

HIGH TEMPERATURE MEMBRANE WORKING GROUP

MEETING MINUTES Wednesday, May 14, 2007 Arlington, VA (Crystal City Marriot)

The meeting was held in Arlington and was attended by 44 people. The updated agenda for the meeting is posted online at <u>www1.eere.energy.gov/hydrogenandfuelcells/pdfs/htmwg07_agenda.pdf</u>

The meeting began with a welcome from Amy Manheim, who reminded the group that their work is more than just a government grant, and that their work is one of the most important efforts that will go into realizing fuel cells for hydrogen.

John Kopasz discussed the agenda for the evening, as well as proposed targets (Fig. 1) for FreedomCar including humidity targets and evaporating points. It was noted that having both the conductivity and the resistivity targets will define the thickness. Whatever meets the durability targets, will amount to what thickness meets the targets.

0	0				
Characteristic	Units	2006 status	2005 target	2010 target	2015 target
Maximum operating temperature	°C	80	120	120	120
Area specific resistance at:					
Maximum operating temp and water partial pressures from 40 - 80 kPa 80°C and water partial pressures from	$Ohm \ cm^2$	0.03	0.02	0.02	0.02
25 - 45 KPa 30°C and water partial pressures up to	Ohm cm ²	0.03	0.02	0.02	0.02
4 kPa -20°C and water partial pressures up to 0.1 kPa	$\begin{array}{c} Ohm \ cm^2 \\ Ohm \ cm^2 \end{array}$	0.04 0.3	0.03 0.2	0.03 0.2	0.03 0.2
Oxygen cross-over ^a	mA/cm ²	5	5	2	2
Hydrogen cross-over ^a	mA/cm ²	5	5	2	2
Cost ^b	\$/m ²	15 ^c	200	20	20
Durability with cycling					
At operating temp ≤80°C	hours	~2000 ^d	2000	5000 ^e	5000 ^e
At operating temp >80°C	hours	(not avail. ^f)		2000	5000 ^e
Unassisted start from	°C	-20	-30	-40	-40
Thermal cyclability in presence of condensed water		Yes	Yes	Yes	Yes

Figure 1: New Targets Proposed for Membranes

James Fenton encouraged further dialogue on the go/no-go decision points for conductivities since they are contractual.

The agenda for this meeting was developed to provide information on the proposed universal membrane classification scheme, membrane/MEA durability test conditions, membrane conductivity, and possible networking activities with Europe via CARISMA. The following presentations are available on-line at www1.eere.energy.gov/hydrogenandfuelcells/2007_htmwg_archives.html

- Universal Membrane Classification Scheme–Mr. Kopasz
- Membrane/MEA Durability Test Conditions-Tom Benjamin
- Membrane Conductivity In-Plane Testing Procedures–Mr. Bekkedahl
- CARISMA A Networking Project for High Temperature PEMFC MEA Activities in Europe– Anca Faur Ghencia

I. Universal Membrane Classification Scheme

Mr. Kopasz described a variety of possible polymer membranes to investigate, such as hydrocarbon, fluorocarbon, inorganic, branched, comb, hyperbranched, dendritic, with additives, or polymer membranes with structural supports. His presentation focused on the problem of figuring out what avenues should be pursued, which are dead ends, and how such decisions should be made. A universal membrane classification scheme (Fig. 2) would help to accomplish the following:

- Track different types of approaches
- Determine which strategies are most fruitful
- Determine which strategies are dead ends
- Improve our understanding of proton transport
- Help maximize our return on HTM research

Mr. Kopasz implored the group to identify where their projects belonged in the classification scheme, to indicate subgroups for collaboration, to express their testing concerns, and to share input on the possible requirements. This could eliminate the need to develop individual tests for each membrane.

Conduction			Molecular approach			Additive approach				micro/nano-engineering approach							
Mechanism	Morphology		Random	Polymer	Structured Polymer		additive	anic tive Inorganic additive				support		lonomer			
			Mono Polymer	Polymer blends	Graft	Block	Self assemblying domains		8102	т102	ZrHPO4	HPA	Zeolte	Porous	Fibrous	Porous	Fibrous
Aqueous Cor																	
	Sulfonic acids																
		Fluorosulfonic acids															
		HC-Sulfonic acids															
	Hydrous Metal oxide	25															
		8102	i	i									i			i	
		TIO2															
	Sulfonyl Imides			i									i			i —	
		Fluorosulfonyi Imides						•									
Non aqueous	conduction	•															
	Inorganic oxides																
		HPAs															
		Metal Oxides															
		ZrHPO4															
	P-acids																
		Phosphoric acids															
		Phosphonic acids															
	heterocyclic bases																
		Imidazoles															
		triazoles															
		oxazoles															
	ionic liquids																
		imidazolium saits															
		quaternary ammonium saits															

Figure 2: Proposed Universal Membrane Classification Scheme

Mr. Kopasz encouraged possible recommendations for changes. One recommendation was to test membranes in an MEA to see if it fails. Another was to attach additional columns to the classification scheme to indicate a level of completion.

There were inquiries on accessing information submitted into the classification scheme, which had yet to be decided. Mr. Kopasz felt information should be made available to everyone so that every group would have a sense of what others were working on and their progress. That subject was still up to debate though. There were also questions whether it would be made public or not, which would be decided at another time.

II. Membrane/MEA Durability Test Conditions

The next presentation by Tom Benjamin focused on Membrane and MEA Accelerated Stress Test Protocols. He pointed out that accelerated stress test protocols are needed to reduce new product introduction cycle, and a lifetime estimate is needed now. The failure mode in an accelerated test must be the same as the failure mode in a "normal" operation.

Mr. Benjamin indicated that relative humidity cycling accelerates mechanical failures in the absence of electrochemical degradation. In an accelerated testing of initial fluoride release versus lifetime (Fig. 3), cycle characteristics affect degradation.



Figure 3: Accelerated Testing of Initial Fluoride Release vs. Lifetime

Mr. Benjamin explained that the mission of the U.S. Fuel Cell Council's (USFCC) Durability Task Force is to establish standardized non-application specific, accelerated test protocols to evaluate the durability of various fuel cell components. He examined the differences between USFCC's method and DOE's MEA Chemical Stability and Membrane Mechanical Cycle tests. Other notable differences included:

- USFCC Draft Protocol includes Fenton's test as an ex-situ membrane chemical stability assessment.
- USFCC Draft Protocol also includes DuPont DD-4 which is a combined (alternating) humidity and load cycle.

Mr. Benjamin pointed out that the accelerated stress test protocols have not been generally correlated with actual life under "normal" operating conditions. The protocols are test cycles only. Conditioning procedures and analysis techniques are not described. Membranes other than PFSA may need different cycles.

According to the DOE solicitation entitled, "High Temperature, Low Relative Humidity, Polymer-Type Membranes (DE-PS36-GO95020)," applicants should also show that the material can be expected to meet durability targets in the aggressive environment of a fuel cell, i.e., the material must have good chemical stability and be resistant to oxidation by peroxide. Additionally the material must demonstrate the ability to meet the cost and durability targets in the aggressive environment of the fuel cell, and have good mechanical and chemical stability under highly oxidizing conditions per the Funding Opportunity entitled, "Research and Development of Fuel Cell Technology for the Hydrogen Economy (DE-PS36-06GO96017)."

Since many group members were not MEA experts, there was a question about not going to higher current densities with the test. Higher current densities were not used because they are dependent on the design of each cell, as well as the MEA. It is not currently possible for everyone to make an MEA which can go to higher current densities for longer periods of time.

III. Membrane Conductivity In-Plane Testing Procedures

Tim Bekkedahl of BekkTech tested the following samples:

•	N112	•	N117
•	NRE212	•	N1035
•	NRE211	•	N1135

The testing procedures sample preparation used a sample that was cut to approximately 3mm x 20mm and assembled into the BekkTech Conductivity Cell. The cell was then assembled into Fuel Cell Technologies fuel cell hardware. Operating conditions were controlled by the BT-512 BekkTech Membrane Conductivity Test System which includes a Keithley 2400 Sourcemeter for electrical measurements. The cell temperature was ramped to the operating temperature, and the sample was tested first at 30°C, then 80°C, then 120°C.

The testing conditions cell pressure were

- At 30° C 100kPa, ~15kPa gauge at BekkTech
- At 80° C 100kPa, ~15kPa gauge at BekkTech
- At 120°C 230kPa, ~145kPa gauge at BekkTech

Testing Conditions Relative Humidity:

- Hold for 2 hours at 70% RH
- Adjust RH as follows, holding for 15 minutes at each RH: 60%, 50%, 40%, 30%, 25%, 20%
- Adjust RH as follows, holding for 15 minutes at each RH: 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 100%
- It should be noted that 100% RH was later dropped, for it proved too difficult to accurately reach

There was a surprise for Nafion Samples at 30°C, 80°C and 120°C with N1135 at 120°C (3-30-07). It strayed from the pack in all three instances. There is no current explanation for it.

The next step for membrane conductivity in-plane testing is to perform gauge studies (with FSEC and Scribner Associates, Inc. Associates) to document the repeatability & reproducibility of in-plane conductivity testing between labs. Next, sensitivity analysis studies regarding length, width, thickness, and RH measurements will be performed with FSEC. Also, procedures will be developed for reliable measurement of sample thickness. (Currently, BekkTech is investigating tools and procedures.) Lastly, samples developed by HTMWG participants will be tested.

Feedback followed, including questions about using manufacturer's thickness for the study. Bekktech thickness was used in the study, which is an area that needs to be worked on. A variation of thickness will be included in the updated procedure across the membrane that has to be accounted for. Dr. Fenton pointed out that there will be variation in thickness depending simply on location. There will be a different thickness for a test in Florida as opposed to Colorado. It was also noted that the same results are achieved whether hydrogen or nitrogen is used in the experiments. There was a question about possible errors with consistency of the electric fields throughout the membrane. This has to do with whether the ions are traveling parallel to the sides of the membrane and perfectly perpendicular to the cross sectional area of the membrane. By having the membrane much much narrower then the distance between the center two electrodes this is guaranteed. This requirement is not really being met because the leads are about 5 mm apart and the membrane is 3mm wide. The fact is many people (including Florida) test membranes 10 mm wide and get fine results seems to indicate that this is not a very large effect.

Mr. Beckkedahl indicated that the dimension will make results look better, but swelling and length will make it look worse. The two dimensions in the cross-sectional area will look slightly worse due to swelling. Not all has been accounted for but it is still a good comparative tool from membrane to membrane to look at. It could be modeled and a correction factor can be applied.

Another physical phenomenon akin to plasticized polymers is where the plasticizer, a moldable component for reasons of interfacial surface tension, tends to migrate to the surface sometimes. Maybe the water concentration of the surface, even in equilibrium situations, is greater than the middle for membranes so the conductivity is artificially higher.

This program includes in-plane, the current focus now, and through-plane. The comparison of those two techniques is well controlled in the dimensional and relative humidity aspects, which can provide significant information. Through plane conductivity activity that Scribner Associates, Inc. is working will not be available until next year; therefore, the current focus is on in-plane.

Dr. Fenton mentioned that membranes were previously 7 ml thick and in a natural real working cell there were large amounts of water concentrations, but now membranes are only 1 ml thick, which is clearly better in ratings. Several experiments can be performed to see how membranes swell and recalibrate the lengths. After the test, the membrane can be opened to identify where the wires have made impressions. The alternative is making the electrode smaller and more sophisticated. According to Mr. Bekkedahl, an interesting project could be to model it and then apply a correction factor. In the past, the interfacial contact lengths are much smaller in lengths in the conduction mechanism so it is much more dominant by many orders of magnitude.

The experiment can be done under a certain relative humidity and then balanced with either hydrogen or nitrogen to obtain the same results. All of the tests presented were performed with hydrogen, and every sample had been tested in nitrogen. For the nitrogen tests, N112 (Fig. 4) and N117 (Fig. 5) have been tested extensively under hydrogen and nitrogen, and the same results were obtained. For these tests, the typical gas pressure was 100 kPa absolute at 30°C, which is about 115 kPa gauge; whereas, it is 230 kPa absolute at 120°C, which is 145 kPa gauge.



Figure 4: N112 at each temperature with four electrode conductivities

Figure 5: N117 at each temperature with four electrode conductivities



Nafion membranes and similar ones unfortunately undergo secondary crystallization at low temperatures, which affect the amount of water absorbed compared to boiling temperatures, which is hysteresis. Mr. Bekkedahl revealed that the results are not the same going up to 100% and coming back down compared to what was achieved going up originally because of hysteresis. Starting from 70% and sweeping down from dry to wet condition obtains lower results than compared to wet to a dry condition. Most of those differences have been equilibration constants. Some samples like to be conditioned at higher temperature and go back to a lower temperature to operate. During in-plane conductivity of Nafion-like samples, the affect of crystallization has not been observed. Once 80 °C is reached, it equilibrates quickly. The result is obtained from taking a piece of the extruded material, measuring it at 30 °C, and boiling it up because the thermal conditions changed. At 80 °C, it will change as it approaches the 100 °C conditioning temperature.

All of the data shown was for four probe conductivity calculations, but two probe were also used. The degree to which the contact makes a difference on "to pro" measurements could be introducing error with

the "to pro" measurements used. Mr. Bekkedahl indicated that the platinum dots used were not high quality catalyst so the over-potential associated are extremely high. Platinum sheets were observed too, but because of durability and cost the robust platinum dots were used. In the small current densities areas, it is a very good reading. At low local polarization without splitting water, the readings between the two are good, which is a catalyst argument.

A lot of studies have been done and there have been no problems with clamping pressure (i.e., how much screws are tightened). Adjustments may be made to define more clearly where the interface actually is to ensure that the length associated with the center platinum electrode remains unchanged.

With the incorporation time, drifts have been seen up to 6 hours compared to the 15 minutes. Mr. Bekkedahl revealed that most of the drift seen can be traced to relative humidity, especially when it has been changing. Relative humidity was either measured or a saturator was used that offers an accurate dewpoint. This provided very consistent results over periods of time, which was always bracketed by conductivity gathered from decreasing relative humidity and the conductivity resulting from the increasing relative humidity. It is always in between them. It is a cost effective way to minimize the time on tests and to bracket the delivery value. Dr. Fenton stressed the importance of controlling the relative humidity, which is simply managing the dewpoints. If this is not done, large errors of relative humidity may result. Therefore, there will be debate on whether relative humidity measurements will be required directly within the fuel cell. A protocol will be designed for existing testing.

Mr. Kopasz asked about the 30% variation between the labs, especially on how large the bracket is between heating up and cooling down. Mr. Bekkedahl answered that there is a very large difference in conductivity at 30°C as it decreases and increases in relative humidity, which depends on how fast it can equilibrate at that temperature. At 80°C and 120°C, the difference is very small in the order of 15% difference between the two. Within the Bekktech lab, it is about 25% from the highest to the lowest when accounting for all of the in-house measurement errors over the years. Among Bekktech, Scribner Associates, Inc., and Florida Solar Energy Center (FSEC), it is about 30% variation and most of it appears to be geometric difference, not relative humidity.

Graphs can be adjusted by changing the geometric dimensions. For example, two curves taken at Bekktech about ten days apart from the same sample on 212 have very good agreement; however, if they did not agree, an adjustment and argument can be made addressing the problem. A case can be made whether the error is associated with relative humidity or geometric dimensions regarding the characteristic curve for Nafion in the relative humidity region. Dr. Fenton indicated that they are working on trying to figure out whether multiple occurrences in the same spot for Nafion at 30% may be due to relative humidity error or it may be geometric. Mr. Bekkedahl reasoned that in the different curves there are activation energies which look like geometric shifts resulting from larger samples or samples with more acids. If the geometric dimensions are adjusted, then the curves would lie directly on top of each other.

A representative from Fuel Cell Energy questioned whether the large jump in conductivity appeared consistently (such as in N1135, Fig. 6) and if it was due to area control or due to the material. Mr. Bekkedahl indicated that these types of jumps only occur during 30°C, which is unexplainable. It appears that the two points (90% and 100%) continue to fall on the same line during the down sweep. It may not be due to a relative humidity shift, but possibly membrane ready-up phenomenon. At these low temperatures, it is possibly relative humidity control. There are no jumps associated with other temperatures other than the low temperatures.



Figure 6: N117 at each temperature with four electrode conductivities

According to Mr. Bekkedahl, the importance of absolute numbers between laboratories is to develop a robust protocol that would be repeatable from lab to lab. Thirty percent error does not determine what will be or not be successful. A diagnostic tool needs to be absolute. Comparative analysis can be done if it is within one lab on one machine.

Mr. Bekkedahl indicated that once the protocol is developed and tested at different facilities then the cause of hysteresis can be traced to either a system change or membrane change. In the same system at BekkTech with different samples, there were changes in hysteresis, which indicates a sample effect. Mr. Bekkedahl also believes there is a system effect on hysteresis. A system with porous graphite plates versus a system with smooth aluminum plates may have different effects on the hysteresis. Although this effect is not desired, there are interesting results when looking at membrane hysteresis and rate of water absorption. It may be an advantage to understand the properties of humidity-related hysteresis when going up and down in order to control it.

Dr. Fenton mentioned that Mr. Bekkedahl showed conductivity measurements as a function of time, for example, N117 absorbs more water due to its larger volume and is also slower compared to N112, which are visible in the measurements. The argument would be if one has reached a true steady state. Mr. Bekkedahl does bracketing by going down and up where the answer is in the middle. Depending on the membrane, there is the ability to adjust based on level of reproducibility. According to Mr. Bekkedahl, the goal of this procedure is to eliminate the equilibration time by obtaining as close to equilibrium measurement at the shortest amount of time than to study it. Equilibration time may be a function of the diffusion coefficient because it varies between polymers.

Taking a look at the kinetics of absorption for thinner membranes, it is difficult to change the range of Pascal timescale that the membrane responds significantly slow for Nafion. Within a chamber of five seconds, Nafion must be 20 mm thick to get a reasonable kinetic study. It is difficult to change the relative humidity fast enough for the membrane response is slow in comparison.

BekkTech has tested many membranes other than Nafion but the information is not yet public. There is a lot of data available from the High Temperature Membrane Program from two year ago that is publicly available.

Regarding relative versus absolute measurements, it would be valuable for laboratories to directly compare their measurements on their own material to a mis-qualified Nafion-based standard material that everyone could have access to and not rely on isolated numbers. Mr. Bekkedahl hoped his data becomes the standard especially since the samples are commercially available and could be tested in any laboratory. Once a robust procedure is formulated, the measurements should be comparable. If it is not, then there needs to be discussion on the results, which could be due to a longer or shorter test and the type of sample. The relative numbers will be critical. Since Nafion has hysteresis effect, the goal should be to develop a protocol to eliminate it, which could be replicated at any lab to get the same results.

For instance, glassy polymer and rubbery polymer have different rates of diffusion and equilibrium. As an example, glassy polymer takes more than 2 hours to equilibrium and the Nafion is very quick. Since equilibrium time is a significant variable, the advantage is going down below the equilibrium to a drier condition so when returning to it the data is off-based from the equilibrium coming from the opposite direction, thus allowing one to bracket the equilibrium quickly rather than waiting for 2 hours or more to achieve the absolute equilibrium by going down to a drier condition and coming back up. While following the protocol, equilibrium may be reached when values level off. The equilibrium is always between the down and up sweeps. The intent of the protocol is to allow testing for all different kind of samples, not just Nafion. BekkTech welcomes ideal samples for 8 hours a day, 3 day long tests to hit equilibrium.

The larger gap in the relative humidity at 90% versus 30 % means the activation energy is higher at 90%. Looking at the activation energy at different concentrations for protons in water, the higher proton conductivity indicates higher activation energy, which means something else is happening. According to Mr. Bekkedahl, the focus is not to analyze the cost/benefits of Nafion, but to utilize it as a standard for protocols. If everyone is measuring about 15-20%, then it is successful. Further, FSEC is studying the sources of errors in the sensitivity analysis. If there is a difference from sample to sample, it is probably in the equivalent lengths or acid concentration, which FSEC will take into account. If there is sample-to-sample variation within the statistical error, then it is acceptable. It was suggested to prepare numerous standard samples and measure them fully hydrated at one temperature and distributing the standards to other laboratories so they can normalize to the standard samples for absolute versus relative.

Since BekkTech, Scribner Associates, Inc., and FSEC identified weak aspects of protocol, a new generation of the protocol will be developed and sent around to numerous laboratories for round robin testing of the samples. The goal is to look at characteristics of samples and obtain reliable valuables. The physical measurements are what are acceptable. The relative humidity and chemistry are difficult to gauge, so the laboratory would have to rely on their own judgment.

IV. CARISMA

Anca Faur Ghenciu presented on the <u>C</u>oordination <u>A</u>ction for <u>R</u>esearch on <u>I</u>ntermediate and High Temperature <u>S</u>pecialized <u>M</u>embrane Electrode <u>A</u>ssemblies (CARISMA), a networking project for high temperature polymer electrolytic membrane fuel cell (PEMFC) membrane electrode assembly (MEA) activities in Europe. CARISMA was initiated from the European Union's Autobrane (<u>automotive</u> mem<u>brane</u>) Project Structure, which works towards membranes for automobile applications and is made up of 30 contractors consisting of 17 industrial partners, 6 universities, and 7 research institutes. The goal is to network activities in membranes, catalysts, GDL/MEA, stack/validation, etc... with crosscutting activities in durability, deprivation, and proton transfer. The key to the Autobrane program is to reach the 100°C automotive temperature for MEAs.

Although the group is rooted in technical targets, CARISMA networks (funded) research activities in Europe on high temperature membrane electrode assemblies and components. Coordination activities are centered about membranes, catalysts, and high temperature MEAs with cross-cutting activities on high temperature durability/degradation of MEA components, identification of H+ transfer mechanisms in low free conditions, and technical specifications for high temperature PEMFC applications. CARISMA assembles expertise in high temperature PEMFC in European research institutes universities and include committed stakeholders from subject matter experts; industrial developers of high temperature MEAs, membranes, catalysts, gas diffusion layers, carbon supports; as well as end users of high temperature MEAs/stacks. The group also interacts with the Hydrogen and Fuel Cells Platform to refine the Research Agenda (SRA) and facilitate interaction with equivalent groups in other continents. CARISMA would like to establish a sustainable mechanism for continuing networking/coordination action after the project is complete.

CARISMA is structured into nine workpackages (Fig. 7) with specific deliverables (Fig. 8) and project activities. There is a management forum interlinking the projects to the Hydrogen and Fuel Cells Platform as well as the International Cooperation, which links CARISMA to other countries and networks. CARISMA recently submitted application for an IPHE Collaborative Project endorsement in March 2007.

Projects interact within Europe via workshops, which are held for each of the workpackages (e.g., Catalyst workshop in Paris, France on May 15th and 16th; Tools and methodologies for aging and degradation studies workshop in Grenoble, France on July 5th and 6th; Fundamental and applied aspects of PEM FC membranes workshop for fuel cell membranes during November 12th to 14th). In addition, an International Conference on Materials for high temperature MEA will be held in September 2008. Other activities include an International Symposia and special journal editions resulting from the workshops and International Conference. Current networking activities are available on http://carismanetwork.eu.



Figure 7: CARISMA Workpackage Structure

Deliverable	Deliverable title	Delivery date/ Month	Nature	Dissem. level ²	
DM1	Activity and management reports, financial statements etc, year 1	12	R	со	
DM2	Activity and management reports, financial statements etc, year 2	24	R	co	R = Report
DM3	Project presentation material	6	0	PU	P = Prototype
DM4	Report on raising public participation and awareness (obligatory deliverable)	24	R	RE	D = Demonstrator O = Other
DM5	Input to and refinement of SRA	18	R	RE	
DM6	Final plan for using and disseminating knowledge (obligatory deliverable)	24	R	RE	Dissemination level codes:
DM7	Links established with HT membrane/MEA working group in the US and other third countries	From month 4	o	RE	PU = Public
DC1	Kick-off workshop on high temperature membranes	3	0	co	programme participants (including
DC2	Summary report on enhancing stability of Pt catalysts at high temperature and opportunities for stabilisation of non- noble catalysts	18	R	со	the Commission Services). RE = Restricted to a group specified by the consortium (including the Commission Constriance)
DC3	International conference on high temperature MEAs	12	0	RE	CO = Confidential, only for
DC4	Summary report on impact of high temperature operation on MEA component degradation	24	R	со	members of the consortium (including the Commission Services).
DC5	Communication to MEA conference on proton conduction mechanisms in low RH environment	12	o	RE	
DC6	Sets of materials properties specifications for transport and stationary applications	12	R	RE	

Figure 8: CARISMA Workpackage Deliverables

Based on the similarity of the structures of the CARISMA and US Department of Energy's HTMWG, there may be possible joint coordination activities, such as the following:

- Joint hospitality suites at US conferences/ seminars
 - o FC Seminar San Antonio, TX (October 15-19, 2007)
 - o American Chemical Society
 - American Institute of Chemical Engineers
- Use HTMWGs and other meetings (Gordon Conference on Fuel Cells) as opportunities to promote further interactions Europe/ USA / IPHE in the field of HT PEM FC/ MEA and components
- Joint sessions in special editions of fuel cells journals (in Europe and USA) 2008
- Dedicated CARISMA event to further promote International Coordination Action

V. Next Meeting

The next High Temperature Membrane Working Group meeting will coincide with the Electrochemical Society meeting in October 2007. The Electrochemical Society will hold their PEM FC Symposium that month during which 300 papers will be presented.