Electronic Supplementary Material (ESI) for Energy & Environmental Science

Hybrid electric power device for simultaneous generation and storage of electric energy

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SUPPORTING INFORMATION

Fabrication of PANI/Au anodes

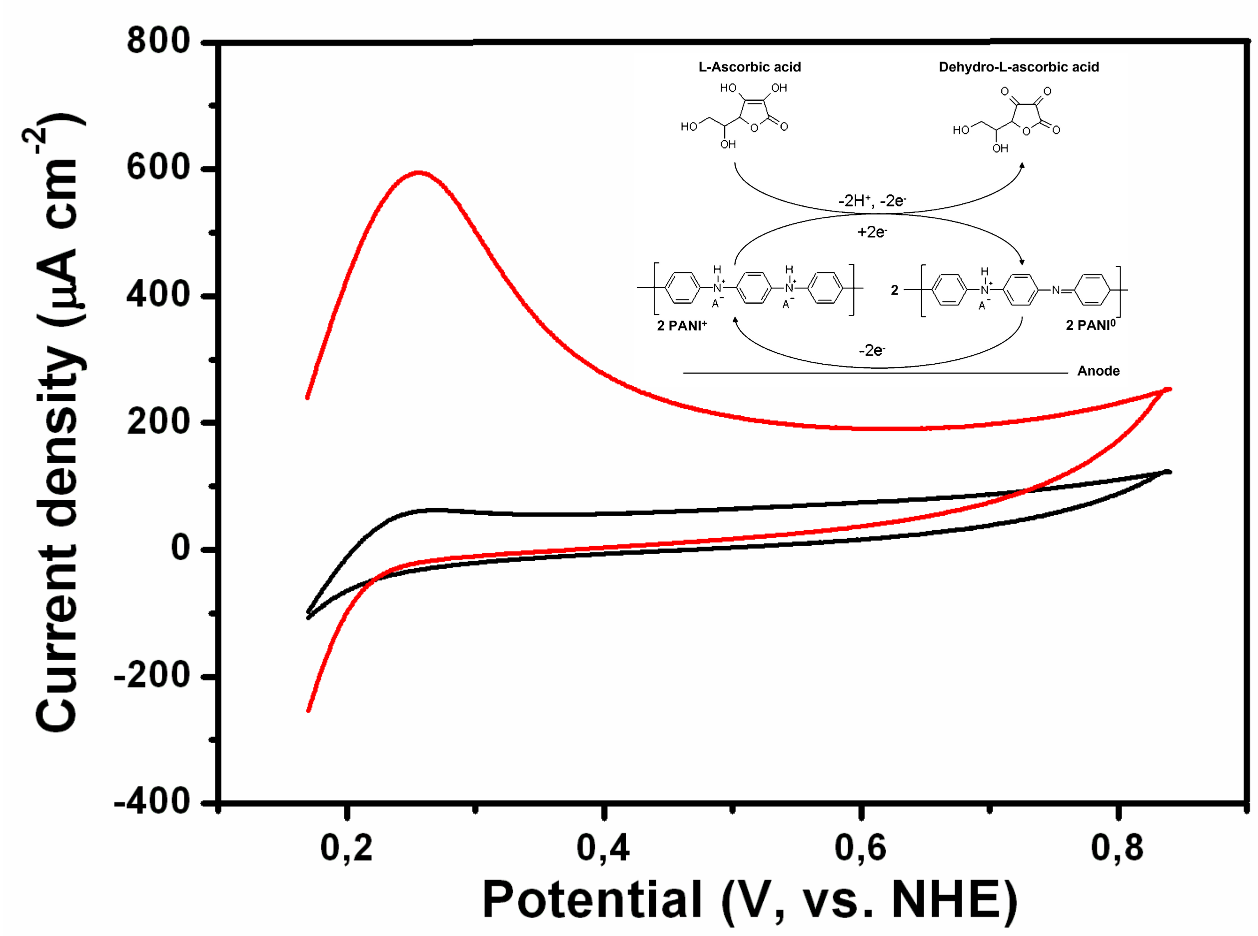
The electropolymerization of aniline was executed using the protocol described in Ref.[1]. Briefly, 50 mL of deionised water, 5 mL of concentrated hydrochloric acid, and 0.75 mL of aniline were mixed in a single compartment cell. The reaction was carried out under an applied potential of 0.94 V *vs.* NHE for 1 h. Then, the PANI/Au electrodes were rinsed with deionised water and dried at room temperature.

Fabrication of PtNPs/Au cathodes

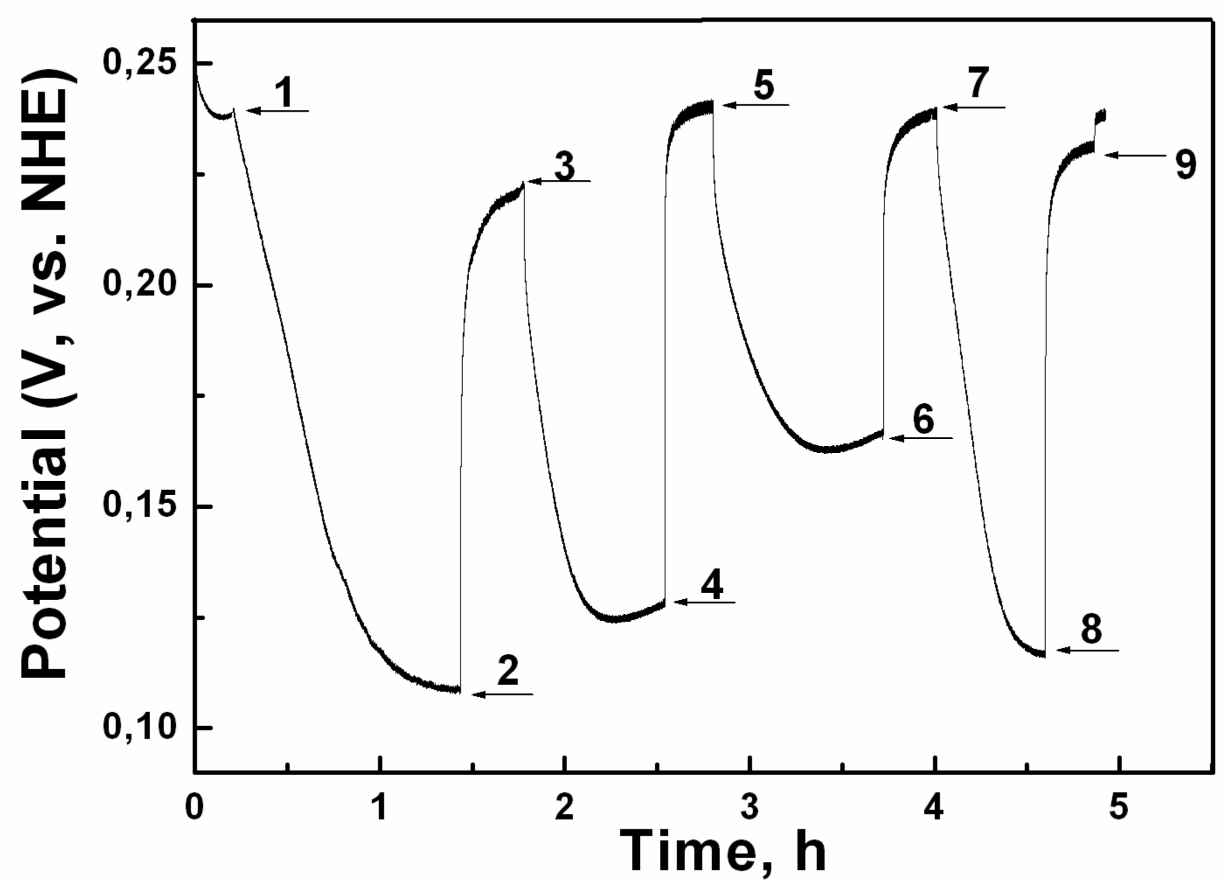
Au electrodes were submerged into 1 mM K_2PtCl_6 solution with 0.1 M KCl as supporting electrolyte, and the electrodeposition of Pt on the surface of an Au electrode was carried out by applying nine 400 s potential steps from 0.5 to -0.7 V *vs.* NHE. The PtNPs/Au electrodes were rinsed with deionised water and dried at room temperature.

Supporting references:

1. S. Bhadra, N. K. Singha and D. Khastgir, *Journal of Applied Polymer Science*, 2007, **104**, 1900-1904.
2. A. Ambrosi, A. Morrin, M. R. Smyth and A. J. Killard, *Analytica Chimica Acta*, 2008, **609**, 37-43.
3. V. A. Sethuraman, J. W. Weidner, A. T. Haug, M. Pemberton and L. V. Protsailo, *Electrochimica Acta*, 2009, **54**, 5571-5582.
4. C. M. Sanchez-Sanchez and A. J. Bard, *Anal. Chem.*, 2009, **81**, 8094-8100.
5. R. Kotz and M. Carlen, *Electrochimica Acta*, 2000, **45**, 2483-2498.

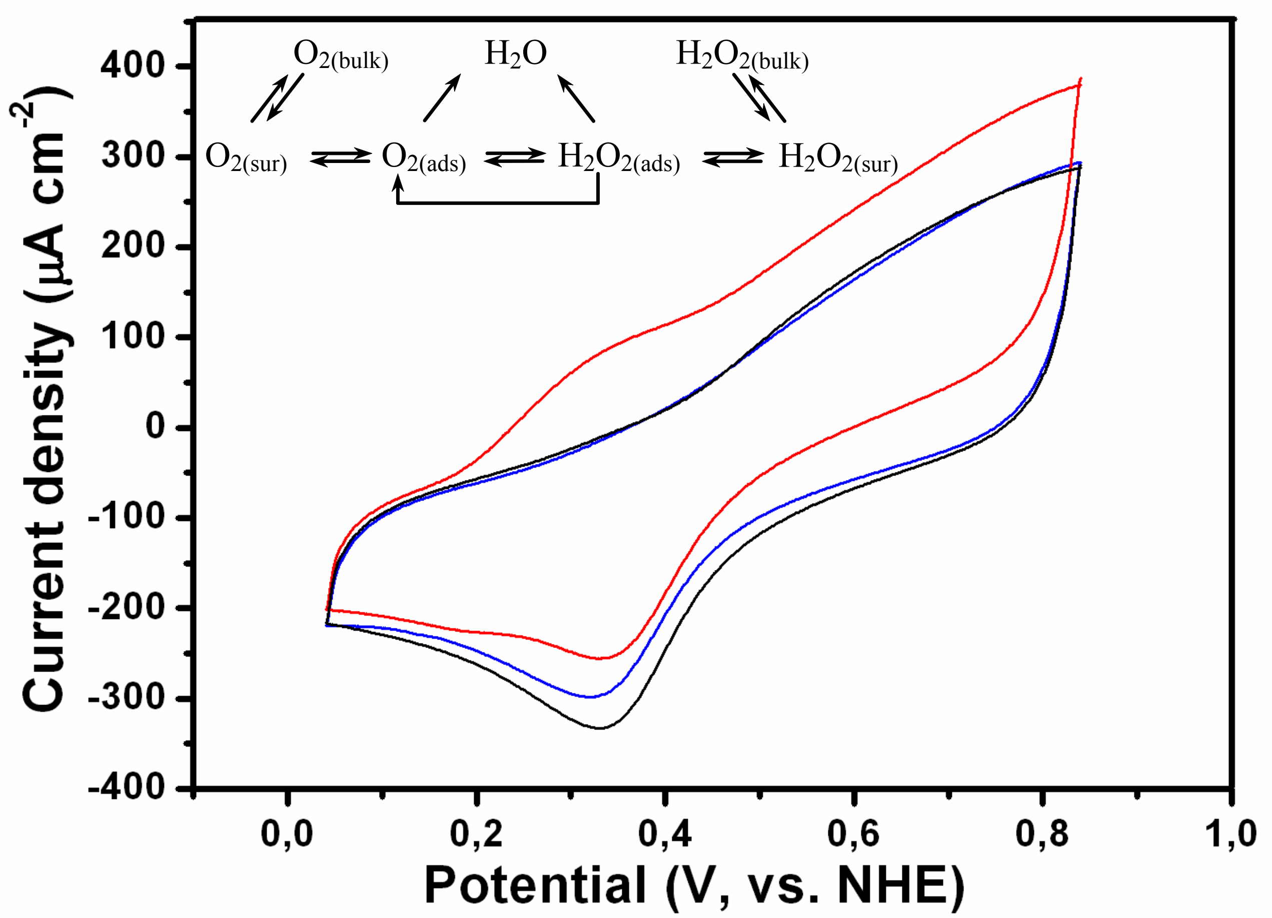


Supporting Figure S1 Typical cyclic voltammograms of PANI modified Au electrodes in air saturated PB, pH 7.4; without (black) and with (red) 1 mM ascorbate. Conditions: 20 mV s^{-1} scan rate, second cycle. Insert: the electrooxidation reaction scheme of of ascorbate on PANI modified Au anodes. Additional details can be found in Ref.[2].

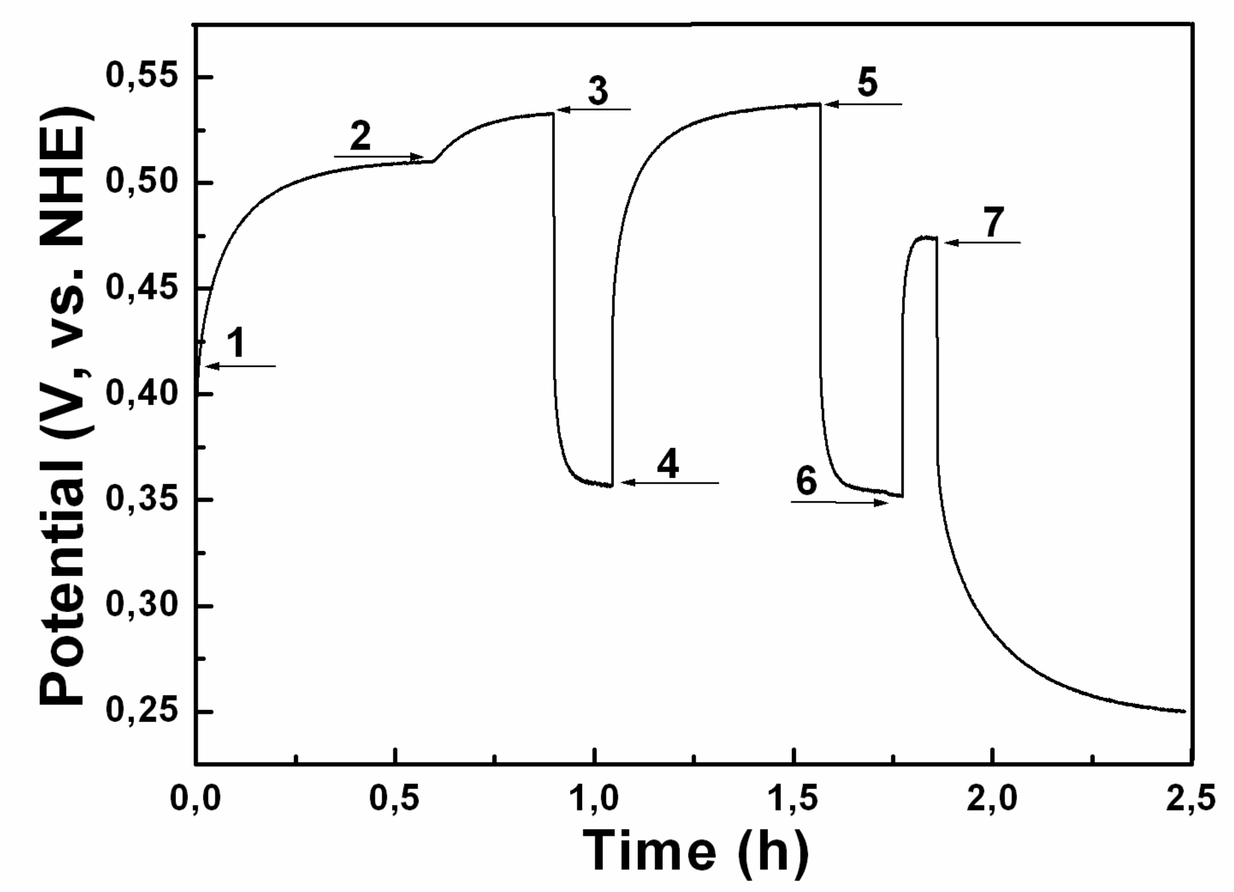


Supporting Figure S2 Charge/discharge curves of an Au anode with immobilised polyaniline/carbon nanotubes composite (PANI/CNTs), submerged in PB, pH 7.4

1 – adding ascorbic acid to the solution
2 – discharging at a constant load of 10 kΩ
3 – disengaging the load
4 –discharging at a constant load of 2 kΩ
5 – disengaging the load
6 – discharging at a constant load of 5 kΩ
7 – increasing the ascorbic acid concentration to 1.5 mM
8 – discharging at a constant load of 5 kΩ
9 – final discharge at a constant load of 2 kΩ

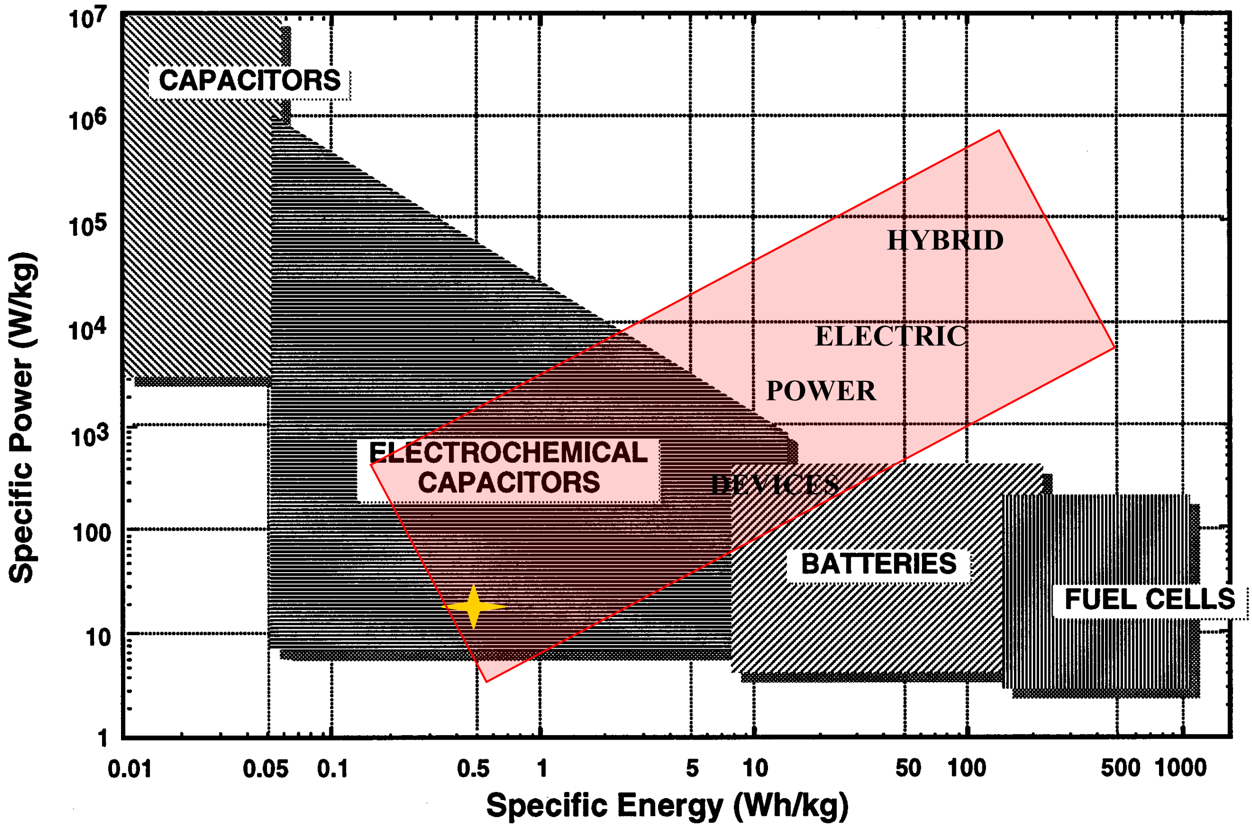


Supporting Figure S3 Cyclic voltammograms of a Au/PtNPs cathode in PB, 7.4 without (black and blue) and with (red) 1 mM ascorbate. The blue trace was obtained after measurement in the ascorbate containing solution, without additional electrode cleaning. Conditions: 20 mV s^{-1} scan rate, second cycle. Insert: a schematic representation of different pathways during oxygen electroreduction; according to Sethuraman *et al.* (Ref.[3]), with some additions and changes. Additional details concerning hydrogen peroxide formation during oxygen electroreduction on metal electrodes can be found in Ref.[4].



Supporting Figure S4 Charge/discharge curves of a Au/PtNPs/PPy/CNTs composite cathode, submerged in PB, pH 7.4

1 – charging in an air saturated solution
2 – starting the O_2 bubbling
3 – discharging at a constant load of 5kΩ
4 – disengaging the load
5 – discharging at a constant load of 5kΩ
6 – disengaging the load
7 – starting the N_2 purging



Supporting Figure S5 Ragone plot for various energy storage and conversion devices. The indicated areas are rough guidelines. Adapted from Kötz and Carlen (Ref.[5]), with some additions and changes. The parameters of the ascorbate/oxygen HEPD are marked with a yellow star.