Novel electrode PtCr/PAA (polyamic acid) for efficient ethanol oxidation reaction

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- Preliminary Results
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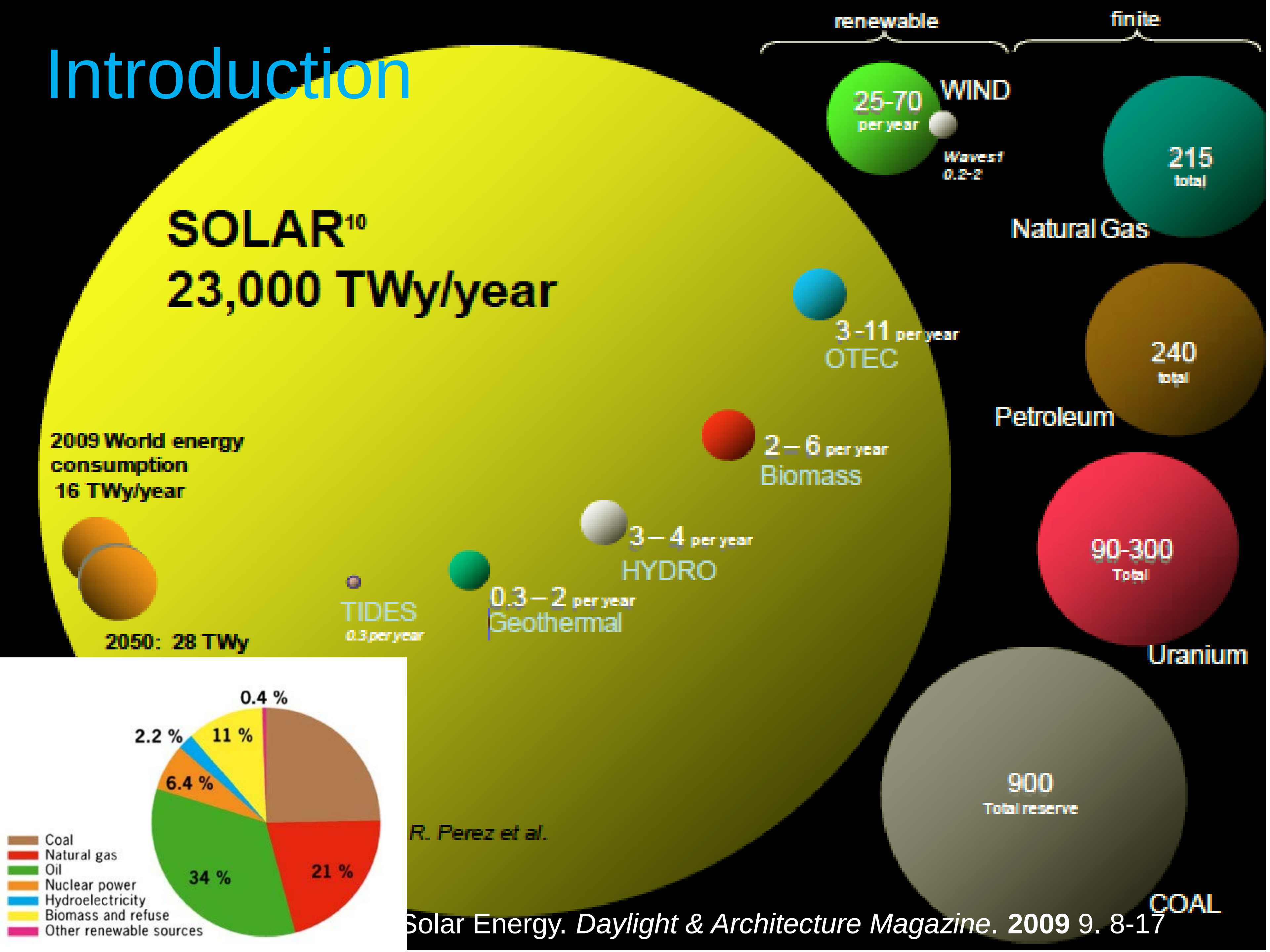
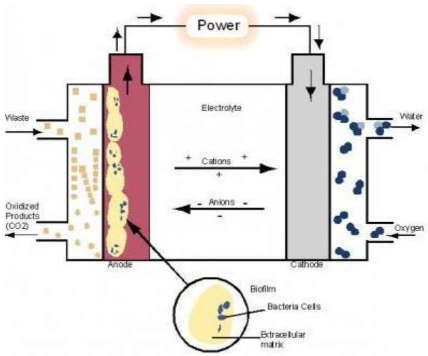
Introduction

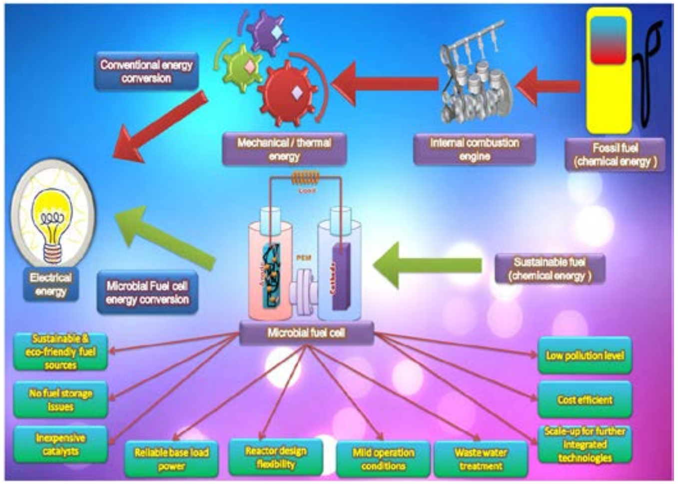


Solar Energy. *Daylight & Architecture Magazine*. **2009** 9. 8-17

Fuel Cells

❖Microbial Fuel Cells (MFC):

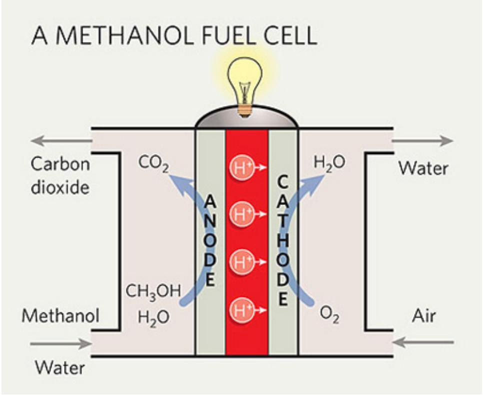


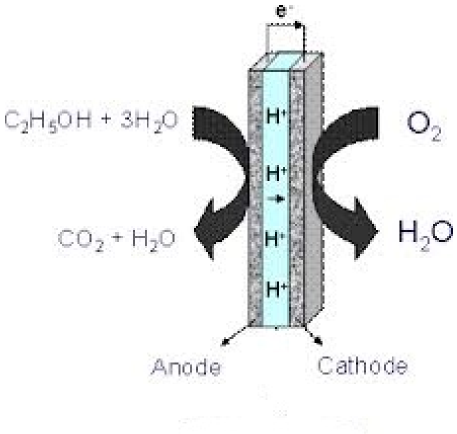


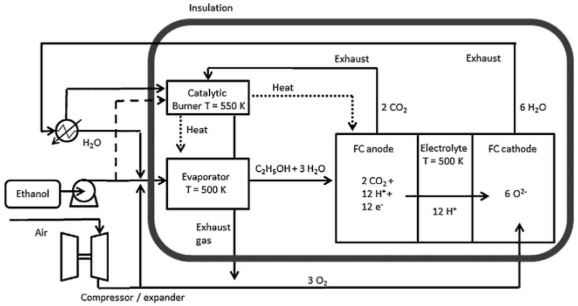
❖Direct Alcohol Fuel Cells :

Direct Methanol fuel cells (DMFCs)

Direct Ethanol Fuel cells (DEFCs)







Ethanol is a promising fuel in the so-called direct ethanol fuel cell (DEFC)

- ❖ less toxic
- ❖ easy to store and transport due to its relatively higher boiling point
- ❖ has higher energy density due to the nature of 12 electron transfer
- ❖ has been qualified as a substantial energy source since it can be produced in large quantities from agriculture products, even some waste part, like grass.

Factors Affecting the efficiency of fuel cells

- Design of the device
- Nature of chemical substrate
- The internal and external cell resistances
- The ionic strength
- **The electrode materials**
  - **Carbon materials**
  - **Catalyst/ Carbon** → **Challenge : NOT STABLE**

Nafion Membrane

Vulcan Membrane

Objectives- Novel electrode material for EOR

For the electrochemical route, the complete oxidation product is CO_2.

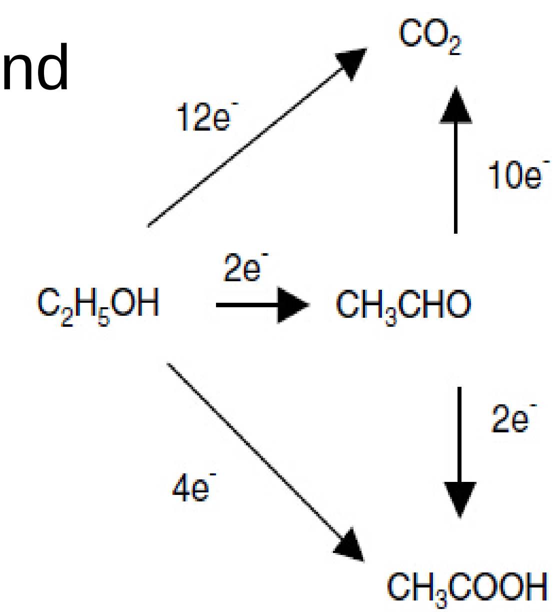
$$C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$$

The partial oxidation to acetaldehyde and acetic acid releases 2 and 4 e-, res

$$C_2H_5OH \rightarrow CH_3CHO + 2H^+ + 2e^-$$

and

$$CH_3CHO + H_2O \rightarrow CH_3COOH + 2H^+ + 2e^-$$



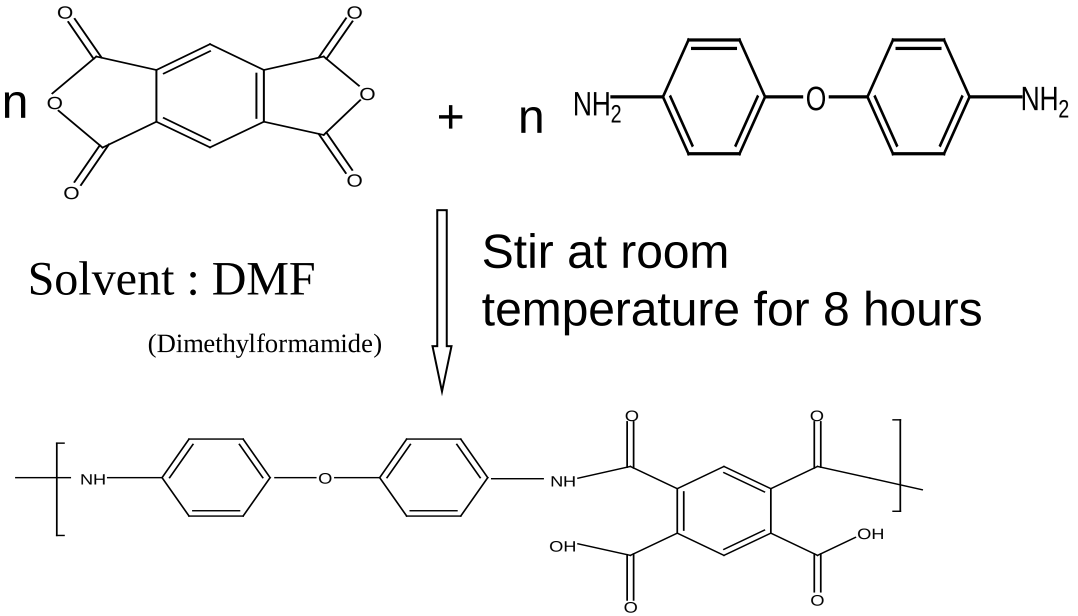
Novel electrode material PAA/PtCr/ GC

PMDA

(Pyromellitic dianhydride)

ODA

(4,4-Oxidianilline)



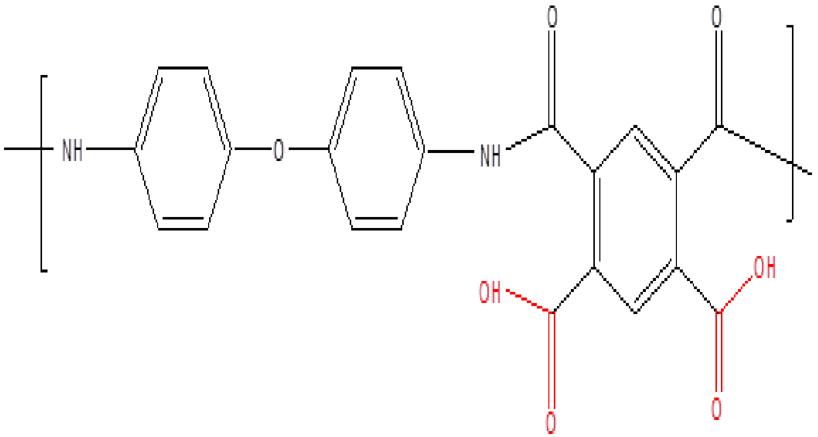
Poly (amic acid)

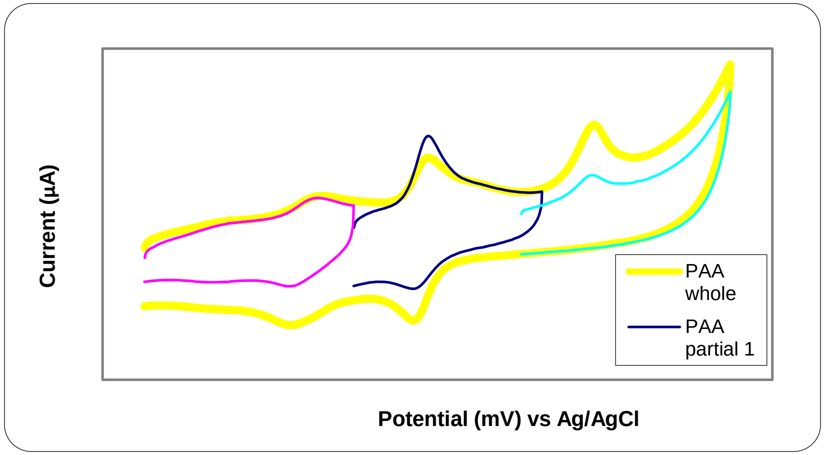
What is PAA ?

Schematic representation of the formation of PAA .

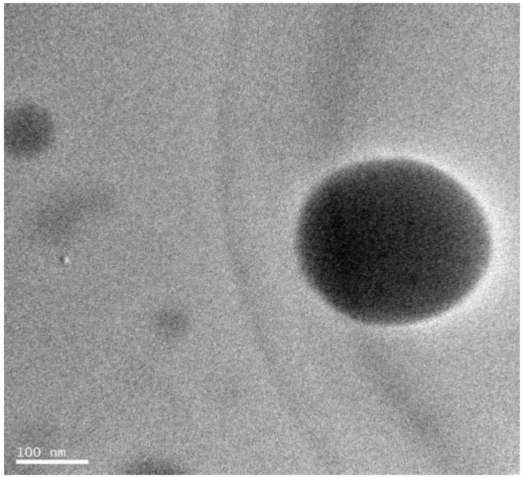
Why Polyamic acid (PAA)?

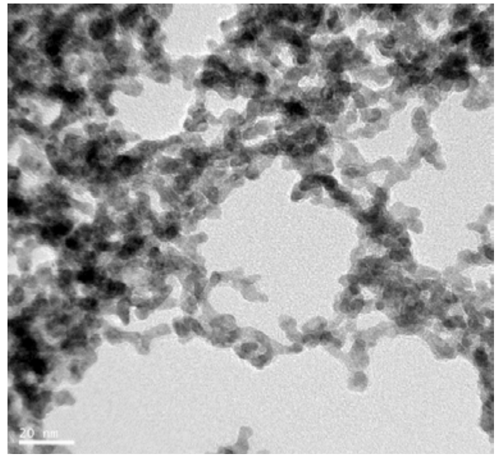
- Conductive
- Biocompatibility
- Ease of preparation
- Flow of electronic charges
- Redox stable
- Surface functional groups
- Permeability

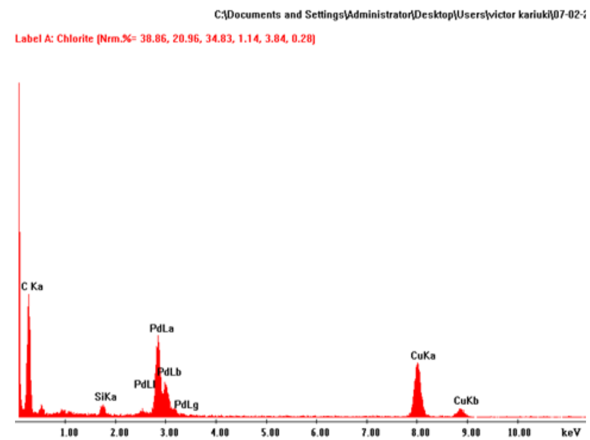




PAA stabilized the nanoparticles while maintaining wettability

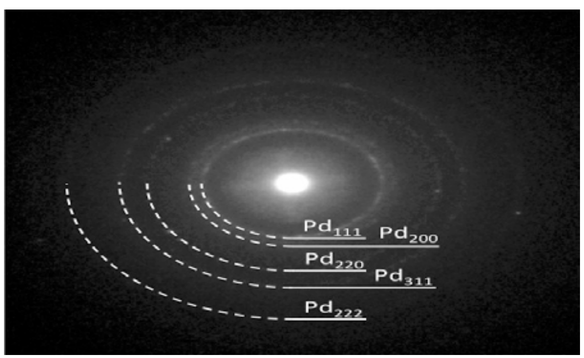




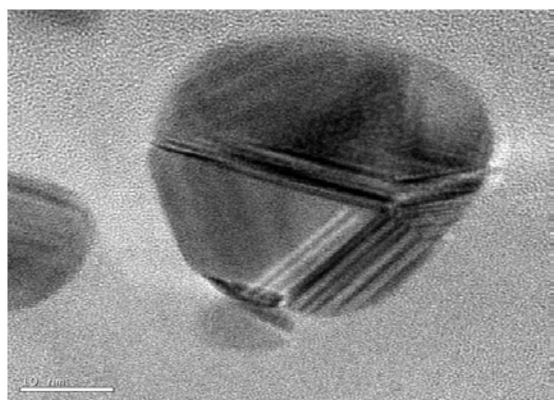


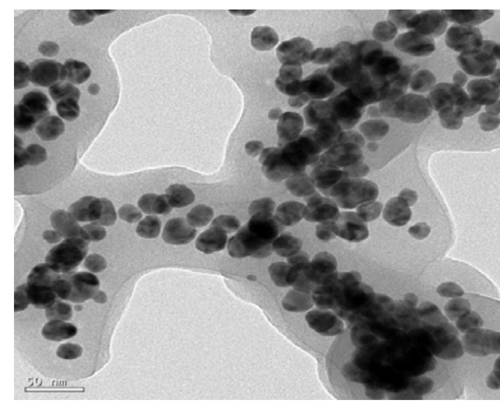
PdNPs stabilized with PAA

PdNPs with no PAA



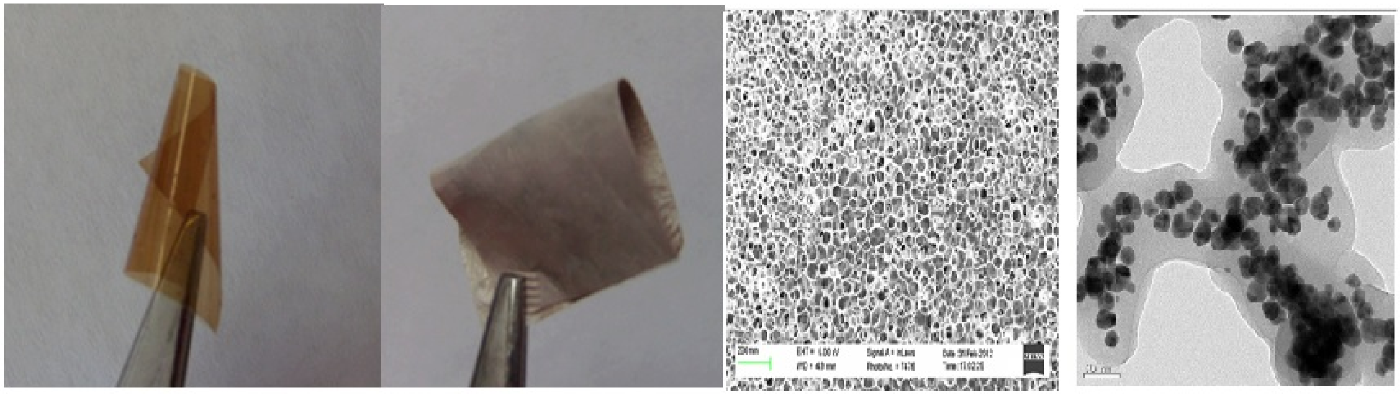
X-ray diffraction pattern shows crystalline particles were formed with uniform size & random size distribution.



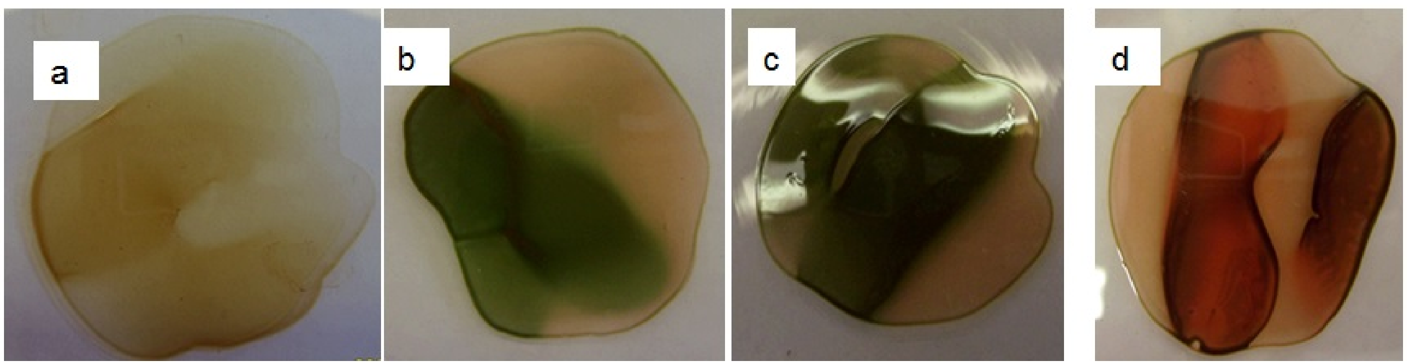


HRTEM of nanosilver with PAA: Particles are twinned with 5 fold symmetry

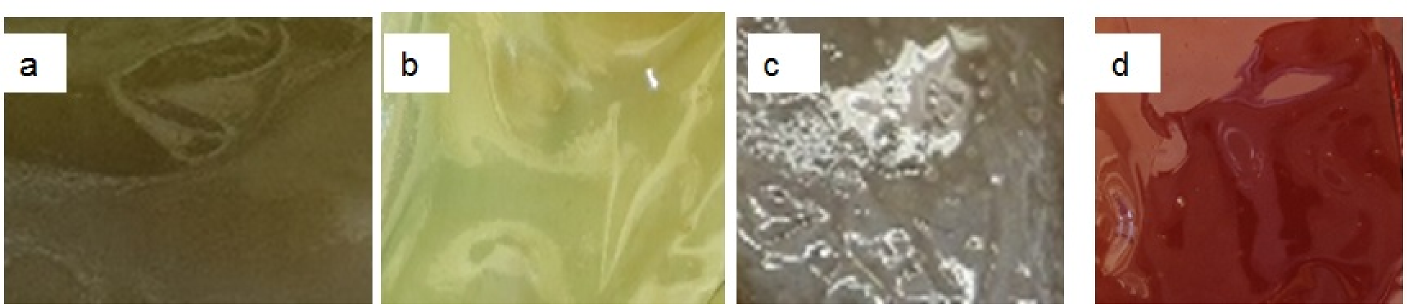
Classic PAAs



- Stable :300̊C
- Flexible
- Mechanically strong
- Porous



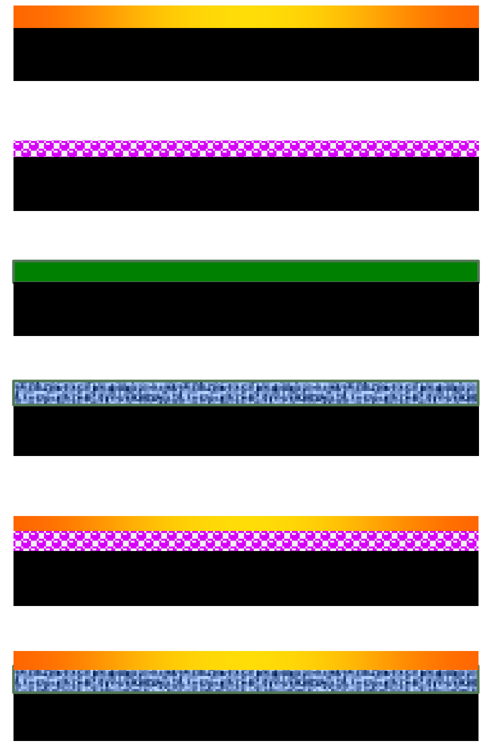
Temperature dependence of PAA a-75 ˚C,b-150˚C,c-250˚C,d-300˚C



Fluorescent PAA biomembranes: A-PAA-CS with %0.3 GA, B-PAA-DA, C- l-PAA 15 h incubation D- m-PAA-DA with for 15 h

Working Electrodes Designed

- PAA/GC (Glass Carbon)
- Pt/GC
- Cr/GC
- PtCr/GC
- PAA/Pt/GC
- PAA/PtCr/GC



PAA spin coated layer

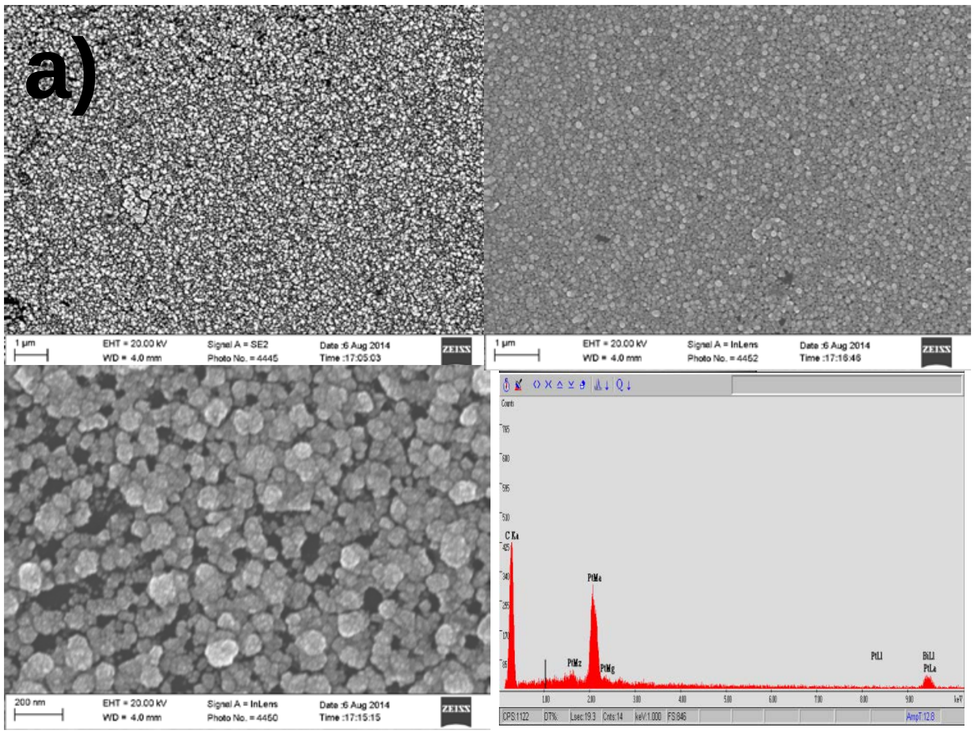
Pt particles electrodeposited

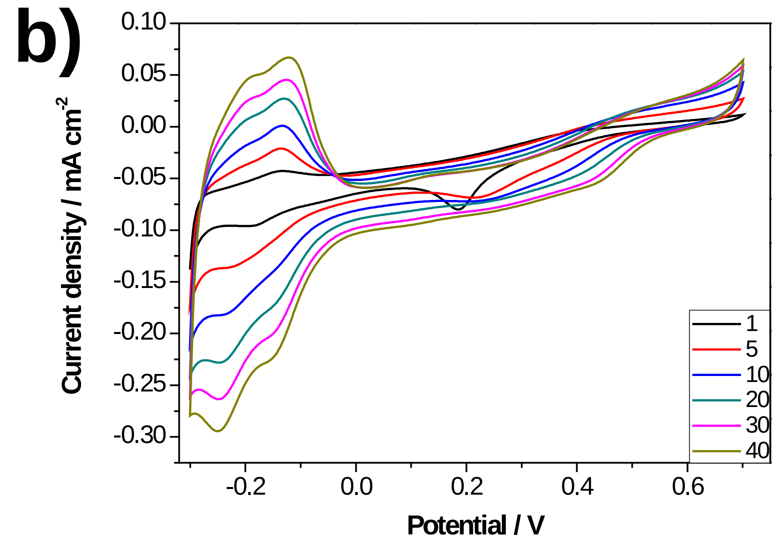
Pt and Cr particles electrodeposited

GC – glassy carbon electrode

Cr particles electrodeposited

Electrodeposition of Pt on GC





a) SEM images of Pt deposited on GC surface and EDS spectra as proof the existence of the platinum; b) Cyclic voltammograms of electrodeposition

Three-electrode system:

Working Electrode – GC

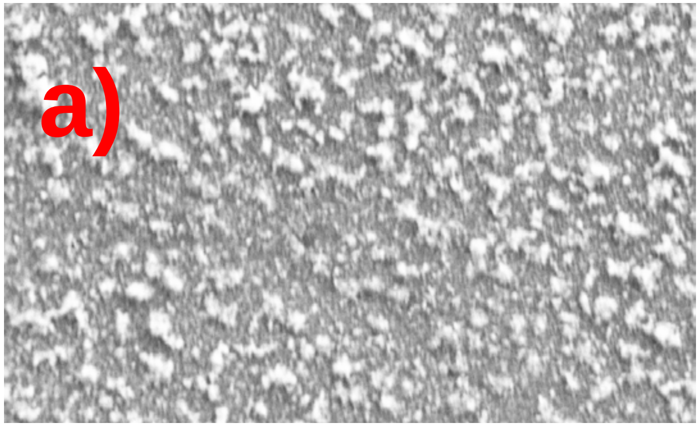
Counter Electrode - Carbon

Reference Electrode - Ag/AgCl

Conditions： 0.01M HCl + 8×10^{-4} M $PtCl_4$

Scan rate：10 mV/S, Sweep 40 cycles

Electrodeposition of PtCr on GC – CV method



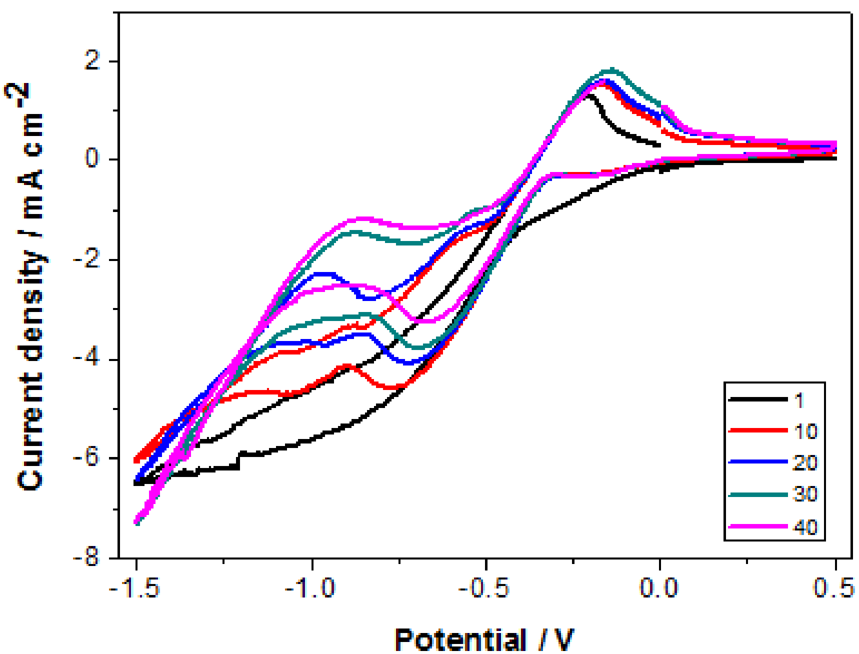
Three-electrode system:

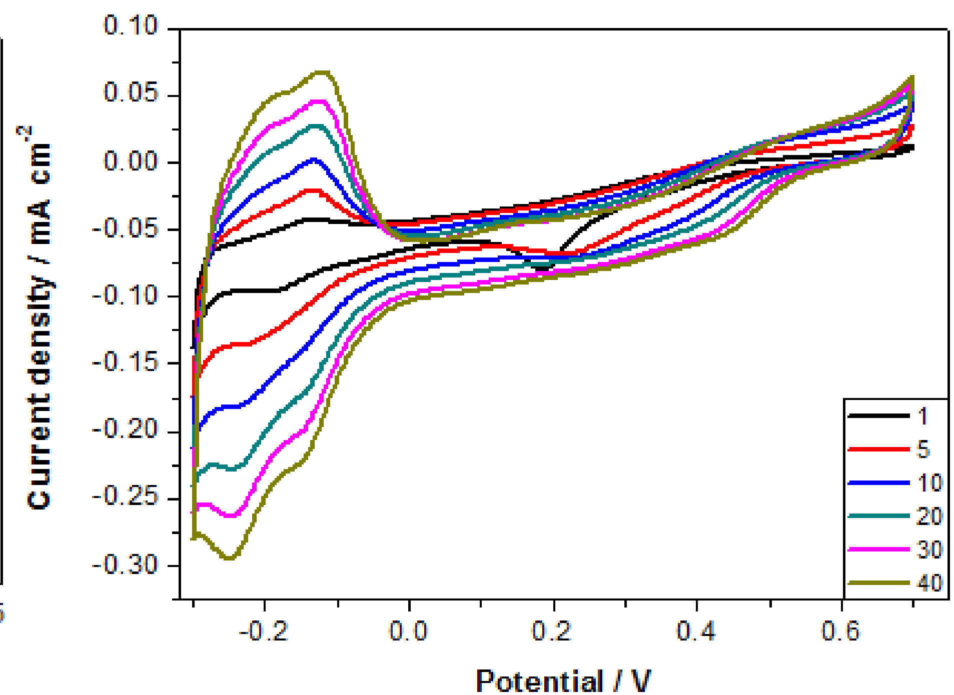
Working Electrode – GC,

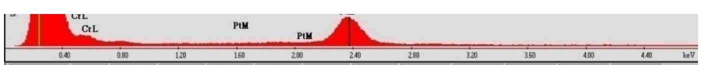
Counter Electrode - Carbon

Reference Electrode - Ag/AgCl

Conditions : $0.01M\ HCl + 8 \times 10^{-4}\ M\ PtCl_4 + 2 \times 10^{-4}\ M\ CrCl_2$

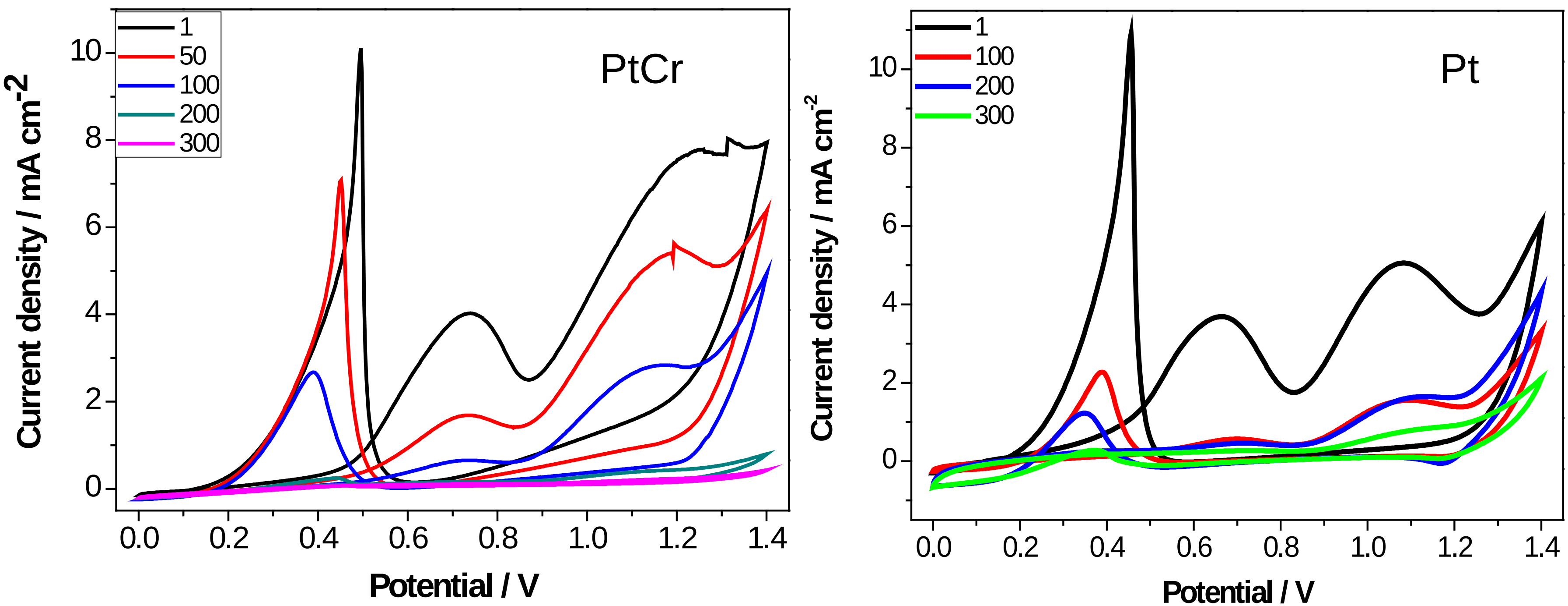




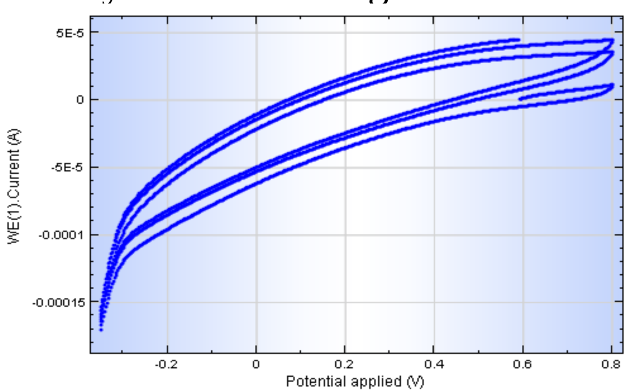


platinum and chromium, b) Cyclic voltammograms of electrodeposition

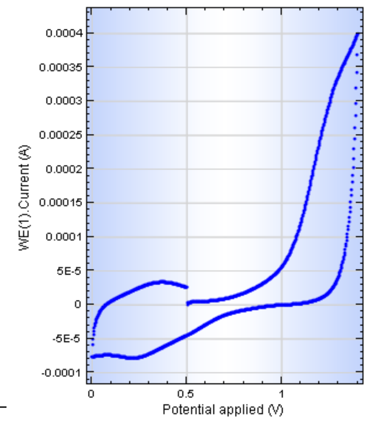
Study of PtCr/GC and Pt/GC for EOR



Cyclic voltammograms of ethanol oxidation reaction in 0.1 M $HClO_4$ and 1 M ethanol of PtCr and Pt.

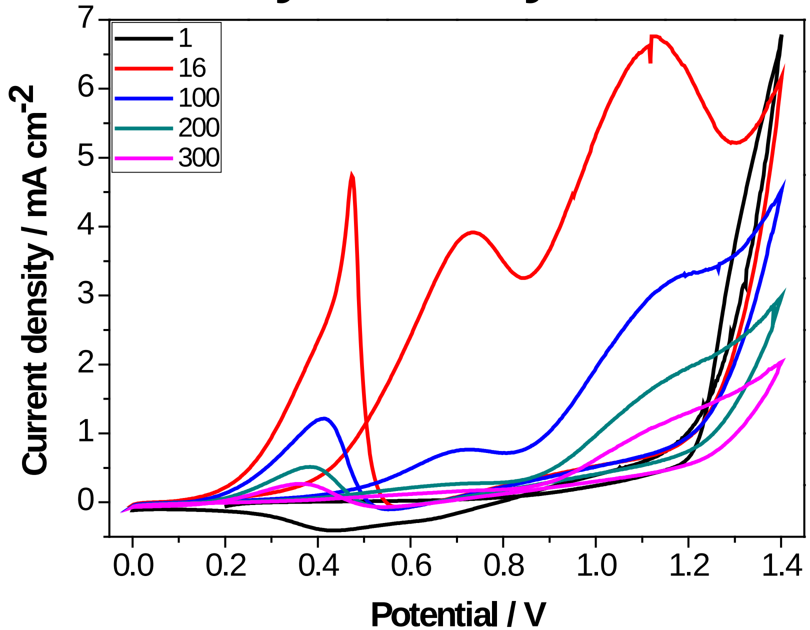


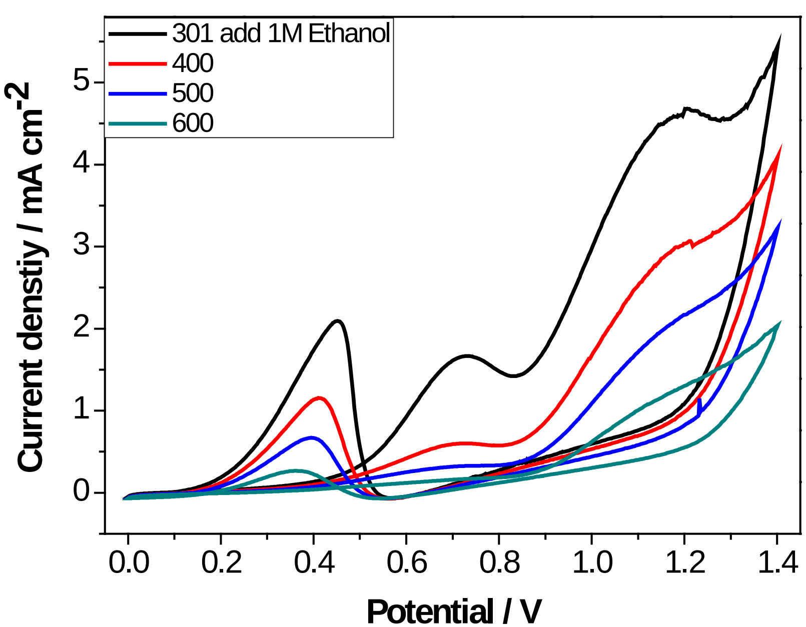
Cyclic voltammograms of ethanol oxidation reaction in 0.1 M $HClO_4$ and 1 M ethanol of PAA

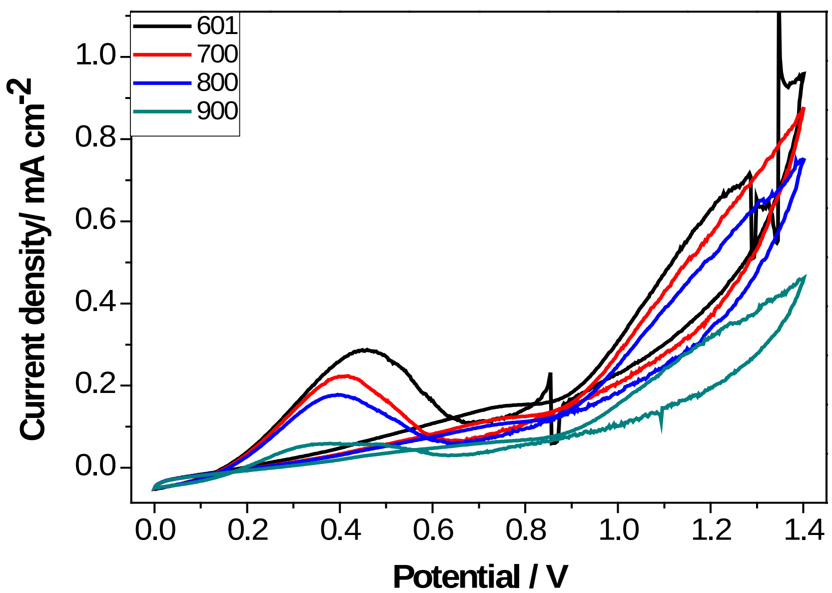


Cyclic voltammograms of ethanol oxidation reaction in 0.1 M $HClO_4$ and 1 M ethanol of Cr

Stability study of PAA/PtCr/GC for EOR







Scan cycles	Current density	Time (h)	Scan cycles	Current density	Time (h)
1	0.00	0.00	500	0.81	38.88
16	4.85	1.24	600	0.25	46.67
100	1.40	7.78	601	0.32	46.74
200	0.86	15:56	700	0.22	54.44
300	0.37	23:33	800	0.18	62.22
301	2.45	23:41	900	0.05	70.00
400	1.12	31.11			

Summary &Conclusions

- Catalyst PtCr is more stable on the glass carbon than Pt particles. That will help to improve the efficiency of fuel cell.
- PAA alone is not active towards the ethanol oxidation reaction. Conversely, the Pt/GC, PtCr/GC and PAA/PtCr/GC electrodes exhibit oxidation currents for ethanol oxidation reaction.
- After PtCr/GC is coated with PAA, based on the current of ethanol oxidation, the activation of working electrode decreased. This is due to the insufficient conductivity of PAA.
- Without coating of PAA, the electrodeposited catalysts are very easily lost into solution.

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Any Questions ?