Graphene-based electrically conductive coatings for wearable microneedle biosensors

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Microneedle-based biosensing provides an attractive path towards continuous health monitoring - the use of microneedles causes substantially lower pain to the user than traditional hypodermic needles while providing accurate sensing information [1]. Due their small footprint and ease of application, such biosensors are easily worn with minimal nuisance to the user, enabling wearable health sensing anywhere and at any time. Electrochemical microneedle biosensors typically require the microneedles to be electrically conductive - a task which has previously been accomplished using vacuum-deposited gold coatings [2]. As gold is an expensive material and the process requires deposition under high vacuum, it is desirable to replace the gold evaporation with a low-cost and scalable process.

Graphene and related materials such as graphene oxide (GO) and reduced GO (rGO) have emerged as suitable materials for electrochemical biosensors [3]. In this work, novel rGO coatings are developed to provide the electrical conductivity required for the microneedle sensing. The coatings can be deposited in a scalable manner using spray-coating, they can be easily functionalised due to their carbon-based chemistry and form ultra-thin conformable conducting films which are non-toxic. Here, GO is synthesised using well-established methods and it is deposited using a customised automatic spray-coating instrument. Several different methods for the subsequent reduction to rGO are compared to determine their suitability for the microneedle substrates. The glucose sensing enzyme is then immobilised using different protocols, and finally, the suitability of the coatings for electrochemical biosensing is demonstrated by sensing glucose in solution. The coatings do not rely on metal layers or metal nanoparticles, reducing the costs and complexity of the sensors. The developed needle substrate can be seen in Figure 1.

References

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[2] Gowers, S. A., et al. ACS Sensors, 2019, 4, 1072–1080
[3] Prattis I., et al. "Graphene for biosensing applications in point-of-care testing.", Trends in Biotechnology, 2021 (in press)

Figures

Figure 1. Graphene-based conductive coating on polymer microneedles