Carbon based electrodes for nerve impulse conduction

Marek Pawlikowski[1], Zbigniew Gulbinowicz[1], Rafał Drobnicki[1], Daniel Janczak[1]
[1]Institute of Mechanics and Printing, Warsaw University of Technology, Warszawa, Poland
Email: marek.pawlikowski@pw.edu.pl

Summary

Research on electrodes capable of conducting electrical nerve impulses is constantly being developed. The best material for that purpose seems to be carbon or graphene, or a material based on graphene with additives. In the paper, we are proposing a new technique for making carbon electrodes for use in neurology, namely the technique of screen printing on thin foils. We have printed electrodes using paste with two types of binder, namely vinyl chloride copolymer-based binder in the solvent 2-(2-Butoxyethoxy) ethyl acetate from Novelinks, and polymethyl methacrylate PMMa MW350000 in the same solvent. As the main component of the paste, we used fine-grained graphite MG1596 micropowder, and conductive carbon black. In our research we concentrated on measurements of the electrodes' impedance and on determination of the possible electrical signal distortion produced by the electrodes. The aim of the study is to optimize the electrodes for possible use in nerve impulse conduction.

Introduction

The aim of the presented research is to design and produce, using screen printing, a flexible electrode that will ultimately be able to conduct electrical impulses generated by the nerves.

Attempts are being made to produce neural electrodes based on carbon or graphene [1,2]. However, these electrodes are still characterized by too high impedance and electrical capacity, low conductivity, and signal-to-noise ratio (SNR), which limits their use in the process of reconstructing the conduction of nerve impulses.

In the paper we propose a method for producing carbon-based electrodes in printed electronics technology. Additionally, the possibility of using additives that can reduce the electrode impedance are considered.

Methods

The path conducting the impulses was made of a carbon-based paste. It was printed on a biocompatible foil. We obtained the electrodes less than 100 µm thick. The other dimensions varied from 1x26 mm to 25x30 mm. We have printed electrodes using paste with two types of binder, namely 24% weight vinyl chloride copolymer-based binder in the solvent 2-(2-Butoxyethoxy) ethyl acetate from Novelinks (LARO), and 8% polymethyl methacrylate PMMa MW350000 in the same solvent (PMMA). As the main component of the paste, we used fine-grained graphite MG1596 micropowder (10÷30 %), and conductive carbon black CB (4÷8%).

During the experimental work we subjected the electrodes to electrical impulses of known shape and parameters (amplitude, frequency) and compared the input signal with the output one from the electrodes. The measurements were conducted by means of a UTG1022X waveform generator. Impedance and electrical capacity were also measured.

Results and Discussion

Our results showed that the electrical performance of the PMMA MG1596 electrodes is very sensitive to the electrode dimensions. Conversely, the LARO CB electrodes revealed very good electrical conductance. In Figure 1 the electrical performance of 3x26 mm electrodes is presented.

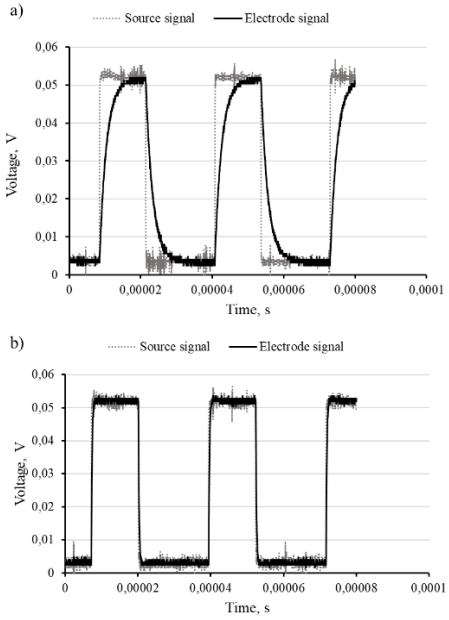

Figure 1: Comparison of electrical signal conduction of the electrodes: a) PMMA and b) LARO CB.

The impedance of the mentioned electrodes equals 16.3 Ohm (PMMA) and 7.68 Ohm (LARO CB). The electrical capacity is 108 nF (PMMA) and 227 nF (LARO CB).

Conclusions

The preliminary studies show superiority of LARO CB electrodes over PMMA electrodes.

Acknowledgments

Research was funded by Warsaw University of Technology within the Excellence Initiative: Research University (IDUB) programme.

References

[1] Li K et al. (2023). *J Nanobiotechnology*, **21**: 181.
[2] Heyazi MA et al. (2023). *J Biomed Phys Eng*, **13**: 573-576.