Electrical properties with relaxation through human blood

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The present work aims to study the effects of the blood-microstructure on the electrical conduction from two different but correlated properties: Electrical and mechanical (viscosity), and to derive useful parameters for the evaluation of electrical conduction as a function of the blood viscosity. ac-conductivity and dielectric constant of normal and diabetic blood are measured in the frequency range 10 kHz–1 MHz at the room temperature. An empirical relation relating the resistivity and viscosity of the blood has been presented. The results show that a microfluidic device is a viable and simple solution for determination of electrical and rheological behaviors of blood samples. © *2010 American Institute of Physics.* [doi:10.1063/1.3458908]

I. INTRODUCTION

In recent years the measurement of blood impedance through an alternating current has been suggested as a noninvasive approach to determine some blood disorders.[1] Human blood has non-Newtonian fluid dynamic characteristics, the most important of which is the correlation between its microstructure and the electrical and mechanical properties. The intrinsic and extrinsic microcells, molecules, bacteria, protein, hormones, glucose, chemicals, vitamins, and antibodies affect drastically the chemical and physical characters of the viable fluid. For example, Zhou *et al.*[2] showed that deformability of erythrocyte is found to alter the wetting dynamics of red blood cell (RBC) suspensions during their invasion into capillaries. This effect shows the importance of the RBC deformability on microvascular perfusion by directly measuring the flow of blood through a microchannel network with realistic dimensions and architecture similar to real microcirculation.[3] This prevents eventually the congenital dyserythropoietic anemia.[4] Moreover, Zhou and Chang[5] found that blood suspension fails to penetrate a capillary with radius less than 50 μm even if the capillary is perfectly wet table. This is of great significance and consequences in evaluating blood flow occlusion after selective pulmonary artery perfusion.[6] Moreover, Basuray and Chang[7] demonstrated that the characteristic relaxation frequency of induced nanodipoles by dielectrophoresis is inversely proportional to the charging and discharging time of the diffuse-layer capacitance in microfluids, which affects both the electrical and mechanical properties of the blood.

In general, the electrical properties of human blood have received much of interest some decades ago for many reasons.[8–10] First, they determine the pathways of current flow through the body and, thus, are very important in the analysis of a wide range of biomedical applications, such as functional electrical stimulation and the diagnosis and treatment of various physiological conditions with weak electric currents, radio-frequency hyperthermia, body composition, and electrocardiography.

Second, on a more fundamental level, knowledge of these electrical properties can lead to an understanding of the underlying basic biological processes either on macroscopic level or microscopic one and to correlate between the two extents. Third, biological impedance studies have long

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