Controlling cell signaling using magnetic nanoparticles and alternating magnetic fields

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Iron oxide magnetic nanoparticles (MNPs) with diameter of 20-25 nm dissipate heat when exposed to weak alternating magnetic fields (AMFs) with amplitudes <50 mT and frequencies of 100-600 kHz. This heat can be exploited to activate cells that have thermally sensitive ion channels on their membrane via magnetothermal modulation. One example for such ion channel is the transient receptor potential vanilliod 1 (TRPV1), the capsaicin receptor, a non-selective cation channel that is calcium-permeable and can be activated by heat with temperature threshold above 42ºC. Previous studies have demonstrated the expression of TRPV1 in various peripheral organs as well as sensory neurons. AMF has high penetration rate with no deleterious effects, and therefore suitable for the activation of cells within deep organs in the body.

We exploit the magnetothermal approach to control calcium signaling in cells within deep organs and with a minimally invasive scheme. We introduce magnetically-controlled stress hormone release from adrenal glands- corticosterone and epinephrine [1], demonstrated in cell cultures and in vivo. Abnormal regulation of hormones produced within the adrenal gland have been linked to altered stress response and controlling their release is particularly relevant in psychiatric and mental disorders.

In another design, we exploit the magnetothermal approach to guide axonal growth via enhanced calcium influx in a model of sensory nerve regeneration and suggests a new mechanistic strategy to overcome the limited axonal regeneration that exists in nociceptive sensory neurons and central nervous system neurons [2].

References

[1] D. Rosenfeld et. al, *Science Advances*, (2020) eaaz3734.

[2] D. Rosenfeld et. al, *Advanced Functional Materials*, (2022), 0224558.

Figures

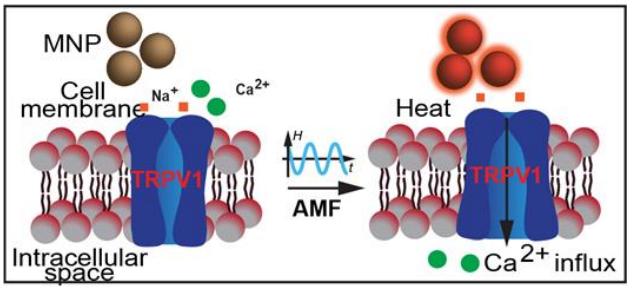

Figure 1. Magnetothermal approach to control calcium influx by modulating TRPV1