of Physics and Technology for Advanced Batteries (Ministry of Education), College of Physics, Jilin University, Changchun 130012, P. R. China.

\textsuperscript{b}State Key Laboratory of Superhard Materials, College of Physics, Jilin University, Changchun 130012, P. R. China.

*Corresponding author email: yjwei@jlu.edu.cn (Y. Wei); Tel: 86-431-85155126.
**Fig. S1** Schematic of the crystal structure of (a) hexagonal VS$_2$, and (b) trigonal VS$_2$.

**Fig. S2** V and S elemental mappings of the VS$_2$ nanosheets.
**Fig. S3** Cycling performance of the VS$_2$ nanosheets in MRB at the current density of 50 mA·g$^{-1}$.

**Fig. S4** CV curve of a three-electrode cell, using the APC+LiCl/THF hybrid electrolyte, stainless steel foil as the working electrode, and Mg foil as the reference and counter electrodes.
**Fig. S5** Charge-discharge curves of the VS$_2$ nanosheets at different current densities in LMIB.

**Fig. S6** (a) Rate capability and (b) charge-discharge curves at different current densities of the VS$_2$ nanosheets in LIB.
Fig. S7 (a) Surface and (b) cross section SEM images of the Mg anode after 500 cycles.

Fig. S8 Simulated XRD patterns of pristine VS$_2$, Li$^+$, THF, Ph$_2$Mg and Ph$_4$Al$^+$ inserted VS$_2$. 
**Fig. S9** FTIR pattern of the VS$_2$ nanosheets in LMIB collected after the first charge.

**Fig. S10** V, S, Mg and Al elemental mappings of the charged VS$_2$ electrode in LMIB.
Fig. S11 GITT curves of the VS$_2$ nanosheets in LIB and LMIB cells during discharge process.