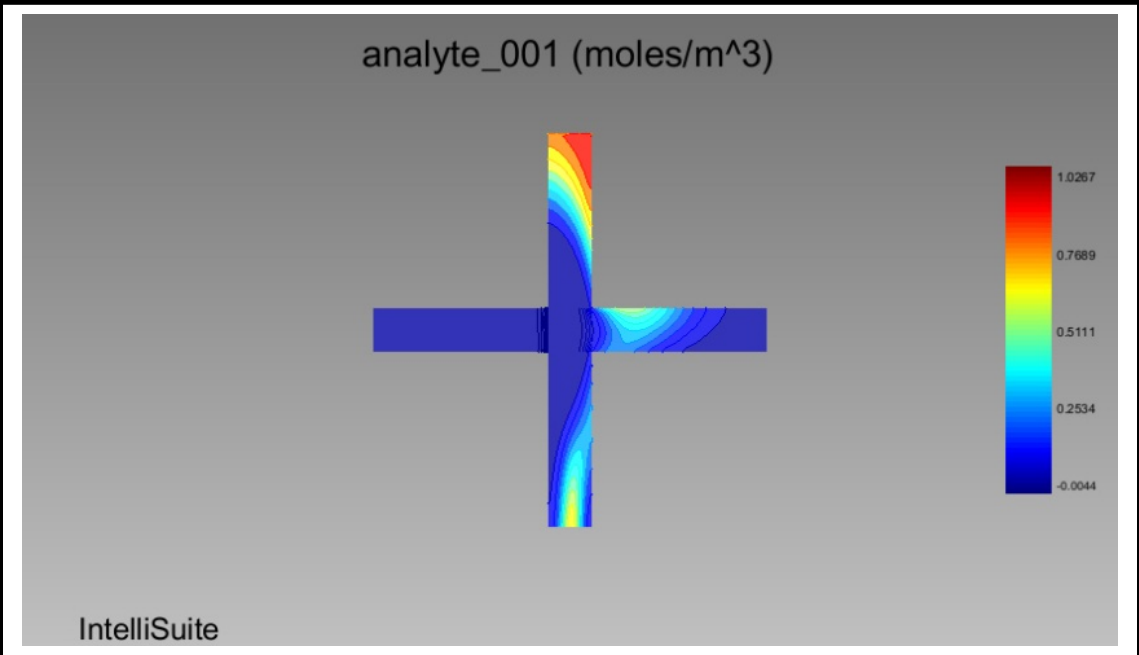
Application Note

Electrophoresis Analysis of A Cross Injector



Application Note: Electrophoresis Analysis of A Cross Injector
Version 8.6/PC

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1. Introduction

Electrophoresis is the motion of particles dispersed in a fluid under the influence of a spatially uniform electric field. The particle migration is due to the presence of a charged interface between the particle surface and the surrounding fluid. Specifically, the dispersed particles have electric charges on their surfaces, and an external electric field exerts an electrostatic force on the charges to cause the migration.

Because positively-charged ions will move toward a negative electrode and negatively-charged ions will move toward a positive electrode, electrophoresis can be used as a technique to separate oppositely-charged ions. In fact, electrophoresis has become a main technique for molecular separation in cell biology.

In a microfluidic separation system, the injector is a very critical component because it determines the shape and quantity of the analyte to be used for separation and analysis. Common microfluidic electrokinetic injector forms include the T, double-T, cross and double-cross, etc.

Figure 1 shows the topology of a 2-stage cross injector. In the first stage (loading stage), a driving electric field in the vertical direction pulls the analyte downward and an accessory electric field in the horizontal direction pinches the analyte. In the second stage (dispensing stage), an accessory electric field vertically moves the analyte away to ensure a clean exit while a driving field horizontally drives the analyte from the intersection into the separation channel.

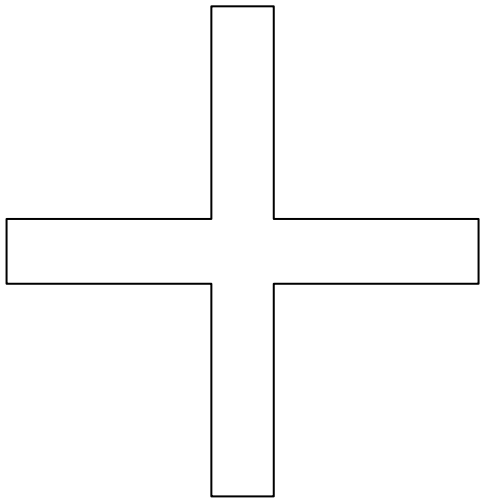

Figure 1 Topology of a cross injector

This example will demonstrate the electrophoresis analysis of the performance of a cross injector model.

2. Electrophoresis analysis

2.1. Open the model file

Click *Start … Programs … IntelliSuite … Microfluidic*

This opens a window of the Microfluidic Analysis module.

Click *File … Open*

From the `IntelliSuite\Training\Application_Notes\Electrophoresis\` folder, select the file `Cross_Injector.save`.

Figure 2 shows the model of the cross injector.

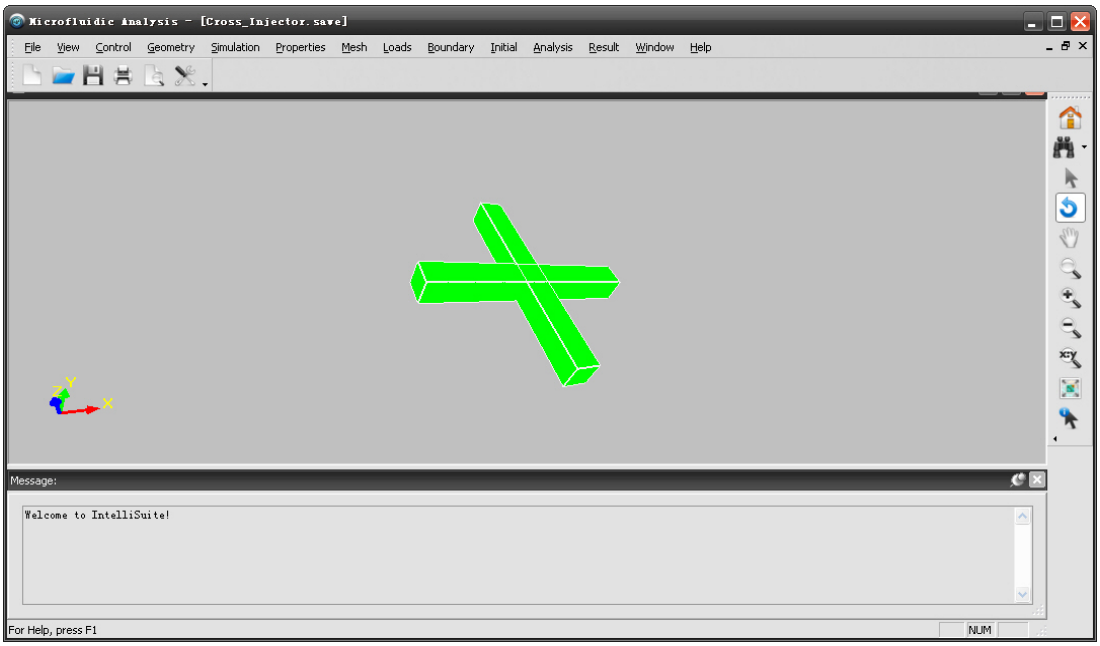

Figure 2 Model of the cross injector

2.2. Set up the simulation

Click *Simulation … Simulation Setting*

A simulation setting dialog box will appear. Specify the simulation settings as shown in Figure 3.

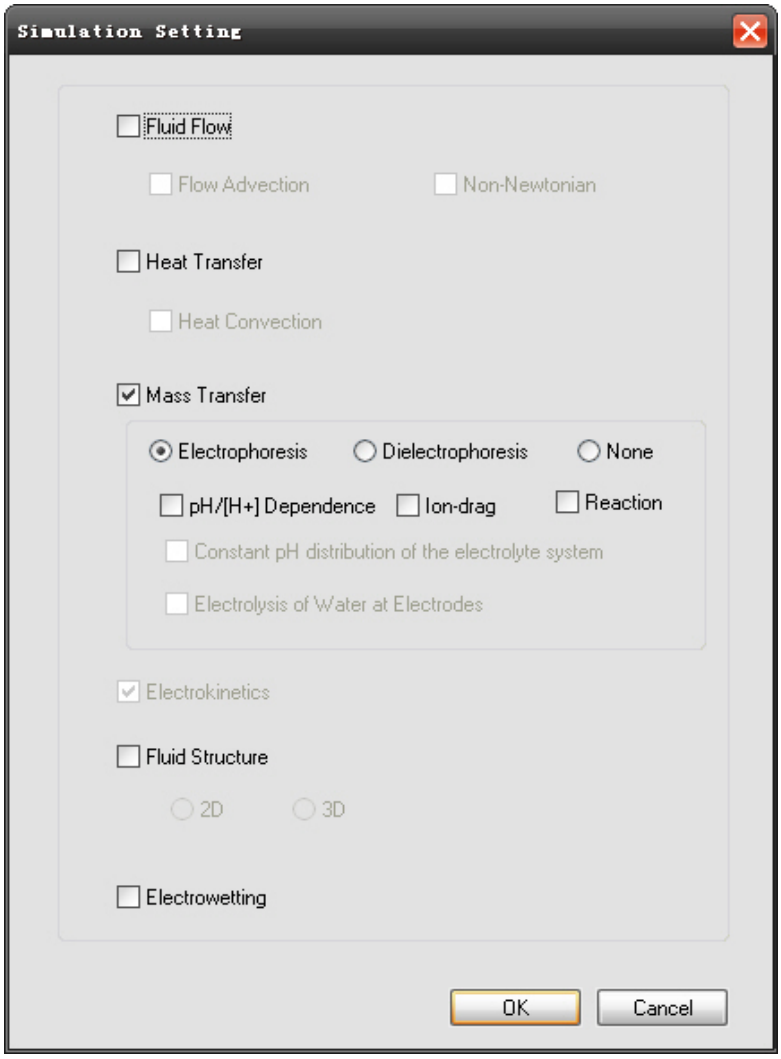

Figure 3 Simulation setting dialog box

2.3. Edit entity properties

The analyte should be added before simulation.

Click *Properties … Edit Fluid (Global)*

A property editing dialog box will pop up, as shown in Figure 4.

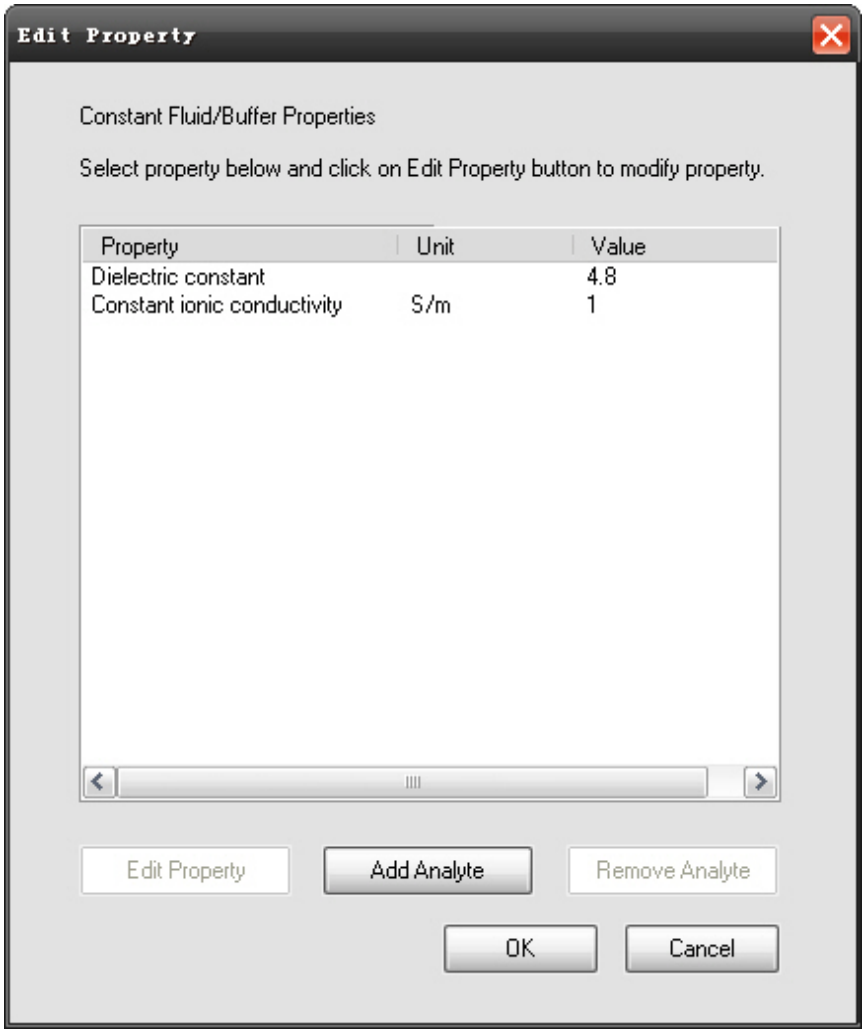

Figure 4 Property editing dialog box

Click on **Add Analyte**. After the analyte property specification dialog box pops up, enter property values as shown in Figure 5.

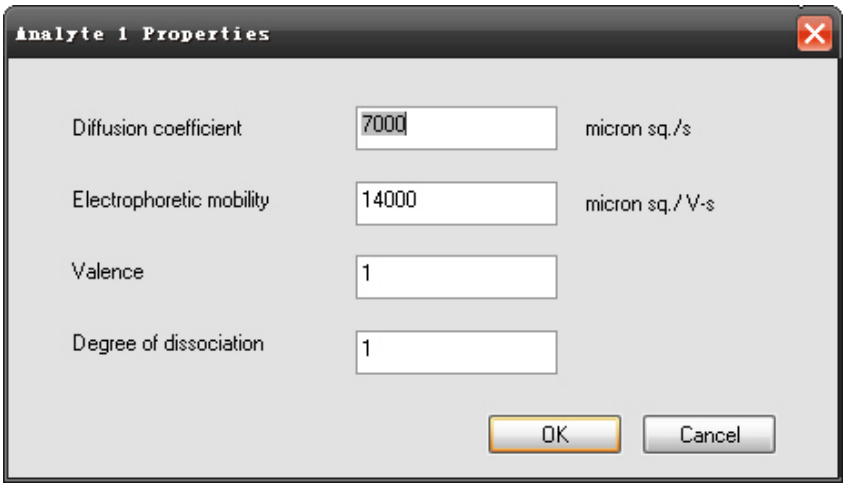

Figure 5 New analyte properties

2.4. Mesh the structure

Click *Mesh … Auto … Maximum Mesh Size*

Enter a maximum mesh size of 10 μm as shown in Figure 6.

Note: The mesh refinement will not be displayed, but will be used for simulation.

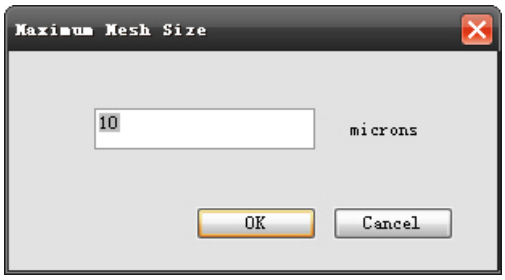

Figure 6 Maximum mesh size

2.5. Set boundary conditions

Click *Boundary … Electrokinetics BC … Voltage*

Set the voltage on the top surface of the port on the top (mixer) as a function of time (Figure 7).

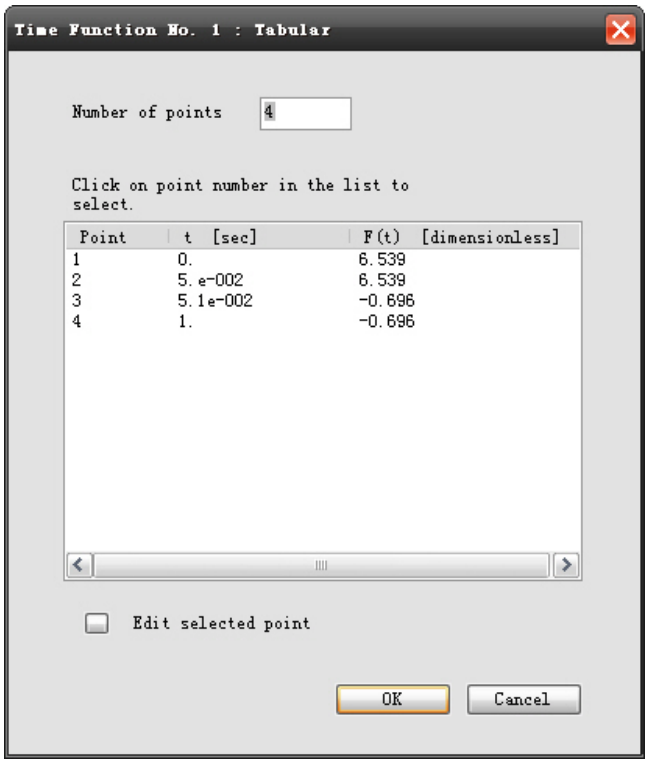

Figure 7 Voltage at the mixer (top port)

Set the voltage on the right surface of the port on the right hand side (separator) as a function of time (Figure 8).

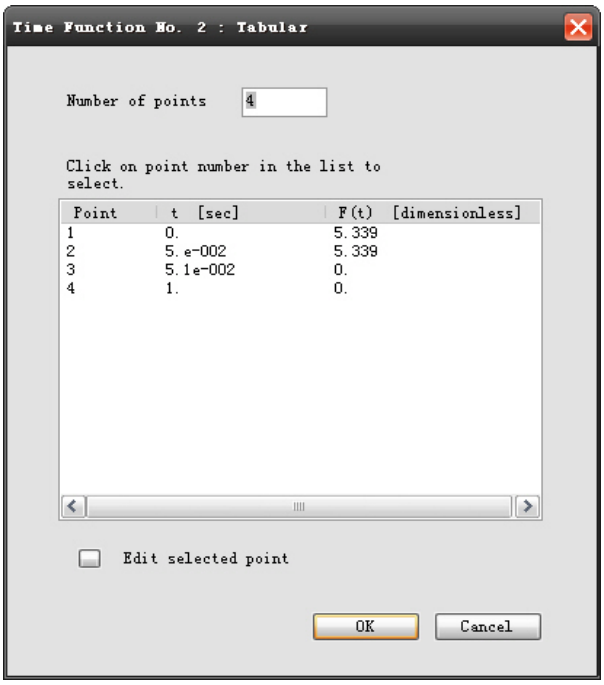

Figure 8 Voltage at the separator (right port)

Set the voltage on the bottom surface of the port on the bottom (waste port) as a function of time (Figure 9).

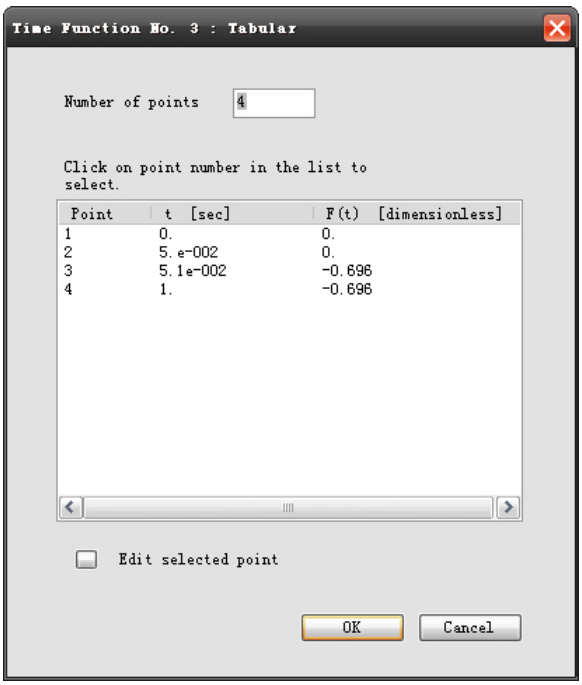

Figure 9 Voltage at the waste port (bottom port)

Set the voltage on the left surface of the port on the left (buffer) as a function of time (Figure 10).

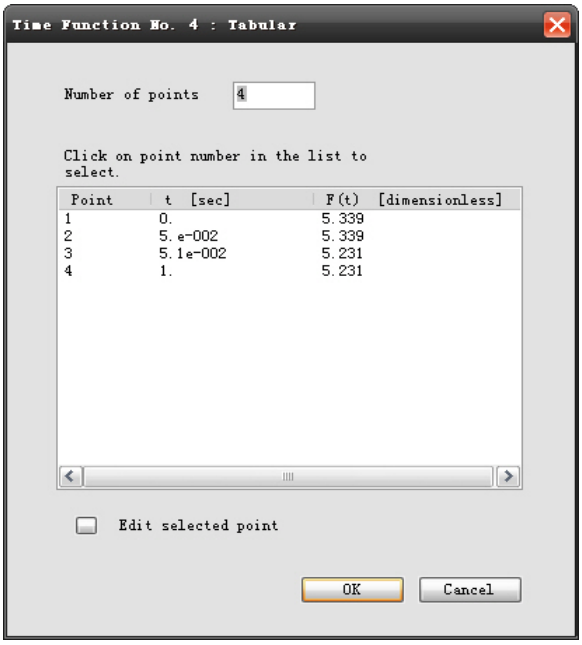

Figure 10 Voltage at the buffer (left port)

Click *Boundary … Mass BC … Analyte concentration*

Click on the top surface of the port on the top (mixer) to select it. Double click on **Analyte-1**. Set the analyte concentration on the top port as a function of time (Figure 11).

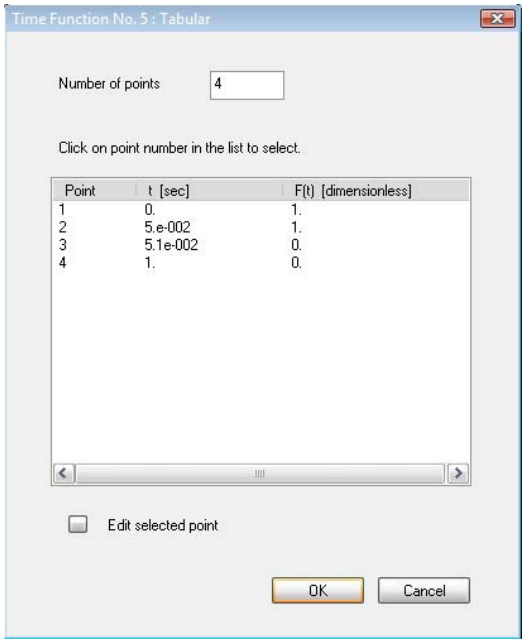

Figure 11 Analyte concentration on the top port

2.6. Run the analysis

2.6.1 Define convergence criteria

Now the user can define the convergence criteria for this simulation.

Click *Analysis … Transient*

A transient analysis parameter setting dialog box will pop up. Set the parameters as shown in Figure 12. Specifically, enter 0.01 for the flow/heat/mass transfer tolerance, and 0.0001 for the electric potential tolerance, which are the convergence limits for one time step. Set 50 for the number of iterations, which is the maximum iteration number at one time step. Set 1e-3 for the time step increment, which is the time step interval. Enter 0.1 second for the final solution time (Final time option), and 50 for the number of dumps, which is the temporary result file number.

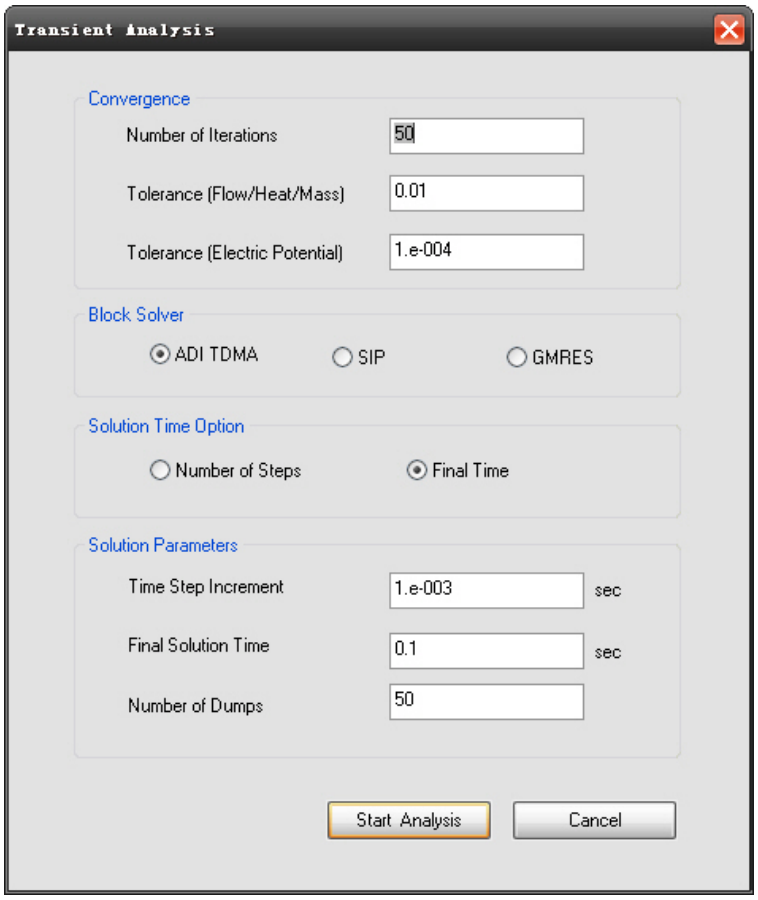

Figure 12 Transient analysis parameters

2.6.2 Start simulation

Click *Start Analysis*

2.7. View the results

When the simulation is finished, the resulted dump files can be shown in the postprocessor module of Visualease.

Click *Result … Select Dump*

Select `dump_001.dat`.

Click *Result … Open Visualease*

Select `analyte_001` in Visualease. View frames 25 (Figure 13) and 32 (Figure 14).

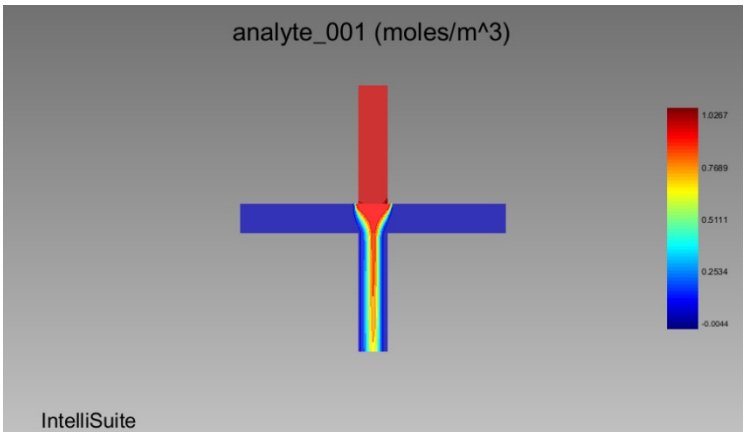

Figure 13 Loading stage

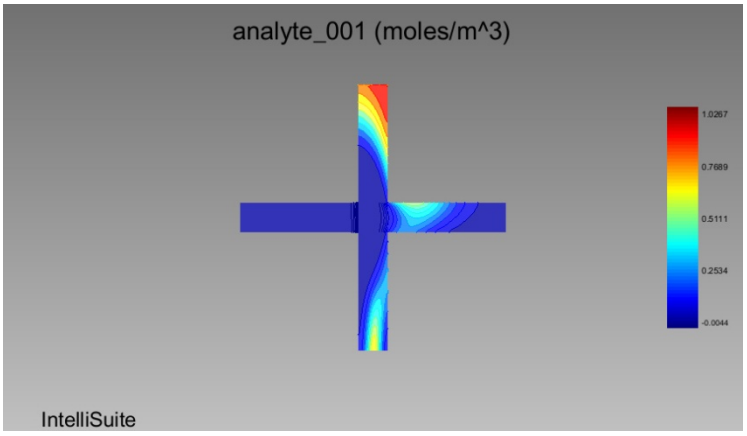

Figure 14 Dispensing stage

References

[1] R. Magargle, J.F. Hoburg and T. Mukherjee, An injector component model for complete microfluidic electrokinetic separation systems, *NSTI-Nanotech 2004*, V1(77-80)

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