Supporting information

Phosphonated Phenol-formaldehyde Based High-temperature Proton Exchange Membrane with Intrinsic Protonic Conductors and Proton Transport Channels

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Fig. S1 GPC chart of phenol-formaldehyde oligomer.
Fig. S2. AFM images of 40PPF-Na/PBI membrane

Fig. S3. $^1$H-NMR spectrum of phenol-formaldehyde oligomer in DMSO-$d_6$. 
Fig. S4. $^1$H-NMR spectrum of phosphonated phenol-formaldehyde oligomer in DMSO-$d_6$.

Fig. S5 $^{31}$P-NMR spectrum of phosphonated phenol-formaldehyde oligomer in DMSO-$d_6$
Fig. S6 Thermogravimetric curve of phosphonated phenol-formaldehyde oligomer in N$_2$ atmosphere.

Fig. S7 Proton conductivity of PTFE/40PPF.
Fig. S8 Single cell performance of PBI membrane at 140°C and 160°C without humidification.