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Minimally-Invasive Gene Transfection by Chemical and Physical Interaction of Atmospheric Pressure Plasma Flow[1]

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Non-equilibrium atmospheric pressure plasma irradiated to the living-cell is investigated for medical applications such as gene transfection, which is expected to play an important role in molecular biology, gene therapy, and creation of induced pluripotent stem (iPS) cells. However, the conventional gene transfection using the plasma has some problems that the cell viability is low and the genes cannot be transferred into some specific lipid cells, which is attributed to the unknown mechanism of the gene transfection using the plasma. Therefore, the time-controlled atmospheric pressure plasma flow is generated and irradiated to the living-cell suspended solution for clarifying the transfection mechanism toward developing highly-efficient and minimally- invasive gene transfection system. In this experiment, fluorescent dye YOYO-1 is used as the simulated gene and LIVE/DEAD Stain is simultaneously used for cell viability assay. By the fluorescence image, the transfection efficiency is calculated as the ratio of the number of transferred and surviving cells to total cell count. It is clarified that the transfection efficiency is significantly increased by the short-time (<4 sec) and short-distance (<40 mm) plasma irradiation, and the high transfection efficiency of 53% is realized together with the high cell viability (>90%). This result indicates that the physical effects such as the electric field caused by the charged particles arriving at the surface of the cell membrane, and chemical effects associated with plasma-activated products in solution act synergistically to enhance the cell-membrane transport with low-damage.

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