Supplemental Information

High Rate and Stable Symmetric Potassium ion Batteries Fabricated with Flexible Electrodes and Solid-state Electrolytes

Ke Lu[a,1], Hong Zhang[b,1], Siyuan Gao[a], Yingwen Cheng[a,*], Houyi Ma[b,*]

[a] Department of Chemistry and Biochemistry, Northern Illinois University, DeKalb, IL 60115, United States

[b] Key Laboratory for Colloid and Interface Chemistry of State Education Ministry, School of Chemistry and Chemical Engineering, Shandong University, Jinan, Shandong, 250100, China

E-mail: ycheng@niu.edu (Y.C.) and hyma@sdu.edu.cn (H.M.)

[1]Authors with equal contribution.

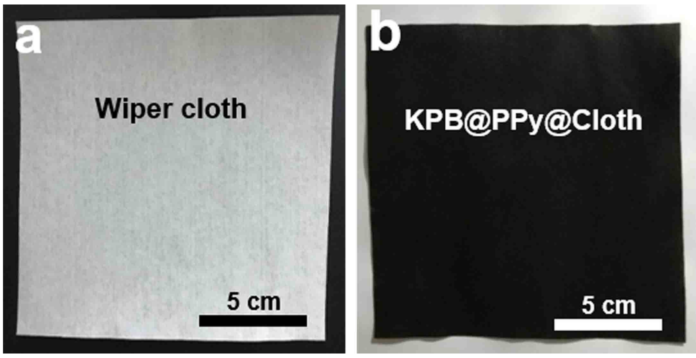

Figure S1: Photographs of (a) flexible and mechanically strong commercial wiper cloth and (b) as-synthesized KPB@PPy@Cloth composite cloth. The large size of these clothes suggest our method of electrode fabrication is scalable.

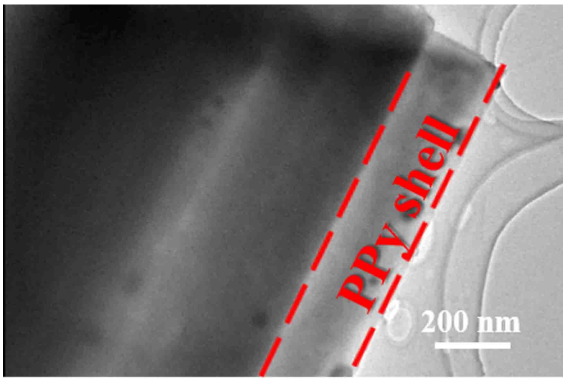

Figure S2: TEM image of the PPy@Cloth composite that shows the PPy shell formed uniform coatings around the cloth fiber and had thickness of ~ 200 nm.

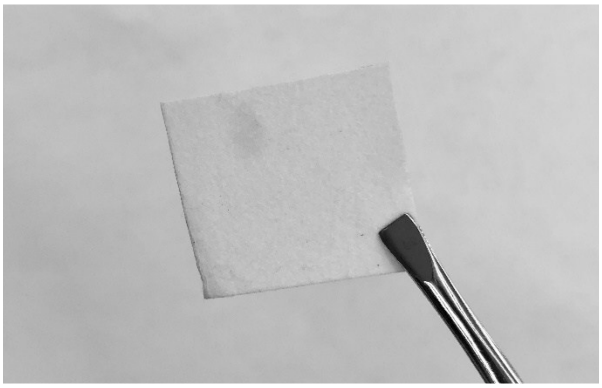

Figure S3: Photograph of a piece of pristine wiper cloth (without ppy coating) after immersing in the KPB particle synthesis solution. The cloth had its original white color and didn't show any signature color of KPB particles. We conclude that KPB particles nucleate and grow almost exclusively in solution, as opposed to grow on the surface of the cloth.

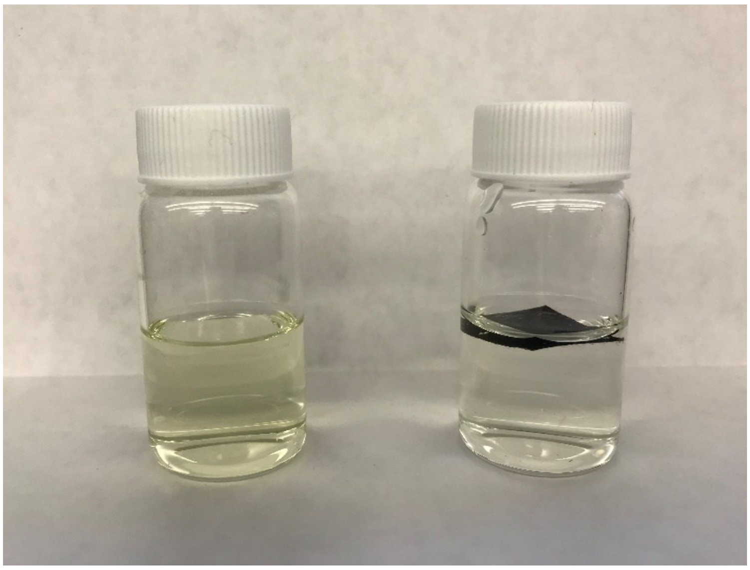

Figure S4: Comparison of the adsorption ability of a piece of pristine wiper cloth (left) and a piece of PPy@Cloth (right) when immersed in 0.1M $K_4Fe(CN)_6$ solution. The PPy coated wiper cloth showed strong adsorption of $[Fe(CN)_6]^{4-}$ as evidenced by noticeable discoloration after 1 hour.

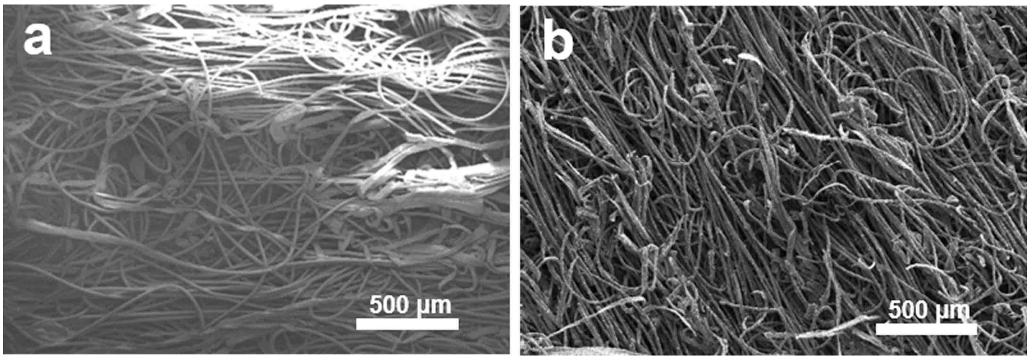

Figure S5. SEM images of (a) PPy@Cloth electrodes and (b) KPB@PPy@Cloth electrodes.

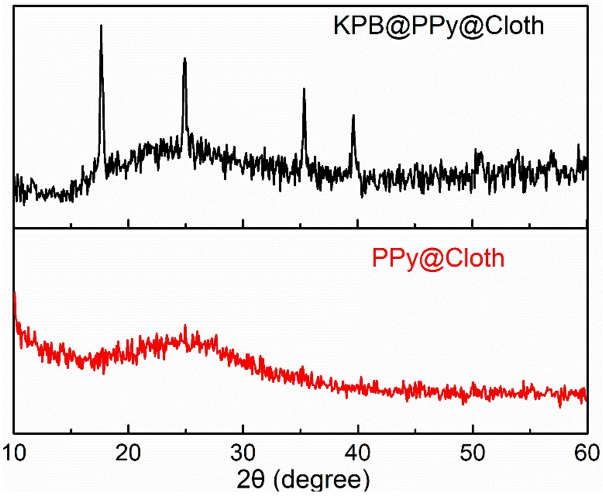

Figure S6. XRD patterns of (top) KPB@PPy@Cloth and (bottom) PPy@Cloth electrodes.

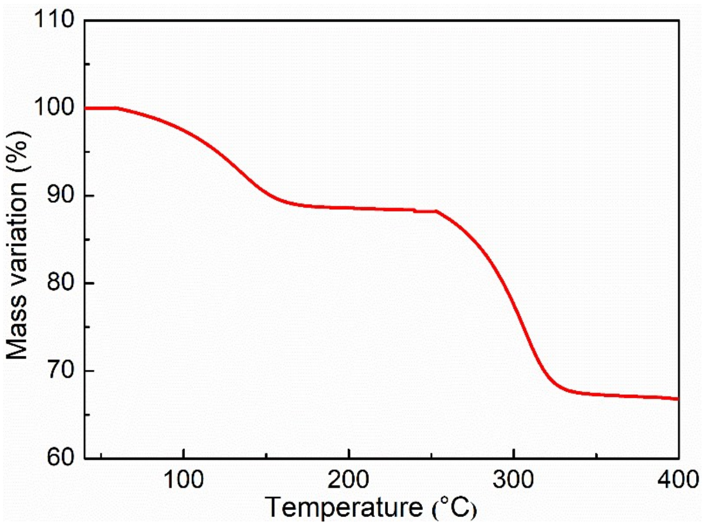

Figure S7. TGA curve of the as-prepared potassium Prussian blue nanoparticles.

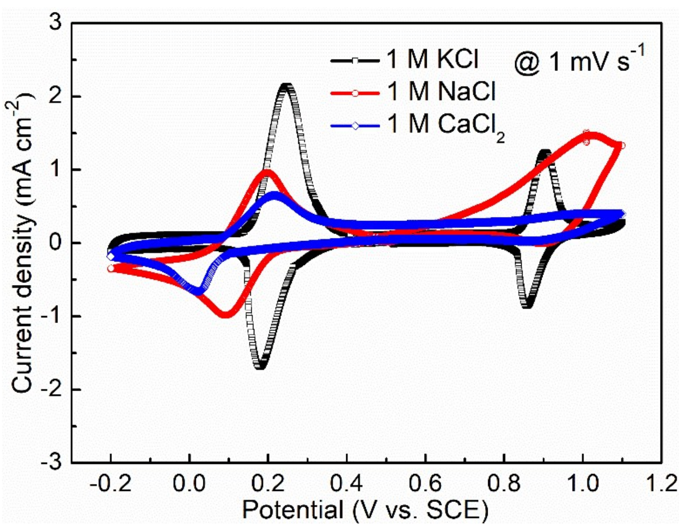

Figure S8. Comparison of CV curves of Cloth@PPy@KPB electrodes in different electrolytes, the scan rate was 1.0 mV/s.

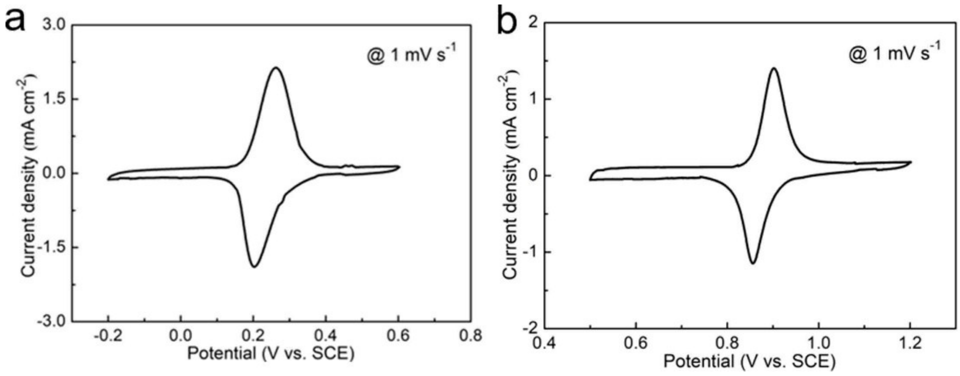

Figure S9: CV curves of KPB@PPy@Cloth electrodes acquired at 1 mV/s in the voltage window of (a) -0.2 - 0.6 V and (b) 0.5 - 1.2 V.

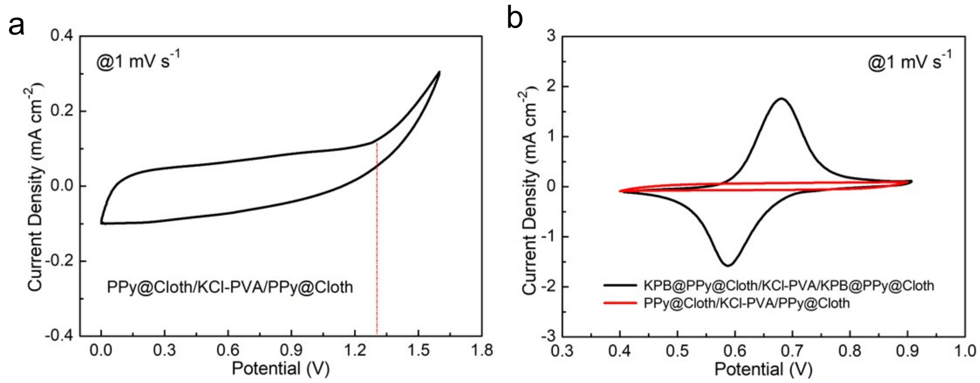

Figure S10: a) CV curve of the gel electrolyte that shows it has a stability window of about 1.3V,and there was noticeable current increases due to electrolyte decomposition beyond 1.3V: b) comparison of CV curves acquired from KPB@PPy@Cloth electrodes and PPy@Cloth electrodes immersed in the gel electrolyte. The emphasis here is to show that the gel electrolyte itself won't contribute to faradic currents and the observed redox peaks were mainly from reactions with KPB particles.

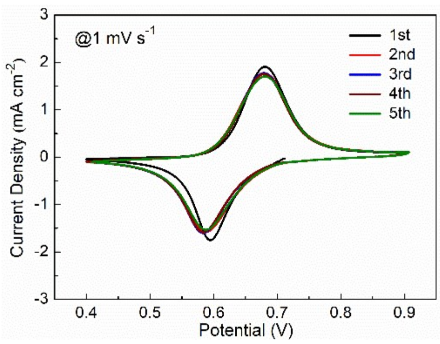

Figure S11: Initial 5 CV cycles of the full cell, the data was acquired at 1 mV s^{-1}.

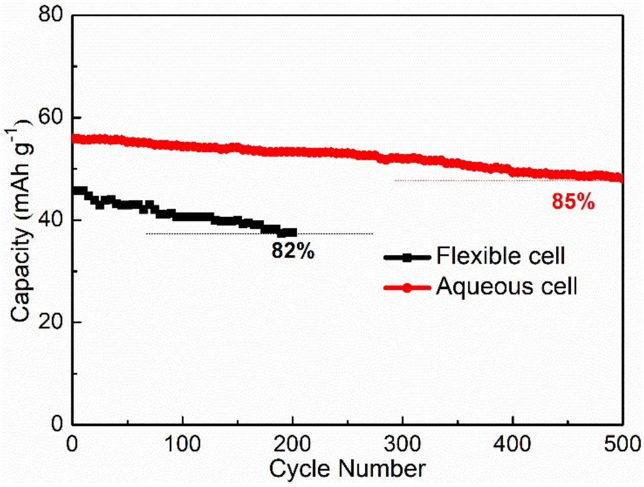

Figure S12. Comparison of cyclic stability at a current density of 500 mA g^{-1} for symmetric full cells assembled with aqueous electrolytes (0.1 M KCl) and flexible solid-state gel electrolytes.

Table S1. Element analysis results of the as-synthesized potassium Prussian blue particles for accurate determination of their chemical formula.

Element	C	N	Fe	H	K	H_2O (TGA)
wt.%	21.21	24.82	34.71	1.25	7.76	11.37

Table S2. Comparison of electrochemical performance of Prussian blue based electrodes in similar applications.

	Materials	**Capacity/current density**		**Capacity retention (%)/cycles**	**Ref.**
1	**KPB@PPy@Cloth**	**125 mAh g^{-1}/ 100 mA g^{-1}**	**52 mAh g^{-1}/ 2000 mA g^{-1}**	**89.5%/500**	**This work**
2	Cubic Prussian blue crystals	80 mAh g^{-1}/ 500 mA g^{-1}	26 mAh g^{-1}/ 5000 mA g^{-1}	91%/1200	Zhou et al. [1]
3	$K_2FeFe(CN)_6$	121.4 mAh g^{-1} /0.5 C	41 mAh g^{-1}/ 60 C	95.8%/200	Liu et al. [2]
4	Prussian blue particle	121.4 mAh g^{-1}/ 100 mA g^{-1}	66 mAh g^{-1}/ 500 mA g^{-1}	22.8%/1100	Padigi et al. [3]
5	KPB nanoparticle	75 mAh g^{-1}/ 50 mA g^{-1}	36 mAh g^{-1}/ 400 mA g^{-1}	86.5%/100	Zhang et al. [4]
6	$FeFe(CN)_6$ nanocube	130 mAh g^{-1} /100 mA g^{-1}	75 mAh g^{-1}/ 20 C	77%/100	Zhang et al. [5]

Reference:

1. L. Zhou, M. Zhang, Y. Wang, Y. Zhu, L. Fu, X. Liu, Y. Wu and W. Huang, *Electrochimica Acta*, 2017, **232**, 106-113.
2. C. Liu, X. Wang, W. Deng, C. Li, J. Chen, M. Xue, R. Li and F. Pan, *Angewandte Chemie International Edition*, 2018, **57**, 7046-7050.
3. P. Padigi, J. Thiebes, M. Swan, G. Goncher, D. Evans and R. Solanki, *Electrochimica Acta*, 2015, **166**, 32-39.
4. C. Zhang, Y. Xu, M. Zhou, L. Liang, H. Dong, M. Wu, Y. Yang and Y. Lei, *Advanced Functional Materials*, 2017, **27**, 1604307.
5. J. Zhang, D. Zhang, F. Niu, X. Li, C. Wang and J. Yang, *ChemPlusChem*, 2017, **82**, 1170-1173.