Development of a Low-Cost, Durable Membrane and MEA for Stationary and Mobile Fuel Cell Applications

Scott Gaboury
Atofina Chemicals, Inc.
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Project Safety

- Evaluation of safety practices is a mandatory part of developing our Standard Operating Procedure (SOP) documentation for any new procedure. Hydrogen and platinum handling have been particular points of discussion to help develop best practices.

- Findings of scheduled laboratory inspections, observations, and personal protective equipment (PPE) usage are reviewed regularly.

- Internal safety audits are a key part of safety our efforts, and new efforts in external audit programs offers an added level of review through Modern Safety Management being implemented at Atofina and Health and Safety Improvement Plans being implemented at Johnson Matthey

- Johnson Matthey and Atofina also participate in the Responsible Care Program to voluntarily raise safety standards above minimum requirements

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Team

- Atofina Chemicals, Inc.
  - Georgia Tech
- Johnson Matthey Fuel Cells, Inc.
- UTC Fuel Cells
  - University of Hawaii

Project Overview/Objectives

- **To develop low-cost, high-durability membranes**
  - Optimize chemistry & process
  - Validate scale up

- **To develop MEAs based on these membranes**
  - Optimize MEA for new membrane
  - Validate MEA performance

- **To validate the MEA performance in single cells and in stacks**

Budget*

Atofina & Partners	$2,240,564
DOE	$5,771,351
Total	$8,011,915

*FY-04, 05, 06

Technical Barriers and Targets

- **DOE Technical Barriers for Fuel Cell Components**
  - O. Stack Material and Manufacturing Cost
  - P. Durability

- **DOE Technical Target for Fuel Cell Stack System for 2010**
  - Cost $35/kW
  - Durability 5000 hours

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Approach

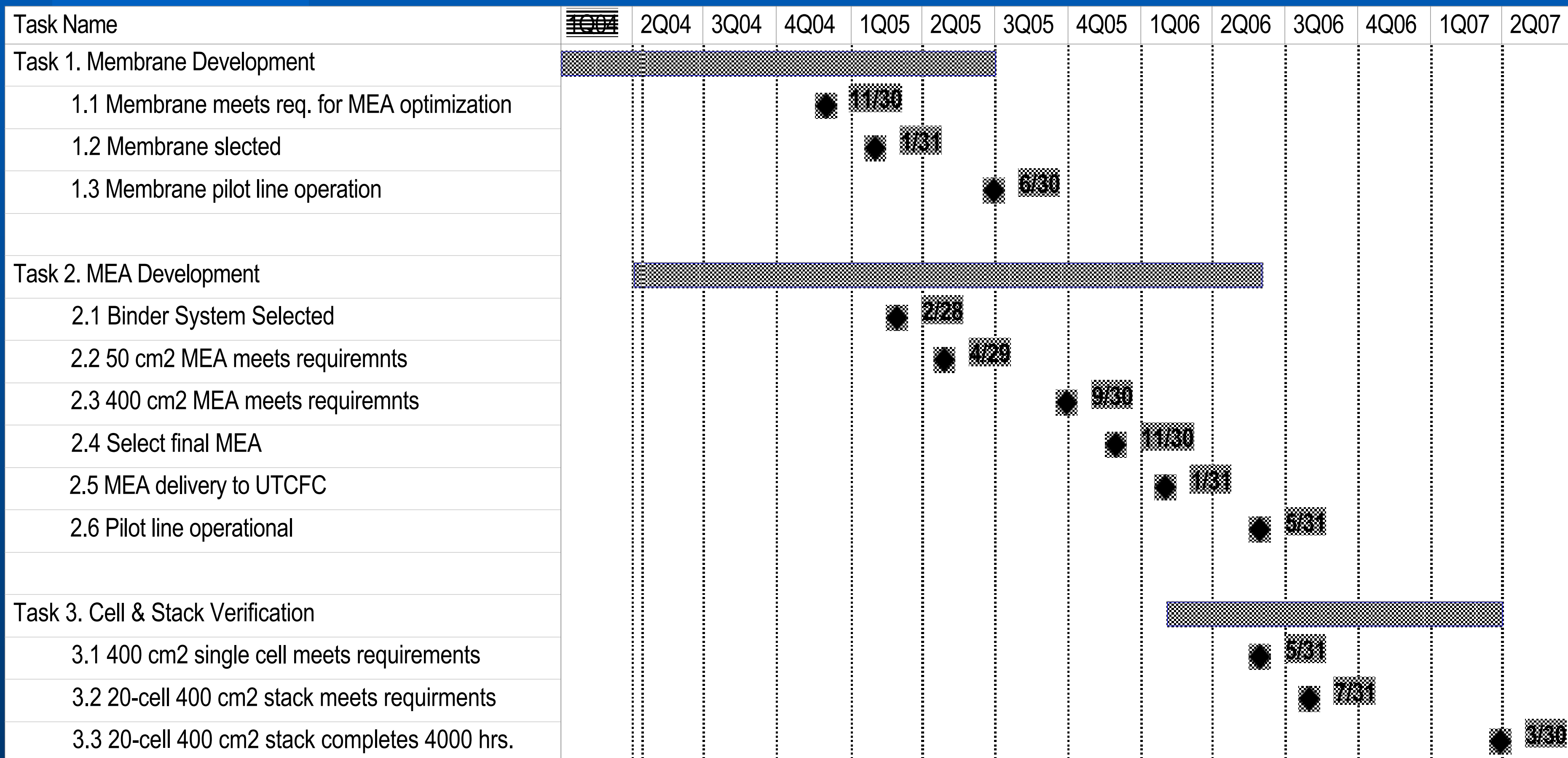
- **Kynar® PVDF (Polyvinylidene fluoride) is very stable in highly corrosive environments, for example:**
  - Acidic media (HF, HCl, HBr…)
  - Electrochemically stable (Lithium batteries…)

- **The membrane consists of a blend of Kynar PVDF and a proprietary polyelectrolyte.**

- **This approach is highly tunable:**
  - The type of Kynar used
  - The composition of the polyelectrolyte
  - The process to blend them

- **As the chemistry of the membrane is very different from that of existing materials, the MEA will have to be redesigned accordingly.**

Program Timeline



Georgia Tech: Technical Progress

High-Throughput Screening:

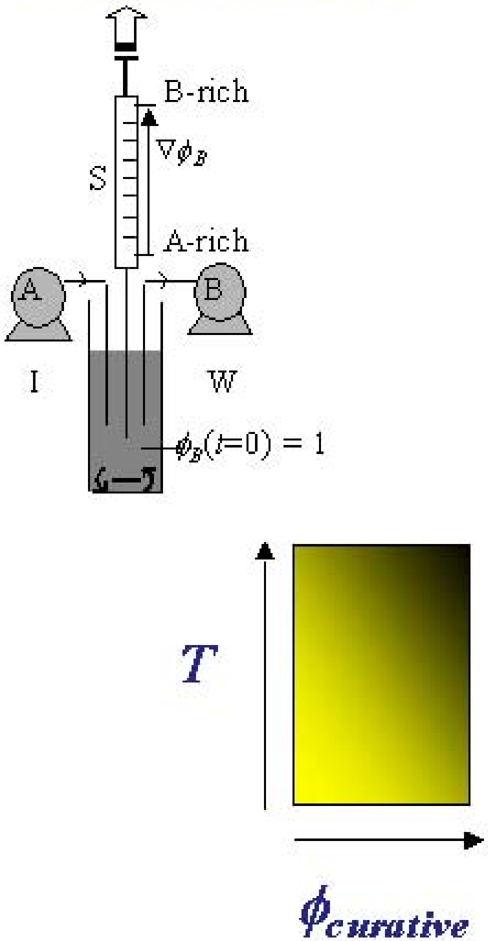
- **Designed 2 novel rapid screens**
  - Water sorption – preliminary data stage
  - Conductivity – instrument construction stage

- **Existing screens**
  - Mechanical properties
  - Spectroscopy (FTIR, UV-Vis)

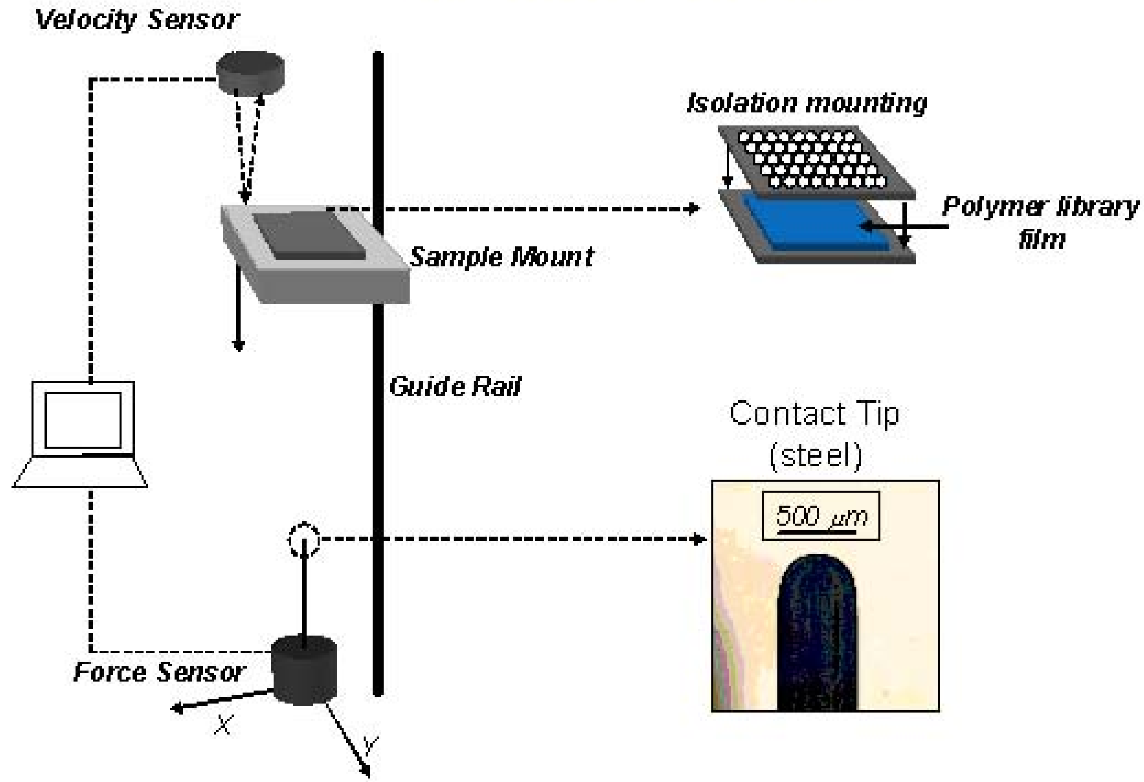
- **Existing synthesis – gradient libraries**

Georgia Tech:
High-Throughput Synthesis & Mechanics

Gradient Libraries

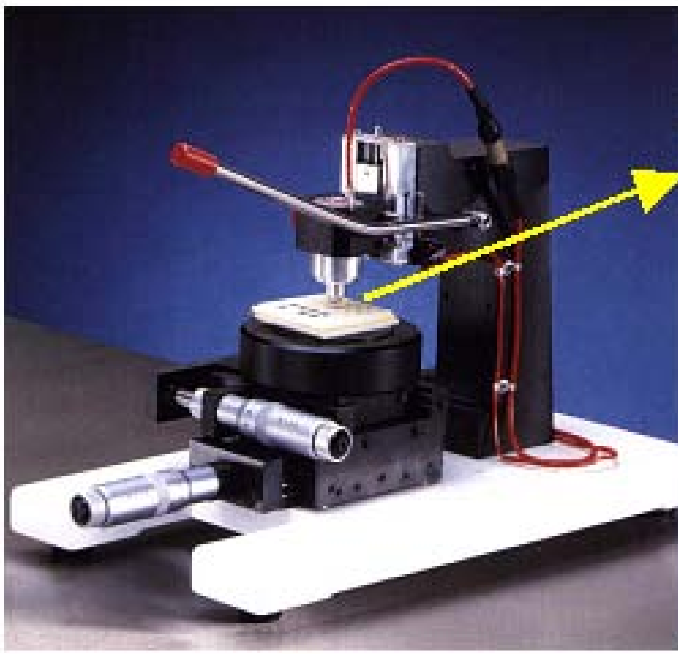


Mechanical Screening



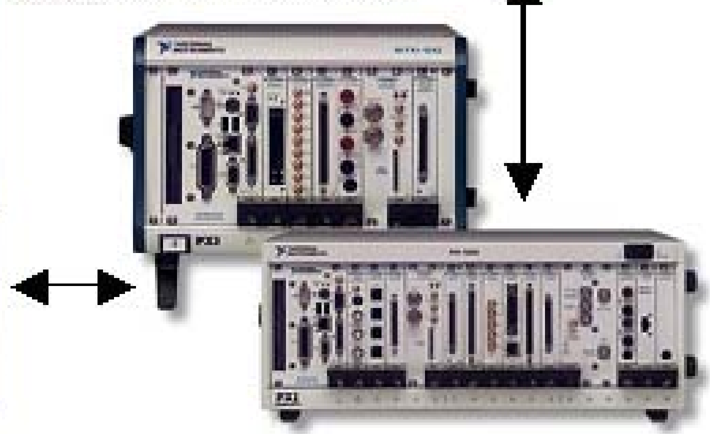
Georgia Tech: High-Throughput Conductivity

Rapid point-to-point
Jandel Scientific



4-point probe
600 µm spacing

Screw allows pressure to be user adjusted



PXI-Based AC Signal Generator and Measurement

Atofina: Technical Progress

Membrane Development:

- Conductivity ~130mS/cm (70°C in water)
- Thin films possible: excellent areal resistance
- Good mechanical properties (creep, tear strength…)
- Water swelling behavior similar to PFSA
- MEA prepared using commercial E-TEK® electrodes
- Good polarization curves (H_2, O_2 & Air, 100% RH)
- 2000+ hour endurance test completed

- Lower conductivity at low relative humidities than PFSA

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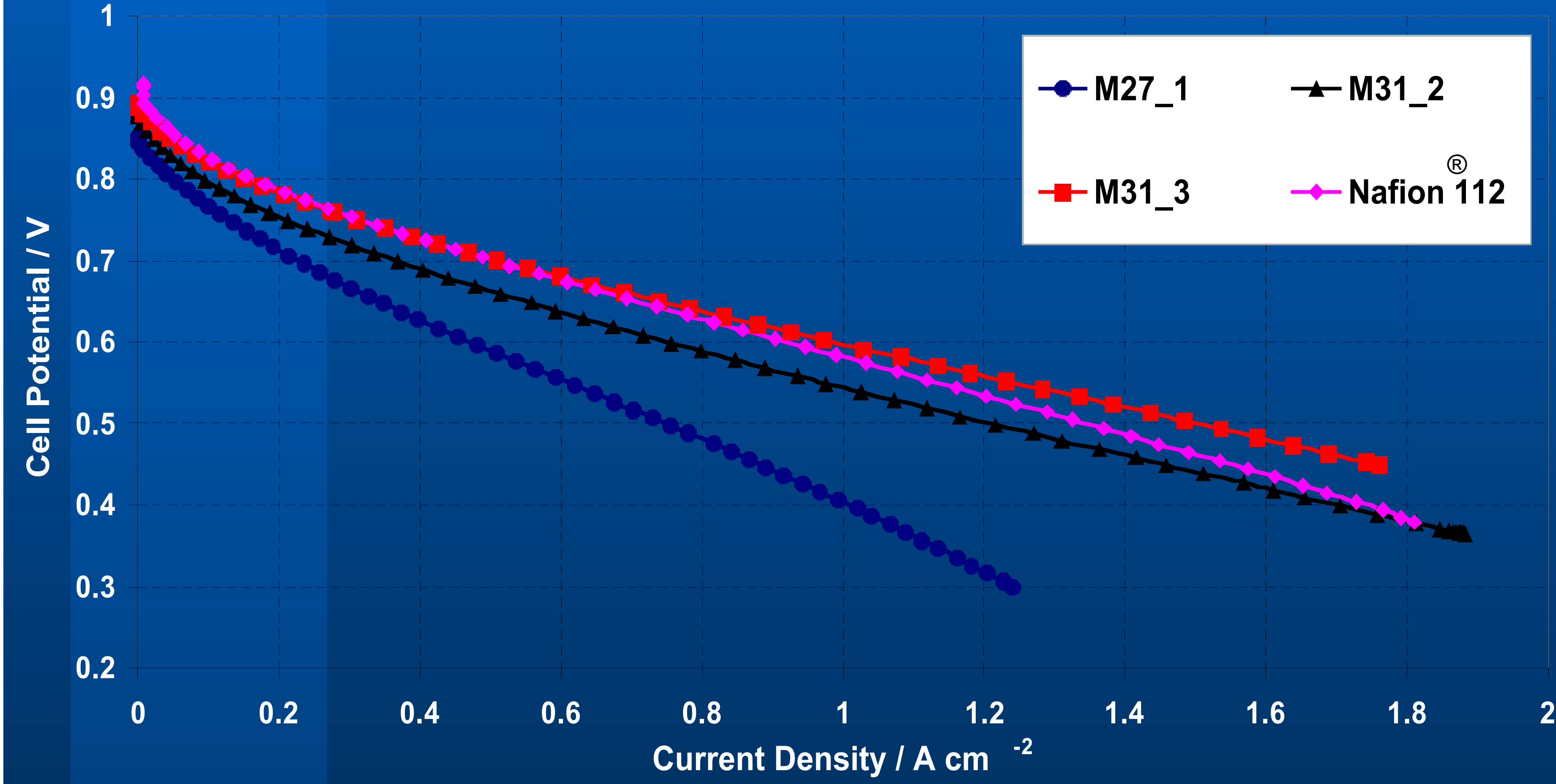
Atofina: Polarization Curves

60°C, H_2/O_2 (1.4/2.0), 0 psig



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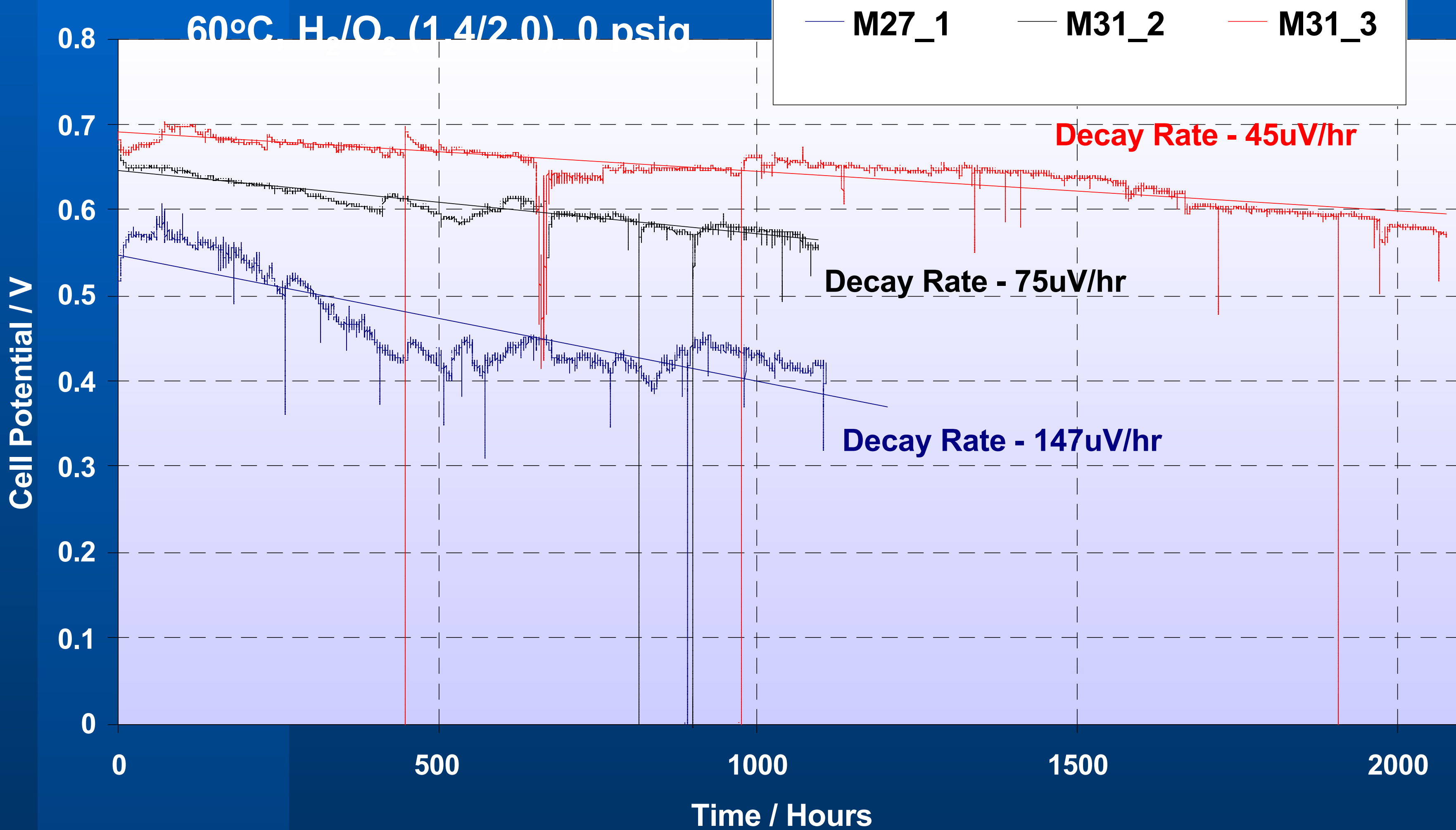
Atofina: Long Term Stability



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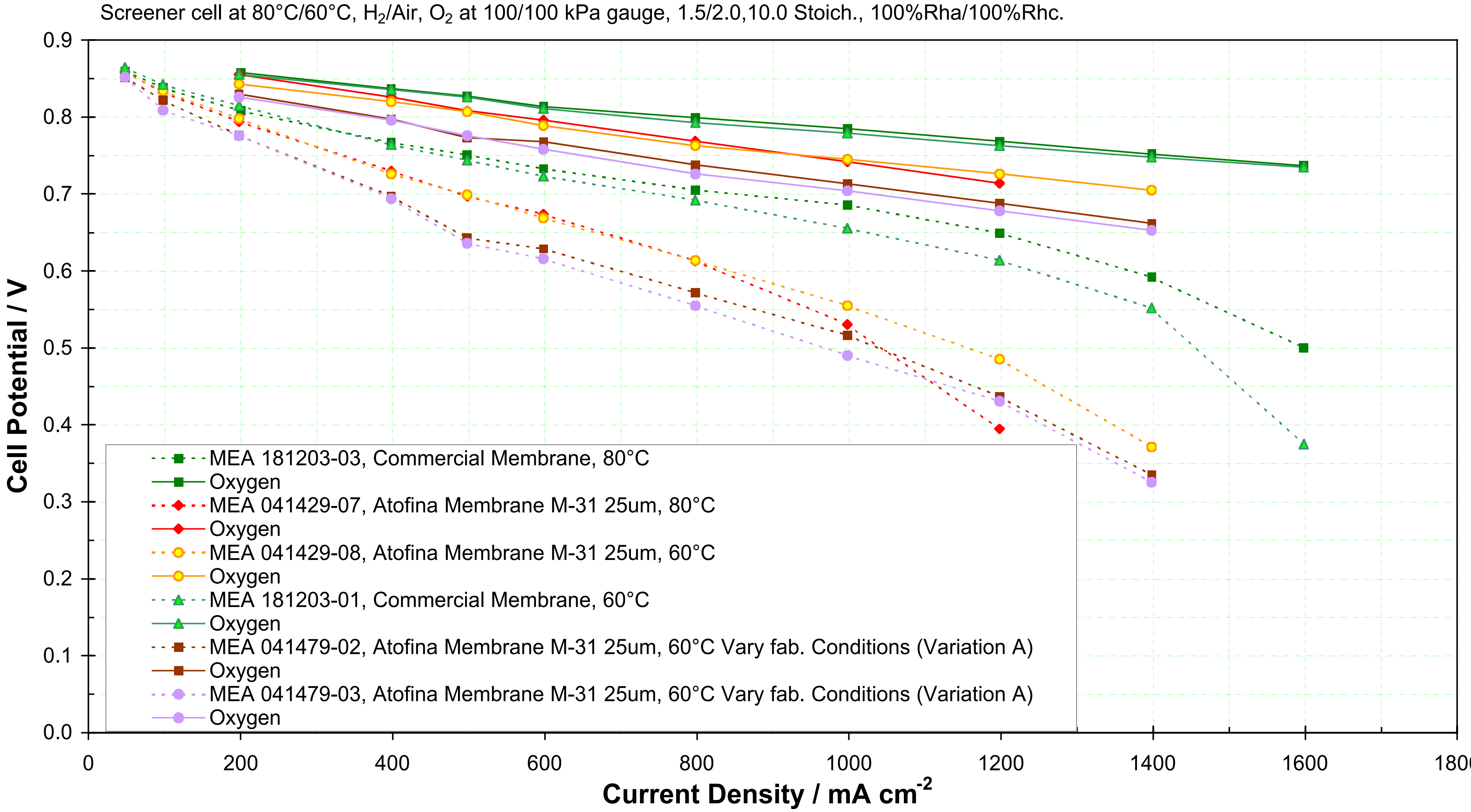
Johnson Matthey: Technical Progress

- **MEA Optimization**
  - JMFC-US test stand commissioned
  - Validation runs confirm consistent results with JMFC-UK
  - Cell temperature evaluation started (80^{o}C & 60^{o}C)
    - Similar performance at both temperatures
    - Less flooding at higher current density with lower temp.
    - 4x longer conditioning at lower temp.
  - First MEA variant made & tested with Atofina membrane
  - High OCV and H_2 permeation resistance observed
    - Lower electrochemical performance compared to standard MEA fabrication conditions
  - Significant drop in electrical resistance noted for most Atofina membrane based MEAs

Johnson Matthey: Temperature & Fabrication Modifications



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Future Work

- **Membrane development**
  - Improve resistance to shorting
    - Kynar® chemistry
    - Polyelectrolyte chemistry
  - Improve water management
  - Continue long term testing
  - Process scale up

- **MEA optimization for Atofina membranes**
  - Evaluation of cell conditions (e.g. temperature, RH, pressure)
  - Optimization of MEA fabrication to gain full membrane performance (e.g. fabrication parameters, GDL, catalyst)

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