Electronic Supporting Information

Electric double layer capacitor and their improved capacitance using redox additive electrolyte

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Fig. S1

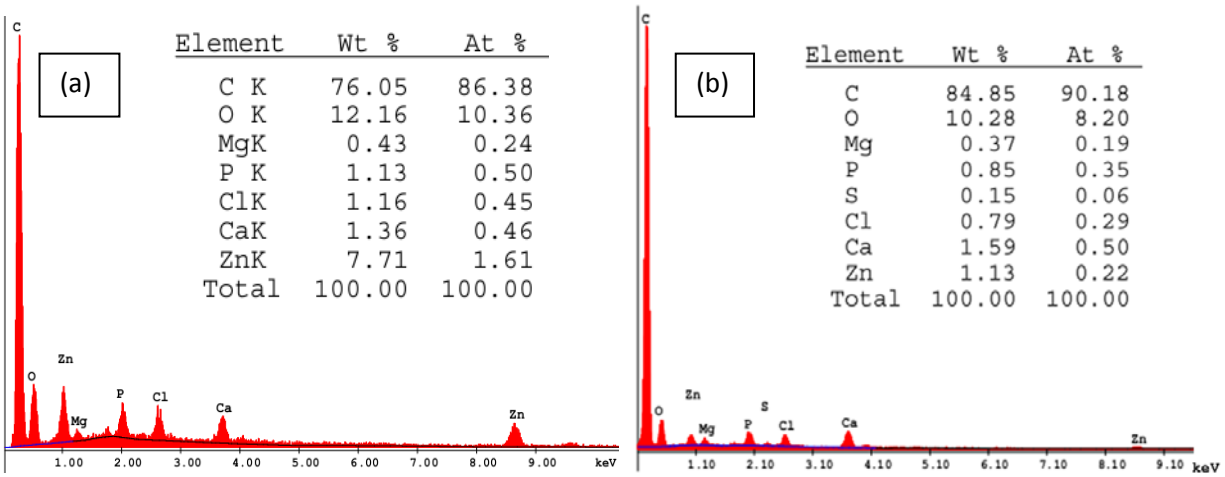

Fig. S1: the EDAX spectra and observed composition of Zn-1 and Zn-5

Fig. S2

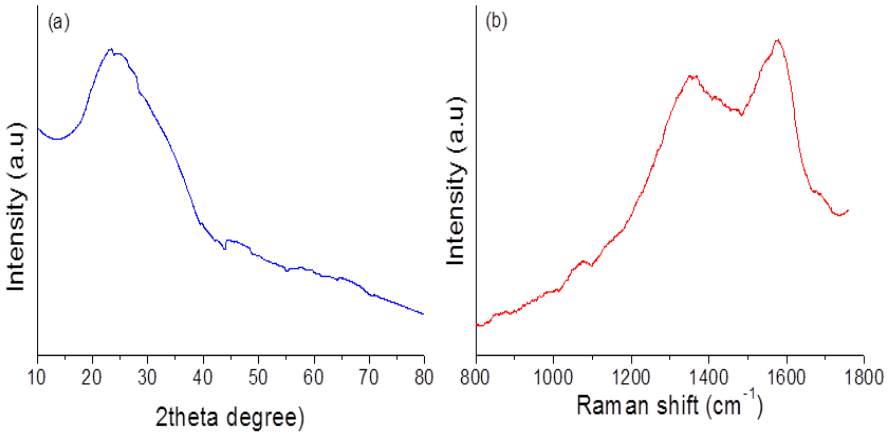

Fig. S2: the XRD pattern and Raman spectra and observed composition of Zn-1.

Fig. S3

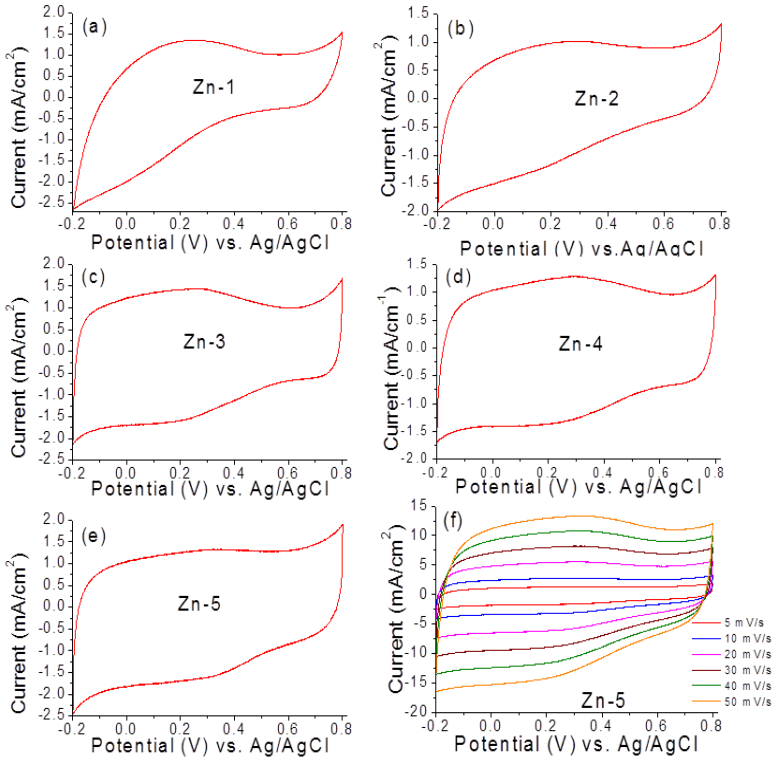

Fig. S3: CV curves of AC electrodes at 5 mV/s and Zn-5 at 5-50 mV/s.

The shape variation in CV curve from oval to almost rectangular shape indicated the improved performance of the AC electrodes resulting from improved conductivity which is due to the decreasing content of oxygen in AC with respect to carbonization temperature.[1]

Fig. S4

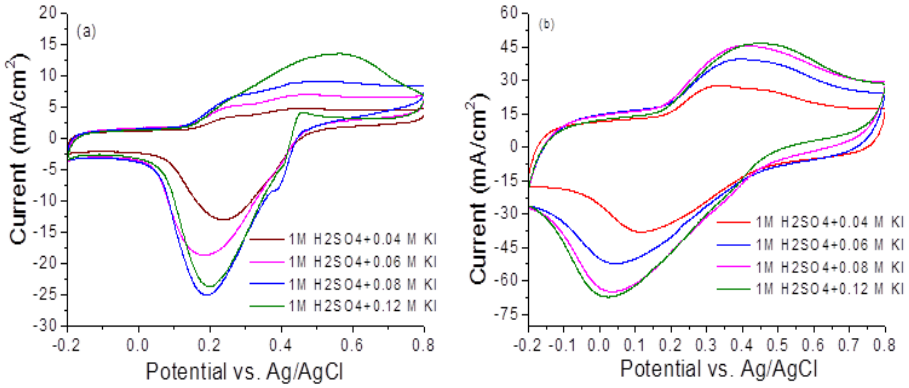

Fig. S4: CV curves optimized electrode (Zn-5) at (a) 5 and (b) 50 mV/s in different concentration of KI.

To optimizing the KI added 1M H_2SO_4 electrolyte, the different KI amount such as 0.04M, 0.06M, 0.08M and 0.12M are used, individually. The average discharge current were calculated form CV curve such as 3, 4.4, 5.5 and 5.7 mA at lower scan rate of 5 mV/s and 17.4, 23.7, 26.7 and 26 mA at higher scan rate of 50 mV/s for 0.04 M, 0.06 M, 0.08 M and 0.12 M of KI. Whereas, the maximum discharge current value (5.7 mA) is received for 0.12 M of KI at lower scan rate but which is delivered the lower discharge current (26 mA) at higher scan rate than 0.08 M of KI (26.6 mA) . So, that the 0.08M KI added 1M H_2SO_4 electrolyte as considered as the best system for AHK.[2]

Fig. S5

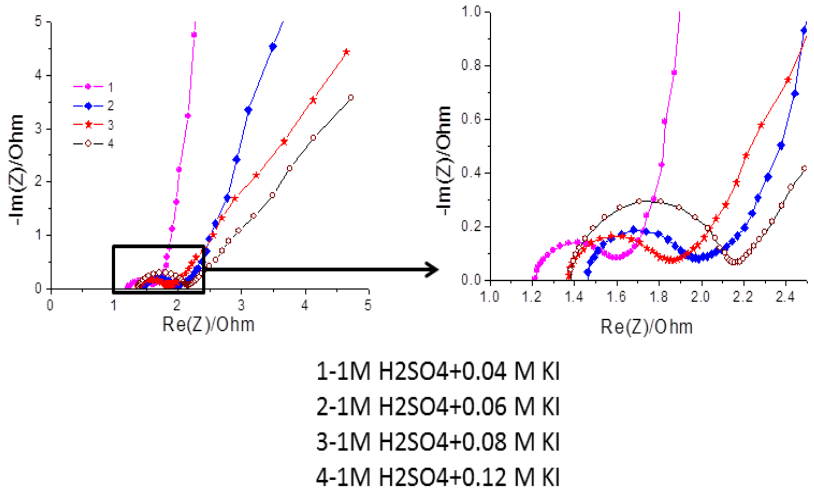

Fig. S5: Nyquist plots of optimized electrode (Zn-5) in different concentration of KI.

Among the tested KI (as 0.04M, 0.06M, 0.08M and 0.12M) mixed 1M H_2SO_4 electrolytes the intermediate electrochemical conductive behaviour (table S1) has obtained for 0.08M KI added 1M H_2SO_4 electrolyte in that which is considered as optimized additive electrolyte for AHK.

Table S1:

KI amount (in M)	Solution resistance (R_s)	Charge transfer resistance (R_{ct})
0.04	1.21	0.39
0.06	1.46	0.5
0.08	1.37	0.47
0.12	1.38	0.77

Fig. S6

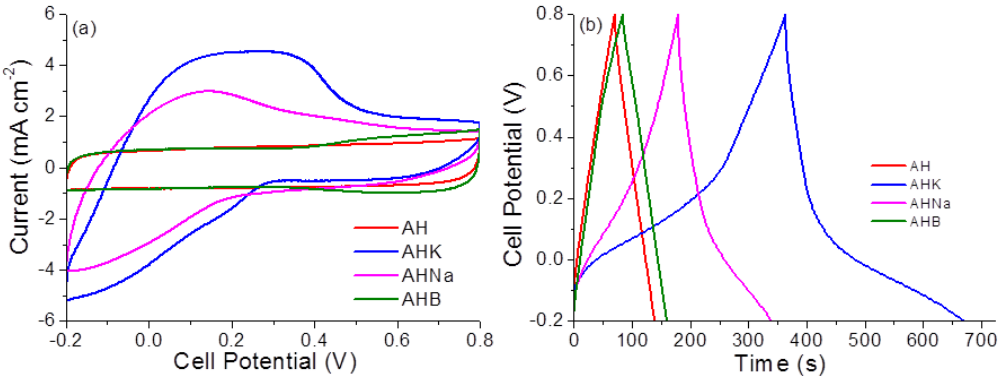

Fig. S6: CV curve and charge discharge curve of AH, AHK, AHNa and AHB at 5 mV/s and 2 mA cm^{-2}.

Fig. S7

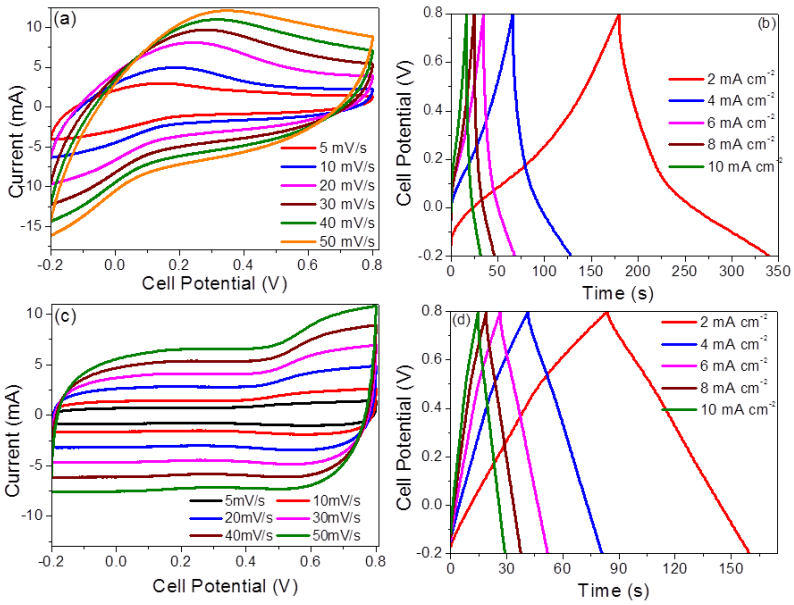

Fig. S7: (a, c) CV curves at 5-50 mV/s and (b, d) charge-discharge curves at 2, 4, 6, 8 and 10 mA cm^{-2} of AHNa and AHB

Fig. S8

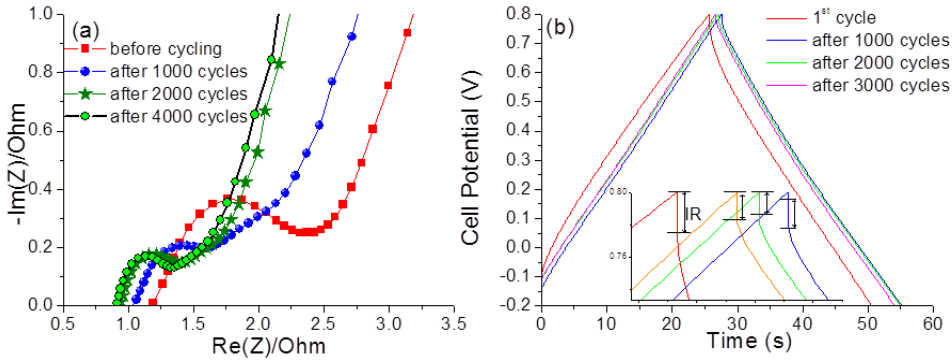

Fig. S8: (a) Nyquist plots and (b) charge discharge curves (at 5 mA cm^{-2}) of AH at before and after cycles

The Nyquist plot clearly shows that the decreasing of resistance (increasing the conductive) behaviour of the AH with respect to cycles which is associated with the possible of their removal of oxygen during cycles. Moreover, the discharging time also increasing with cycles, it tells the improved discharge capacitance of the AH. In addition, IR drop also decreased with cycles, reveals the improved conductivity of the AH.[3]

References:

1 Z. Lin, Y. Liu, Y. Yao, O. J. Hildreth, Z. Li, K. Moon and C. P. Wong, *J. Phys. Chem. C*, 2011, **115**, 7120.

2 W. Chen, R. B. Rakhi, L. Hu, X. Xie, Y. Cui and H. N. Alshareef, *Nano Lett.*, 2011, **11**, 5165.

3 Y. Chen, X. Zhang, D. Zhang, P. Yu and Y. Ma, *Carbon*, 2011, **49**, 573.