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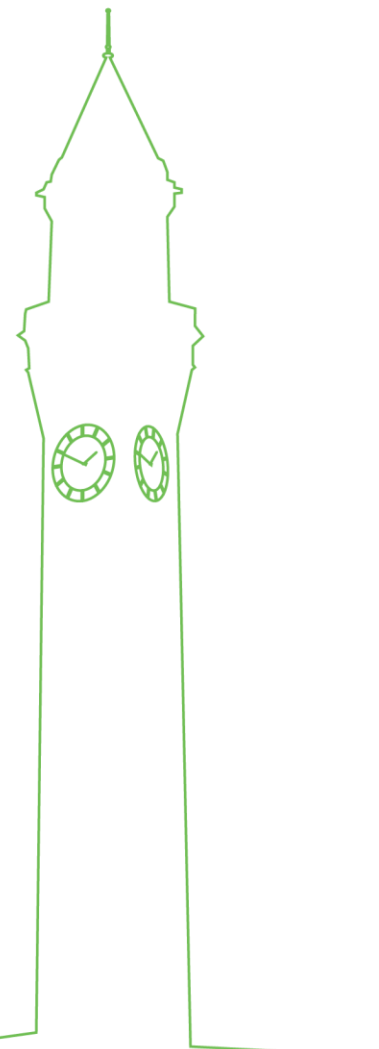
# Iron Cation Contamination Effect on the Performance and Lifetime of the MEA

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# Content

- Motivation - STAMPEM
- Literature overview
- Methodology
- Results and discussion
- Conclusions



# Motivation

- The use of metallic BPPs in PEFC stacks:
  - Are there any contaminants leaching from the BPP?
  - How much of it is absorbed into the MEA?
  - How is it affecting the MEA?



# Motivation

- Contaminants level was measured using Inductive couples plasma (ICP) method for MEAs after operation
  - Results showed an increase in Fe and Cr concentration even for coated samples.

**What is the effect of the contaminants on the performance and lifetime of the MEA?**



# STAMPPEM

## □ *Ex-situ* introduction of contaminants to MEAs

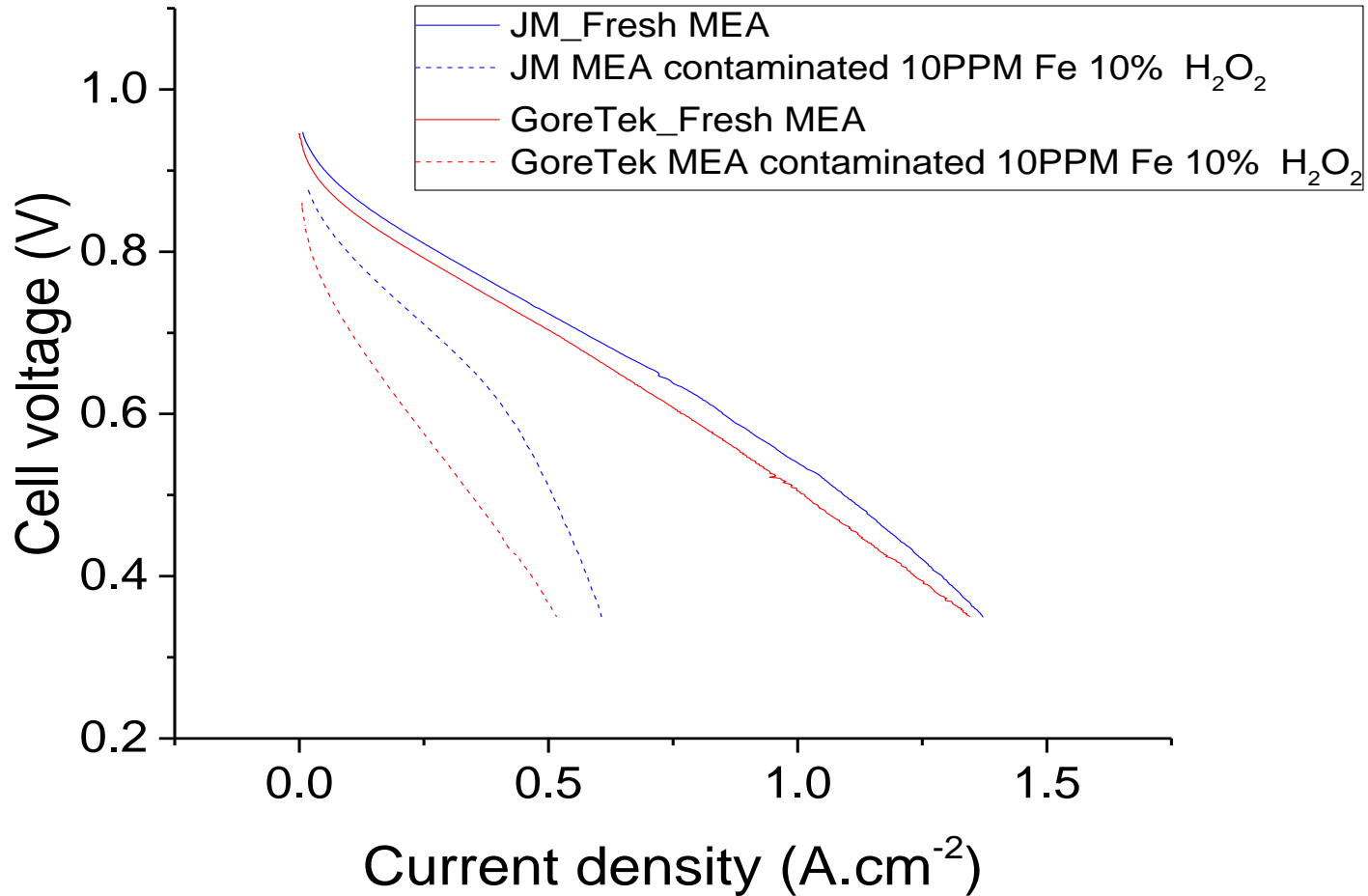
MEA	Fe Concentration ( $\mu\text{l/g}$ )
JM fresh MEA	14
JM MEA (10% $\text{H}_2\text{O}_2$ , 10 PPM Fe)	77
GoreTek Fresh MEA	4.5
GoreTek MEA (10% $\text{H}_2\text{O}_2$ , 10 PPM Fe)	160



10PPM Fe + 10%  $\text{H}_2\text{O}_2$   
24 hrs



# STAMPEM



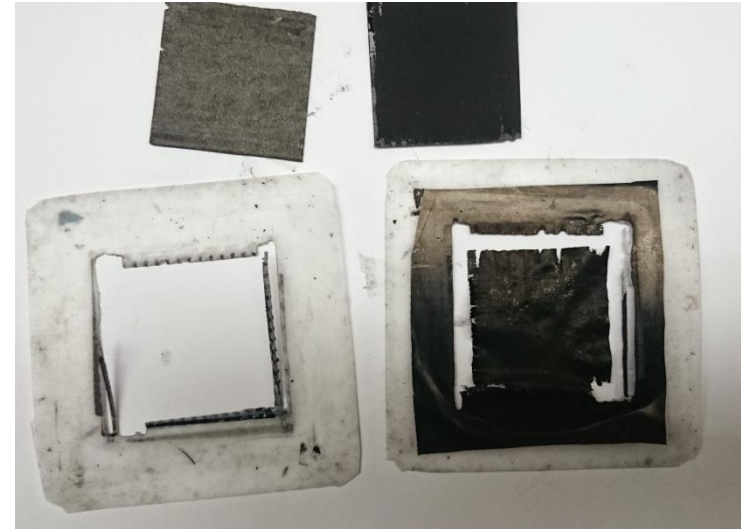
# STAMPEM

MEA	OCV (air) (V)	I @ 0.6V (air) (A.cm <sup>-2</sup> )	Cell ohmic resistance (mΩ.cm <sup>2</sup> ) @ 0.8V
JM fresh MEA	0.95	0.79	160
JM MEA (10% H <sub>2</sub> O <sub>2</sub> , 10 PPM Fe)	0.90	0.43	195
GoreTek Fresh MEA	0.95	0.77	150
GoreTek MEA (10% H <sub>2</sub> O <sub>2</sub> , 10 PPM Fe)	0.86	0.22	370



# STAMPEM

- MEA failure after short operation
  - 8 hrs at 0.6 V
  - Polarisation curve and EIS characterisation
- Degradation of the MEA on the around the edges of BPP and Gasket layer



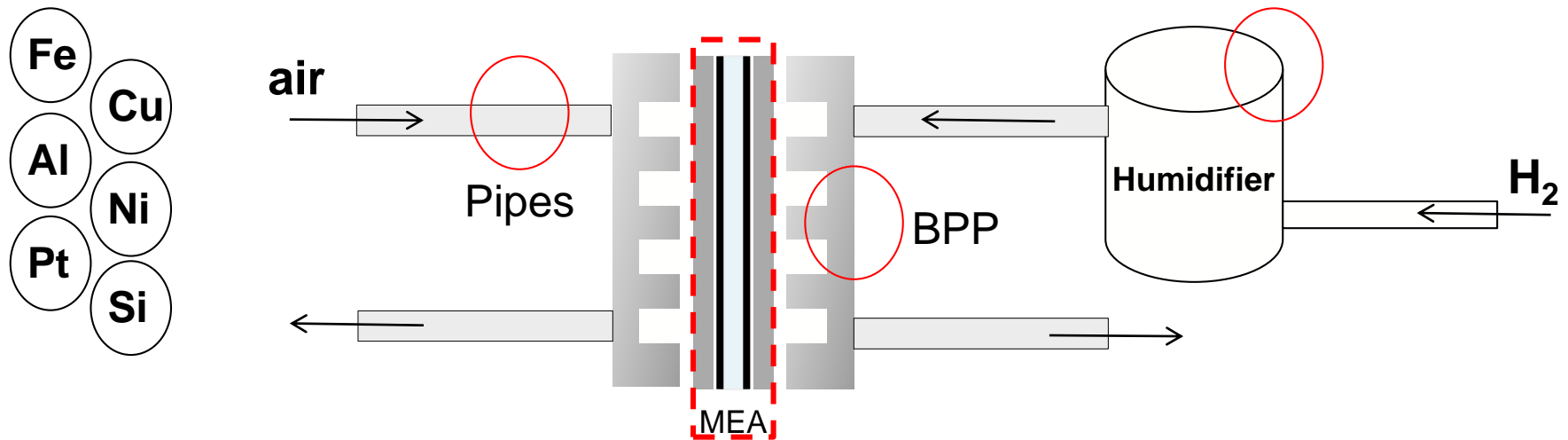
Operation < 10 hrs





# Literature overview

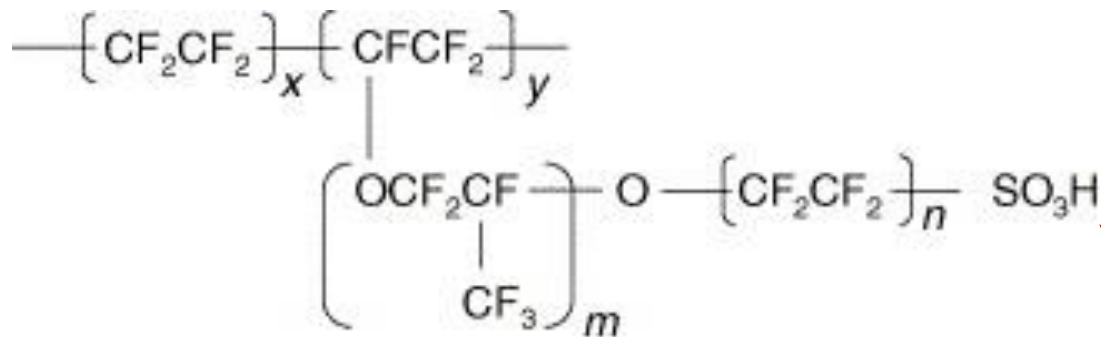
- Elements leaching from fuel cell system components.
- These elements are deposited in either the catalyst layer or the polymer membrane.



# Literature overview

## □ Effect of contaminants:

- Reduction in the performance
  - Decrease in membrane conductivity
  - Affect water diffusion through the membrane



Fe



# Overview overview

- Effect of contaminants:
  - Reduction in the performance
  - Enhance the membrane degradation rate

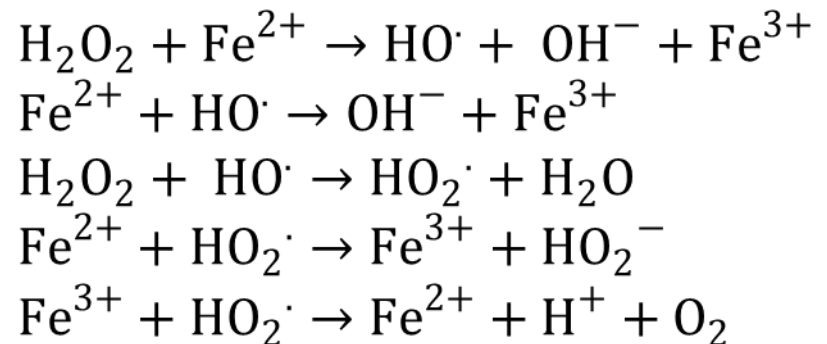
Increase radicals formation



Membrane decomposition



- Lower EW
- Lower conductivity



S. Zhang *et al*, Int. J. Hydrogen Energy. 34 (2009)

Z. Luo *et al*, Int. J. Hydrogen Energy. 31 (2006)

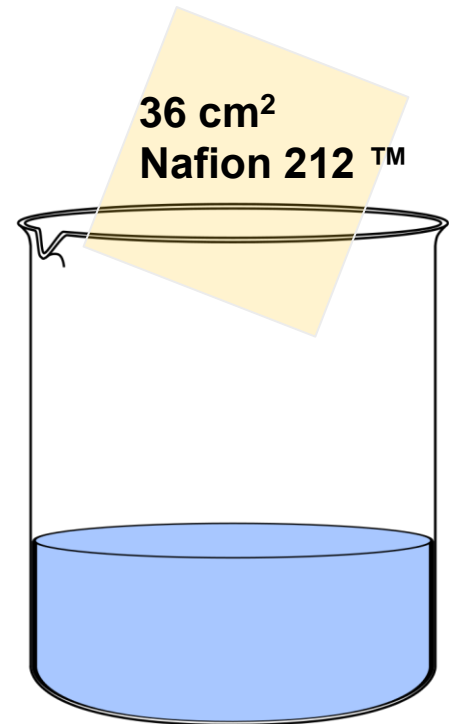
T. Kinumoto *et al*, J. Power Sources. 158 (2006)



# Methodology

## □ Introduction of contaminants

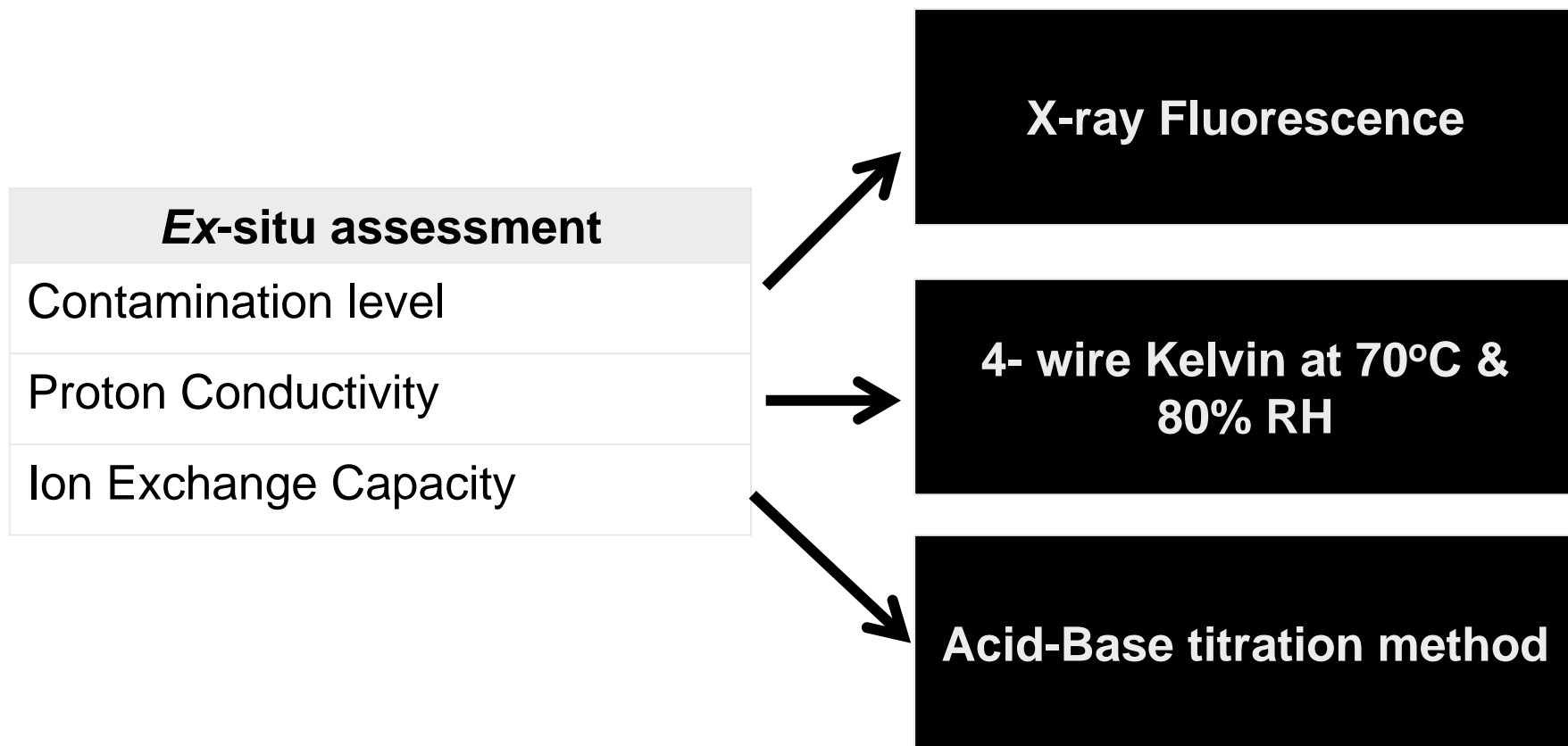
<b>Effect of Fe<sup>2+</sup> concentration (10% H<sub>2</sub>O<sub>2</sub>)</b>	<b>Effect of H<sub>2</sub>O<sub>2</sub> concentration (10 PPM Fe<sup>2+</sup> )</b>
<b>Iron concentration</b>	<b>Hydrogen peroxide concentration</b>
0 PPM	0%
5 PPM	5%
10 PPM	10%
20 PPM	



**250ml solution at  
70°C with constant  
stirring**



# Methodology



# Methodology



MEAs were fabricated and tested *in-situ*

## ***In-situ* assessment**

Polarisation curves (IV)

Electrochemical Impedance Spectroscopy (EIS)

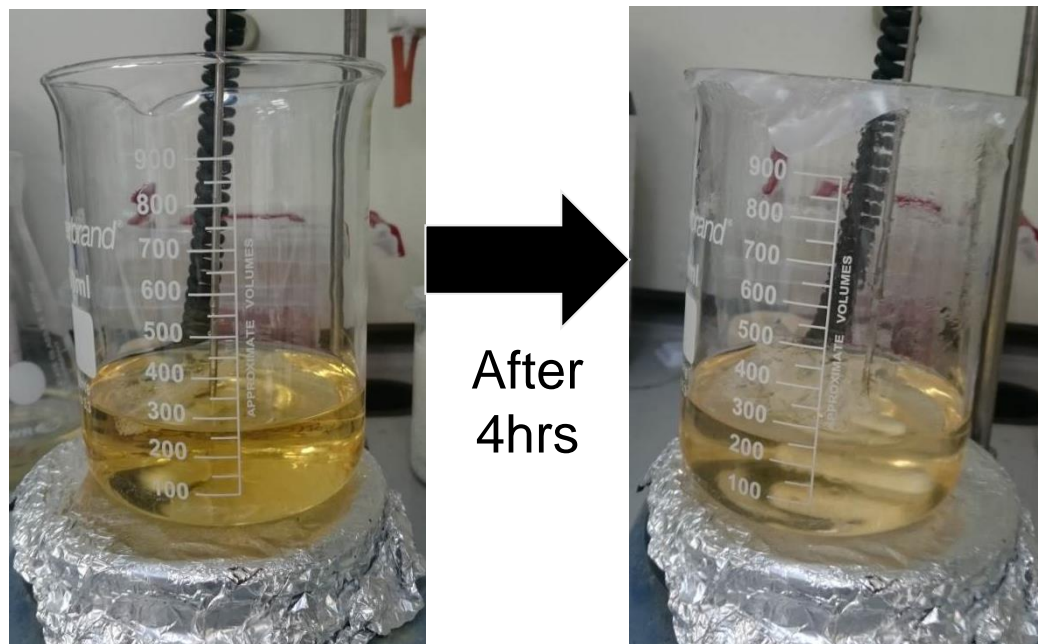
Cyclic voltammetry (CV)

Operating conditions

- T : 70°C
- P : 2 bar
- RH: 100% anode, 50% cathode
- Stoichiometry: 1.2 anode, 2.4 cathode



# Results and Discussion



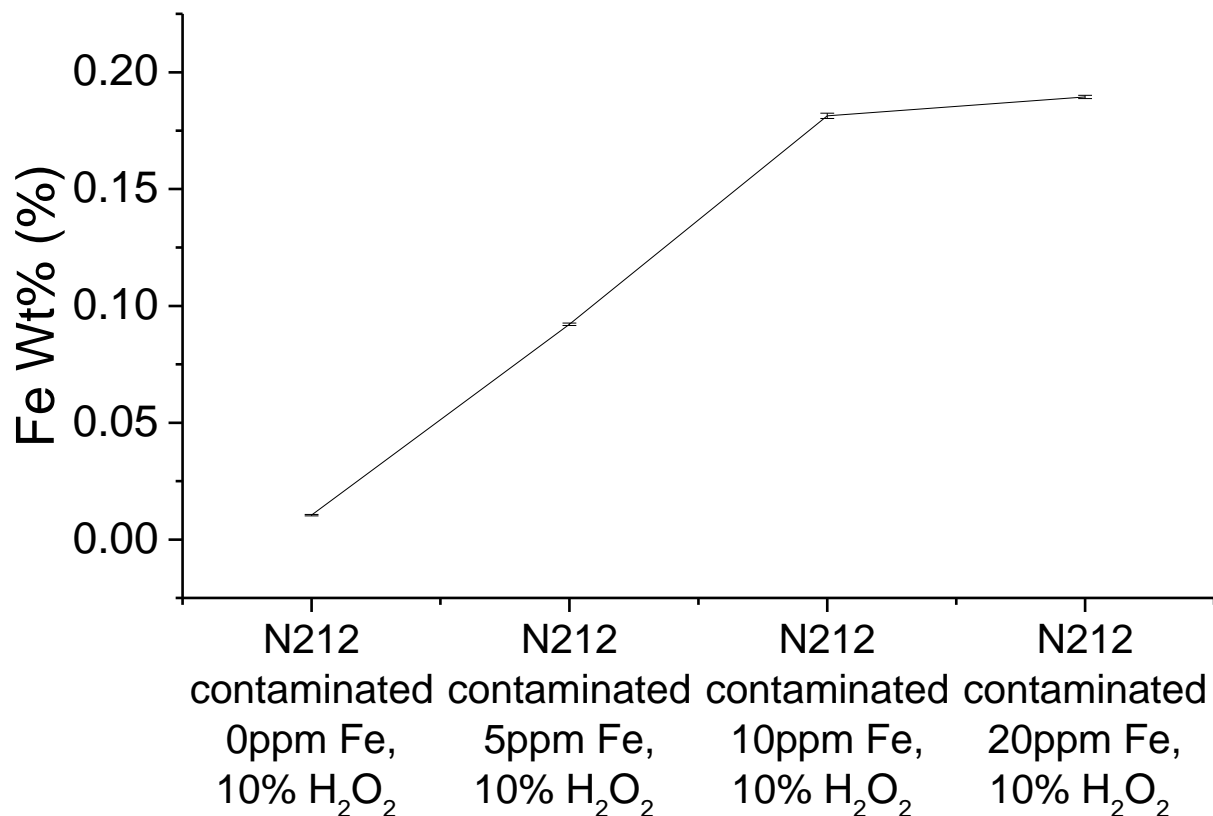
Fe 20PPM, 10% H<sub>2</sub>O<sub>2</sub>

- The solution colour cleared after 24hrs.
- No measurable change in pH is detected.
- Visual inspection showed no defects in the membrane.



# Results and Discussion

## □ The effect of Fe concentration



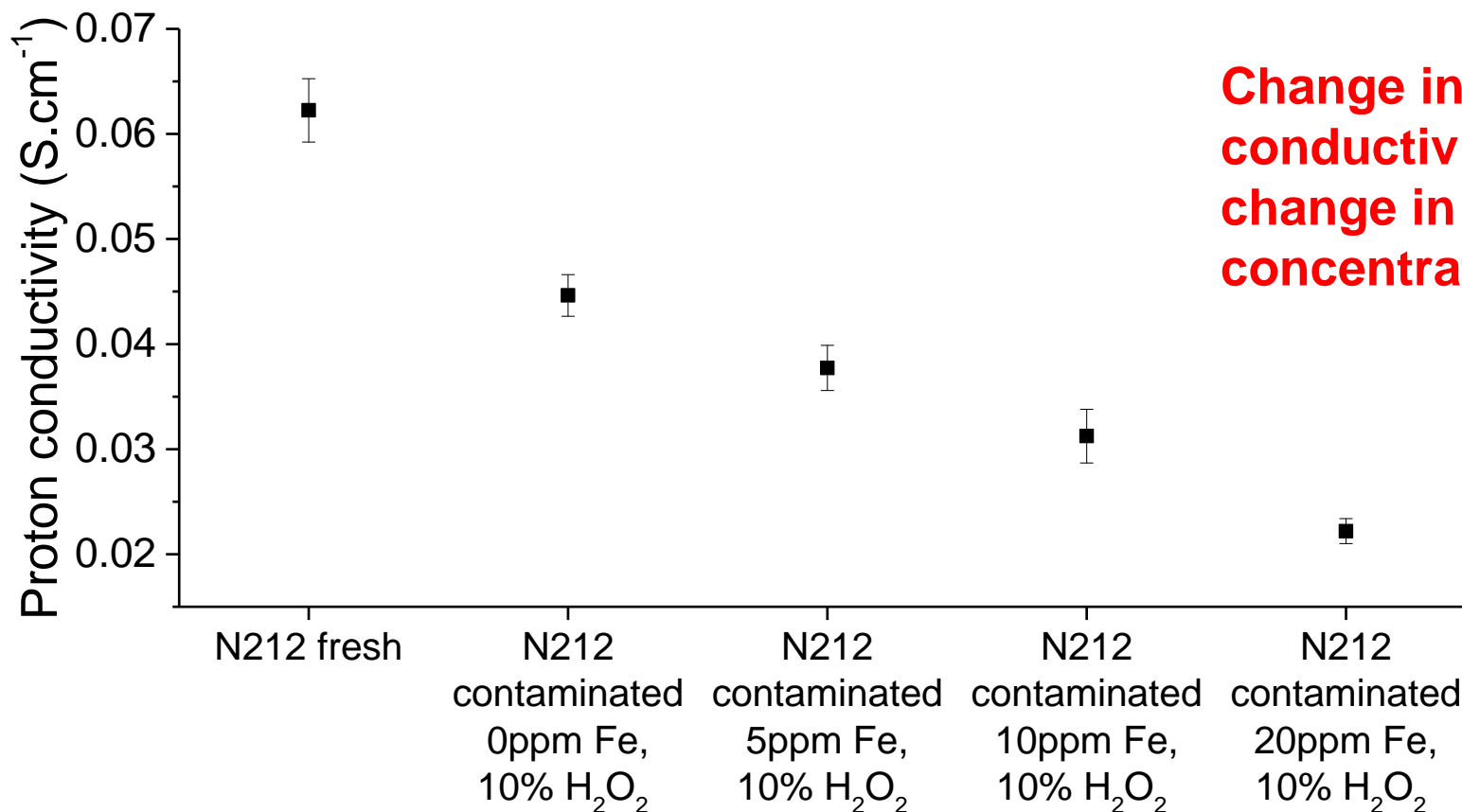
**XRF results: Change in Fe loading with the change in Fe concentration**





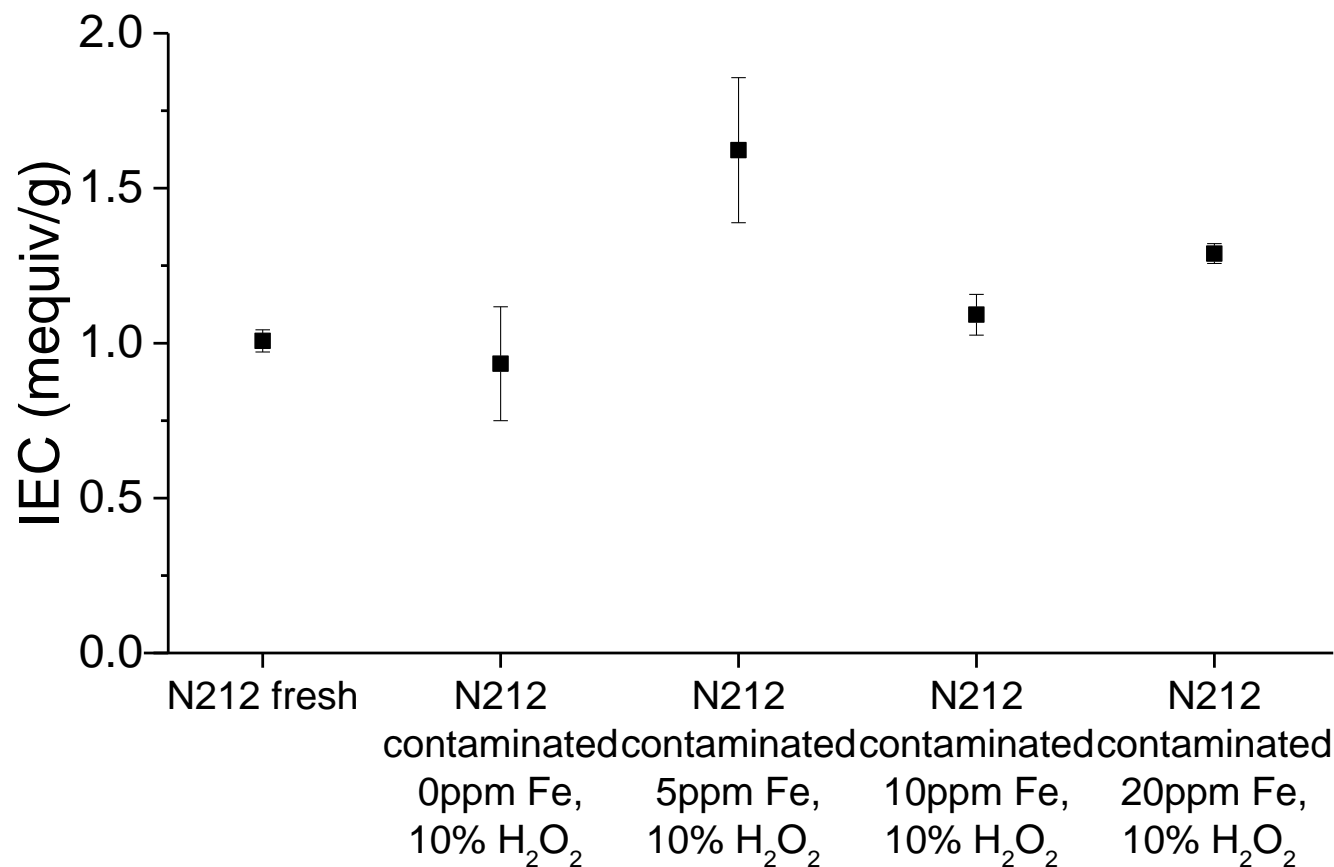
# Results and Discussion

## □ The effect of Fe concentration



# Results and Discussion

## □ The effect of Fe concentration



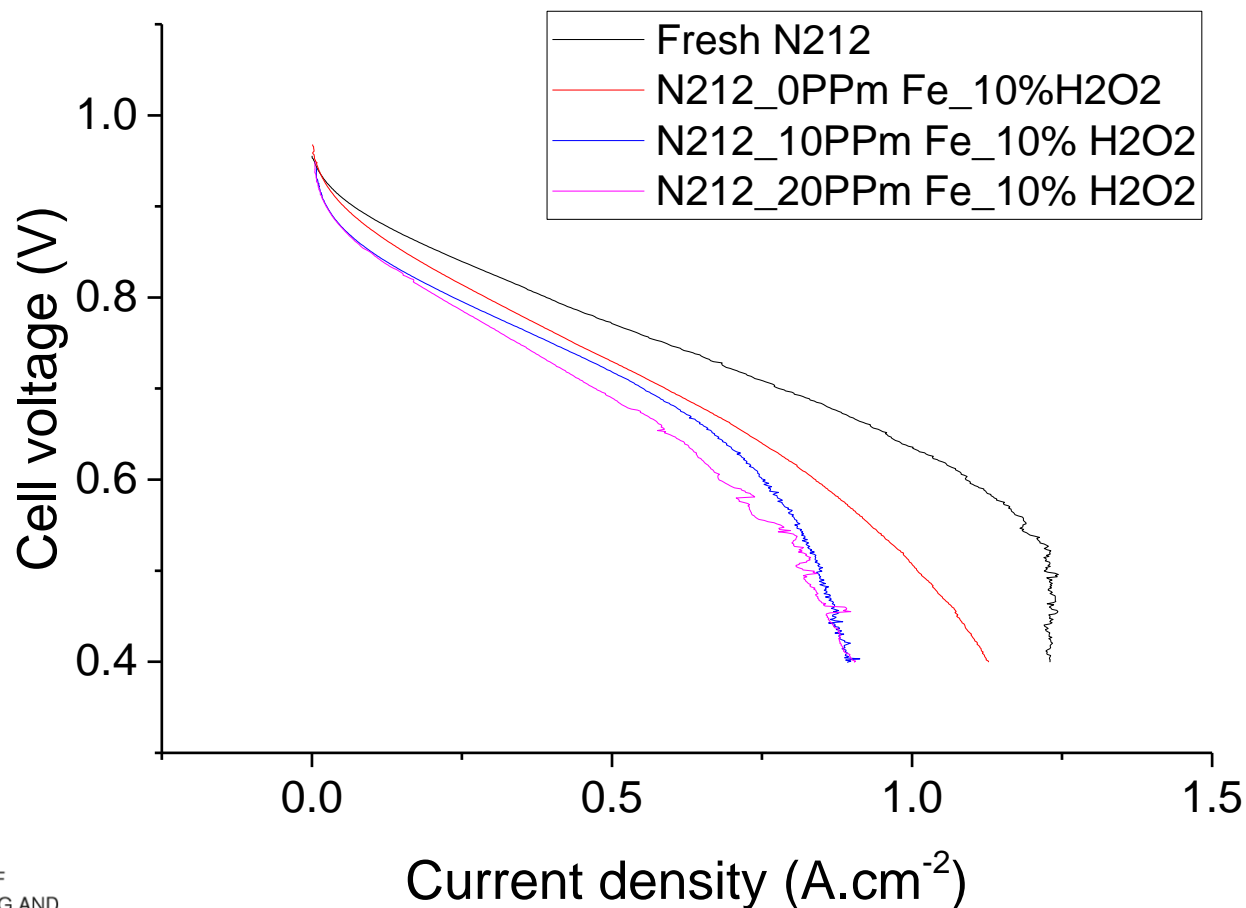
**Change in Ion Exchange capacity with the change in Fe concentration**



# Results and Discussion

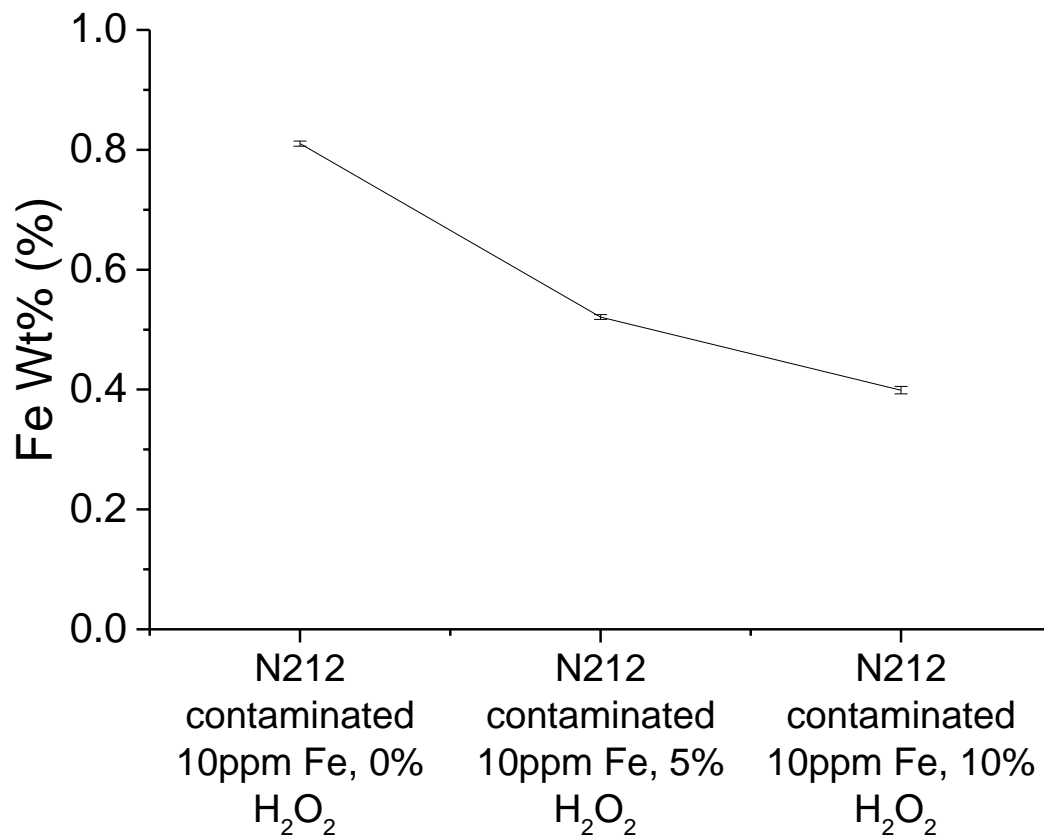
## □ The effect of Fe concentration

- No change in OCP, Ohmic resistance or CV for the MEA.
- The increase in iron level increases performance drop.



# Results and Discussion

## □ The effect of H<sub>2</sub>O<sub>2</sub> concentration

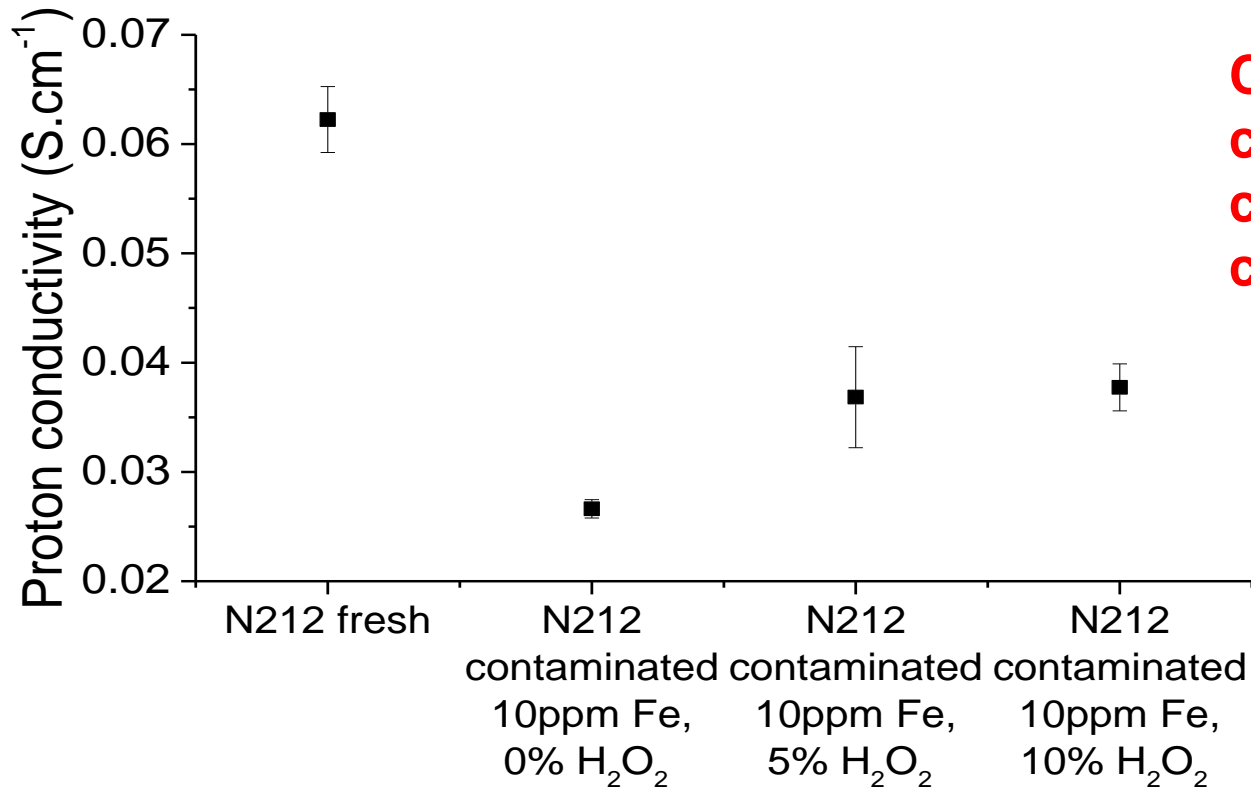


**XRF results: Change in Fe loading with the change in H<sub>2</sub>O<sub>2</sub> concentration**



# Results and Discussion

## □ The effect of $\text{H}_2\text{O}_2$ concentration

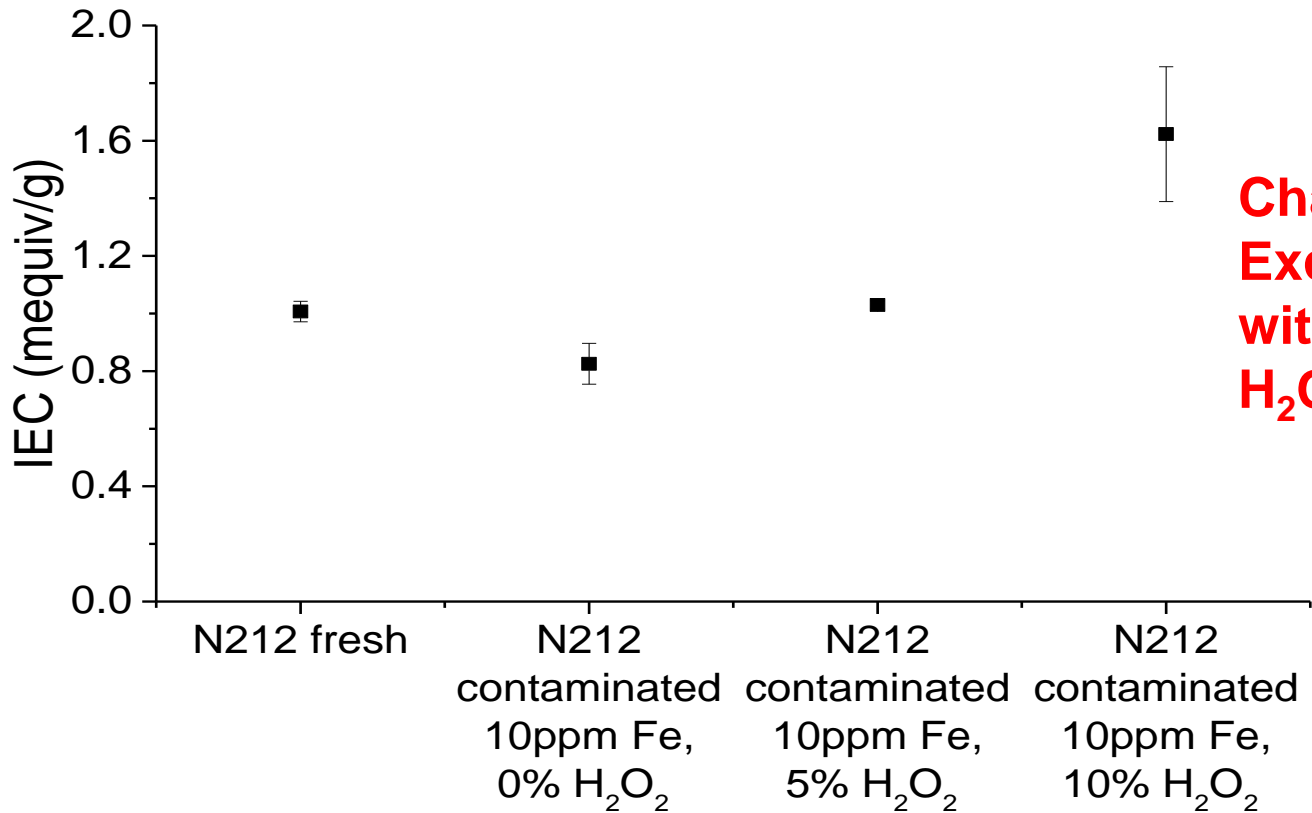


**Change in proton conductivity with the change in  $\text{H}_2\text{O}_2$  concentration**



# Results and Discussion

## □ The effect of $\text{H}_2\text{O}_2$ concentration



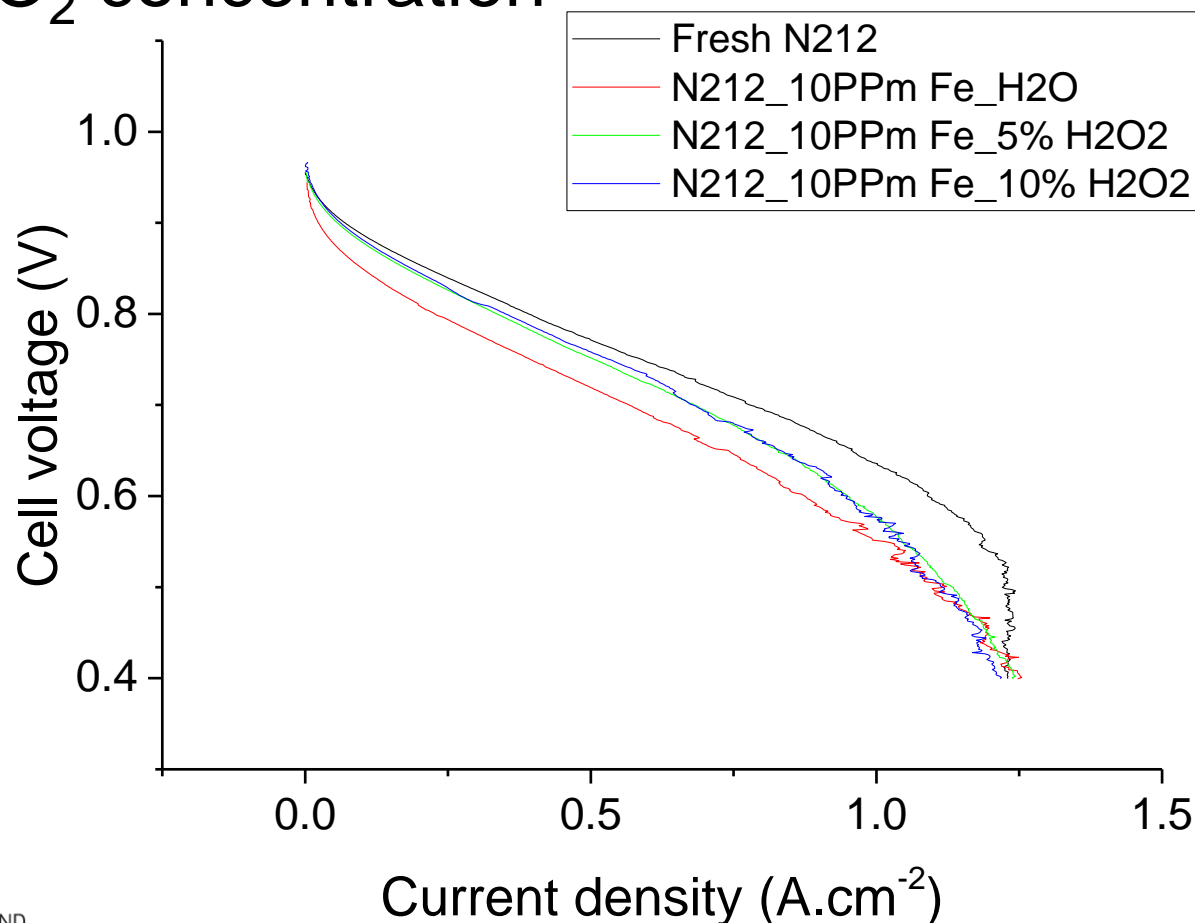
**Change in Ion Exchange capacity with the change in  $\text{H}_2\text{O}_2$  concentration**



# Results and Discussion

## □ The effect of $\text{H}_2\text{O}_2$ concentration

- No change in OCP, Ohmic resistance or CV for the MEA.
- No clear negative effect of  $\text{H}_2\text{O}_2$



# Conclusions

- The presence of the catalyst layer significantly increases the effect of the contaminants.
- Low levels of Fe result in a significant change in the membrane properties.
- $\text{H}_2\text{O}_2$  concentration in the presence of Fe has relatively small effect on the MEA performance.
- Proton conductivity is the primary property affected by the iron contamination, however; the effect on the membrane structure is still need to be explored.





# Future work

- A systematic study of the effect of cations in the presence of Pt catalyst layer.
- Quantification of leaching rate of cations from metallic BPPs degradation – a characterisation property for metallic plates.
- The effect of other elements on the performance of the MEA.



# Acknowledgement

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**Thank you for listening**

