Direct Methanol Fuel Cell Operating With Concentrated Methanol

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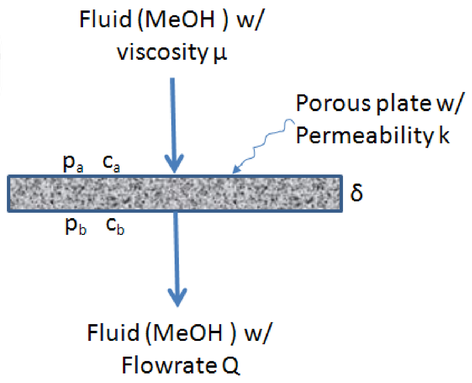
Mass Transport Through Porous Media

Transport in the porous layer

$$Q = \left(\frac{-k \cdot A}{\mu} \cdot \frac{\Delta p}{\delta}\right) + \left(-D_{eff} \cdot A \cdot \frac{M}{\rho} \cdot \frac{\Delta c}{\delta}\right)$$

Q = volumetric flowrate (m^3/sec)
k = permeability (m^2)
A = cross-sectional area (m^2)
Δp = pressure difference (Pa)
μ = dynamic viscosity (Pa*sec)
δ = length over which the pressure drop takes place (m)
D_{eff} = effective diffusivity (m^2/sec)
M = molecular weight of fuel (gm/mole)
ρ = fuel density (gm/mL)
Δc = concentration difference (mole/L)



Fuel Consumption rate

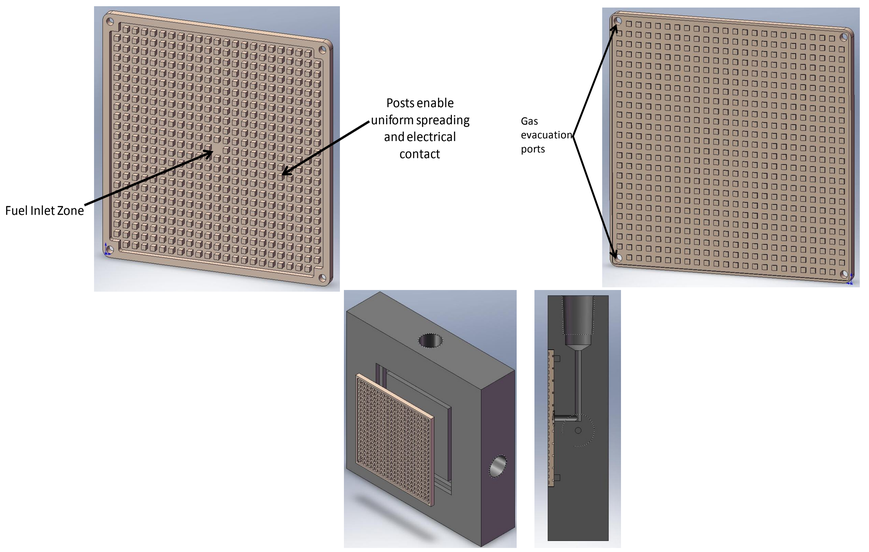
$$Q = \frac{I}{n \cdot F} \cdot \frac{M}{\rho}$$

Q = volumetric flowrate (m^3/sec)
I = operating current (Amps)
n = nr. of electrons exchanged (eq/mole)
F = Faraday's number (C/eq)
M = molecular weight of fuel (gm/mole)
ρ = fuel density (gm/mL)

Matching the rate of discharge of fuel through the porous structure with the fuel consumption at the DMFC anode reduces the methanol crossover

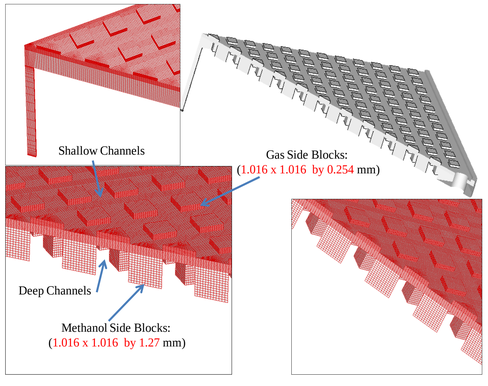
Diffuser Construction

Integrated flow field – diffusion layer (IFDL)

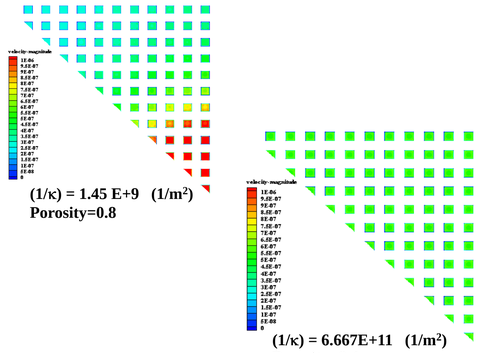


Modeling

Meshing the structure



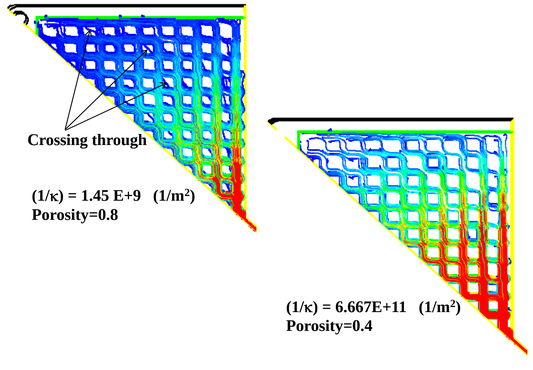
Methanol Velocity on the Lands



(1/κ) = 1.45 E+9 (1/m²)
Porosity=0.8

(1/κ) = 6.667E+11 (1/m²)
Porosity=0.4

Methanol Stream Pathlines



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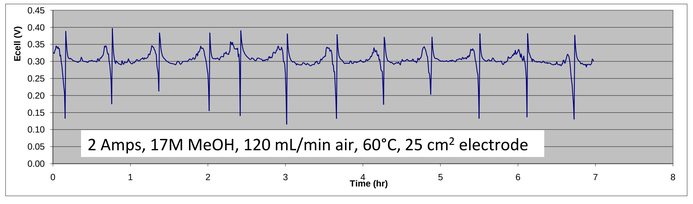
Experimental

Cells are operated in dosing mode



Energy	4.222131	W*hr
GFED	352	W*hr/L
%U	42%	
Eavg	0.30	V
Pavg	24	mW/cm2
Pmax	32	mW/cm2
Ravg	6	mOhm

Various Experimental Conditions

Operating Conditions (Icell, MeOH conc., T°C, Air Flowrate)	GFED (W*hr/Lfuel)	Eavg (V)	Fuel Utilization (%)	Pavg (mW/cm2)	Pmax (mW/cm2)
1 Amp, 13M, 60°C, 200 SCCM	176	0.34	24	14	17
1 Amp, 13M, 60°C, 120 SCCM	313	0.38	39	15	18
1 Amp, 17M, 60°C, 200 SCCM	201	0.40	18	16	21
1 Amp, 17M, 60°C, 120 SCCM	267	0.41	24	16	19
1.5 Amp, 13M, 60°C, 200 SCCM	234	0.34	33	20	23
1.5 Amp, 13M, 60°C, 120 SCCM	134	0.14	46	8	11
1.5 Amp, 17M, 60°C, 200 SCCM	260	0.38	25	23	26
1.5 Amp, 17M, 60°C, 120 SCCM	336	0.37	33	22	28
1.5 Amp, 17M, 50°C, 120 SCCM	302	0.20	56	12	19
1.5 Amp, 17M, 40°C, 120 SCCM	143	0.11	46	7	8
1.5 Amp, 17M, 60°C, 80 SCCM	318	0.28	41	17	23
2 Amp, 13M, 60°C, 200 SCCM	262	0.29	44	23	28
2 Amp, 17M, 60°C, 120 SCCM	352	0.30	42	24	32
2 Amp, 17M, 60°C, 80 SCCM	124	0.13	35	10	20

NuVant Systems Inc.
Advanced Fuel Cell Technology