nanoTherics

AC magnetic field mediated neuronal stimulation in brain tissue

Conventional neuron stimulation by external stimuli is carried out using embedded electrodes within the brain tissue. However, a new methodology has been recently proposed by MIT researchers, which involves using magnetic nanoparticles and AC magnetic fields with frequencies between 100 kHz – 1 MHz to stimulate neurons.

As the FDA have approved magnetic nanoparticles such as magnetite and maghemite, and they are already in use in clinical setups e.g. as MRI contrast reagents, this new technique seems promising. The exciting prospect for magneTherm users would be that these experiments can be carried out using the unique magneTherm technology.

Researchers have demonstrated calcium ion influx in neurons after injecting 22 nm sized magnetic nanoparticles into brain tissue and exciting the neurons by activating heat-sensitive capsaicin receptors (transient receptor potential cation channel subfamily V member 1 : TRPV1) using an external AC magnetic field i.e. nano-magneto thermal excitation. One of the interesting observations was the fact that magnetic nanoparticles localized within the target region due to their surface functionalization can remain there for weeks. This allowed the researchers to re-heat the magnetic nanoparticles, leading to repeated long term nano-magneto thermal excitation of neurons using non-invasive AC magnetic fields. TRPV1 is involved in the recognition and regulation of temperature and is also responsible for the sensation of nociception. Nociceptive neurons produce sequences of action potential in reaction to stimuli which helps to study brain circuitry. Repeated stimulus of TRPV1 would result in desensitization of the receptor resulting in alleviation of pain i.e. a potential analgesic treatment. Furthermore, this research opens new opportunities within our quest to understand neurodegenerative disorders such as Parkinson's, and a possible treatment, as electrode-mediated neuron stimulation has proved effective in reducing tremors in the past. Most of all, this novel, non-invasive technique can provide repeated deep brain stimulation remotely and non-invasively, resulting in zero damage to tissue, unlike electrode implants.

magneTherm aids Magneto Thermal Excitation of Neurons

magneTherm is an unique benchtop technology which generates AC magnetic fields between 100 kHz – 1 MHz with field strengths up to 25 mT (20 kA/m). It has options for a complete physiological setup with internal coils and large diameter external coils to perform *in vivo* research, as shown in figure 1, which allows researchers to carry out studies on magneto thermal excitation research.

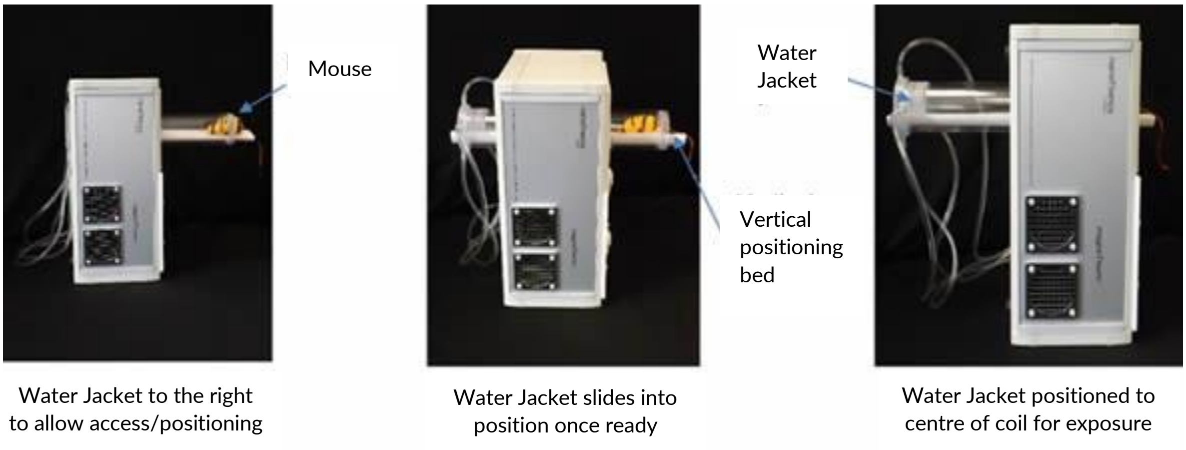

Figure 1: A - magneTherm in vivo internal coil physiological setup with water bath and animal table.

Figure 1: B - magneTherm in vivo external coil setup for rat and rabbit.

The magneTherms Live Cell AMF system allows researchers to perform magneto thermal excitation in cultured neuronal cells and brain tissue slices. It also allows time lapse imaging on a microscope stage under physiological conditions, while subjecting the specimen to an AC magnetic field between 220 kHz – 950 kHz. Figure 2 shows a proof of principle time lapse imaging of shsy5y neuronal cells with 15 nm core size HyperMag magnetite nanoparticles when exposed to AC magnetic field.

This world leading Live Cell AMF technology with its patented accessories allows it to be mounted on fluorescent, optical, confocal microscopes etc., to perform real time imaging and sterile non-contact temperature measurement using optical fibres and IR thermal imaging. Figure 3 shows LC AMF system with its physiological setup mounted onto a microstage.

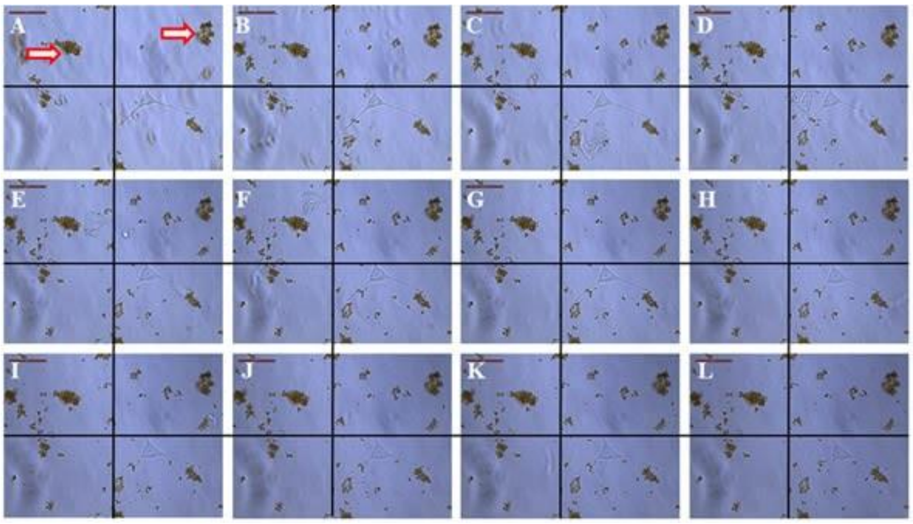

Figure 2: A to L - Time lapse imaging performed every 5 minutes in shsy 5y neuronal cells treated with 1 µl aqueous suspension of 10 mg / ml, 10 nm sized magnetite nanoparticles (Hypermag C) stabilized in DMSA and exposed with a nano magnetic AMF actuation setup. Red arrows point to the magnetic nanoparticles, the black crosshair allows visualisation of cell motility.

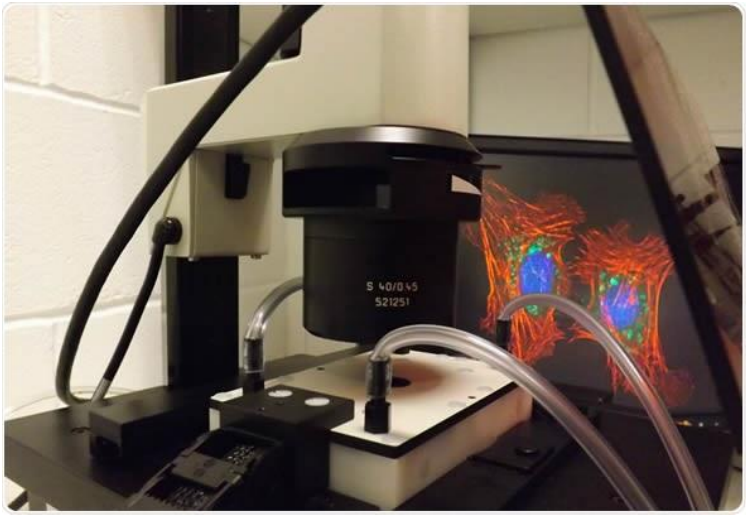

Figure 3: Live Cell AMF system mounted onto a microscope allows researchers to perform magneto thermal excitation studies in cultured neuronal cells, brain tissue/ slices and time lapse imaging on a microscope stage under physiological conditions while exposing to an AC magnetic field between 220 kHz – 950 kHz.

Reference

1. Ritchie Chen, Gabriela Romero, Michael G. Christiansen, Alan Mohr, and Polina Anikeeva. Wireless magnetothermal deep brain stimulation. Science, March 2015 DOI: 10.1126/science.1261821