

MODELING THE BEHAVIOR OF A POLYMER ELECTROLYTE MEMBRANE WITHIN A FUEL CELL USING COMSOL

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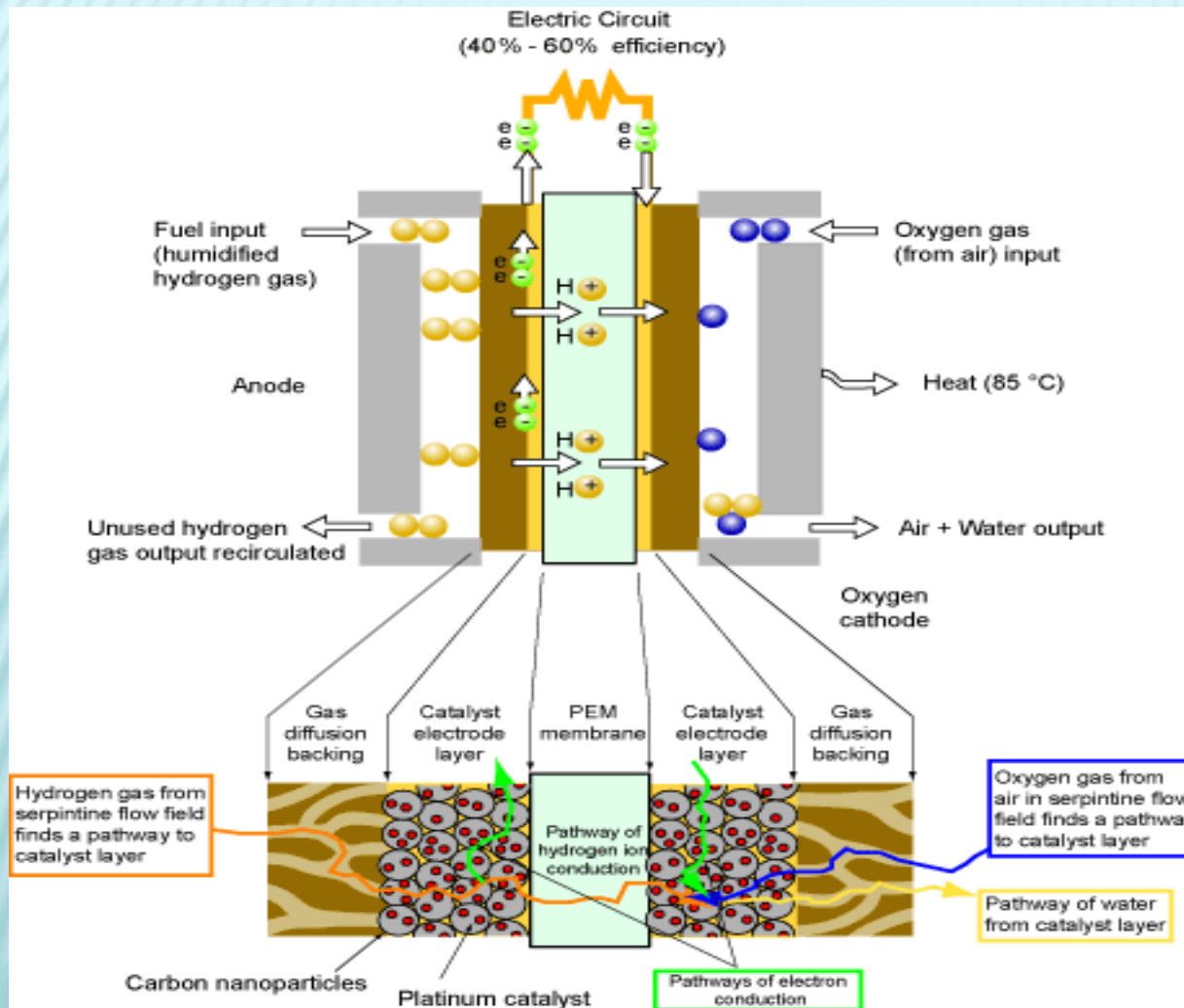
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OBJECTIVES

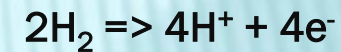
- ✘ To create a model of an acid-base blended Poly(1-vinylimidazole) based membrane using COMSOL Multiphysics 4.2a for a high-temperature proton exchange membrane fuel cell (PEMFC).
- ✘ Investigation of the electron and proton exchange with respect to the velocity and electrolyte conductivity phenomenon within the fuel cell using the developed model has been done.

**PROTON EXCHANGE
MEMBRANE FUEL CELL
(PEMFC)**

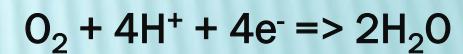
THE PROTON EXCHANGE MEMBRANE FUEL CELL (PEMFC)



At anode:



At cathode:



Net reaction:

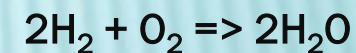


Fig. 2 – Diagram of PEM Fuel Cell

THE PROTON EXCHANGE MEMBRANE FUEL CELL (PEMFC) CONT'D

- ✘ This reaction only produces about 0.7 volts in a single fuel cell.
- ✘ In order to increase the voltage level, a fuel-cell stack is made using bipolar plates.

THE PEMFC MEMBRANE

THE PEMFC MEMBRANE

- ✘ The membrane of the PEMFC is one of the most fundamental parts of the cell as its properties have great impact on the cell's output capability.
- ✘ Most PEMFCs use hydrated membranes.
- ✘ Membrane materials which could be used at temperatures higher than 80°C now had to be developed.
- ✘ One such material is the Poly(1-vinylimidazole) (PVIIm) polymer which was developed by the Fuel Cell Materials Research Laboratory in the Physics Department at UWI.

POLY(1-VINYLMIDAZOLE) COMPOUND

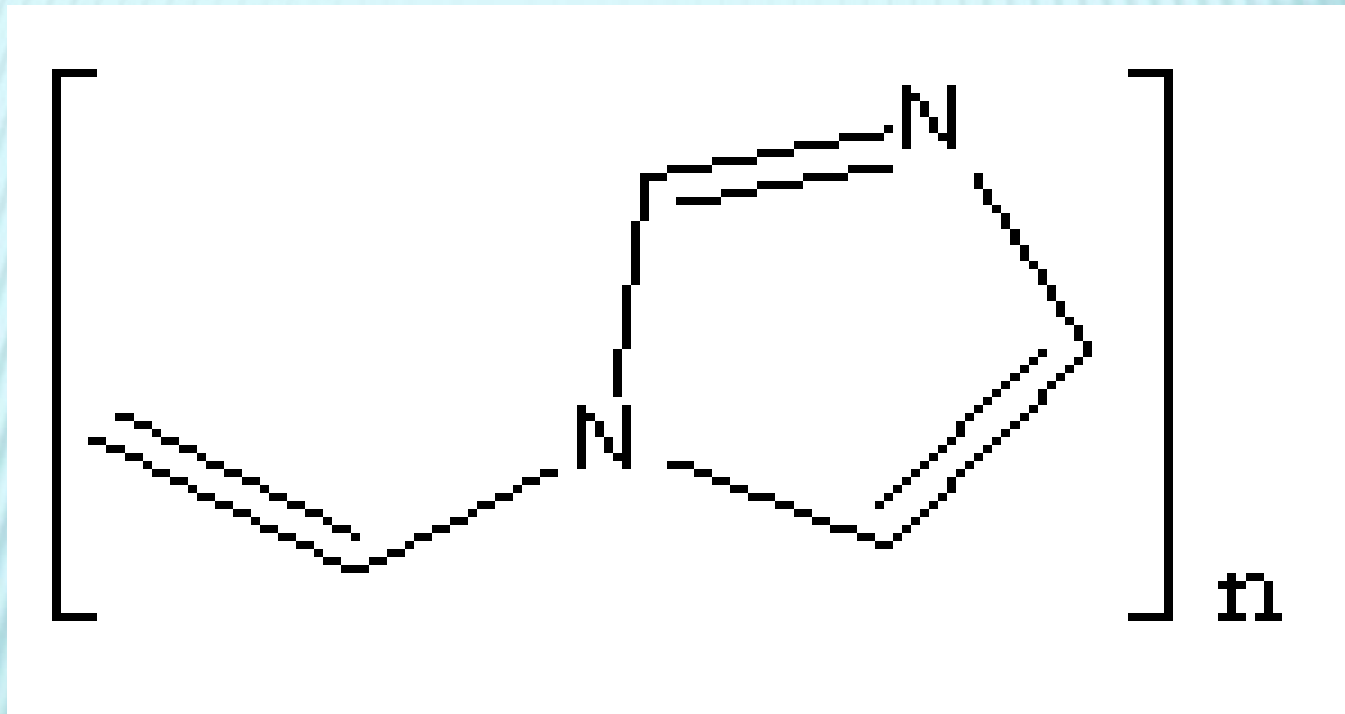


Fig. 3 – Diagram of chemical structure of PVIIm compound

POLY(1-VINYLMIDAZOLE) MEMBRANE

- ✘ This polymer, when combined with triflic acid forms an acid-base ternary composite blend membrane.
- ✘ It also utilizes PVDF-HFP as a polymer for its good mechanical properties which provide a stable hydrophobic backbone.
- ✘ Includes nano-tubular titania to improve conductivity and morphology.
- ✘ Does not require hydration.
- ✘ Can operate at temperatures much higher than 80°C without degradation.

EXPERIMENTAL DATA VALUES

- ✘ The experimental data used to create the model was obtained from experimentations completed by research students at the Fuel Cell Materials Research Laboratory at UWI.
- ✘ The following table shows a sample of the various parameter readings obtained from experimental data performed on the membrane.

- × Table showing the parameter values used in order to model the ternary membrane.
- × Membrane thickness = 0.0542 cm

MATERIAL	ELECTROLYTE CONDUCTIVITY (S/m)	DENSITY (kg/m ³)	DYNAMIC VISCOSITY (Pa*s)	THERMAL CONDUCTIVITY (W/mK)	HEAT CAPACITY (J/kgK)	SPECIFIC HEAT RATIO
Graphite sheet	3.3×10^2	-	0	25	710	1
Carbon fibre	1.25×10^3	1.80	0	1.2	4.77	1
Platinum	9.43×10^6	-	0	-	-	1
Hydrogen and Oxygen	5.5×10^{-6}	-	-	-	-	-
PVIm	1.43×10^{-4}	1.036	0.146	2.53213×10^5	3.7982×10^3	1

Table 3 – Parameters used in modeling

METHOD OF MODELING FUEL CELL WITHIN COMSOL

MODELING STEPS OF FUEL CELL USING COMSOL

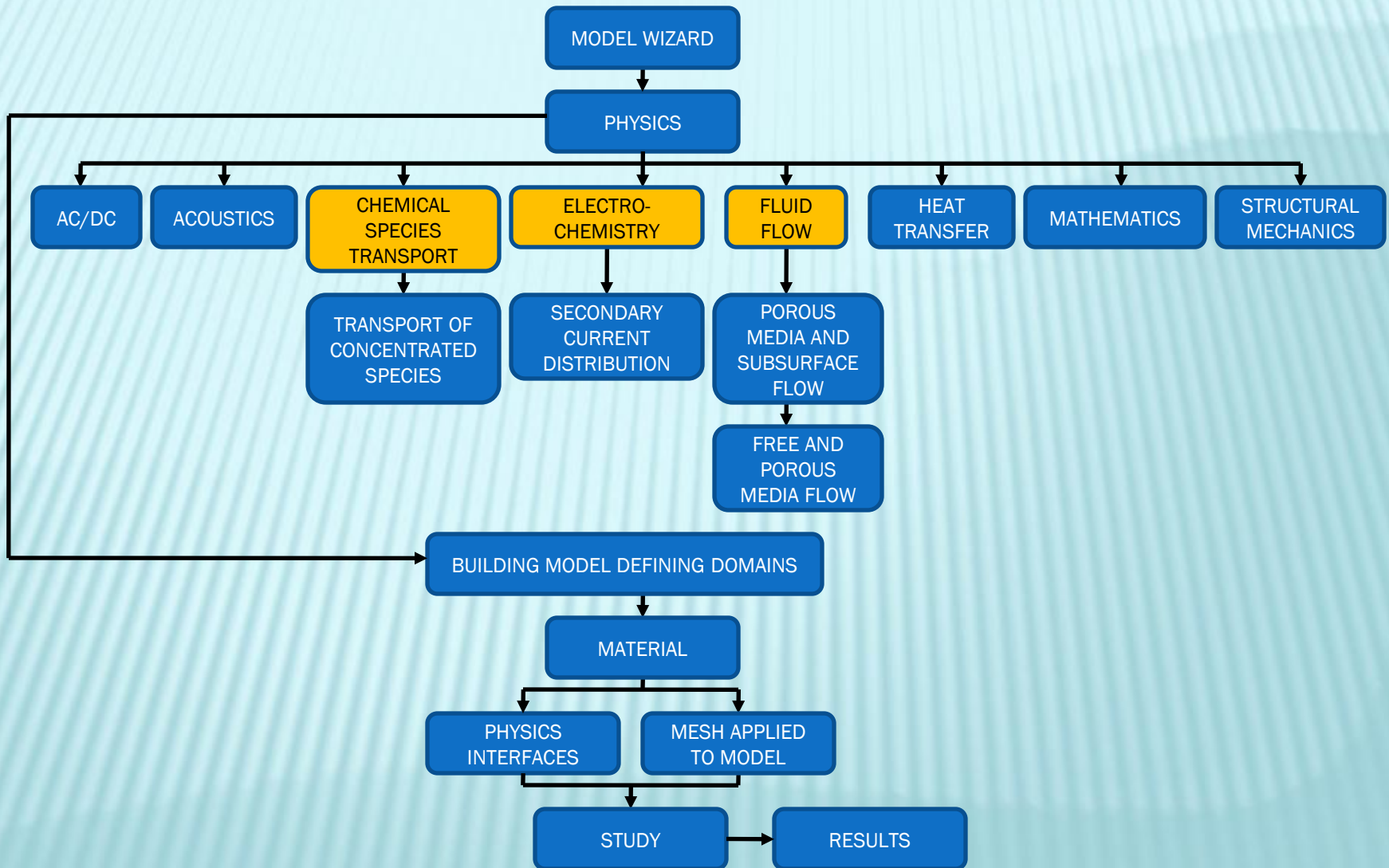


Fig.5 Shows the modelling steps for the PEMFC

RESULTS

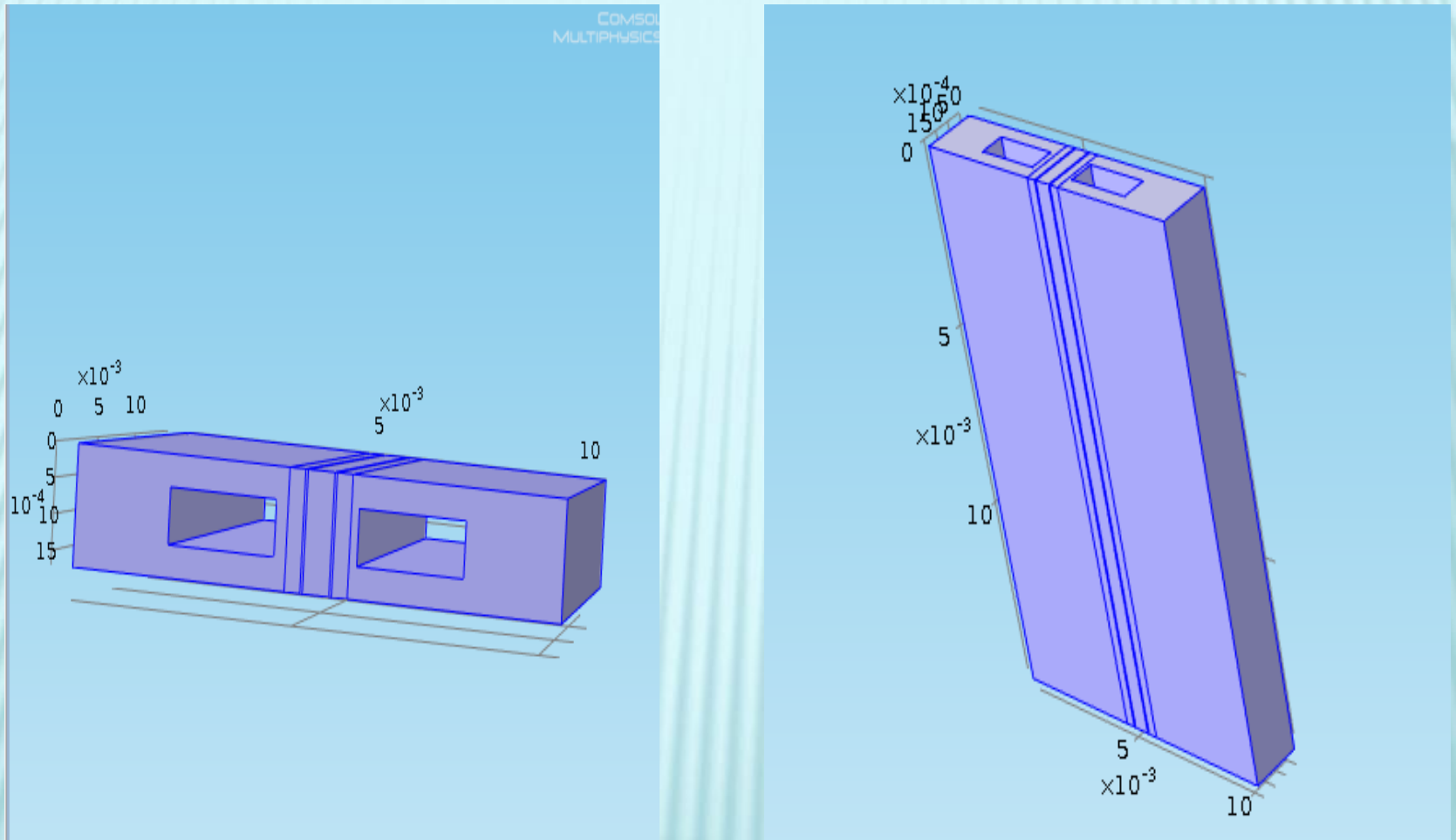


Fig.6: General model of the fuel cell.

RESULTS (CONT'D)

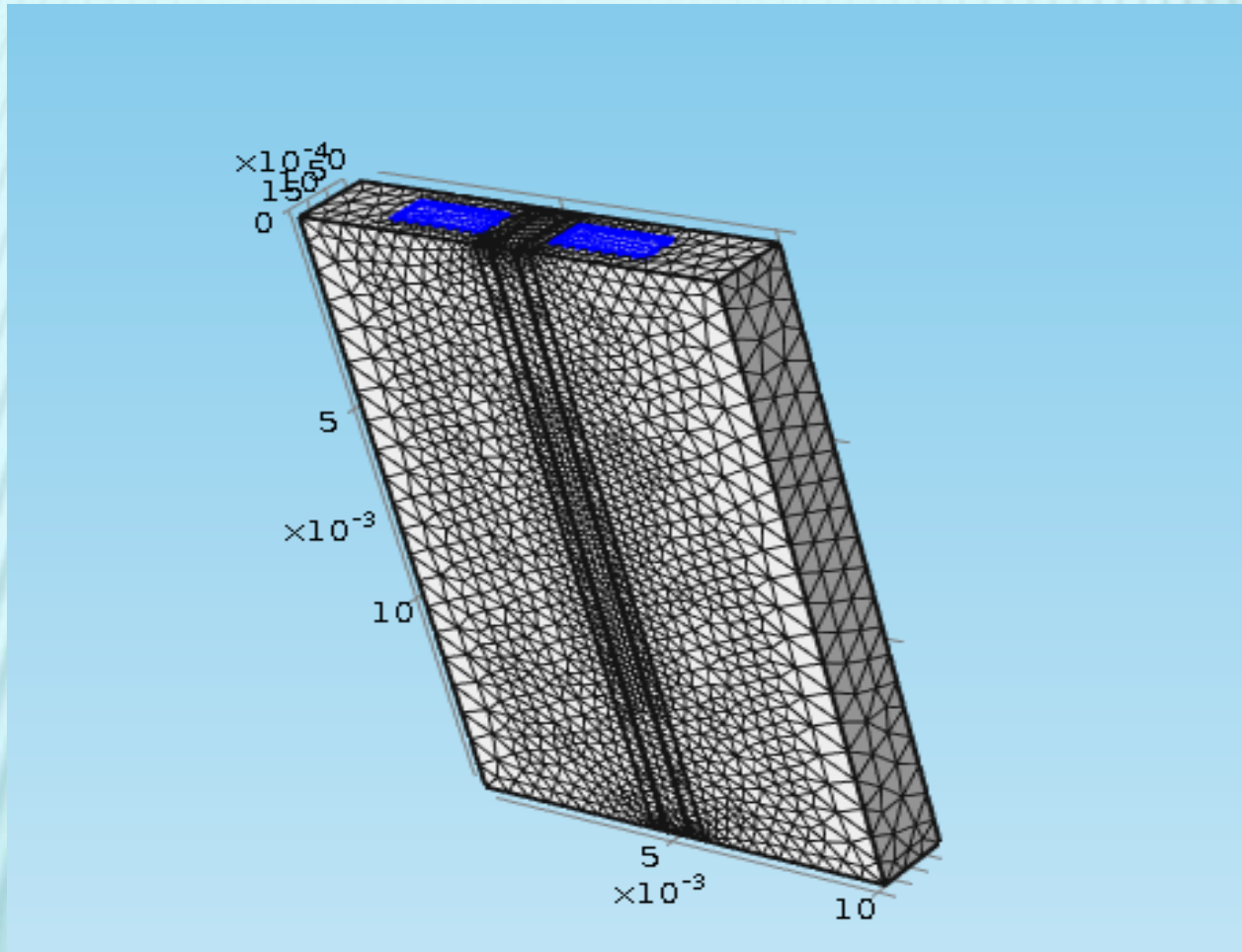


Fig.7: Model with mesh

RESULTS (CONT'D)

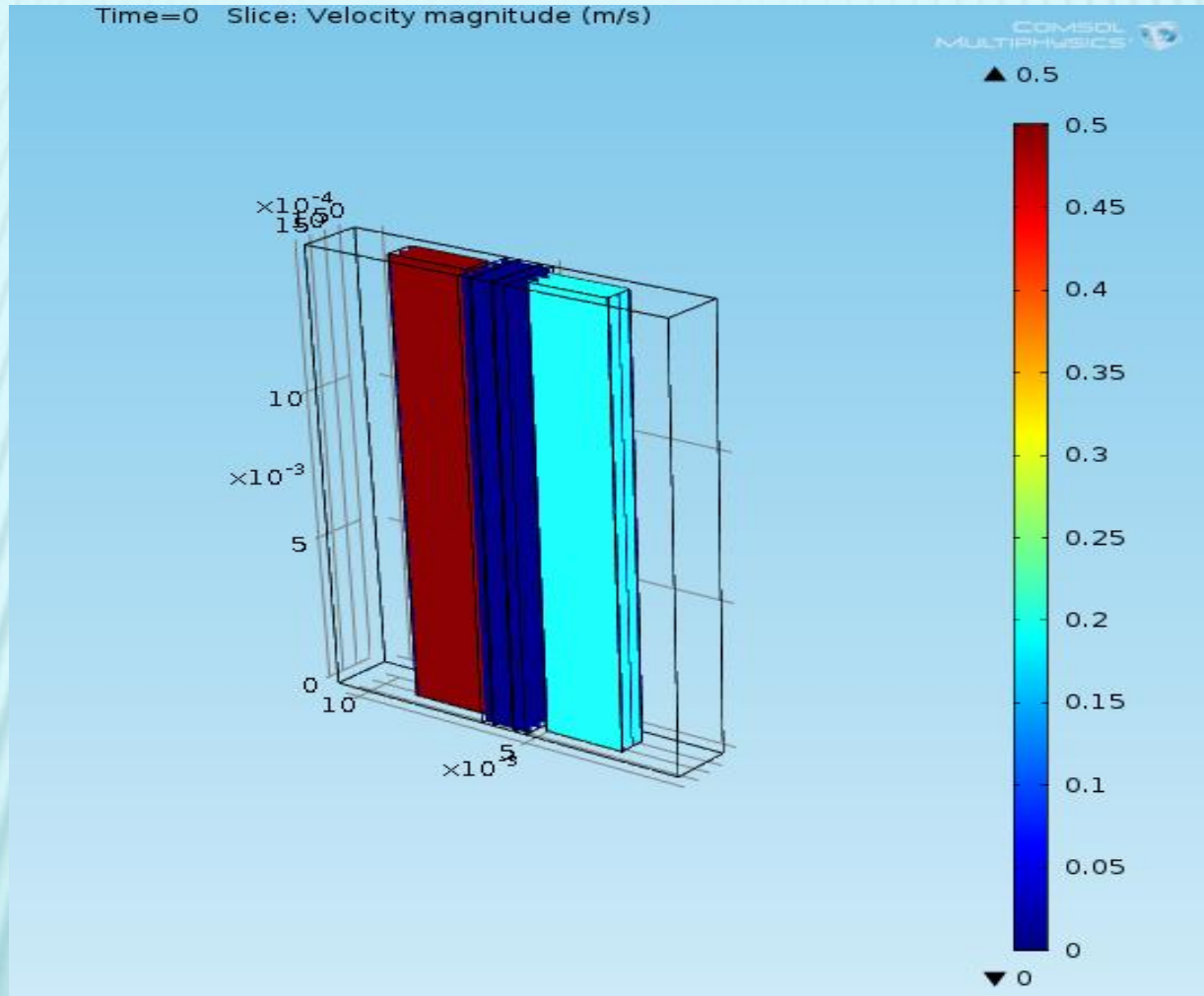


Fig. 8: Shows the velocity within the PEMFC (free and porous media flow)

RESULTS (CONT'D)

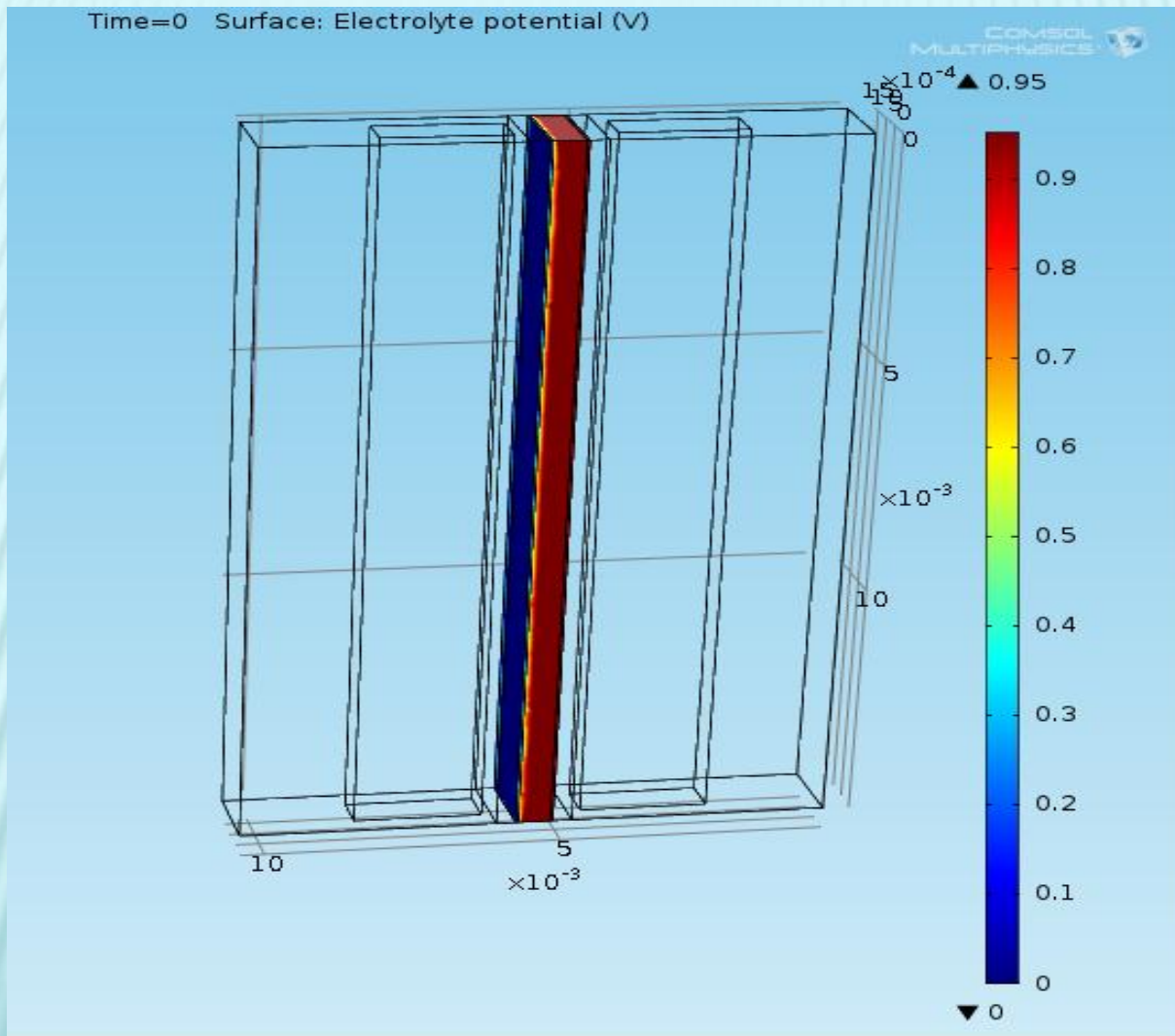


Fig.9:Shows the electrolyte potential in the PVI membrane (for Secondary current distribution)

RESULTS (CONT'D)

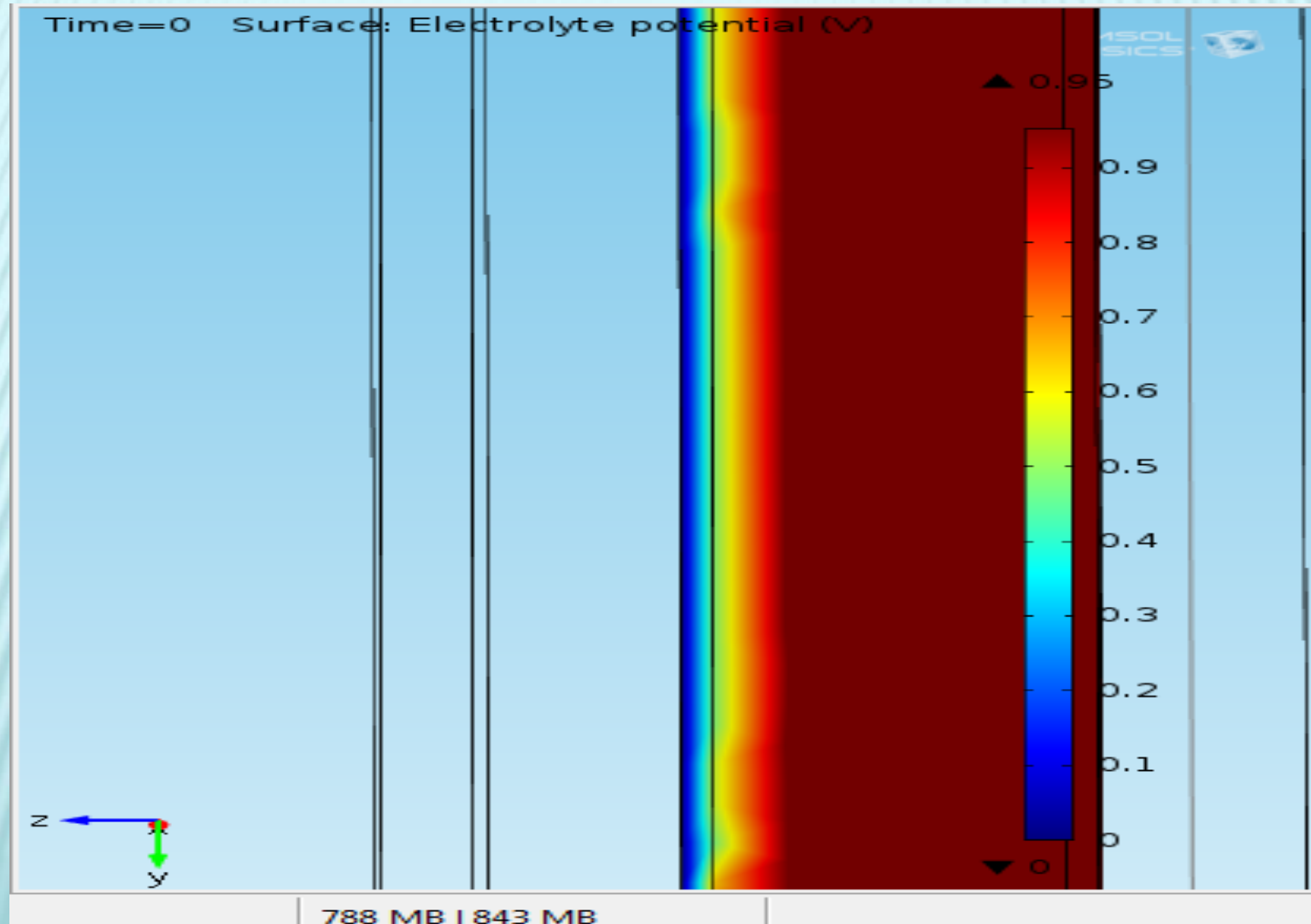


Fig.10: Magnified view of the electrolyte membrane

CONCLUSION

Using data obtained from the fuel cell research laboratory a model of the ternary acid based PVIm membrane was developed within the PEM fuel cell. From this model, the exchange of the electrons and protons with respect to velocity was observed as well as the electrolyte potential of the membrane. When compared to the traditional membrane (0.7V) the PVIm membrane (0.95V) can be deemed to be successful.

ACKNOWLEDGEMENTS

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