Wireless charging-mediated angiogenesis and nerve repair by adaptable microporous hydrogels

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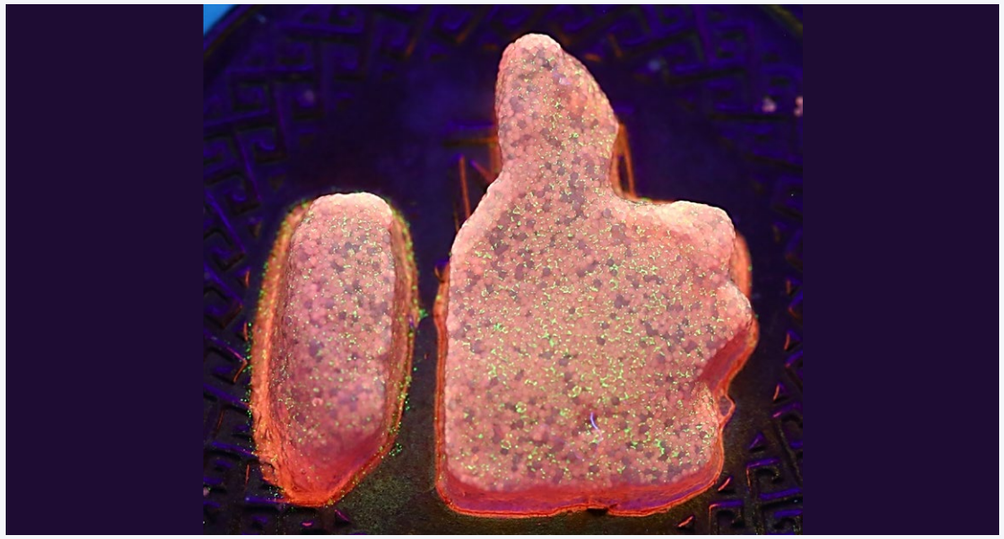

Wireless charging-mediated angiogenesis and nerve repair by adaptable microporous hydrogels from conductive building blocks

Repairing damage to the brain and spinal cord may be medical science's most daunting challenge. Survivors of traumatic brain injury (TBI) may find themselves wondering, can the brain repair? And the possibility is yes. The brain tissue is incredibly resilient and possesses the ability to repair through the process of angiogenesis, neurogenesis. Prof. Shang-Hsiu Hu and his team at National Tsing Hua University displayed a new class of hydrogel-assisted neuroregeneration approaches towards brain injury therapy.At a cost of $400 billion worldwide, an estimated 50 million people suffer from TBI due to the chronic dysfunctions of mood and permeant disability. Clinical trials in TBI to date have not specifically treatments at cerebral atrophy and lack of an effective medical therapy that promotes long-term recovery.

The critical reason for these consequences is that brain damage commonly results in extensive tissue loss and the barrier to tissue regeneration following injury to the central nervous system. However, a long-lasting repair response occurs angiogenesis and neurogenesis into the damaged tissue in the brain is problematic. Following trauma cavity, no extracellular matrix supports cell infiltration into the lesion or physically supports a growing tissue. A large influx of microglia, macrophages and the activation of highly reactive astrocytes, which release pro-inflammatory response and lead to further glial scarring and neuronal death in the peri-trauma area which results in cerebral atrophy (brain shrinkage) occurring in the motor/sensory cortex. These inflammation and glial scarring that impede brain tissue repair, so stimulating angiogenesis and recovery of brain function remain challenging. Currently, hydrogels for brain repair after trauma injury is an emerging treatment option.

Endogenous signals, such as nitric oxide (NO) and electrons, induce multifaceted physiological functions in the regulation of cell fate as well as vascular and neuronal systems. However, clinical difficulties exist due to the short half-life of NO and the lack of tools to spatiotemporally drive gas release and electrical stimulation. Additionals, we propose a "magnetoelectric massager" strategy based on alternating magnetic field (AMF)-triggered on-demand NO release and electrical stimulation to restore brain function in traumatic brain injury. The NO and electron transport system was constructed as a metal-organic framework (MOF)-derived molybdenum carbide octahedron (MoCx-Cu) and an NO donor (S-nitrosoglutathione, GSNO), which was embedded in an implantable silk in a microneedle. Under AMF irradiation, eddy currents on conductive MoCx-Cu induced NO release from GSNO through electrical stimulation, thereby significantly promoting the differentiation and growth of neural stem cell (NSC) synapses. A combined strategy of in vivo traumatic brain injury allows NO and electrical stimulation-mediated inhibition of inflammation, angiogenesis, and neuronal interrogation.

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Research Highlights

- 2022 MOST Outstanding Research Award
- 2022 National Innovation Award- Academic Innovation
- 2022 Future Tech Award
- 2022 Research Award on Biomadical Engineering of Prof. Chao-Ren Lee.

Research Output

- Yi-Chieh Chan, Ya-Hui Lin, Hsiu-Ching Liua, Ru-Siou Hsu, Ming-Ren Chiang, Li-Wen Wang, Tsu-Chin Chou, Tsai-Te Lu, I-Chi Lee, Li-An Chu*, Shang-Hsiu Hu*, In Situ Magnetoelectric Generation of Nitric Oxide and Electric Stimulus for Nerve Therapy by Wireless Chargeable Molybdenum Carbide Octahedrons, Nano Today, 2023, 51, 101935.
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