In-Situ Measurement of Photosynthesis Using Single Synechocystis SP. PCC 6803 in a Microchamber with Gas Barrier Wall
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1. Background
Significance of photosynthesis

[Diagram showing the process of photosynthesis]

Carbon Dioxide → Sugar
Water + Light → Oxygen

Dioxide

Calvin circuit
Aerobic respiration

\[ \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 12\text{H}_2\text{O} \]

Photosynthesis

[Diagram showing an oxygen sensor and a gas barrier layer]

2. Concept
On-chip oxygen monitoring using fluorescent sensor

Measurement area:
Fluorescence at top of chamber is used for oxygen measurement.

Oxygen sensor:
Pt(II) tetakis (pentafluorophenyl) porphyrin

Gas barrier layer
Parylene

Oxygen calibration

\[ \frac{I_{\text{ref}}}{I} = 7.3 \times 10^{-4} \frac{[O_2]}{[O_2\text{ref}]} + 2.9 \times 10^{-1} \]

Compensation of photodegradation

\[ I' = I + \sum \left( \frac{(I_0 - I_n)}{\exp(\ln(I_0) - \ln(I_n))} \right) \]

3. Fabrication of microfluidic chip
Fabrication process
(a) Pattern of chambers
(b) Coat of sensor
(c) Coat of barrier layer
(d) PDMS molding
(e) Sealing by glass

Configuration
Volume: 12 pl (20 µm × 20 µm × 30 µm)
10000 chambers/chip

4. Experiments
Evaluation of photosynthesis by oxygen monitoring

Experimental Condition
Initial [O\text{2}]: 270 umol/l
Initial [CO\text{2}]: 5% Temperature: 303 K Medium: 20 % Fructose aq.

Sample 1
Sample 2
Sample 3

Sample O\text{2} synthesis
Sample 3
Sample 2
Sample 1

Sample O\text{2} synthesis (2000 lux)
Sample 3
Sample 2
Sample 1

Sample Sugar synthesis
Sample 3
Sample 2
Sample 1

Sample Sugar synthesis
Sample 3
Sample 2
Sample 1

Sample Oxygen consumption
Sample 3
Sample 2
Sample 1

O\text{2} synthesis: 2.3 ± 0.46 x 10^{-18} mol/s
Synthesis is controlled by VIS intensity.

5. Conclusions and future work
1. Evaluation of photosynthesis and aerobic respiration single Synechocystis by fluorescent oxygen sensing.
Respiration ratio: 6.4 ± 1.2 x 10^{-13} µmol/s
Sugar production ratio: 3.9 ± 0.8 x 10^{-13} µmol/s
2. Construction of high-throughput screening system of Synechocystis using disrupted of Synechocystis.

6. References
Hisataka Maruyama, Yu Matsuda, Tomohide Niimi, Nobuyuki Unozumi, Kei Nanatani, F. Arai,
IN-SITU MEASUREMENT OF PHOTOSYNTHESIS USING SINGLE SYNECOCYSTIS SP. PCC 6803 IN A MICROCHAMBER WITH GAS BARRIER WALL, Proc. of Micro TAS 2012 (2012).

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