Results of FETC Pre-Workshop Survey

Douglas F. Gyorke (E-mail: gyorke@fetc.doe.gov)
Federal Energy Technology Center
P.O. Box 10940, 626 Cochrans Mill Road
Pittsburgh, PA 15236-0940

This survey was prepared to focus discussion at the Fuel Cell Advanced Research and Technology Development (AR&TD) Workshop, to be held on August 28, 1997, in conjunction with the 1997 Fuel Cell Program Review Meeting, August 26-28, 1997, at the Federal Energy Technology Center (FETC) facilities in Morgantown, West Virginia.

The survey included separate sections for molten carbonate and solid oxide fuel cells and was sent to 40 representatives of the fuel-cell community as selected by the project managers of fuel cell cooperative agreements at FETC.

Twenty-one responses were received: 17 responses to the molten carbonate section and 15 responses to the solid oxide section (many individuals responded to both sections). The number associated with each research topic below indicates the average priority assigned the research topic, according to the following scale:

Low Priority ← **→ High Priority**
1..........2..........3..........4..........5

Each topic area in the survey also provided the opportunity for respondents to suggest other research topics and to offer comments. All the respondent-suggested research topics and comments are listed below in the appropriate topic area. The responses were anonymous, but respondents indicated their relationship to the fuel-cell program. The tally of these relationships may be found at the end of each section.

A. Molten Carbonate Fuel Cells (MCFCs)

1.0 Electrodes (Anode and Cathode)

		Average Priority
1.1	Develop new electrode materials	2.88
1.2	Reduce contact resistance	4.18
1.3	Increase power density	4.19
1.4	Improve endurance	4.25
1.5	Understand physical properties and reaction mechanisms	2.25

1.6 Additional suggested topics related to electrodes:
- Improve cathode strength (3 responses)
- Mechanical strength
- Reduce anode creep
- Creep-resistant cathode
- No new electrode materials are necessary. We need to understand how their mean pore sizes affect the carbonate inventory, etc.
- Internal reforming kinetics and relationship to electrolyte contact
- 1.1, 1.2, and 1.5 connected with improved S tolerance; low cost important!

2.0 Electrolyte

		Average Priority
2.1	Develop alternative electrolytes	3.73
2.2	Improve understanding of migration phenomena	4.06
2.3	Improve reactivity	3.00
2.4	Lower/higher operating temperatures	3.47
2.5	Understand physical properties and reaction mechanisms	2.93

2.6 Additional suggested topics related to electrolytes:
- Understand wetting of oxide surface by carbonate and means to minimize (2 responses)
- Wetting of electrolyte on various materials (wetting angle)
- How wetting and contact angles change with time and gas composition/gas conversions
- Improve understanding of electrolyte role in high voltage dielectric breakdown
- Lower ohmic losses
- Understand and reduce migration
- Alternate support materials

Note: a number of responses indicated that 2.2 above should include segregation in addition to migration.

3.0 Separator Plate/Wet Seal

		Average Priority
3.1	Develop improved aluminization methods to reduce cost and/or improve endurance	3.19
3.2	Develop alternatives to aluminized coating	3.44
3.3	Develop new separator plate materials	3.31
3.4	Develop new high-temperature wet-proofing materials	3.38

3.5 Additional suggested topics related to the separator plate or wet seal:
- Reduce cost of nickel-clad SS
- Develop a low-cost nickel-clad bipolar plate/anode current collector

4.0 Other

		Average Priority
4.1	Develop new processes to reduce manufacturing cost	4.06

What is the most important fuel cell system component for cost reduction?

- Balance of plant (2 responses)
- Inverter
- System piping
- Separator/Bipolar plate (6 responses)
- Current collector (2 responses; one added "takes up space/produces no power")
- Reducing number of SS layers and the contact IR

4.2	Develop standards for accelerated testing	3.12
4.3	Develop procedures for non-destructive testing	2.88

4.4 Additional suggested topics for MCFC Advanced Research:

- Higher cross-pressure tolerance in electrolyte, wet seals, and manifold
- Develop means to minimize electrolyte migration and loss from MCFC
- Understand mechanism of phase transformation and particle growth of matrix
- Approach to fuel processing: external vs. internal; ability to use multiple fuels
- Protection of anode current collector with nickel
- Distributed manifold and other advanced stack configurations
- Impacts of cycling temperatures

Comments:

- Once stack durability and reliability are ensured (doing this should be a high priority) then reducing the decay rate by reducing SS layers becomes important economically. This will require component design and perhaps material changes.
- Stack life and cost are the critical issues!

The primary relationships of the MCFC respondents to the DOE Fuel Cell Program are:

8	Fuel Cell Developers
3	AR&TD Researchers
1	Fuel cell component supplier
1	Other sponsor of fuel cell research
4	Other: One retired developer/funder and three consultants for sponsors or developers

B. Solid Oxide Fuel Cells (SOFCs)

1.0 Cathode (Air Electrode)

		Average Priority
1.1	Cathode-electrolyte interface characteristics	4.14
1.2	Mechanical and electrochemical properties of cathode	3.00
1.3	Alternative cathode materials	2.86
1.4	Lower cost cathode fabrication	3.73

1.5 Additional suggested topics related to the cathode:
- New electrodes for low-temperature electrolytes

2.0 Anode (Fuel Electrode)

		Average Priority
2.1	Sulfur tolerance of anode	3.38
2.2	Mechanical and electrochemical properties of anode	3.15
2.3	Alternative anode materials	2.85
2.4	Lower cost anode fabrication	3.64

2.5 Additional suggested topics related to the anode:
- New low-temperature anodes; interfacial phenomena for low temperature cells
- Anode/electrolyte interface

3.0 Electrolyte

		Average Priority
3.1	Mechanical and electrochemical stability of electrolyte	2.85
3.2	Alternative electrolyte materials	3.29
3.3	Lower cost/alternative electrolyte fabrication methods	4.07

3.4 Additional suggested topics related to the electrolyte:
- Low temperature electrolytes (2 responses)

4.0 Interconnects and Seals

		Average Priority
4.1	Mechanical and electrochemical stability of interconnect	4.21
4.2	Ceramic and/or ceramic metal seals	4.60

4.3 Additional suggested topics related to interconnects and seals:
- Metallic interconnects
- If planar, approach to separator plates

5.0 Other

		Average Priority
5.1	System scale-up	4.33
5.2	Develop materials to operate in an alternate temperature range	4.14

What temperature range?

- 500 to 600 °C
- 500 to 750 °C
- 500 to 800 °C (2 responses)
- 600 to 700 °C
- 700 °C
- 700 to 800 °C
- less than 800 °C
- about 800 °C
- planar: 800 °C; 1,000 °C for tubular

What is the most critical component that requires development for operation at these temperatures?

- Anode
- Cathode (3 responses)
- Electrodes (2 responses)
- Electrolyte (2 responses)
- Interconnect (3 responses)
- Cathode/Electrolyte Interface

5.3	Develop standards for accelerated testing	3.08
5.4	Develop procedures for non-destructive testing	3.31
5.5	Develop operational controls for load following	2.62
5.6	Evaluate the effects of pressurization	3.62
5.7	Investigate internal fuel reforming (natural gas and other fuels)	3.36
5.8	Develop lower cost cell fabrication and assembly methods	4.50
5.9	Additional suggested topics for SOFC Advanced Research:	

- SOFC Applications

Comments:

- The U.S. needs a second generation SOFC Program. The Westinghouse technology is being commercialized.
- The question on SOFC depends critically on configuration; i.e., tubular vs. planar.

The primary relationships of the SOFC respondents to the DOE Fuel Cell Program are:

6	Fuel Cell Developers
3	AR&TD Researchers
2	Other sponsors of fuel cell research
4	Other: all four provide support or consulting services for sponsors or developers