Reconstructive neurosurgery

The topological cues of fibrous scaffolds (in particular extracellular matrix (ECM)-mimetic nanofibers) have already proven to be a powerful tool for influencing neuronal morphology and behavior. The remote photothermal treatment provides additional opportunities for neuronal activity regulation. A combination of these approaches can provide “smart” 3D scaffolds for efficient axon guidance and neurite growth. Antonova et al. proposed two alternative approaches for obtaining biocompatible photothermal scaffolds: surface coating of nylon nanofibers with light-to-heat converting nanoparticles and nanoparticle incorporation inside the fibers. We have determined the photoconversion efficiency of fibrous nanomaterials under near-infrared (NIR) irradiation, as well as biocompatible photothermal treatment parameters. We also measured photo-induced intracellular heating upon contact of cells with a plasmonic surface. In the absence of NIR stimulation, our fibrous scaffolds with a fiber diameter of 100 nm induced an increase in the proportion of β3-tubulin positive cells, while thermal stimulation of neuroblastoma cells on nanoparticles-decorated scaffolds enhanced neurite outgrowth and promoted neuronal maturation. We demonstrate that contact guidance decorated fibers can stimulate directional growth of processes of differentiated neural cells. We studied the impact of nanoparticles on the surface of ECM-mimetic scaffolds on neurite elongation and axonal branching of rat hippocampal neurons, both as topographic cues and as local heat sources. We show that decorating the surface of nanofibers with nanoparticles does not affect the orientation of neurites, but leads to strong branching, an increase in the number of neurites per cell, and neurite elongation, which is independent of NIR stimulation. The effect of photothermal stimulation is most pronounced when cultivating neurons on nanofibers with incorporated nanoparticles, as compared to nanoparticle-coated fibers. The resulting light-to-heat converting 3D materials can be used as tools for controlled photothermal neuromodulation and as “smart” materials for reconstructive neurosurgery [1)].

1)

Antonova OY, Kochetkova OY, Kanev IL. Light-to-Heat Converting ECM-Mimetic Nanofiber Scaffolds for Neuronal Differentiation and Neurite Outgrowth Guidance. Nanomaterials (Basel). 2022 Jun 23;12(13):2166. doi: 10.3390/nano12132166. PMID: 35808000.