Proceedings of the 2nd International Conference on Fluid Flow, Heat and Mass Transfer
Ottawa, Ontario, Canada, April 30 – May 1, 2015
Paper No. 142

Hematocrit and Microchannel Dimension Effects on Human Blood Rheology at Low Shear Rates

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Extended Abstract

Understanding the rheology of blood can provide indications of various pathological conditions or physiological processes. The lack of established parameters of the velocity profile of blood flow in microcirculation is under investigation for current research and modelling. Blood comprises of solid particles suspended in a plasma matrix, which makes the rheology at the micro-level complex. This complexity arises due to the continuum assumption of the Navier-Stokes equations breaking down. Approaching the microcirculation conditions in experiments will help in studying the pathological counterparts.

Blood is a non-Newtonian fluid and exhibits shear thinning and a rheological hysteresis at low shear rates (Bureau *et al.* 1980). Bureau *et al.* (1980) studied rheological hysteresis of blood using Couette flow viscometers for healthy human blood, to compare with samples containing pathological conditions. Constitutive models have since been proposed to model the aggregation and disaggregation of blood (Owens 2006, Fenech *et al.* 2009), which agree with the experimental data from Bureau *et al.* (1980). The aim of this study is to investigate the blood viscosity in rectangular channels with dimensions comparable to smaller blood vessels (diameter of 100 micrometres and below). The viscosity at this scale is investigated by measuring pressure drop and blood flow rate using cutting edge microfluidics technology.

Human blood samples are washed and prepared at different hematocrits. The blood is pressure driven through a microchannel network, which is fabricated in a polydimethylsiloxane (PDMS) chip. The chip design consists of two tapered chambers connected together with parallel channels, which are relatively small compared to the chambers. Located in each chamber are micropillars, which have the aim to mix and disaggregate the blood cells. The joining channels are designed to have a rectangular cross section, with a height of 100 micrometres. A range of channel widths will be examined to investigate their influence on the cell-free layer within the channels, as previously studied by Fåhræus and Lindqvist (1931) and Fedosov *et al.* (2012). Two-dimensional serpentine channels will be connected in series between the inlet and first chamber. These channels provide the ability to fine-tune hydraulic resistance and, consequently, the pressure drop across the small parallel channels. A low differential pressure sensor is connected inline before and after the tapered chambers, which can measure ±5 inches of water (±1245 Pascals). A microflow sensor is connected to the outlet tube of the chip to measure the flow rate, which has a measurement range of ±7 microlitres per minute.

Preliminary experimental results using water or human blood samples indicate the feasibility to precisely control and measure the pressure and flow rate with computer controlled timing. This control allows for a timed and uniform process, with an aim to reduce the settling of blood cells. The effect of hematocrit and channel width on the viscosity at low shear rates will be analysed using the microfluidic designs. These parameters will be used for the characterization of pathologically impaired flows, for the validation of computational models of microcirculation, and for biomedical engineers designing lab-on-a-chip devices.

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