TRA105 Fuel Cell Systems

Fuel cell modelling and materials design optimization (Materials comparison)

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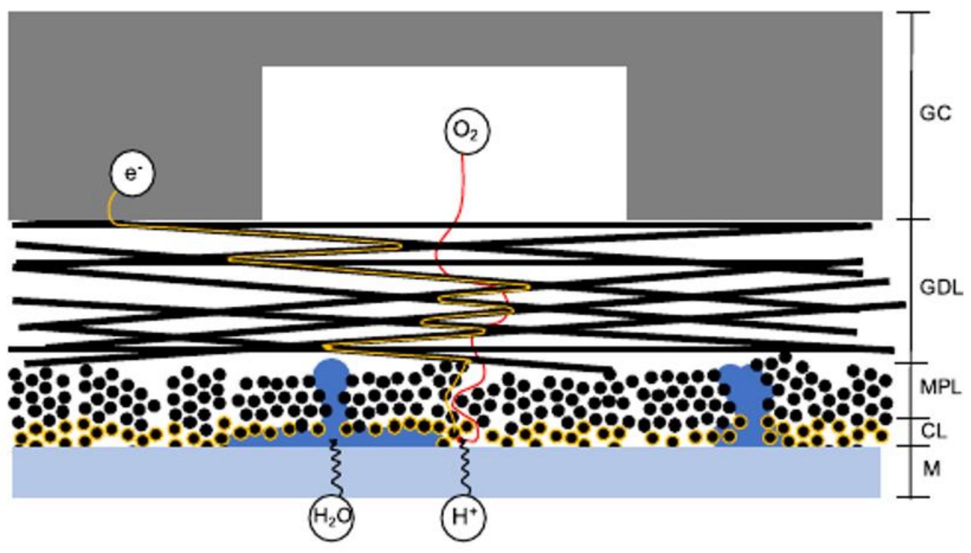

Figure1 Schematic of the components within a fuel cell, illustrating the dual transport mechanisms of the GDL. Electrons are transported in the solid fibers (yellow), while reactants (oxygen) and products (water) are transported through the void space (red). Gas Channel (GC), Gas Diffusion Layer (GDL), Micro-porous Layer (MPL), Catalyst Layer (CL) and Membrane (M) are shown on the diagram.

https://www.researchgate.net/publication/337382298_Enhancing_the_Performance_of_Fuel_Cell_Gas_Diffusion_Layers_Using_Ordered_Microstructural_Design

Introduction

- Core of PEMFC consist of polymer electrolyte membrane sandwiched between 2 thin catalyst and two porous electrodes which are called as GDL.

- The GDL is the key component for regulating the transport phenomena inside the cell and, in turn, its design is an important factor to determine cell performance. the GDL porous microstructure is fundamental in determining the two-phase (liquid–gas) dynamics and distribution in the cell, a complex mechanism of mass transport that affects the management of the produced water, of great interest to investigate the interplay between two-phase flow phenomena and GDL microstructure, in order to establish efficient water management strategies, and increase the performance, robustness and competitiveness of fuel cells in the energy market.

- GDL are made of made up of pressing the highly porous woven carbon fibers into carbon paper or carbon cloth. These are produced usually with Micro Porous Layer (MPL), to provide surface area for catalyst and contact with membrane. The GDL is also produced with Hydrophobic Treatment (Poly Teflon Coating) for keeping the water intact inside the membrane (water management). It also provides high electrical and thermal conductivity along with chemical and corrosion resistance.

Method : Description of materials

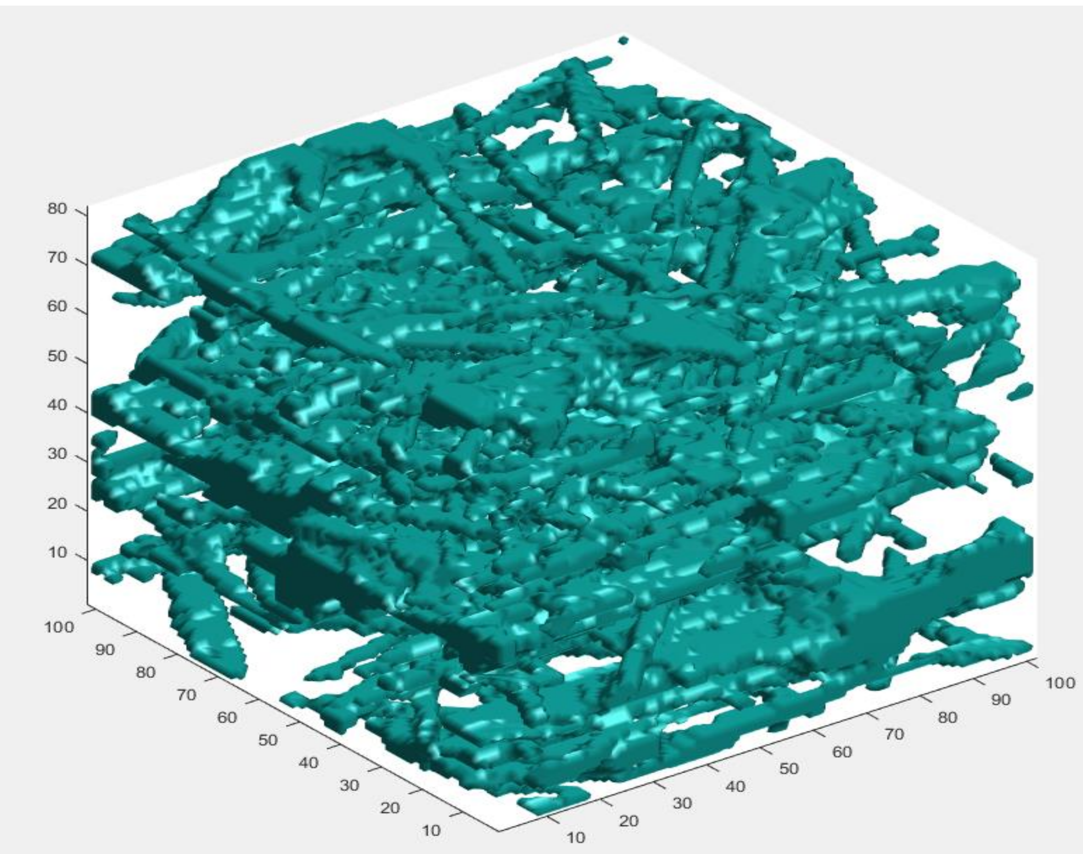

Figure2.1 3d image of SPECTRA

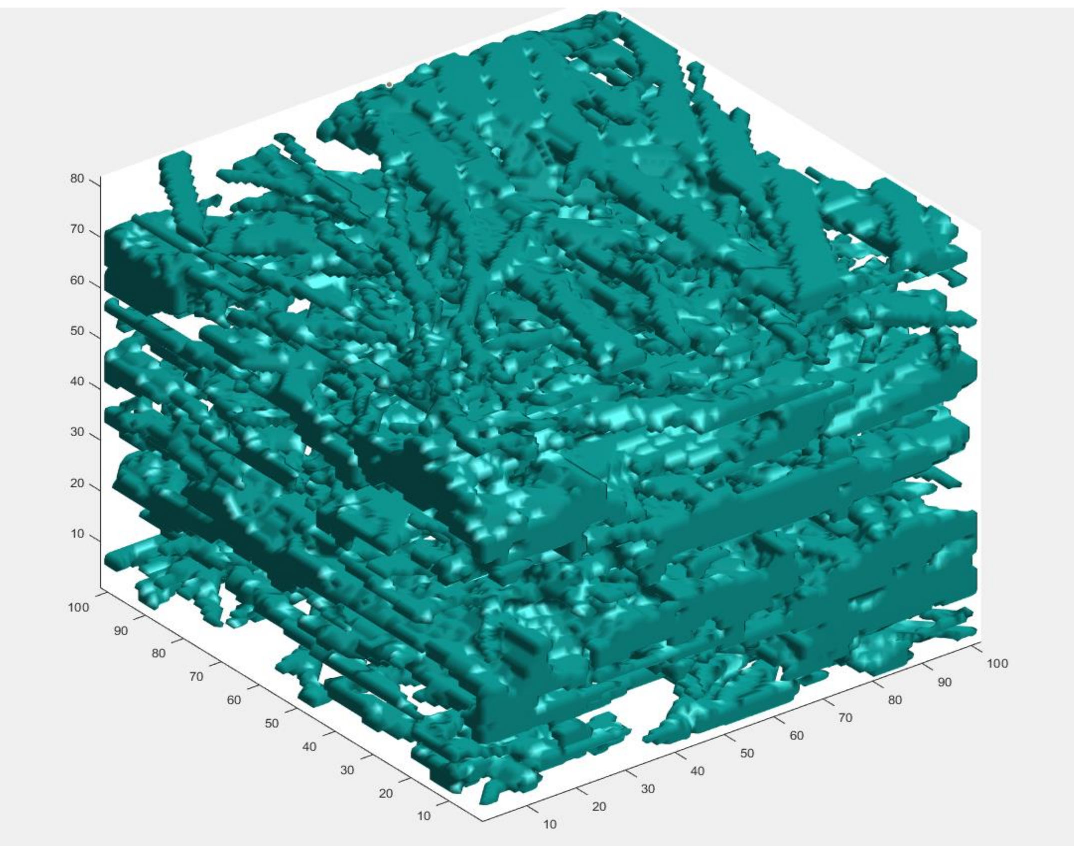

Figure2.2 3d image of AVCARB

- Possible GDL Materials Used are Carbon cloth, paper, Graphite felt, Wet proofed GDLs, wire mesh and cloth, Clearance GDLs.
- **Features of GDL**
- 100–500 μm thickness
- The diameter of fibers composing the GDLs is typically 10–15 μm
- the mean pore size is 50–120 μm

Pore size distribution of 2 materials (The pore size distributions are calculated using the watershed algorithm presented in (Rabbani et al. 2014) .These images are obtained through the three-dimensional geometry of the GDL material (AvCarb and Spectra) is acquired and reconstructed via X-ray CT. For that purpose, a metrological CT system (Nikon Metrology MCT225) is used, which is characterised by micro-focus X-ray source (minimum focal spot size equal to 3 μm), 16 bit detector with 2000 × 2000 pixels and cabinet ensuring controlled temperature of 20 ◦ C.

Discussion and Conclusion

The GDL layers which has web of carbon fibers (random nature) in size of micrometers aids in both electron and fluid transport to and from Catalyst layer.

Pore Size distribution radius of SPECTRA is averaged around 5 micron where as AVCARB, the radius is averaged around 4 micron.

The main difference seen between them is that the pore size distribution is more evenly distributed in AVCARB in compared to SPECTRA, this affects the rate at which the gas diffusion occurs, rate transfer of electrons, and transport rate of water. This factor ensures AVCARB has better effects than SPECTRA, in gas/water transport distribution as microstructural variations have in determining the dynamics along the medium thickness of fuel cells.

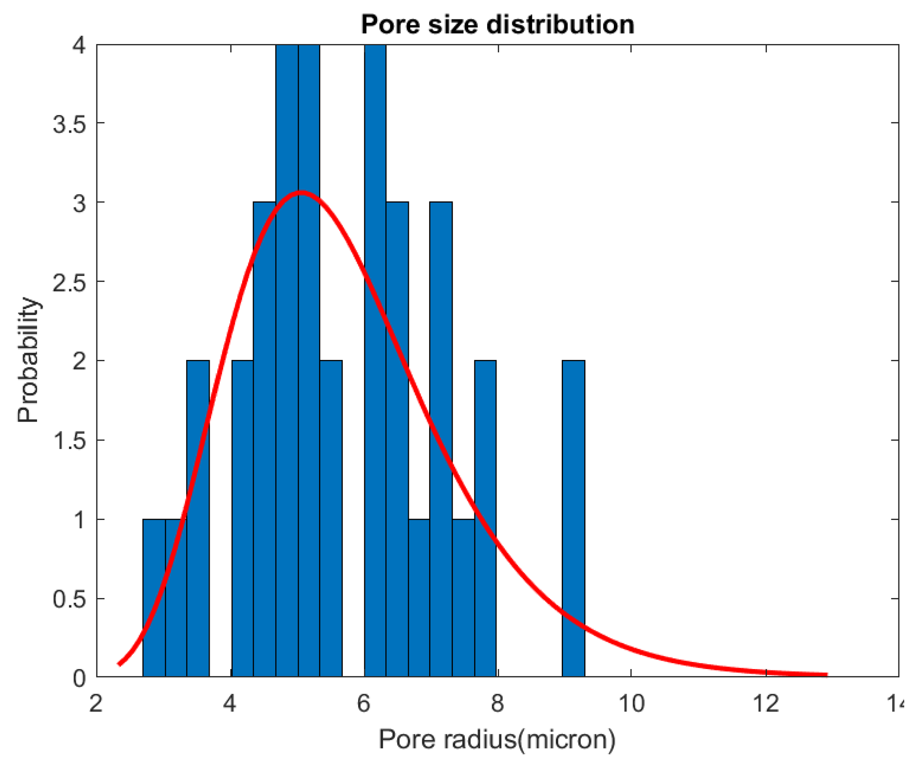

Figure3.1 Pore size distribution of SPECTRA (red curve is the best fit for the PSD, normal distribution)

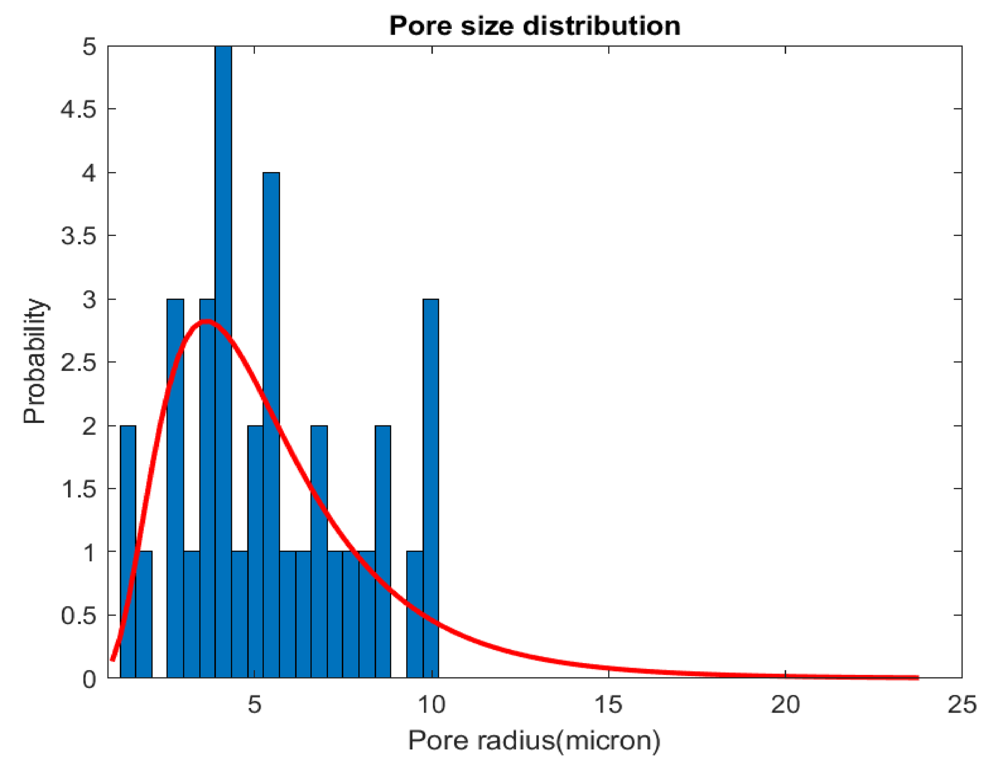

Figure3.2 Pore size distribution of AVCARB (red curve is the best fit for the time dependency

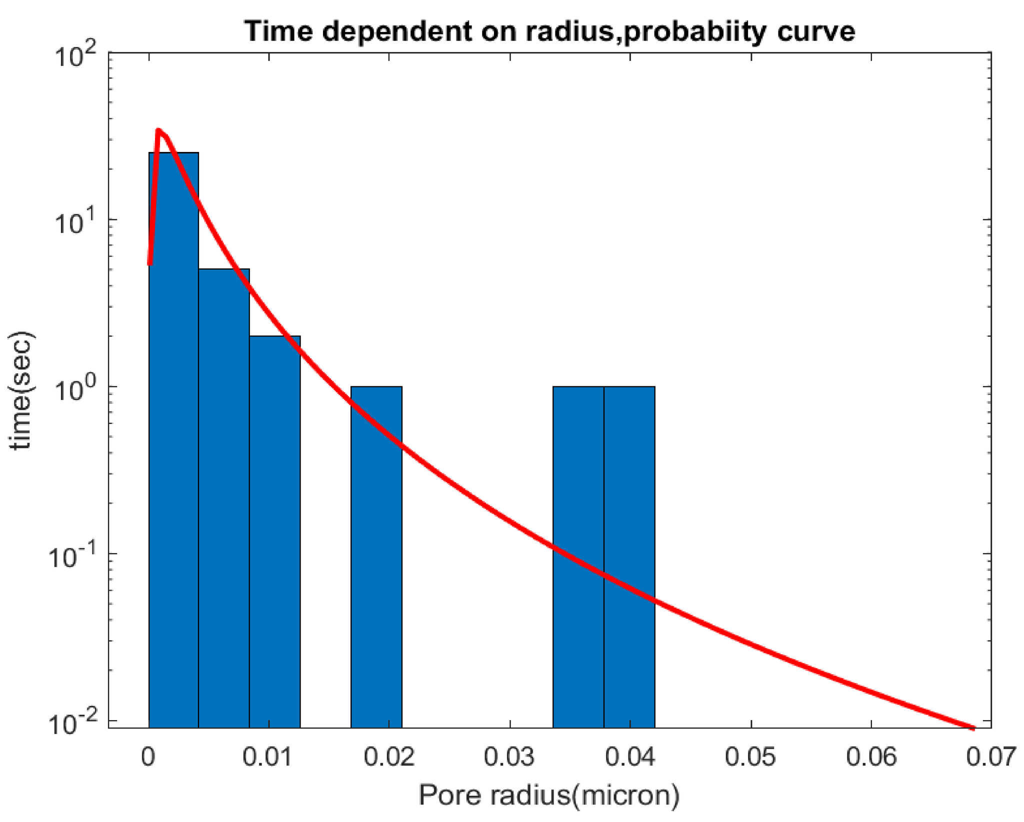

Figure4.1 Time distribution of SPECTRA (red curve is the best fit for the time dependency)

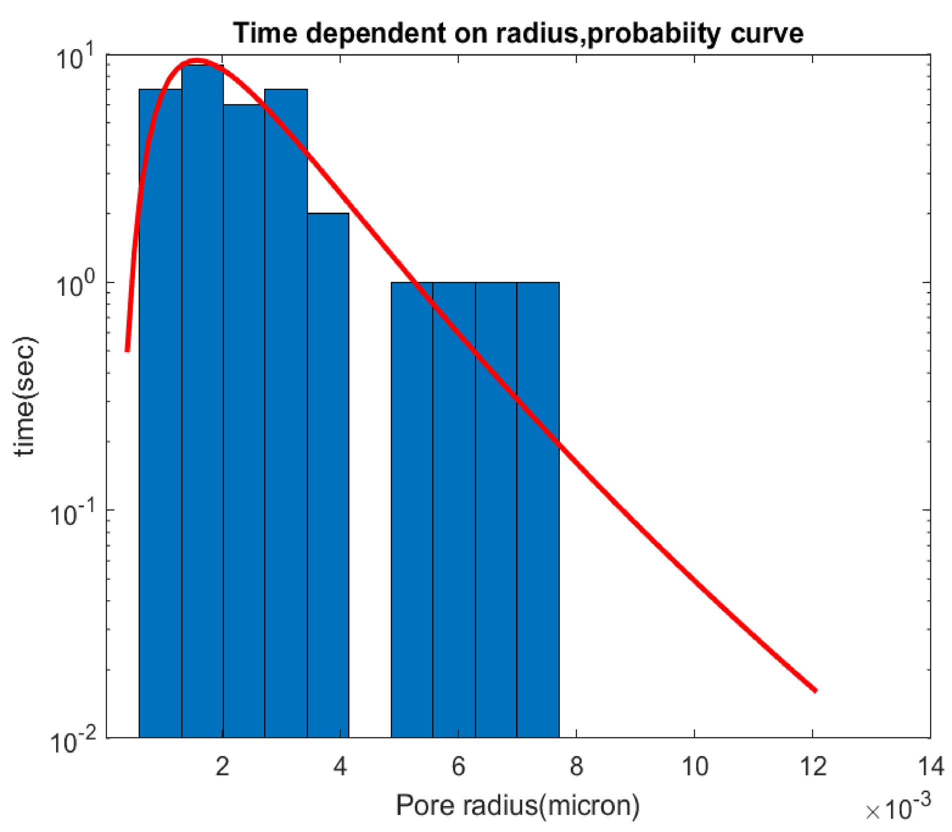

Figure4.2 Time distribution of AVCARB (red curve is the best fit for the time dependency

From the graphs of time vs pore radius, it can be noticed that the time needed for water to be transported from the catalyst layer to the gas channel, and vice-versa, AVCARB presents a higher probability of fast ejection times of water, but also a considerable probability of having very slow ejection times. Whereas, on contrast, SPECTRA has lesser probability of faster ejection times. This is due to the fact that the pore size distribution of AVCARB is evenly distributed and hence has high probability of fast ejection times.