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Up converting nanoparticles mediated Optogenetics for deep tissue neural activation

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Abstract

Optogenetics is an emerging powerful tool to investigate the nervous system. However, the use of low tissue penetrating visible light limits its therapeutic potential. In this study, we synthesize NaGdF4:Yb3+/Tm3+@NaGdF4 nanoparticles and presented it for deep penetration of neural activity using fully implantable micro-devices. Up-conversion nanoparticles (UCNPs) used as transducers to convert locally near-infrared (NIR) energy into visible light in order to stimulate neurons expressing different opsin. We focused on near infrared (980 nm) light. In our setup, UCNPs packaged in a glass micro-optrode to form an implantable device with long-term biocompatibility. We showed that NIR (980 nm) illumination is reliably trigger activity in mice brains. The up-conversion neural stimulation technique implemented to modulate brain activity in various regions, including the striatum, ventral tegmental area, and visual cortex. Furthermore, imaging on brain tissue slices performed at KFUEIT (Pakistan) to understand spatial distribution and signal strengths for optogenetics activation of the micro-optrodes loaded with UCNPs. Notably, our microscale device is least one order of magnitude smaller in size (~90 μm in diameter) and two orders of magnitude lighter in weight (less than 0.8 mg) approximately than existing optogenetic devices based on light-emitting diodes. This feature allows implantation of UCNPs-optrode to achieve modulation of brain function to control complex behavior of mouse. This technology will opens up new possibilities for deep penetration of neural activity in the brain of mouse.

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