2021「中技社科技獎學金」
2021 CTCI Foundation Science and Technology Scholarship
境外生生活助學金
Living Grant for International Graduate Students

An anti-inflammatory electroconductive hydrogel with self-healing property for the treatment of Parkinson's disease

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Introduction Parkinson's disease (PD) is one of the most common neurodegenerative diseases. Herein, we designed an electroconductive hydrogel with self-healing and anti-inflammatory properties based on dialdehyde polyurethane, gold nanoparticles, and chitosan derivative. The hydrogel was prepared under physiological conditions with good biodegradability, proper conductivity, and small-gauge needle injectability. The hydrogel promoted the proliferation and differentiation of neural stem cells (NSCs) towards neuronal cells, and demonstrated an anti-inflammatory and rescue effect on inflamed NSCs (~80%). Injection of the electroconductive hydrogel into the brain of PD rats recovered their motor functions, signified by a relief of the spontaneous circling speed and an increase in the densities of tyrosine hydroxylase positive neurons and fibers. The in vitro and in vivo findings indicate that this electroconductive, self-healing, and biodegradable hydrogel may serve as a promising vehicle without additional cells or drugs for the treatment of PD.

Hydrogel properties

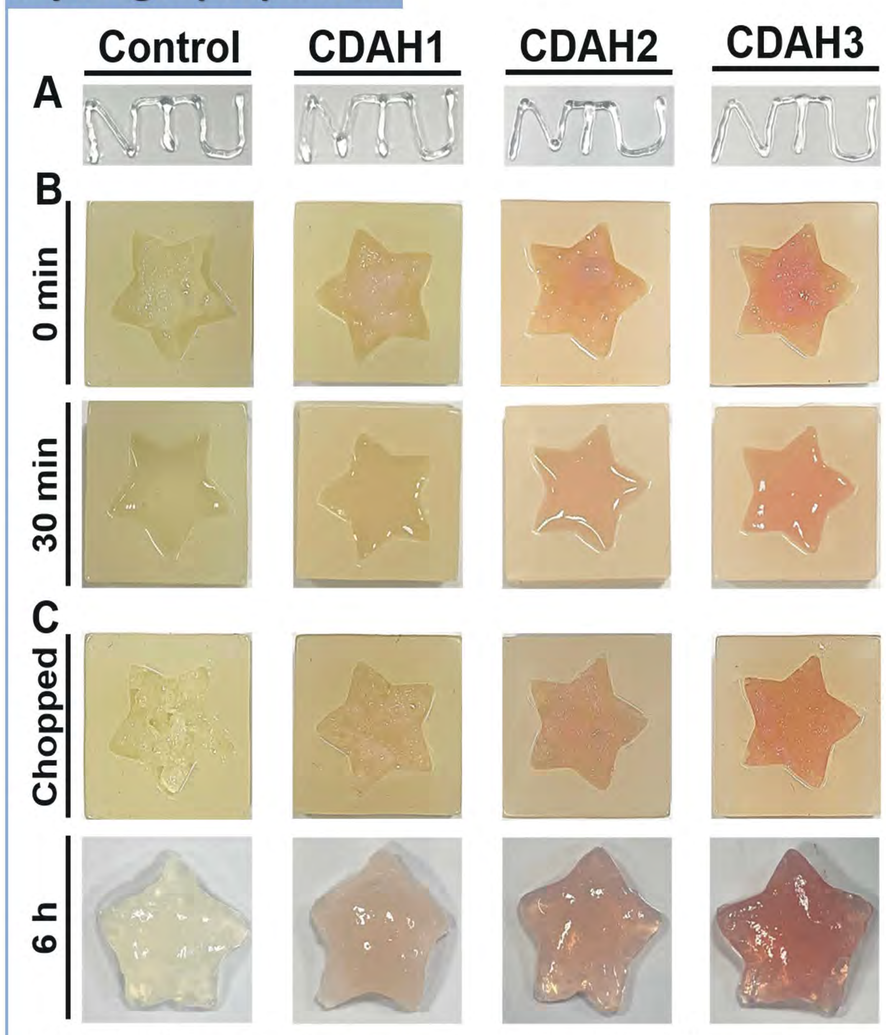

Fig. 1 Macroscopical A) injectable, B) self-adaptable, and C) self-healing of the electroconductive hydrogels using a star-shaped mold through 30-gauge needle.

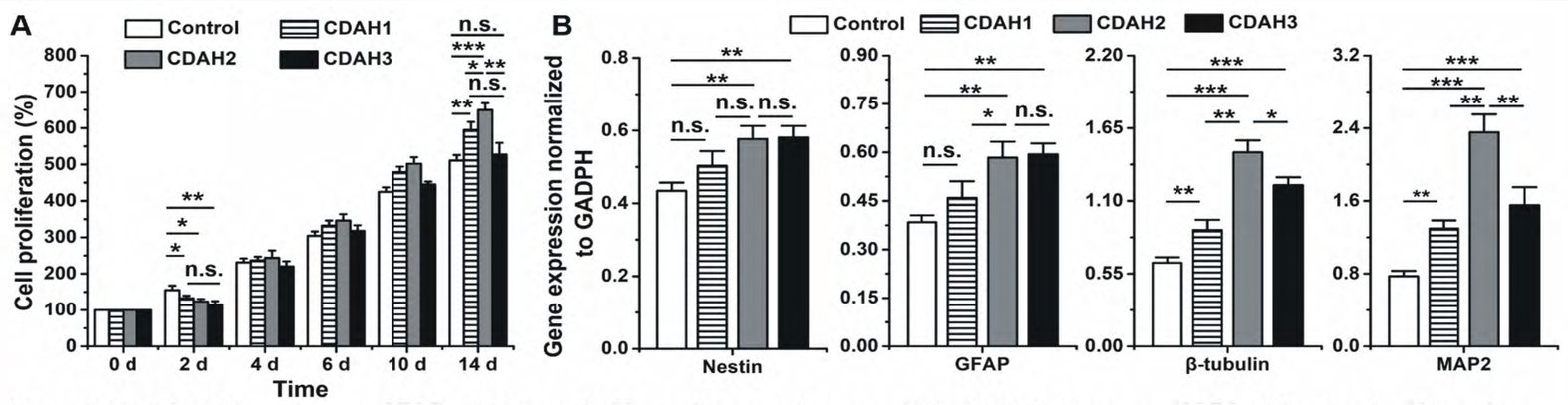

Fig. 2 A) Proliferation and B) differentiation of neural stem cells (NSCs) encapsulated in the hydrogels.

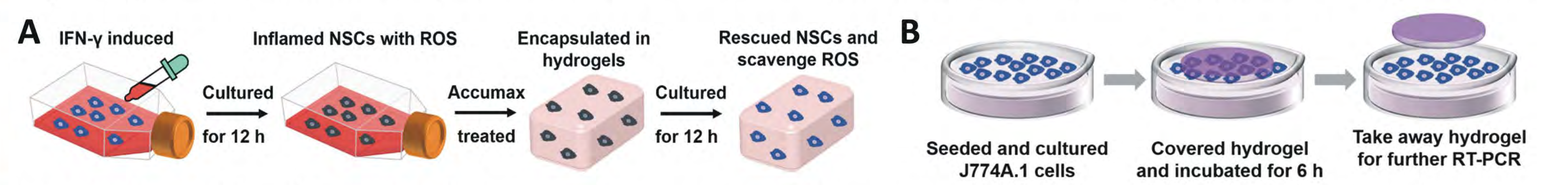

Fig. 3 Illustration for A) the in vitro inflammatory NSC assay and B) the in vitro macrophage immune response simulation assay.

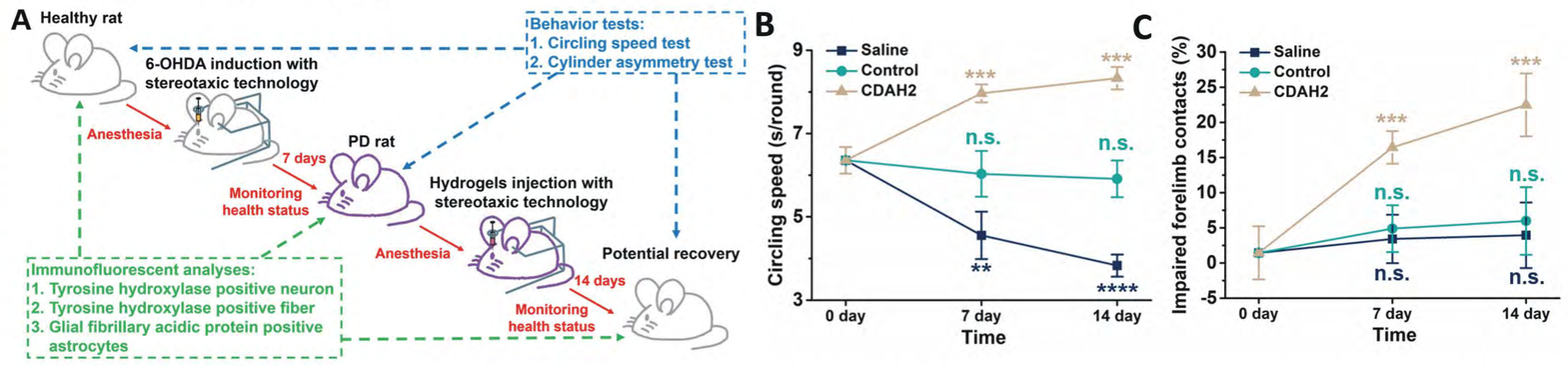

Fig. 4 (A) Schematic illustration of the PD rat model. (C, D) Quantitative assessment for the functional recovery of saline/hydrogel-treated PD rats as compared to the untreated PD rats (0 day), including the left-side circling speeds (E) and the impaired forelimb contact proportion (F).

Conclusion All the results demonstrated CDAH hydrogels have good physicochemical properties, biocompatibility, and adequate conductivity. Rapid self-healing and shear-thinning properties were verified by rheological testing. NSCs showed better cell viability and greater cells proliferation in electroconductive hydrogels versus nonconductive (without nanogold) ones, and inclined to differentiate towards neurons. The hydrogels also had ROS scavenging and anti-inflammatory properties that may rescue inflamed NSCs in vitro. The biocompatibility and therapeutic effect of injected hydrogels was confirmed in vivo by the PD rat model, where the injected hydrogel effectively promoted the motor function recovery and alleviated histological neurodegeneration in PD rats. These findings support conductive CDAH hydrogels as promising biomaterials for neuroprotection and PD treatment.