# In-situ durability studies of carbon-based PEMFC-electrodes

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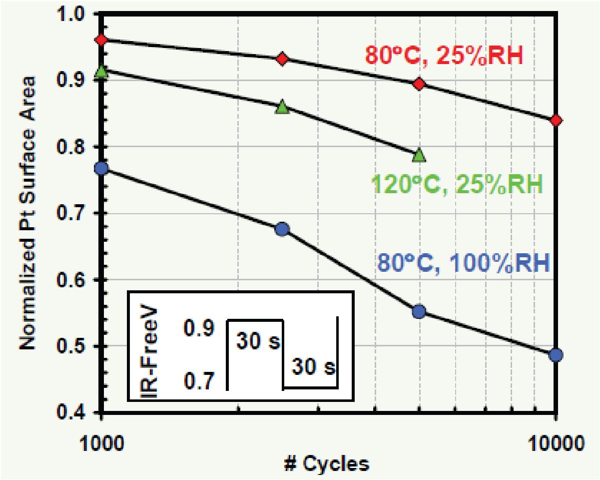
# Background

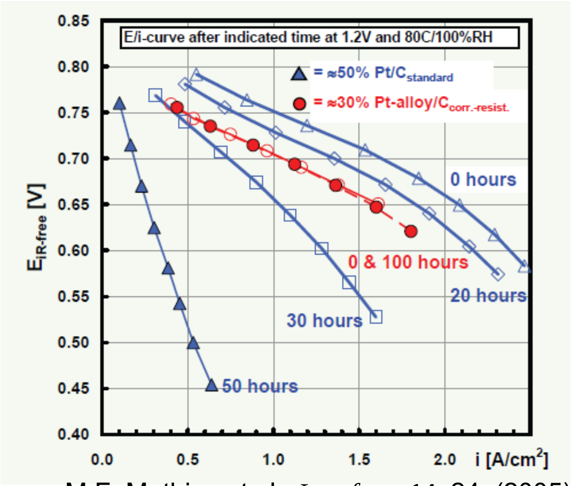
**Introduction**
Experimental
Results
Conclusions

Two suggested and commonly used accelerated degradation tests (ADT) of fuel cell electrodes and its carbon support are:

## Potential cycling




## Potentiostatic holds




M.F. Mathias et al., *Interface*, **14**, 24, (2005).

These have been used in both liquid electrolyte and in fuel cell and shown a large variation in result

- The aim of this work is to evaluate different degradation methods and characterize the effect on different carbon-based PEMFC-electrodes with electrochemical methods.

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# Electrodes

## Thin Model Electrodes

- Fast fabrication of well-defined electrodes for testing in fuel cells
- Low loading (3nm=6 µg/cm$^2$) → Low currents →

  Low IR-drops

  Limited water production

  Limited heat production

  Use of diluted $H_2$ on the counter electrode

## Pipetted Electrodes

- Only small amount of ink is needed
- Good control of loading
- Fast electrode preparation

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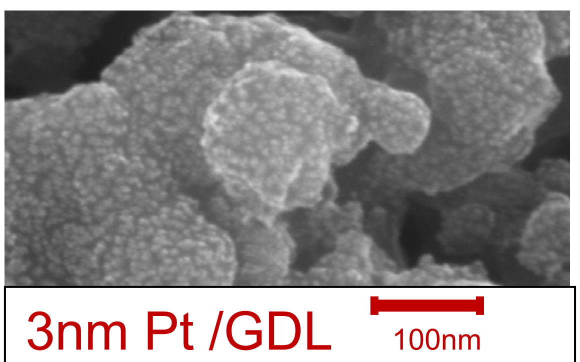


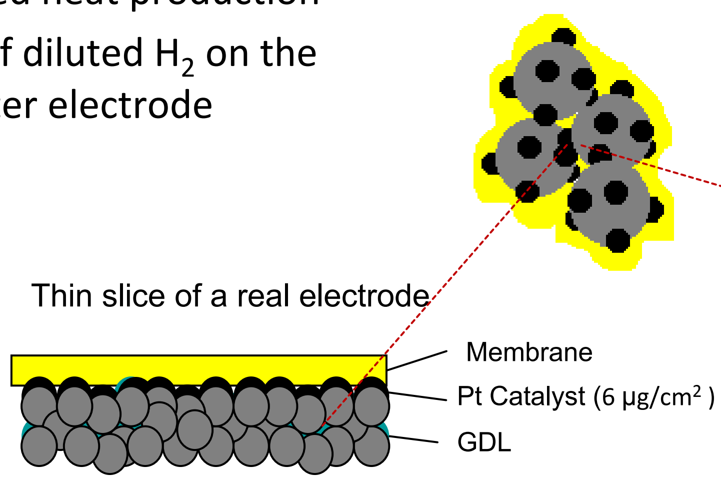


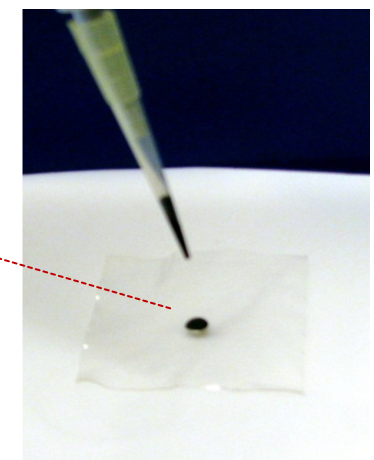

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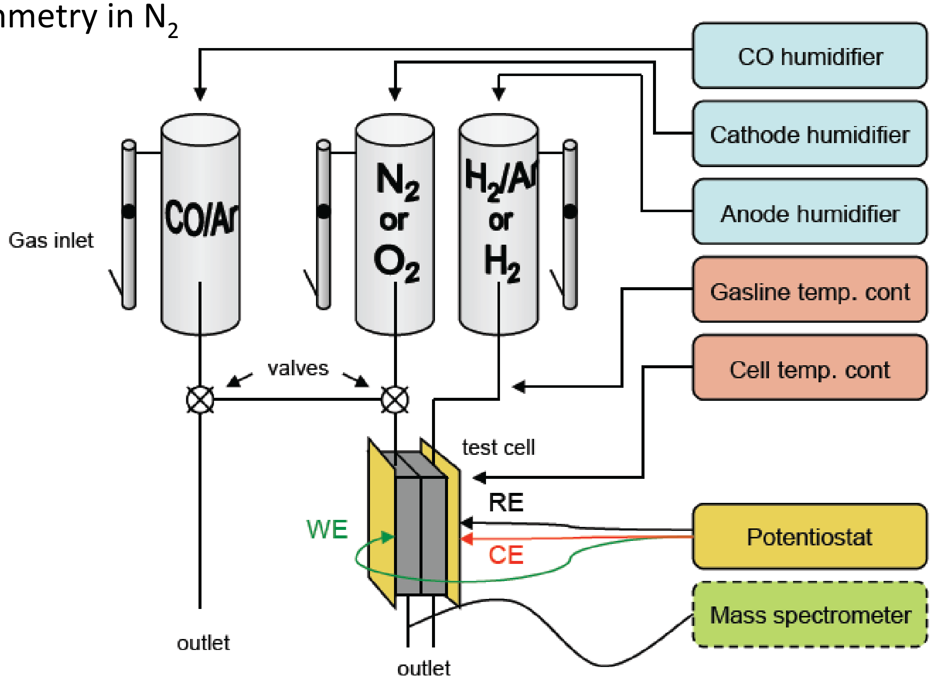
# Measurement protocol

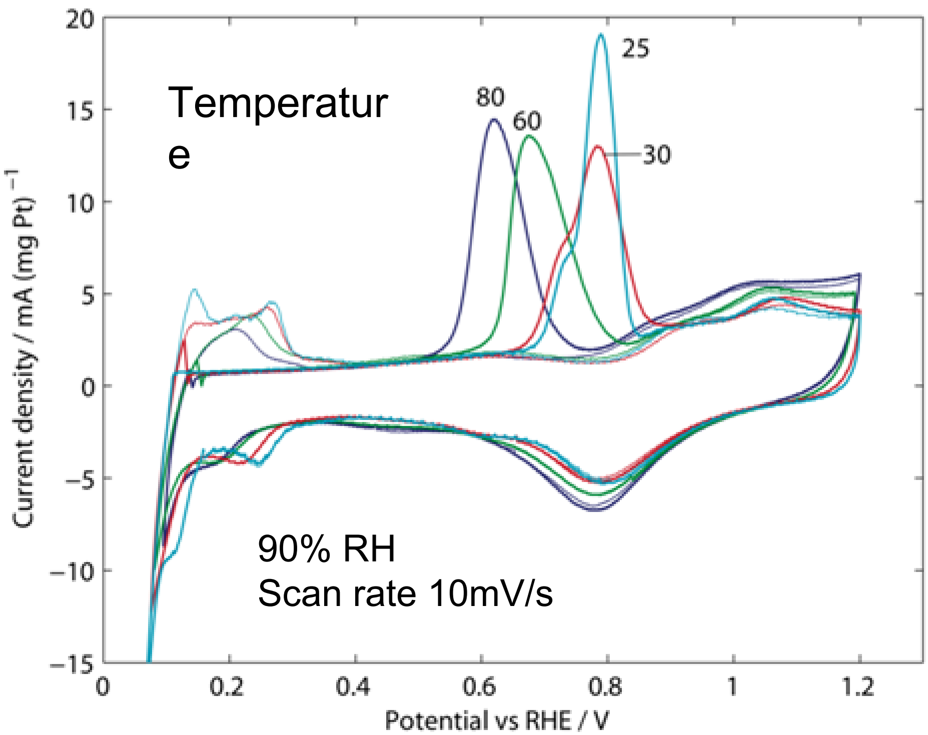
- Activation
  Cycling and potentiostatic hold over night (18h) in $O_2$
- Degradation
  Cycling in $O_2$ or $N_2$ and potentiostatic holds in $O_2$ or $N_2$
- Status check by:
  Polarisation curves in $O_2$
  Cyclic voltammetry in $N_2$
  CO-stripping

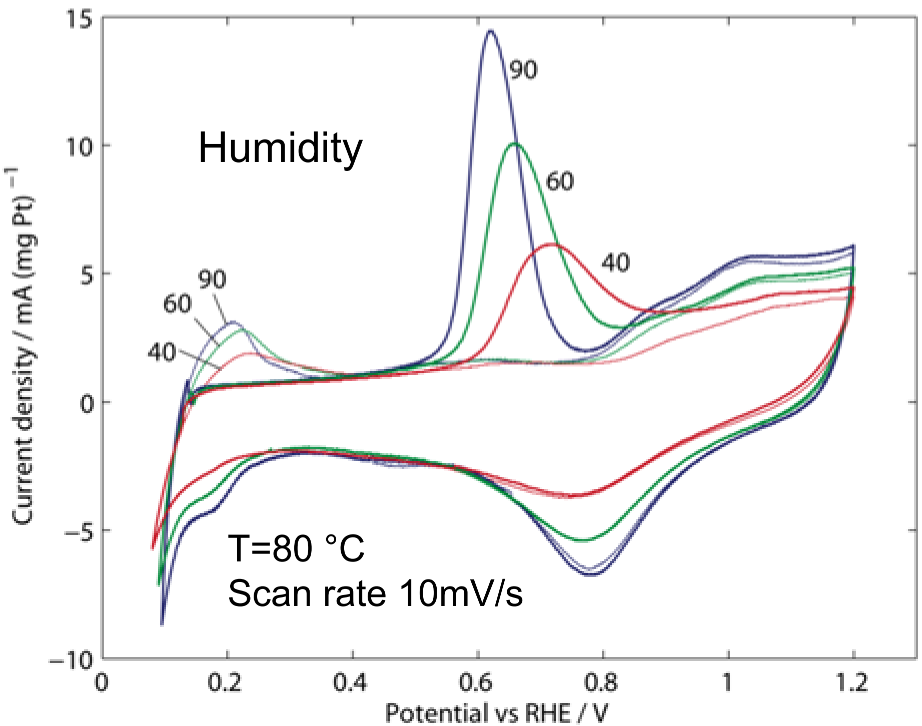


# Status check by CV and CO-stripping

## Effect of temperature and humidity on porous electrodes






R W Lindström, K Kortsdottir, G Lindbergh, submitted to ECS Transactions

# Cycling of model electrodes - Impact of humidity

T=80°C, ADT: 1000 cycles 0.6-1.2V at 20mV/s in $N_2$



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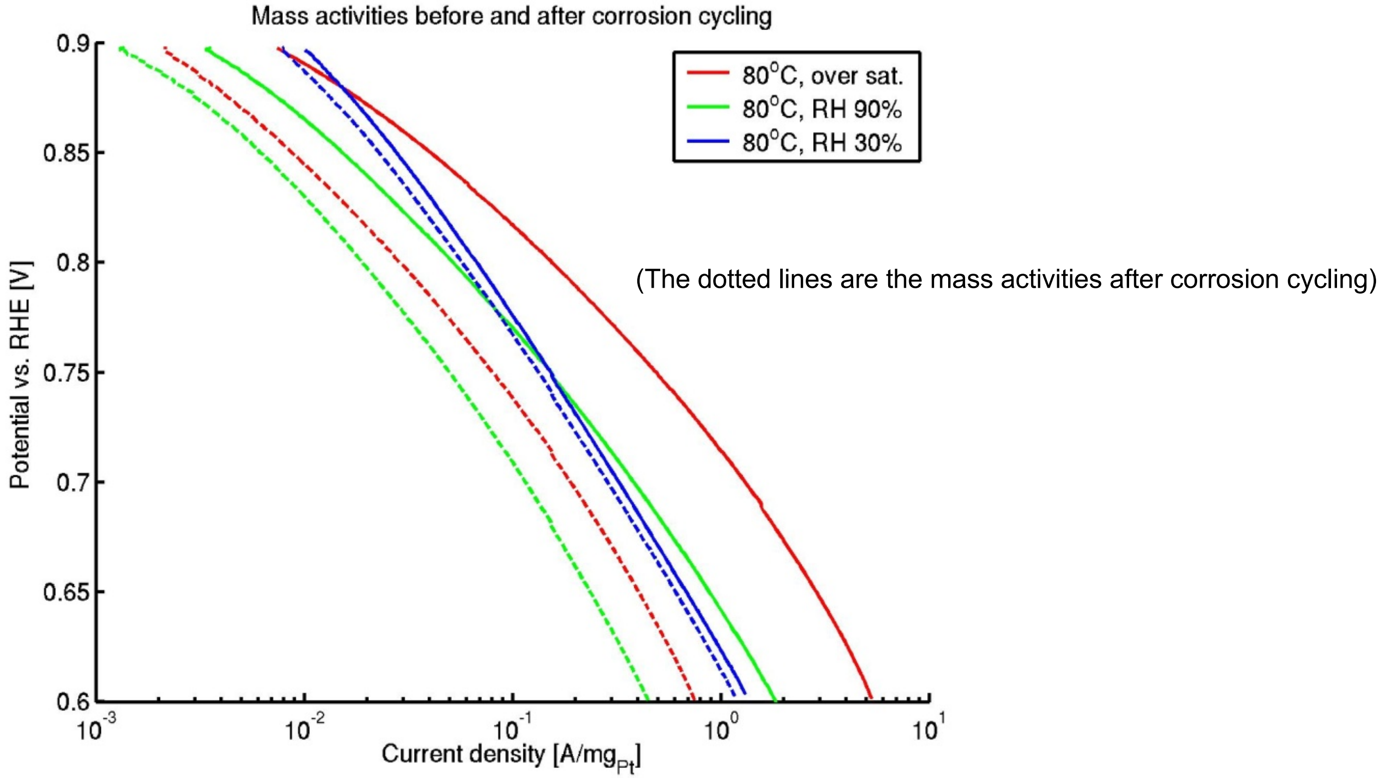


- Loss in activity corresponds to loss in surface area seen in $N_2$ (not shown here)
- Higher humidity results in higher activity loss
- After corrosion test 30 % RH renders the highest mass activity

# Cycling of model electrodes

T=80°C, RH 90%, ADT: 1000 cycles 0.6-1.2V at 20mV/s in $N_2$



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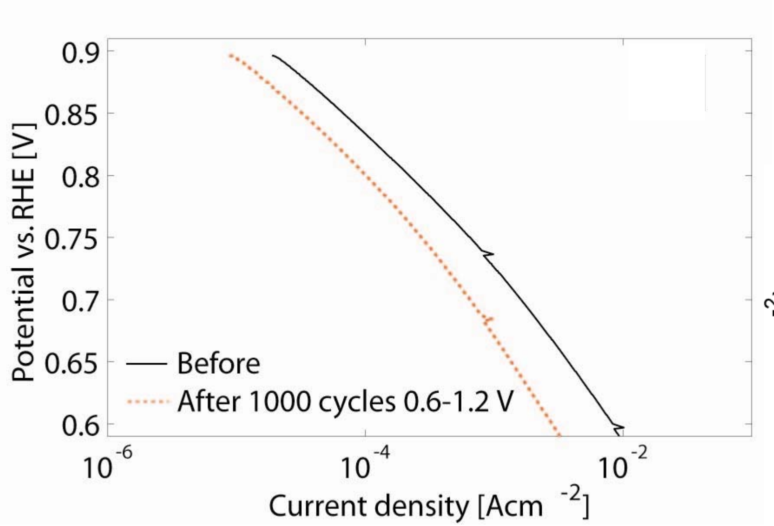


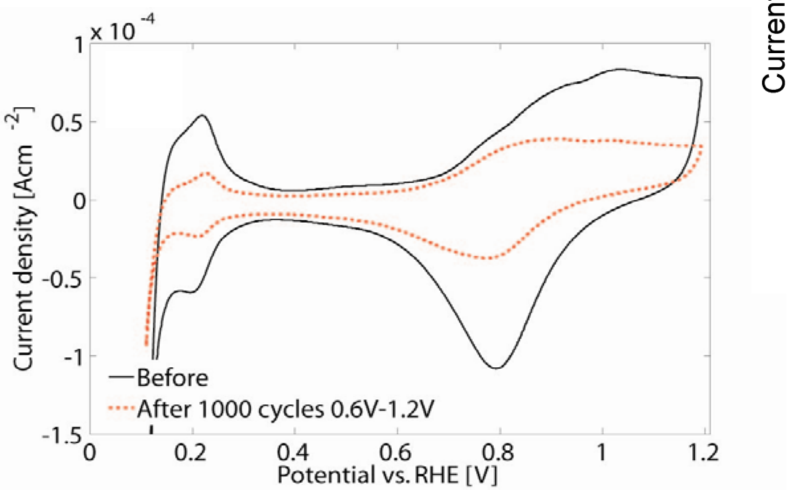


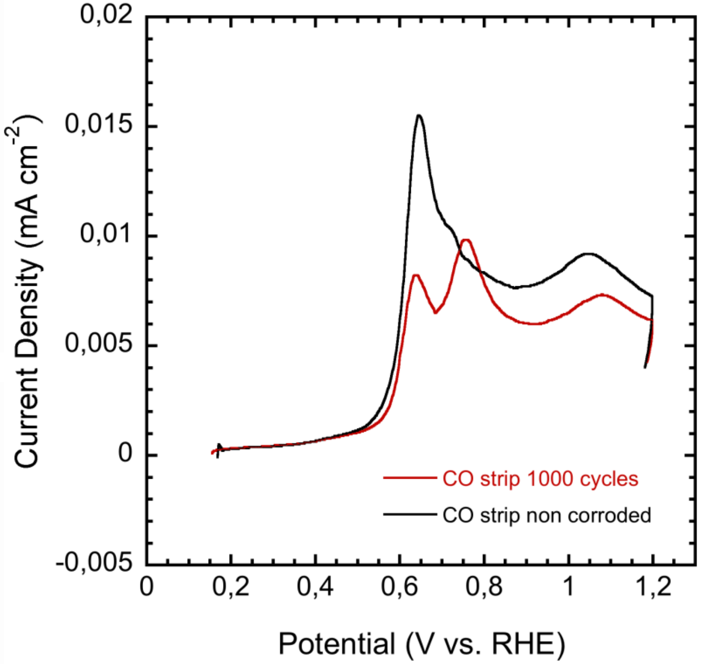

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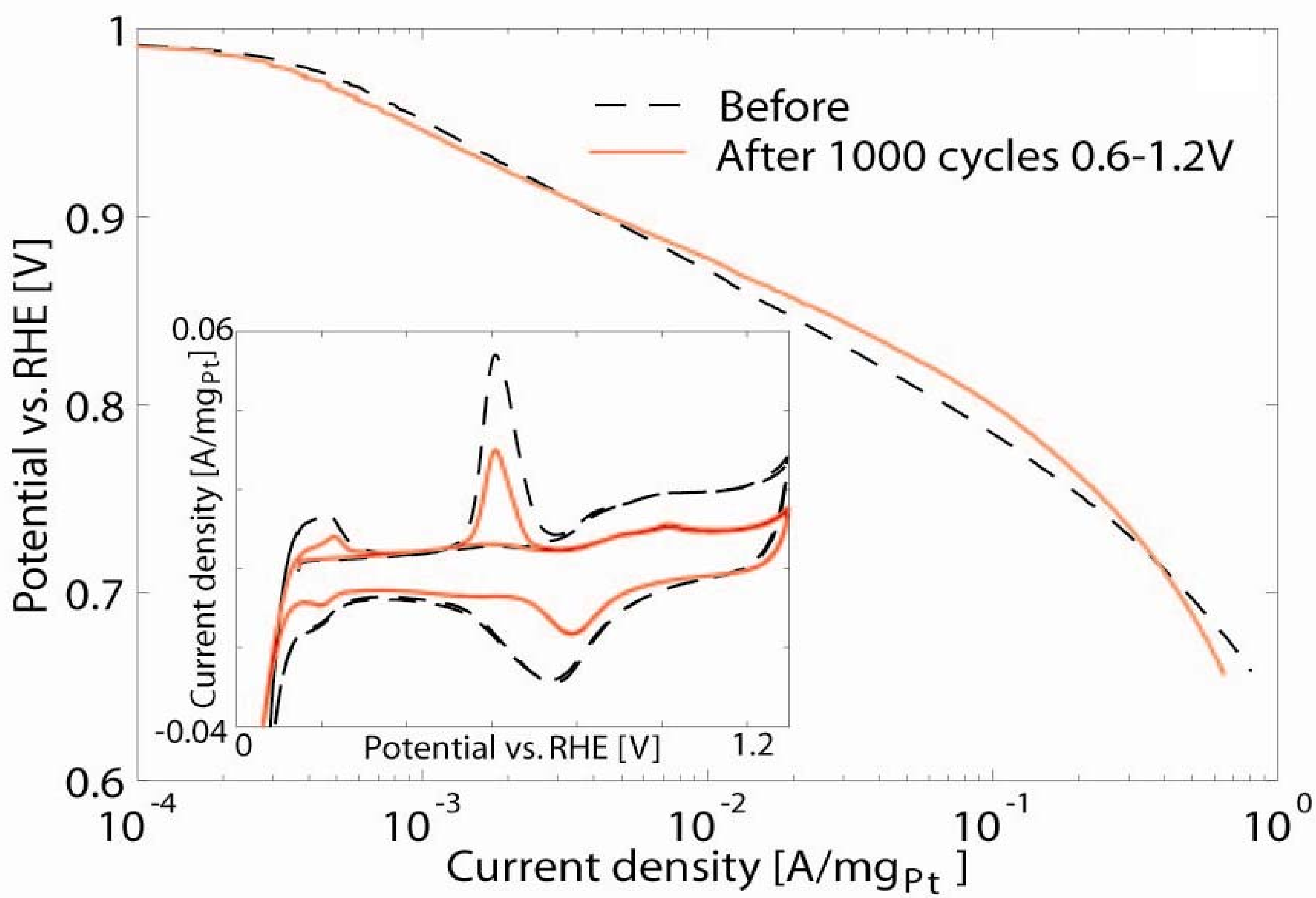
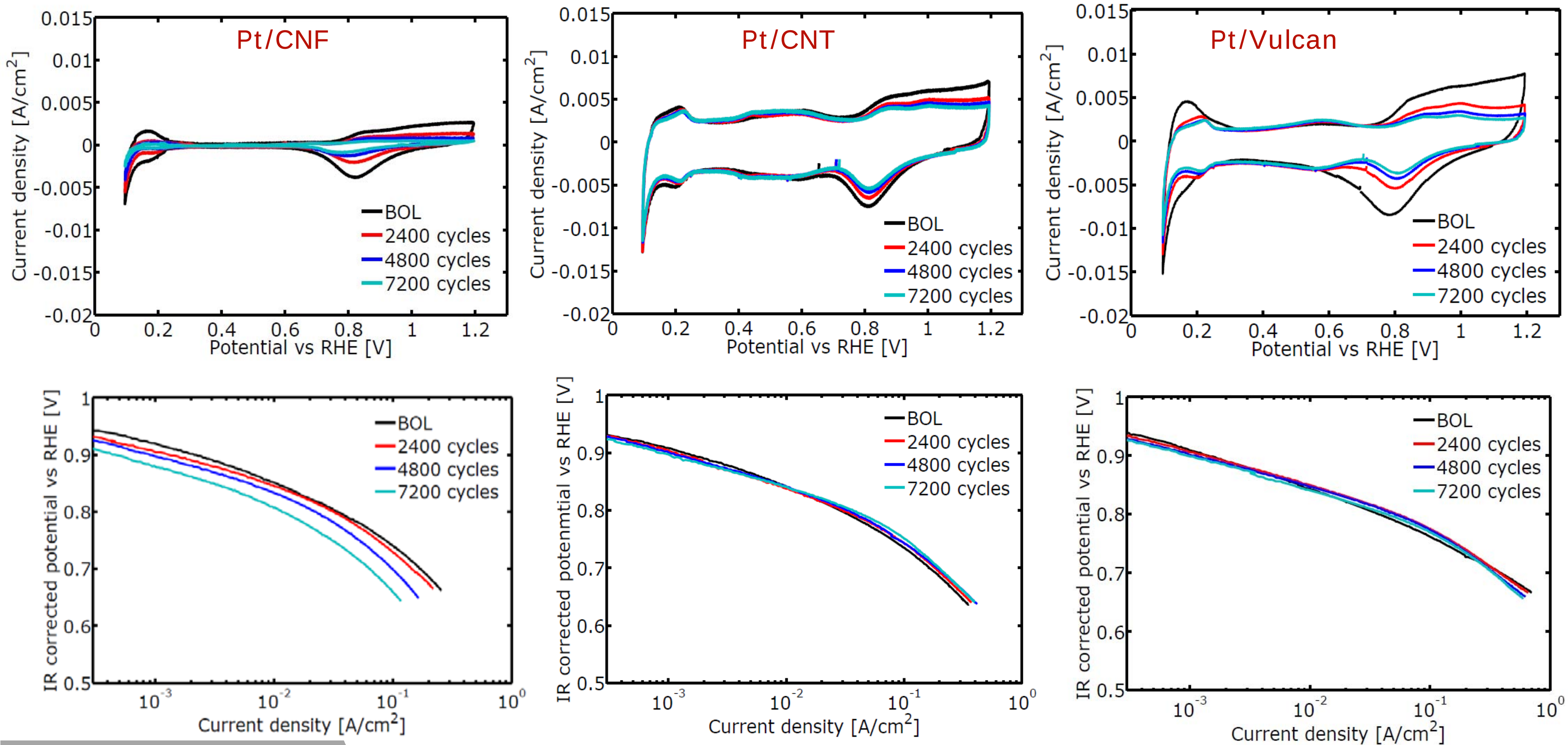
# Cycling of porous electrode

20 wt% Pt on Vulcan XC-72, T=80°C RH=90%, ADT: 0.6-1.2V at 20mV/s in $N_2$



# Cycling of different types of carbon-based electrodes

20wt% Pt, T=80°C, RH 90%, ADT: 0.6-1.2V at 40mV/s in $O_2$



# Potentiostatic holds - model electrodes

T=80°C, RH 90%, ADT: Potentiostatic hold for 100h



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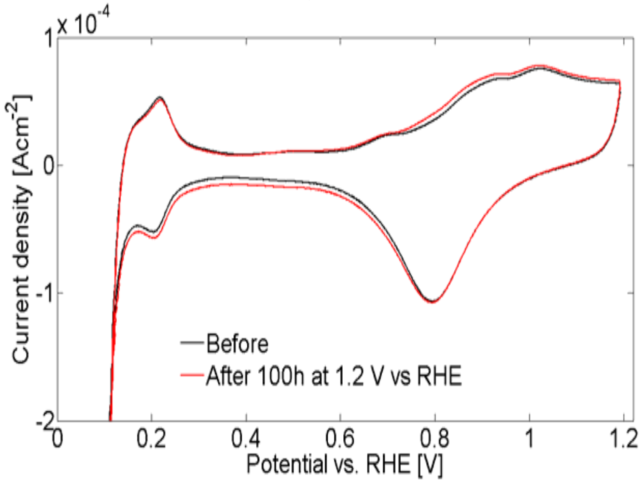
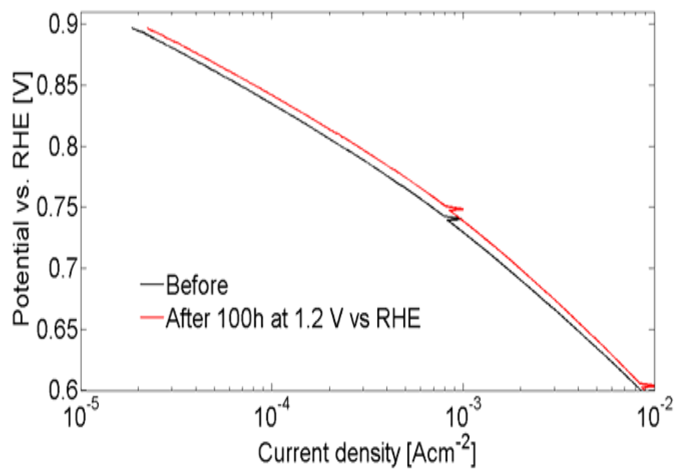
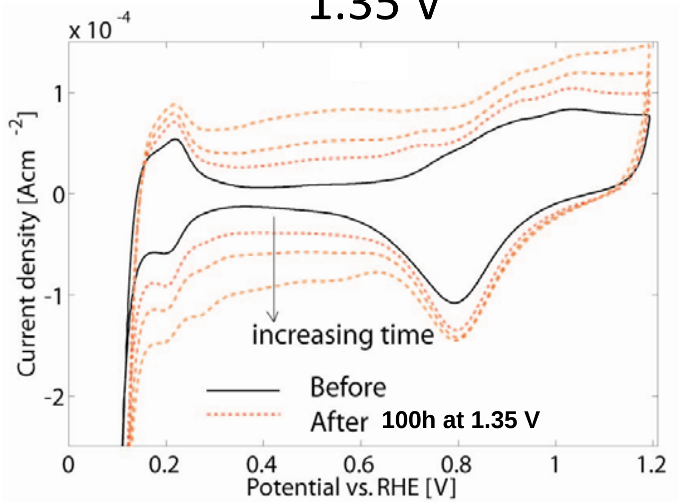
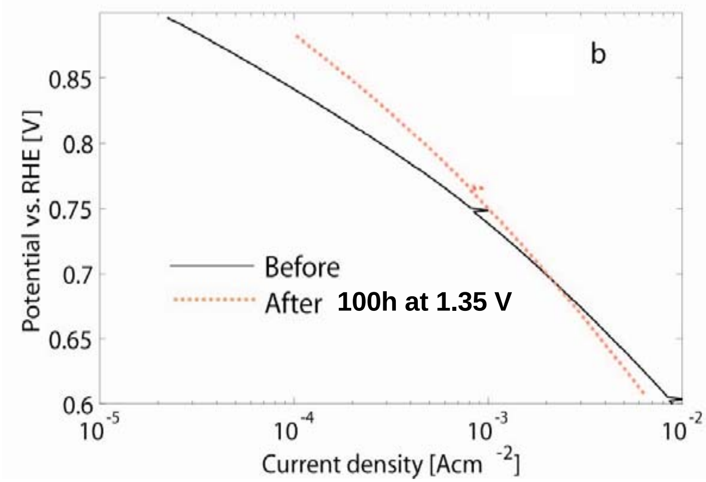
## 1.2 V




## 1.35 V



# Potentiostatic hold - porous electrode

16 wt% Pt on low surface, non graphitised carbon, T=80°C RH 90%

ADT: 100h at 1.2 V



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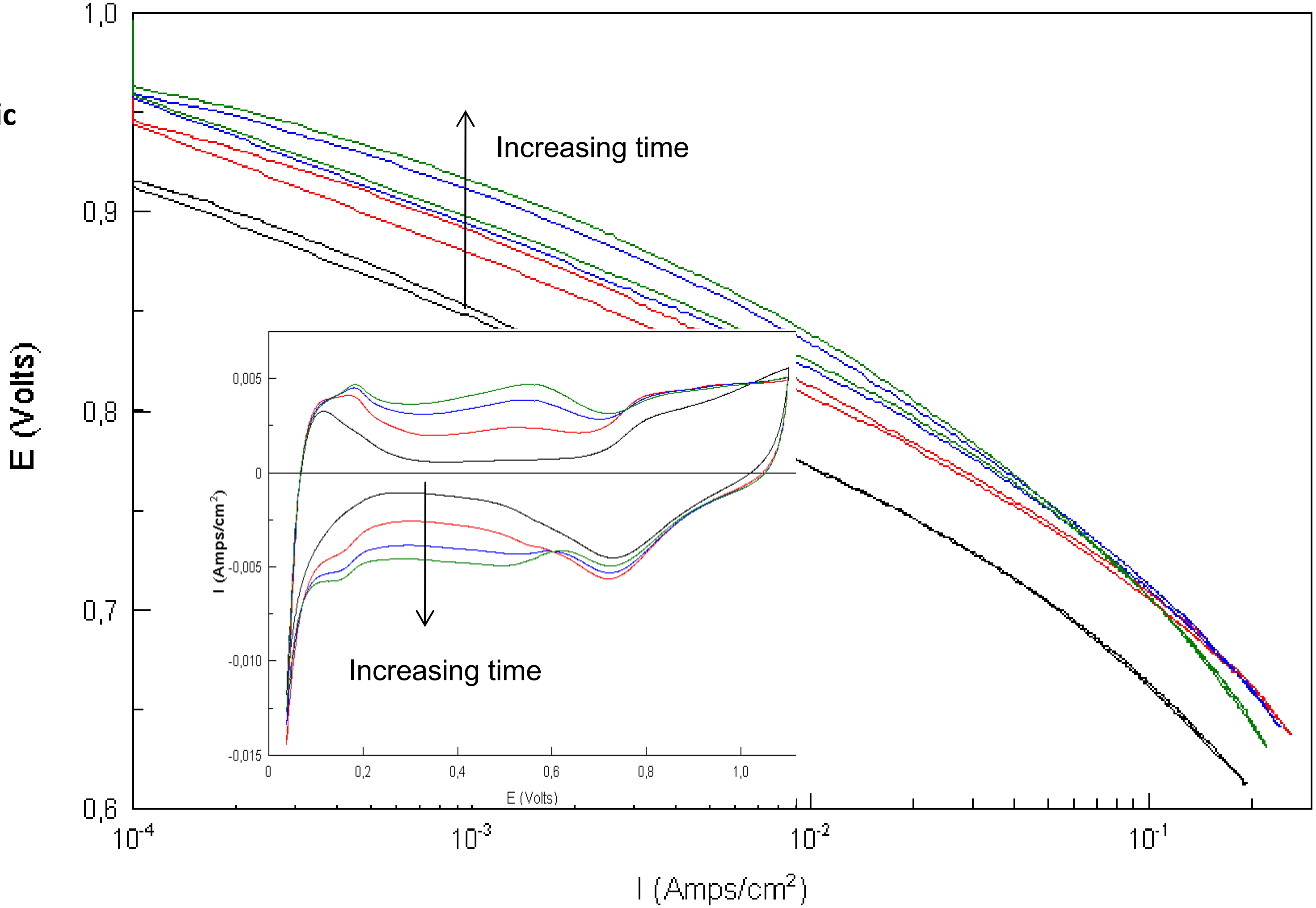
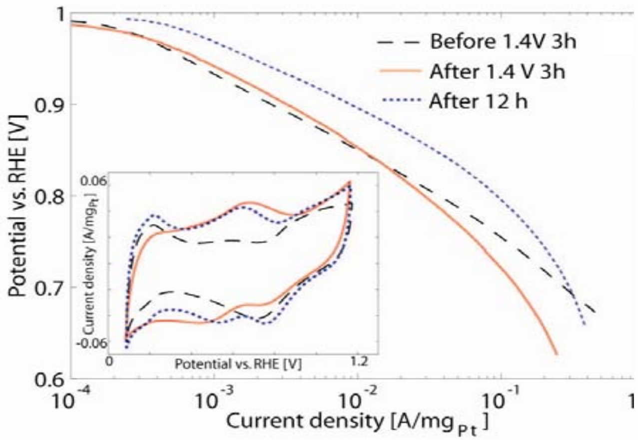
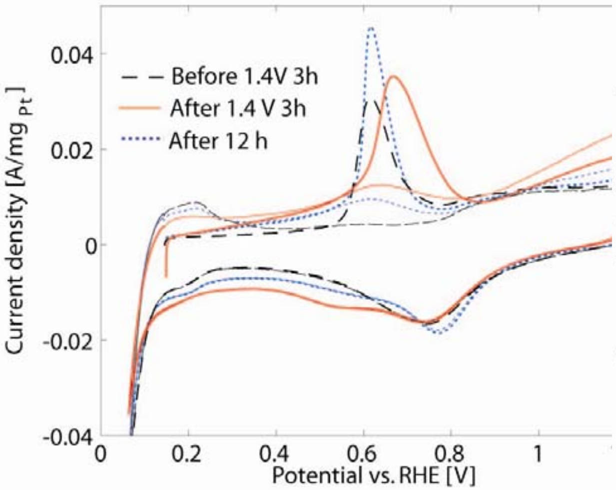


# Potentistatic hold 3h at 1.4V vs RHE

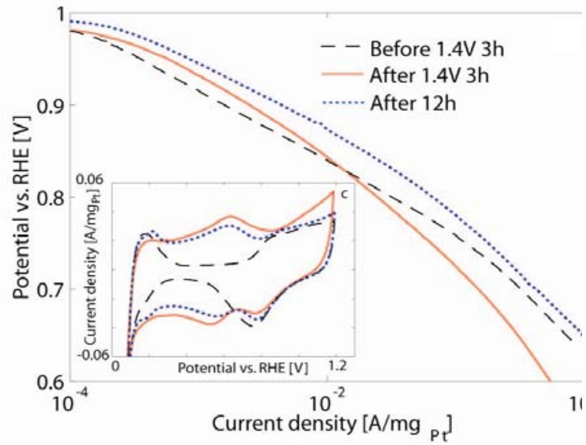
T=80°C RH 90%

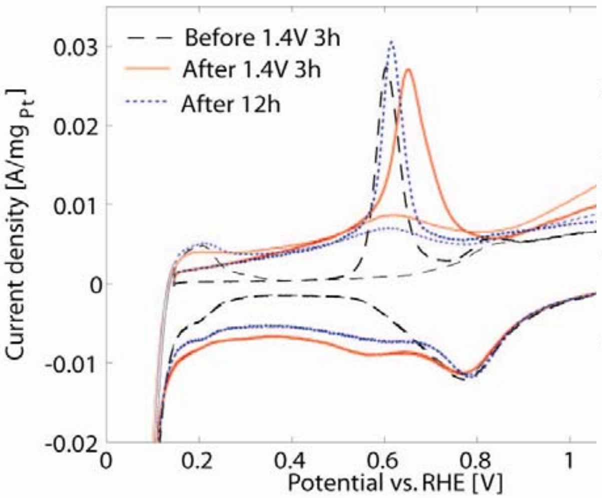
## Pt on Vulcan XC-72



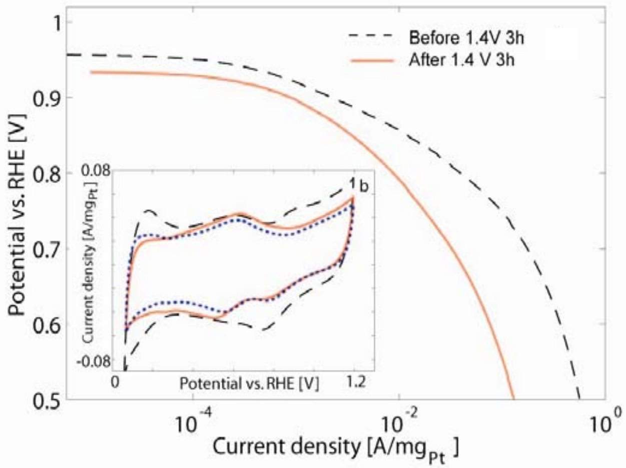



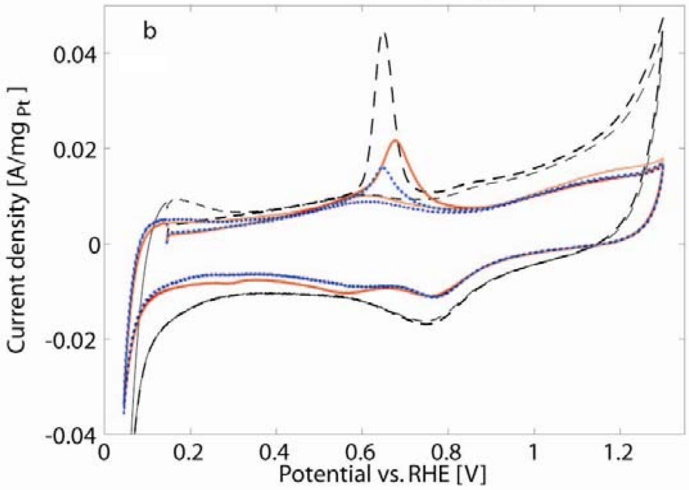

## Pt on low surface, non graphitised carbon




## Pt on high surface area, graphitised carbon



# Conclusions



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## Methodology

- The charge of $H_{upd}$ in the fuel cell is dependent on temperature and humidity while the charge of CO adsorption is less dependent of these parameters
- The electrochemical active surface area can not be used to predict the activity for oxygen reduction since they do not necessary correlate
- Potentiostatic holds can be used to compare the stability of different carbon supports, but high potentials are needed which results in drying of the electrode which would not occur during normal operation of the fuel cell

# Conclusions

## Durability of different carbon-based electrodes

- Pt/CNT is more durable in terms of Pt stability and Pt/CNF is clearly more stable in terms of carbon stability compared to Pt on Vulcan
- The surface area of the carbon support seems to be more important for the stability of the electrode than the degree of graphitization
- An improved activity for oxygen reduction may be related to a moderate increase in the measured double layer capacitance

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Thank you for your attention!