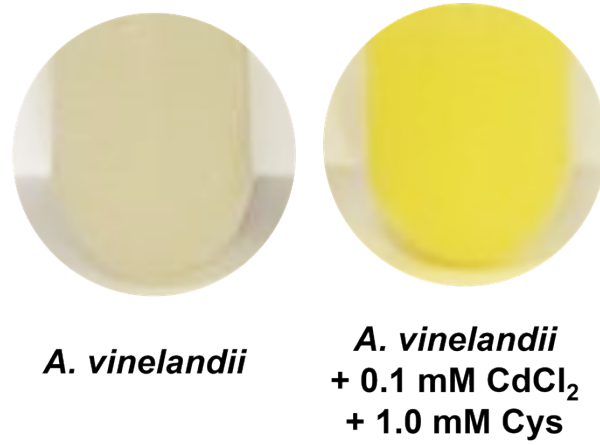


## Supporting information

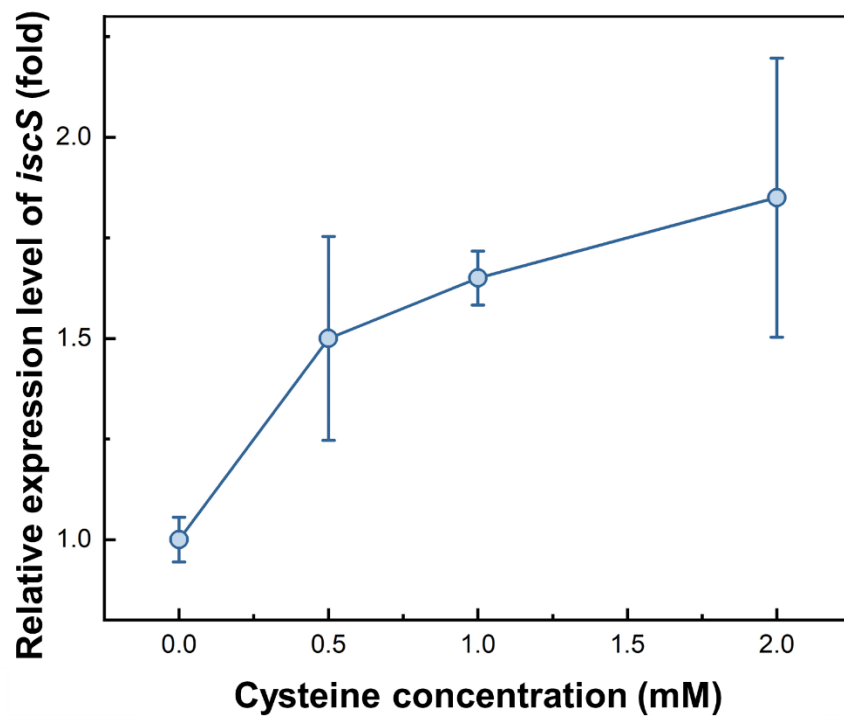
### ***In vivo* synthesis of semiconductor nanoparticles in *Azotobacter vinelandii* for light-driven ammonia production**

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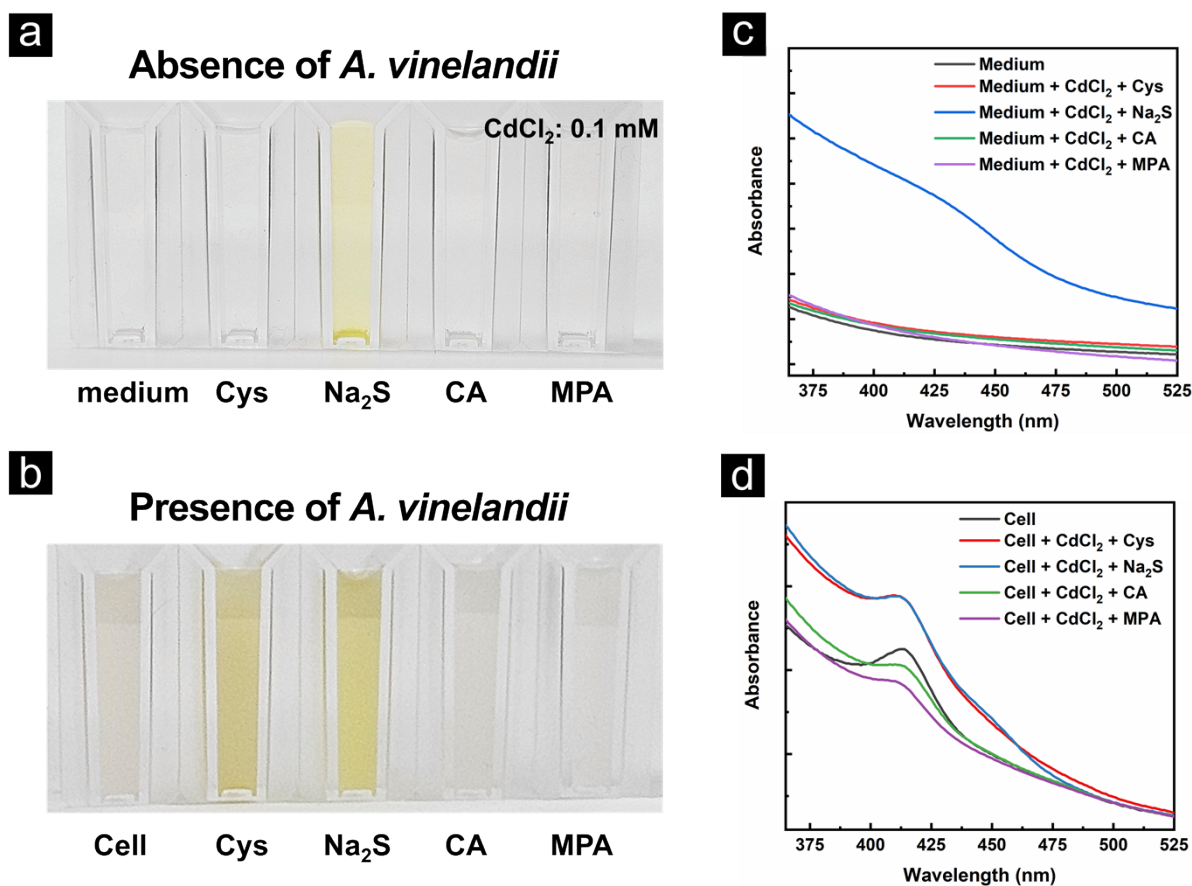
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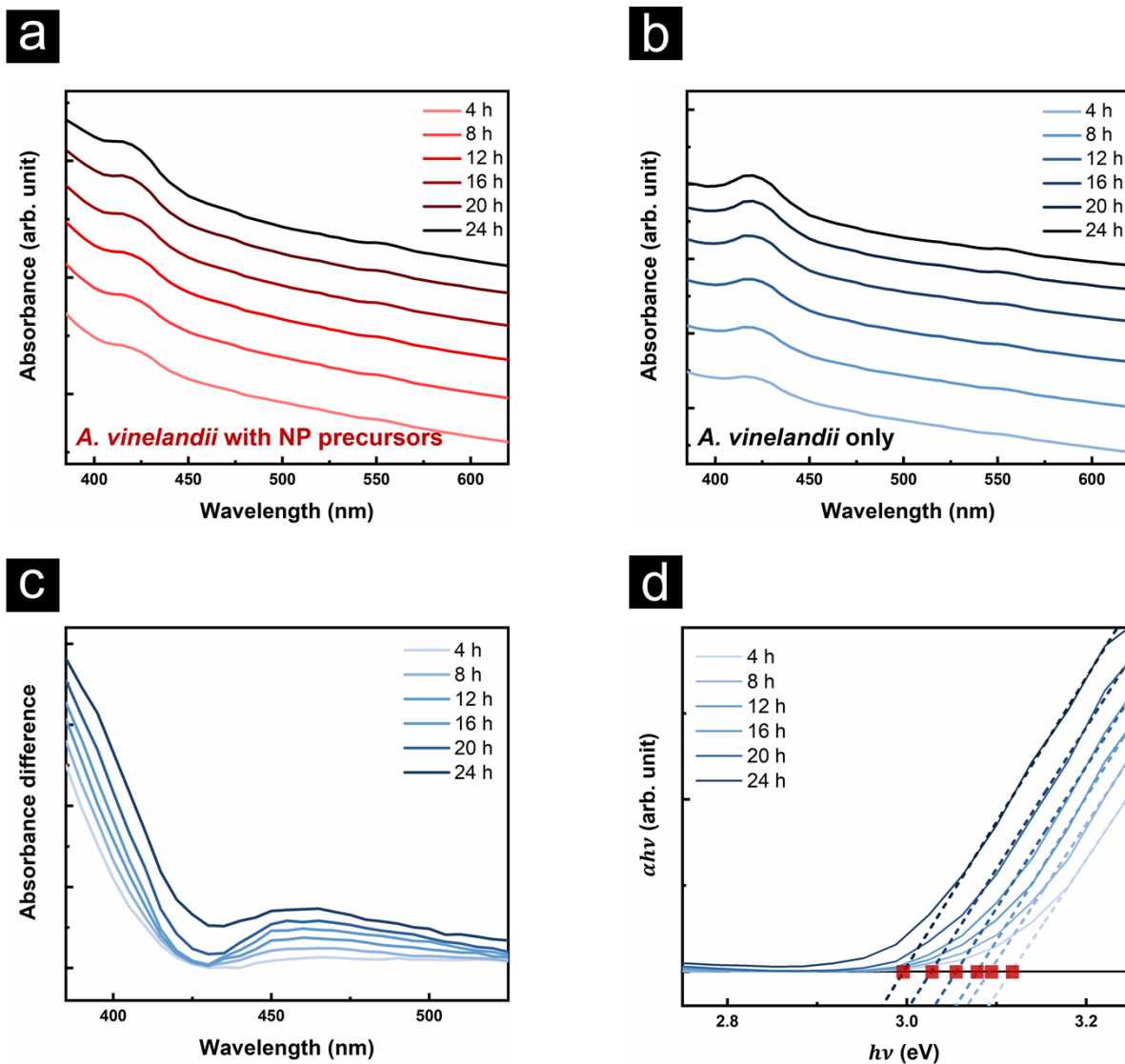
**Fig. S1** Photographs of *A. vinelandii* only (left) and *A. vinelandii* cultured in a medium containing 0.1 mM CdCl<sub>2</sub> and 1.0 mM cysteine (cys) (right). The images illustrate the coloration differences in response to the presence of the biosynthesis precursors



**Fig. S2** Relative expression level of *icsS* gene of *A. vinelandii* cell with varying cysteine concentrations of the culture condition.



**Fig. S3** Photographs of the culture media containing 0.1 mM CdCl<sub>2</sub> and various sulfur precursors—cysteine (Cys), sodium sulfide (Na<sub>2</sub>S), cysteamine (CA), and 3-mercaptopropionic acid (MPA)—after the cultivation condition (24 h, 30 °C) in (a) the absence and (b) the presence of *A. vinelandii*. The characteristic yellow color represents the synthesized CdS nanoparticles. Absorption spectra of the corresponding culture media in (c) the absence and (d) the presence of *A. vinelandii*.



**Fig. S4** Absorbance of *A. vinelandii* cultured for 24 h at 30 °C in (a) a medium with NP biosynthesis precursors and (b) a medium without precursors. (c) Absorbance difference between of *A. vinelandii* when cultured in a medium with nanoparticle biosynthesis precursors versus a control medium. (d) Tauc plot for determining the band gap of CdS nanoparticles synthesized within the *A. vinelandii*. Red squares represent the x-intercepts of corresponding tangents (dashed line) for estimating band gaps of nanoparticles.

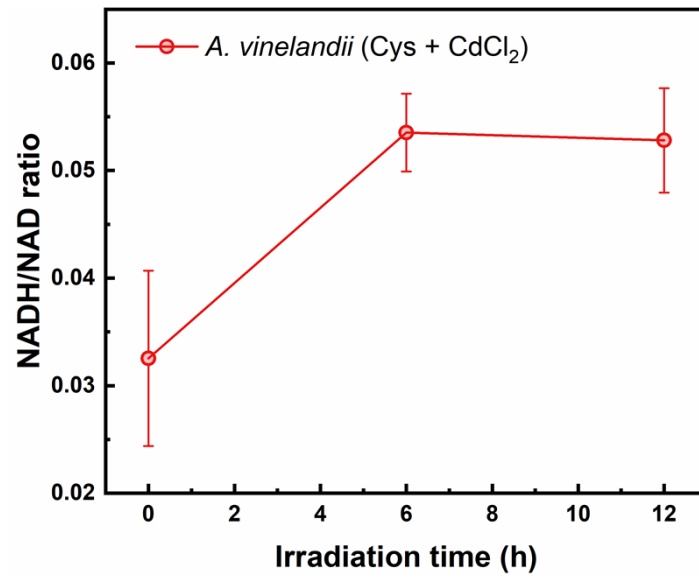


Fig. S5 NADH/NAD ratio of *A. vinelandii* (Cys + CdCl<sub>2</sub>) biohybrid under light irradiation.



**Fig. S6** TEM image of CdS nanoparticle with the (111), (200) lattice fringe of CdS cubic structure.

**Table S1.** Comparative table of inorganic-bacteria biohybrid for light-driven ammonia production with N<sub>2</sub> fixation

<b>Bacteria species</b>	<b>Photosensitizer</b>	<b>Light source</b>	<b>Strategy</b>	<b>Productivity (mol NH<sub>4</sub><sup>+</sup>/mol cells)</b>	<b>Ref.</b>
<i>A. vinelandii</i> (DJ995)	CdS/ZnS, CdSe/ZnS, InP/ZnS, Cu <sub>2</sub> ZnSn <sub>5</sub> S <sub>4</sub> /ZnS QDs	400 nm LED	Mixing cell and QDs	4 x 10 <sup>7</sup>	1
<i>A. vinelandii</i> (DJ995)	Au nanoclusters	400 nm LED	Mixing cell and Au nanoclusters	1 x 10 <sup>8</sup>	2
<i>A. vinelandii</i> (KCTC2426)	InP/ZnSe QDs	400 nm LED	Cell co-culture with QD during growth phase	1.4 x 10 <sup>8</sup>	3
<b><i>A. vinelandii</i> (KCTC2426)</b>	<b>CdS nanoparticles</b>	<b>400 nm LED</b>	<b>Intracellular NP <i>in vivo</i> biosynthesis</b>	<b>1.8 x 10<sup>8</sup></b>	<b>This work</b>



## Reference

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