PANI/Au/Fe_3O_4 Nanocomposite materials for high performance electrochemical capacitors

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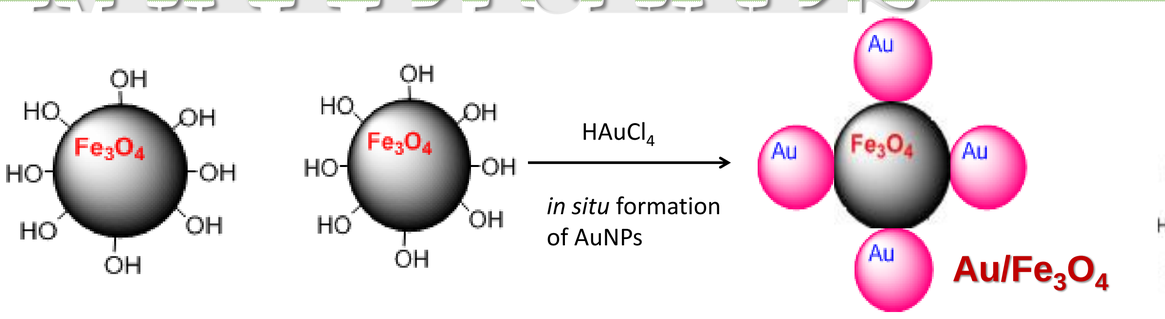
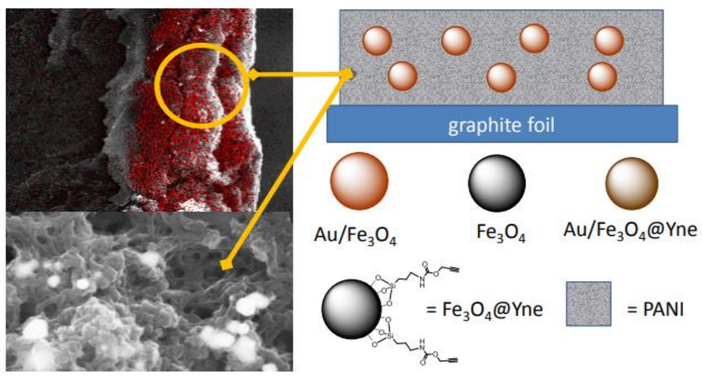
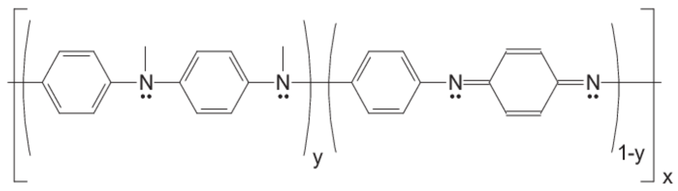
MATERIALS



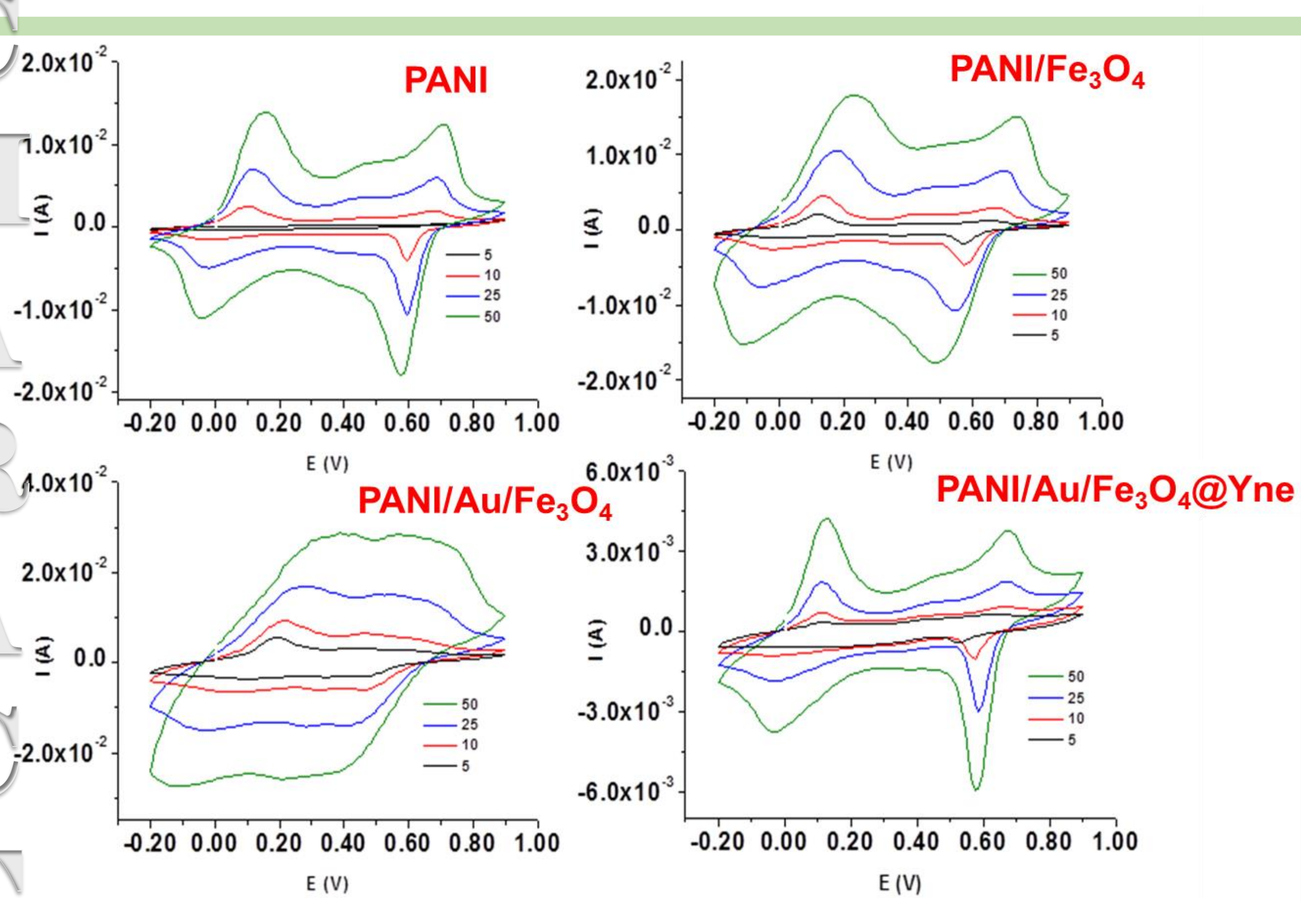


Metal oxides are redox pseudocapacitive materials. In the present work the behaviour of magnetite and gold nanoparticles is investigated. Fe_3O_4 is chosen for its low toxicitiy and faradaic properties. Electrodes are prepared using cyclic voltammetry.
Electrodepositation conditions:
0.5 M H_2SO_4 + 0.1 M $LiClO_4$ (called ES solution) **-0.2 V < E < +0.89 V, 50 mV/s, 60 cycles.** 0.1 M ANI, 2.0 gL^{-1} nanoparticles (under stirring), are added. Grafite sheets are used as support.(1)

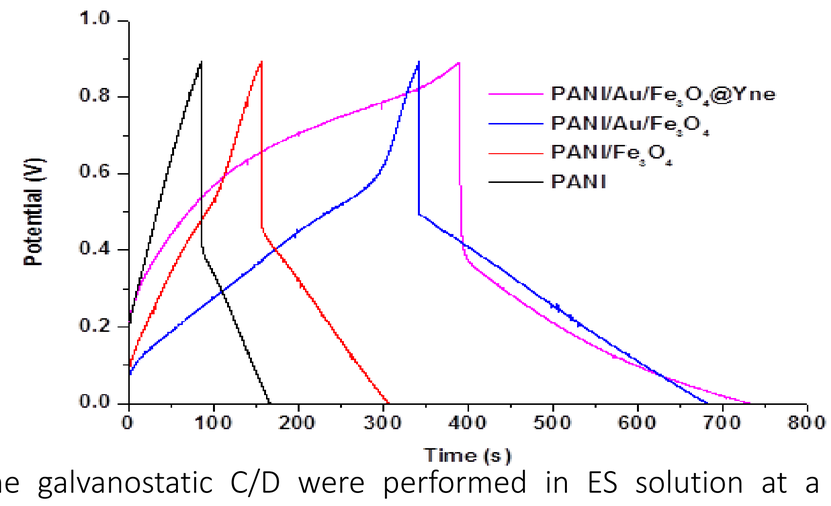


PANI is a conductive polymer which has an high specific capacitance due to multi-redox reactions, good electronic proprieties and low cost for its abundance.

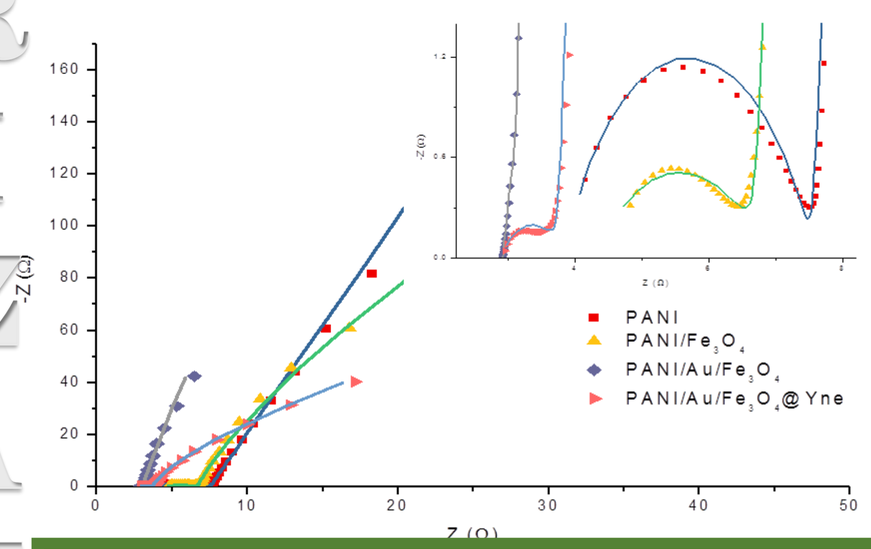
CHARACTERIZATION



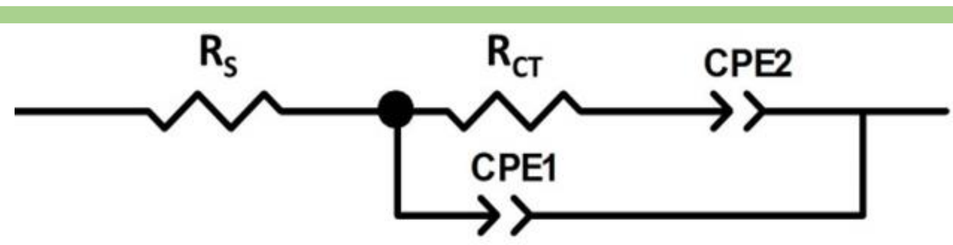
Cyclic voltammetries to characterize the electrodes are performed in ES solution at different scan rates. The peak current increases with increase in scan rate demonstrating the high power capability and reversibility of the material. The better conductivity and the lower resistance is due to the faradaic behaviour of magnetite and the bigger size of gold nanoparticles in PANI/Au/ Fe_3O_4.



The galvanostatic C/D were performed in ES solution at a constant current density of 0,5 mA cm^{-2}. The nonlinear and asymmetrical curves suggested their pseudocapacitance behaviour, resulting from redox reaction at the electrode/electrolyte interface.



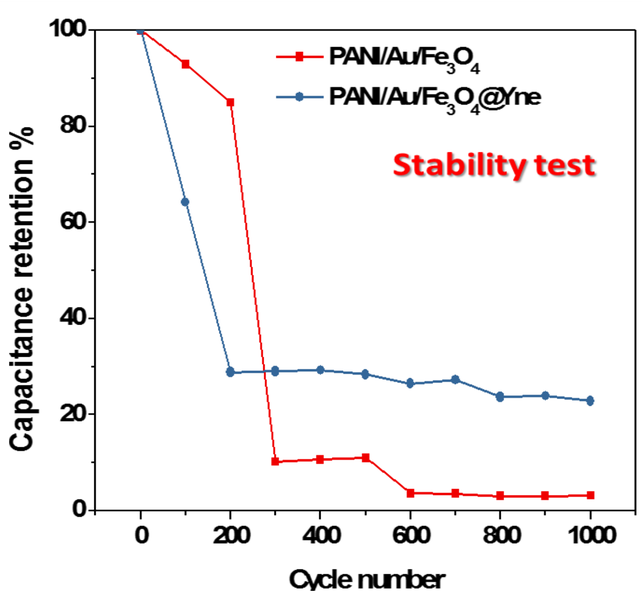
The impedance spectra displays a depressed semi-circle at the high frequency region due to the lower resistivity at the electrode/ electrolyte interface. The slight deviation from the vertical line in the low frequencies is due to the inhomogeneity of polyaniline film.



Electrode	R_S Ω	R_{CT} Ω	CPE1 $\Omega^{-1} s^n$	CPE2 $\Omega^{-1} s^n$
PANI	3.8	3.70	0.0002	0.085
PANI/Fe_3O_4	4.3	2.50	0.006	0.107
PANI/Au/Fe_3O_4	2.9	0.57	0.137	0.214
PANI/Au/Fe_3O_4@Yne	2.9	0.96	0.033	0.237

CPE2 in the equivalent circuit represents the pseudocapacitance in the film and it's the main contribution from the pseudocapacitors.

The PANI/Au/Fe and PANI/Au/Fe3O4@Yne electrodes where chosen to prepare a gel-state symmetric supercapacitor in which the two electrodes of the device are similar and separated from a polymeric gel electrolyte (PMMA + ES).



Stability tests show a drastic decreasing of performance for both devices within 200 cycles probably due to the properties of the gel-electrolyte prepared. The presence of Yne increase the device stability.

[1] B. Ballarin, M. Cristina, D. Nanni, C. Parise, D. Barreca, G. Carraro, A. Riminucci, I. Bergenti, V. Morandi, A. Migliori, et al., *Ceram. Int.* **2019**, *45*, 449–456.