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SUMMARY OF FINDINGS

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From Doughnuts to Energy: Miniature Enzyme driven Biofuel Cells

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Enzymatic biofuel cells are green energy sources that harvest electrical energy from the surrounding environment. Utilization of the abundant biofuels is based on the enzymatic conversion of the organic matter in the presence of active biocatalysts. In order to provide maximum fuel conversion we have designed and fabricated polymer based microfluidic devices as platforms for the biofuel cells. The design was supported by a detailed theoretical study of the mass transport and reactions within the channel. Stable immobilization of enzyme catalysts on metal and carbon electrodes results in a prolonged operation of a constructed biofuel cell.

The aim of this EPA funded project was to develop cost effective microfluidic platforms for enzymatic biofuel cells as part of the on-going fundamental research into alternative energy sources.

Key Words: **energy, biofuel cell, enzyme, microfluidics, modelling**

Background

Ever-growing demands for energy have driven research on alternative power sources and became a strategic theme for governments across the world due to its major impact on global economies and the environment. Among novel alternative sources of energy electrochemical devices have attracted very strong interest with substantial investment in the development of fuel cells. Concurrently, increasing need for renewable and environmentally friendly devices has triggered the evolution of biofuel cells, a special type of devices utilizing commonly available biological catalysts and natural substrates. The operational principle of these cells relies on the conversion of chemical energy embedded in organic fuels, such as alcohols and carbohydrates, into electrical energy via redox reactions.

Proposed applications of biofuel cells include powering portable electronic devices, remote sensor platforms deployed out-of-the laboratory and implantable or swallowable diagnostic devices. Relative to traditional fuel cells, due to their simplified design, they are a viable option for smaller, lighter, simpler, cleaner and less expensive power sources. Enzymatic biofuel cells in particular reproduce naturally occurring electrochemical processes and can operate without the use of expensive noble catalysts such as platinum.

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Key points & Findings

- Major advantages of these devices include pollutant-free emissions and the utilization of ambient compounds, e.g. glucose and oxygen, as fuel and oxidant respectively. Integration onto microfluidic platforms enables further system miniaturization and fuel efficiency. Although still in its infancy, the development of microfluidic biofuel cells is of utmost significance for the realisation of a new generation of biological cells.
- Devices fabricated in the course of this project have the potential to greatly improve the performance of already existing enzymatic biofuel cells.
- This project has achieved its goals and demonstrated how environmentally-friendly and efficient devices harnessing biochemical sources of energy may be developed in a miniaturized fashion, in a way that could be easily integrated with autonomous sensor modules.
- It has also extended the scientific knowledge on energy conversion in microfluidic devices and has created the basis for the development of innovative energy sources.
- This work is interdisciplinary in nature and includes: simulation study in order to optimise the device designs; fabrication of polymer based microfluidic platforms; surface modification of metal electrodes with enzyme catalysts and ultimately the assembly of the micro-fabricated platforms with biological entities to form an operational enzymatic biofuel cell.

Recommendations

- It is envisaged that the proposed technology will be able to provide energy to sensor platforms deployed in the environment. The undertaken research offers great prospects for the development of miniaturized energy sources that can be used to power autonomous sensor modules de-localised within the environment for monitoring purposes.
- Carefully designed and fabricated microfluidic devices are now possible which can lead to improvements in the quantity of energy converted which goes beyond the current state of the art.

For Further Information

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Please refer to: www.tyndall.ie/content/microfluidic-biofuel-cells