Microfluidic Electrical Impedance Spectroscopy for Blood Analysis

by

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ABSTRACT

The study of the electrical properties of red blood cells (RBCs) plays a crucial role in advancing our understanding of human health. As RBCs age, they undergo changes that affect hemorheology and blood microcirculation, which have far-reaching implications for disease research. Furthermore, the shortage of RBC storage units can be a major issue for patients, underscoring the importance of characterizing RBC aging with respect to cell densities. In individuals with abnormal hemoglobin disease, alterations in hemoglobin and its functionality can modify the volume and density of RBCs, making their study even more crucial. To this end, our aim is to investigate the impedance alterations of RBCs after distributing them into different layers based on their densities. We have developed a novel method for non-invasive, rapid, and real-time single-cell analysis of RBCs. Our approach involves the use of electrical impedance spectroscopy (EIS) to study the cells after performing cell fractionation. Our studies indicate an increasing trend for RBC resistance and a decreasing trend for the cell membrane as the density of the layer increases. Additionally, we have developed a method for extracting hemoglobin with high purity from fresh blood samples. By passing lysed RBCs through ultrafiltration devices and removing debris and membranes, we were able to isolate hemoglobin. Using the EIS technique, we studied the alterations of impedance over a frequency range, obtaining valuable insight into the electrical properties of hemoglobin.