Dielectric Properties of CHO Cells Obtained Using a Microwave Interferometer Based Dielectrophoresis Cytometer

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Studying biological phenomena at the cellular level allows understanding the basics of cellular function and the mechanism of their interactions with internal or external stimuli. Among available single cell analysis techniques such as, fluorescent labeling, magnetic labeling, mechanical, and electrical approaches, electrical ones are of special interest due to their minimum influence on the natural state of cells. Dielectrophoresis (DEP) cytometry- translation of cells in a non-uniform electric field- is an electrical based technique previously employed for differentiation and characterization of cells (R. Pethig, *Biomicrofluidics*, 2010). In this work we employ a microwave based DEP cytometry technique that we have developed to obtain dielectric parameters of Chinese Hamster Ovary (CHO) cells, a cell line with prominent pharmaceutical applications for production of therapeutic proteins. Cell electrical parameters are not well established. We present a model for CHO using a double shell model comprising the cell membrane, cytoplasm, nuclear envelope, and nucleus.

A cell exposed to a non-uniform electric field experiences a DEP force with an amplitude and direction that is dependent on the polarizability of the cell with respect to its surrounding medium. Since the cell polarizability is related to the charging time constant of its internal compartments as well as the cell/medium interface, measurements of the DEP induced actuation of a cell over a frequency range can be used to infer its dielectric properties.

Using a microfluidic device with embedded actuating and sensing electrodes we actuate and measure the DEP response of individual cells while in flow. Determination of the cell DEP induced translation is achieved electronically using a microwave interferometer which senses the capacitance change of sensing electrodes due to a cell before and after DEP application (G. Ferrier et al., *Lab on a Chip*, 2009). The microwave interferometer operates near 1GHz where interfacial dispersion is reduced and combined with a lock-in-amplifier the detection sensitivity of the system is 230 zF for a 42 Hz bandwidth. The DEP actuation of cells is performed over the frequency range of 0.6 to 10 MHz where dispersions due to the cell membrane, cytoplasm, nuclear envelope, and nucleus are pronounced. Measuring the DEP response of approximately 300 cells at different frequencies and medium conductivities and using an optimization procedure, we are able to obtain the membrane capacitance, cytoplasm conductivity, nuclear envelope capacitance, and nucleus conductivity of CHO cells.