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New poly(3,4-ethylenedioxythiophene) coatings for neural recording and stimulation

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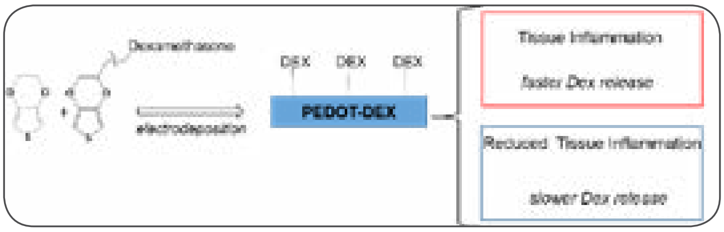
Statement of the Problem: The development of implantable neural microelectrodes has revolutionized the field of biomedical applications by enabling bidirectional communication with the nervous system at high resolution. Unfortunately, one of the main concerns related to chronically implanted neural microelectrodes is related to the adverse reaction of the surrounding tissue, which is known to encapsulate the neural microelectrodes after few weeks post implantation, leading to significant worsening of recording/stimulation quality. Among various approaches aimed to minimize inflammatory reaction and gliosis while preserving the electrochemical integrity of microelectrodes, the possibility of delivering anti-inflammatory drugs from the surface of neural implants represents a challenging strategy. For this purpose, the conductive polymer poly(3,4-ethylenedioxythiophene) (PEDOT), is commonly electrodeposited onto the microelectrodes in conjunction with the negatively charged dexamethasone sodium phosphate (Dex-P). Following this methodology, the drug release can be promoted by applying a cathodic trigger that reduces PEDOT to its neutral state, while enabling the free diffusion of the drug. Unfortunately, the inclusion of Dex-P as a dopant has been reported to negatively affect both electrochemical properties and stability of PEDOT coatings.

Methodology & Theoretical Orientation: In this study, for the first time, the anti-inflammatory drug dexamethasone (Dex) was chemically anchored to the surface of electrodeposited PEDOT, thereby enabling the drug release upon the hydrolysis of the chemical bond between Dex and the PEDOT film. This approach would account for a self-adjusting release system that promotes the delivery of the drug by local changes in the biologic environment.

Conclusion & Significance: The big challenge of this study was to realize self-adjusting release of drugs by neural implants, as a consequence of post implantation inflammatory biological triggers. Here we found that the covalent bond between Dex and PEDOT composite coatings can account for a biologically controlled drug release system.



Recent Publications

1. Cogan S F (2008) Neural stimulation and recording electrodes. Annual Review of Biomedical Engineering 10:275–309.
2. Williams J C, Hippensteel J A et al. (2007) Complex impedance spectroscopy for monitoring tissue responses to inserted neural implants. Journal of Neural Engineering 4:410-423.
3. Castagnola E, Carli S et al. (2017) Multi-layer PEDOT-dexamethasone and PEDOT-PSS-CNT coatings on glassy carbon microelectrode arrays for controlled drug release. Biointerphases 12:031002.
4. Boehler C M and Asplund M (2015) A detailed insight into drug delivery from PEDOT based on analytical methods: Effects and side effects. Journal of Biomedical Materials Research Part A 103(3):1200-1207.
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Biography

Stefano Carli has completed MSc and PhD in Chemistry from the University of Ferrara, Italy. He has devoted his PhD investigations to the development of new photochromic dyads. From 2009 to 2016 his research activity was oriented on dye sensitized solar cells, perovskite solar cells, as well as on new catalysts for light-induced water splitting. Currently he is a Postdoctoral Researcher at the Italian Institute of Technology and his research is focused on the development of new smart materials for neural sensing and stimulation. One of the main concerns of his research is the reduction of tissue inflammation as a consequence of neural probes implantation. For this purpose, new drug release systems from conductive polymers (PEDOT) are under investigation.

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