Lead Research and Development Activity for DOE's High Temperature, Low Relative Humidity Membrane Program

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Project ID
FC15

Overview

Timeline

- Start: April 1, 2006
- End: March 31, 2011
- 20% Complete

Budget

- Total project funding
  - DOE - $2,500K
  - Contractor - $625K
- Funding for FY06 $250K
- Funding for FY07 $500K

Barriers

- Barriers addressed
  - D. High Conductivity at Low RH & High T
  - C. High MEA Performance at Low RH & High T
  - A. Membrane and MEA durability
- Targets
  - Conductivity = 0.07 S/cm @ 80% relative humidity (RH) at room temp using alternate material – 3Q Yr 2 milestone
  - Conductivity >0.1 S/cm @ 50% RH at 120 ^{o}C – 3Q Yr 3 Go/No Go

Partners

- BekkTech LLC – In–plane conductivity protocols
- Scribner Associates – Through-plane conductivity protocols
- Project management

Objectives

- New polymeric electrolyte / phosphotungstic acid membranes
- Standardized Characterization Methodologies
  - Conductivity f(RH, T, Prep. Procedure) [Through- & In-Plane]
  - Characterize mechanical, mass transport and surface properties of membranes
  - Predict durability of membranes and MEAs fabricated from other eleven HT Low RH Membrane Programs
- Provide HTMWG members with standardized tests and methodologies (Short Courses)
- Organize HTMWG bi-annual meetings

Approach

Task 1. Non-Nafion® based Poly[perfluorosulfonic acid] - phosphotungstic acid composite membrane and membrane electrode assembly (MEA) fabrication

Task 2. Sulfonated poly(ether ketone ketone) or sulfonated poly(ether ether ketone) - Phosphotungstic Acid Composite Membrane and MEA Fabrication

Task 3. In-Plane Conductivity Measurements

Task 4. Through-Plane Conductivity Measurements

Task 5. Characterize Performance of MEAs

Task 6. Membrane and MEA Durability

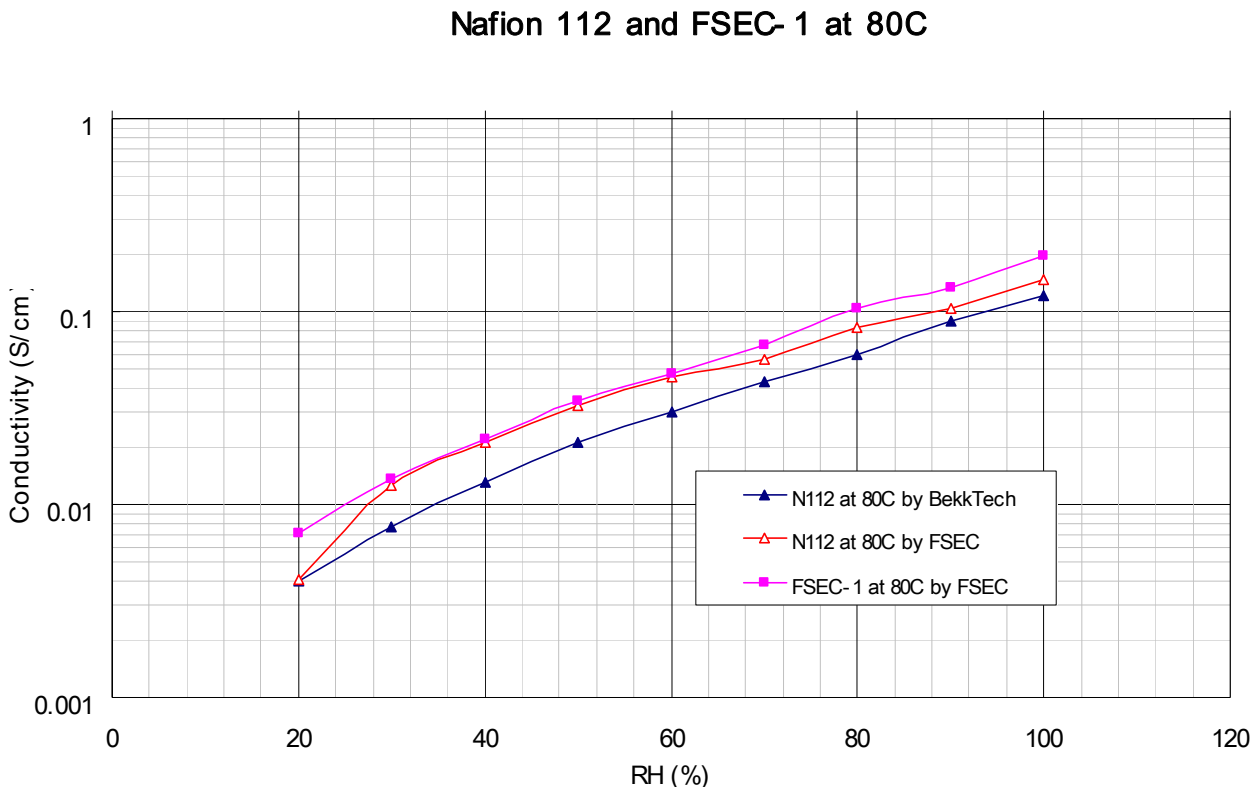
Task 7. Meetings and Activities of HTMWG

Accomplishments/ Progress/Results

- **Task 1.** PFSA low eq. wt.-Teflon®- Phosphotungstic Acid Composite Membrane and MEA Fabrication

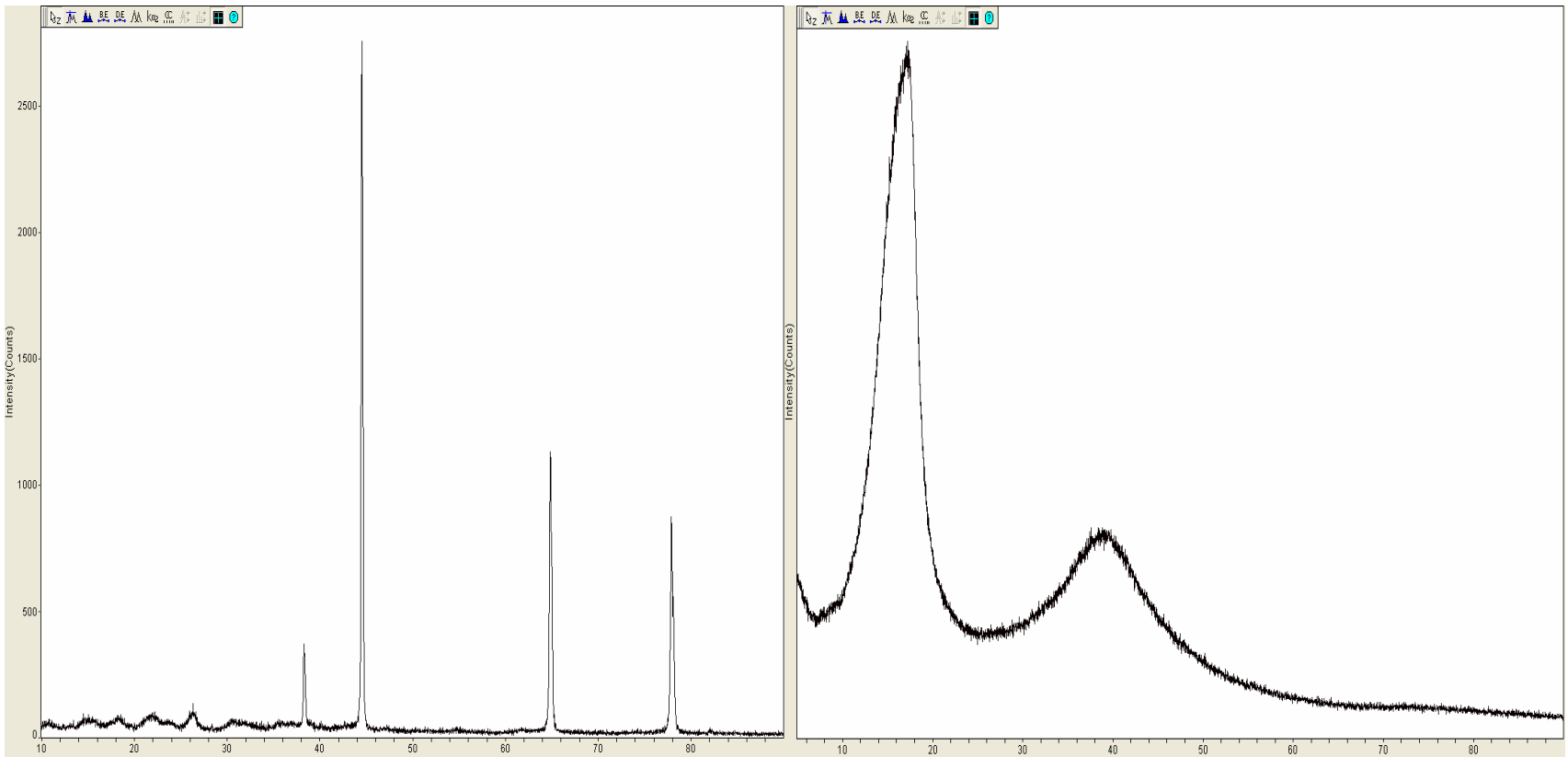
  - Fabricated and tested FSEC-1 (solved RH issue for fabrication)
  - Identified and procured alternative low equivalent weight (EW) poly[perfluorosulfonic acid] (PFSA) ionomer
  - Demonstrated process for 1100 EW, started trials on 750 EW

Accomplishments/ Progress/Results



FSEC-1 showed improvement in conductivity compared to Nafion 112

Accomplishments/ Progress/Results

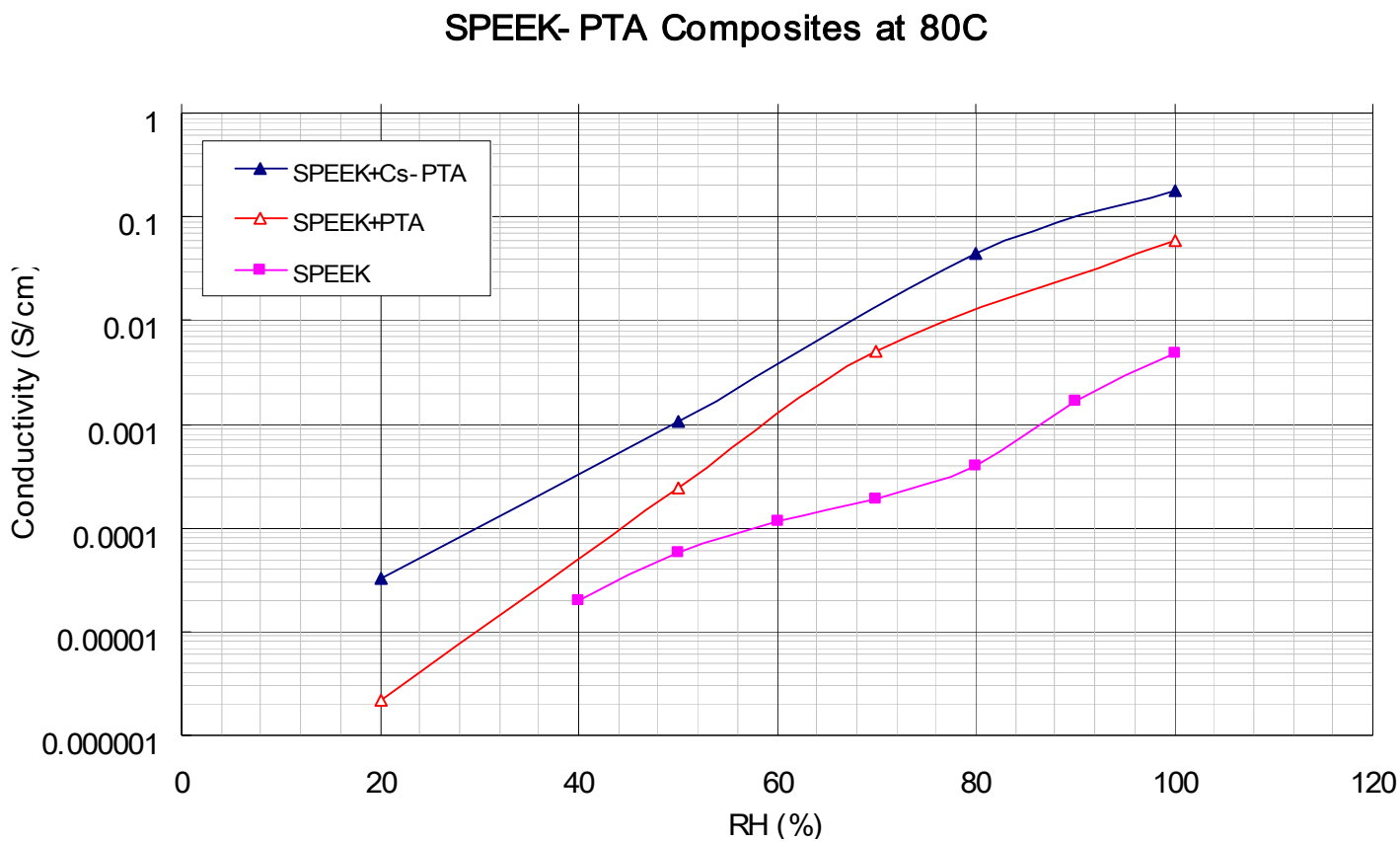


The XRD pattern of FSEC I membrane, left, exhibiting the increased crystalline nature due to incorporation of PTA in the Nafion® matrix and Nafion 112, right.

Accomplishments/ Progress/Results

- **Task 2.** SPEEK and SPEKK-based PTA Composite Membranes
  - SPEEK prepared at 30, 60, and 85% degrees of sulfonation
  - SPEKK prepared at 10, 60, and 80% degrees of sulfonation
  - Optimum ranges of sulfonation determined
  - 15% by weight PTA composites fabricated
  - Preliminary σ_{H+} vs RH data obtained (completion of Year 1 milestone)

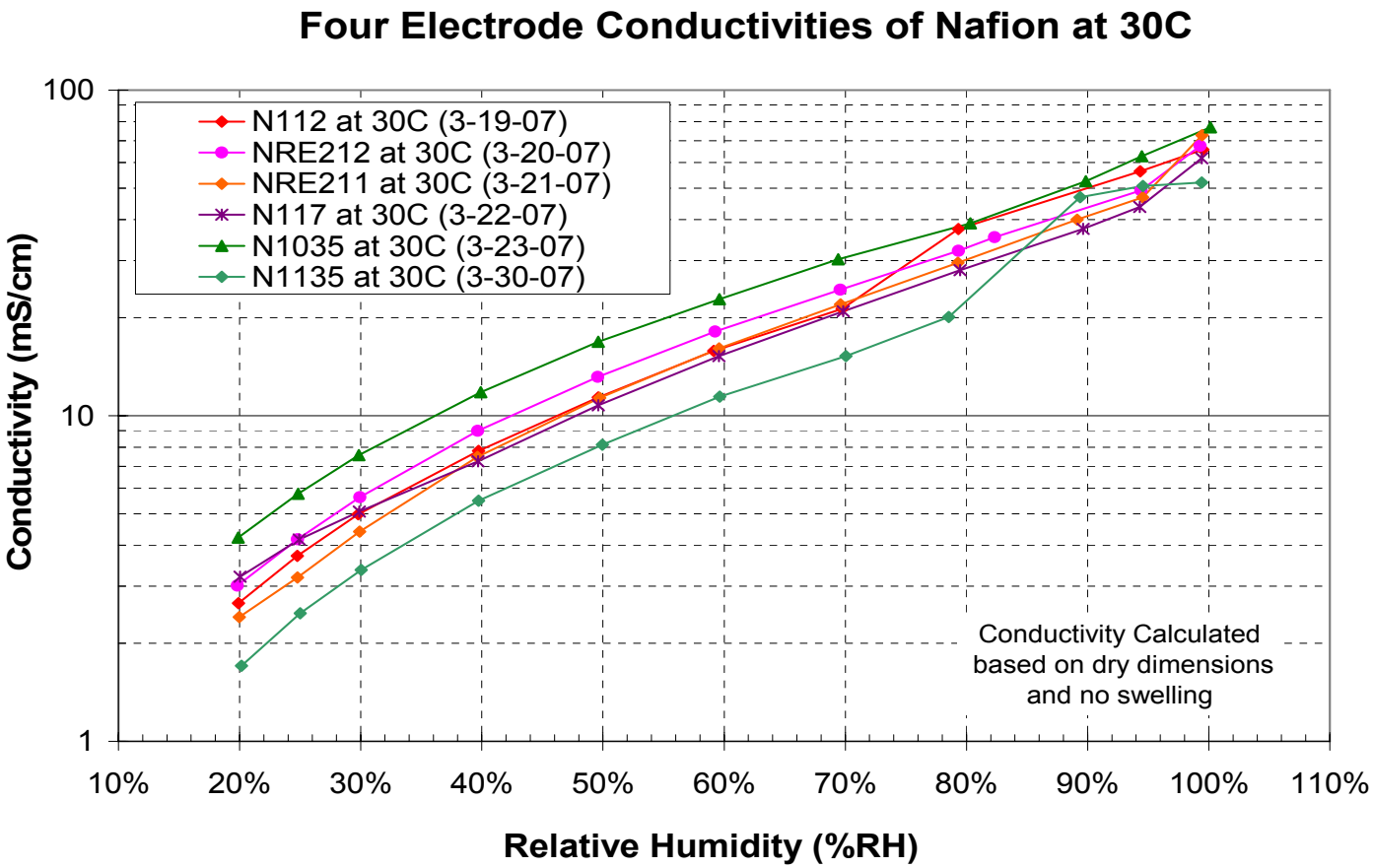
Accomplishments/ Progress/Results



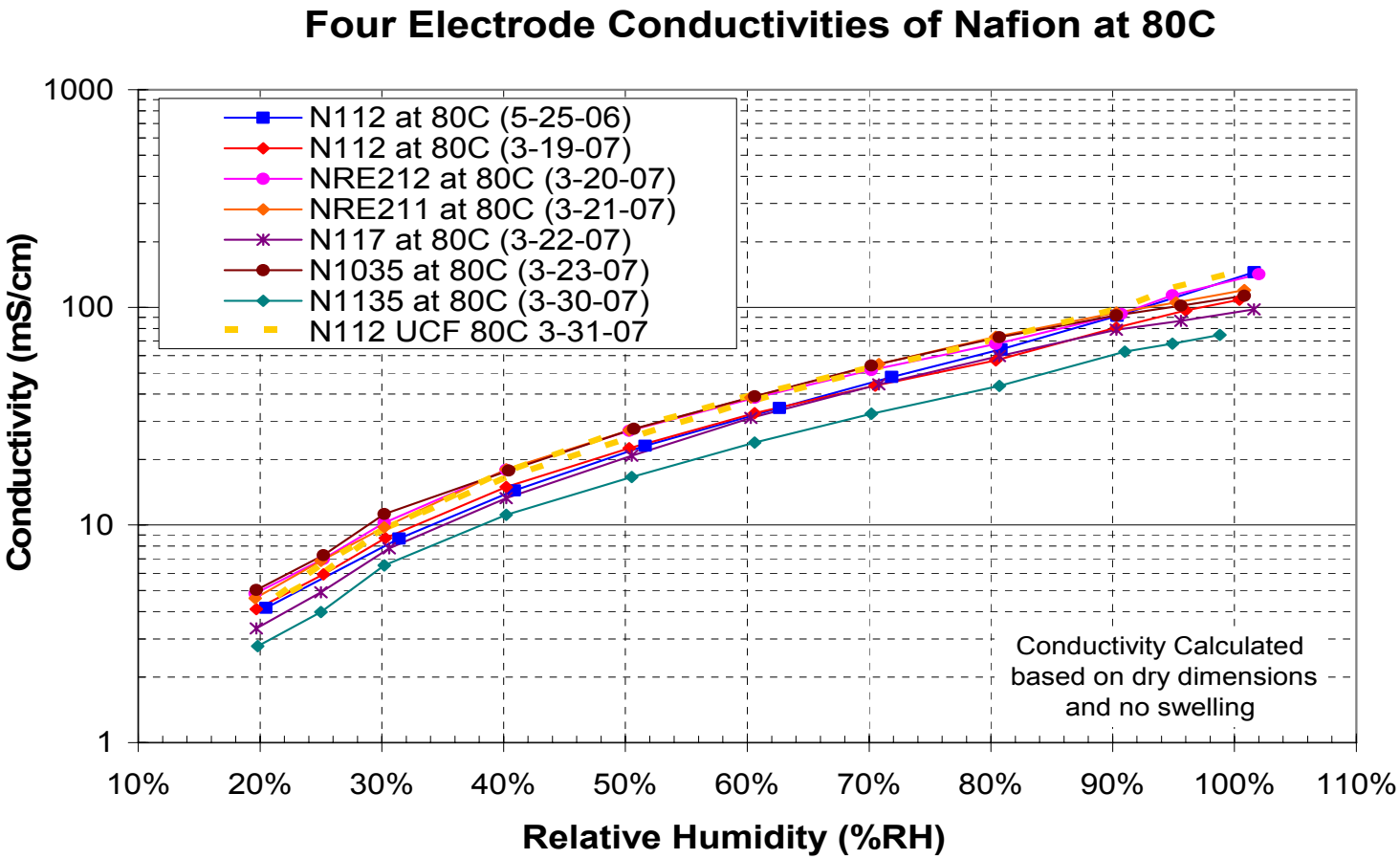
Accomplishments/ Progress/Results

- **Task 3.** In-Plane Conductivity Measurement
  - Established baseline for commercial membranes
  - Nafion® NRE-211, NRE-212, N1135, N1035, and N117 samples tested at 30 ^{o}C, 80 ^{o}C & 120 ^{o}C
  - Results compared for FSEC, BekkTech and Scribner

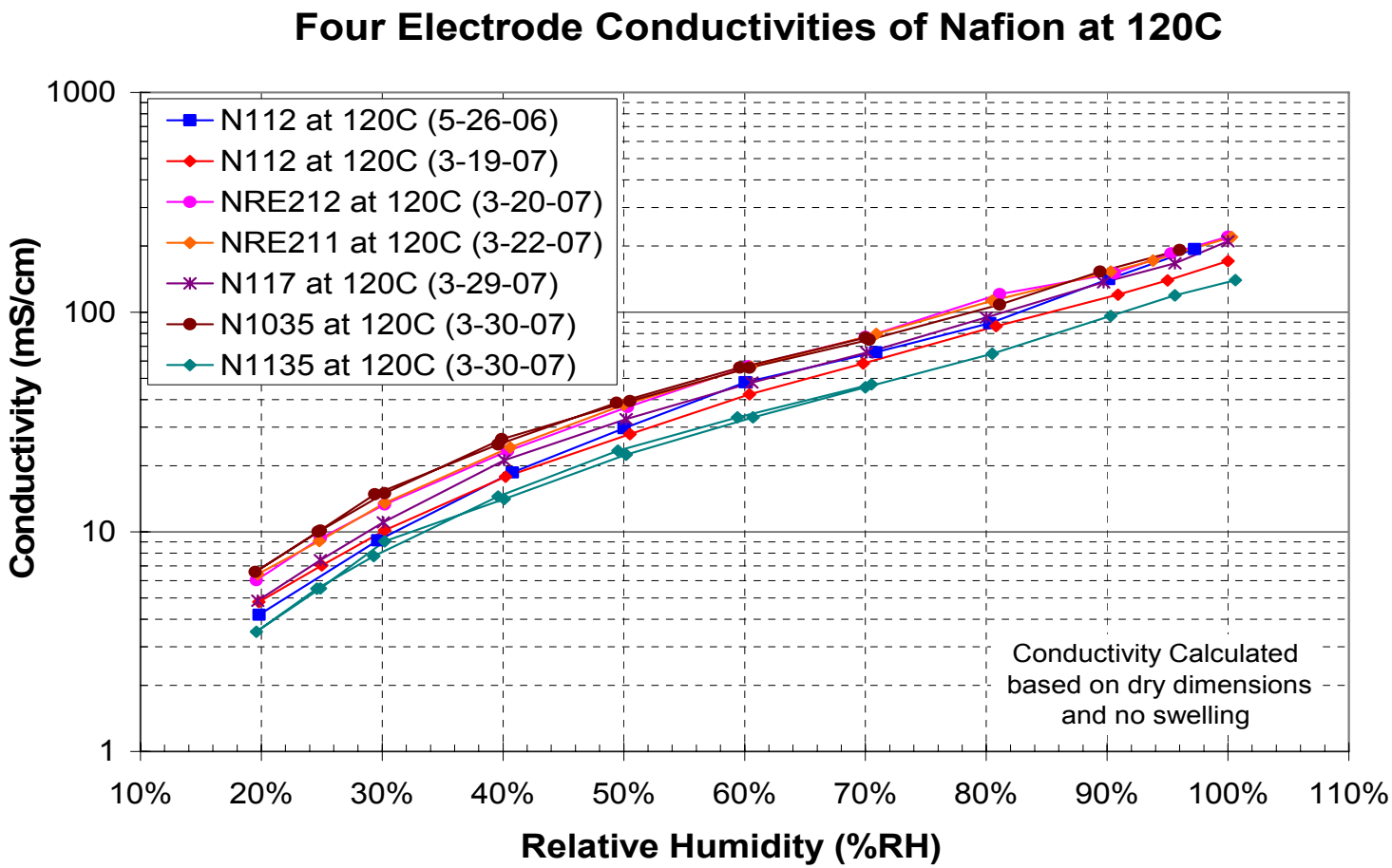
Accomplishments/ Progress/Results



Accomplishments/ Progress/Results



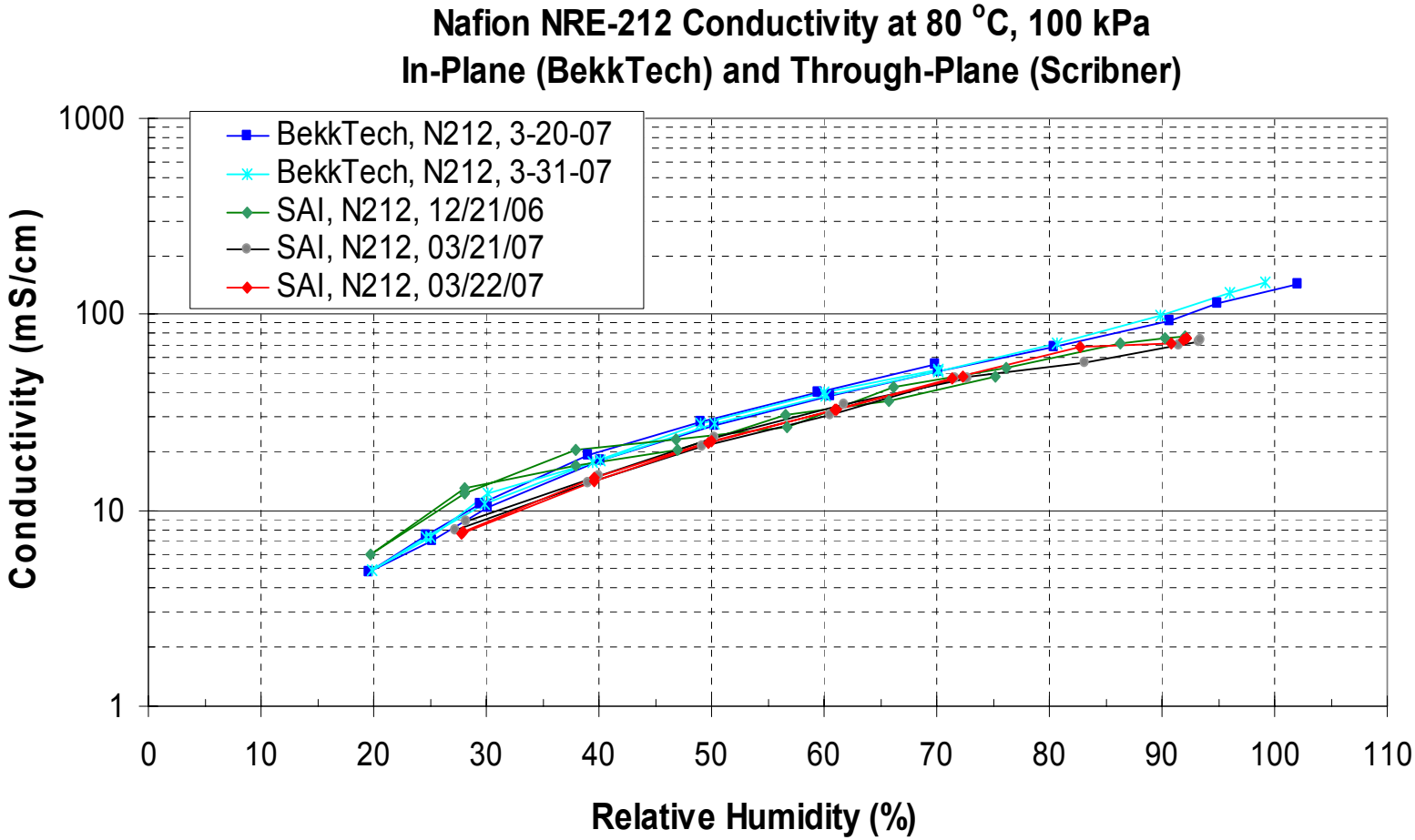
Accomplishments/ Progress/Results



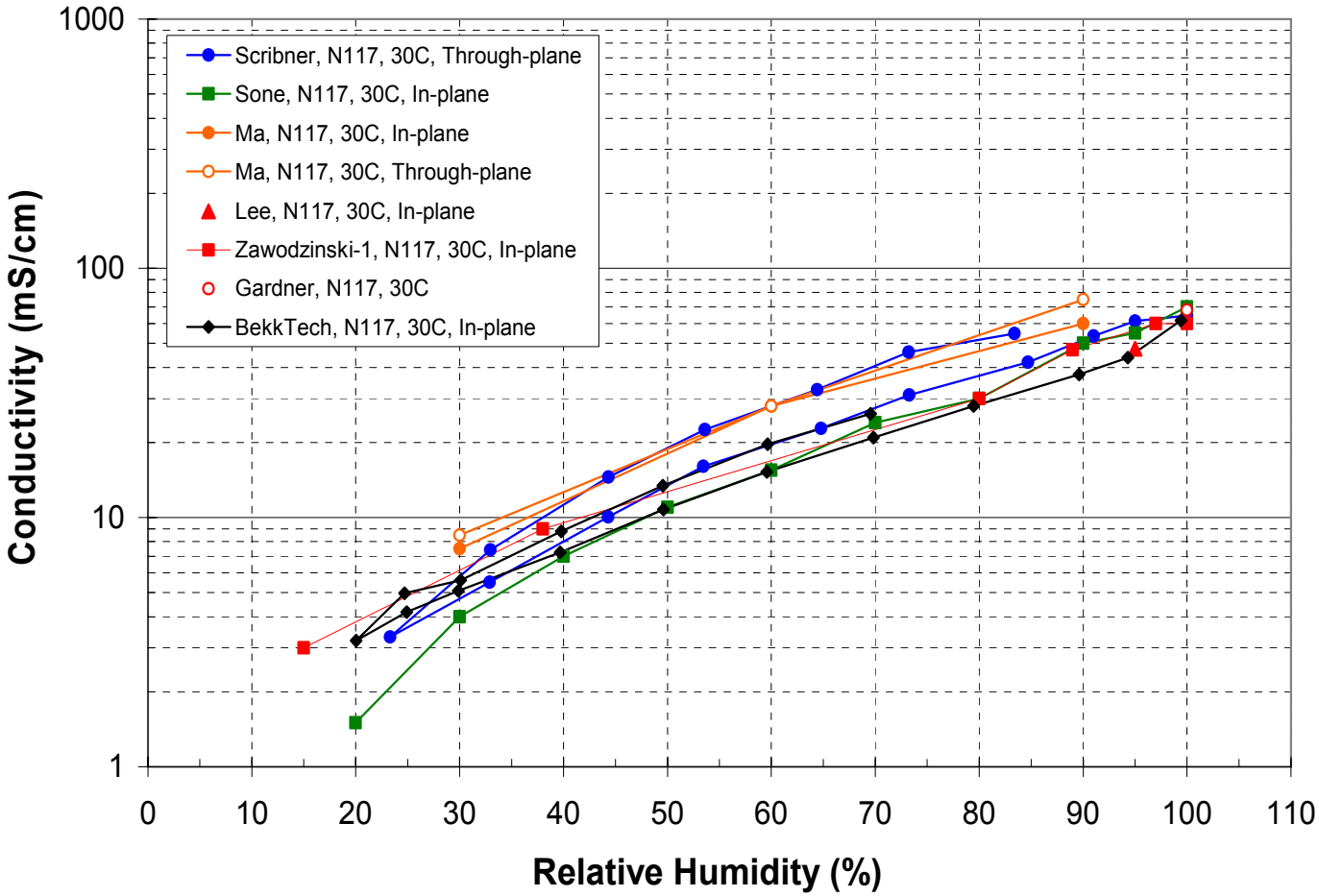
Accomplishments/ Progress/Results

- **Task 4. Through-Plane Conductivity Measurement**
  - Developed & verified performance of primary components of prototype through-thickness membrane conductivity test system, MTS (Year 1 milestone).
  - Method allows direct measurement of through-plane conductivity of bare membranes.
  - Developed MTS gas handling system for improved rapid relative humidity cycling at 30 – 120 ^{o}C.
  - Developed MTS hardware for safe high temperature, pressurized operation.
  - Gathered and compared Nafion® through-plane and in-plane conductivity (literature and BekkTech).
  - Demonstrated feasibility of using Model 850C Compact Fuel Cell Test System (Scribner Assoc. Inc.) for wet-dry gas mixing for rapid dew point and relative humidity cycling.

Accomplishments/ Progress/Results



Summary of Reported Nafion 117 Conductivity at 30 °C



Future Work

- Complete trials on 800 EW material
- Complete analysis of in-plane and through-plane conductivity of commercial membranes (late Sept. 2007)
- Complete characterization of first three membranes from Topic 1 awardees (late Dec. 2007)
- Demonstrate conductivity of 0.07 S/cm, 50% RH, 25 ^{O}C (late Dec. 2007)
- Establish MEA test protocol (June 2008)

Summary

Relevance - A new membrane material for PEM Fuel Cells with sufficiently improved conductivity at high temperature(120 ^{o}C) and low RH is required for the transportation F/C market. A new method for measuring membrane conductivities with sufficient accuracy and reliability is required for DOE program decisions.

Approach - Develop and demonstrate new materials for membranes, and define and apply new tools and procedures for membrane conductivity testing.

Tech. Accomplishments /Progress- Demonstrated ability to fabricate baseline membrane materials (Nafion®, SPEEK, and SPEKK). Demonstrated ability to test in-plane conductivity and developed method for through-plane conductivity. Again demonstrated improved conductivity due to PTA addition.

Summary

Tech. Trans. /Collaboration- Formed active partnership with BekkTech and Scribner Associates. Established formal working relationship with the HTMWG

Proposed Future - Fabricate and test new membrane formulations with low EW poly[perfluorosulfonic acid] ionomers, and new formulations of SPEEK,SPEKK. Perform conductivity test on these membranes, as well as the membranes supplied by the Task 1 members. Conductivity testing will be conducted using the new tooling and procedures that are verified in this program.