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Near-infrared optogenetics: A novel design for controlling the electric activity of targeted cells with upconverting nanoparticles

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Optogenetics is an innovative technology now widely adopted by researchers in different fields of the biological sciences. However, due to the weak tissue penetration capability of the short wavelengths used to activate light-sensitive proteins, an invasive light guide has been used in animal studies for photoexcitation of target tissues. Upconverting nanoparticles (UCNPs), which transform near-infrared (NIR) light to short-wavelength emissions, can help address this issue. To improve optogenetic performance, we enhanced the target selectivity for optogenetic controls by specifically conjugating the UCNPs with light-sensitive proteins at a molecular level, which shortens the distance as well as enhances the efficiency of energy transfer. We tagged V5 and Lumio epitopes to the extracellular N-terminal of channelrhodopsin-2 with an mCherry conjugated at the intracellular C-terminal (VL-ChR2m) and then bound NeutrAvidin-functionalized UCNPs (NAv-UCNPs) to the VL-ChR2m via a biotinylated antibody against V5 (bV5-Ab). We observed an apparent energy transfer from the excited UCNP (donor) to the bound VL-ChR2m (receptor) by measuring emission-intensity changes at the donor-receptor complex. The successful patch-clamp electrophysiological test and an intracellular Ca2+ elevation observed in the designed UCNP-ChR2 system under optogenetic manipulation confirmed the practical employment of UCNP-assisted NIR-optogenetic functionality. This work represents a significant step towards improving therapeutic optogenetics.

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Optical trapping in liquid crystals: Recent results

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We report our recent results about optical trapping in liquid crystals. Trapping in these materials is due to the optoelastic interaction occurring between a colloidal particle and a “ghost” colloid which results from the local distortion of the liquid crystal induced by a laser beam. This kind of interaction is induced by minimization of the elastic free energy of the system leading to particle trapping by the ghost colloid, as is the case occurring between two real colloidal particles. The effect has been investigated under experimental conditions which prevent the occurrence of conventional optical trapping induced by high gradient optical fields. We show that application of a low frequency electric field to a homeotropic sample of a nematic liquid crystal is able to control the strength and the range of the force acting on the nematic colloid. In case of liquid crystal with positive dielectric anisotropy the existence of a quenching voltage is demonstrated above which no interaction takes place, while in case of negative dielectric anisotropy an extremely large interaction range is demonstrated. Interaction range of few hundred microns has been observed.

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