COVER STORY
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Neuroprostheses are a category of biomedical devices which encompasses instruments and methods for neural recording and neuromodulation. Although such devices in neuroscience have been widely used, the field is still in its infant stage and is far from reaching its full potential in clinical use. Many of today's most burdensome and debilitating chronic diseases, in particular Central Nervous System diseases, can be effectively treated using neuroprostheses. Recent advances in novel microfabrication technologies have resulted in reduction in the size as well as the cost of such devices [1]. The microfabricated devices are expected to generate new methods for acquiring electrophysiological information and modulating neural activity [2]. Despite such potential, introducing clinical applications of neuroprostheses has been very slow.

One of the limiting factors that prevent neuroprostheses from translating into clinical use is the gradual loss of their functionality after implantation due to the foreign body reaction characterized by a glial cell reaction [3]. Thus, reducing the tissue reaction to implanted neuroprostheses becomes a necessary requirement, as the dimensions of microelectrodes shrink to the same size scale as cells in order to capture the most clinically useful information. A very small number of cells can greatly degrade the electrical properties of the implanted microelectrodes over a relatively short period of time. Traditionally, cell adhesion to the biomaterials surface has been prevented by surface modification with cell-resistant polymer layer, such as poly(ethylene glycol), or by releasing a drug that can prevent cellular reaction.

The article in this issue from the groups of Professor Philippe Renaud and Professor Jeffrey Hubbell at the Ecole Polytechnique Fédérale de Lausanne in Switzerland describes a method for preventing tissue reaction by controlled release of a drug [4]. For drug release from the biomaterials surface, the drug-containing polymer layer is usually applied to the device surface. Since the device surface needs to be exposed to the environment, it cannot be coated with the permanent polymer layer. But controlled release over a period of months requires a polymer layer or a matrix system that remains for weeks and months. The authors of the article solved the problem with a very simple, and yet highly elegant, approach. The dexamethasone was loaded into poly (propylene sulfide) nanoparticles which were then layered onto the microfabricated cortical neuroprostheses using poly(ethylene oxide) (PEO) coating. The beauty of this approach is that the PEO coating dissolves to expose the electrode surface. The nanoparticles provide a mechanism of long-term delivery of dexamethasone in the vicinity of the tissue–device interface, alleviating the problem of the tissue reaction that forms around neurological implants.

There have been other approaches attempted for localized drug release in the brain by many research groups [5]. The work by Professor Renaud and his colleagues, however, is unique in utilizing drug-containing nanoparticles embedded in the water-soluble PEO layer and in quantitatively demonstrating the efficacy of the approach using electrical spectroscopy techniques. The impact of this fundamental work is expected to be widespread, as it not only suggests a viable method for controlled drug release around neuroprostheses, but also provides a unique and objective validation method that can be used to compare efficacy results between different research groups. Furthermore, the approach of coating the drug-containing nanoparticles using water-soluble PEO can be used for all implantable biomedical devices.

References

[1] D.R. Kipke, R.J. Vetter, J.C. Williams, J.F. Hetke, Silicon-substrate intracortical microelectrode arrays for long-term recording of neuronal spike activity in cerebral cortex, IEEE Trans. Neural Syst. Rehabil. Eng. 11 (2003) 151–155.
[2] J.O. Dostrovsky, A.M. Lozano, Mechanisms of deep brain stimulation, Mov. Disord. 17 (2002) S63–S68.
[3] D.H. Szarowski, M.D. Andersen, S. Retterer, A.J. Spence, M. Isaacson, H.G. Craighead, J.N. Turner, W. Shain, Brain responses to micromachined silicon devices, Brain Res. 983 (2003) 23–35.
[4] A. Mercanzini, S.T. Reddy, D. Velluto, Ph. Colin, A. Maillard, J.-C. Bensadoun, J.A. Hubbell, Ph. Renaud, Controlled release nanoparticle-embedded coatings reduce the tissue reaction to neuroprostheses, J. Control. Release 145 (2010) 196–202.
[5] Y.H. Zhong, R.V. Bellamkonda, Controlled release of anti-inflammatory agent alpha-MSH from neural implants, J. Control. Release 106 (2005) 309–318.

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