A biocompatible conducting polymer stimulates the changes needed for nerve regeneration

October 31 2014

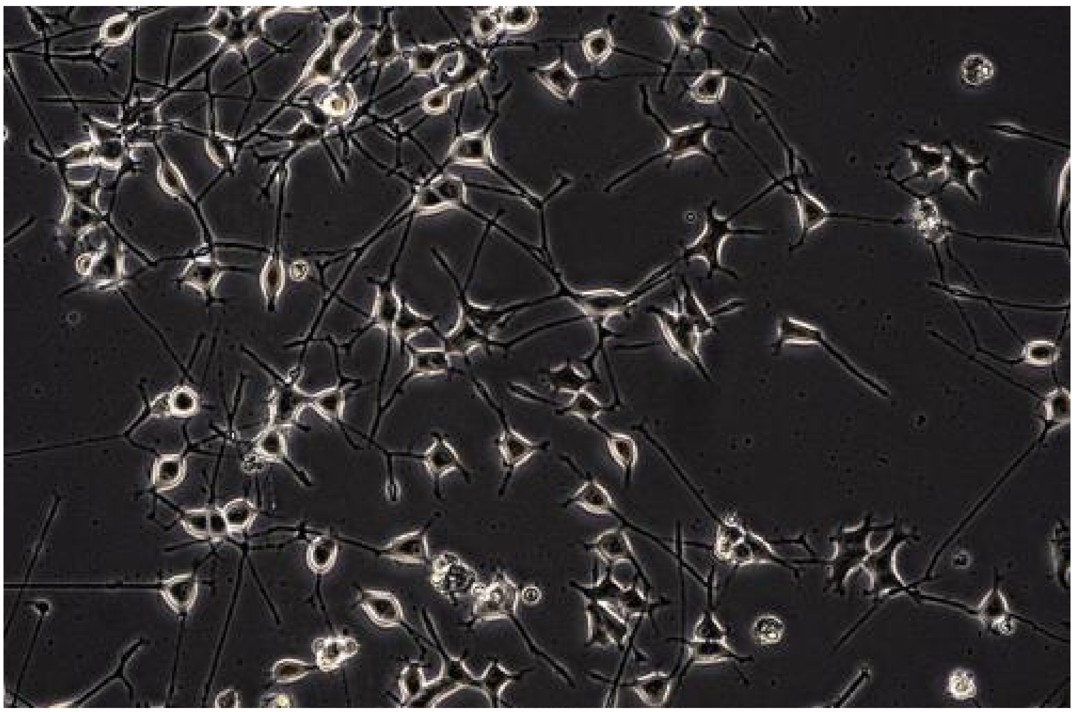

Figure 1: Nerve cells showing the extended neurite outgrowths (dark bands) stimulated by application of the electrically conducting polymer. Credit: B. Zhu et al.

Promoting the guided regeneration of nerve cells could transform the treatment of a vast range of debilitating conditions, including brain injuries, nerve damage and degenerative neurological diseases.

Electrically stimulating the outgrowth of 'neurites'—new projections from nerve cells—is a promising avenue of research, but it has been hampered by immune rejection and scar tissue insulating the electrodes from the targeted cells. Progress has reached a bottleneck because traditional electronic materials, mostly metals and semiconductors, are unable to provide the biocompatibility and mechanical strength needed for stable electrical transmission.

Researchers in Japan, China and Taiwan, led by Hsiao-hua Yu of the RIKEN Responsive Organic Materials Laboratory (now at the Institute of Chemistry, Academia Sinica, Taiwan), have now potentially broken through this bottleneck with the development of a targeted, electrically conducting polymer that mimics the cell membrane.

The researchers used polyethylenedioxythiophene polymers assembled from two monomer units, each carrying a chemical component designed to mimic a crucial aspect of cell membranes. One monomer has a peptide group that replicates the selective binding between cells and the extracellular matrix outside cells. The other monomer carries a mixture of hydrophilic and hydrophobic parts mimicking the phospholipid molecules of cell membrane lipid bilayers.

When a mixture of nerve cells and connective tissue cells was added to a layer of the polymer in a culture dish, the peptide component allowed the nerve cells to bind preferentially to the polymer. Applying electrical stimulation to the cells through the conducting polymer promoted significantly more neurite outgrowths from the nerve cells than achieved using alternative methods (Fig. 1).

Crucially, the system avoided the nonspecific interactions with other cells and biomolecules that can cause the problems found with existing methods. In tests with Schwann cells, which support nerve cell growth and development, the polymer also stimulated increased secretion of proteins required for nerve regeneration. Altering the peptide carried by the polymer could allow a variety of cell types to be targeted, greatly extending the range of applications.

"The ultimate goal of our research is to promote tissue regeneration, particularly neuron regeneration, including within the brain," says Yu. In addition to regenerating cultured cells for grafting into patients, Yu also envisages creating bioimplanted devices that could stimulate in situ nerve regeneration in a patient. "Our conducting polymer could also be used to coat the materials in neuroprosthetic devices to provide an electrical interface capable of more specific interactions toward cells and proteins while preventing the problems of rejection by the patient's immune system."

More information: Zhu, B., Luo, S.-C., Zhao, H., Lin, H.-A., Sekine, J., Nakao, A., Chen, C., Yamashita, Y. & Yu, H.-h. "Large enhancement in neurite outgrowth on a cell membrane-mimicking conducting polymer." *Nature Communications* 5, 4523 (2014). DOI: 10.1038/ncomms5523

Provided by RIKEN