Lactate monitoring of sweat using the screen-printed lactate biosensor and PDMS channels

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Abstract

Wearable sensors for the monitoring of lactate levels during exercise are expected to be useful for the training of athletes. In this study, we have fabricated a lactate sensor with a microchannel that plays the role of supplying new sweat to the electrode and removing old sweat. We have tested these sensors in a lab environment and are currently performing field trials with exercising test volunteer persons.

1. Introduction

In recent years, wearable sensors have been attracting attention for the application in various fields such as medical care, nursing care, and sports[1)]. In particular, the use of lactate sensors for long-term monitoring of lactate levels in sweat has attracted much attention[2)]. The thus obtained lactate levels are expected to be useful for the evaluation of exercise intensity and fatigue level, and to judge health status of the tested person. We have previously fabricated a lactate sensor equipped with a microchannel made of polydimethylsiloxane (PDMS) to measure lactate in real time[3)]. However, the fabricated microchannel had a structure in which bubbles that entered during measurement were trapped. As a result, the air bubbles touched the electrode of the sensor and the response of the sensor became unstable. In this study, we further improved the lactate sensor with a microchannel for the use as wearable sensor to measure lactate in sweat during exercise.

2. Experiment

Sensor chips were prepared according to our previous report[3)]. In short, leads were screen-printed on a polyimide film using silver ink, followed by Ag/AgCl ink for the reference electrode and carbon ink for the counter electrode. Glycidyl methacrylate-grafted MgO-templated carbon (GMgOC) ink was used for the working electrode. The enzyme-modified electrode was prepared by dropping 3.0 μL of thionine and LOx (15 U) on the working electrode, followed by chitosan, which formed a film on top of the electrode. For continuous monitoring of lactate, the lactate sensor was combined with PDMS flow channels. The concentration correlation of the lactate sensor was evaluated by

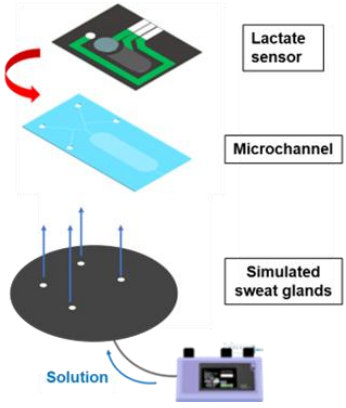

Fig.1 Schematic view of the evaluation with lactate sensor with a microchannel

chronoamperometry (applied potential: 0.1 V). The measurements were performed in 0.1 mol dm^{-3} phosphate buffer solution (pH 4.5) containing 1-50 mmol dm^{-3} lactate. The measurement solution was set to pH 4.5 based on the results of the exercising test. Figure 1 shows a schematic diagram of a lactate sensor with a channel, in which a lactate solution is pumped through simulated sweat glands to evaluate the sensor response. The lactate solution flows into the channel through the simulated sweat glands and collects in the circular reservoir in the center, and then is discharged out of the channel.

3. Results and discussion

Figure 2 shows the relationship between lactate concentration and current density at pH 4.5. The vertical axis of the Figure 2 is the difference between the obtained current value and the background current value. In the range of 1 to 50 mmol dm^{-3} lactate, the current increased with concentration. This suggests that the lactate level can be detected even in acidic sweat. Currently, we are conducting field trials using the fabricated lactate sensor and are measuring lactate in sweat during exercise.

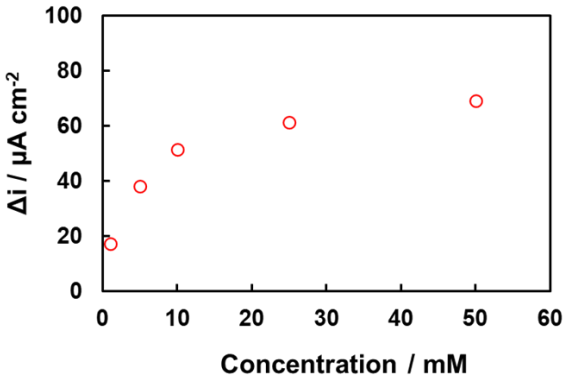

Fig.2 Relation between current density and lactate concentration

4. Conclusions

A lactate sensor with PDMS channels was fabricated to detect changes in lactate concentration in sweat in real time. By attaching the microchannel to the lactate sensor, new sweat was supplied to the electrodes and old sweat was discharged. A lab test with artificial sweat glands and a syringe pump showed that the lactate concentration could be measured in the range of 1 to 50 mmol dm^{-3}. This enables us to detect lactate during exercise.

Acknowledgments

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References

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