Electronic Supplementary Material (ESI) for Lab on a Chip.

Water pollutant monitoring by whole cell array through lens-free detection on CCD

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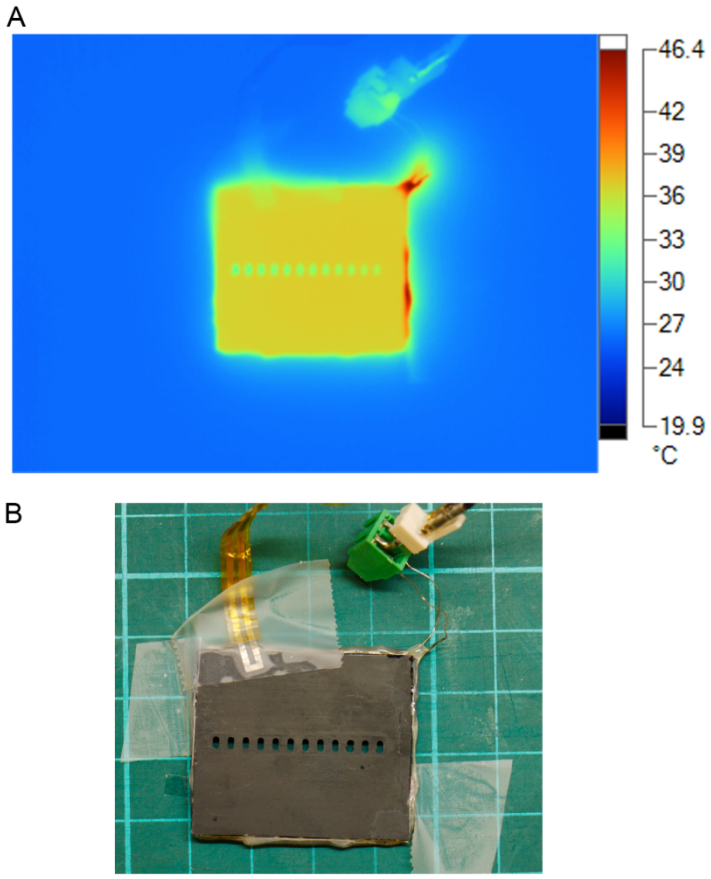
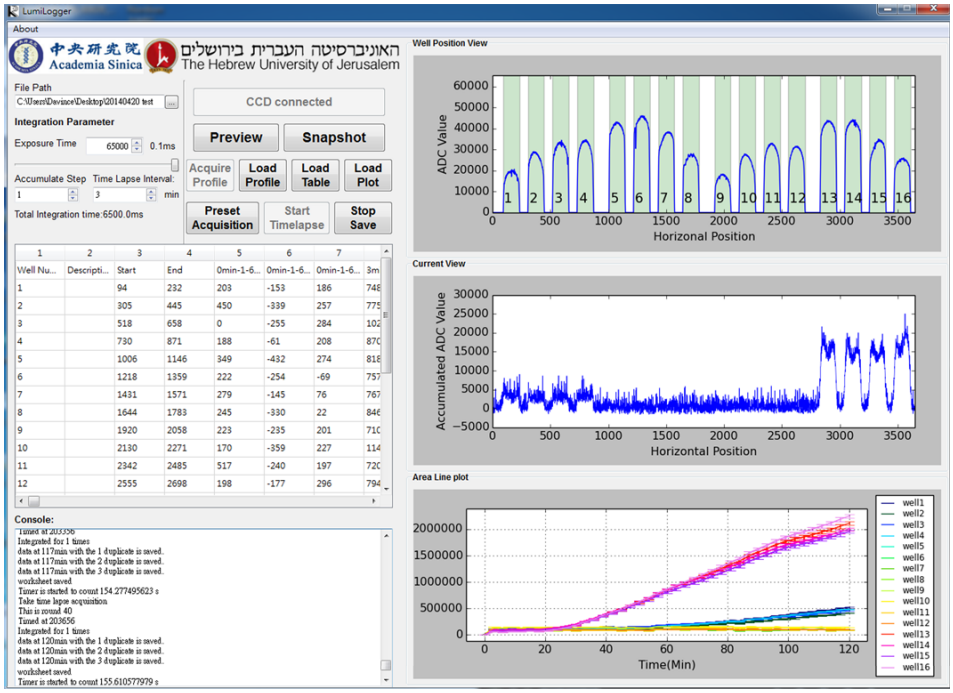
Supplementary Information

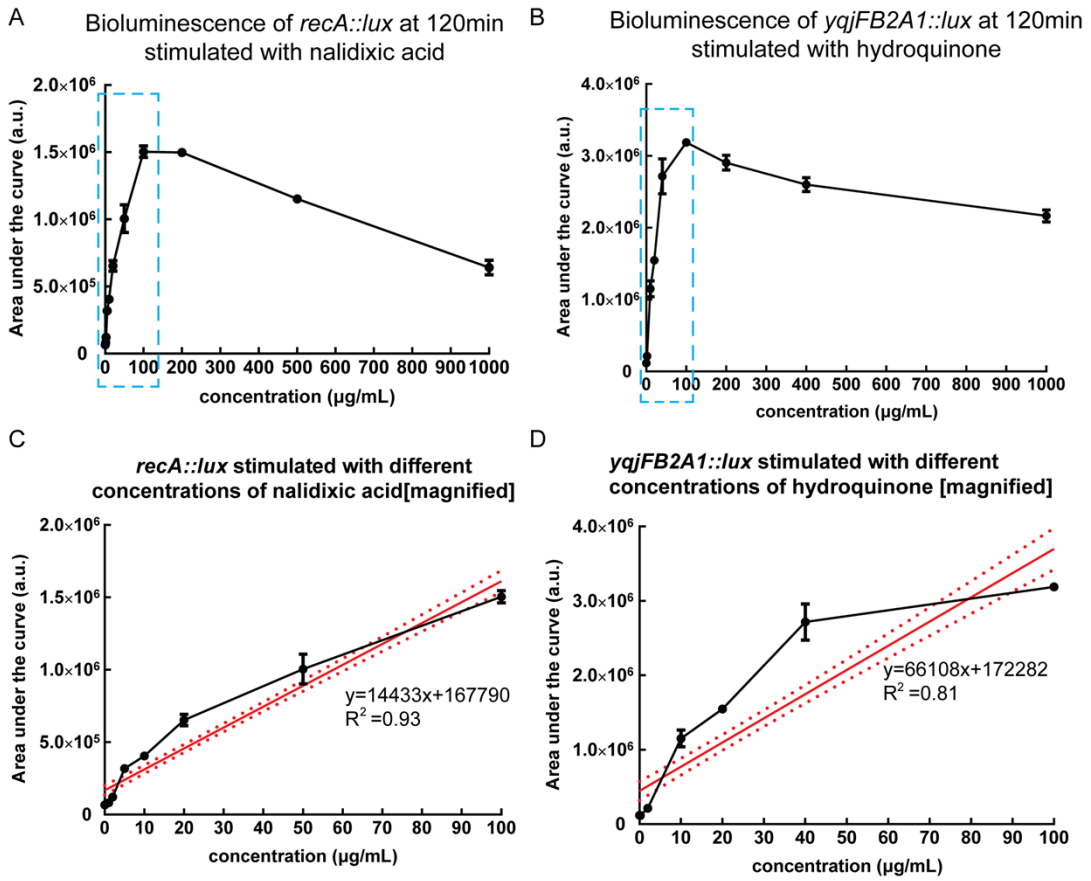
I. Supplementary figures and tables



SUPPL. FIG. 1 (A) An infra-red thermo-image of a heated AMC showing uniform temperature distribution (B) The photo picture of the same AMC



SUPPL. FIG. 2 A screenshot of LumiLogger after two hours of experiment.



SUPPL. FIG. 3 The linearity of nalidixic acid and hydroquinone concentration to area under the curve at 120 mins. (A) The bioluminescence of *recA::lux* at 120min stimulated with different concentrations of nalidixic acid. (B) The bioluminescence of *yqjFB2A1::lux* at 120 mins stimulated with different concentrations of hydroquinone. (C) The magnified view of the linear region (blue dashed box) in (A). The linear regression line is in red and 95% confidence interval is in red dash lines. (D) The magnified view of the linear region (blue dashed box) in (B). The linear regression line is in red and the 95% confidence interval region is in red dashed lines.

Reporter	Stimulant	First time point to significant difference (v.s. 0 min)	P value
recA::lux	1000 μg/mL NA	21 min	<0.0001
	500 μg/mL NA	21 min	<0.0001
	200 μg/mL NA	21 min	<0.0001
	100 μg/mL NA	21 min	<0.0001
	50 μg/mL NA	39 min	<0.01
	20 μg/mL NA	49 min	<0.05
	20 μg/mL NA	54 min	<0.0001
	10 μg/mL NA	54 min	<0.05
	10 μg/mL NA	60 min	<0.01
	5 μg/mL NA	63 min	<0.05
	5 μg/mL NA	69 min	<0.0001
	2 μg/mL NA	n/a	*p*>0.05
	1 μg/mL NA	n/a	*p*>0.05
	0.5 μg/mL NA	n/a	*p*>0.05
	0 μg/mL NA	n/a	*p*>0.05
yqjFB2A1::lux	1000 μg/mL Q	15 min	<0.0001
	400 μg/mL Q	15 min	<0.0001
	200 μg/mL Q	12 min	<0.0001
	100 μg/mL Q	12 min	<0.05
	100 μg/mL Q	15 min	<0.0001
	40 μg/mL Q	15min	<0.01
	20 μg/mL Q	18 min	<0.05
	20 μg/mL Q	21 min	<0.0001
	10 μg/mL Q	21 min	<0.01
	2 μg/mL Q	45 min	<0.01
	0.2 μg/mL Q	n/a	*p*>0.05
	0 μg/mL Q	n/a	*p*>0.05

SUPPL. TABLE. 1 A table of ANOVA results of time and concentration of nalidixic acid (NA) and hydroquinone (Q) as within subject factors.

II. Calculation of light collection efficiency in LumiChip

In the lens-free configuration, the light collection efficiency (Q) can be calculated as follows. To approximate the light collection efficiency in our setup, we consider the bacteria cells residing in the wells on AMC as point light sources and the AMC as a lithographic mask (SUPPL. FIG. 4) with a circular surface area, whose diameter is the well width. The angle of light cone (θ, SUPPL. FIG. 4) for each point light source can be calculated. For simplicity, we only considered the points along the center line.

The light collection efficiency is defined as the fraction of total emitted bioluminescent light that passes the well bottom[1].

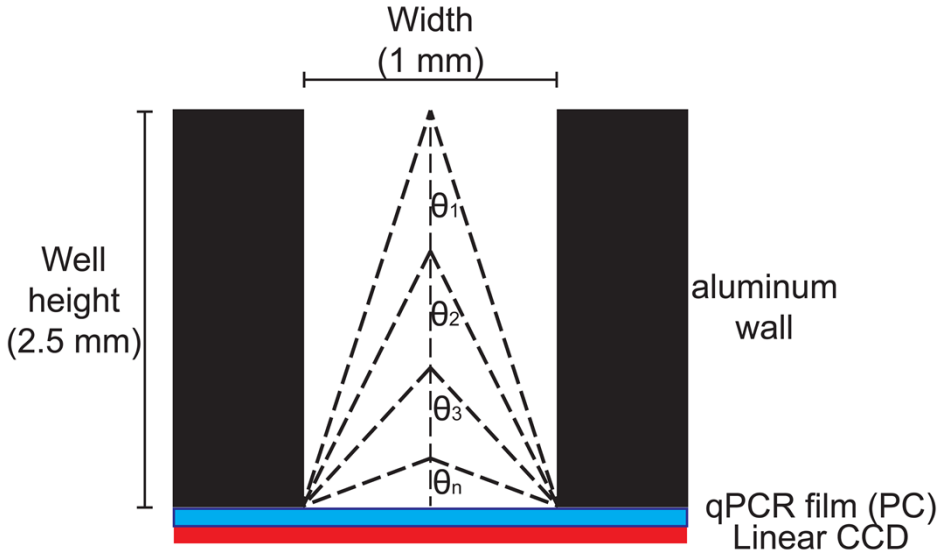
$$Q = \frac{\sin^2\theta}{2} \qquad \text{eq (1).}$$

The average light collection efficiency in the 16-member array chip in this study can be calculated by equation 2 by considering every point in the 1-mm wide well as a point light source. The angle of the light cone at the far end of the well, θ_1, can be calculated by $\tan^{-1}(0.5/2.5)$ as 11.31°.

$$Q_{avg} = \frac{1}{\theta_n - \theta_1}\int_{\theta_1}^{\theta_n}\frac{\sin^2\theta}{2}d\theta \qquad \text{eq (2).}$$

$$= \frac{1}{\frac{\pi}{2} - 11.31 \times \frac{\pi}{180}}\int_{11.31\times\frac{\pi}{180}}^{\frac{\pi}{2}}\frac{\sin^2\theta}{2}d\theta = 28.5\%$$

The estimated upper limit of light collection efficiency in our system is 28.5%. In comparison, a theoretical limit of the light collected by a fiber optic can be as high as 50%.



SUPPL. FIG. 4 The cross-section diagram of an AMC chip well, optically-clear film (not to scale), and the CCD surface.

Reference

[1] E. Karplus, in *Photoproteins in Bioanalysis*, eds. S. Daunert and S. K. Deo, Wiley-VCH, Weinheim, 1 edition., 2006, pp. 199–223.