Development of High Temperature Membrane and Electrode Assembly for Proton Exchange Membrane Fuel Cell Device

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U. Of Connecticut (UConn) Subcontract

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Objectives

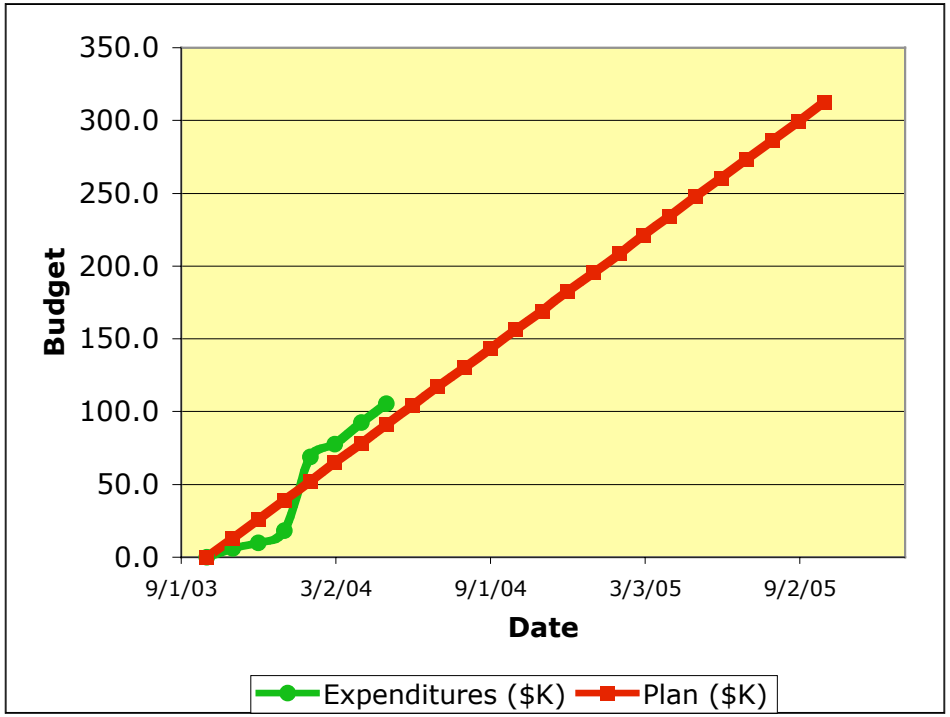
- Overall: Develop MEAs to Operate PEMFC at 120^{o}C

- Ist Six Months: Materials & Processing Development
  - Develop novel polymer blends for 120^{o}C & low RH
  - Establish laboratory capability
  - Fabricate blends into membranes and catalyst layers

- Final 18 Months: MEA Feasibility at 120^{o}C & low RH
  - Characterize membrane resistance and strength
  - Fabricate MEAs from blends & show feasibility
  - Optimize MEA performance
  - Optimize Pt loading in MEA
  - Demonstrate MEA durability (100 hours)

Budget

- Total Funding = $312K
- DOE/Contractor = 80/20
- Funding in FY04 = $156K



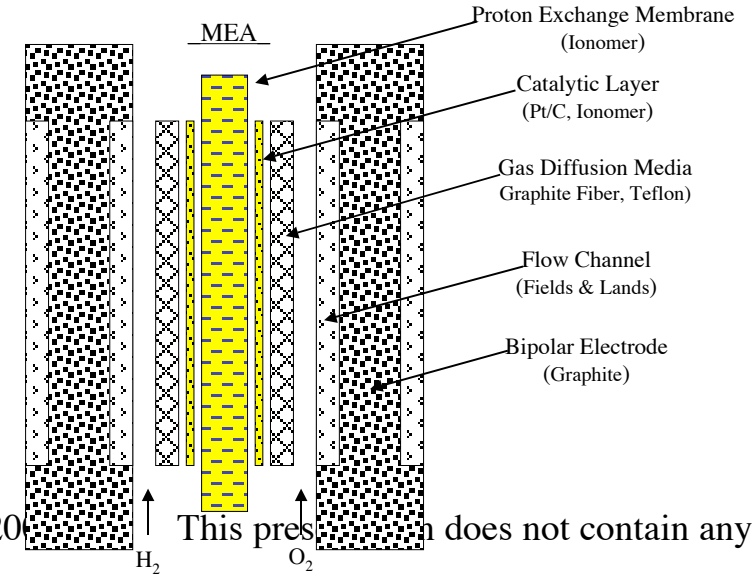
Technical Barriers and Targets

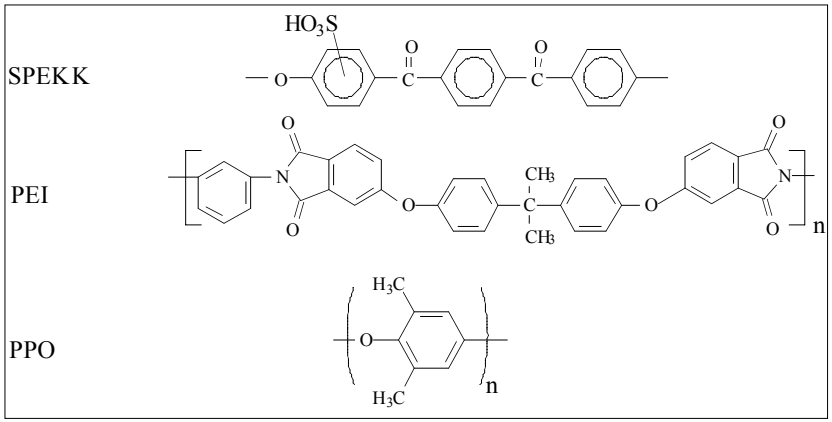
- Proton Conductivity Too Low in Ionomers at Low RH
  - Low (25-50%) Relative Humidity (RH) at 120^{o}C
  - Low RH Reduces Membrane Water Content
  - Water Needed for Grotthuis Conduction Mechanism

- Targets
  - Membrane Specific Conductance: 0.1 S/cm @ 120^{o}C, 30%RH
  - Membrane Strength: Adequate (20kPa)
  - MEA Resistance: 0.1 Ωcm^2 @ 120^{o}C, 30%RH

Technical Approach

- Replace Nafion© with Novel Polymer Blend
  - Sulfonated Poly Ether Ketone Ketone (sPEKK)
  - Complimentary Polymer (PEI, PBI, etc.) Replaces Water
- Engineer Blend Morphology to Improve Connectivity
  - Connect Isolated Ionic Domains
- Fabricate Prototype MEAs from Blend
  - Substitute Blend for Nafion in Membrane and Catalytic Layer
  - Demonstrate MEA Feasibility at Low RH



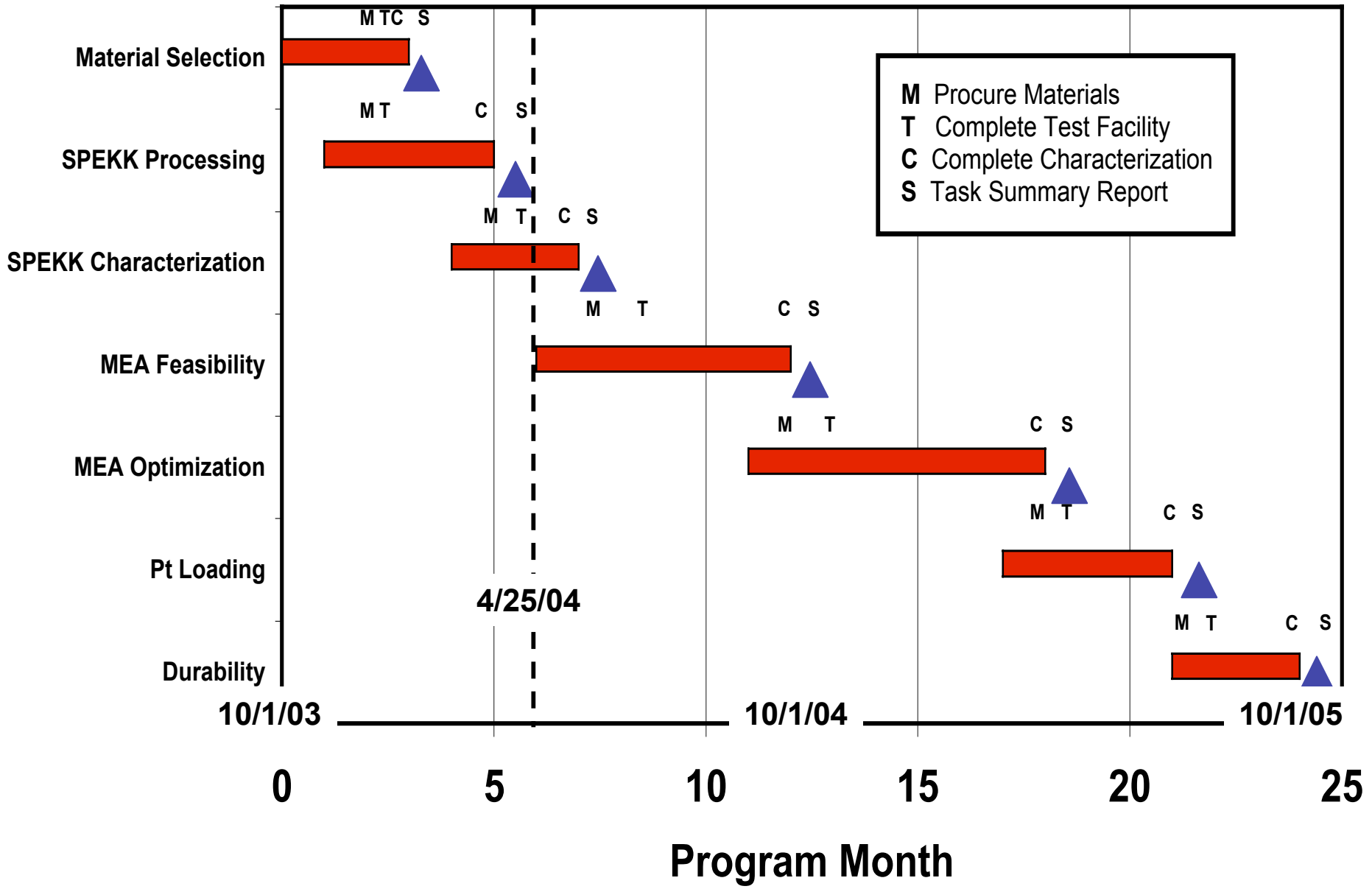


Project Safety

- **Safety Analysis**
  - **Failure Mode and Effects Analysis (FMEA)**

- **Safety Issues and Mitigations**
  - **Hydrogen Flammability**
    - **+ Area Hydrogen detector**
    - **+ Small volumes**
    - **+ Leak testing**
  - **Electrical Shock**
    - **+ Insulated 120V**
  - **Hazardous Solvents**
    - **+ Fume hood for drying**
  - **Flammable Solvents**
    - **+ Flammable solvents cabinet**

Program Tasks Milestones

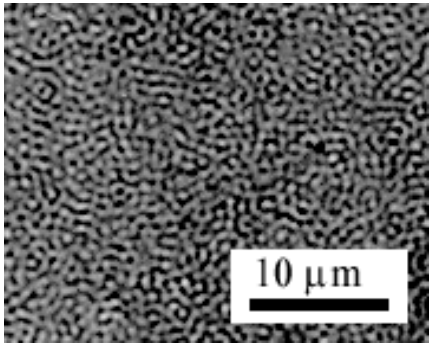


Technical Accomplishments

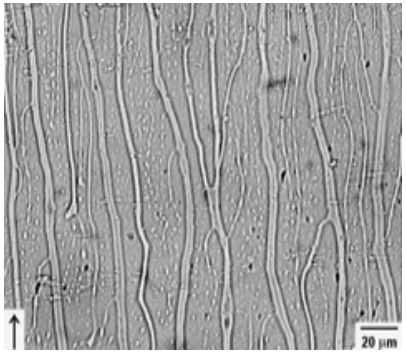
- Identified Preferred Blend (UConn) Task A
  - sPEKK & PEI
- Set up New Laboratory Capability (OPM)
  - Instron/DSC/TGA
  - Fume hood
  - Membrane conductance vs T and RH
  - Fuel cell tests stations (2)
- Trained Staff in MEA Fabrication (OPM)
  - Decal method similar to Nafion
- Demonstrated sPEKK MEA Feasibility (UConn)
  - 0.35 Ωcm^2 MEA at 80^oC

Technical Progress (UConn)

Domain Morphology

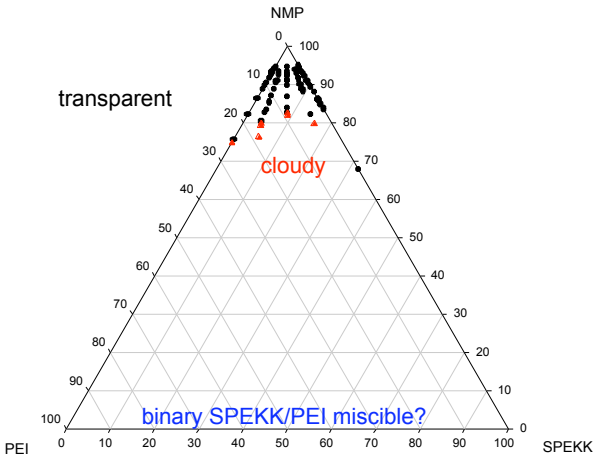


Polymer blend Spinodal morphology



EF oriented polymer morphology

sPEKK/PEI Phase Diagram



Electric Field Orientation (EFO)

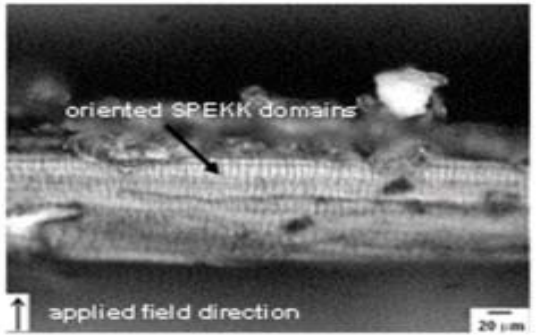


Fig. 4. 30/70 SPEKK (IEC = 1.9 meq/g)/PEI blend membrane oriented at 200°C in an electric field (1 kV/cm; f = 20 Hz) applied across the thickness of the membrane

Improved Conductance

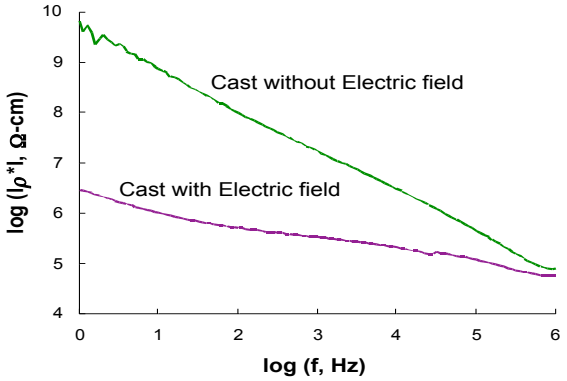


Fig. 5. Effect of EFO on the resistivity of the membrane shown in Fig. 4.

Technical Progress (OPM)

Materials Testing

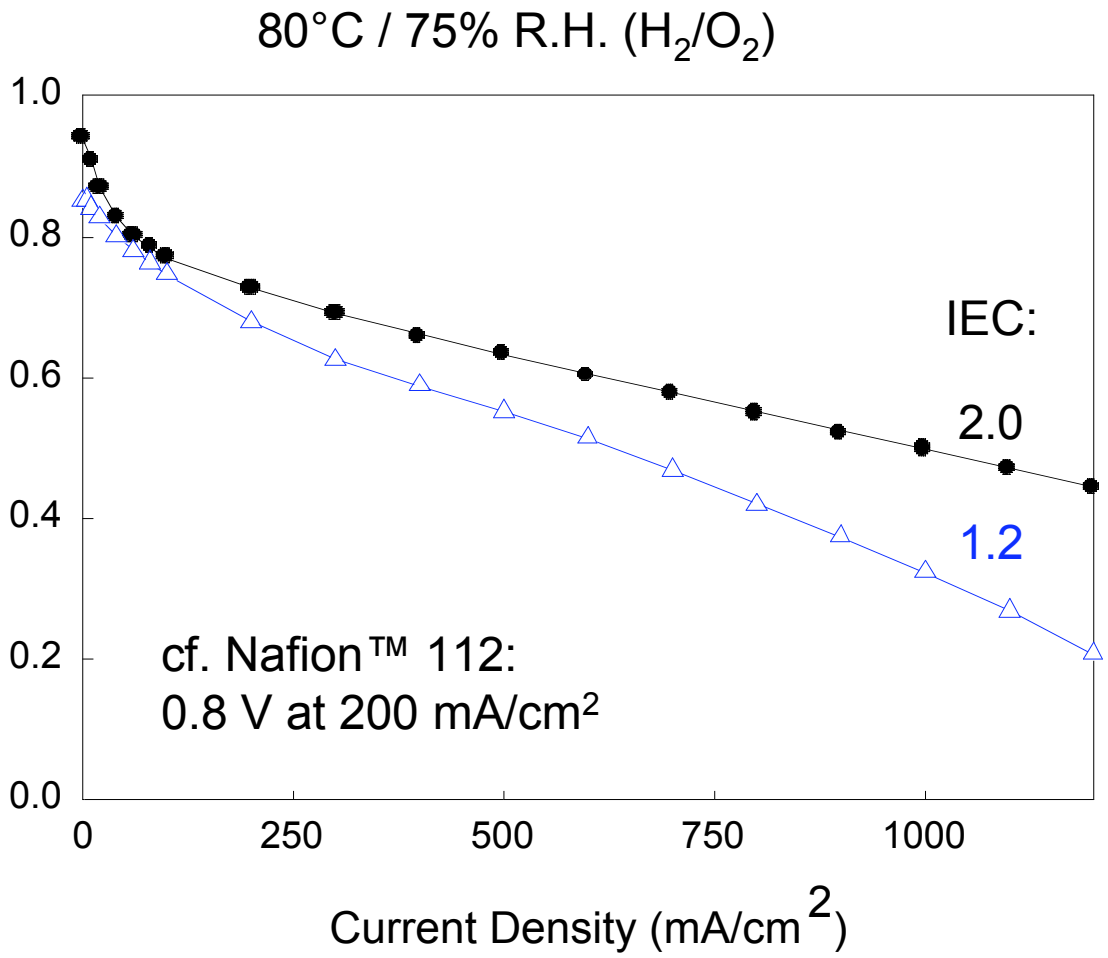
Fume Hood

Conductance vs T & RH

Fuel Cell Test Stations

Technical Progress (UConn)

sPEKK-based MEA Performance



Interactions and Collaborations

SPEKK Blend Development: UConn

- Principal Investigators
  - + Prof. Robert Weiss
  - + Prof. Monty Shaw
- Post-Docs & Grad. Students
  - + Steven Swier
  - + Jonathan Gupton
  - + Jeffery Gaza
  - + V. J. Ramani

OEM Contacts: OPM

- Honda
- GM
- Proton Energy
- FumaTech

Future Work

- FY 2004: Feasibility of sPEKK-Based MEAs
  - Measure: sPEKK Blend Conductance vs T & RH
  - Fabricate: sPEKK based MEAs
  - Feasibility: Demonstrate 3 Ωcm^2 MEA @ 120^oC

- FY 2005: Optimization of sPEKK-Based MEAs
  - Optimize: Demonstrate 3 Ωcm^2 MEA @ 120^oC
  - Pt Loading: Show effect of reduced Pt & Ru
  - Durability: <10mV/hr @ 100 hours