Redox Gradients in Materials and Unwired Bipolar Electrodes in Neural Systems

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Electrical activity underpins all life, but is most familiar in the nervous system, where long range electrical signalling is essential for function. The use of external fields can compensate for at least some functional deficits, if they occur. However, its potential to also promote repair at the cellular level has only been demonstrated in vitro. Although there is consistent evidence that external electric fields promote cell growth, not much attention is given to the electrode materials. Furthermore, electrodes are usually connected to the power source. Recently a new possibility has emerged. An external system may polarize a conducting material immersed in the bio-electrolytes, creating a bipolar unwired electrode with induced anode and cathode in opposite poles of the material.

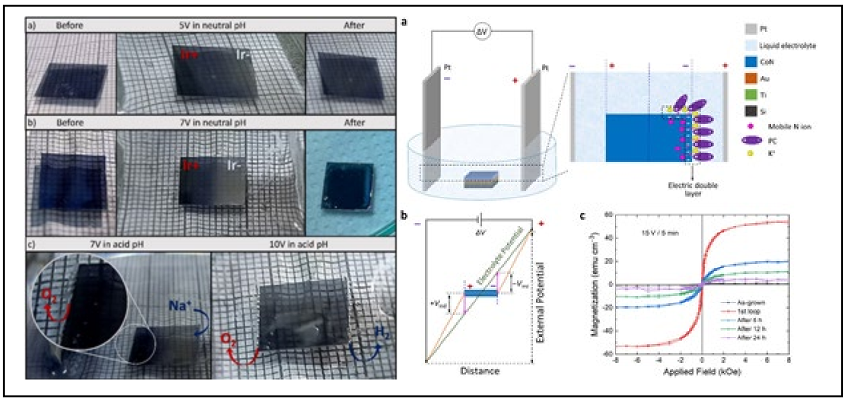

Fig. 1. *Example of bipolar electrodes: Change in colour in IrOx and Ferromagnetism induced in CoN.*

The use of a wireless method to create electrical interactions with a biological system represents a paradigm shift and may allow new applications in vivo where physical wiring is not possible. Several key aspects are observed: The global impedance changes in the cellular media when conducting materials are immersed even if no percolation does exist; the material itself, when mixed conducting systems are chosen, offers a significant redox and ionic gradient across, that expands stimulation in time even after the external field is off; changes in resistivity occur at the material that create complex dipoles and oscillating behaviours. Therefore, neurons are exposed to a variety of voltage gradient profiles, depending on the material and the electric field protocol. As a consequence, different neural behaviours are observed. In some cases, the speed of growth is enhanced, while in others, neurite growth turns towards one of the poles. This work will show a summary of the local resolution studies that evidence the redox and ionic gradients. Finally, additional properties with influence on the biological system are considered, like the *in situ* generation of volatile or permanent ferromagnetism on the material implanted, with possible future applications. This strategy emphasizes how nerve growth can be encouraged at injury sites wirelessly to induce repair, and how we may benefit from the induced fields in polarized conducting materials to achieve localized therapies.

References

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