**Diffusional Tortuosity**:

This module computes the tortuosity based on the computed Molecular diffusion, result of the “Molecular Diffusivity Experiment Simulation” module.

This module needs to be attached to the Spreadsheet that include the Apparent Molecular diffusivity value.

This module need as second input the binary data representing the pore phase. When attached to the spreadsheet, the module will try to retrieve automatically this binary data. If necessary it is possible to manually select the right binary input from “Binary image” port.

The output is a Spreadsheet including the “Diffusional Tortuosity” value. This value is computed using following formula:

Solution’s bulk diffusivity

: Apparent Molecular diffusivity

𝜑: Volume Fraction of Pore space

This equation is derived from following equation:

Reference:

Epstein, Norman. "On tortuosity and the tortuosity factor in flow and diffusion through porous media." *Chemical engineering science* 44.3 (1989): 777-779

**Thermal Tortuosity**:

This module computes the tortuosity based on the computed Molecular diffusion, result of the “Thermal Conductivity Experiment Simulation” module.

This module needs to be attached to the Spreadsheet that include the Apparent Thermal Conductivity value.

This module need as second input the binary data representing the pore phase. When attached to the spreadsheet, the module will try to retrieve automatically this binary data. If necessary it is possible to manually select the right binary input from “Binary image” port.

The output is a Spreadsheet including the “Thermal Tortuosity” value. This value is computed using following formula:

Thermal conductivity of pore phase

: Apparent thermal conductivity

𝜑: Volume Fraction of Pore space

Reference:

Cooper, S. J., et al. "Image based modelling of microstructural heterogeneity in LiFePO4 electrodes for Li-ion batteries." *Journal of Power Sources* 247 (2014): 1033-1039.

**Electrical Tortuosity**:

This module computes the tortuosity based on the computed Formation factor, result of the “Formation Factor Experiment Simulation” module.

This module needs to be attached to the Spreadsheet that include the Formation Factor value.

This module need as second input the binary data representing the pore phase. When attached to the spreadsheet, the module will try to retrieve automatically this binary data. If necessary it is possible to manually select the right binary input from “Binary image” port.

The output is a Spreadsheet including the “Electrical Tortuosity” value. This value is computed using following formula:

Formation Factor

𝜑: Volume Fraction of Pore space

Reference:

E Ullman, William J., and Robert C. Aller. "Diffusion coefficients in nearshore marine sediments 1." *Limnology and Oceanography* 27.3 (1982): 552-556.

**Flow Tortuosity**:

This module computes the tortuosity based on the computed Flow Velocity vector field, result of the “Absolute Permeability Experiment Simulation” module.

This module needs to be attached to the vector field volume data.

This module need as second input the binary data representing the pore phase. When attached to the spreadsheet, the module will try to retrieve automatically this binary data. If necessary it is possible to manually select the right binary input from “Binary image” port.

The output is a Spreadsheet including the “Flow Tortuosity (Magnitude)” and/or “Flow Tortuosity (Streamlines)” values, depending the method selected.

Regarding the “Magnitude” method, the value is computed using following formula:

Regarding the “Streamlines” method, Streamlines are generated from the vector field. The tortuosity of each streamlines are measured. The Tortuosity of the pore phase can be computed by averaging tortuosity of all streamlines:

There is potentially 2 outputs generated: A Spreadsheet including the computed tortuosity. In case of “Streamlines” method has been used, a SpatialGraph containing all streamlines information is also generated.

From a the generated SpatialGraph, it is possible to generate a “Tortuosity distribution” graph, which is also highly valuable information for some applications.

Reference:

Aaltosalmi, Urpo. *Fluid flow in porous media with the lattice-Boltzmann method*. No. 3/2005. University of Jyväskylä, 2005.

Tye, F. L. "Tortuosity." *Journal of Power Sources* 9 (1983): 89-100.

**Method**:

2 methods can be selected: “Magnitude” and “Streamlines”

**Orientation**:

This is initialized depending the setting of the “Absolute Permeability experiment Simulation” module. Other Orientation will be disable.

**Streamlines Density**:

This port is visible only when the “Streamlines” method is checked.

Higher density will lead to generate more streamlines. On large data computing time can be long when using too high density

**Minimum length ratio**:

This port is visible only when the “Streamlines” method is checked.

When equal to 1 only fiber with a distance start to end is equal or greater than the height of the sample.

Reducing this value will allow keep streamlines that are shorter than the height of the sample

**Display**:

This port is visible only when the “Streamlines” method is checked and Apply button has been pressed.

2 options can be selected: “Streamlines” and “Histogram”.

When “Streamlines” display option is checked, The streamlines can be visualized inside the 3D viewer. The tortuosity of each streamlines are mapped with color. Red streamlines have highest tortuosity while Blue ones have a a low tortuosity

When “Histogram” display option is checked, A graph showing the tortuosity distribution appears in the 3D viewer.

**Streamlines Tortuosity**:

This port is visible only when the “Streamlines” display option is checked.

Colormap used for mapping Tortuosity with the streamlines.

**Streamlines Scale**:

This port is visible only when the “Streamlines” display option is checked.

Adjust the scale of displayed streamlines.