Carbon supported Pd-Ni and Pd-Ru-Ni nanocatalysts for the alkaline direct ethanol fuel cell (DEFC)

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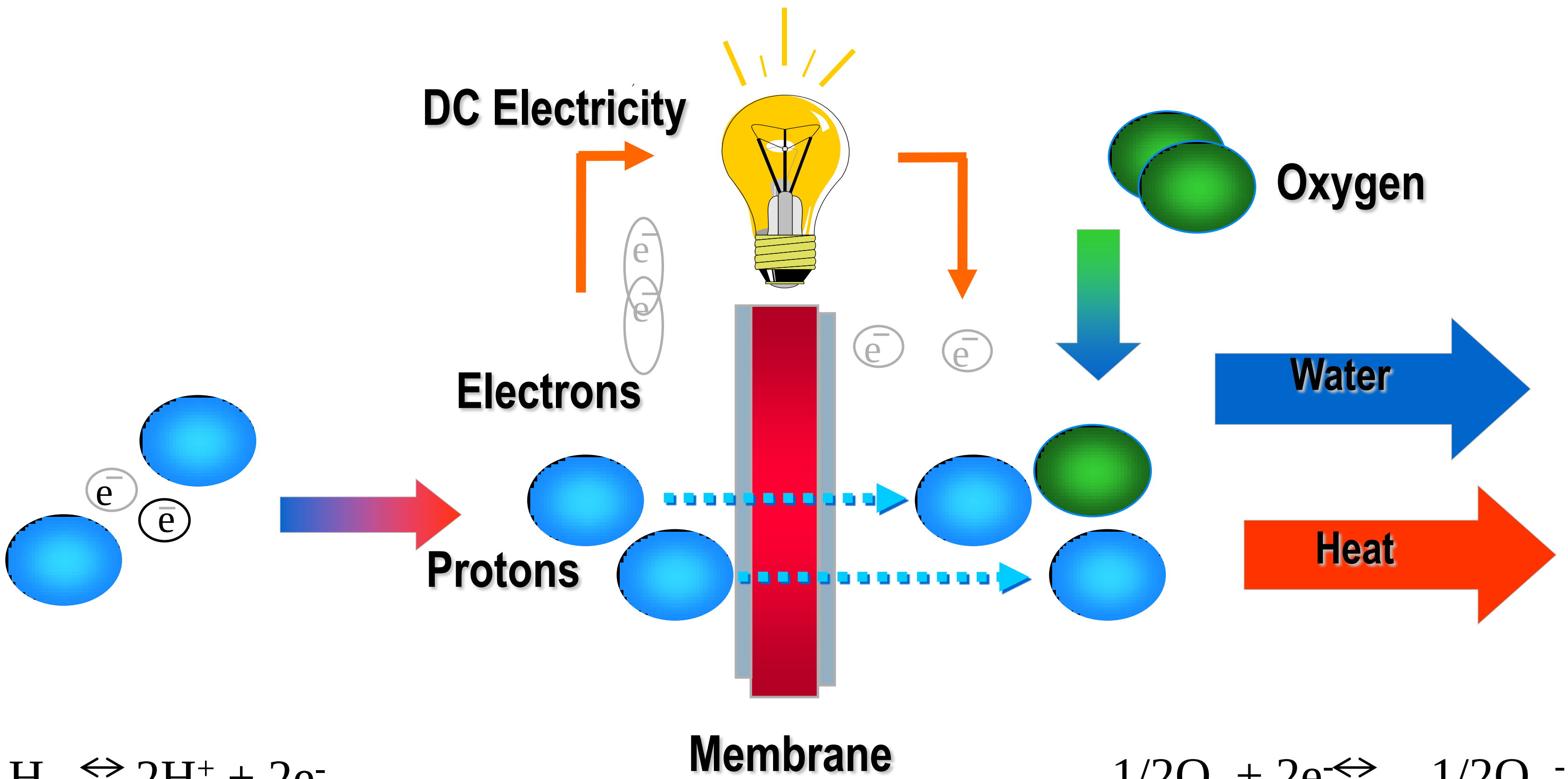
Outline

- Background and Introduction
- Synthesis of nanocatalysts
- Characterization and Electrochemical Evaluation of the nanocatalysts
- DEFC Performance measurement in alkaline medium
- Concluding remarks
- Acknowledgements

What is a fuel cell (FC)?



$H_2 \leftrightarrow 2H^+ + 2e^-$ $1/2O_2 + 2e^- \leftrightarrow 1/2O_2^{--}$

0 Volts ~1.23 Volts

$$H_2 + 1/2O_2 \rightarrow H_2O$$

Approx, 1 volt or less/cell, therefore add cells together

What is a FC? (cont'd)

- Categorized *based on the type of electrolyte* used.

Fuel Cell Type	Current Density (mA/cm^2)	System Efficiency	Fuel Proc. Complexity	Stack Power Density	Transient Capability
Alkaline	60 - 120	35 - 50	Medium	Medium	High
PAFC	100 - 400	35 - 45	Medium	Medium	Medium
MCFC	100 - 200	45 - 55	Low	Low	Low
SOFC	100 - 300	45 - 50	Low	Medium	Low
PEMFC	**400 - 900**	**32 - 40**	**High**	**High**	**High**

- Electrolyte is sandwiched between anode and cathode.
- Anode catalyst: fuel oxidation
- Cathode catalyst: oxygen reduction

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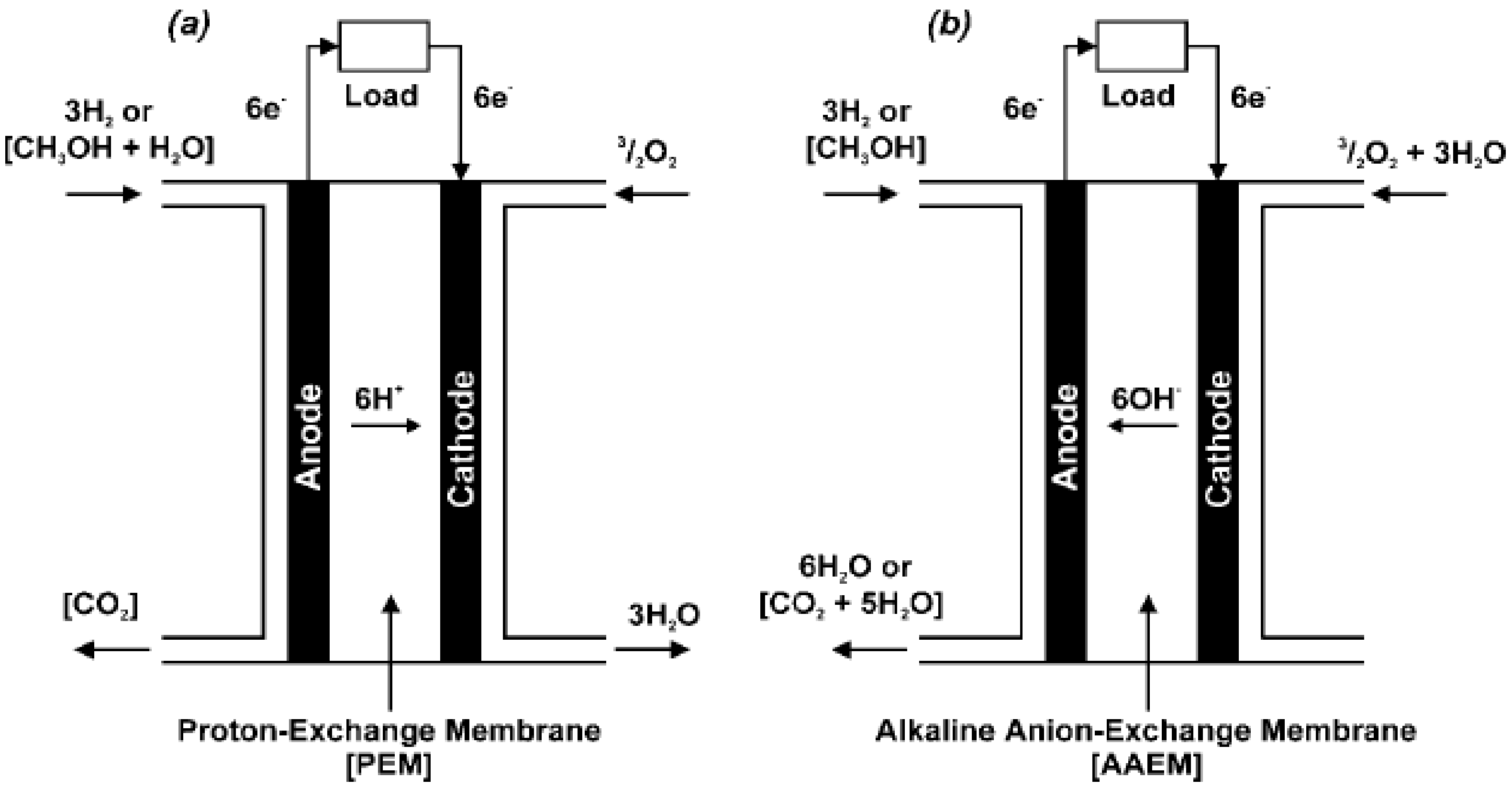
Proton exchange membrane Fuel cell (PEMFC): Challenges

- Catalysts: slow electrode kinetics, CO poisoning of Pt at low temp.
- Membrane: high fuel permeability, high cost

Alkaline Anion exchange membrane Fuel cell (AEMFC): Alternative

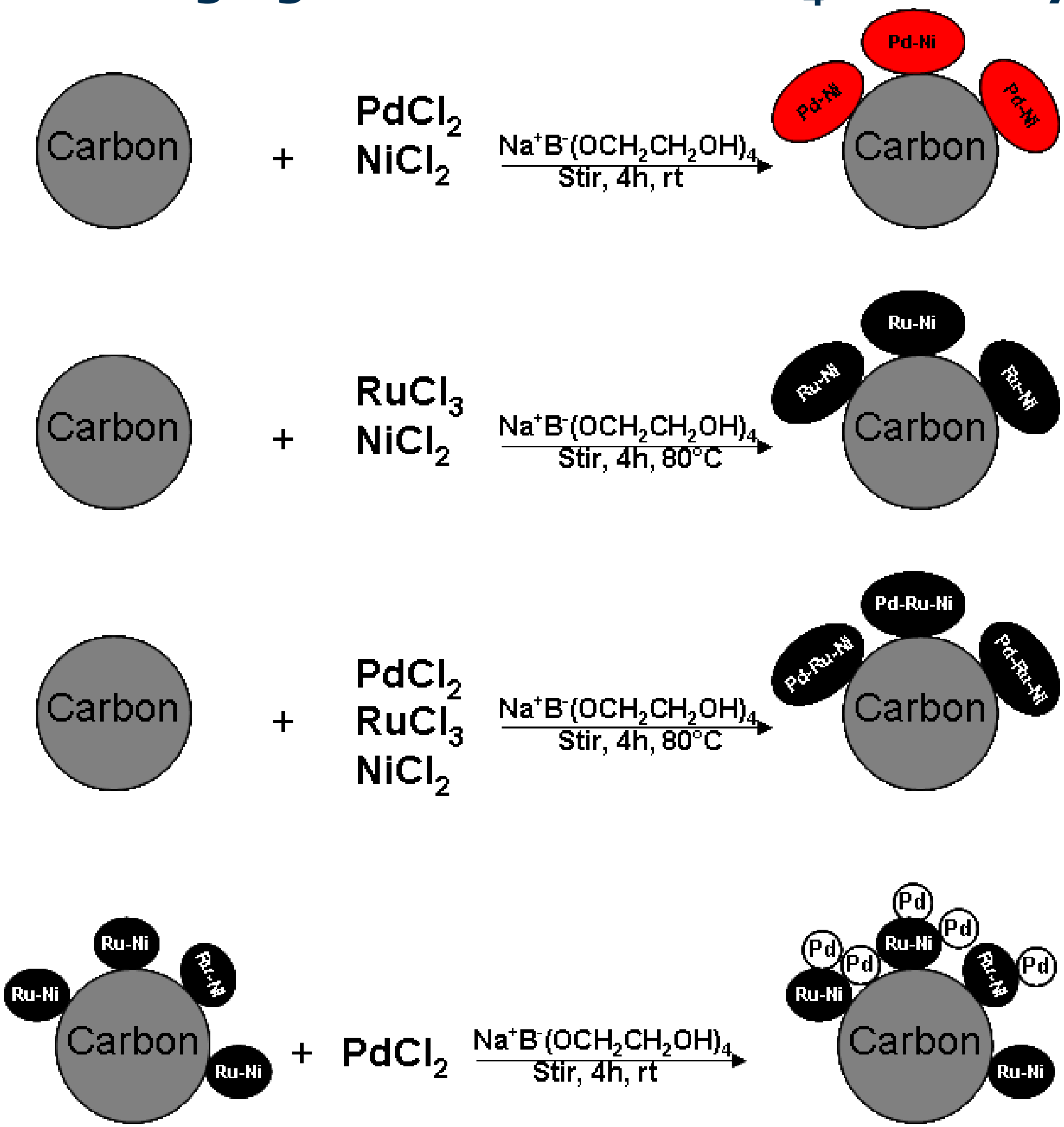
- Catalysts: use non-noble metals, faster kinetics of oxygen reduction and alcohol oxidation
- Membrane: reduced or no alcohol crossover

DAFC vs alkaline DAFC



Synthesis of nanocatalysts

reducing agent: mixture $NaBH_4$ and ethylene glycol



Pd-Ni/C

Ru-Ni/C

Pd-Ru-Ni/C (co-reduction)

Low ethanol oxidation performance vs Pd+Ru-Ni/C

Pd + Ru-Ni/C

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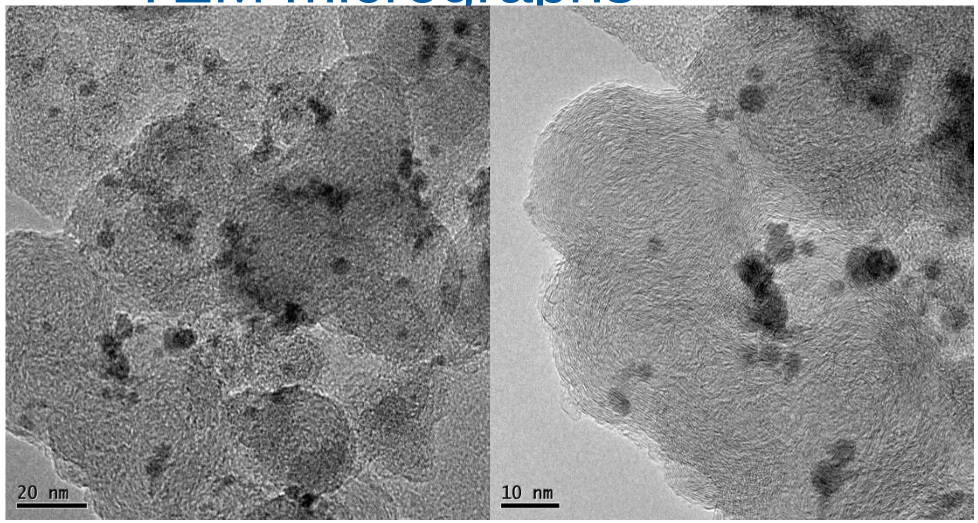
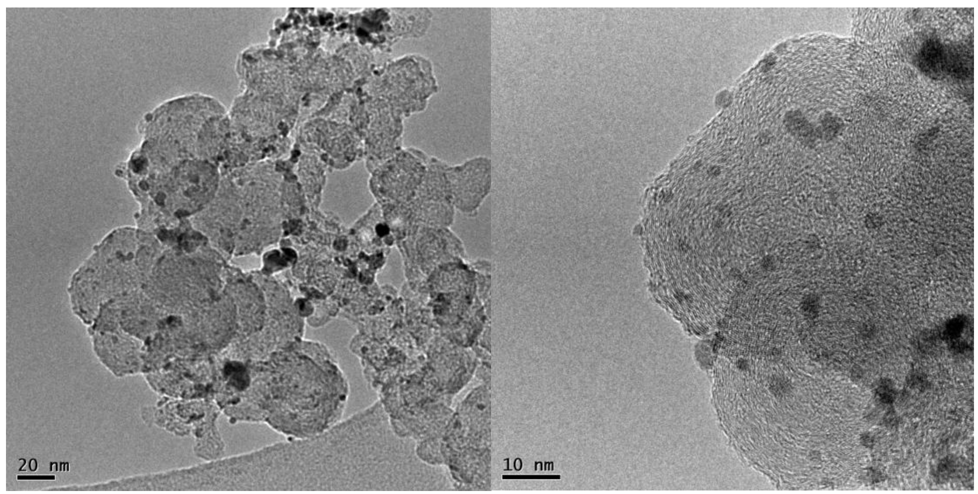
Characterization of nanocatalysts

TEM micrographs

Binary:
7+- 0.8 nm

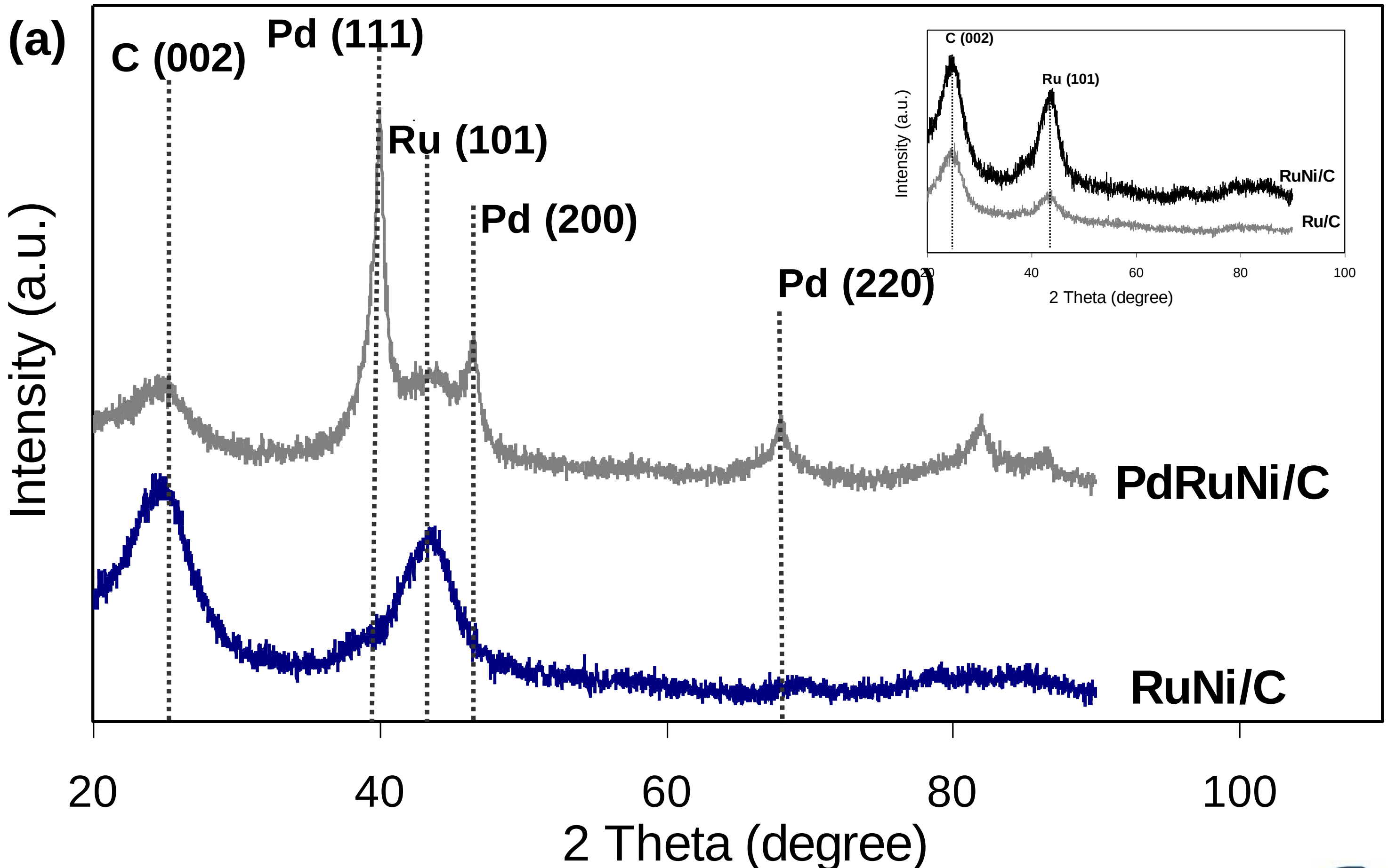


Ternary
6+- 0.5nm



Modibedi et al, International J. Hydrogen Energy 36 (8) 2011 4664-4672

XRD micrographs of nanocatalysts



Pd fcc

(insert XRD patterns of Ru/C and Ru-Ni/C)

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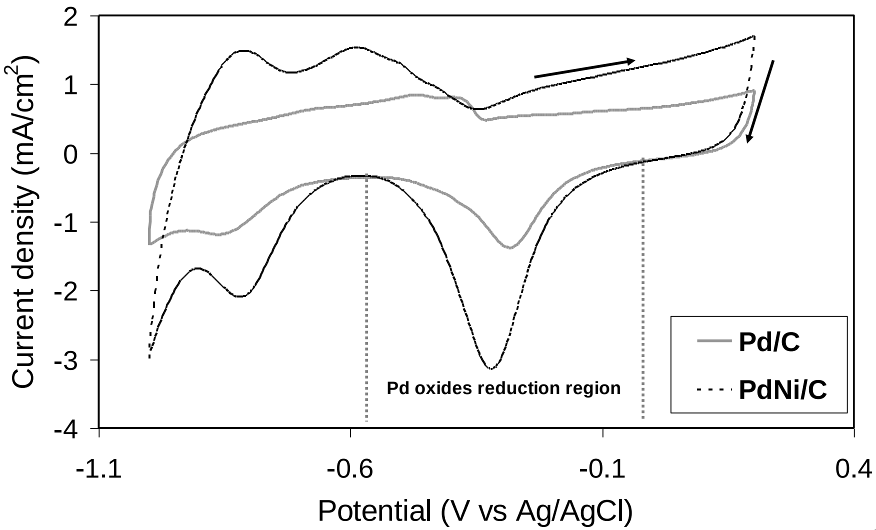
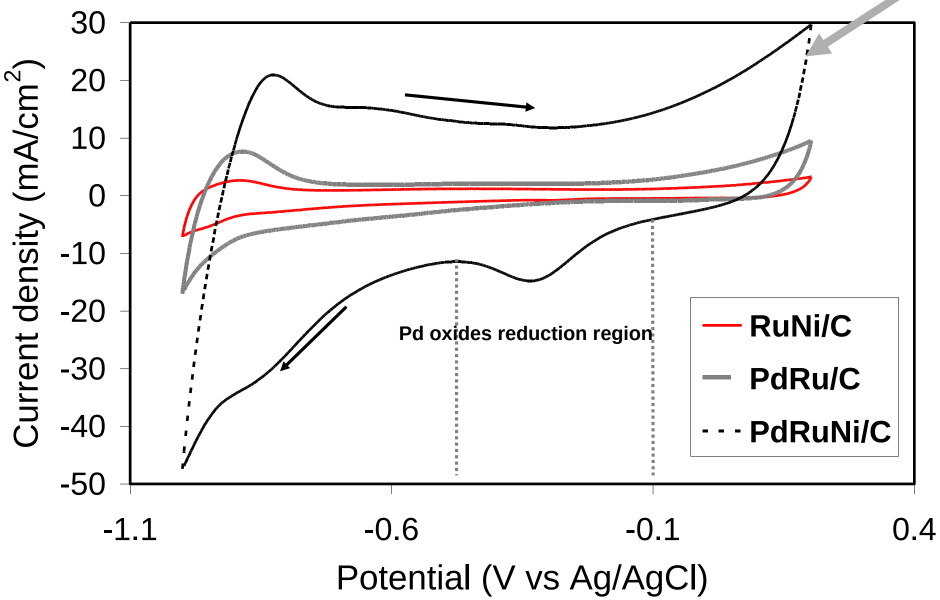
Electrochemical Evaluation

cyclic voltammograms in 0.5 M NaOH





Pd+ Ru-Ni/C

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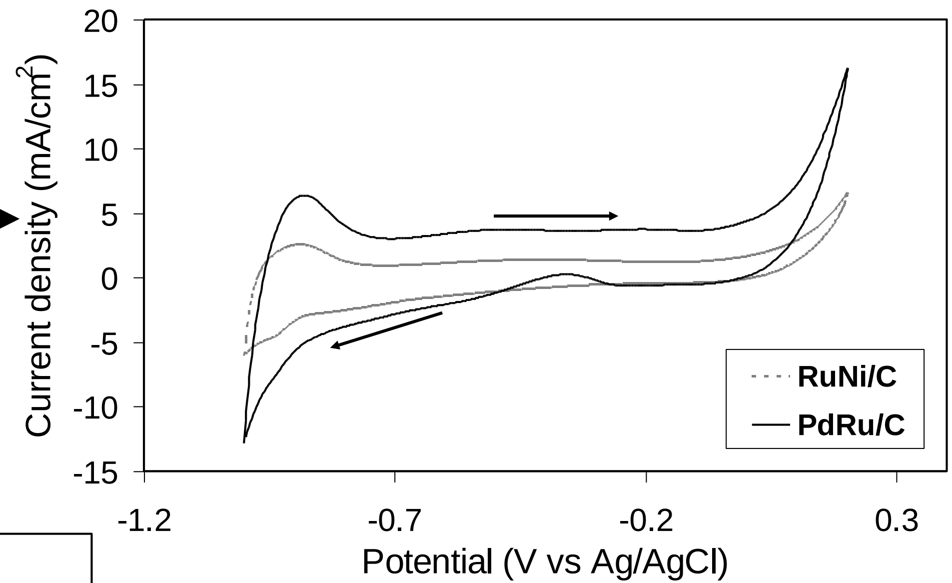
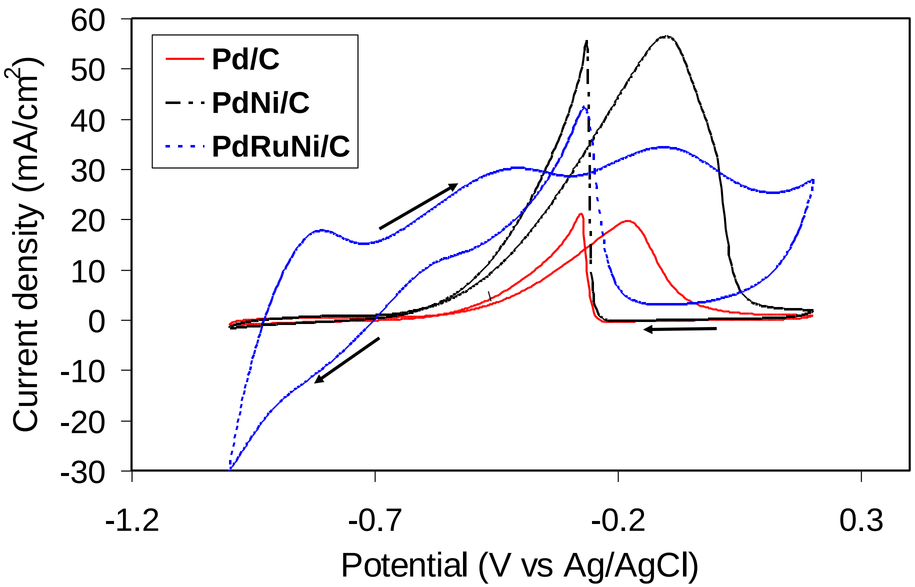
Electrochemical evaluation

cyclic voltammograms in ethanol

RuNi/C and PdRu/C:
no or low activity towards ethanol oxidation





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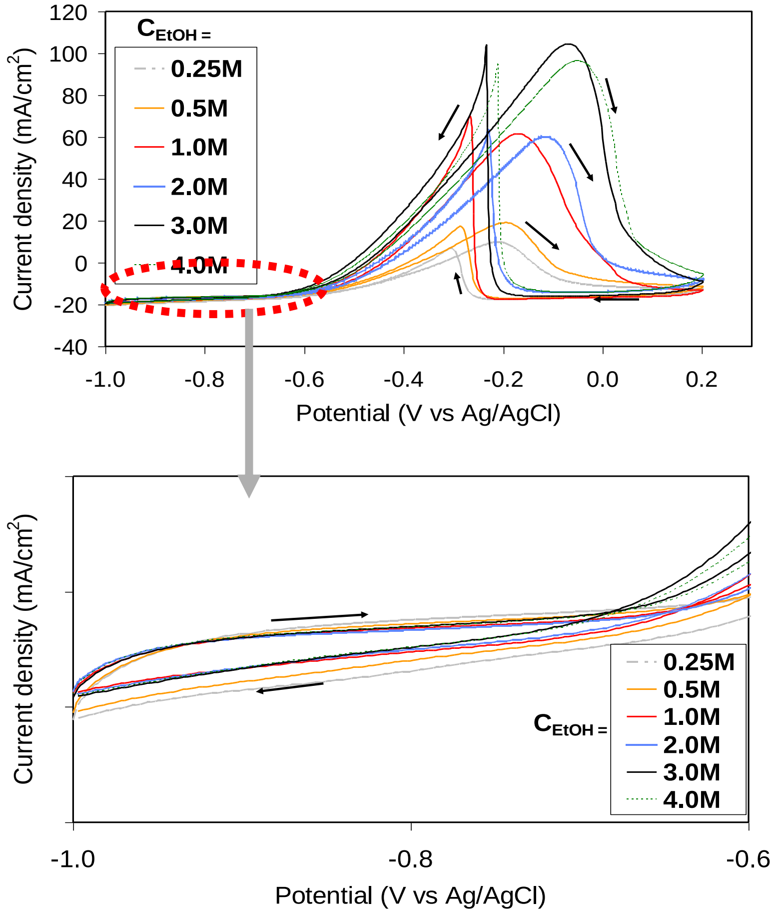
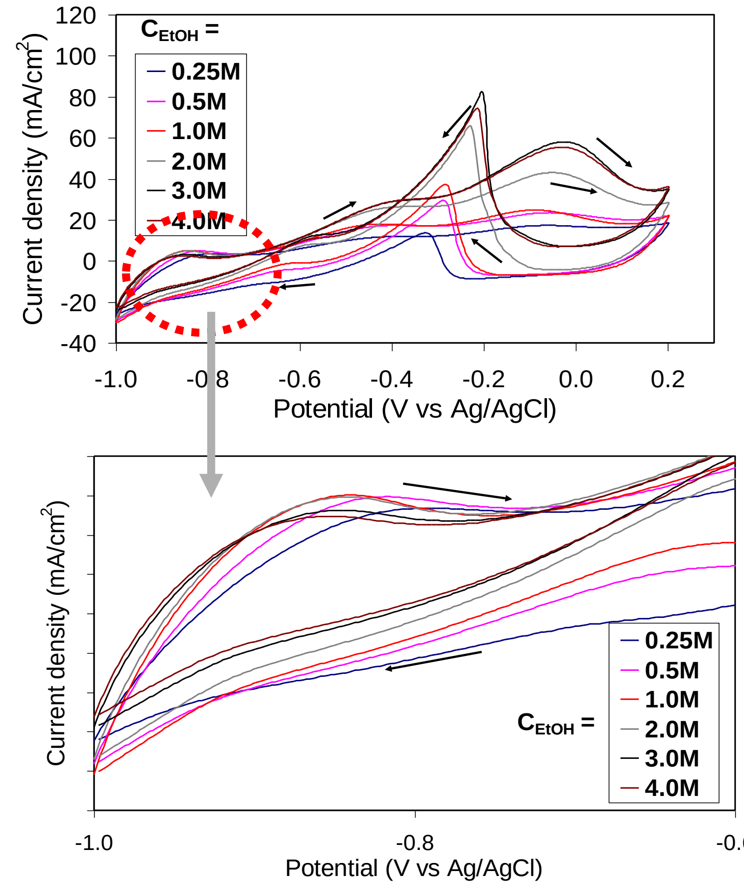
Concentration studies effect on current density

PdNi/C



PdRuNi/C



↑[EtOH] up to 3 M ↑coverage of the CH_3COads species on the nanocatalyst surface

Resulting in increase in current density

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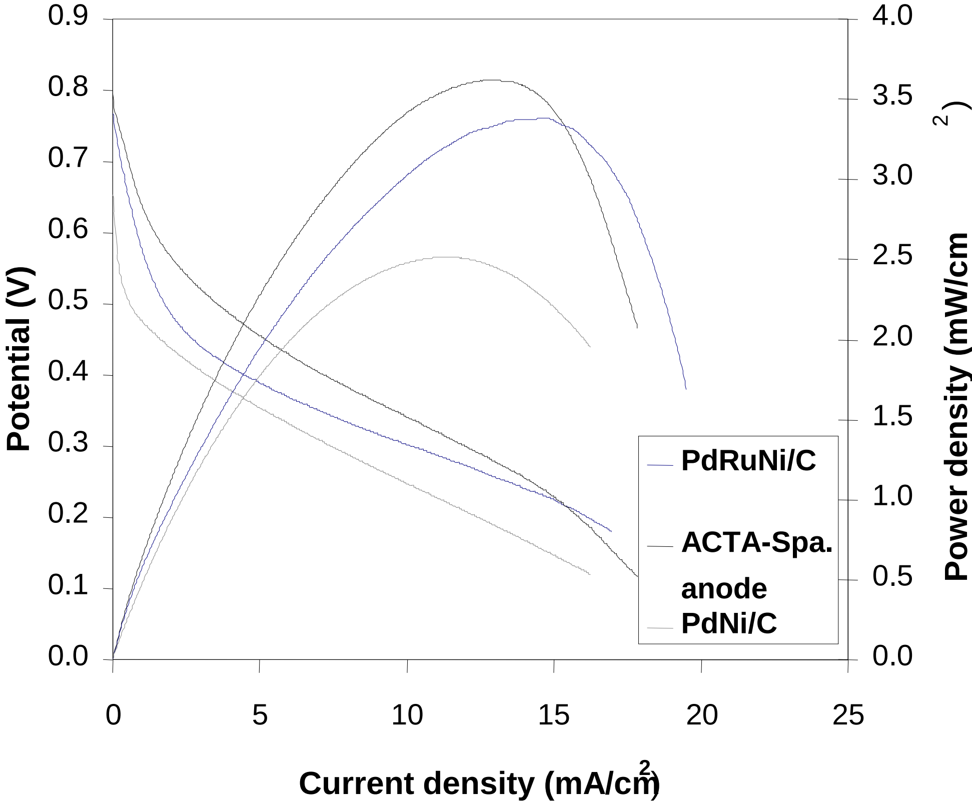
Alkaline DEFC performance: passive state

Electro-catalyst	Open circuit voltage (V)	Power/total loading (mW/mgPd)
PdCeO2/C (ACTA-SpA)	0.795	3.1736
PdNi/C	0.653	3.1916
PdRuNi/C	0.768	2.5798
PdRuSn/C	0.623	0.2386

Polarization and power curves



Cathode: 0.1mg/cm2 FeCo (ACTA-SpA)

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Conclusions

- Pd-Ni/C and Pd-Ru-Ni/C were prepared by chemical reduction method
- nanocatalysts higher activities towards ethanol electro-oxidation
- effect of ethanol concentration variation – current density
- binary Pd-Ni/C performs better than ternary nanocatalyst - current density

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Thank You

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