Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Fabrication of MEA based on Sulfonic Acid Functionalized Carbon supported Platinum Nanoparticles for Oxygen Reduction Reaction in PEMFCs

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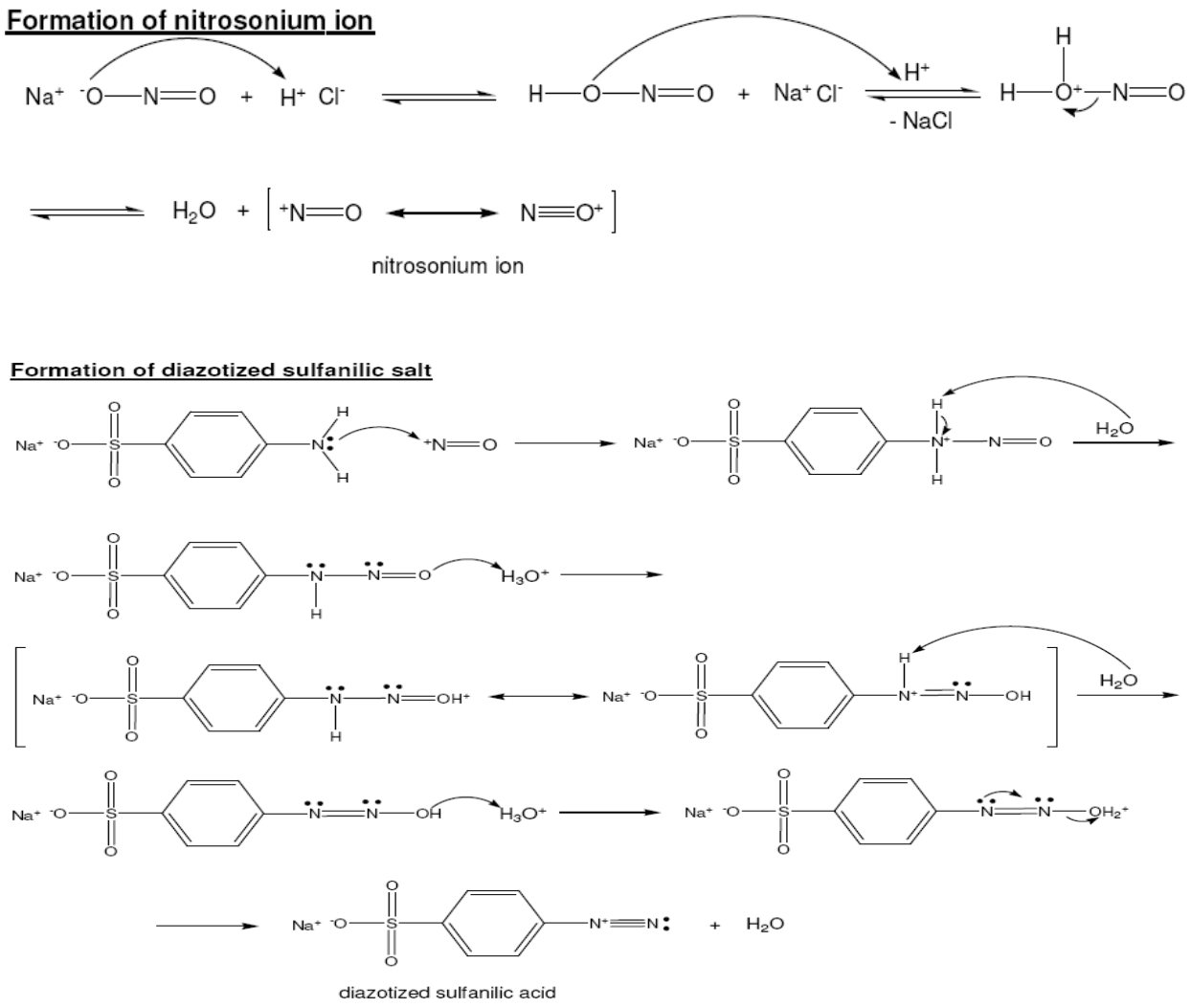


Fig. S1. Schematic diagram for the formation of 4-sulfobenzenediazonim Salts.

(a)

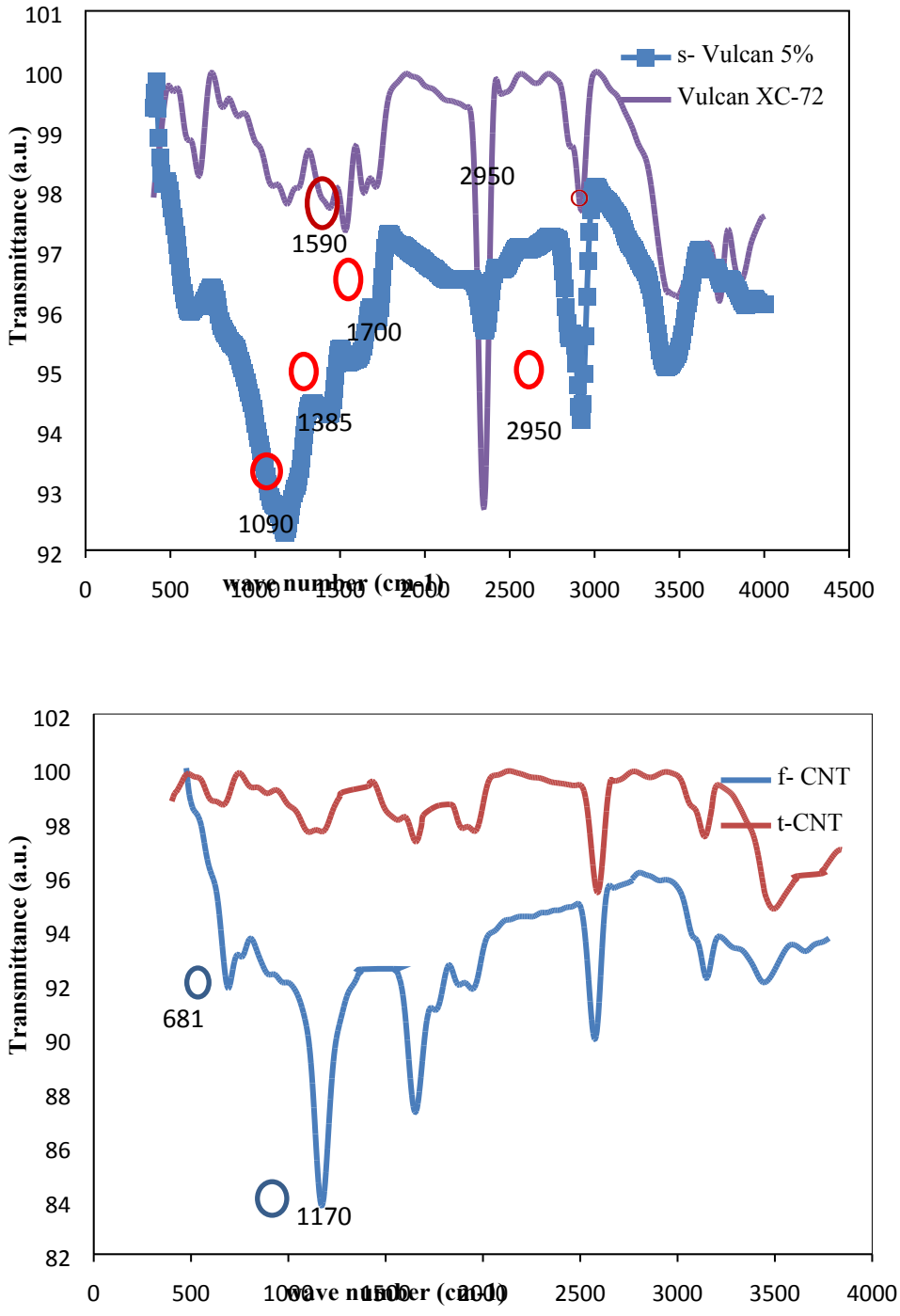


Fig. S2. FTIR spectra for (a) unmodified and modified Vulcan XC-72.

(b) Purified (t- CNT) and modified (f-CNT) MWCNTs.

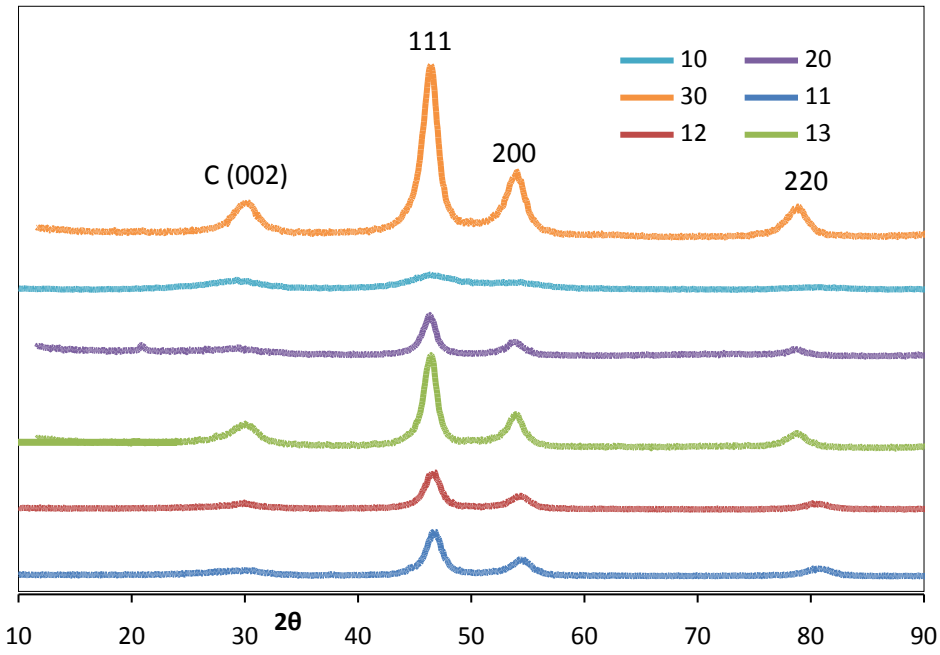


Fig. S3. X-ray diffraction (XRD) patterns for different catalysts.

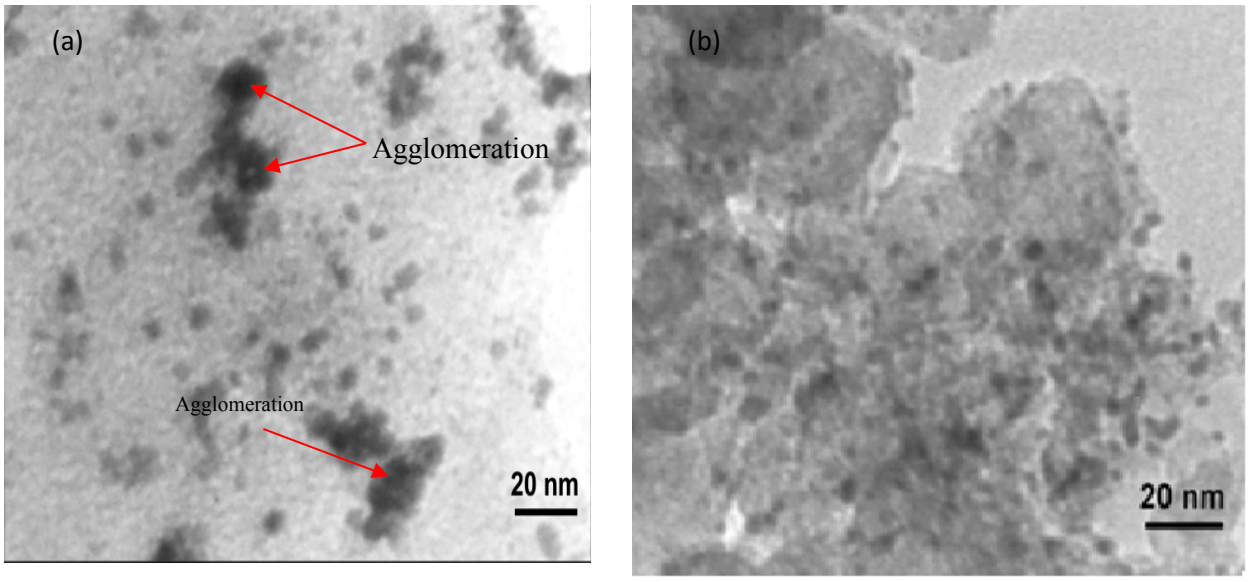


Fig S4. TEM images of (a) commercially available Electrochem Pt/C catalyst (Pt loading 10 wt%). (b) Pt/ (f- Vulcan XC-72R(25%)+f-MWCNT(75%) catalyst (Pt loading10 wt%).

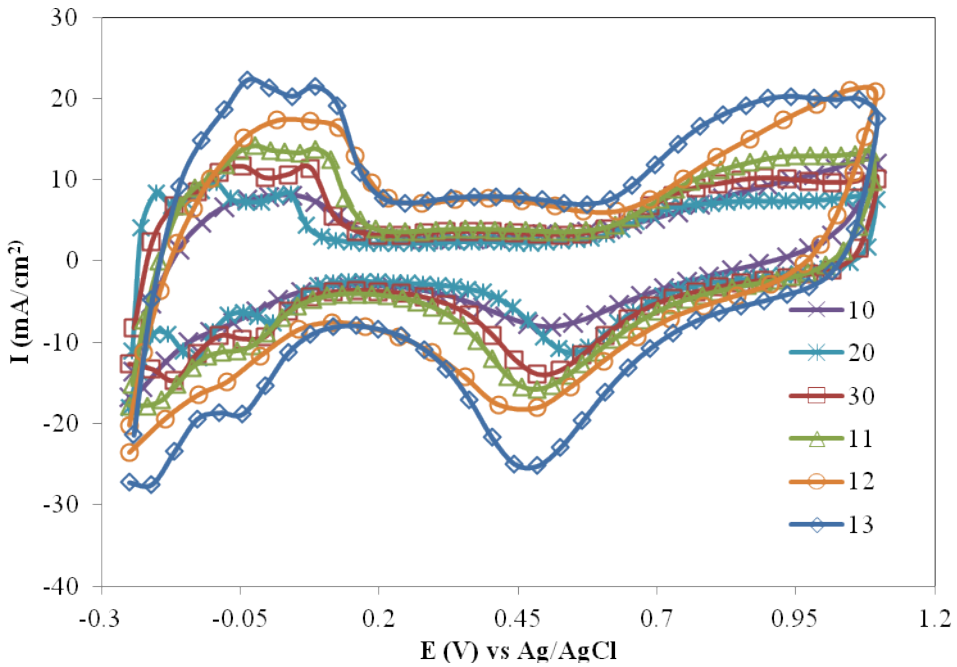
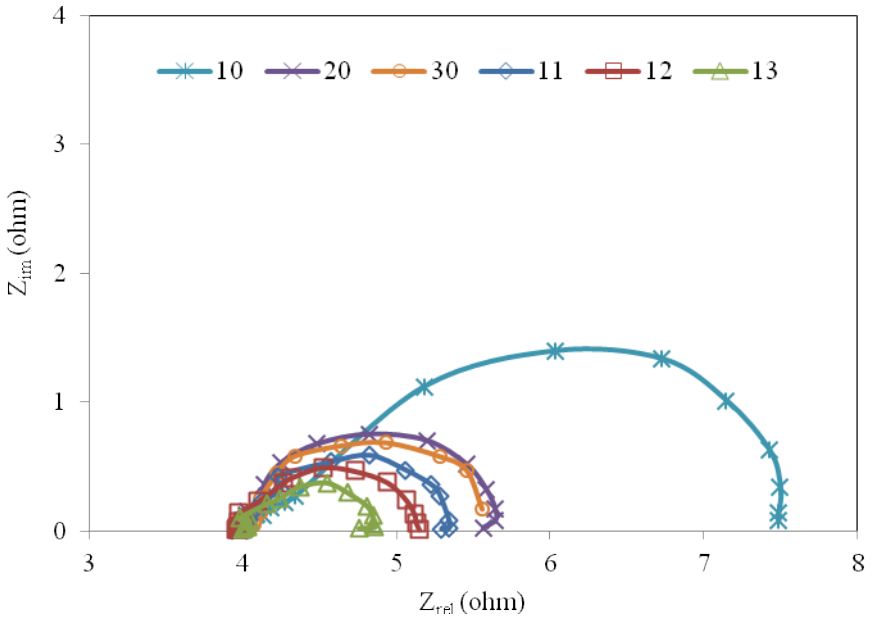


Fig. S5. Cyclic voltammograms for the modified catalyst with varying phenylsulfonic acid loading (in w/o) and amounts of MWCNTs (0.031415 cm^2 GC at 25ºC; under argon atmosphere; scan rate = 50 mVs^{-1}).



(b)

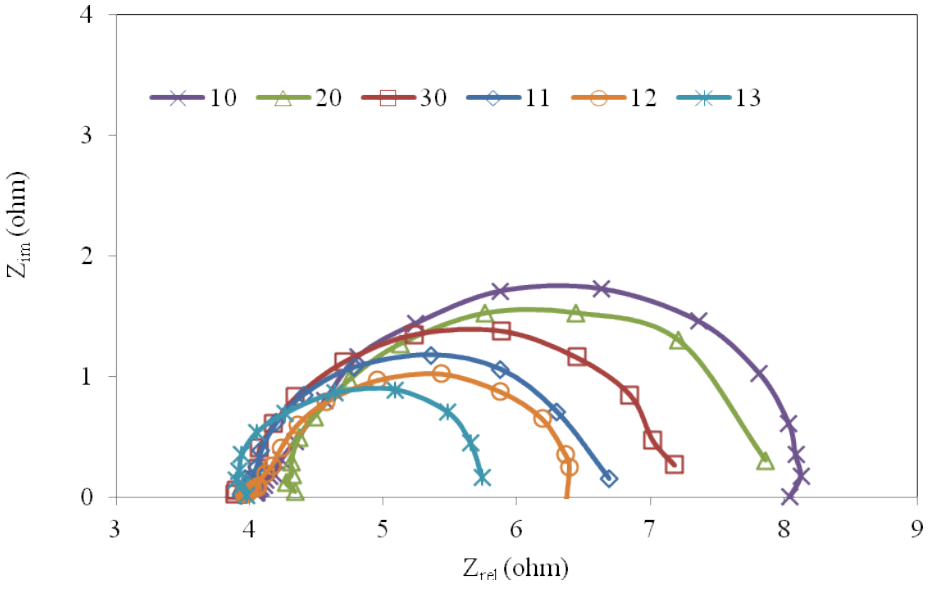


Fig. S6. Nyquist plots of the impedance response from 100 kHz to 30 mHz for different catalysts under oxygen atmosphere (a) at 300 mV (b) at 600 mV vs. Ag/AgCl at 25 ^{0}C. (Pt loading: 0.5 mgcm^{-2}).

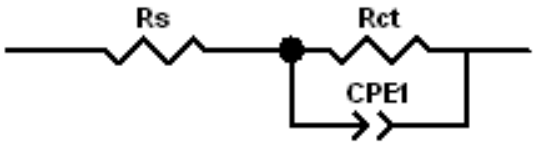
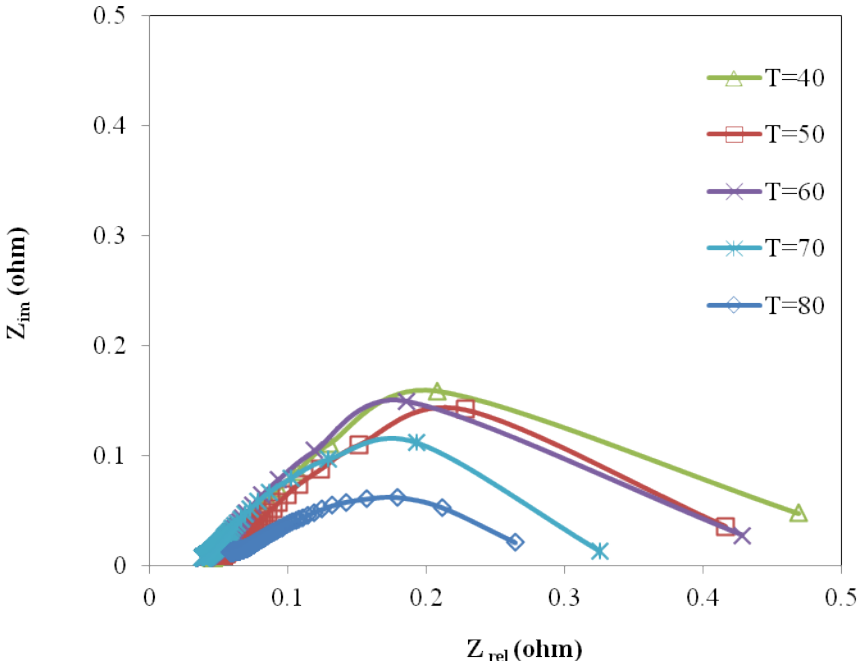
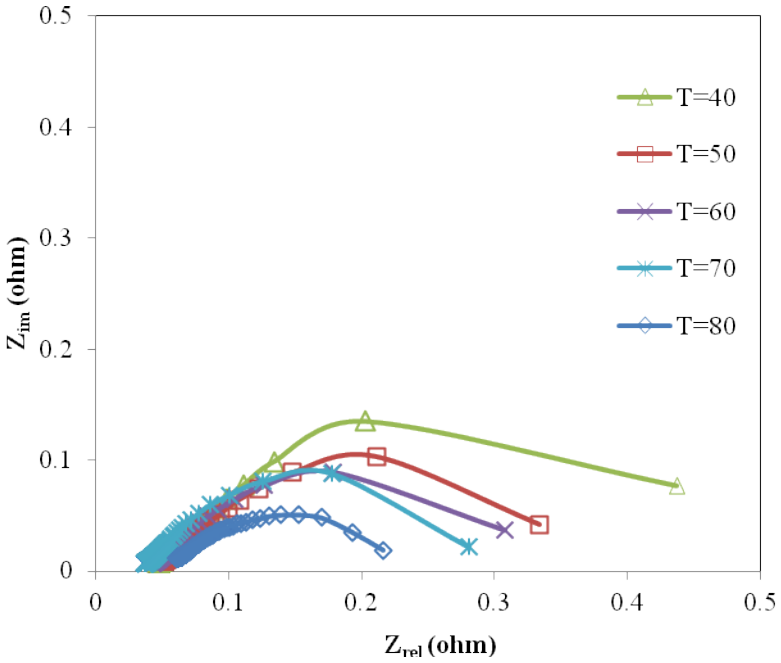


Fig. S7. Schematic representation of the equivalent circuit for the different electrodes.

(a)


0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
T=40
T=50
T=60
T=70
T=80
Z im (ohm)
Z rel (ohm)

(b)


0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
T=40
T=50
T=60
T=70
T=80
Z im (ohm)
Z rel (ohm)

(c)

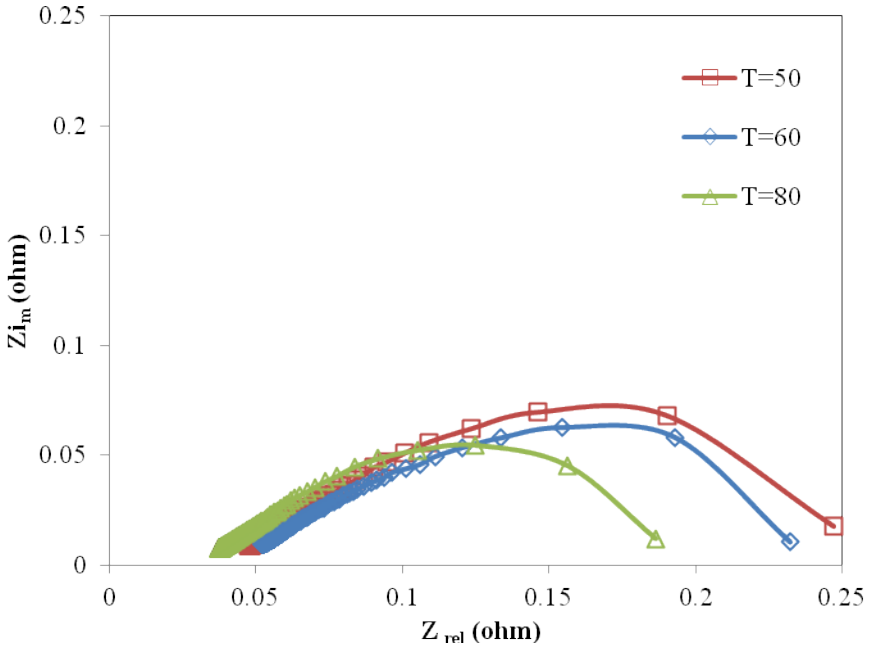


Fig. S8. Impedance spectra of a single cell with MEA-1 from 1 mHz to 1000 kHz , 90% relative humidity, different cell temperatures and 1.5 atm back pressure for the anode and cathode. The flow rates are 300 $mlmin^{-1}$ for hydrogen and 500 $mlmin^{-1}$ for oxygen (a) at 0.3V (b) at 0.5 V (c) at 0.7 V.

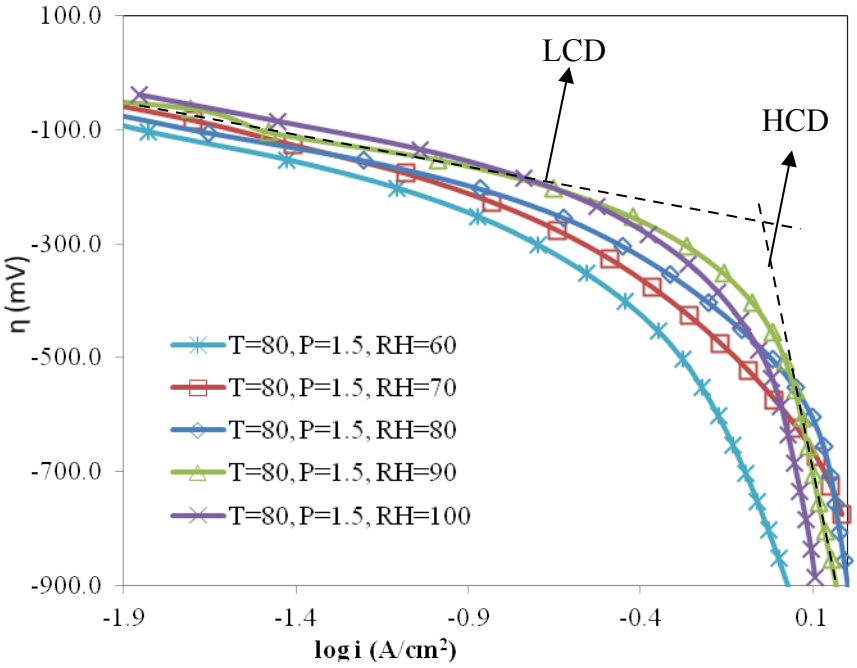
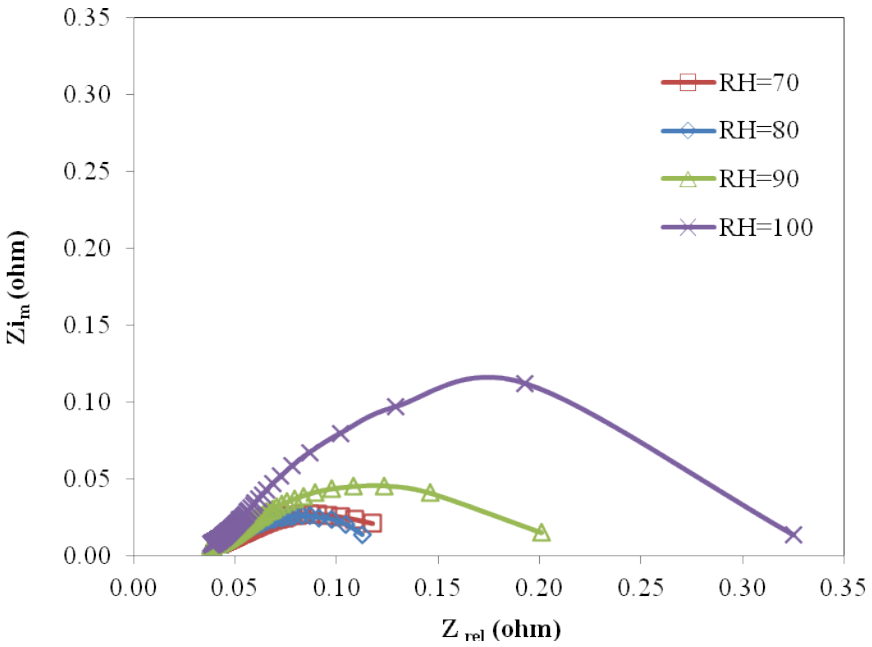
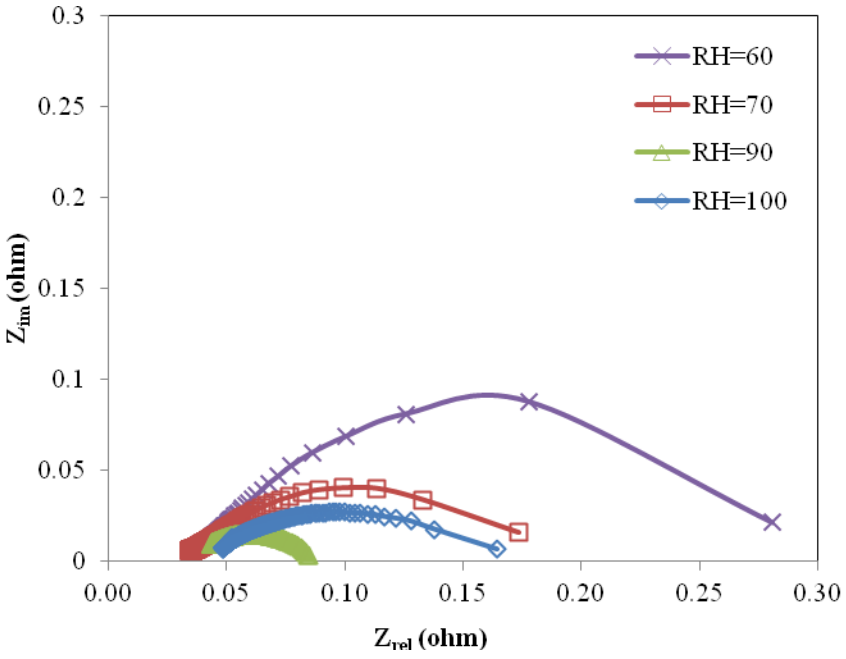


Fig S9. The plot of η vs. *log i* for different relative humidities (T=80ºC and a gas pressure at the back of the electrodes of 1.5 atm)

(a)


0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Zi_m (ohm)
Z_rel (ohm)
RH=70
RH=80
RH=90
RH=100

(b)


0.3
0.25
0.2
0.15
0.1
0.05
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Z_im (ohm)
Z_rel (ohm)
RH=60
RH=70
RH=90
RH=100

(c)

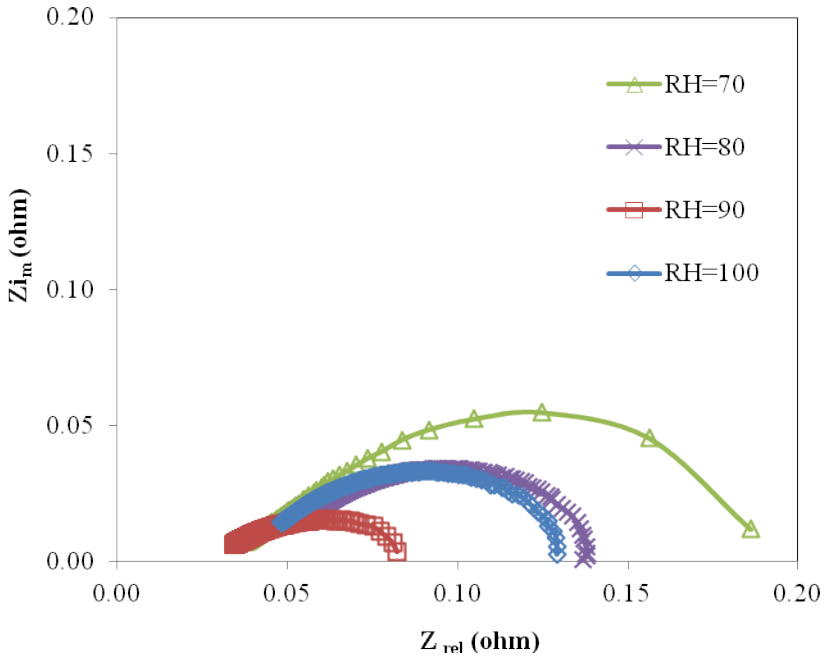
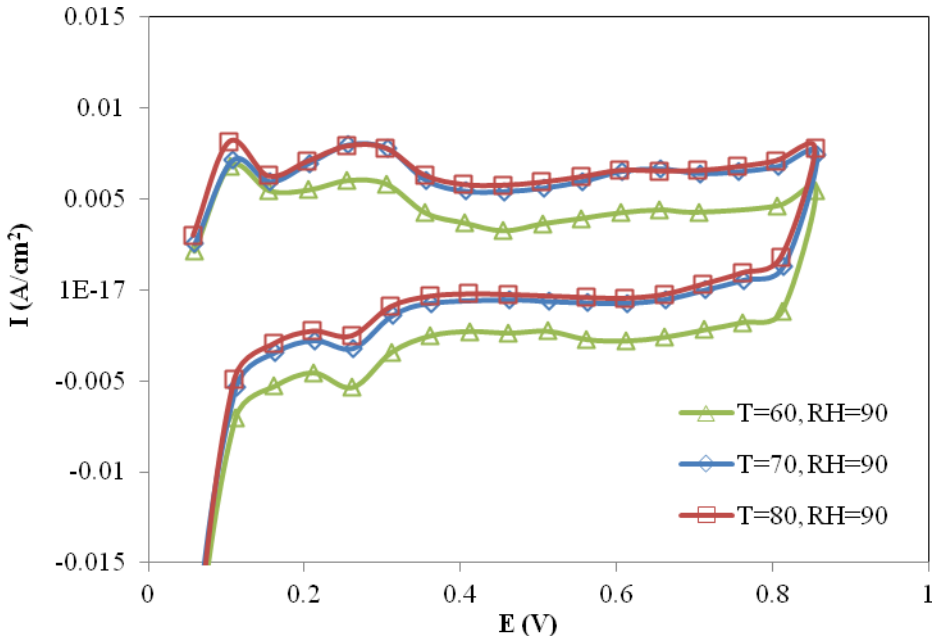


Fig. S10. Impedance spectra of a single cell with MEA-1, from 1 mHz to 1000 kHz, for different relative humidities, cell temperature 80ºC and 1.5 atm absolute back pressure for the anode and cathode. The flow rates are 300 $mlmin^{-1}$ for hydrogen and 500 $mlmin^{-1}$ for oxygen (a) at 0.3 V (b) at 0.5 V (c) at 0.7 V.

(a)



(b)

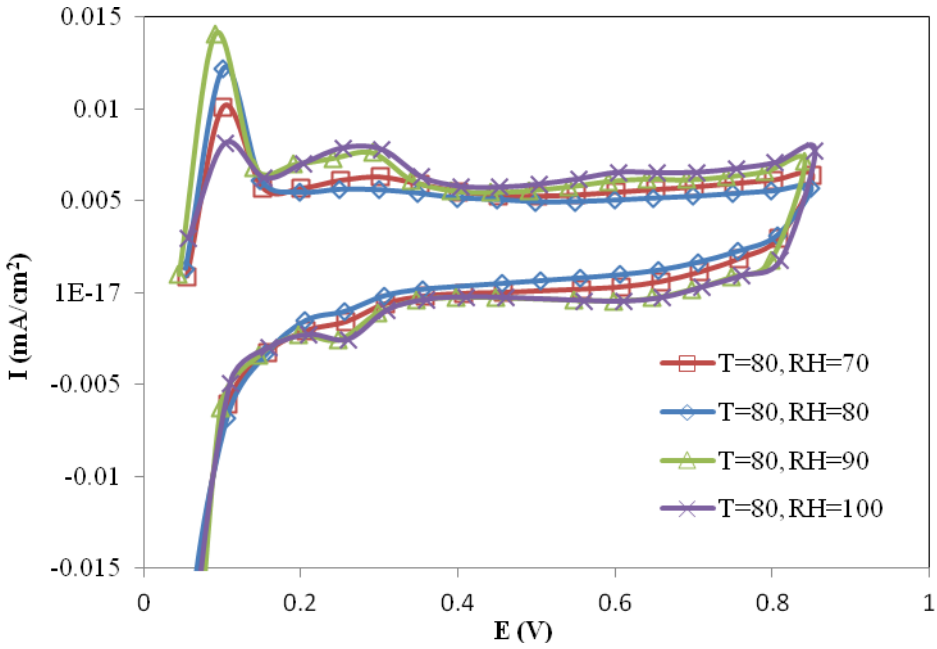


Fig. S11. Cyclic voltammogram of a single cell with MEA-1 (a) effect of temperature (b) effect of relative humidity (*RH*) (scan rate=50 mVs^{-1}, cell area:6.25 cm^2, N_2 and H_2 streams at cathode and anode, respectively, and an anode and cathode absolute back pressure of 1.5 atm.

Fig. S3. As shown in Fig. S3, the first peak located at a 2θ value of about 30° referred to the graphite (0 0 2) plate of the MWCNT and Vulcan XC-72R support. The other three peaks were characteristic of face centered cubic (fcc) crystalline Pt, corresponding to the planes (1 1 1), (2 0 0), (2 2 0) and at 2θ values of about 46°, 54°, 80°.

Fig. S7. In this circuit, the high frequency intercept on the real axis is due to solution resistance (R_s). A parallel combination of R_{ct} and *CPE* has been analyzed to form the semicircle, whose diameter has been considered as the charge transfer resistance due to oxygen reduction reaction (ORR) and *CPE* indicates the double layer capacitance. Considering the porous nature of electrodes, the double layer capacitance is expressed as constant phase elements (*CPE*) in the equivalent circuit model [36].