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Hydrogel-based conducting polymer electrode systems for effective stimulation of cells and tissues

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In vitro assays using an electrical stimulation system are required for quantitative investigation of the electrophysiological functions of cells such as neurons, cardiac cells, and skeletal muscle cells, as well as for stem cell-derived organs and tissues in the near future. Conventional electrical stimulation has been performed using a pair of electrodes immersed away from the cells at either side of the culture chamber because the faradic reaction at stimulation electrodes often causes evolution of cytotoxic gas and pH change. We have utilized a composite of the conducting polymer poly(3,4-ethylenedioxythiophene) (PEDOT) and polyurethane (PU) that retains large surface capacitance (~10 mF cm-2) and thus in order to conduct non-faradaic electrical stimulation with charge/discharge currents. Here, we will present applications of the PEDOT/PU electrodes to the effective stimulation of skeletal muscle cells and cardiomyocyte cells derived from induced pluripotent stem cells (hiPSCs). Skeletal muscle cells were cultured so as to wrap around a PEDOT/PU electrode wire to enable their selective stimulation even when they were co-cultured with other electrically-excitable cells. The advantage of this new culture system was demonstrated in the study of chemotactic interaction of monocytes and skeletal muscle cells via myokines. On the other hand, the hydrogel-based bioreactor integrated with organic electrodes (PEDOT/PU or PEDOT-coated carbon fabric) has been fabricated for efficient electrical stimulation of the spheroids of cardiomyocytes differentiated from hiPSCs. The spheroids were cultured in the bioreactor, and their beating frequency was synchronized to frequency of electrical stimulation applied by the electrodes.

Biography

Nishizawa has received his PhD degree from Tohoku University in 1995. He has published more than 150 papers in reputed journals. Reserach interest is in medical electronic devices made of soft/wet organic materials. .

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