Preparation and characterization of anode catalysts for the direct alcohol fuel cells (DAFC): methanol and ethanol

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Outline

- Introduction
- WHY DAFC?
- Preparation and Characterization of electro-catalysts
- Results and Discussion
- Future work
- Acknowledgements

Introduction

- To reduce pollution produced by burning fossil fuels, energy production must become cleaner and the use of energy more effective.
- Alternatives to fossil fuel: Wind power, Solar PV, Fuel cell (FC)…
- FC offer an attractive combination of highly efficient fuel utilisation and environmentally-friendly operation

- Device that uses a chemical fuel such as hydrogen and an oxidant, e.g., oxygen to generate electricity directly from electrochemical processes
- The by-products from an operating fuel cell are heat and water

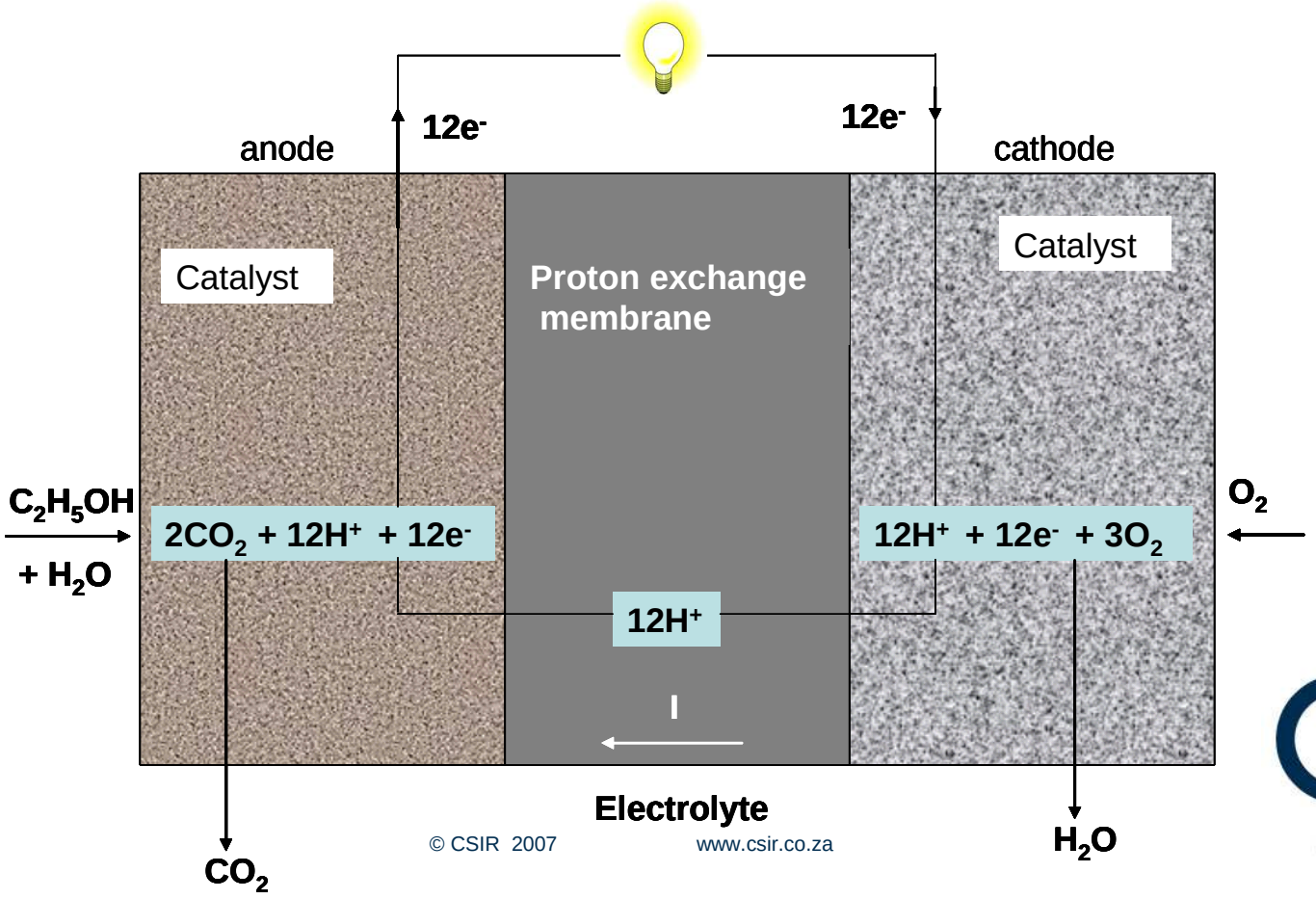
Types of fuel cells (FC)

- Alkaline Fuel Cell (AFC): Electrolyte-alkaline potassium hydroxide, 80°C
- Molten Carbonate Fuel Cell (MCFC): Electrolyte-carbonate-salt-impregnated ceramic matrix, 650°C
- Solid Oxide Fuel Cell (SOFC): Electrolyte- hard, non-porous ceramic compound, 700-1000°C
- Phosphoric Acid Fuel Cell (PAFC): Electrolyte-liquid phosphoric acid, 180-200°C
- Polymer Electrolyte Membrane Fuel Cell (PEMFC): Electrolyte- solid polymer membrane (typically Nafion), around 70°C

Besides H_2 as fuel, chemical energy in alcohols can be directly converted into electricity. Examples: methanol and ethanol

WHY DAFC?

- Easy transportation and storage of the fuel
- Does not require a reformer
- Liquid fuel is compatible to existing infrastructure
- High energy density (ethanol 8kWh/kg, methanol 6.1kWh/kg)



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Challenges of DAFC

- Alcohol crossover from anode to cathode catalyst.

  ORR catalyst tolerant to alcohol,

  membrane reduce alcohol crossover
- CO poisoning on anode catalyst
- Catalyst able to break C-C bond

DEFC vs DMFC

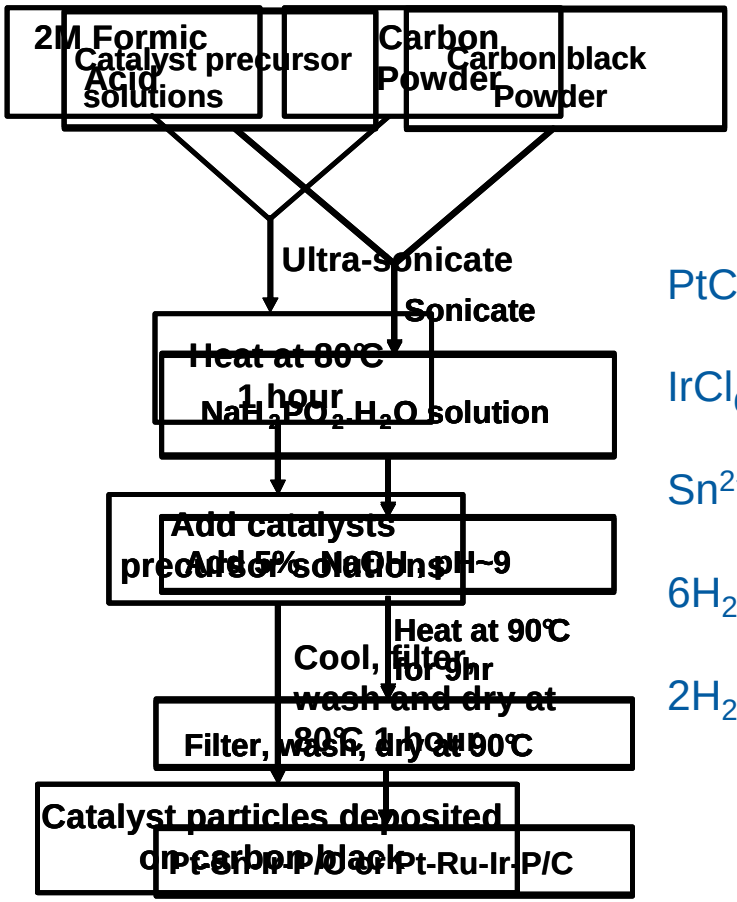
- Ethanol: low toxicity and widely available but its reactivity is slightly lower than methanol' reactivity.

Electro-catalysts

- Best binary catalysts for methanol and ethanol electro-oxidation: Pt-Ru and Pt-Sn respectively.
- The enhanced performance is not good enough in the presence of CO.
- More active electro-catalysts are critically needed
- Ternary catalysts: Iridium may promote the oxidation of the adsorbed CO on Pt.
- Non-metallic elements (N, P and S), reduces the size of a PtRu/C catalyst

Preparation of Electro-catalysts

Method1/2



Method3

Reducing agents: Formic acid and $NaH_2PO_2.H_2O$

$PtCl_6^{2-} + 2H_2PO_2^- + 2H_2O = 2H_2PO_3^- + 4H^+ + 6Cl^- + Pt$

$IrCl_6^{2-} + 2H_2PO_2^- + 2H_2O = 2H_2PO_3^- + 4H^+ + 6Cl^- + Ir$

$Sn^{2+} + H_2PO_2^- + H_2O = H_2PO_3^- + 2H^+ + Sn$

$6H_2PO_2^- = 2H_2PO_3^- + 2H_2O + 4OH^- + 4P$

$2H_2PO_2^- + 2H_2O = 2H_2PO_3^- + 2H_2$

Molar ratios
Pt:Sn:Ir (3:1:1)
Pt:Ru:Ir (3:3:1)
Total catalyst loading : 20wt%

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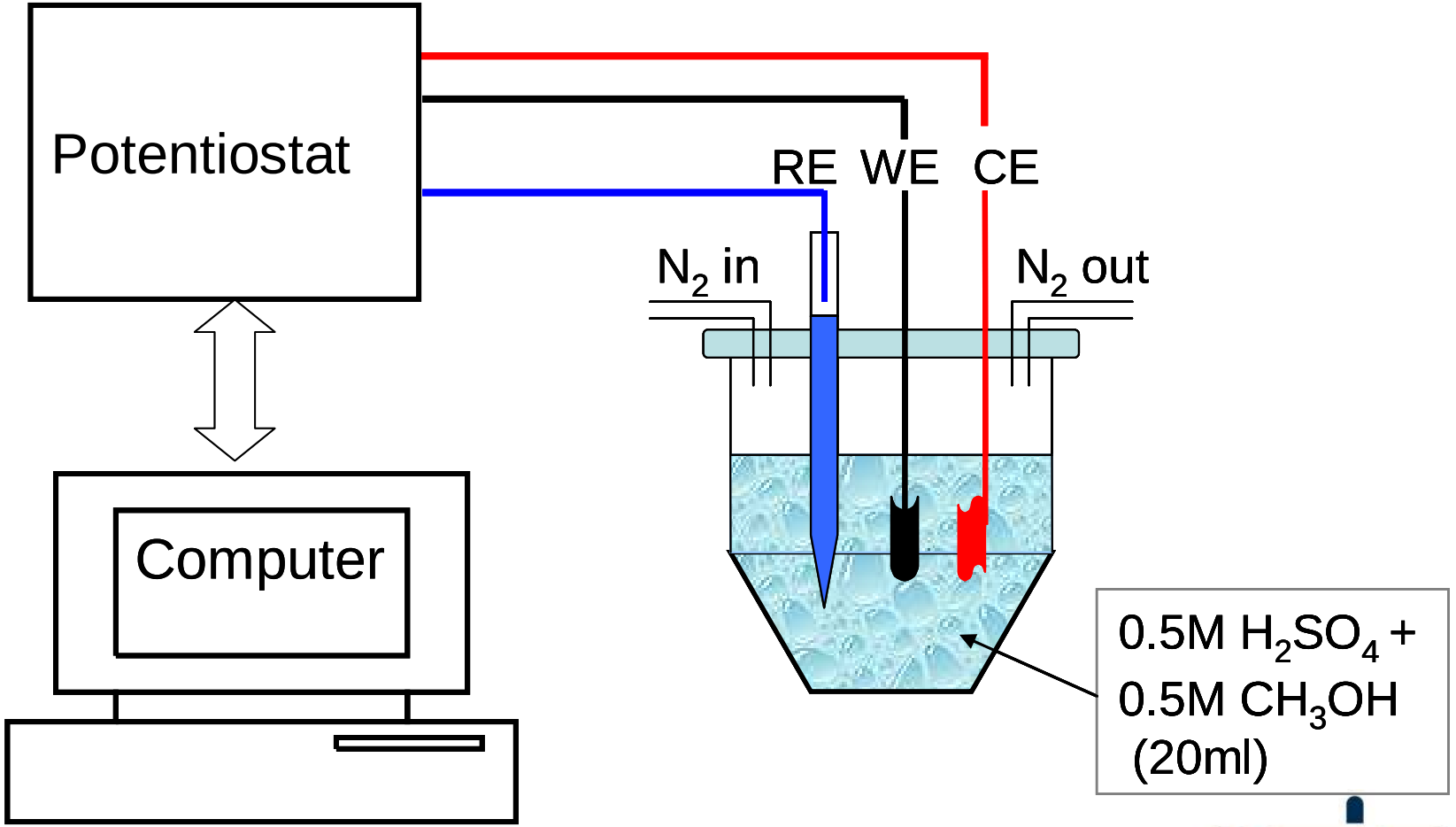
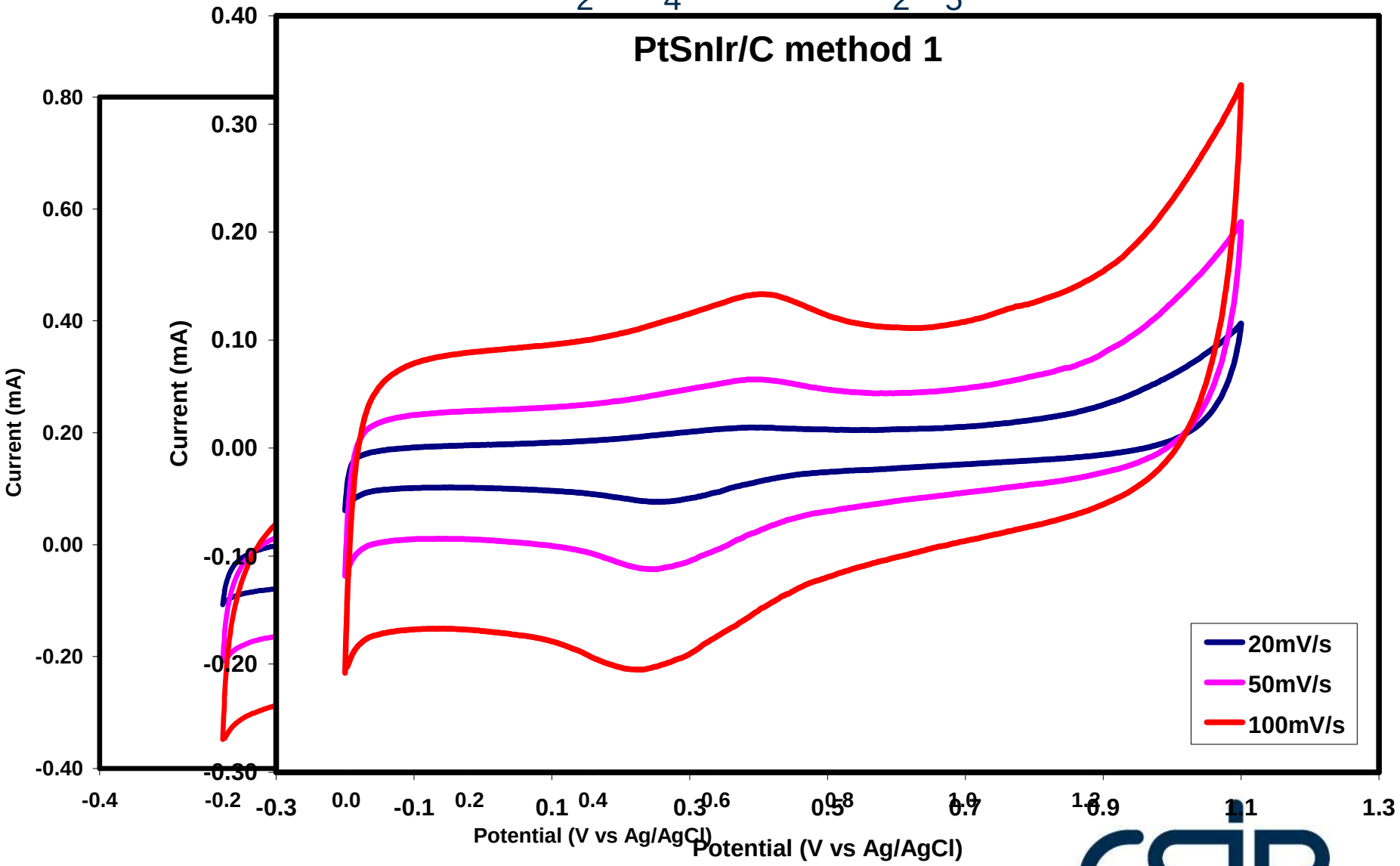
Experimental set-up : Electrochemical Characterization



RESULTS AND DISCUSSION

0.5M H_2SO_4 + 0.5M C_2H_5OH



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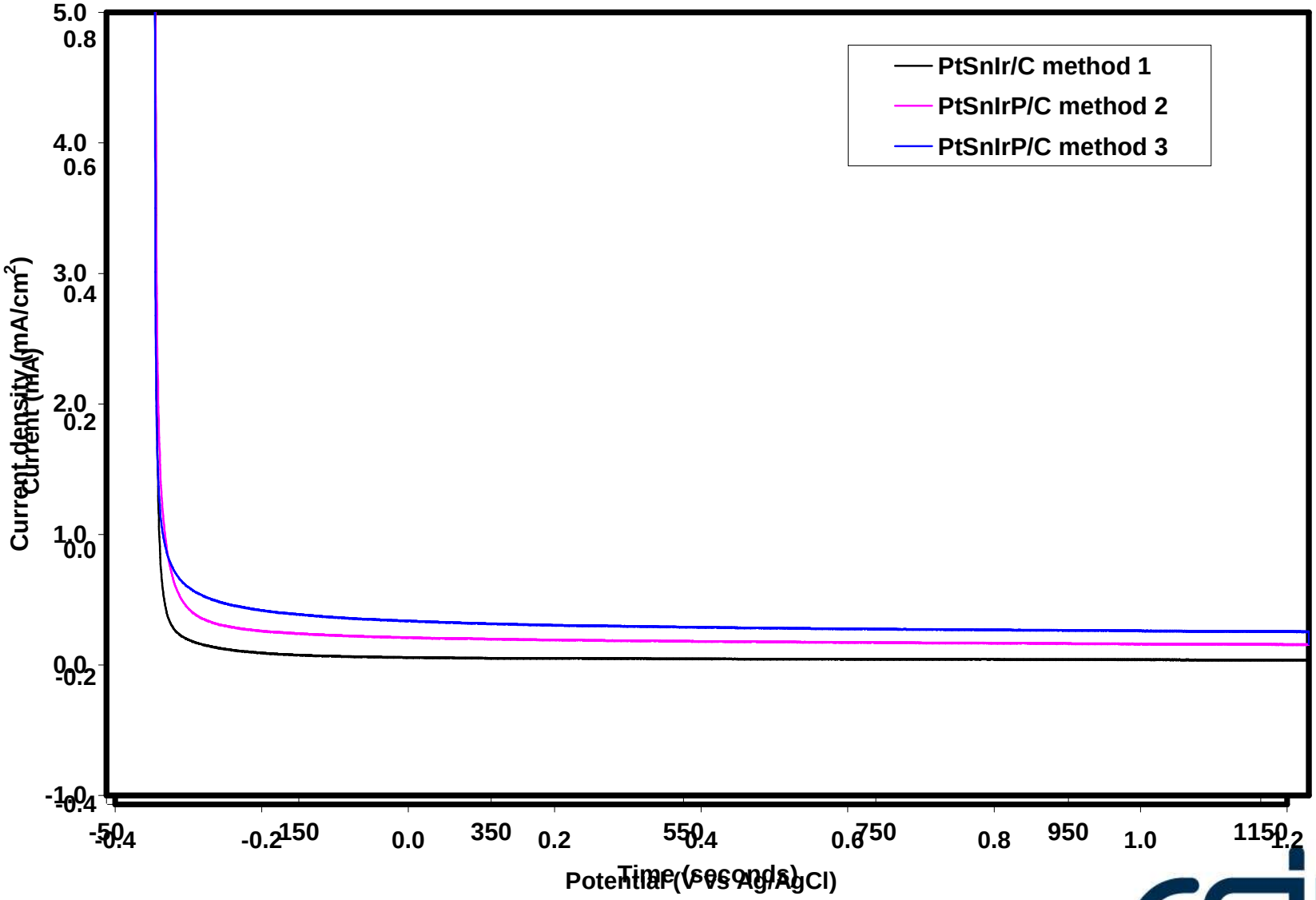

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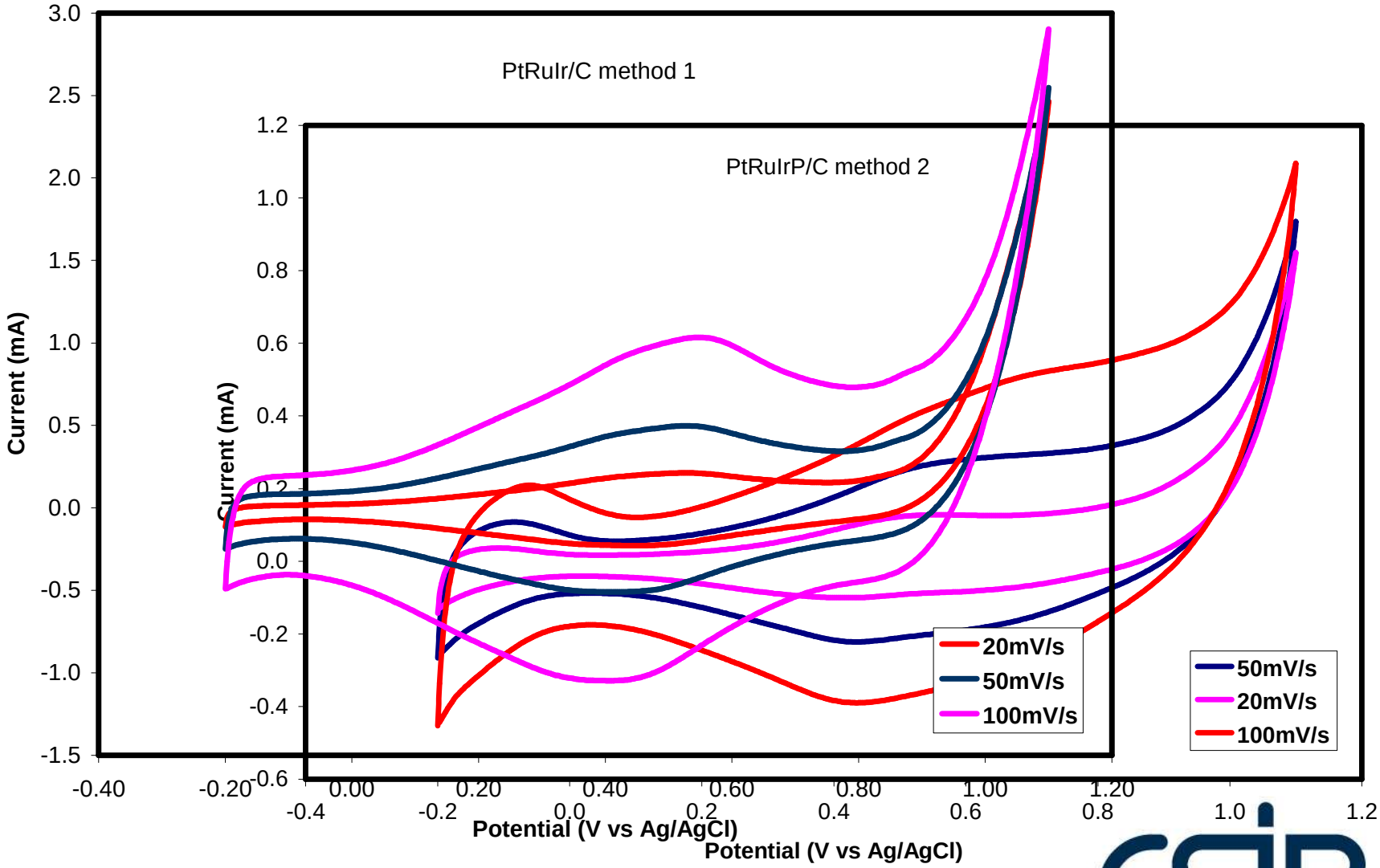
0.5M H_2SO_4 + 0.5M CH_3OH



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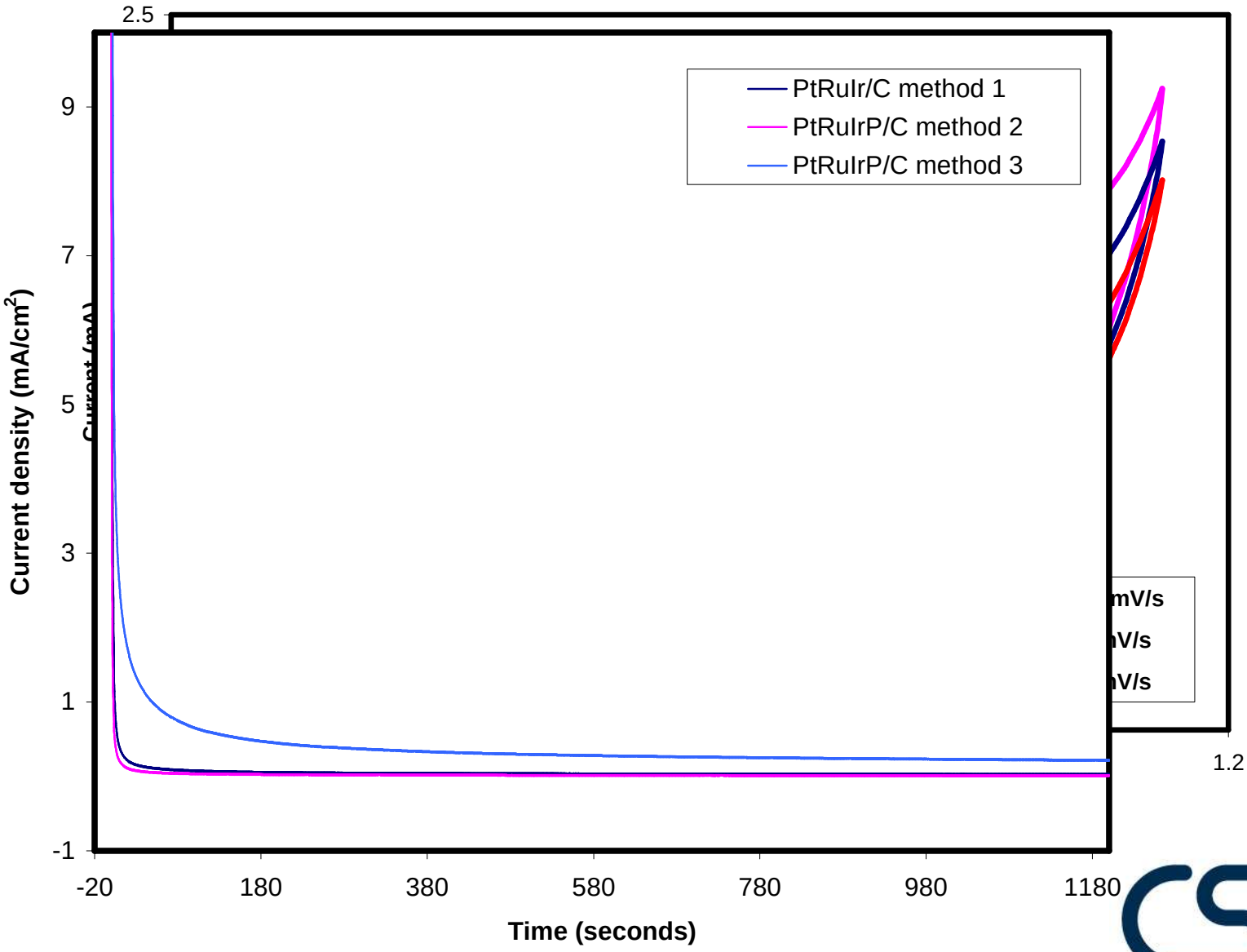

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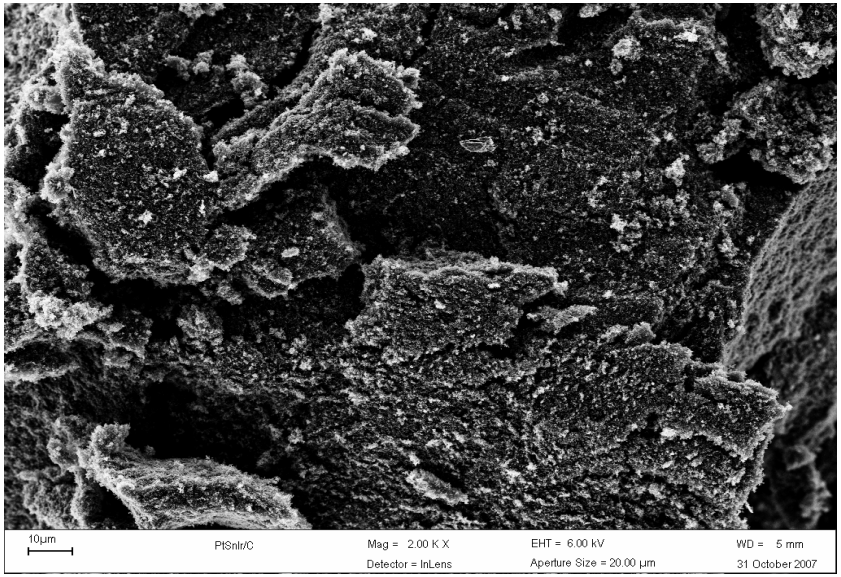
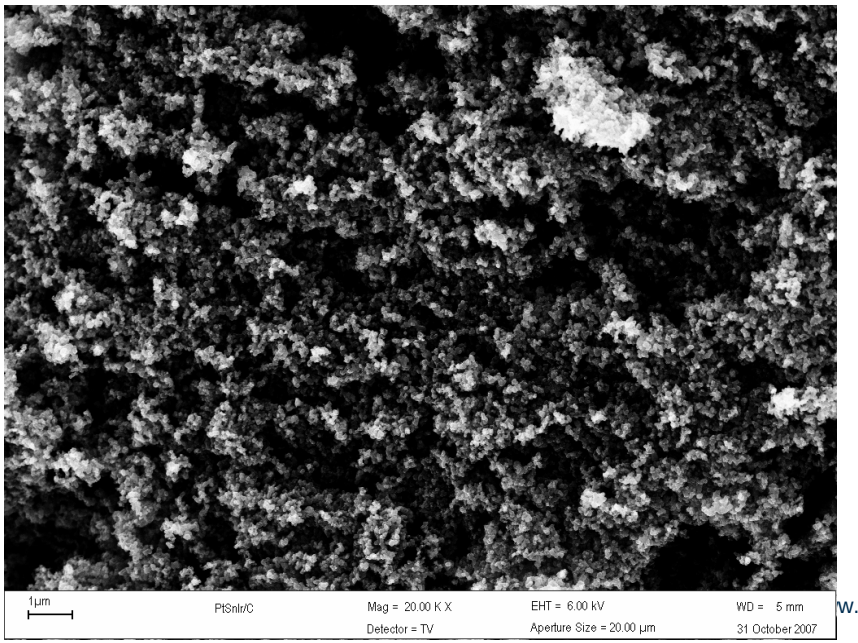
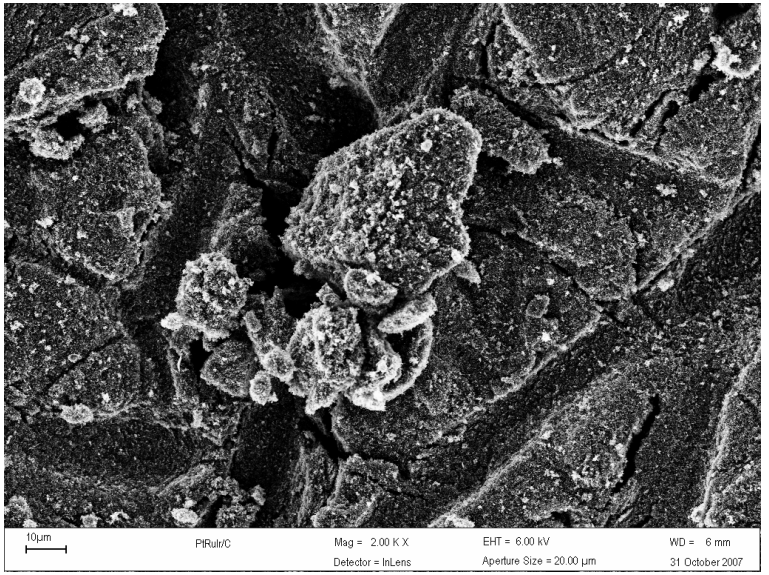
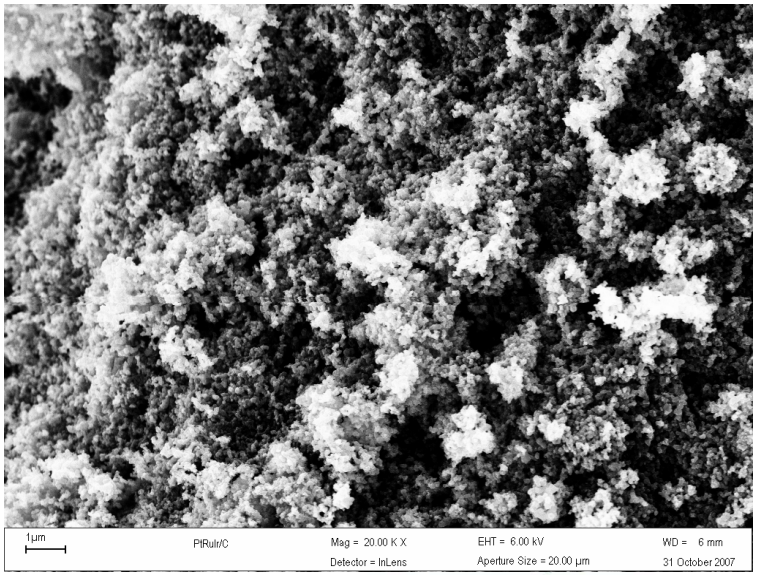
Pt-Sn-Ir/C

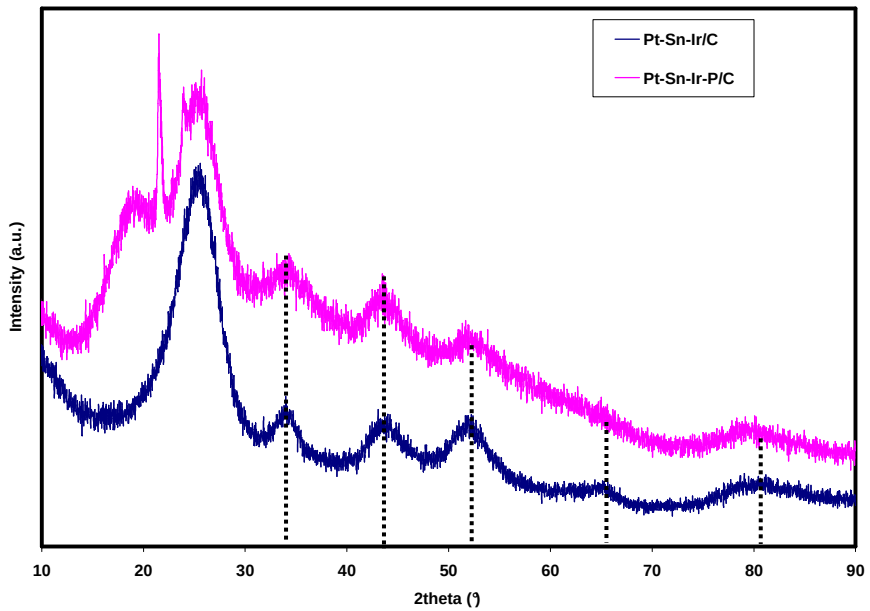


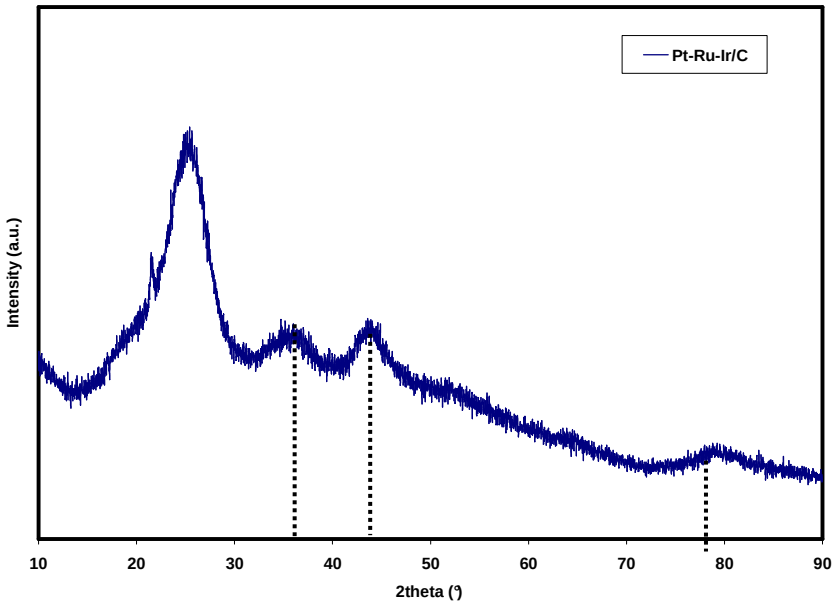


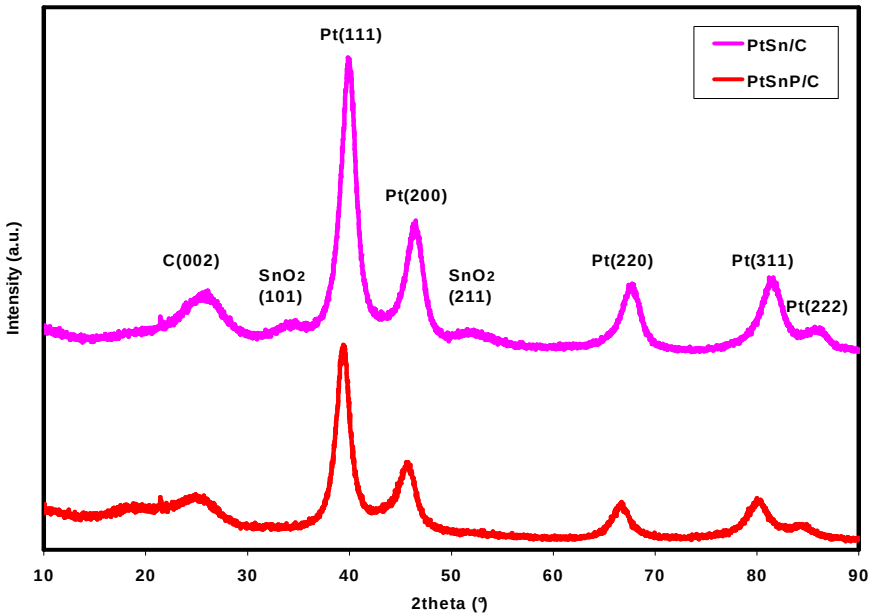
Pt-Ru-Ir/C

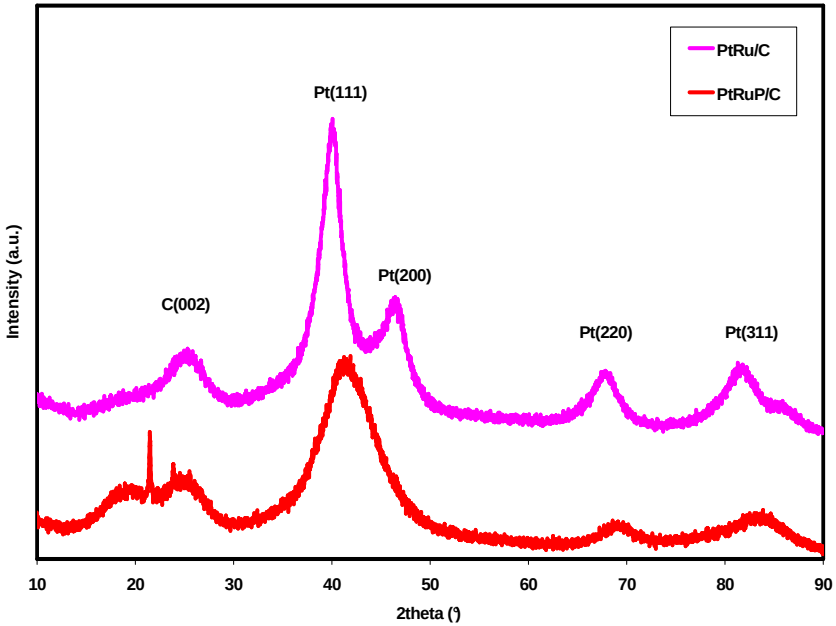








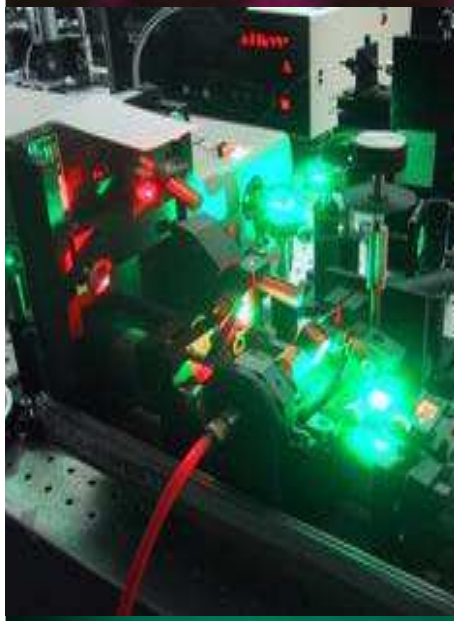




http://www.webmineral.com/X-Ray/shtml

Conclusions

- Electro-oxidation of methanol and ethanol takes place on electro-catalysts prepared.
- Kinetics of electro-oxidation reactions are different for various catalyst compositions
- Effect of P: high current density - improved performance
- Electro-catalyst performance depends on the preparation procedure



Future work

- Catalyst preparation
  - -Optimize catalyst composition
    (Add Ir, P to Pt-Sn and Pt-Ru)
- Characterization:
  - -Electrochemistry
    (Cyclic voltammetry, Impedance spectroscopy)
  - -Structural and elemental analysis
    (TEM, EDX, XPS, ICP)
- MEA fabrication and performance tests in a unit fuel cell
  - -Methanol and ethanol

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Thank you