Microfluidic Simulation Of A Separation System Of T.cruzi From Blood Samples

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Abstract

In 2014, it was estimated that there are between 6 to 7 million people worldwide infected by Chagas disease and approximately 25 million people are currently at risk. The parasite Trypanosoma cruzi (T. cruzi) causes this disease and according to the World Health Organization (WHO) it can be found all over the world with its highest incidence rates in Latin American countries. In the United States, the Center for Disease Control (CDC) ranks Chagas among the top five neglected parasitic infections (NPI) and, consequently, considers Chagas disease a public health system target.
The Chagas disease develops in two phases. First, the acute phase, where the parasite freely circulates in the bloodstream. This phase is asymptomatic and generally lasts for about 8 to 12 weeks. The current available treatments are effective only during this phase. The second phase is the chronic phase, where the parasites invade heart and digestive muscles. In this phase, the disease is detectable with the aid of antibody-based testing systems.
To address these challenges, we are developing a spiral microfluidic system to separate and detect the parasite in blood samples. Using COMSOL Multiphysics® software we designed and simulated a parametric geometry in to analyze different parameters on the Chagas separation from the blood cells. The device consists of 5 turns, a 0.5mm wide channel and 4 outlets with a 60° opening (Figure 1). Using a CFD Module, we modeled the behavior of the fluid as a laminar flow with a Reynolds number of 10. Using a Particle Tracing Module, parasites and red blood cells were defined as spheres with a diameter of 30µm and 8µm respectively. In addition, we defined the drag force and the lift force, which will generate the separation of the particles. In a curvilinear microchannel, the interaction of Dean drag and lift forces usually results in an equilibrium position along the channel periphery. The Drag force was assumed like Stokes drag and the lift force was defined as an external force in the physic of particle tracing.
The convergence of the solutions was tested by evaluating the changes of the fluid velocity at different locations in the spiral, as a function of the number of element in the mesh. The convergence is achieved above approximately 2 million elements. The velocity profile describes a parabolic behavior; however, the outer wall of the microchannel in the spiral experimented a higher velocity, as compared to the inner wall. Finally, results of particle tracing suggested that the most influential factors are the number of turns, the initial spiral radio, and the distance between the end of the spiral and the outputs.

Figures used in the abstract

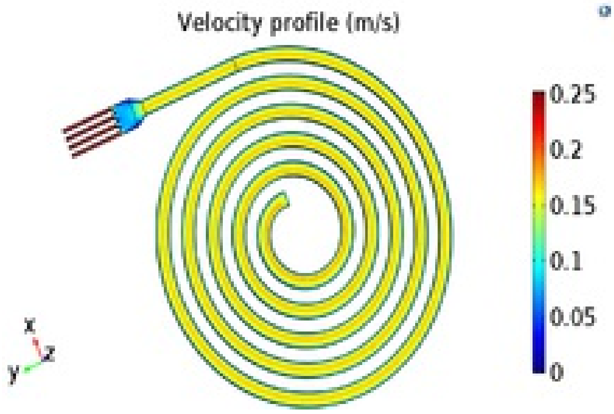

Figure 1 : The velocity field in the microfluidic device.