Carbon fibre microelectrodes for neuroscience applications

Jian Fang  
*Deakin University*

Zhigang Xie  
*Deakin University*

Gordon G. Wallace  
*University of Wollongong*, gwallace@uow.edu.au

Xungai Wang  
*Deakin University*

Follow this and additional works at: [https://ro.uow.edu.au/aiimpapers](https://ro.uow.edu.au/aiimpapers)

Part of the [Engineering Commons](https://ro.uow.edu.au/aiimpapers), and the [Physical Sciences and Mathematics Commons](https://ro.uow.edu.au/aiimpapers)

**Recommended Citation**  

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library: research-pubs@uow.edu.au
Carbon fibre microelectrodes for neuroscience applications

Abstract
Microelectrodes have shown outstanding performance in neural signal recording, neural stimulation and electrochemical sensing. Compared with their micro-sized counterparts, microelectrodes normally exhibit improved signal-to-noise ratio, fast response time and can work with limited sample volumes. Microelectrodes are required to have good biocompatibility, low electrical impedance and long-term stability in many biomedical applications. Carbon fibres are manufactured from polymeric precursor fibres through carbonization, and high carbon content makes carbon fibres electrically conductive, corrosion resistant, biologically safe and inert. Therefore, carbon fibre has been considered as an ideal candidate for making microelectrodes.

In this work, single carbon fibres were loaded into capillary tubes and fabricated into microelectrodes. The surface of the microelectrodes was functionalized with electrochemically reduced graphene oxide (rGO) sheets, decorated with carbon dots (CDs). It has been demonstrated that this surface modified microelectrode could achieve a high sensitivity and selectivity in detecting dopamine (DA), in the presence of ascorbic acid (AA) and uric acid (UA).

Keywords
neuroscience, microelectrodes, fibre, applications, carbon

Disciplines
Engineering | Physical Sciences and Mathematics

Publication Details

This conference paper is available at Research Online: https://ro.uow.edu.au/aiimpapers/1755
Carbon Fibre Microelectrodes for Neuroscience Applications

Jian Fang¹,², Zhigang Xie¹,², Gordon Wallace¹,³, Xungai Wang¹,²
¹ARC Centre of Excellence for Electromaterials Science (ACES)
²Australian Future Fibres Research and Innovation Centre (AFFRIC), Institute for Frontier Materials, Deakin University, VIC, Australia
³Intelligent Polymer Research Institute (IPRI), University of Wollongong, NSW, Australia
xwang@deakin.edu.au

INTRODUCTION
Microelectrodes have shown outstanding performance in neural signal recording, neural stimulation and electrochemical sensing. Compared with their micro-sized counterparts, microelectrodes normally exhibit improved signal-to-noise ratio, fast response time and can work with limited sample volumes. Microelectrodes are required to have good biocompatibility, low electrical impedance and long-term stability in many biomedical applications. Carbon fibres are manufactured from polymeric precursor fibres through carbonization, and high carbon content makes carbon fibres electrically conductive, corrosion resistant, biologically safe and inert. Therefore, carbon fibre has been considered as an ideal candidate for making microelectrodes.

In this work, single carbon fibres were loaded into capillary tubes and fabricated into microelectrodes. The surface of the microelectrodes was functionalized with electrochemically reduced graphene oxide (rGO) sheets, decorated with carbon dots (CDs). It has been demonstrated that this surface modified microelectrode could achieve a high sensitivity and selectivity in detecting dopamine (DA), in the presence of ascorbic acid (AA) and uric acid (UA).

APPROACH
Unsized carbon fibres without any surface treatment were used in this work. Graphene oxide was prepared via the Hummer method and water-soluble carbon dots with strong blue fluorescence were synthesized through a hydrothermal process using sodium citrate and ammonium bicarbonate as the starting materials.

RESULTS AND DISCUSSION

Three kinds of carbon fibres were used during the microelectrode preparation in this work: pure carbon fibres (CF), carbon fibres with electrochemically reduced GO on the surface (rGO/CF) and carbon fibres modified with electrochemically reduced GO and carbon dots (rGO+CD/CF). The structure of the fabricated carbon fibre microelectrode is illustrated in Figure 1. One end of the carbon fibre was sealed in a pulled capillary tube while the other end was bonded through conductive epoxy to a gold wire for electrical connection.

Figure 1. Illustrated structure of carbon fibre microelectrode

It can be seen that the positions of UV absorption maximum peak (332 nm) and fluorescent excitation peak (345 nm) are very close. The inset image clearly shows the bright blue light displayed from the CD solution under UV light with excitation at 365 nm, which is corresponding to its emission spectra, also shown in Figure 2. It has also been observed that the
CDs exhibited the highest fluorescent intensity when they were excited at 345 nm (Figure 3).

By decorating the GO sheets with carbon dots, oxidation peak of all three neurotransmitters in the solution can be found on the CV curve of the rGO+CD/CF microelectrode. This significant improvement has probably been contributed by increased surface area and improved electrostatic interaction.

CONCLUSION

Graphene oxide sheets have been decorated with carbon dots, electrochemically reduced and deposited onto carbon fibre surface for detecting low concentration dopamine (DA), ascorbic acid (AA) and uric acid (UA) in aqueous solution. The decoration of carbon dots leads to significantly improved sensitivity and selectivity of the surface modified carbon fibre microelectrodes, which can be attributed to increased accessible surface area and enhanced electrostatic interaction with DA. The results suggest that surface modified carbon fibre maybe an ideal microelectrode material for various neuroscience applications, such as biosensing and neuro signal recording.

KEYWORDS
Carbon fibre, Microelectrode, Neurotransmitter, Neuroelectrode

ACKNOWLEDGMENT
This work is financially support by Australian Research Council (ARC) through ARC Centre of Excellence for Electromaterials Science (ACES). The authors also would like to thank Carbon Nexus for kindly providing unsized carbon fibres.

REFERENCES