# Bacterial Cellulose Membranes

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# Objective

Development of a thermostable inexpensive proton conductive polymer membrane suitable for use in a polymer electrolyte membrane fuel cell.

# Principle Requirements

*(1)Thermal stability (operating at >120$^{o}$C)*

- Facilitates stack and system management
- Increases CO tolerance of catalyst layer
- Improves electrode kinetics
- minimizes catalyst cost

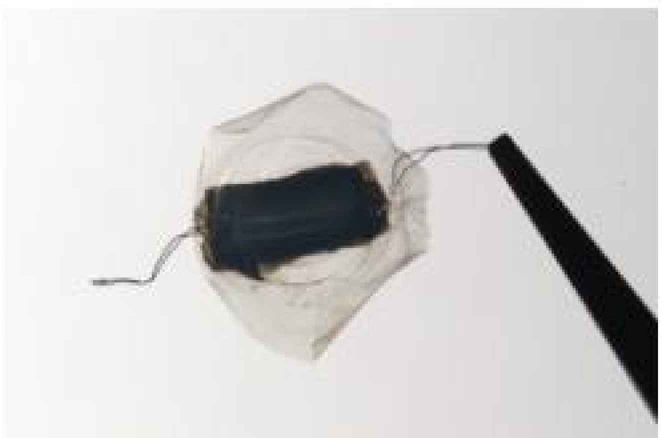
*(2) Proton conductance*

- Conditions conducive to proton conductance from the anode to the cathode through the polymeric medium must be maintained or increased

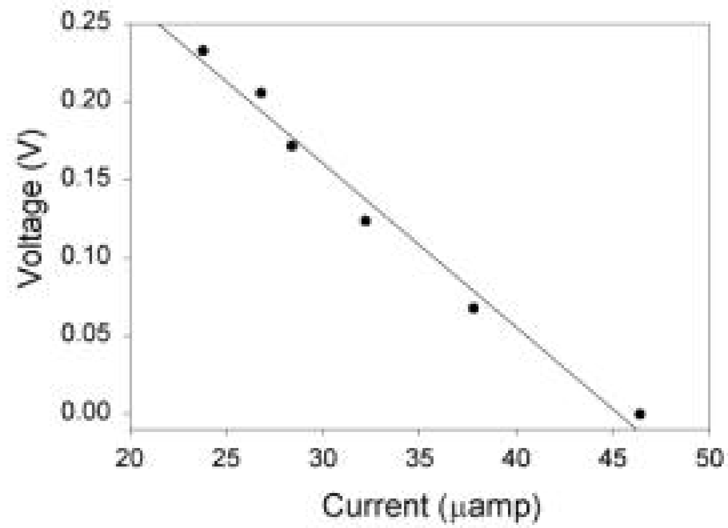
# Background

**Laboratory grown bacterial cellulose**

**Palladium Deposited by Bacterial Cellulose**



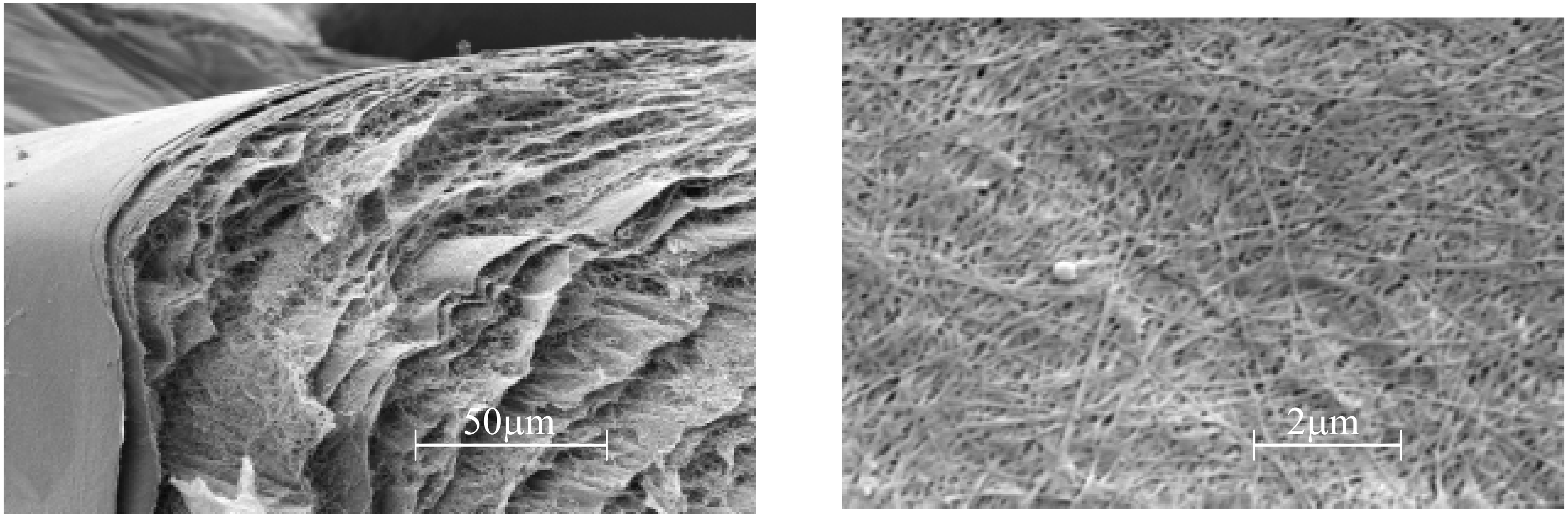
**Bacterial Cellulose MEA**



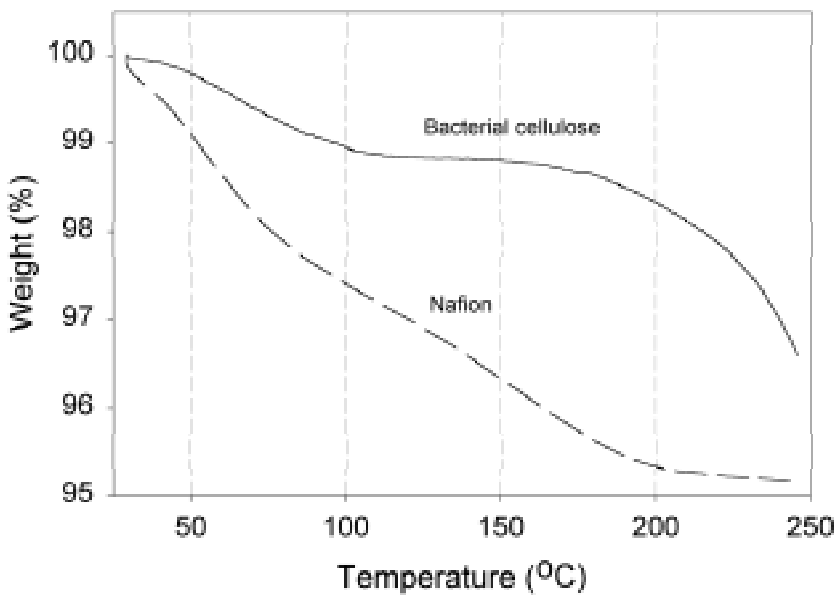

**Voltage vs. Current Curve for MEA**

Cultivation of Bacterial Cellulose

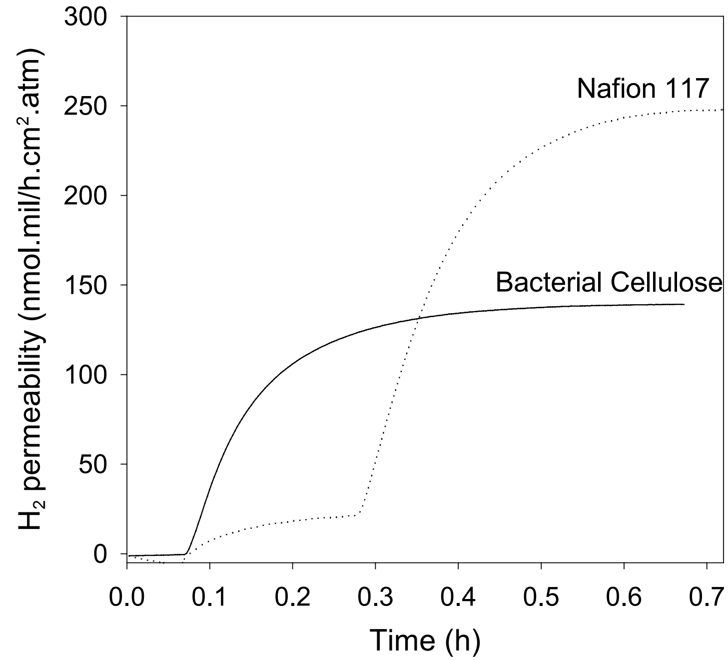
Processed Bacterial Cellulose




SEM micrographs of freeze-dried Bacterial Cellulose

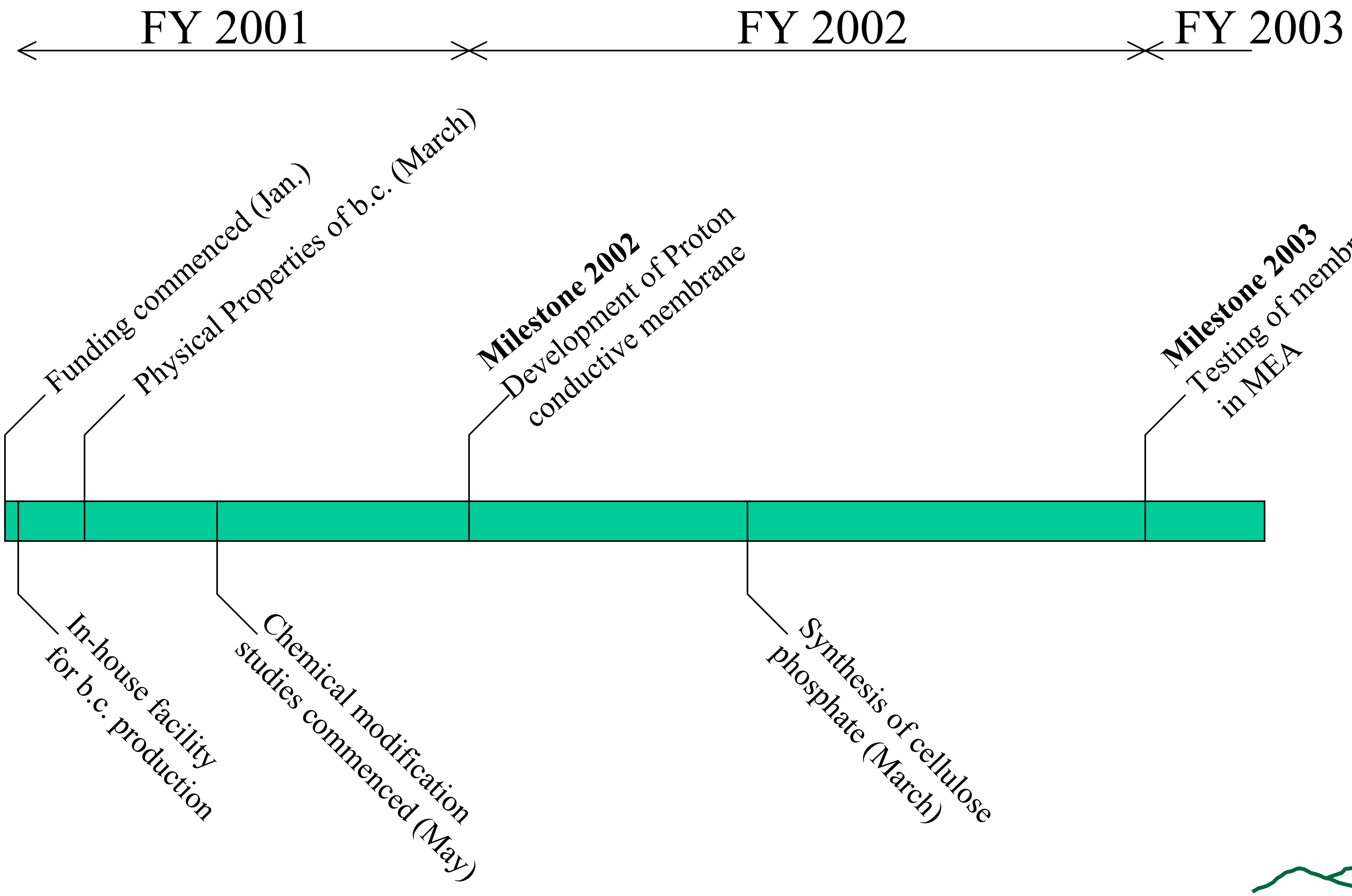



**TGA analysis Profiles of Bacterial Cellulose and Nafion 117®**




**$H_2$ crossover characteristics of Bacterial Cellulose and Nafion 117®**

# Project Timeline



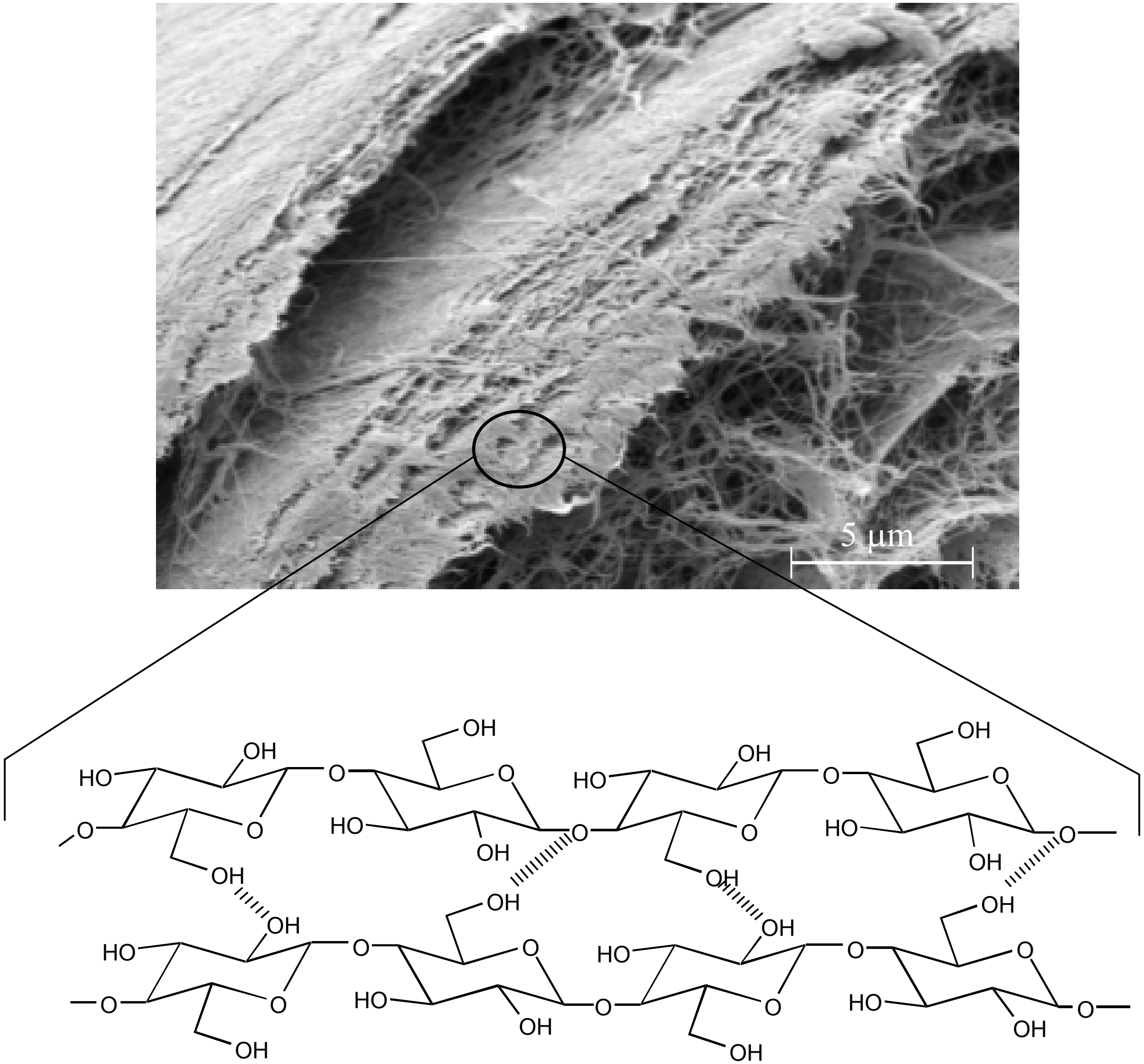
# Milestone FY 2002

- Synthesis of proton conductive membrane for PEM fuel cell by chemical modification of bacterial cellulose.

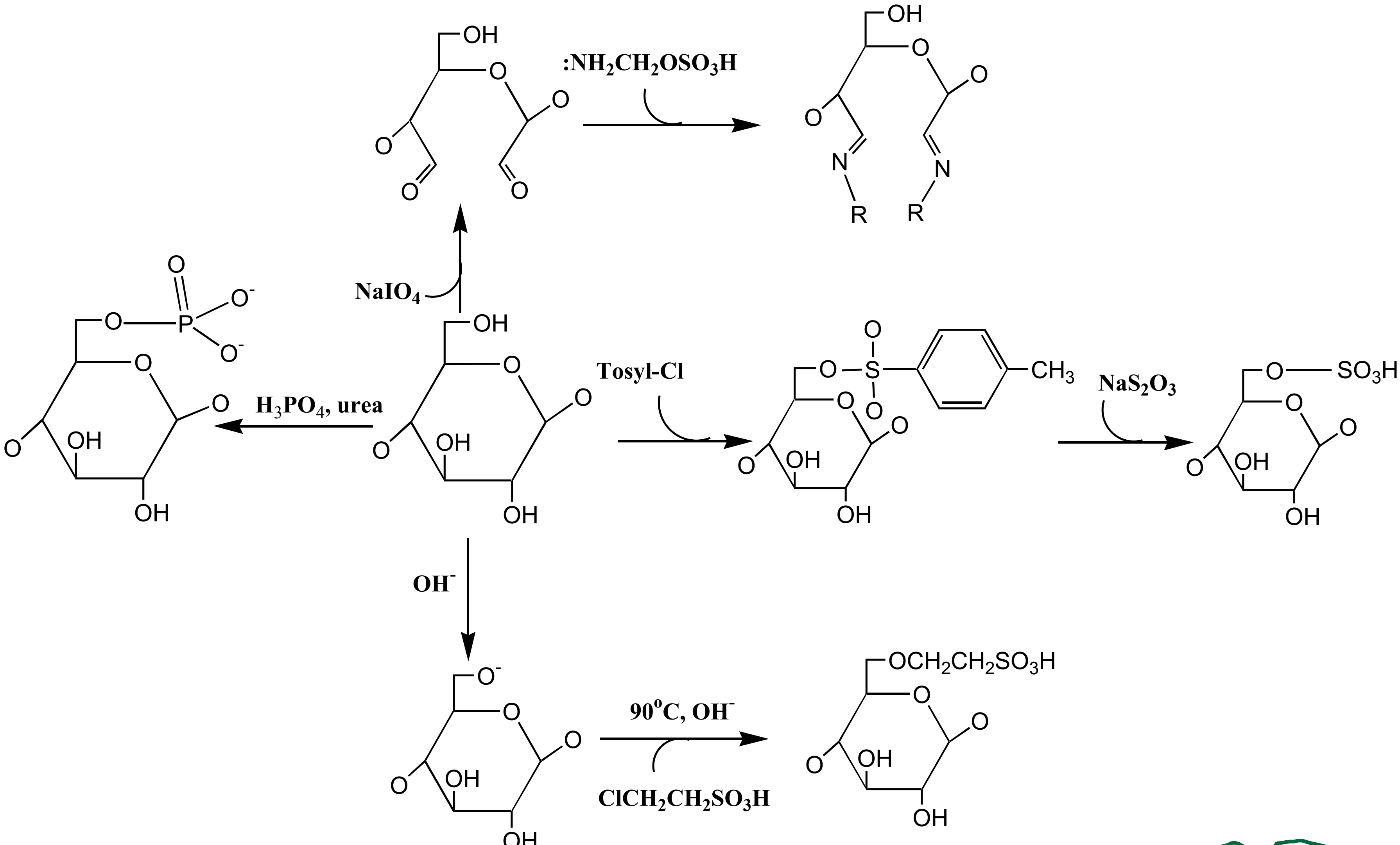
# Metric

•A membrane with an operating temperature $\geq 130^{o}C$ (based on the stability of the native membrane) and ion-exchange capacity of 1 mequiv/g.

# Approach



# Chemical Modification of Bacterial Cellulose



# Accomplishments

| Membrane characteristics | | Native cellulose | Cellulose phosphate | Nafion 117® |
|---|---|---|---|---|
| Physical properties | Dry membrane thickness (mm) | 0.010 | 0.023 | 0.199 |
| | Wet membrane thickness (mm)[1] | 0.032 | 0.081 | 0.225 |
| | $H_2O$ content / g dry membrane (g/g)[1] | 3.47 | 3.16 | 0.31 |
| | Thermal stability ($^oC$) | 130 | 245 | <90 |
| | Ion exchange capacity (mequiv/g) | 0 | 1.3 | 0.9 |
| | $H_2$ crossover (nmol.mil/h.cm$^2$.atm)[2] | n.d. | 267.2 | 2039.4 |
| Mechanical stability | Resistance to crease/crack: dry | Yes | No | Yes |
| | hydrated | Yes | Yes | Yes |
| | Resistance to tearing: dry | No | No | Yes |
| | hydrated | Yes | Yes | Yes |
| | Resistance to gas pressure (dry) | n.d. | 30 psi | >50 psi |
| Chemical stability | Acid stability (% weight loss)[3] | 12 | 39 | 2.5 |

[1]Determined after heating to 99$^oC$ for 2.5 hours in $H_2O$
[2]Measured at 20 psi $H_2$ (100%) and 25$^oC$
[3]Determined after incubation in 0.5M $H_2SO_4$ at 95$^oC$ for 45 hours

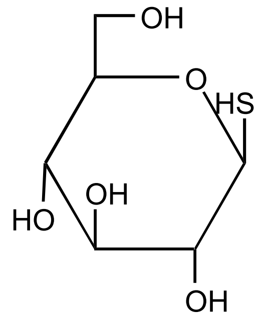
# Highlights in Relation to DOE Technical Targets for Fuel Cell Membrane Component

| Component | Requirement | Current Status |
|---|---|---|
| Cost | \$5/kW | n.d. |
| Stability w/RH 20-100%:(a) | <2mV | $245^{o}$C |
| (b) | <10% swelling | 316% |
| $H_2$ crossover | $<1mA/cm^2$ | $18.82\ \mu A/cm^2$ |
| Area-specific resistance | $0.1\ ohm\text{-}cm^2$ | n.d. |

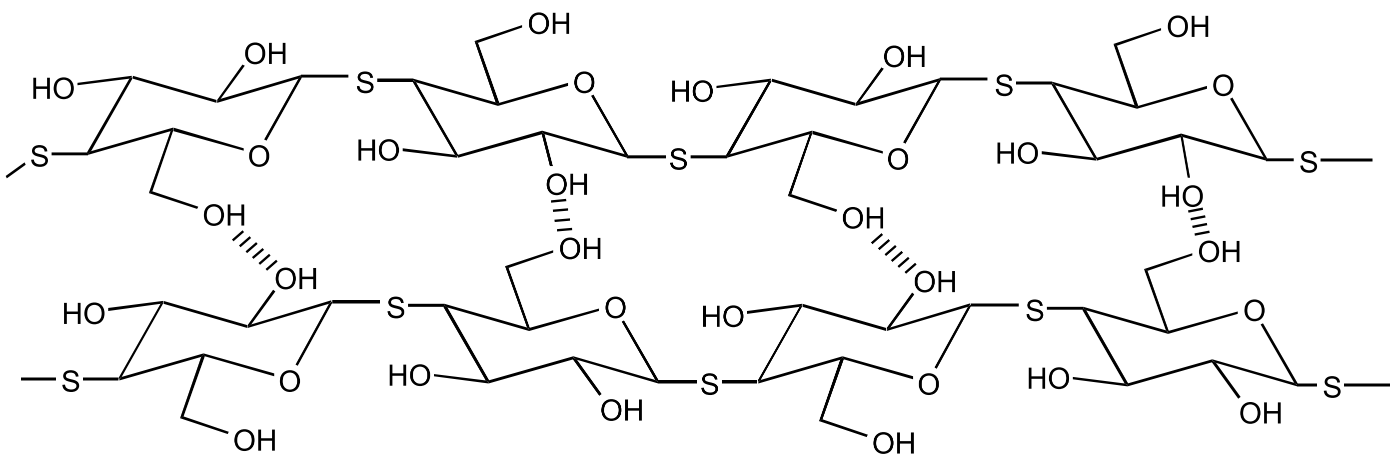
# Responses to Comments from FY2001

- Mechanical stability
- Chemical stability
- Lack of collaborations

# Strategy to Produce Cellulose with Increased Acid Stability



**Thio-glucose**



# Plans/Future Milestones

*FY2002*

- Complete characterization of phosphate membranes. Other methods attempted still need to be revisited and evaluated.

*FY2003*

- Characterization of membrane properties in MEA.

*Future work*

- Bacterial polymerization of activated glucose monomers
  - Projected advantages:
    - Greater control over the distribution of acid groups
    - Possibility of producing membranes with novel tailored properties

# Acknowledgements

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