Supporting Information:

**Designed Synthesis of Unique Single-crystal Fe-doped LiNiPO$_4$ Nanomesh as the Enhanced Cathode for Lithium Ion Batteries**

**Figure S1.** Schematic illustration of Fe-doped LiNiPO$_4$ and Li ion diffusion pathway along [010].
Figure S2. (a) SEM image and (b) HRTEM image of Fe-doped NiNH₄PO₄·H₂O nanosheets.
Figure S3. Comparison of NiNH₄PO₄·H₂O and Fe-doped NiNH₄PO₄·H₂O. (a) XRD patterns and (b) Optical images of NiNH₄PO₄·H₂O nanosheets before and after doping with Fe.
Figure S4. XPS spectra of (a) Ni 2p, (b) Fe 2p, (c) P 2p and (d) O 1s of the hierarchical Fe-doped LiNiPO$_4$ nanomesh.
Figure S5. The schematics to introduce the mechanism through Fe-doped NiNH$_2$PO$_4$·H$_2$O nanosheet to Fe-doped LiNiPO$_4$ nanomesh while maintaining the single crystal feature. From the calculation based on the (001) crystal plane of the precursor and the final samples, the crystal mismatch is close to 0%.
Figure S6. BET profile of the hierarchical LiNiPO$_4$ nanomesh.
Figure S7. (a) XRD pattern of pure LiNiPO$_4$ nanomesh. (b) The corresponding EDS analysis.
Figure S8. SEM images at different resolutions of Fe-doped LiNiPO₄ (a), (c) and LiNiPO₄ nanomesh (b), (d) for comparison.
Figure S9. (a) The galvanostatic charge-discharge profiles of pure LiNiPO$_4$ nanomesh over 30 cycles at the rate of 0.1C. (b) CV profile of pure LiNiPO$_4$ nanomesh for 2.0-4.95 V. (c) Comparison of galvanostatic measurement of Fe-doped LiNiPO$_4$ and LiNiPO$_4$ nanomesh.
Figure S10. (a) SEM and (b) TEM images to clarify the well-maintained nanomesh structure after 100 cycles of galvanostatic charge-discharge.
**Figure S11.** SEM image of LiNiPO$_4$ nanomesh after 30 cycles of galvanostatic charge-discharge.
Figure S12. Comparison of AC impedance of Fe-doped LiNiPO$_4$ nanomesh (red dot line) and LiNiPO$_4$ nanomesh (green dot line) from 0.01Hz to 100 kHz.
<table>
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<tr>
<th>Composite</th>
<th>Conductivity / S cm⁻¹ (298K)</th>
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<tr>
<td>LiNiPO₄</td>
<td>3.24 x 10⁻⁴</td>
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<tr>
<td>Fe-doped LiNiPO₄</td>
<td>5.02 x 10⁻⁷</td>
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*Table S1*: Conductivity of both LiNiPO₄ and Fe-doped LiNiPO₄ for comparison.