Influence of $K_3Fe(CN)_6$ on the electrochemical performance of carbon derived from waste tyres by K_2CO_3 activation

Bello[1, 2], D. Y. Momodu[2], M. J. Madito[2], K Makgopa[3], Khavharendwe M. Rambau[4], Julien Dangbegno[2] Nicholas M. Musyoka[4] and N. Manyala[2*]

[1]Department of Materials Science and Engineering, African University of Science and Technology (AUST), Abuja, Nigeria

[2]Department of Physics, Institute of Applied Materials, SARCHI Chair in Carbon Technology and Materials, University of Pretoria, Pretoria 0028, South Africa.

[3]Department of Chemistry, Tshwane University of Technology, Pretoria 0001, South Africa.

[4]HySA Infrastructure Center of Competence, Materials Science and Manufacturing Council for Scientific and Industrial Research (CSIR), Meiring Naude Road, Brummeria, 395 Pretoria, 0001, South Africa

[*]Email address: ncholu.manyala@up.ac.za (N. Manyala)

Corresponding author Tel: +27 (0)12 420 3549, Fax: +27 (0)12 420 2516

Supplementary Material

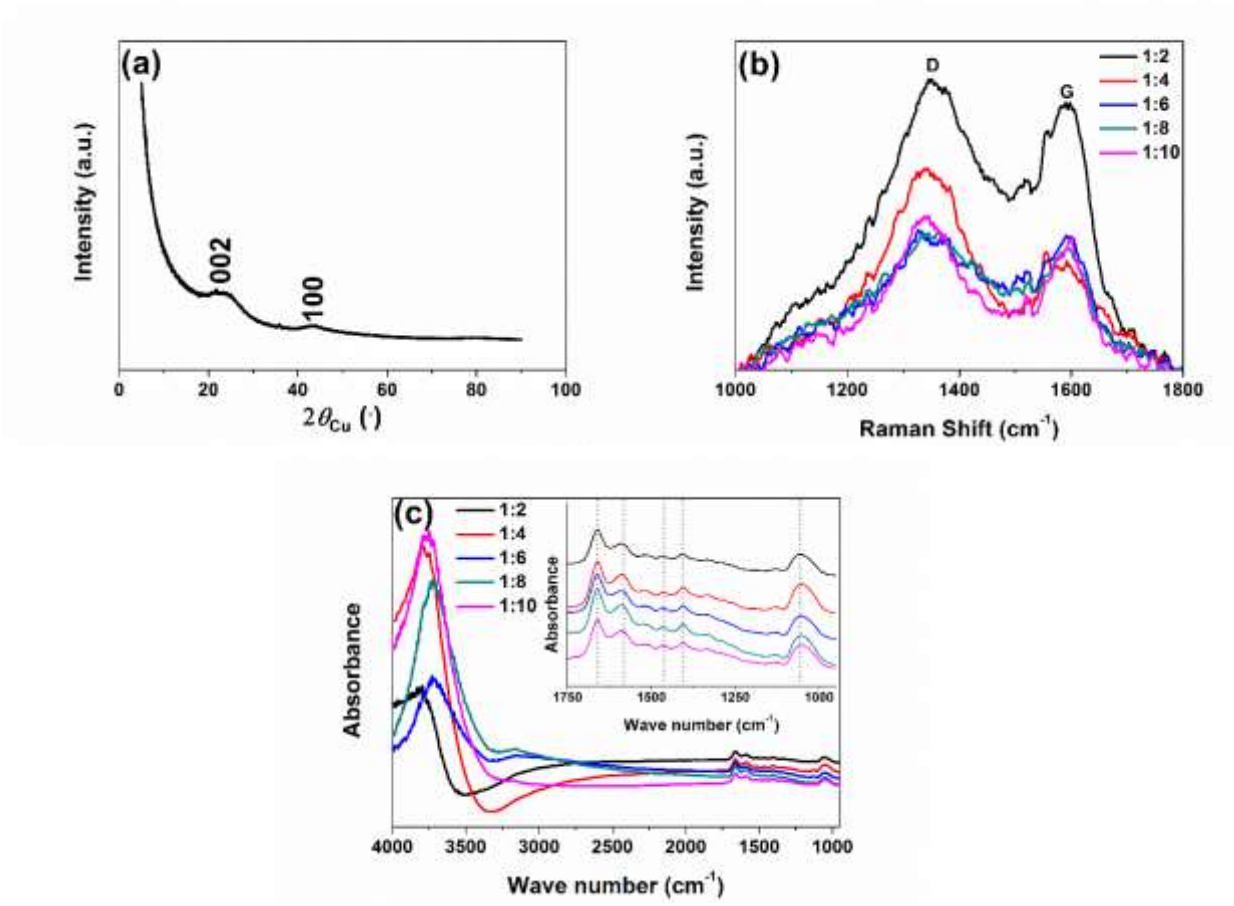


Figure S1. (a) XRD of the optimised 1:8 carbon material, (b) Raman spectra and (c) the FTIR absorbance spectra for the activated carbon samples for varying K_2CO_3 content

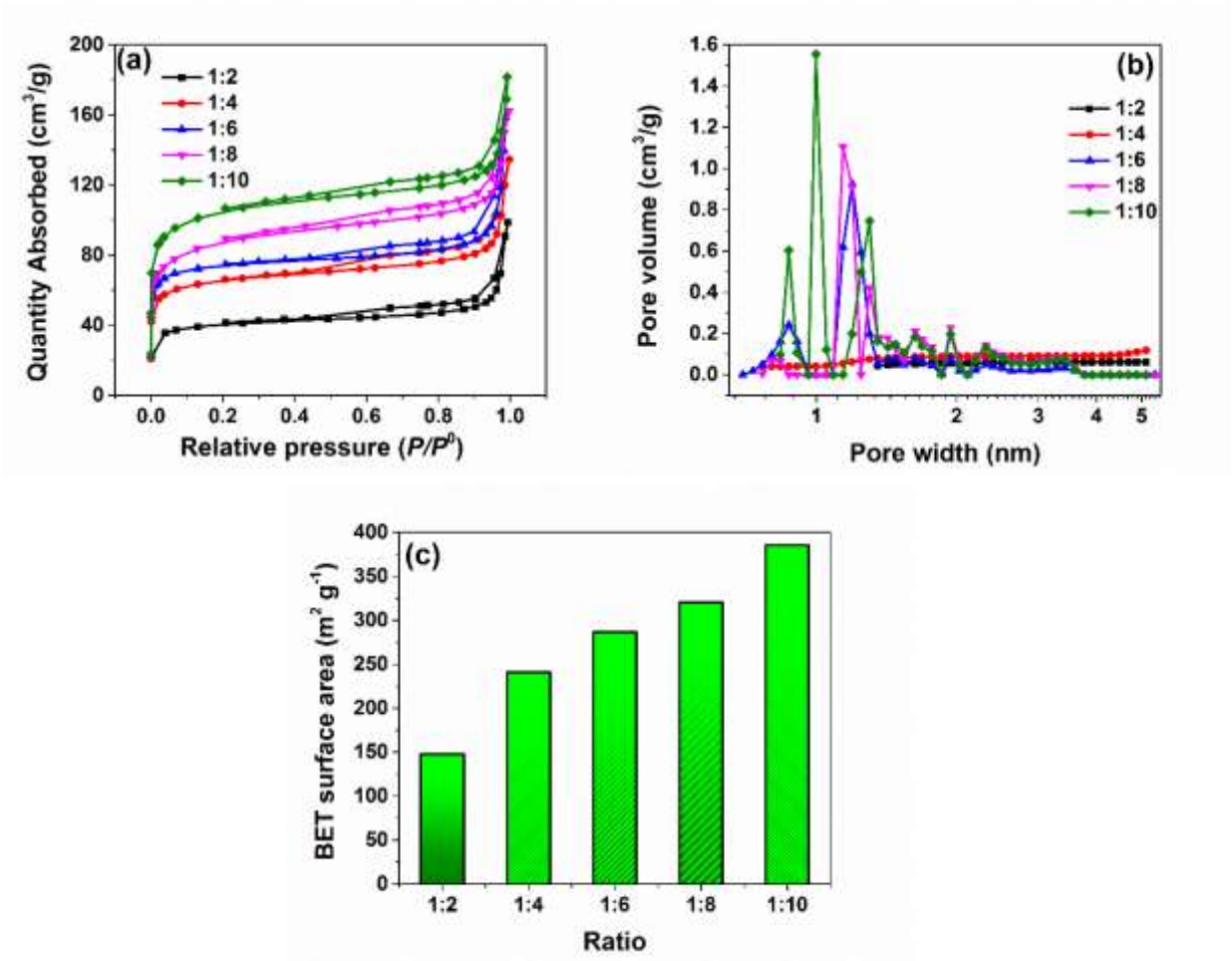
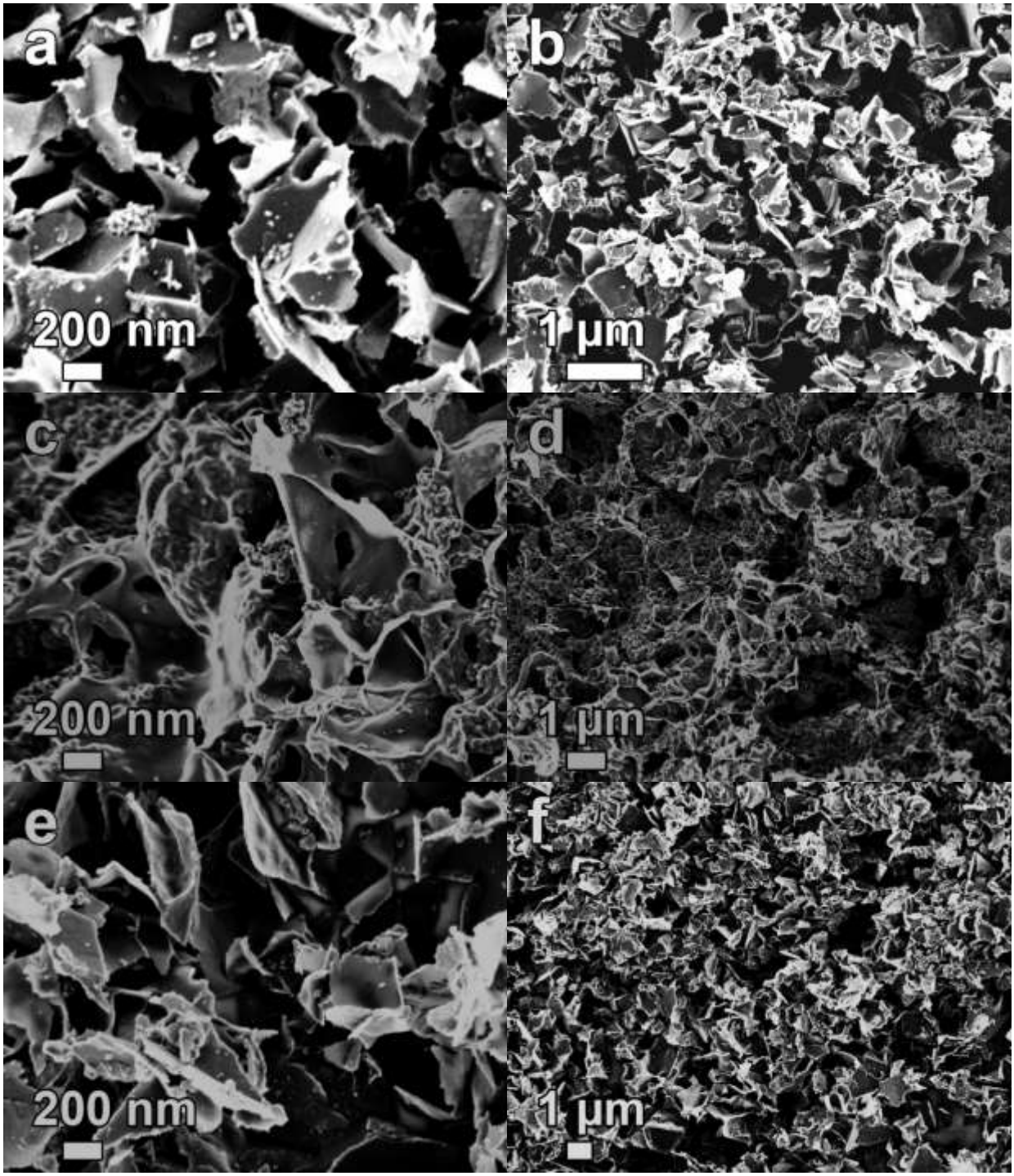


Figure S2. (a) N_2 isotherms and (b) NLDFT PSD of all the five samples (c) bar chart showing SSA vs. raw material: K_2CO_3 ratio for all the five samples.

Table S1 SSA properties extracted from gas sorption analysis

Samples	BET SSA ($m^2 g^{-1}$)	Total pore volume (cm^3/g)	Micropore volume (cm^3/g)
AC-1 (1:2)	147.9	0.058	0.041
AC-2 (1:4)	240.9	0.096	0.065
AC-3 (1:6)	286.6	0.108	0.078
AC-4 (1:8)	320.4	0.132	0.095
AC-5 (1:10)	385.4	0.157	0.088


a
200 nm
b
1 µm
c
200 nm
d
1 µm
e
200 nm
f
1 µm

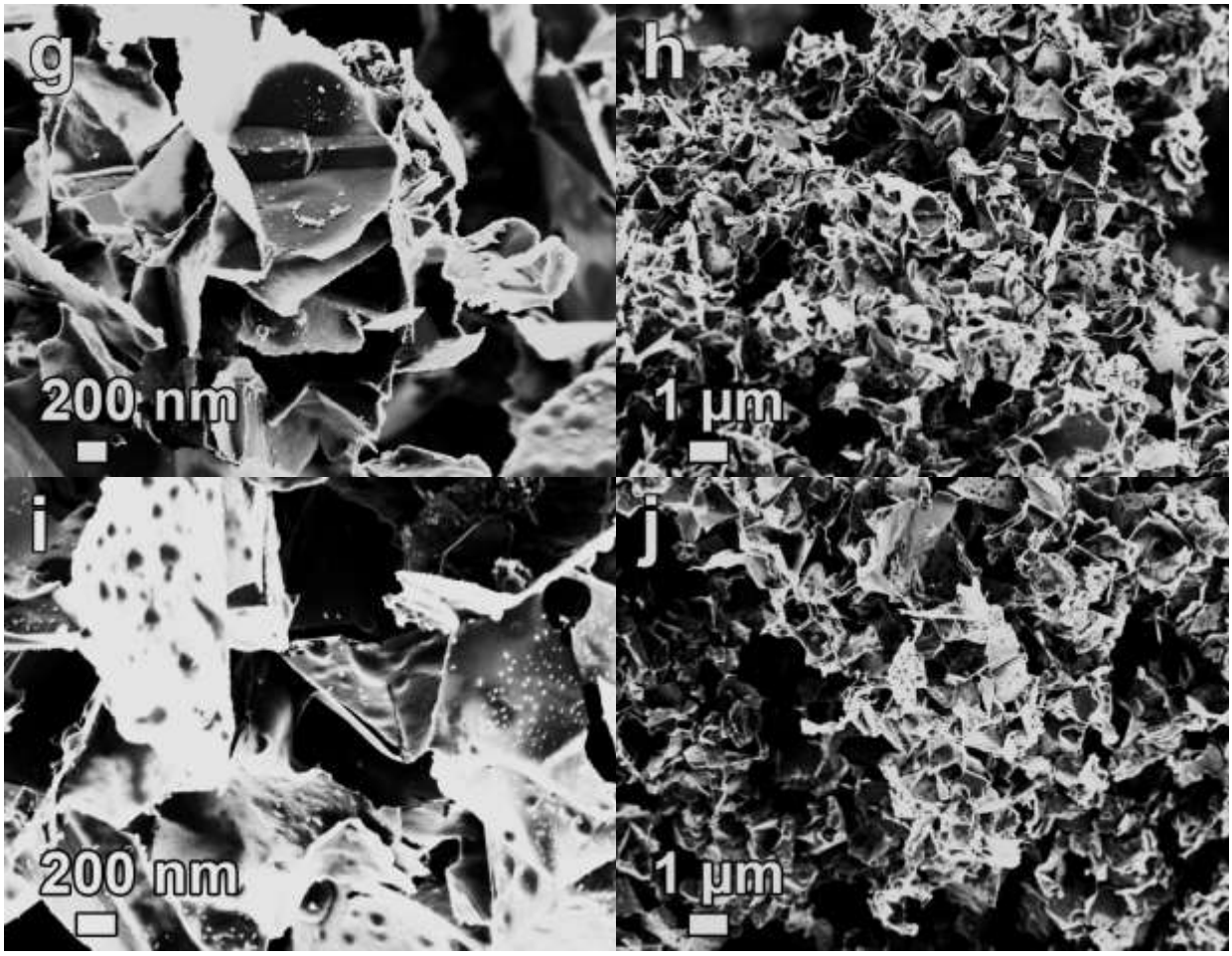


Figure S3 SEM micrographs of the five samples at different magnification (a) sample 1 (1:2) (b) sample 2 (1:4), (c) sample 3 (1:6), (c) sample 4 (1:8) and (e) sample 5 (1:10).

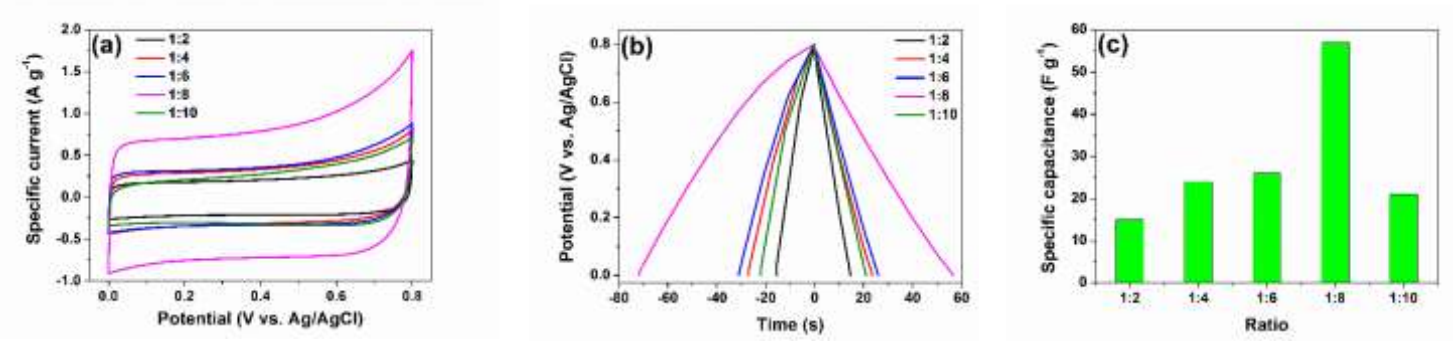


Figure S4 Electrochemical measurement of the five sample 1 M KNO_3 neutral electrolyte (a) CV at 10 mV s^{-1}, (b) GCD at 1 Ag^{-1} and (c) C_{SP} vs. ratio of sample and K_2CO_3. The result also show that the sample with the ratio of 1:8 is the best sample as observed in figure S1 (d), but with a C_{SP} higher in the acidic media.

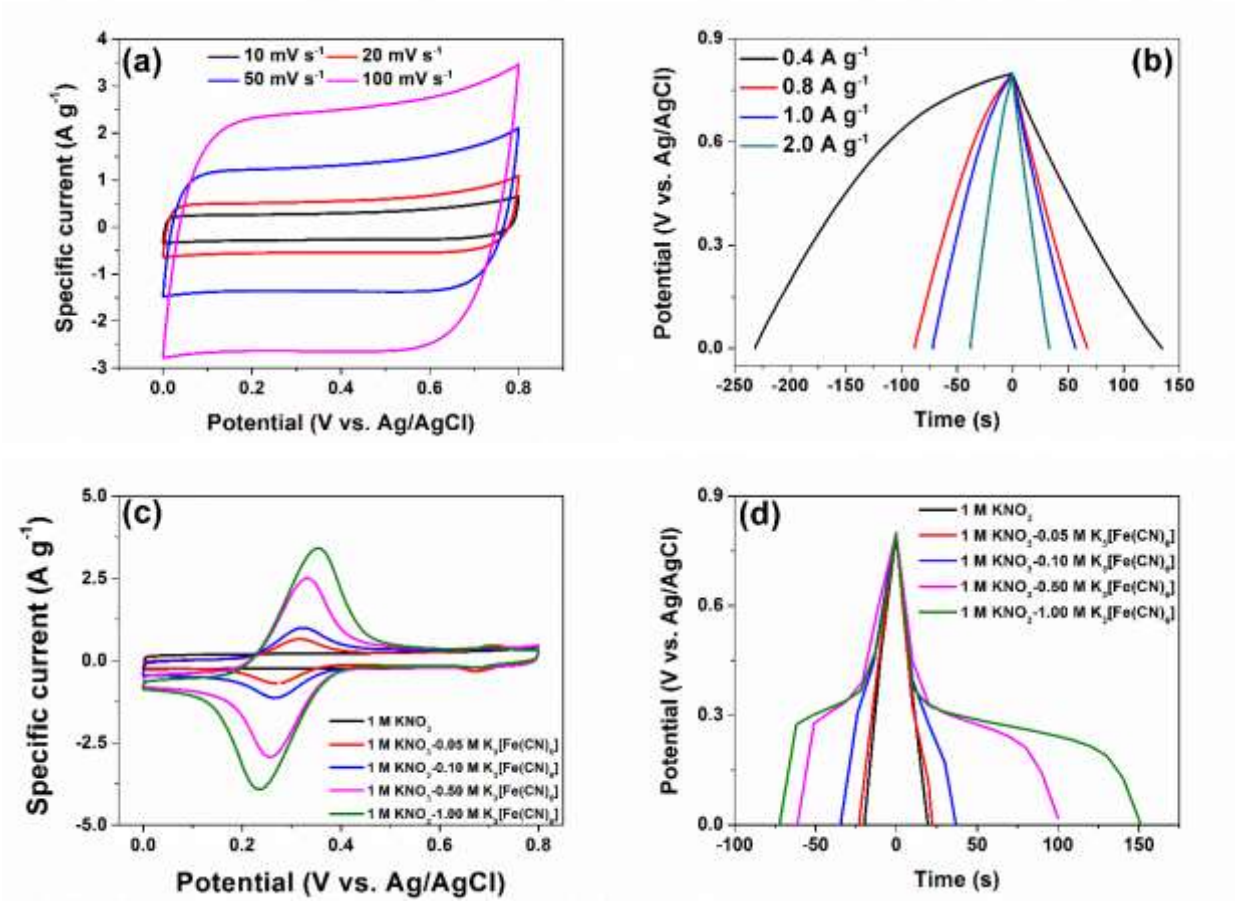


Figure S5 electrochemistry of the optimised 1:8 sample (a) CV at different scan rates (b) the GCD at different current densities in 1 M KNO_3 electrolyte (c) CV and (d) GCD in different concentrations of $K_3Fe(CN)_6$ in 1 M KNO_3.

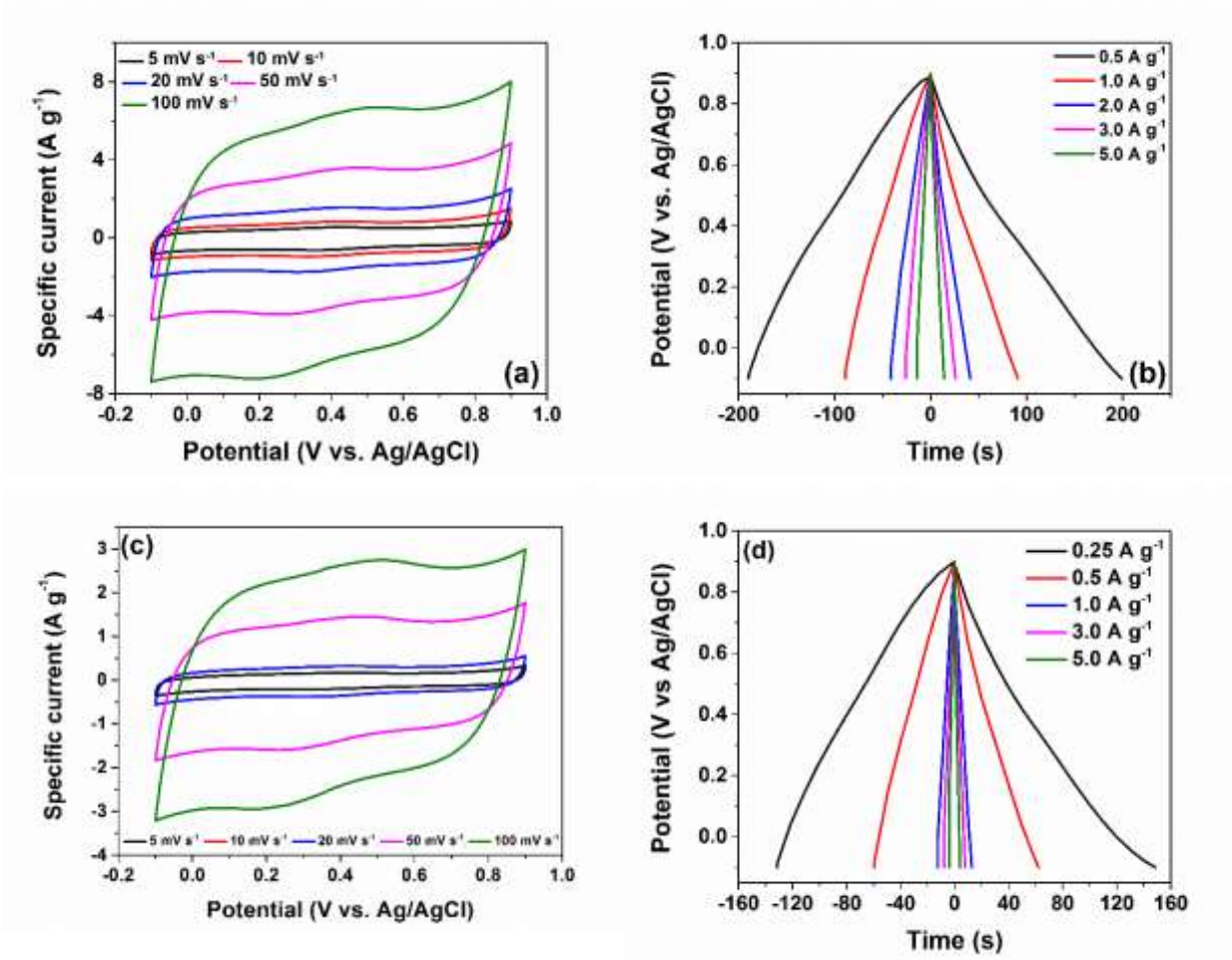


Figure S6 electrochemistry of the optimised 1:8 sample (a) CV at different scan rates (b) the GCD at different current densities in 1 M HNO_3 electrolyte (c) CV at different scan rates (d) the GCD at different current densities in 1 M H_2SO_4 electrolyte

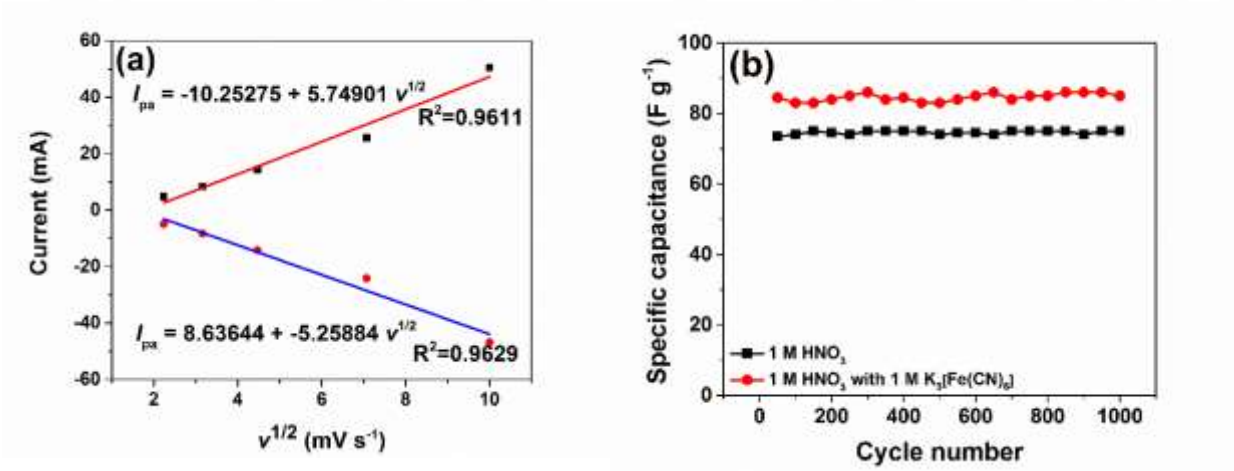


Figure S7 (a)relationship between cathodic and anodic current vs. square root of scan rate of the optimised 1:8 sample in 1 M KNO_3-$K_3Fe(CN)_6$. Showing linear fit indicating a diffusion controlled process and Figure S6 (b) compares the stability in 1 M HNO_3 and 1 M HNO_3-$K_3Fe(CN)_6$.

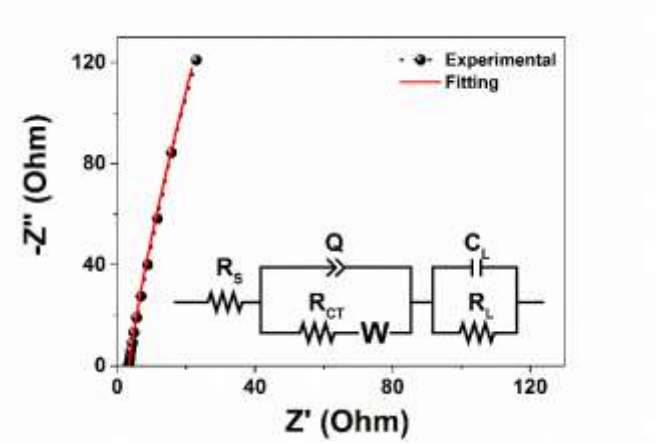


Figure S8 EIS fitting and equivalent circuit diagram of the electrode in the 1 M HNO_3 electrolyte showing similar circuit with the electrodes in the 1 M HNO_3 - 1 M $K_3Fe(CN)_6$.

Table S2 Fitting parameters for the electrode

Samples	**R_S (Ω)**	**CPE (Q)**	**n**	**R_L (Ω)**	**R_{CT} (Ω)**	**C_L (F)**
1 M HNO_3-$K_3Fe(CN)_6$	**2.7**	**0.25**	**0.95**	**0.33**	**0.15**	**0.26**
1 M HNO_3	**3.15**	**0.11**	**0.95**	**1.2**	**0.18**	**0.11**

X^2 = 2.7, $X/\sqrt{N}$ = 0.25 (1 M HNO_3-$K_3Fe(CN)_6$**), X^2 = 0.1, $X/\sqrt{N}$ = 0.707 (**1 M HNO_3**).**