Supplementary Information

Wide Electrochemical Window Ionic Salt for use in Electropositive Metal Electrodeposition and Solid State Li-ion Batteries

Sankaran Murugesan\textsuperscript{a}, Oliver A. Quintero\textsuperscript{a}, Brendan P. Chou\textsuperscript{a}, Penghao Xiao\textsuperscript{a}, Kyusung Park\textsuperscript{b}, Justin W. Hall\textsuperscript{a}, Richard A. Jones\textsuperscript{a}, Graeme Henkelman\textsuperscript{a}, John B. Goodenough\textsuperscript{b} and Keith J. Stevenson\textsuperscript{a*}

\textsuperscript{a}Department of Chemistry and Biochemistry, The University of Texas at Austin, 1 University Station, Austin, Texas, 78712, USA

\textsuperscript{b}Texas Materials Institute and Materials Science and Engineering Program, The University of Texas at Austin, Austin, Texas 78712, United States

* Corresponding author: Keith J. Stevenson (stevenson@mail.cm.utexas.edu) (T) +1-512- 232-9160; (F) +1-512-471-8696
Figure S1a. $^1$H NMR spectrum of PP$_{13}$PF$_6$ in CD$_2$Cl$_2$.

Figure S1b. $^{13}$C NMR spectrum of PP$_{13}$PF$_6$ in CD$_2$Cl$_2$. 
Figure S1c. $^{19}$F NMR spectrum of PP$_{13}$PF$_6$ in CD$_2$Cl$_2$.

Figure S1d. $^{31}$P NMR spectrum of PP$_{13}$PF$_6$ in CD$_2$Cl$_2$. 
**Figure S1e.** FTIR (diamond ATR) spectrum of PP$_{13}$PF$_6$.

**Figure S1f.** Positive ion mass spectrum of PP$_{13}$PF$_6$. 
Figure S1g. Negative ion mass spectrum of PP$_{13}$PF$_6$.

Figure S2. XRD of electrodeposited Sn over stainless steel electrode (red line) and blue lines shows the standard Sn (JCPDS#65-2631).
**Figure S3.** Experimental powder XRD of PP_{13}PF_{6} (red line) compared with the theoretically generated XRD pattern (blue line) using the single crystal structure.

**Figure S4.** Calculated electrostatic potential of Li showing the lithium vacuum level at 2.33 eV. The Fermi-level is calculated as -0.67 eV.
Figure S5. Calculated electrostatic potential of PP$_{13}$PF$_6$, showing a vacuum level of 2.39 eV and a Fermi-level of -6.20 eV.

Figure S6. Cyclic voltammograms of PP$_{13}$PF$_6$ using the asymmetric cell (Li metal/ PP$_{13}$PF$_6$ + 10wt% LiTFSI)/stainless steel block) with different temperatures at the scan rate of 2 mV/s.
Table S1. Impedance and conductivity data of symmetric and asymmetric cells.

<table>
<thead>
<tr>
<th>Symmetric cell</th>
<th>Temp (°C)</th>
<th>Temp (K)</th>
<th>(1/K)</th>
<th>R_p</th>
<th>Conductivity (σ)</th>
<th>log (σ)</th>
<th>ln (σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22.7</td>
<td>295.7</td>
<td>0.00338</td>
<td>76718</td>
<td>2.06E-06</td>
<td>-5.6852</td>
<td>-13.091</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>305</td>
<td>0.00328</td>
<td>33994</td>
<td>4.66E-06</td>
<td>-5.3317</td>
<td>-12.277</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>308</td>
<td>0.00325</td>
<td>24387</td>
<td>6.49E-06</td>
<td>-5.18746</td>
<td>-11.945</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>313</td>
<td>0.00320</td>
<td>5059</td>
<td>3.13E-05</td>
<td>-4.50436</td>
<td>-10.372</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>318</td>
<td>0.00315</td>
<td>2158</td>
<td>7.34E-05</td>
<td>-4.13435</td>
<td>-9.520</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Asymmetric cell</th>
<th>Temp (°C)</th>
<th>Temp (K)</th>
<th>(1/K)</th>
<th>R_p</th>
<th>Conductivity (σ)</th>
<th>log (σ)</th>
<th>ln (σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
<td>298</td>
<td>0.00335</td>
<td>1.08E+05</td>
<td>3.78E-07</td>
<td>-6.42296</td>
<td>-14.789</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>303</td>
<td>0.00330</td>
<td>1.66E+04</td>
<td>9.31E-06</td>
<td>-5.03105</td>
<td>-11.584</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>308</td>
<td>0.00325</td>
<td>9.64E+03</td>
<td>1.61E-05</td>
<td>-4.79401</td>
<td>-11.039</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>313</td>
<td>0.00320</td>
<td>2.24E+03</td>
<td>6.90E-05</td>
<td>-4.16118</td>
<td>-9.581</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>318</td>
<td>0.00314</td>
<td>6.48E+02</td>
<td>2.39E-04</td>
<td>-3.62166</td>
<td>-8.339</td>
</tr>
</tbody>
</table>