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

ASME2011, Washington, DC

Mkhulu K Mathe

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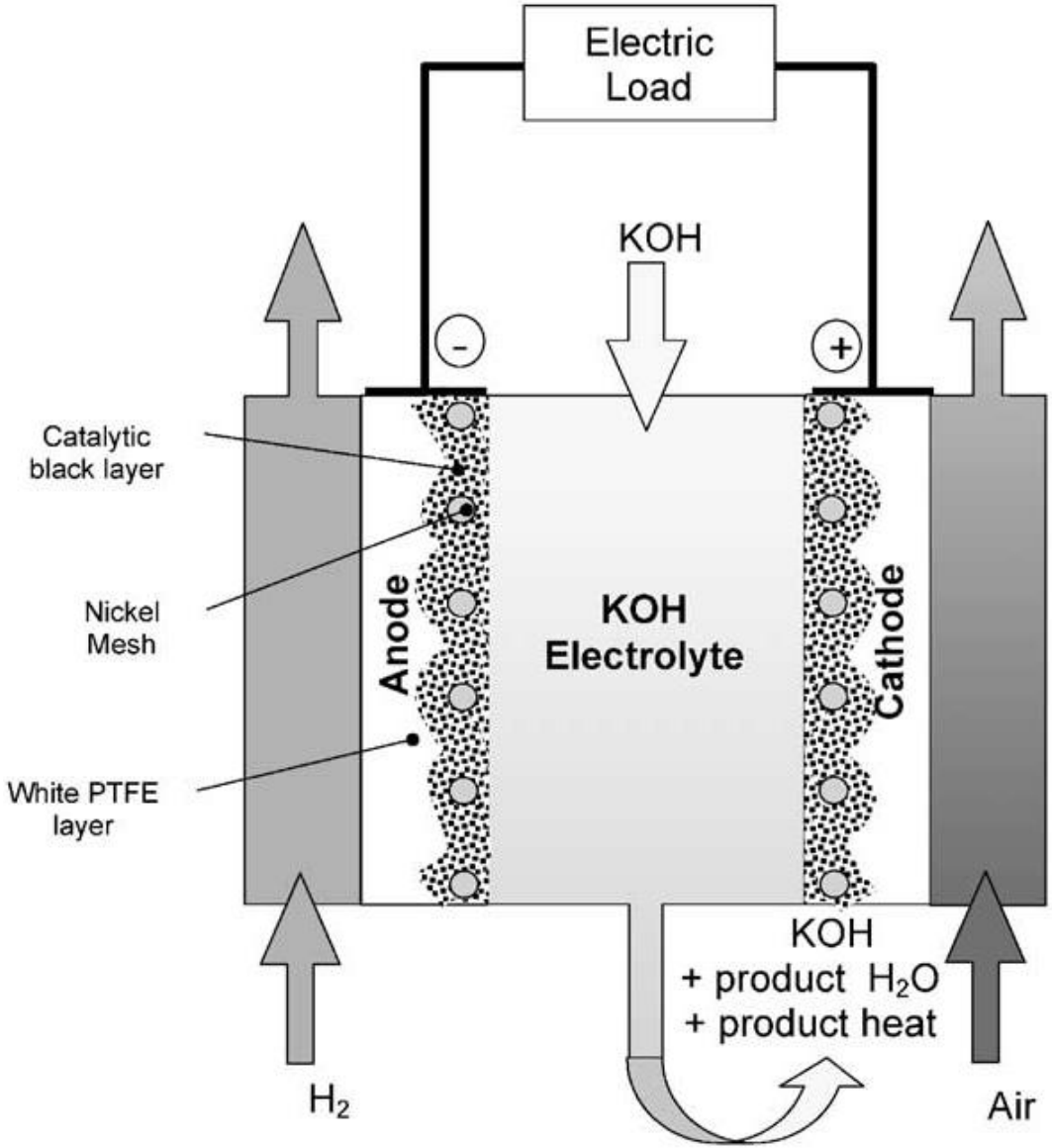
Outline

- Background and Introduction
- Synthesis of Electrocatalysts
- Characterization and Evaluation of the Electrocatalysts
- Performance measurement of the Electrocatalysts
- Concluding remarks
- Acknowledgements



- **DEFC anode studies**
  - synthesis
  - Electrooxidation
  - Performance

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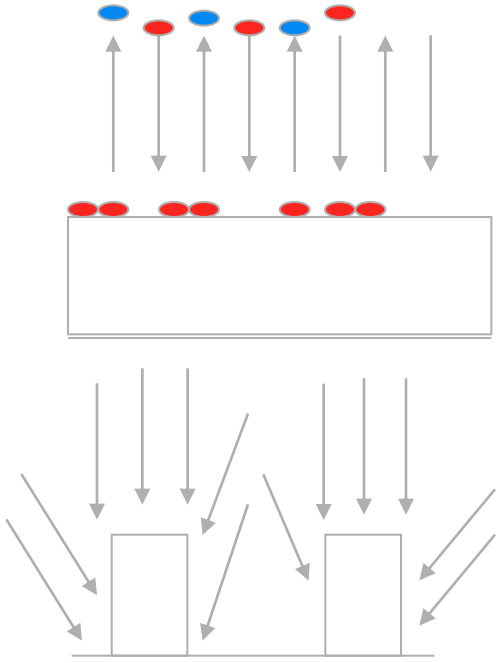
G.F. McLean et al. International Journal of Hydrogen Energy 27 (2002) 507 – 526

Synthesis of electrocatalysts

catalytic active sites (active reaction area)
surface-to-volume ratio
transport of reactants and products

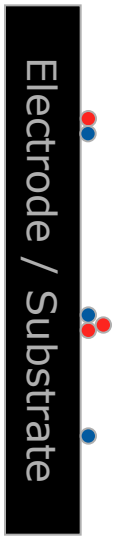


Thin Film

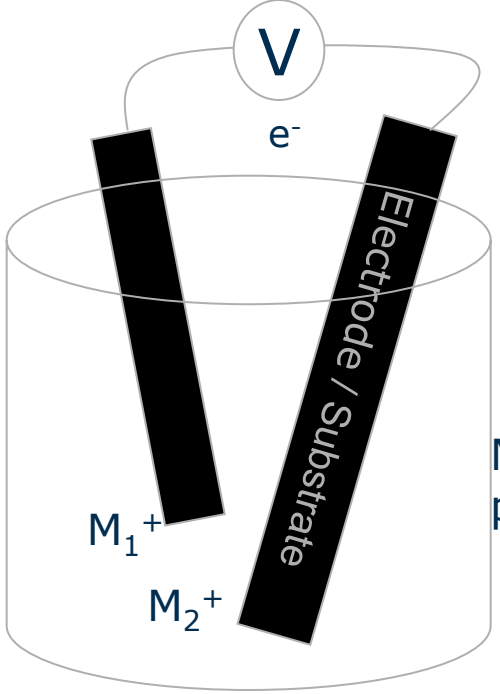
Nanostructures

Electrocatalyst particles have to maintain electronic contact with support

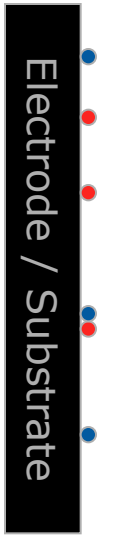
Chemical routes to Nanoparticulate Multimetallic Electrocatalysts



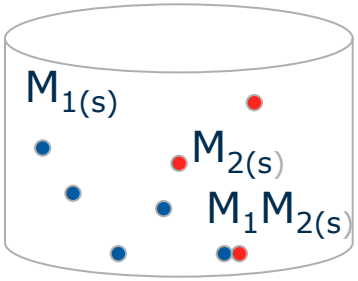
Electrochemical deposition
e⁻



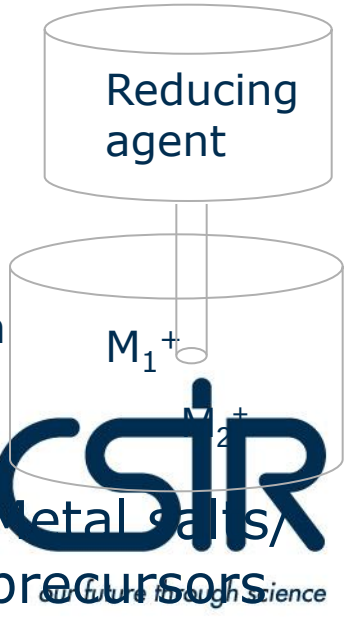
Metal salts/ precursors



Transfer
To Electrode

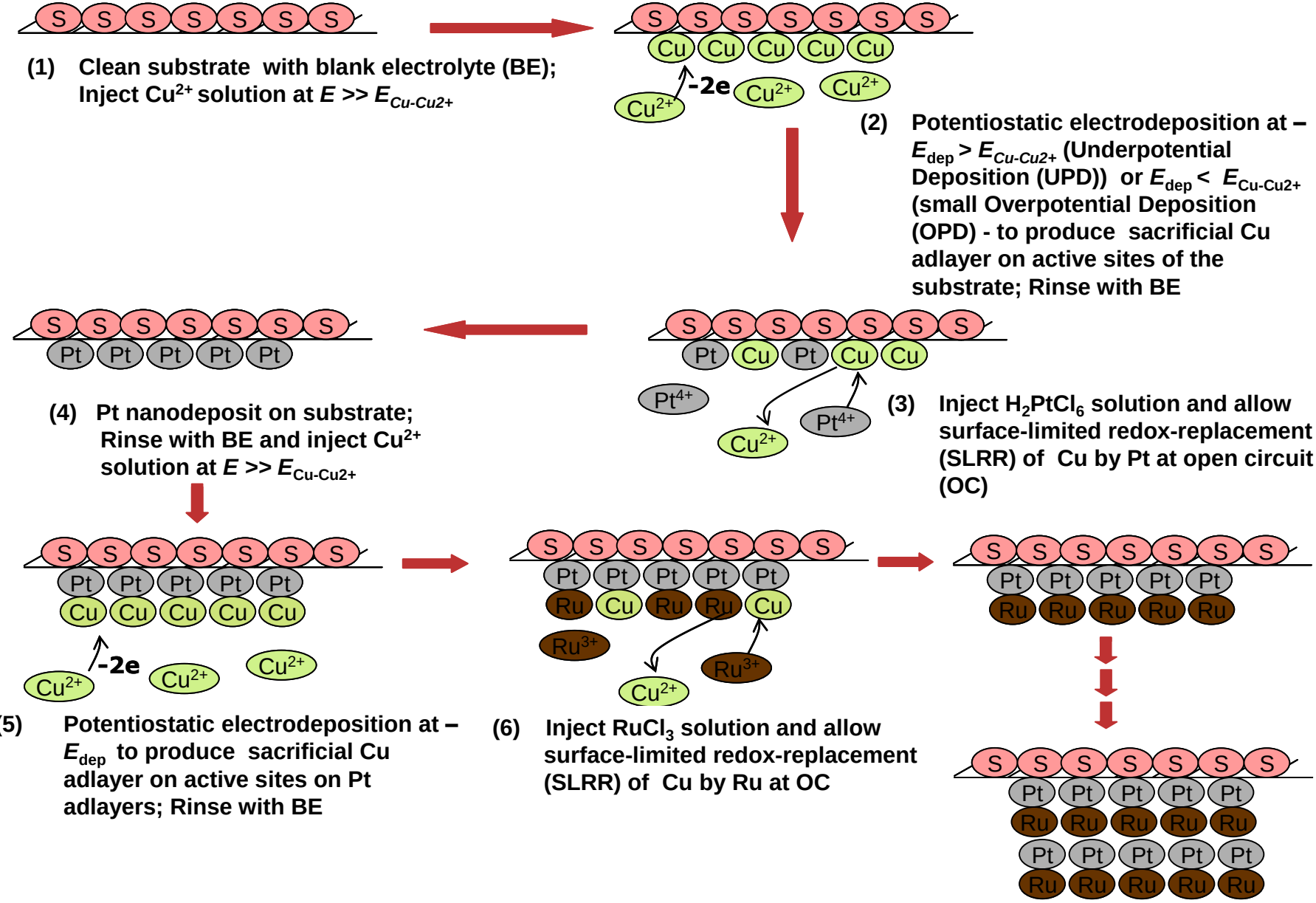


Chemical
Reduction /
Precipitation

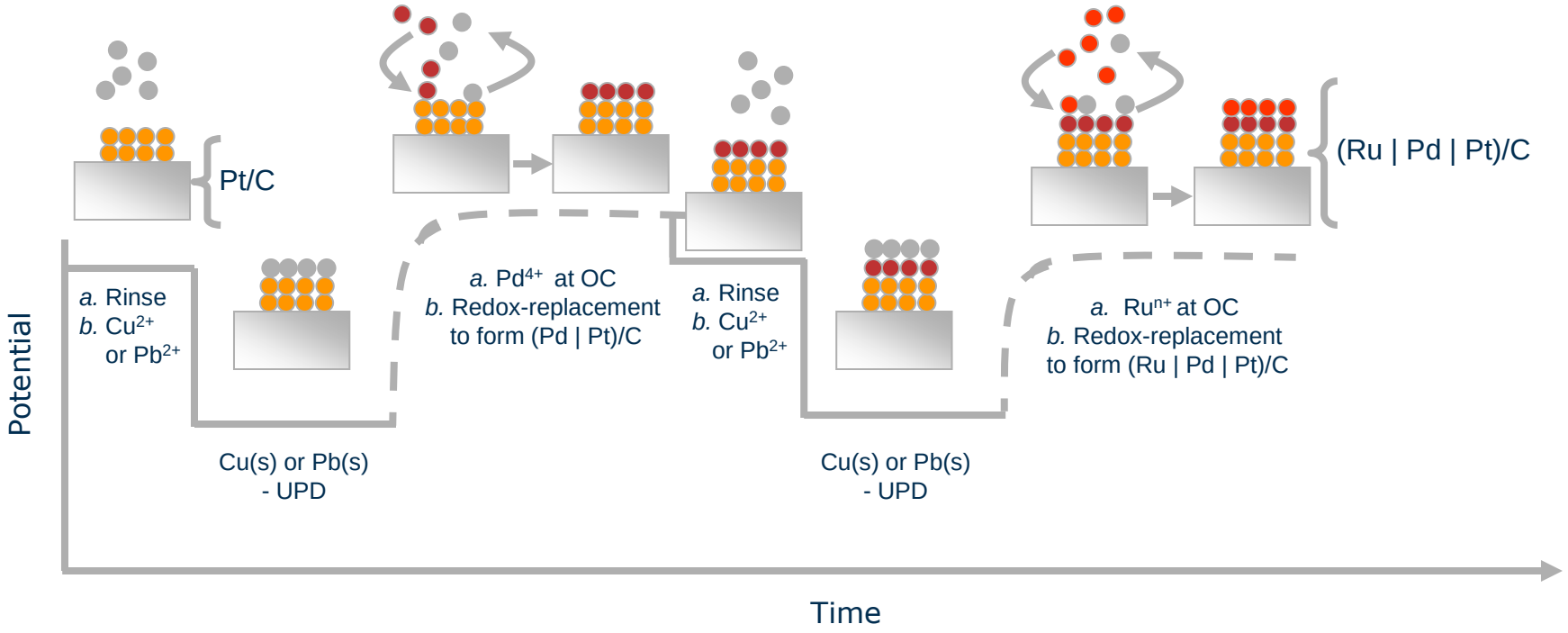


Metal salts/ precursors

Sequential deposition coupled to Surface-limited Redox-replacement reactions (SLRR): Synthesis of multilayered bimetallic RuPt electrocatalyst



Multi-stage electrodeposition



Noble-Metals studied = Pt, Ru, Au, Pd
Substrates = Carbon materials, Gold films

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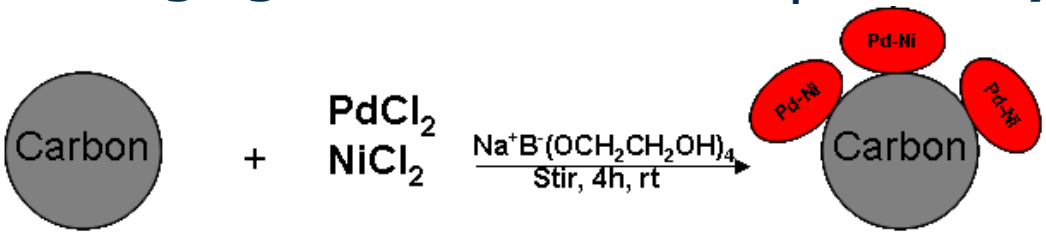
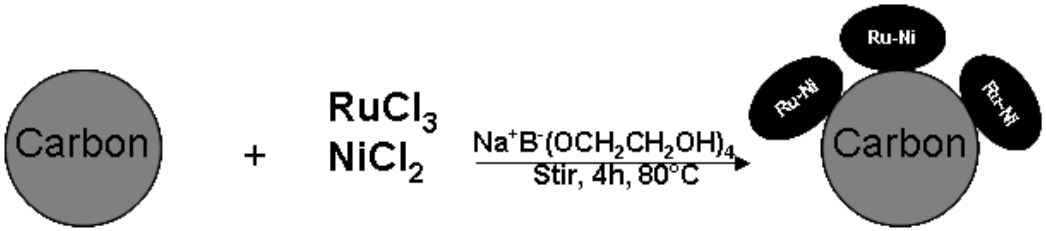
Synthesis of Electrocatalysts

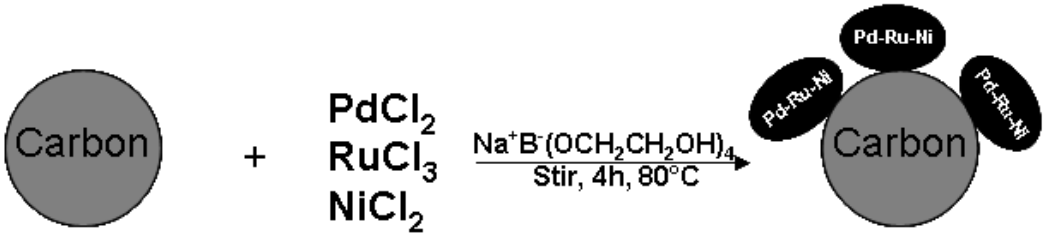
reducing agent: mixture $NaBH_4$ and ethylene glycol



Pd-Ni/C

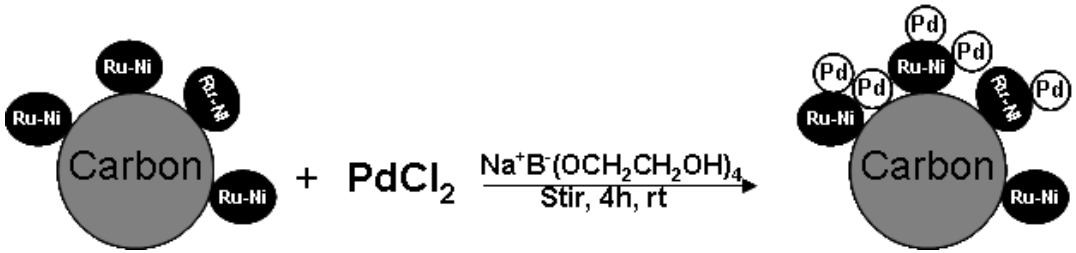


Ru-Ni/C



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

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



Pd + Ru-Ni/C

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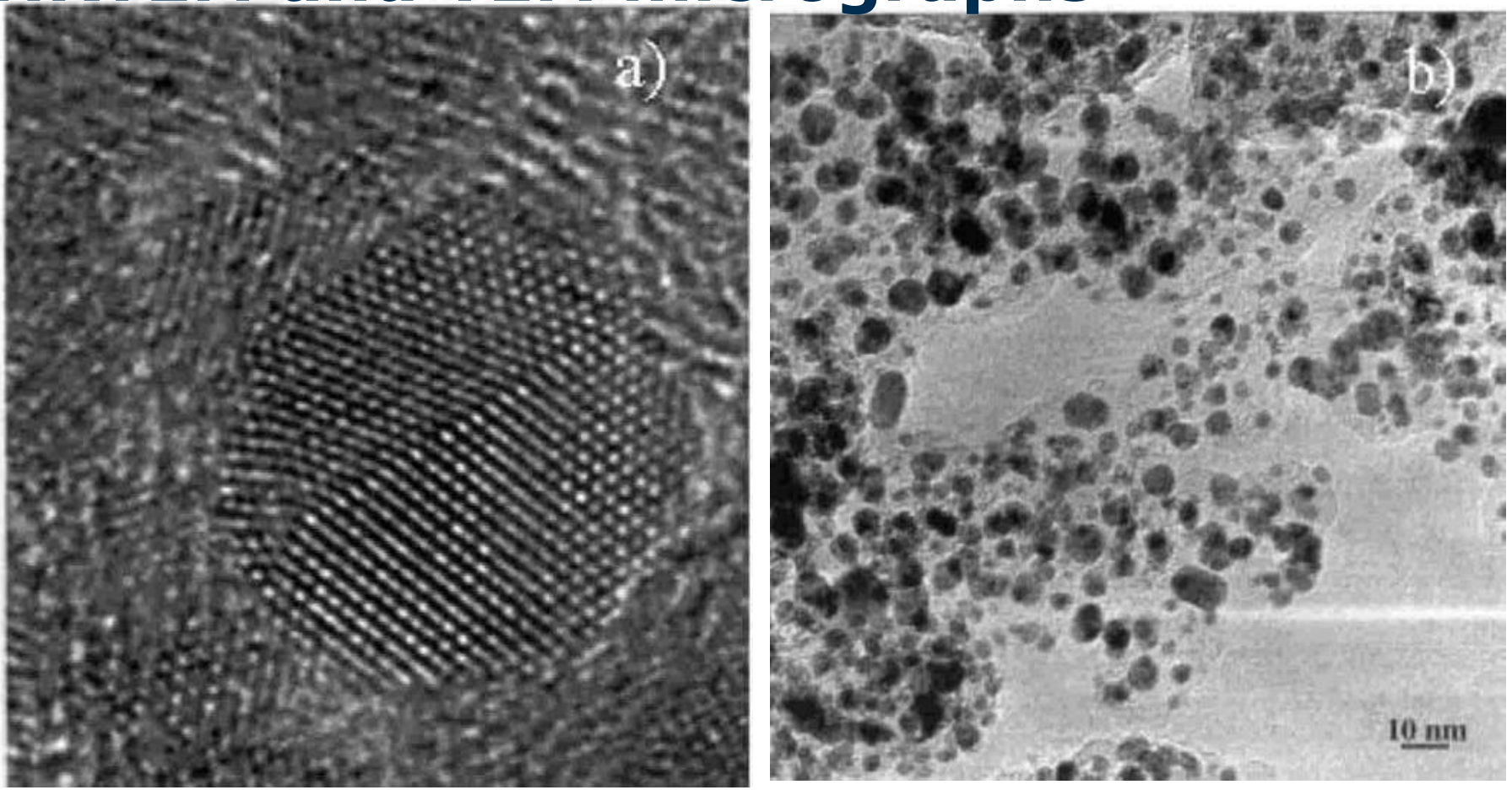
HRTEM and TEM micrographs

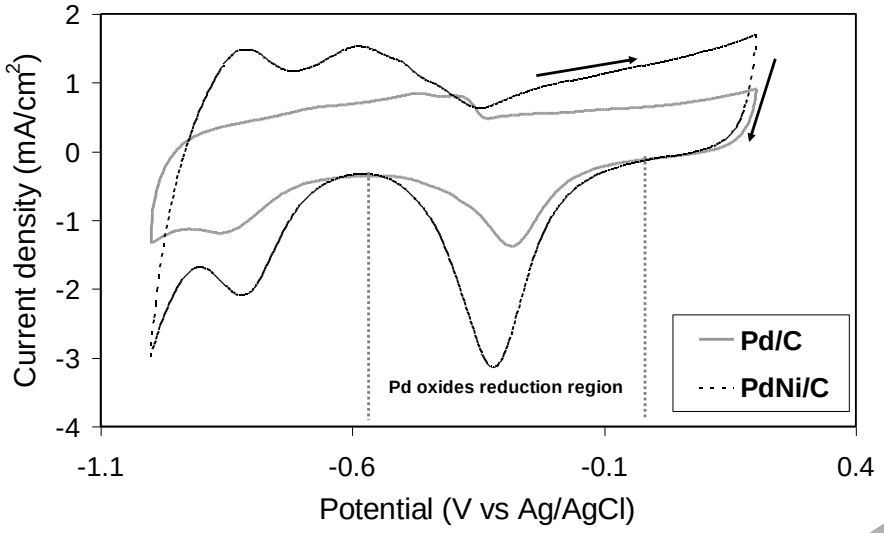


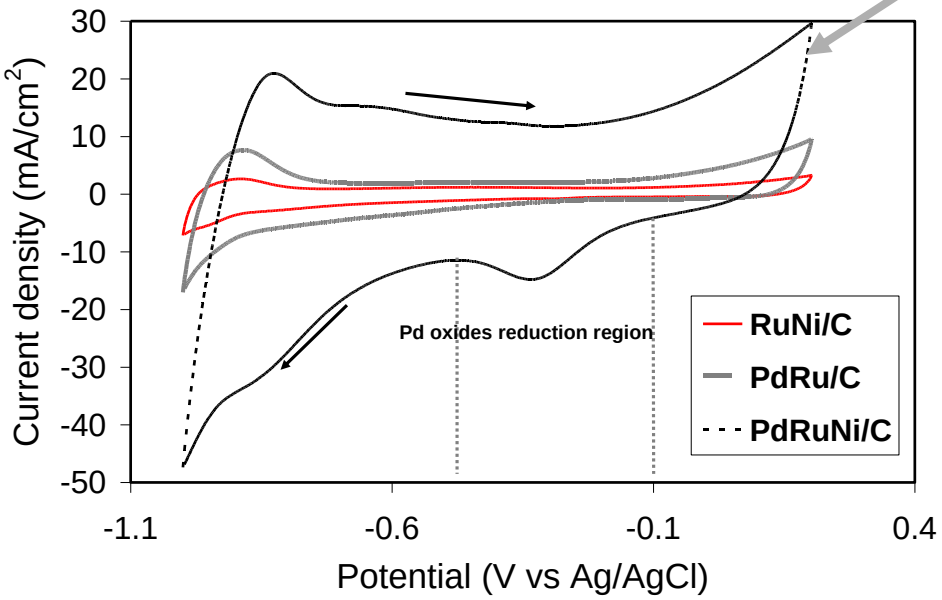
(a) a twinned single Pt2Ru3 nanoparticle of ca. 4.39/0.3 nm characteristic dimensions.
(b) distribution of Pt2Ru3 bimetallic nanoparticles on the high-surface area carbon support.

A.V. Tripkovic´ et al. Electrochimica Acta 47 (2002) 3707/3714

Electrochemical characterization

cyclic voltammograms in 0.5 M NaOH





Pd+ Ru-Ni/C

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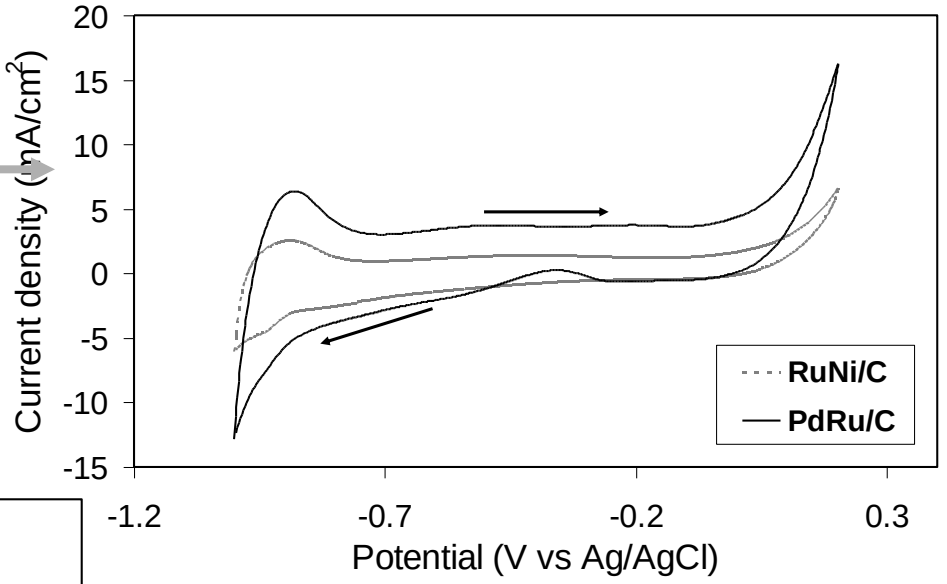
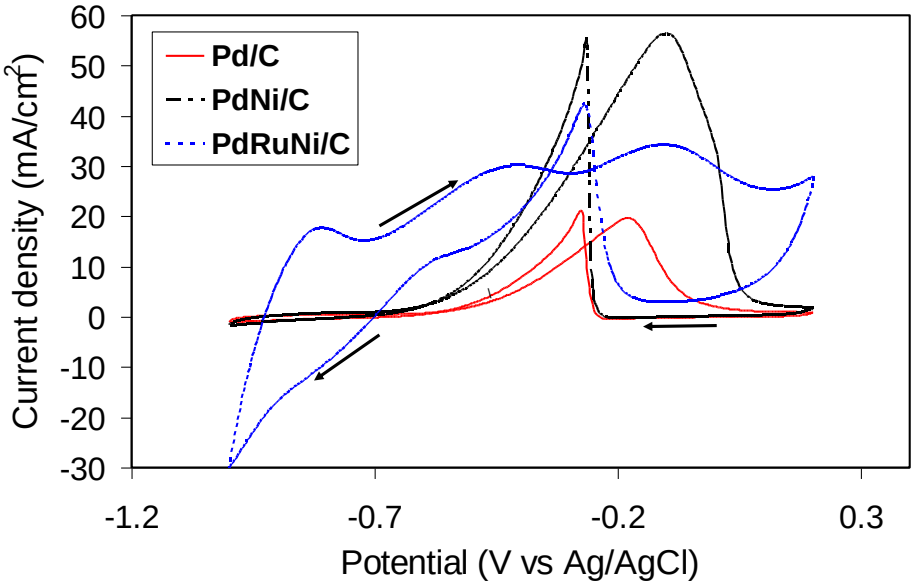
Electrochemical characterization

cyclic voltammograms in ethanol

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





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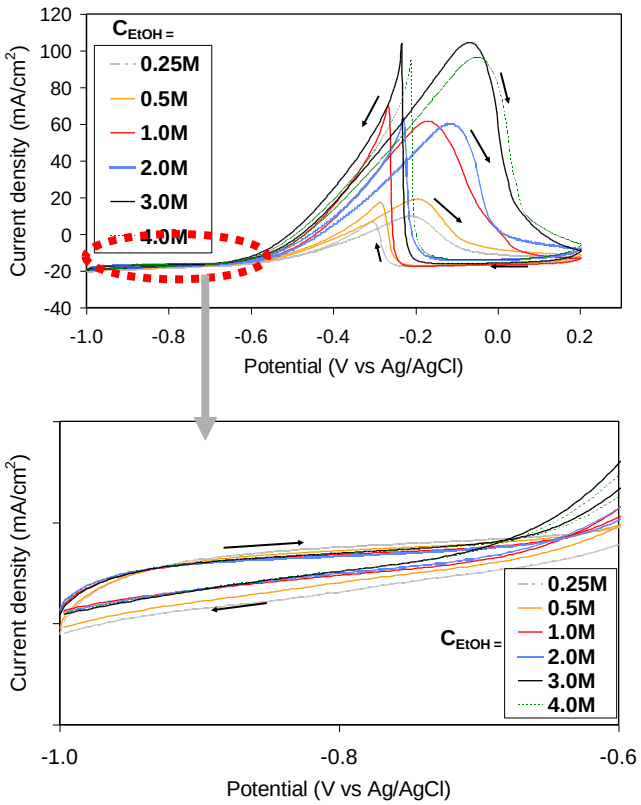
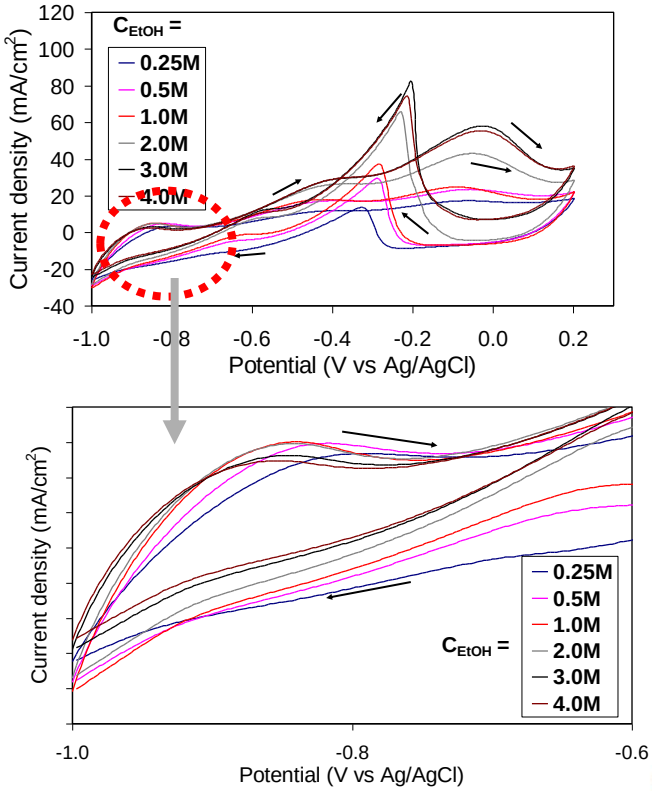
Concentration studies effect on current density

Effect of ethanol concentration

PdNi/C



PdRuNi/C



Raising ethanol concentration up to 3 M increased the coverage of the adsorbed ethoxy (CH_3COads) species on the nanocatalyst surface, thus yielding an increase in current density

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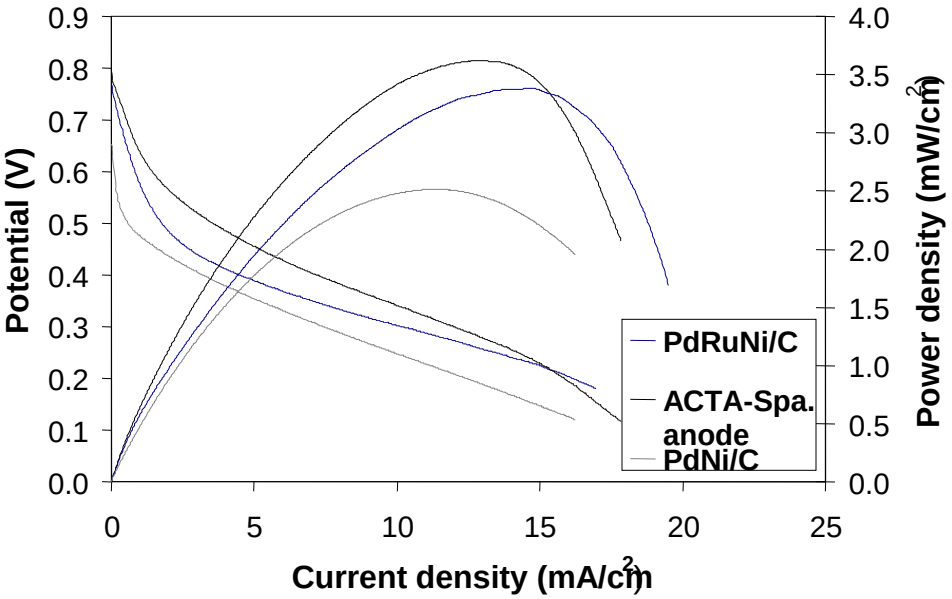
Electro-catalyst performance: passive alkaline DEFC

cell polarisation and current density curves



loading vs. ocv

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

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

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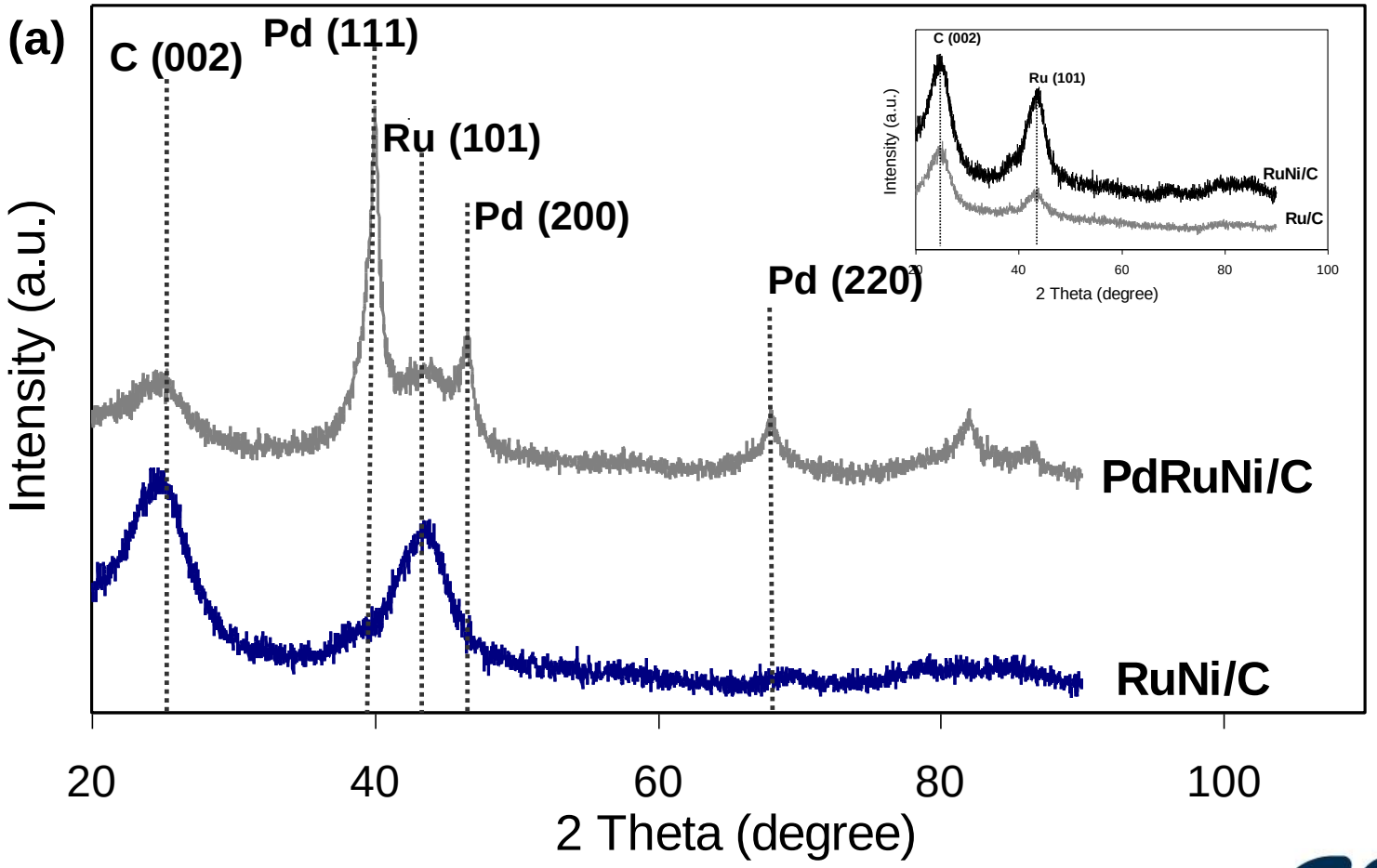
XRD micrographs of electrocatalysts



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

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Conclusions

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

ACKNOWLEDGEMENTS

- Energy & Processes Team
- CSIR Executive

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Thank You

References

- G.F. McLean et al. International Journal of Hydrogen Energy 27 (2002) 507 – 526
- A.V. Tripkovic´ et al. Electrochimica Acta 47 (2002) 3707/3714
- T.S. Mkwizu, et.al. 219th ECS Meeting, 1 – 6 May, 2011, Montreal, Canada