Dual Frequency Dielectrophoresis Study of Single Cells under Controlled Starvation

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1. Extended Abstract

Development of electrical techniques for the characterization and identification of biological cells has attracted growing interest due to its label-free and non-invasive nature. Biological cells show unique dielectric properties which can be employed to monitor their progress from a healthy viable state to non-viable state and to eventual cell death. Dielectrophoresis (DEP) as an electrical-based technique, offers a promising approach to investigate the changes in dielectric properties of single cells [1].

In previous work, we demonstrated how the change in the sign of the DEP force at one frequency could be used to distinguish viable cells from non-viable ones [2]. We have developed a dual DEP cytometer capable of simultaneously measuring DEP response of single cells at two different frequency. In this technique, the first frequency, f_1, is switched between kHz and MHz frequencies to characterize the membrane capacitance and cytoplasm conductivity of viable and non-viable cells. The second frequency, f_2, is set at the frequency in which DEP force reverses and is an indicator of cell viability state.

In this work, the variation in DEP response of single Chinese Hamster Ovary (CHO) cells as they change state from viable to non-viable was investigated. Cell samples were cultured in media without nutrients (glutamine and glucose) and their DEP response was measured at several intervals over 64 hours. The measurement was performed at f_1=6 MHz and 300 kHz, where the DEP response of the cells are dominated by the cytoplasm conductivity and membrane capacitance, respectively. The second frequency, f_2, was set to 7 MHz, and used to differentiate viable cells from non-viable ones. At this frequency, the direction of the DEP force reverses which stems from drastic drop in the ion content of the cytoplasm of non-viable cells. Fig. 1 presents the measurement results over time. It indicates that the state of single CHO cells changes from viable to non-viable after 64 hours of incubation in a medium without nutrients. It also reveals that the decline in the DEP response at 300 kHz is attributed to the decrease in cell membrane capacitance and decline at 6 MHz is attributed to decrease in ion content of the cytoplasm.

2. References

[1] Y. Zheng, J. Nguyen, Y. Wei, and Y. Sun, "Recent advances in microfluidic techniques for single-cell biophysical characterization.," *Lab Chip*, vol. 13, no. 13, pp. 2464–83, 2013.

[2] M. Nikolic-Jaric, T. Cabel, E. Salimi, A. Bhide, K. Braasch, M. Butler, G. E. Bridges, and D. J. Thomson, "Differential electronic detector to monitor apoptosis using dielectrophoresis-induced translation of flowing cells (dielectrophoresis cytometry)," *Biomicrofluidics*, vol. 7, no. 2, pp. 1–14, 2013.

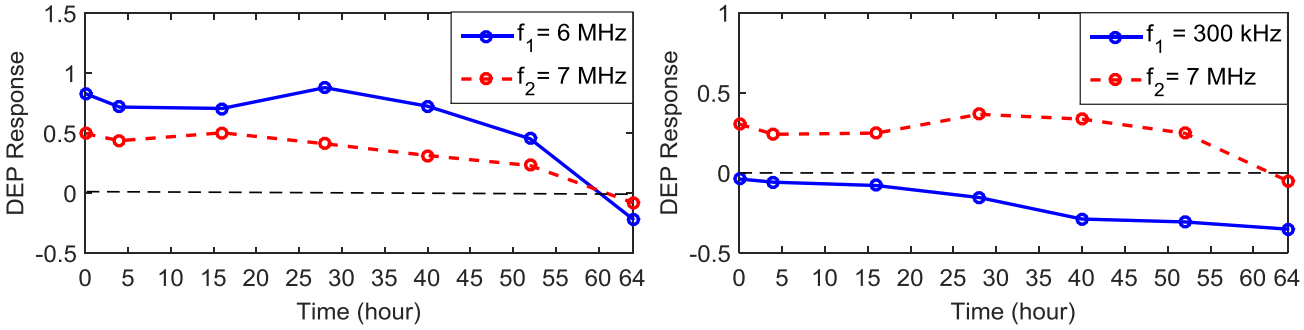

Figure 1. a) DEP response of many single CHO cells undergoing starvation for two different cases f_1= 6 MHz, f_2=7 MHz, and f_1=300 kHz, f_2=7 MHz over 64 hours as the state of the cells change from viable to non-viable.