Relationship between Biophotons and Gases Generated from Cucumber Pieces

Hideyuki KOKUBO[1,2], Satoshi KOYAMA[3,1] and Osamu TAKAGI[1]

[1]*Institute for Living Body Measurements, International Research Institute (Chiba, Japan)*
[2]*Meiji University, School of Information and Communication (Tokyo, Japan)*
[3]*Meiji University Graduate School of Information and Communication (Tokyo, Japan)*

Abstract: The authors discuss the relationships between biophotons and gases generated from cucumber pieces, which were cut and then exposed to air. The generating ratio of whole gases reached its maximum 30 min after they were cut, and then decreased monotonically. The gas composition changed during the process. The intensity of near-infrared biophotons could be approximated by the sum of a chain reaction and a logistic reaction. Specific gases that showed a color reaction of 91D (a passive dositube for formaldehyde) reached a maximum concentration simultaneous to the chain reaction of near-infrared biophotons. The intensity of visual light biophotons could be approximated by the sum of plural logistic equations. Moreover, a chain reaction could approximate an anomalous difference of biophoton intensities between control and experimental samples of cucumber after non-contact healing (laying-on-of-hands). In summer, specific gases that showed a color reaction of 141L (a detector tube for ethyl acetate) reached a maximum generating ratio at a different time from they did in winter.
Keywords: biophotons, green odor, *Cucumis sativus* 'white spin type', near infrared, visual light, gas detection tube, formaldehyde, ethyl acetate, odor sensor, non-contact healing, approximate equation

1. Introduction

In 2006, using biophotons generated from a cucumber (*Cucumis sativus* 'white spin type'), the authors developed a quantitative measurement method for non-contact healing (laying-on-of-hands, bio-PK)[1,2]. They have conducted many studies using this method. The biophoton measurement method can estimate a healer's controlled healing power in just one or two trials.[3] However, the expense of the biophoton measurement equipment has obstructed widespread application of the method. Therefore, inexpensive and easy-to-use methods should be developed to promote further studies.

During their work, the authors noticed a green odor generated by a cucumber. Two mechanisms were identified as the source of cucumber biophotons.[4] One of them is the oxidation reaction of ascorbic acid, and the other is biosynthesis of C9/C6 aldehyde and alcohol (the green odor). Because the amount of gases corresponds to the intensity of biophotons, a healer's controlled healing power can be estimated by measuring the amount of gas released. The authors tested this hypothesis and succeeded in developing an easy-to-use and inexpensive measurement method using a gas detector tube.[5]

In the present paper, the details of the relationships between biophotons and gases generated from a cucumber are discussed.

Hideyuki KOKUBO kokubo@a-iri.org
40A, Yuuki Bldg., Sonno 1108-2, Chiba 263-0051 Japan
Phone: +81-43-255-5481 FAX: +81-43-255-5482
http://wwwsoc.nii.ac.jp/iri

2. Methods

Method 1: An odor level indicator (XP-329 III R, New Cosmos Electric Co., Ltd., Japan) was used to measure the generating ratio of whole gases from cucumber pieces. Four circular slices (thickness: 1 cm) were cut from a cucumber. These slices were placed in a glass Petri dish, which had been previously wrapped with a plastic sheet. Then, the dish was put into a 2.2 l sealed plastic container.[5] An air cleaner was attached to the inlet of the container and XP-329III R was connected to the outlet of the container. The odor intensity was recorded every second at the suction rate of 400ml/min (**Fig. 1**). The experiment was done at room temperature, 24 °C, in August of 2009.

XP-329III R indicator has an indium oxide-based sensitivity hot wire semiconductor sensor, which was kept at approximately 480 °C. Sensor conductance increases when odor molecules are captured on the surface of the sensor. Conductance change is measured as a resistance change, and converted into odor intensity in the range of 0 to 2000. The captured molecules are heated and burned on the sensor surface and changed chiefly into carbon dioxide and water. The response speed is within 20 s.

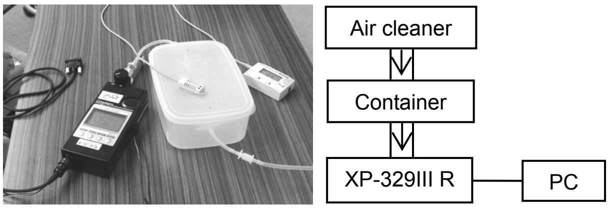

Fig. 1 Measurement with Odor Level Indicator

Method 2: From data in previous studies,[6,2] the authors made approximate equations of intensity transitions of infrared and visual light biophotons generated from cucumber pieces and compared those results with values from gas detector tubes. Gas detector tubes were 91D (a passive dositube for formaldehyde; Gastec Corporation, Japan) and 141L (a short-term gas-measuring detector tube for ethyl acetate; Gastec).

One set of samples comprised of 4 cucumbers. Four circular slices (thickness: 2 cm) were cut from one cucumber. Each slice was cut again into 2 slices (thickness: 1 cm); this gave 4 pairs of pieces. Paired pieces (16 pairs total) were set into 8 Petri dishes under a rule.[6] Petri dishes were set into 8 containers.

91D (for formaldehyde) was set into the container with cucumber samples. The value of the color reaction of 91D was observed every 30 min through the lid of the container.

In experiments with 141L (for ethyl acetate), the interval of measurement was 1 h. Four paired containers (8 containers in total) were used in an experiment. An experimenter measured gas concentrations of the first paired containers 1 h after start, the second pair 2 h after start, the third pair 3 h after start and the fourth pair 4 h after start. In this way, the measurements were taken at 4 different points for every experiment and 24 measurement points were finally obtained. Experiments were executed at room temperature of 24 °C in August and September of 2009.

3. Results

3-1. Generating Ratio of Whole Gases

The authors assumed a chain reaction such that material A changes to B and B changes to C (gas). The generating ratio of C is dC/dt.

$$A = A_0 \exp(-k_1 t)$$

$$dA/dt = -k_1 A$$

$$dB/dt = k_1 A - k_2 B$$

$$dC/dt = k_2 B$$

Therefore,

$$dC/dt = k_1 k_2 A_0 / (k_2 - k_1) \times [\exp(-k_1 t) - \exp(-k_2 t)] \quad \text{(Equation 1)}$$

Relationships between odor level and concentration are different among gases. For example, the odor level is 1600 for 500 ppm ethyl acetate, but the odor level is 1000 for 500 ppm acetic acid.[8] The odor level of ethyl acetate can be approximated by a power-type equation in the range from 1 ppm to 500 ppm (**Fig. 2**).

$$L = 188.31 \times C^{0.3481}$$

Tentatively, odor level was converted into concentration of ethyl acetate although the cucumber does not generate it. **Fig. 3** shows converted values and approximate values calculated by equation 1. Here, k_1 = 5 [/h], k_2 = 0.37 [/h] and A_0 = 25 [ppm].

The gas generating ratio reached a maximum 30 min after they were cut, and then decreased monotonically.

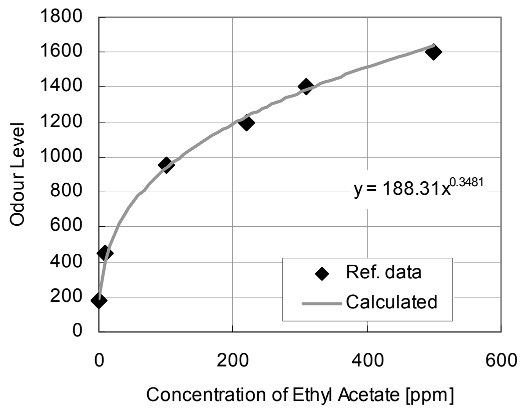

Fig. 2 Odor Level and Concentration of Ethyl acetate
Calculation from reference data in Ref. 8.

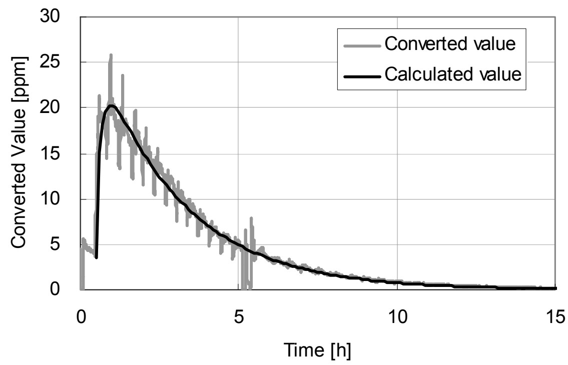

Fig. 3 Converted value as ethyl acetate and calculated value
Data drift at the fifth h was caused by an operation to check the indicator.

3-2. Near-Infrared Biophotons and 91D

The time transition of the intensity of near-infrared biophotons [< 1000 nm] could be approximated by the sum of a chain reaction (IR-1) and a logistic reaction (IR-2).

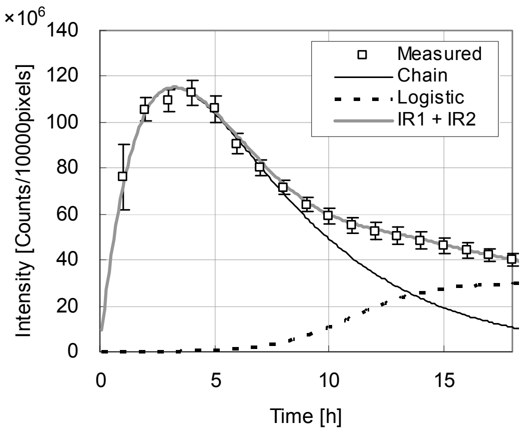

Fig. 4 Measured and Calculated Value of Near-Infrared Biophotons
Error bars are 95% confidence intervals (n=4).

Chain reaction (IR-1): It was assumed that an initial material generates an excited component, and the component returns to the ground state. Here, k_1 and k_2 are coefficients, A is the number of initial materials and B and C are numbers of components in excited and ground states, respectively. The photon emission ratio per unit time is described as follows:

$$dC/dt = k_1k_2A_0 / (k_2 - k_1) \times [\exp(-k_1t) - \exp(-k_2t)].$$

Logistic reaction (IR-2): It was assumed that continuous luminous materials (or luminous cells) increase according to a logistic equation. Here, N is the number of luminous materials, K is carrying capacity (it is considered to depend chiefly on cross-section) and r is the growth rate. Photon emission can be described as follows:

$$N = K/(1+\exp[rK\{t_0 - t\}]).$$

The intensity of near-infrared biophotons from the cucumber can be described as the sum of IR-1 and IR-2.

$$I = k_2 k_1A_0 / (k_2 - k_1) \times [\exp(-k_1t) - \exp(-k_2t)] + K/(1 + \exp[rK\{t_0 - t\}]) \quad \text{(Equation 2)}$$

Here, I is the intensity of photon emission [counts/10000pixels], t is time [h], A_0 = 1.1 × 10^9 [count], k_1 = 0.2 [/h], k_2 = 0.45 [/h], t_0 = 11 [h], r = 2 × 10^{-8}, K = 3 × 10^7.

Table 1 lists the measured value (concentration) of 91D for formaldehyde. Winter data were obtained in December 2008.[5)]

Table 1 Measured Values of 91D (formaldehyde)

Time [h]	Summer [ppm] (n = 2)	Winter [ppm] (n = 2)
0.00	0.0	-
0.50	2.3	0.0
1.00	4.5	0.8
1.50	6.0	1.4
2.00	7.0	2.3
2.50	8.5	2.8
3.00	9.0	3.0
3.50	10.0	3.0
4.00	8.5	2.8
4.50	7.5	2.4
5.00	7.0	2.4
5.50	7.0	1.6
6.00	7.0	1.1
6.50	6.0	1.1
7.00	5.5	1.0
7.50	5.0	0.9
8.00	4.5	0.8
8.50	4.5	0.6
9.00	-	0.5
9.50	-	0.5
10.00	-	0.4
17.75	1.5	-
21.50	0.5	-

In summer, the maximum measured value was larger than 3 times the maximum winter value, and the color reaction continued longer. 91D is designed to measure for 10 h, and data of 17.75 and 21.50 h are reference data. Formaldehyde is never generated in a cucumber. The vanishing of a color reaction of 91D was considered to be caused by high moisture content (humidity 100%), and the complexity of the components of cucumber gas, especially components that show a color reaction of 141L.

Fig. 5 shows the time transitions of near-infrared photons and the measured value of 91D in a relative ratio. A relationship existed between them because their peak times were the same.

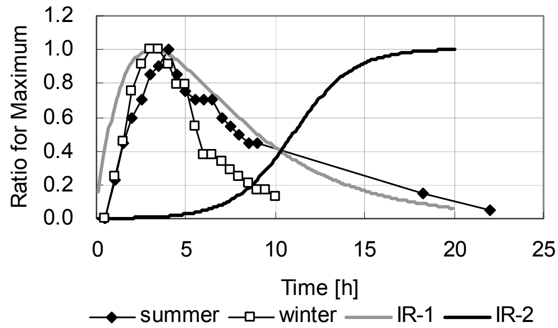

Fig. 5 Time Transition of Near-Infrared Biophotons and Measured Value of 91D

3-3 Visual Light Biophotons

There are many possible models adapted to the time transition of visual light biophotons [< 650nm]. However, it is difficult to judge them because the details of the emission mechanism are unknown at present. In the present study, the simplest logistic model that seems to have some biological validity is discussed.

Assumption: Continuous luminous points increase logistically, and then they finish luminous activity logistically. Moreover, another luminescence occurs later.

Visual light reaction 1: Here, t is the time after cutting the cucumber, t_1 is the point of inflection, N_1 is the number of luminous areas, K_1 is the carrying capacity and r_1 is the growth rate:

$$dN_1/dt = r_1(K_1 - N_1)N_1,$$

then,

$$N_1 = K_1/(1+\exp[r_1K_1\{t_1-t\}]).$$

Visual light reaction 2: N_2 is the number of areas that finish luminous activity and r_2 is the growth rate. Here, the carrying capacity is replaced with k_2N_1 and coefficient k_2 =1:

$$N_2 = k_2N_1/(1+\exp[r_2k_2N_1\{t_2-t\}]).$$

Visual light reaction 3: Later, another luminous activity occurs logistically:

$$N_3 = K_3/(1+\exp[r_3K_3\{t_3-t\}]).$$

Here, t_1 = 4.5 [h], r_1 = 0.00012 [/h], K_1 = 11500, t_2 = 9 [h], r_2 = 0.00003 [/h], t_3 = 14 [h], r_3 = 0.0005 [/h], K_3 = 1500. Measured values can be approximated by the sum of those 3 reactions (**Fig. 6**).

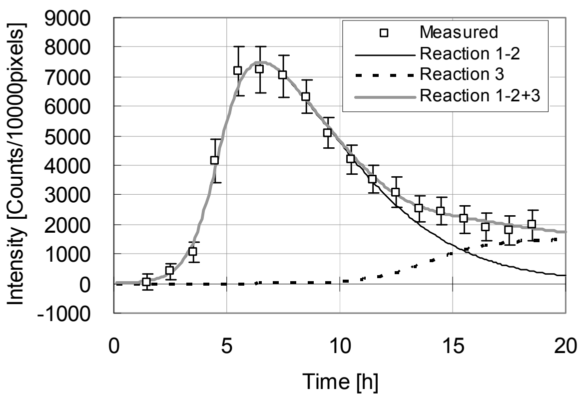

Fig. 6 Calculated and Measured Values of Visual Light Biophotons
Measured values are the photon intensity of control samples in Ref. 2. Zero points of time and intensity have been adjusted. Error bars are 95% confidence intervals (n = 102).

3-4 Approximate Equation of Anomalous Response

The photon intensity of experimental cucumber pieces will be larger than that of control pieces if a healer tries non-contact healing for 30 min to increase the intensity of biophotons generated from cucumber pieces. The difference of intensities is large 5 h after the healing.[2] Here, the authors name it tentatively a bio-PK reaction, which causes the anomalous difference. A bio-PK reaction can be approximated by a chain reaction the same as Equation 1. Here, A_0 = 12000 [counts/10000pixels], k_1 = 0.7[/h] and k_2 = 0.25 [/h].

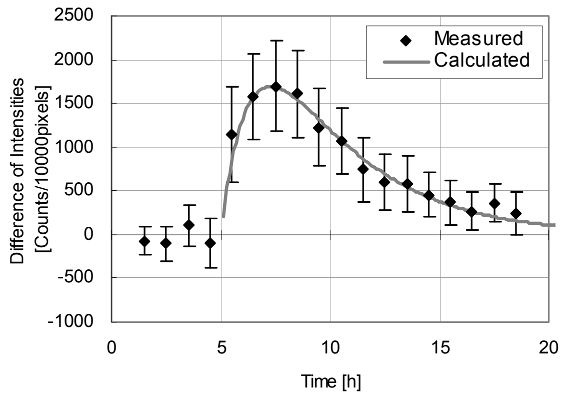

Fig. 7 Anomalous Reaction (bio-PK reaction) and Approximated Values
Error bars are 95% confidence intervals (n =102).

3-5 Detector Tube 141L

Table 2 lists measured values of the detector tube 141L for ethyl acetate. In summer, the cucumber gas concentration increased rapidly and reached larger values than in winter.[5] Moreover, values seemed to drift periodically after 10 h although the reasons are unknown.

Table 2 Measured Values of 141L (August/September in 2009)

time [h]	Average [ppm]	SD	n	time [h]	Average [ppm]	SD	n
1	21.3	2.5	4	13	487.5	53.8	4
2	84.6	35.9	8	14	587.5	47.9	4
3	158.8	89.1	4	15	557.5	20.6	4
4	285.0	79.9	6	16	598.3	67.9	6
5	354.0	78.9	5	17	537.5	68.5	4
6	340.0	43.4	6	18	525.0	133.0	4
7	440.0	37.4	4	19	655.0	42.0	4
8	495.0	114.8	8	20	547.5	68.0	4
9	527.5	77.6	4	21	545.0	179.0	4
10	566.7	98.3	6	22	585.0	61.4	4
11	478.8	82.7	8	23	532.5	68.5	4
12	577.5	93.2	4	24	615.0	83.8	10

Both values in summer and winter can be approximated by logistic equations. Here, however, it is assumed tentatively that summer data are a combination of summer and winter components because the connection was not smooth between the fifth and sixth h in summer data.

$$C = (\text{summer component}) + (\text{winter component}) = k \times K_S/(1 + \exp[r_S K_S\{t_S - t\}]) + k \times K_w/(1 + \exp[r_w K_w\{t_W - t\}])$$

Here, K_S = 310, r_S = 0.005 [/h], t_S = 3 [h], K_w = 240, r_w = 0.005 [/h], t_W = 7 [h], k = 1 [ppm].

Figs. 8 and 9 show measured values of 141L, those differences and approximated values of summer data.

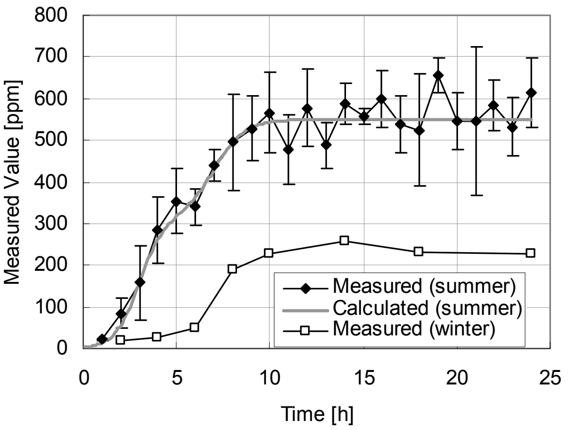

Fig. 8 Measured and Approximated Values of 141L
Error bars are SDs.

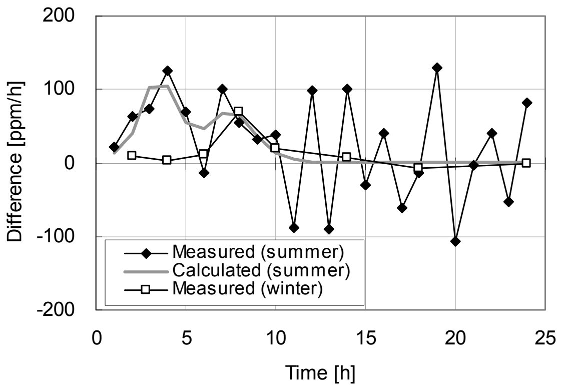

Fig. 9 Difference of Measured Values of 141L and Approximated Values

4. Discussion

Odor indicator test result show that the generating ratio of whole gas decreased monotonically 30 min after they were cut. It was not similar to reactions of gas detector tubes. Therefore, the components of the cucumber gas are considered to have changed with time. Although cucumber gases are considered to be generated chiefly by green odor biosynthesis[4], detected gases of 141L and 91D were possibly generated in later stages of green odor biosynthesis or other reactions, which were induced by green odor biosynthesis. Also, there is the same possibility for biophotons. Measured factors of both gas and biophoton methods are possibly more complex than earlier expectations.

Approximate equations of biophotons suggest that there were emission mechanisms, which started to emit photons 5 or 10 h after the cucumber was cut. Those photons were generated possibly by cell activity under the cut surface. The activity did not generate gas.

Because both peak times of near-infrared biophotons and color reaction of 91D roughly coincide, the IR-1 reaction is considered to have a relation with gases that show the color reaction of 91D. The differences of peak times seemed small between summer and winter even if the difference exists.

In contrast, the relationship between visual light biophotons and color reaction of 141L is more complex. It is considered that there was a relationship between them because the peak time of anomalous reaction (bio-PK reaction) was the same as the peak time for the color reaction of 141L for the winter cucumber.[5] However, there is little evidence to discern whether summer data of the gas were a combination of summer and winter components. Moreover, the authors have not identified the time within which anomalous gas effects occur although 141L can be used to detect anomalous effects even in summer. Further studies are needed to identify the detecting time period and verify that changes depend on seasons.

5. Conclusions

1. When cut cucumber is exposed to the air, the generating ratio of whole gases reaches a maximum 30 min after they were cut, and then decreases monotonically.
2. Components of cucumber gas change with time.
3. Photon emission mechanisms, which start to emit photons 5 or 10 h after cutting, do not generate gases.
4. There are relationships between near-infrared biophotons and biochemical reactions, which show a color reaction of 91D and between the bio-PK reaction and biochemical reactions, which show a color reaction of 141L. However, the reaction of 141L in summer is different from winter. Further studies are needed to understand the details of the difference.

Acknowledgement

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