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Photoelectrical Stimulation for Cancer Therapy

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Abstract : Photoelectrical stimulation of cells with semiconductor organic polymers have been shown promising applications in neuroprosthetics such as retinal prosthesis. Photoelectrical stimulation of the cell membranes can be induced through a photo-electric charge separation mechanism in the semiconductor materials, and it can alter intracellular calcium level through both stimulation of voltage-gated ion channels and increase of intracellular reactive oxygen species (ROS) level. On the other hand, targeting voltage-gated ion channels in cancer cells to induce cell apoptosis through calcium signaling alternation is an effective mechanism which has been explained before. In this regard, remote control of the voltage-gated ion channels aimed to alter intracellular calcium by using photo-active organic polymers can be novel technology in cancer therapy. In this study, we used P (ITO/Indium thin oxide)/P3HT(poly(3-hexylthiophene-2,5-diyl)) and PN (ITO/ZnO/P3HT) photovoltaic junctions to stimulate MDA-MB-231 breast cancer cells. We showed that the photo-stimulation of breast cancer cells through photo capacitive current generated by the photovoltaic junctions are able to excite the cells and alternate intracellular calcium based on the calcium imaging (at 8mW/cm^2 green light intensity and 10-50 ms light durations), which has been reported already to safety stimulate neurons. The control group did not undergo light treatment and was cultured in T-75 flasks. We detected 20-30% cell death for ITO/P3HT and 51-60% cell death for ITO/ZnO/P3HT samples in the light treated MDA-MB-231 cell group. Western blot analysis demonstrated poly(ADP-ribose) polymerase (PARP) activated cell death in the light treated group. Furthermore, Annexin V and PI fluorescent staining indicated both apoptosis and necrosis in treated cells. In conclusion, our findings revealed that the photoelectrical stimulation of cells (through long time overstimulation) can induce cell death in cancer cells.

Keywords : Ca^{2+} signaling, cancer therapy, electrically excitable cells, photoelectrical stimulation, voltage-gated ion channels
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