Pd_xRu_{1-X}, electro-catalyst in direct alkaline ethanol fuel cells

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Abstract

Direct Ethanol fuel cells (DEFCs) are promising candidates. They have a higher energy density, their materials are more available and their handling is easier than the hydrogen based fuel cells. This technology is not yet perfected due to the inefficient electro-oxidation of the ethanol. The factors addressed by this research is the choice of electro-catalyst and the concentration of ethanol provided to the reaction. The development of a catalyst that can fully decompose ethanol into water and CO_2 to release the maximum of energy will permit the ethanol-based fuel cell to be a viable and efficient source of energy in the future.

Objective

Increase the current density produced by the reaction while reducing the onset potential by testing certain ratios of Pd and Ru as electro-catalyst and various concentrations of ethanol to be oxidized.

Methodology

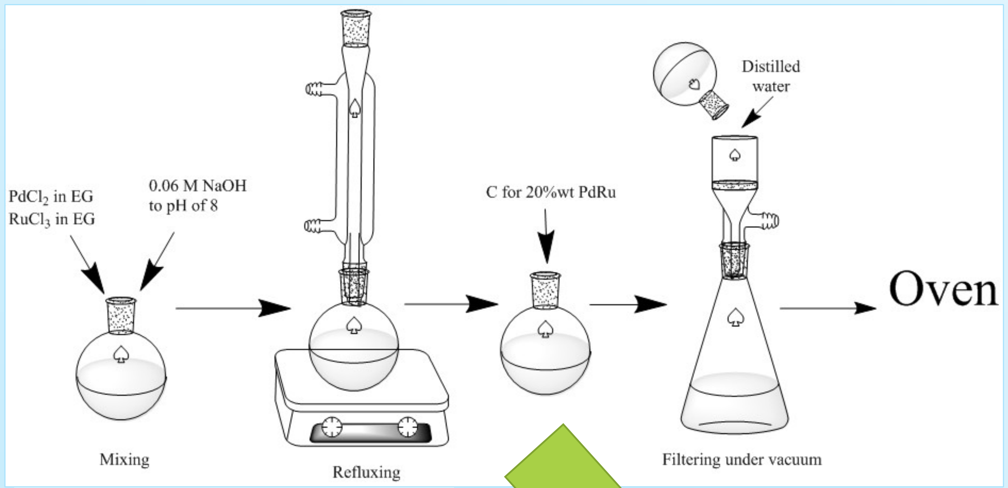

Fig. 1: Method of synthesis

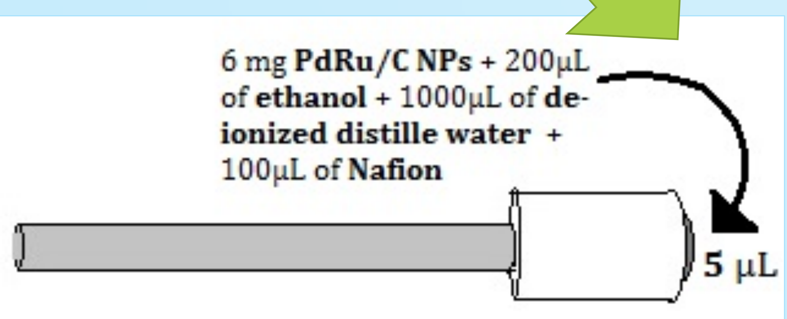

Fig. 2: Method of electrode preparation

Experimentations:

- Cyclicvoltammetry
- Chronoamperommetry
- CO Stripping

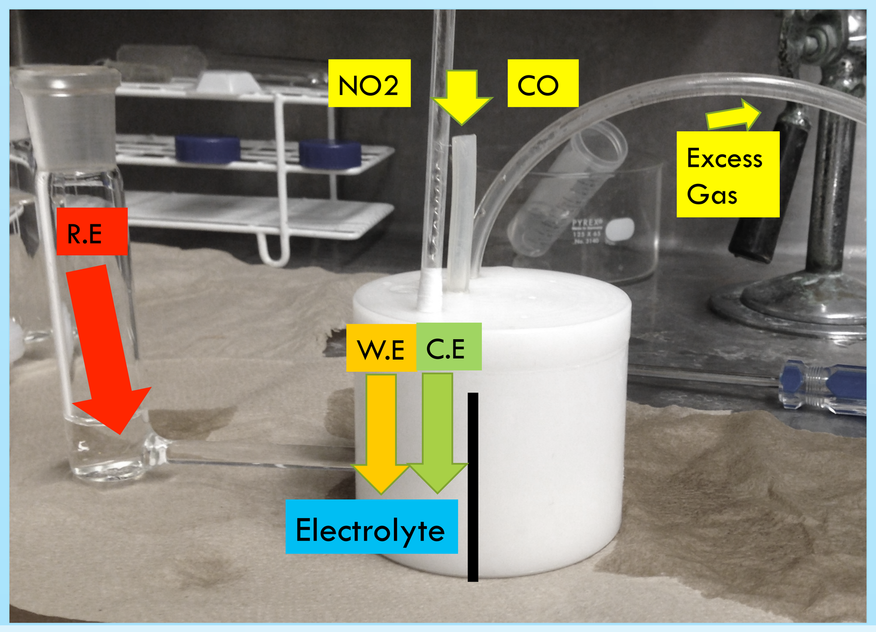

Fig. 3 : Two-compartment-cell made of Teflon used for experimentation

Results

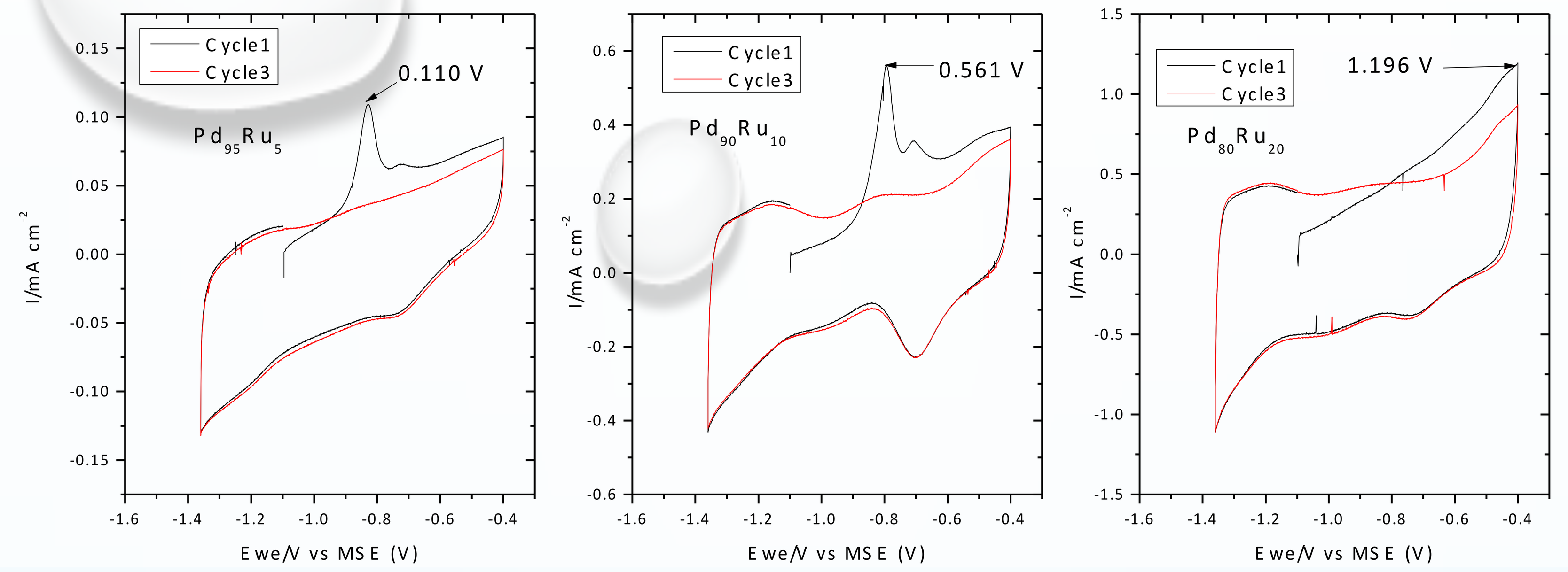

Fig. 4: CO stripping of Pd_xRu_{1-x}/C in 1M KOH

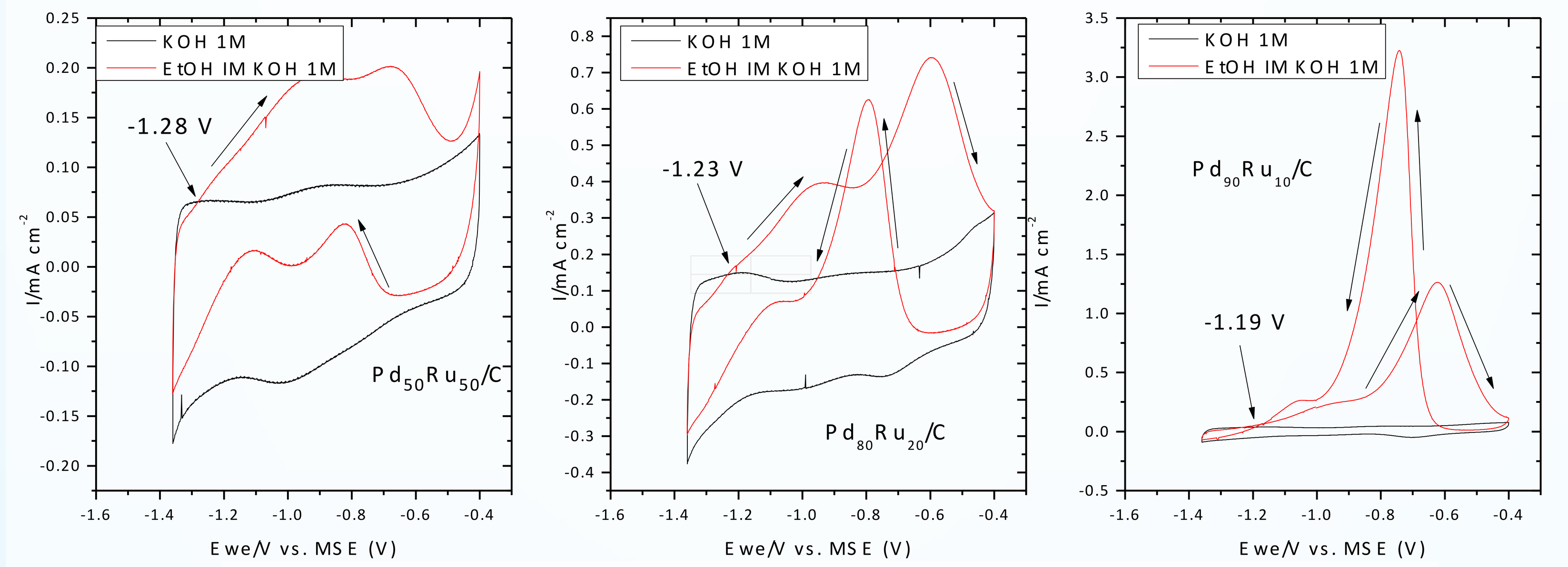

Fig 5: CVs of Pd_xRu_{1-x}/C in 1M KOH (black curve) and 1M KOH+1M EtOH (red curve)

Table 1: Electrochemical potentials and current intensities of Pd_xRu_{1-x} catalysts measured by CV and CO Stripping

Catalyst	Mass of Pd on electrode (mg)	ESCA (cm^2)	Anodic E (V)			Anodic I (mA cm^{-2})	
			E Onset	Ep1	Ep2	Ip	I at -0.96 V
Pd/C	0.00461	0.153714	-0.97	-0.659	-----	2.279	0.018834
PdRu/C 50-50	0.00237	0.648762	-1.28	-0.676	-0.897	0.201	0.12142
PdRu/C 80-20	0.00394	0.581447	-1.23	-0.793	-1.066	0.626	0.228561
PdRu/C 90-10	0.00498	0.916623	-1.19	-0.623	-----	1.263	0.21276
PdRu/C 95-5	0.00440	0.19611	-1.21	-0.635	-----	0.568	0.022922
PdRu/C 99-1	0.00455	0.539421	-1.19	-0.65	-----	3.028	0.154533

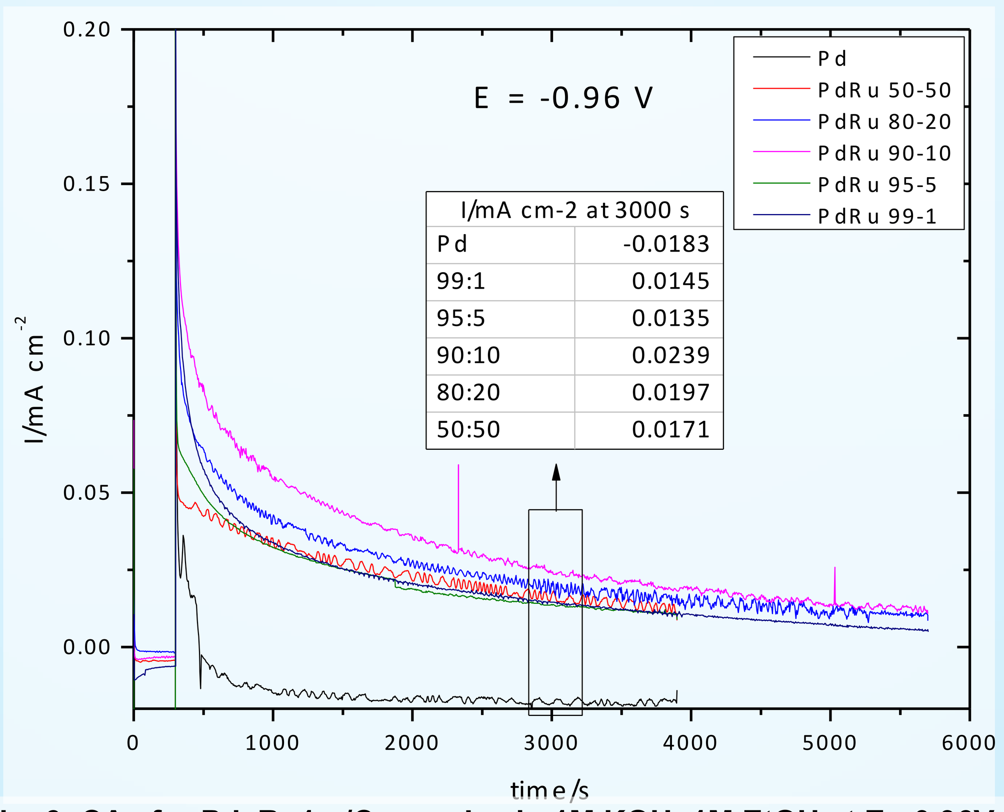

Fig. 6: CAs for PdxRu1-x/C samples in 1M KOH+1M EtOH at E=-0.96V

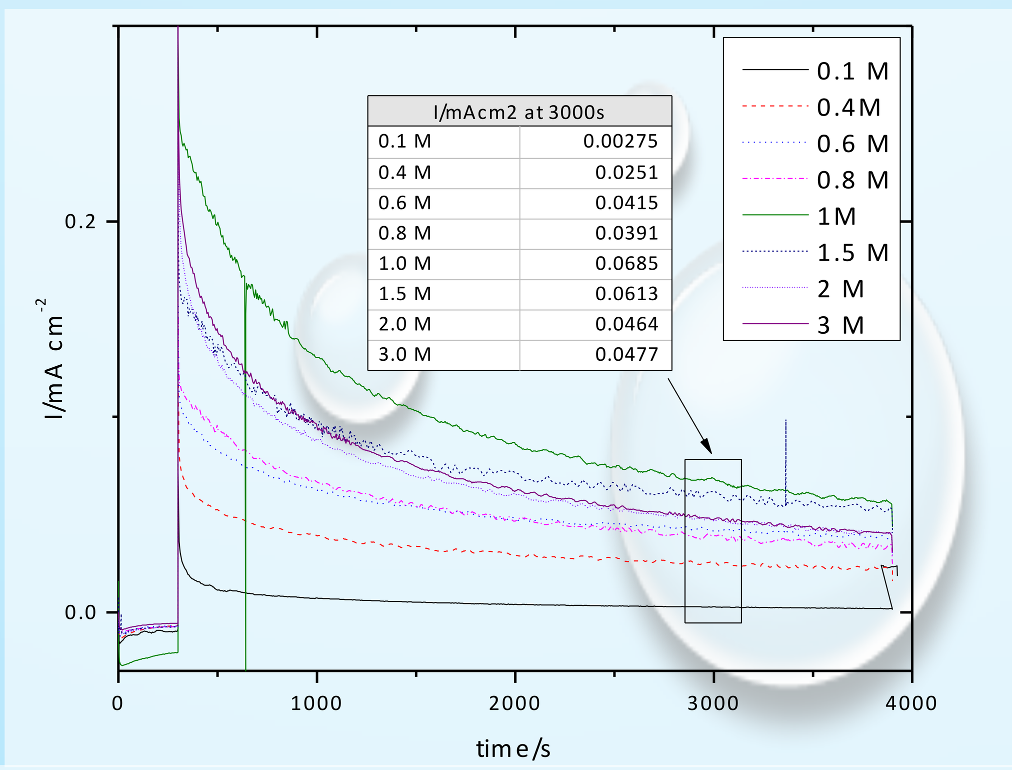

Fig. 7: CAs for various [EtOH] in 1M KOH using Pd95Ru5/C at E=-0.96V

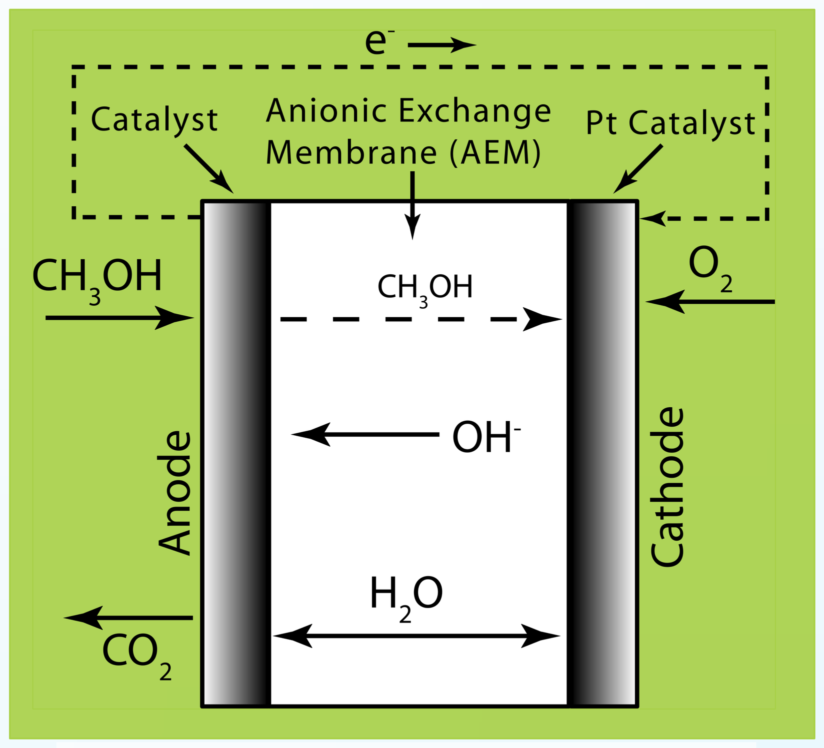

Fig. 8 : Direct Alkaline Methanol Fuel Cell[1]

Discussion

- Electrochemical Surface Area (ECSA) varies on the preparation and application of the catalyst
- Electrochemical activity is optimal at a set potential of -0.96 V. Any lower potential (-1.06 V) reduces the activity to almost no current in the long term.
- Presence of Ru as catalyst enhancer increases current intensity overall. Higher ratios of Ru decrease onset potential.
- Current intensity is optimized at a PdRu atomic ratio of 90:10 but PdRu 50:50 has the lowest onset potential.
- Ethanol concentration increases electrochemical activity up to a peak of 1 M EtOH. Any higher concentration of EtOH decreases current intensity.

Conclusion

- With highest consistent current intensity at a potential of -0.96 V and a low onset potential, $Pd_{90}Ru_{10}/C$ proves to be one of the most effective combination. $Pd_{80}Ru_{20}/C$ presents with a high intensity, a lower onset potential and a smaller loading of Pd which makes it cheaper than the $Pd_{90}Ru_{10}/C$ and an equally viable option.
- 1M is the optimal concentration of ethanol in the electrolyte solution.

Future Work

The next experiments will consist of testing the impact of ionic conductibility of the electrolyte by varying the KOH concentration.
Also, spectroscopy will be used during the experiment in order to identify the intermediates products and understand their impact on the kinetics of the electrochemical reaction.

References

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[1] "Direct Methanol Alkaline Fuel Cell Simple", 2011, http://vector.me/search/engineering, viewed on January 21st 2014.

Acknowledgments

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