Implantable Light Source Development

BME Design Team LEDMAU5: Ruochen Wang, Jacky Tian, Hanna Rainiero, Lisa Xiong
Client: Matyas Sandor, PhD
Advisor: Justin Williams, PhD
Department of Biomedical Engineering, University of Wisconsin- Madison

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

UW BME Design

Abstract

The Sandor lab is investigating immune cell trafficking using photoconversion and optogenetic activation of immune cells utilizing photoactivation. KikGR mouse cells can be photoconverted from green to red when exposed to a 405 nm wavelength light and Ai32 mouse cells can be photoactivated when exposed to a 450-490 nm wavelength range. The current method for photoconversion/photoactivation involves a fiber optic cable with a needle attachment which lacks surface area exposure necessary for efficient photoconversion/activation. A previous semester design that utilized LEDs was improved with a printed circuit board (PCB). LEDs on a breakout board were used for ease of use, testing, and debugging. The LEDs successfully photoconverted KikGR mouse cells and was found to be within the photoactivation range of the Ai32 mouse cells. Temperature changes of LEDs stayed well below tissue coagulation temperatures over time.

Background & Motivation

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- Antibiotic resistant TB strains are increasing prompting the need for alternative therapies [1]
- The Sandor Lab is investigating immune cell trafficking into granuloma sites and immune cell activation [2]
- Current photoconverting/photoactivating devices are expensive and are unable to illuminate a large area
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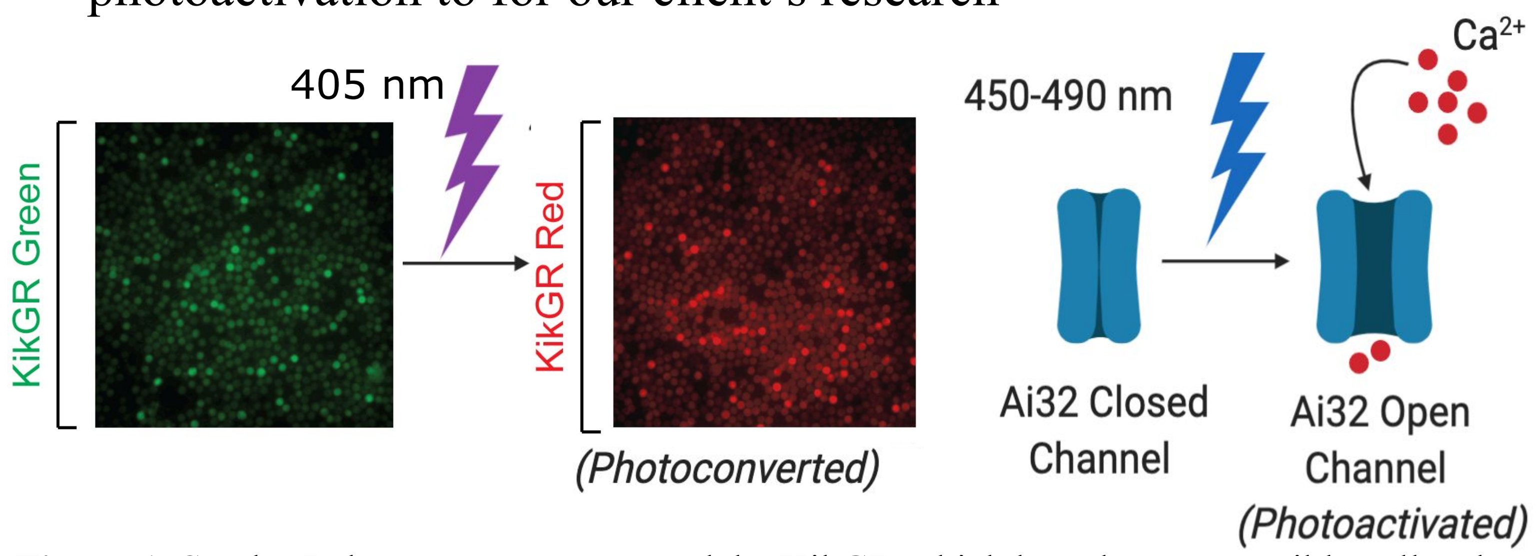


Figure 1. Sandor Lab uses two mouse models: KikGR which has photoconvertible cells when exposed to 405 nm wavelength and Ai32 which has photoactivatable cells that undergo calcium influx by channel rhodopsins after exposure to 450-490 nm light (*Biorender*).

Final Design

Design Specifications:

- Biocompatible, emit minimal heat, and non phototoxic
- Min intensity of 95 mW/cm^2 & 405 nm (KikGR33) and 400 mW/cm^2 & 450-490 nm (Ai32)
- No change in systemic body temperature by 1°C [3]
- No significant impact on LED emission by biocompatible coating

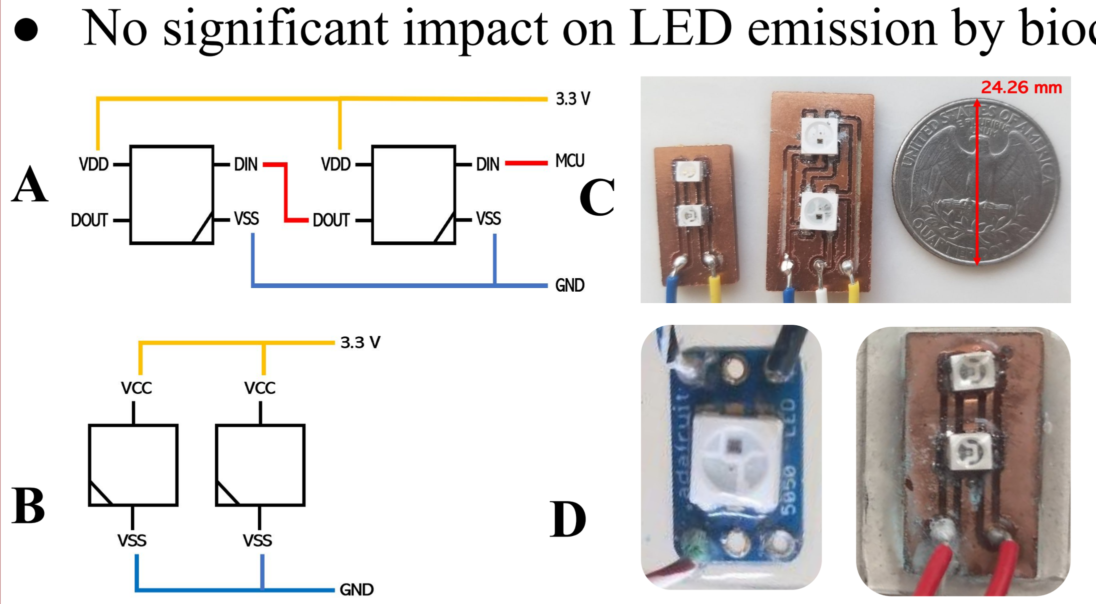
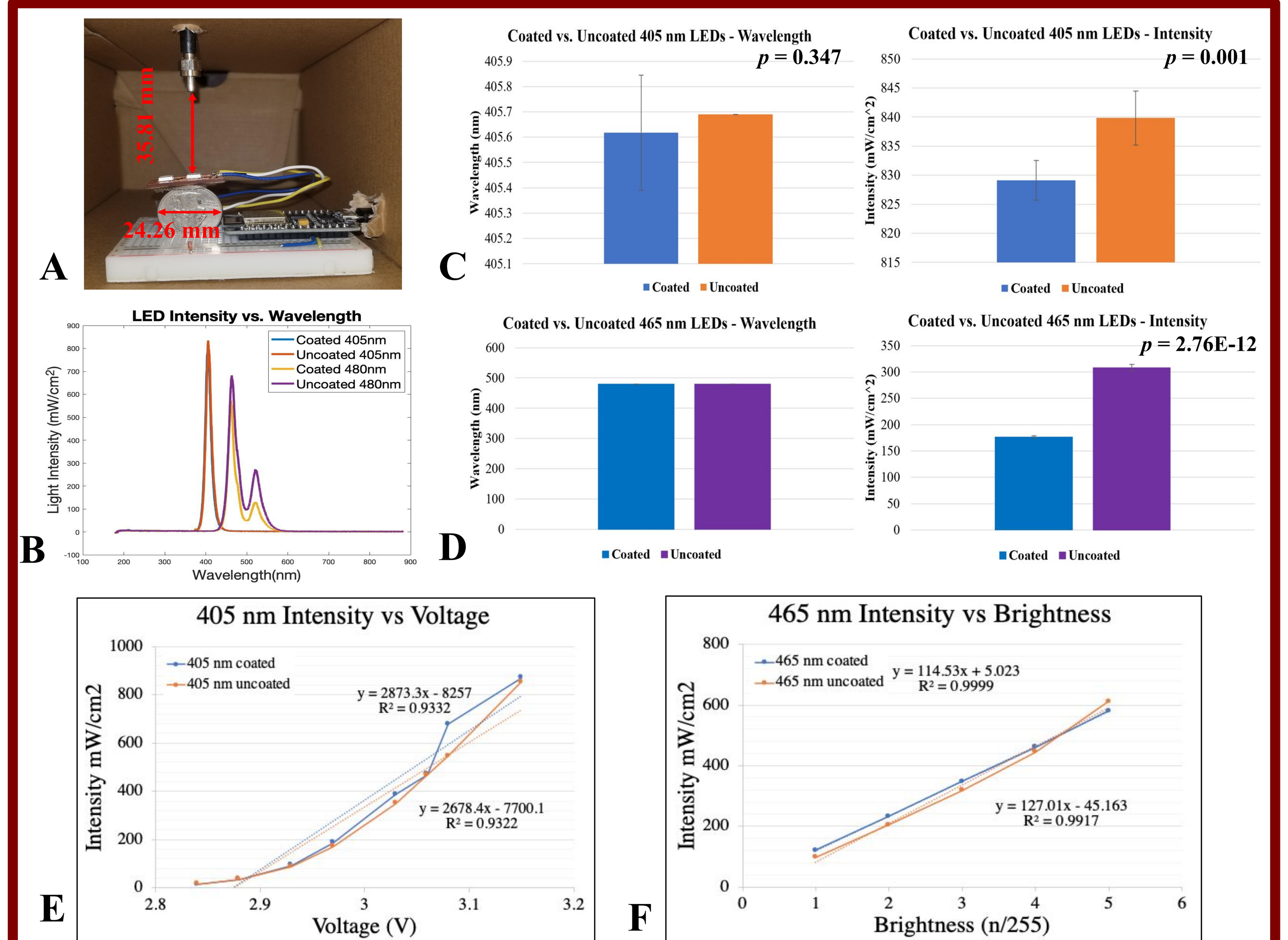


Figure 2. **(A)** 480 nm LED schematic. **(B)** 405 nm LED schematic. **(C)** 480 nm LEDs on a PCB. **(D)** LEDs with PDMS coating.

Device Verification & Validation



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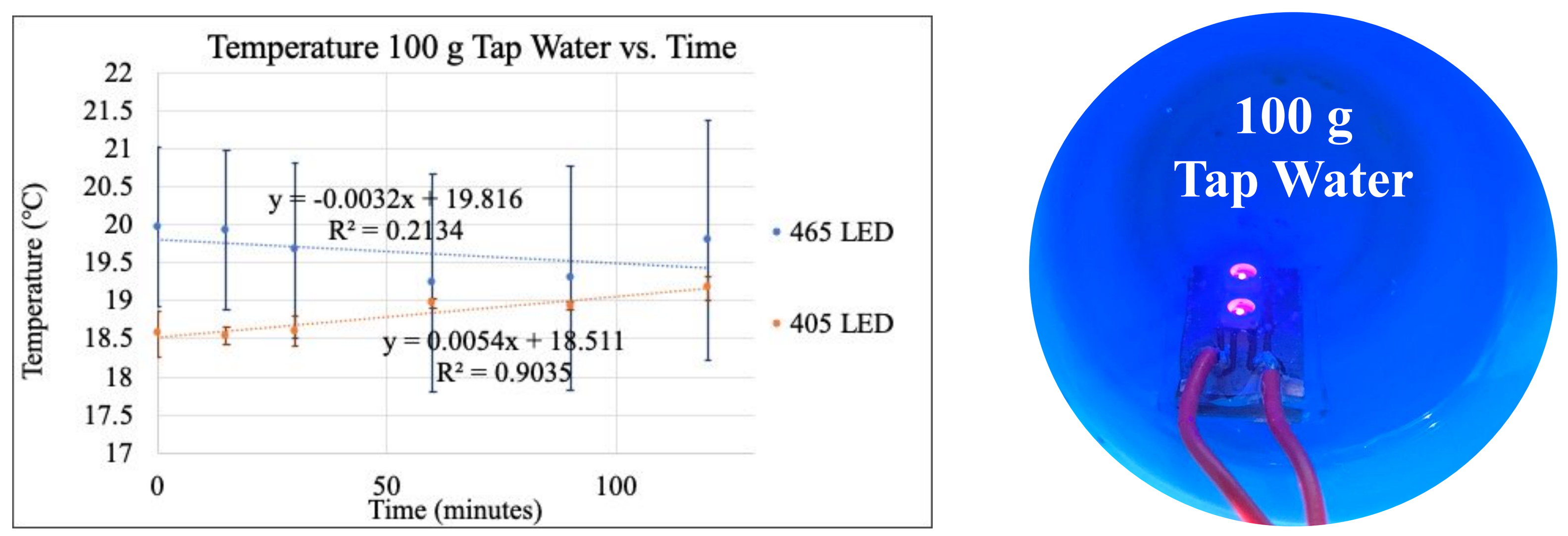

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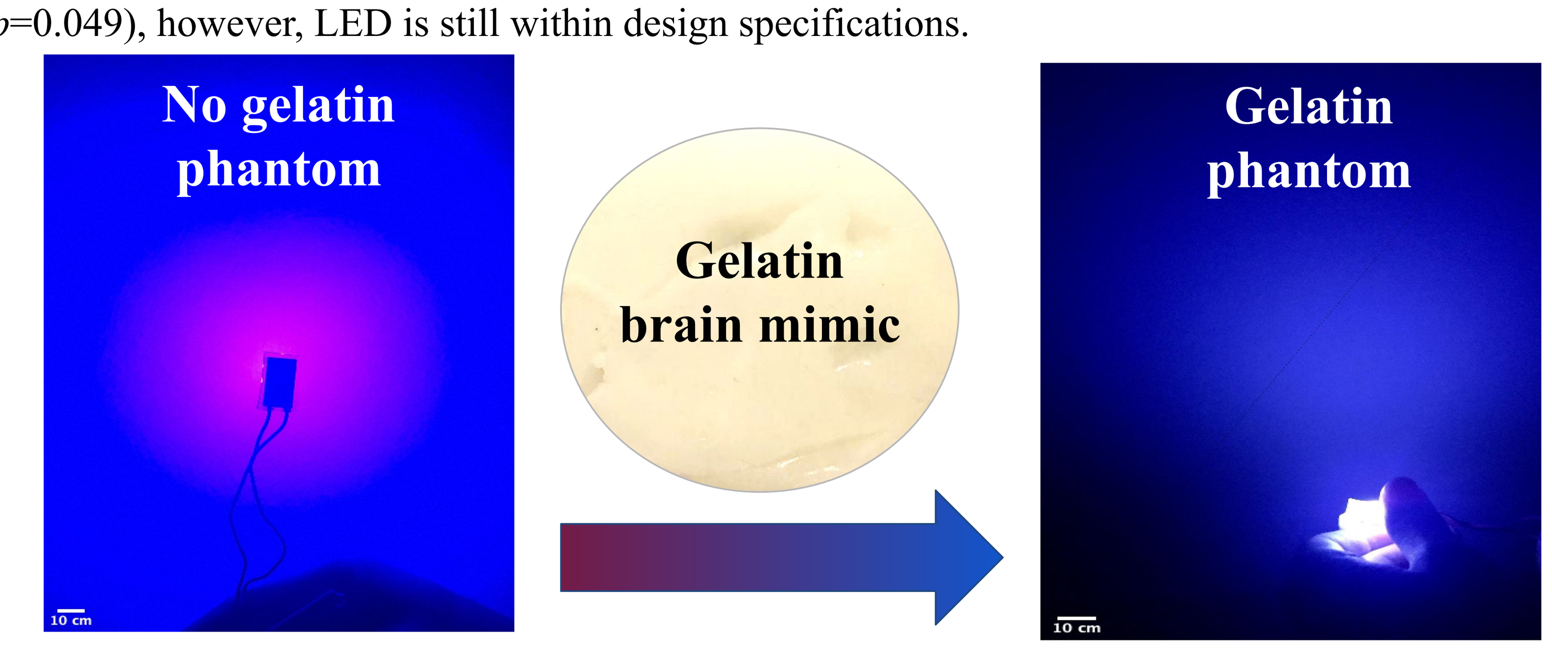

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Material

Material	Quantity	Cost
405nm SMD LEDs	30	$21.40
DC Barrel Jack	3	$2.85
Copper Board	10	$25.30
Power Supply Adapter	2	$12.99
NodeMCU Board	3	$13.98
Gelatin	N/A	$2.69
PDMS	N/A	$0.00
Microcontrollers	2	$0.00
	Total	$79.21

Discussion

Accomplishments:

- Coated PCBs with biocompatible PDMS coating
- PDMS coating does not significantly impact wavelength but does significantly impact intensity though not extensively
- Ensured heat output from LED is safe for *in vivo* studies
- Identified that PDMS does not have suitable durability
- LED wavelength and scatter impacted by gelatin phantom

COVID-19 Potential Application

- Identify immune trafficking targeted therapies in KikGR33/K18-hACE2 (a murine COVID-19 transgenic mouse model) to suppress hyperinflammation in COVID-19 for patients suffering from acute respiratory distress syndrome

Future Work:

- Coat PCBs with veterinary grade epoxy resin
- Test 405 nm LEDs' ability to photoconvert KikGR33 *in vitro*
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- Phototoxicity threshold for intensity and duration
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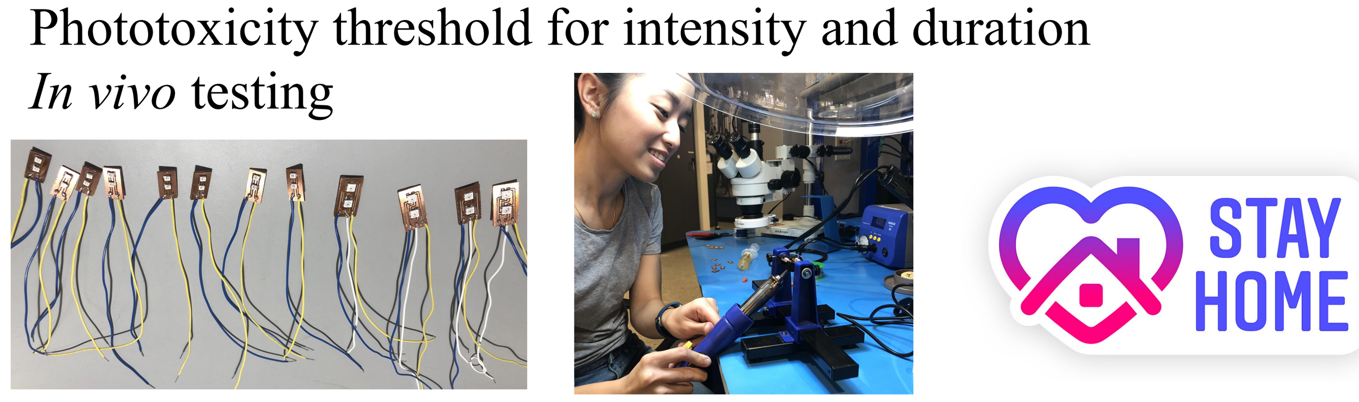

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makerspace

References

[1] "Global tuberculosis report 2018," World Health Organization, 11-Sep-2019. [Online]. Available: https://www.who.int/tb/publications/global_report/en/. [Accessed: 08-Oct-2019]. https://www.nationalgeographic.org/encyclopedia/bioluminescence/. [Accessed: 10-Oct-2018]
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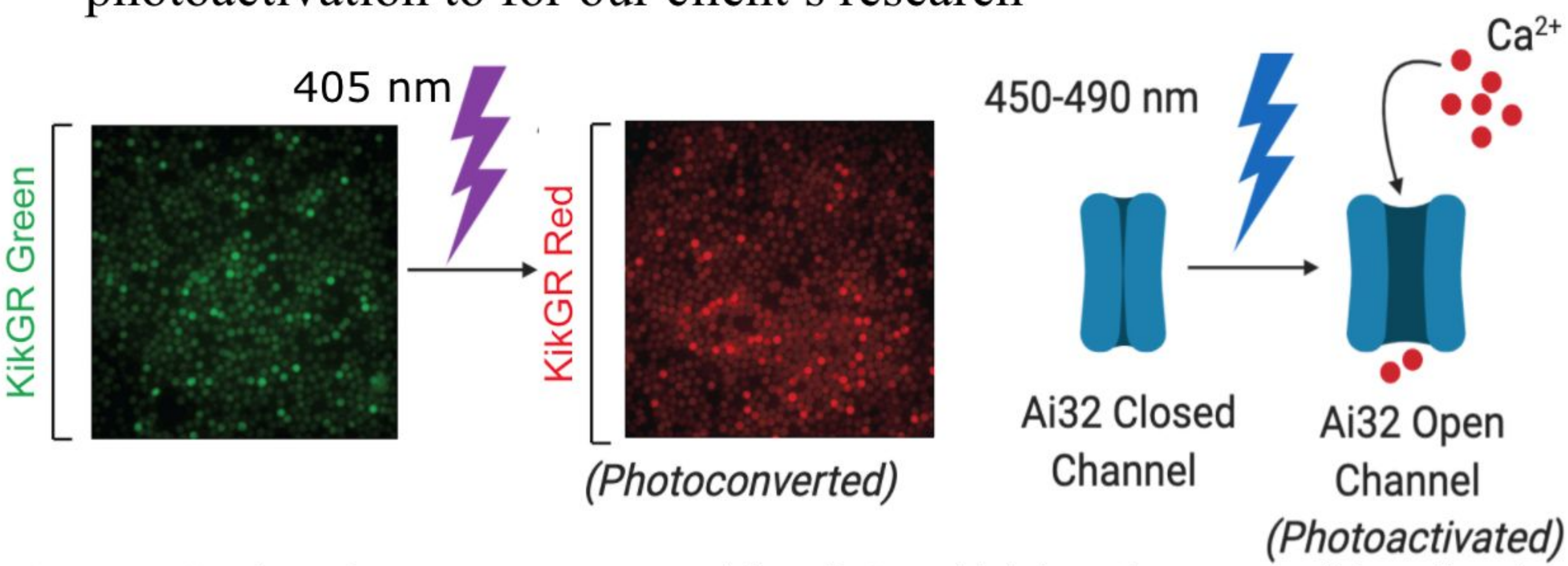

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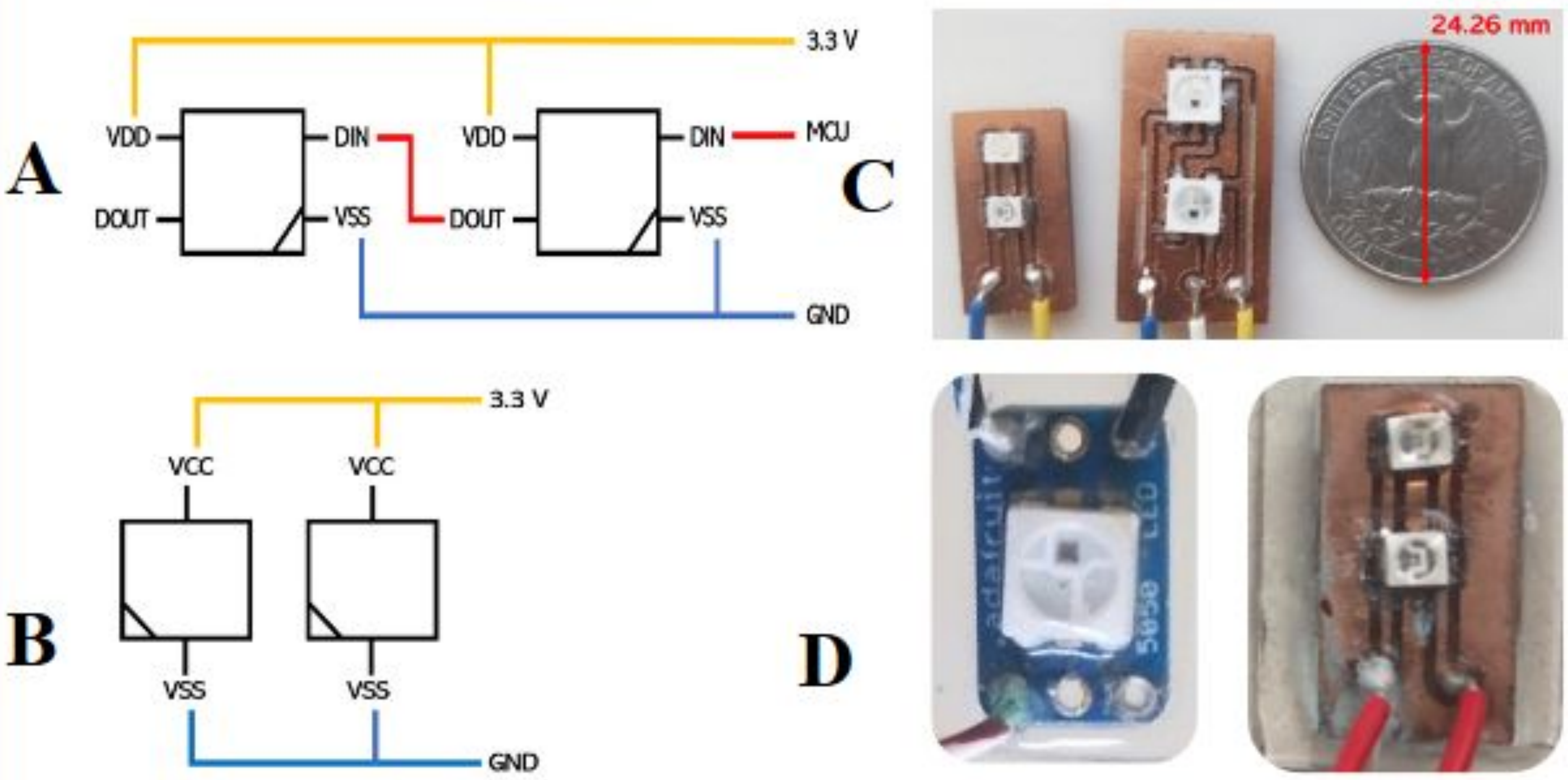

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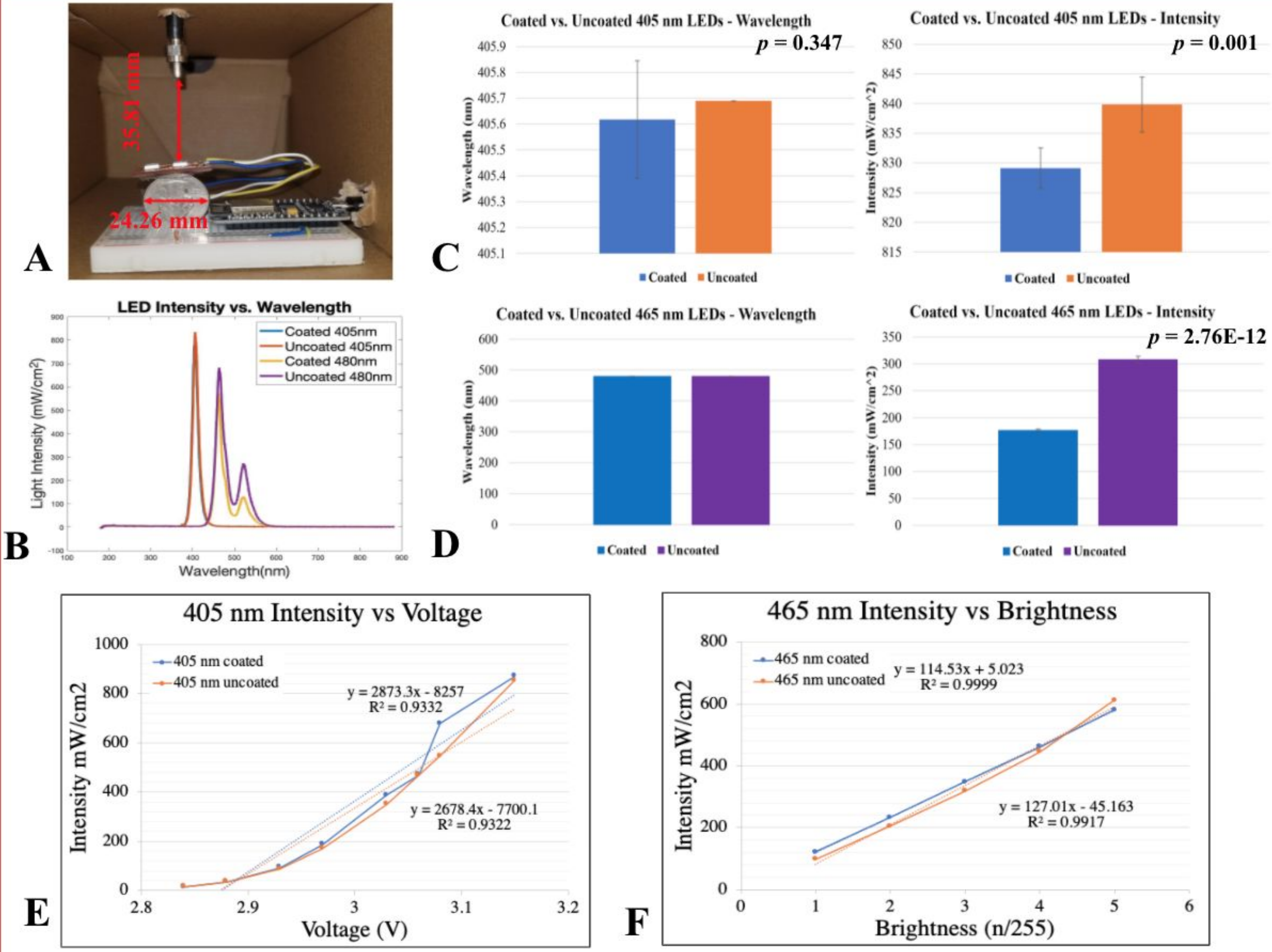

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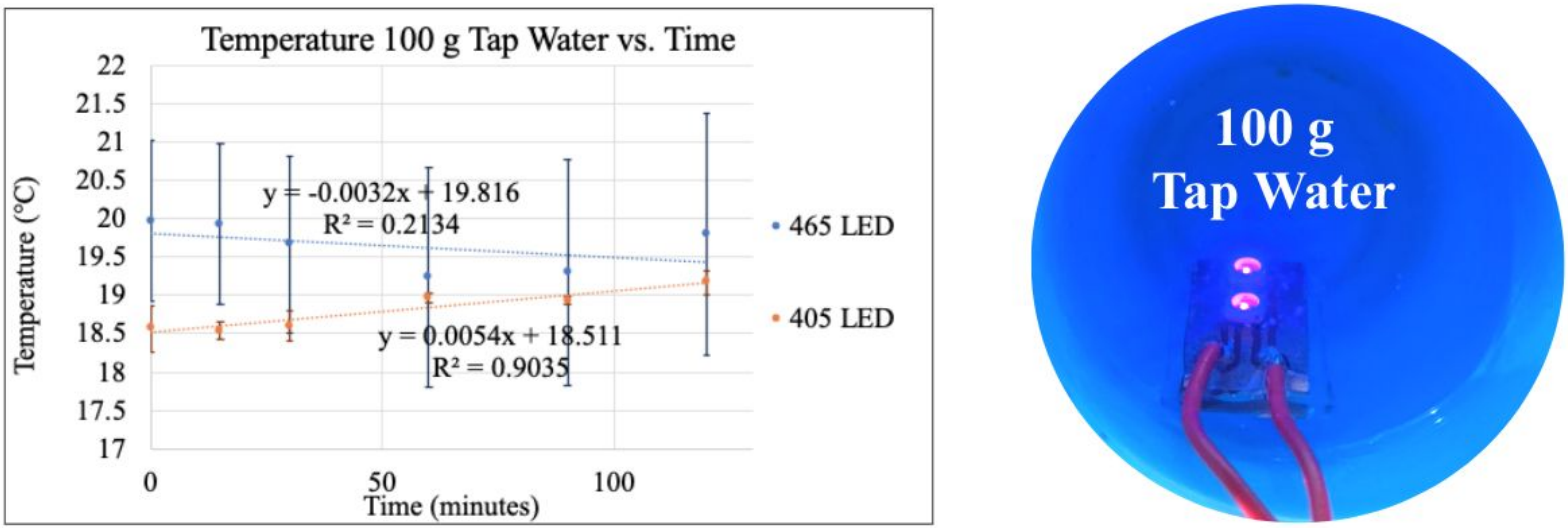

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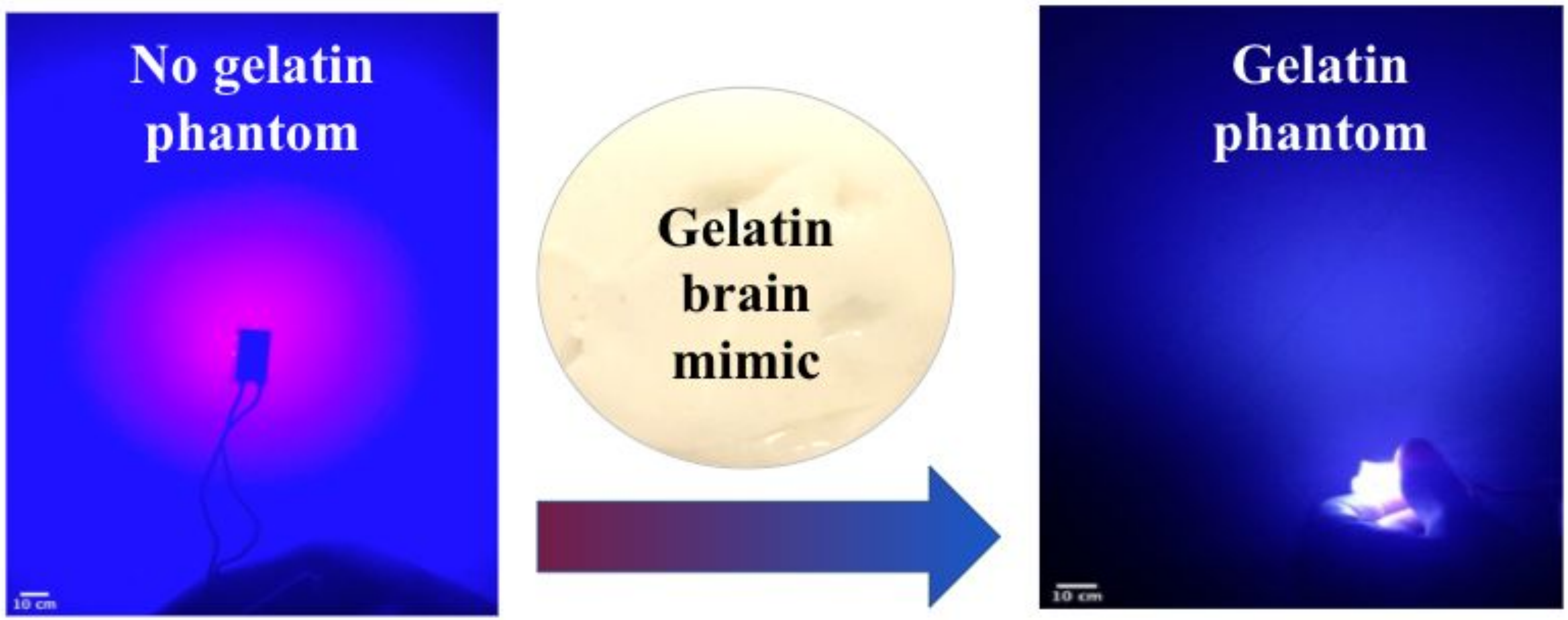

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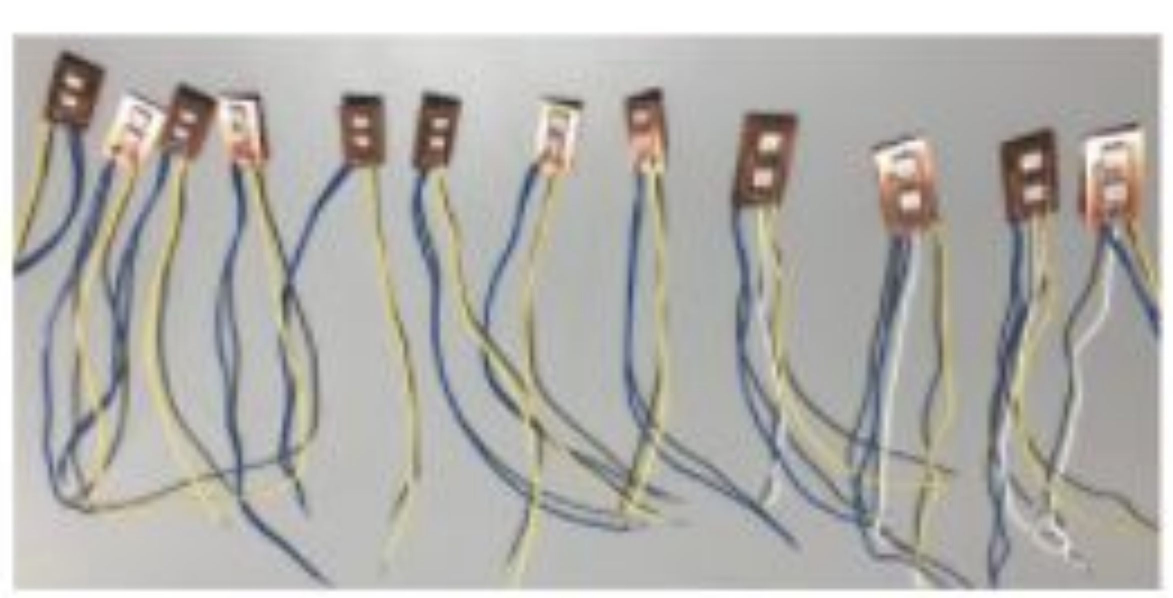

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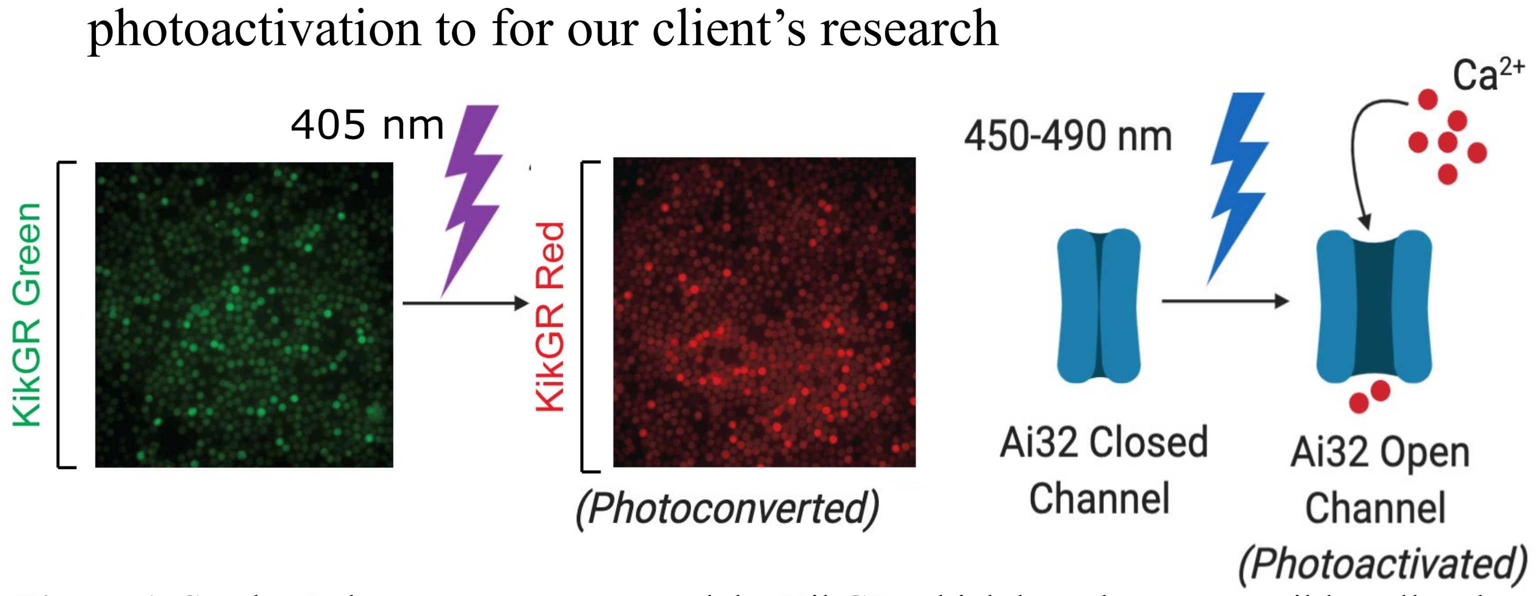

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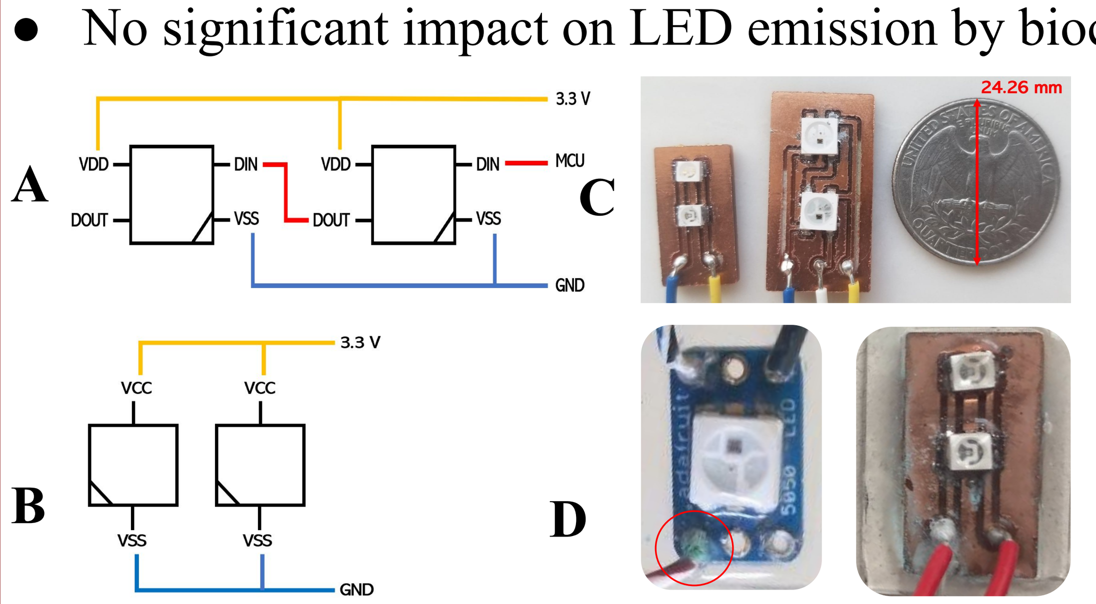

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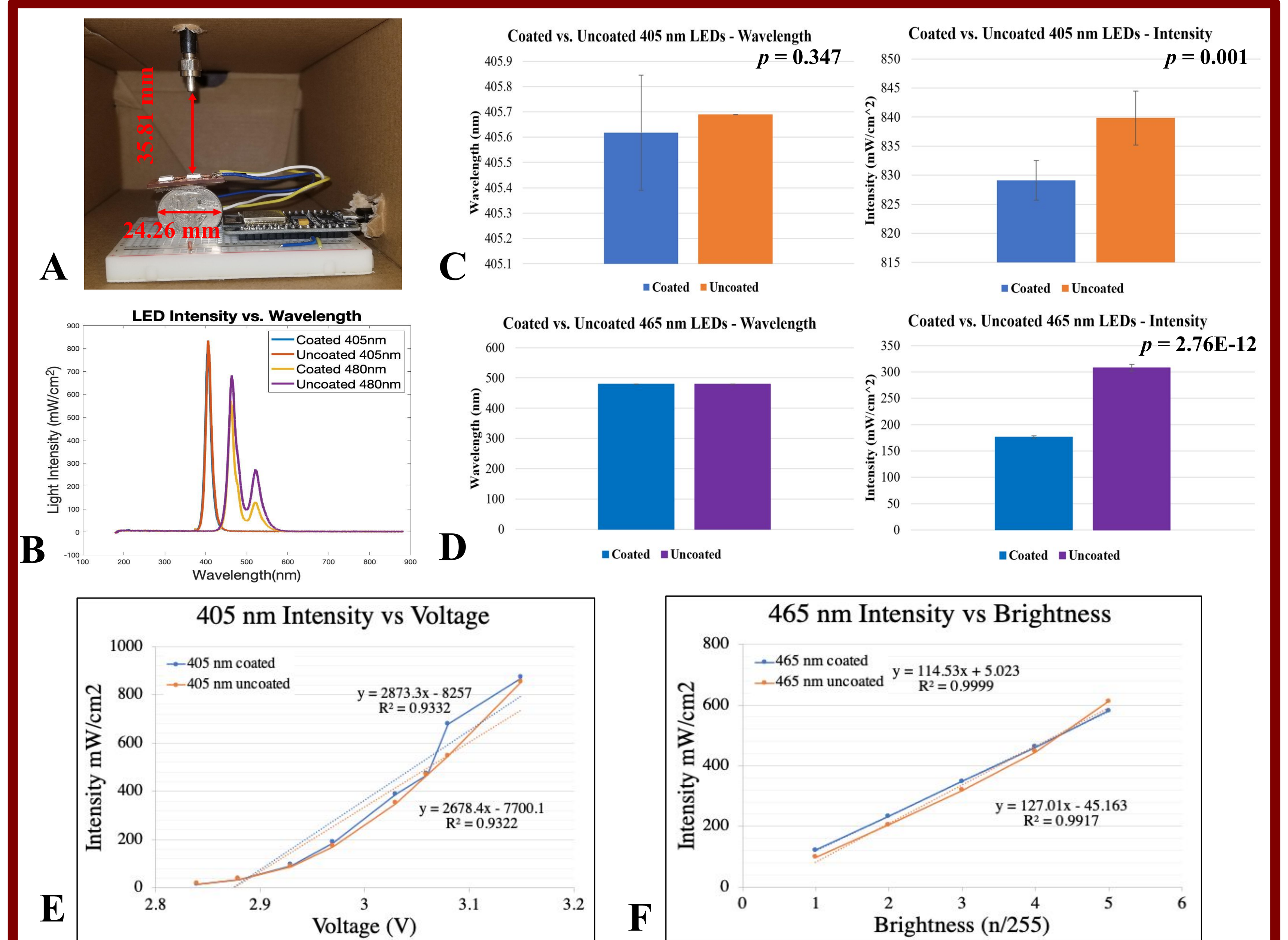

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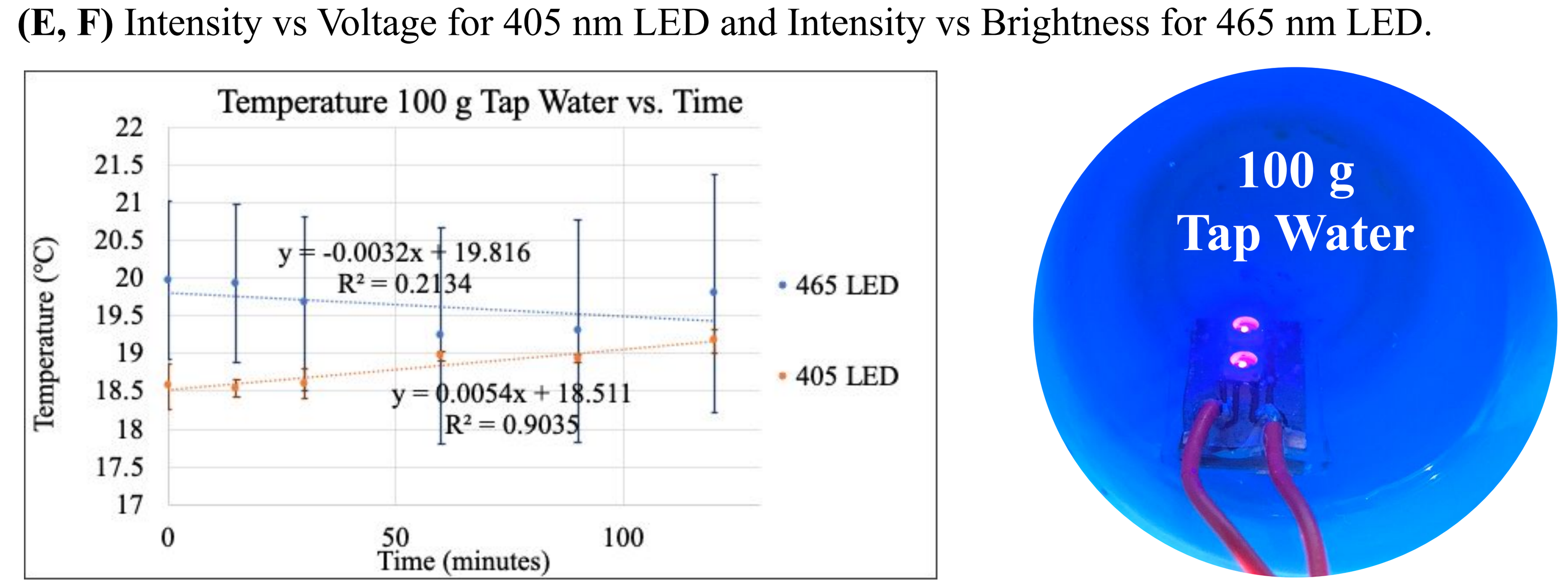

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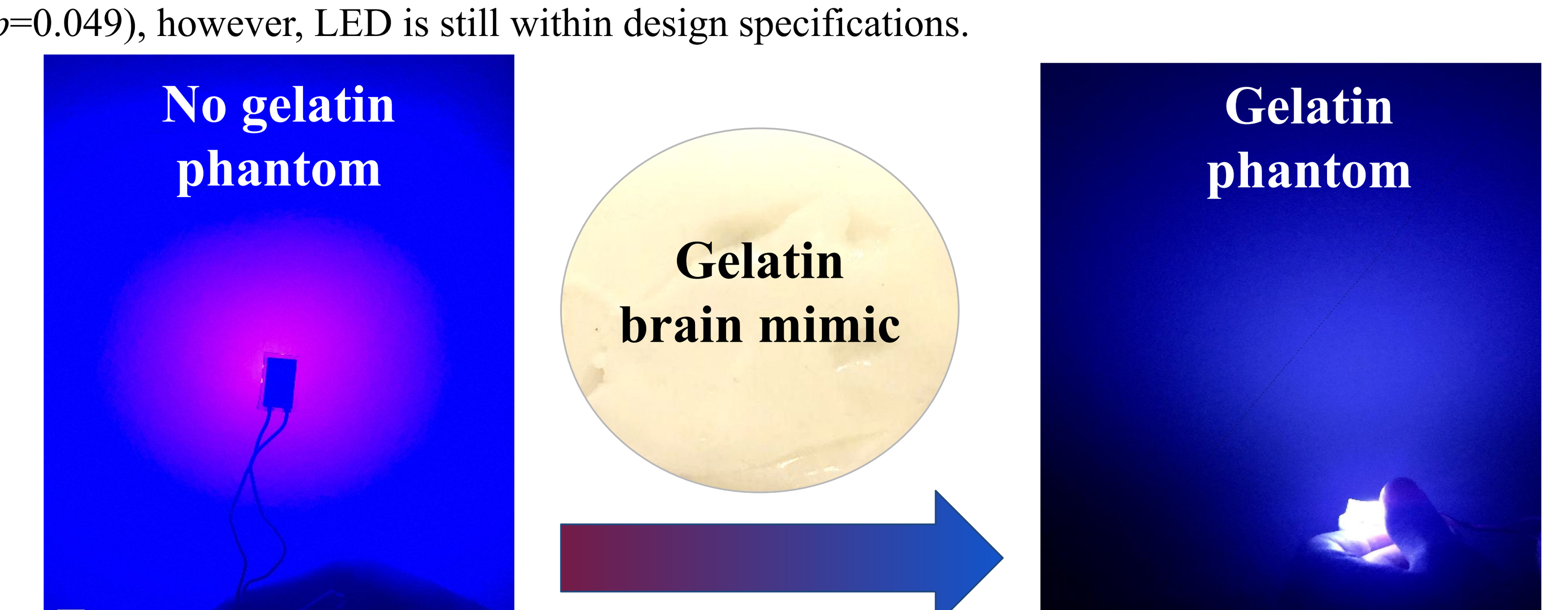

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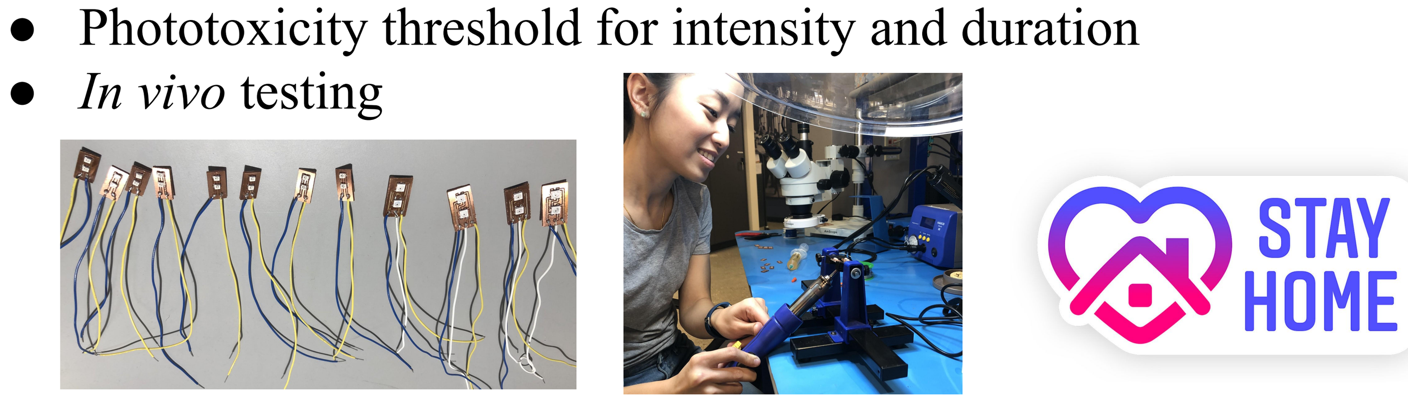

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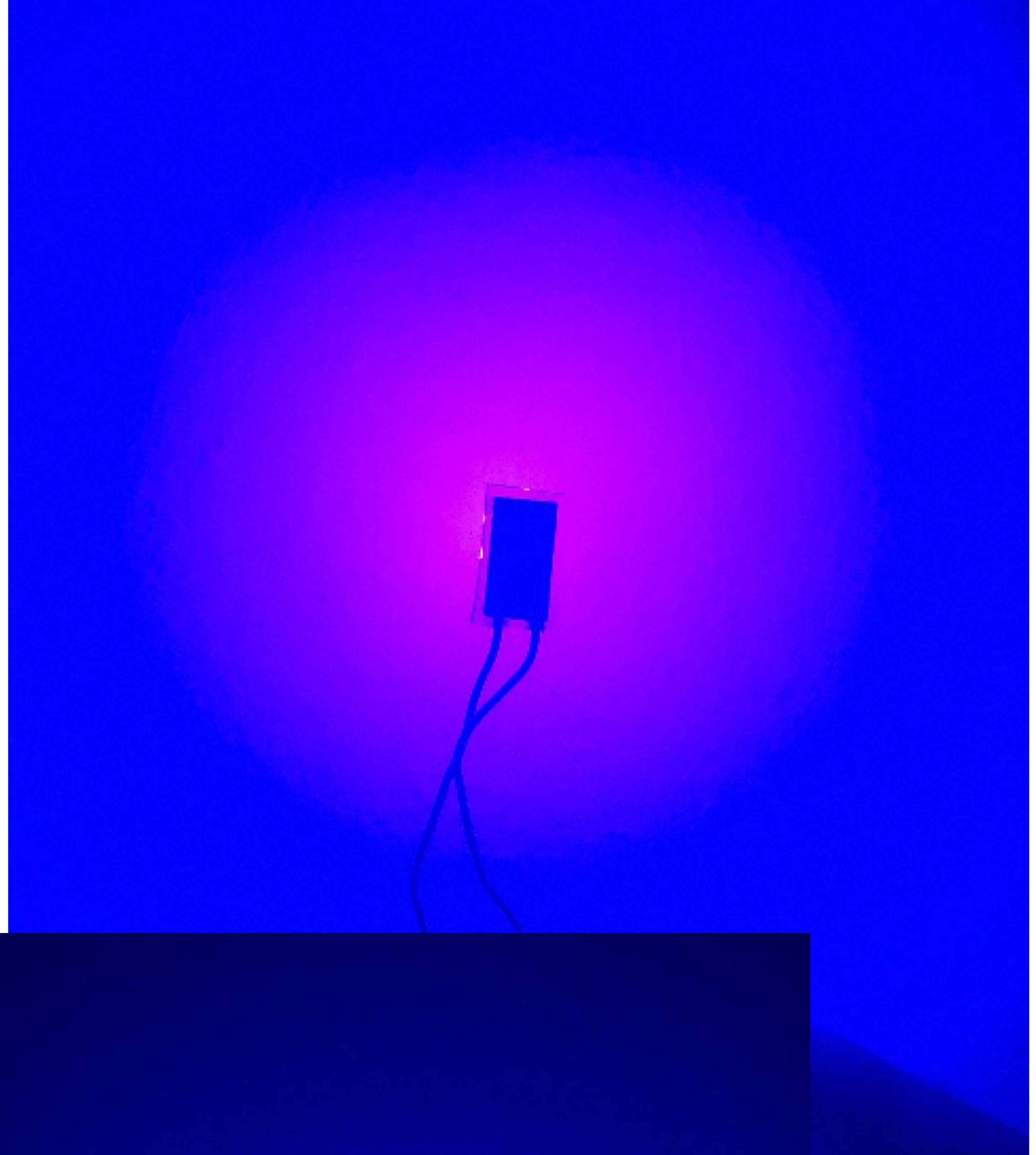
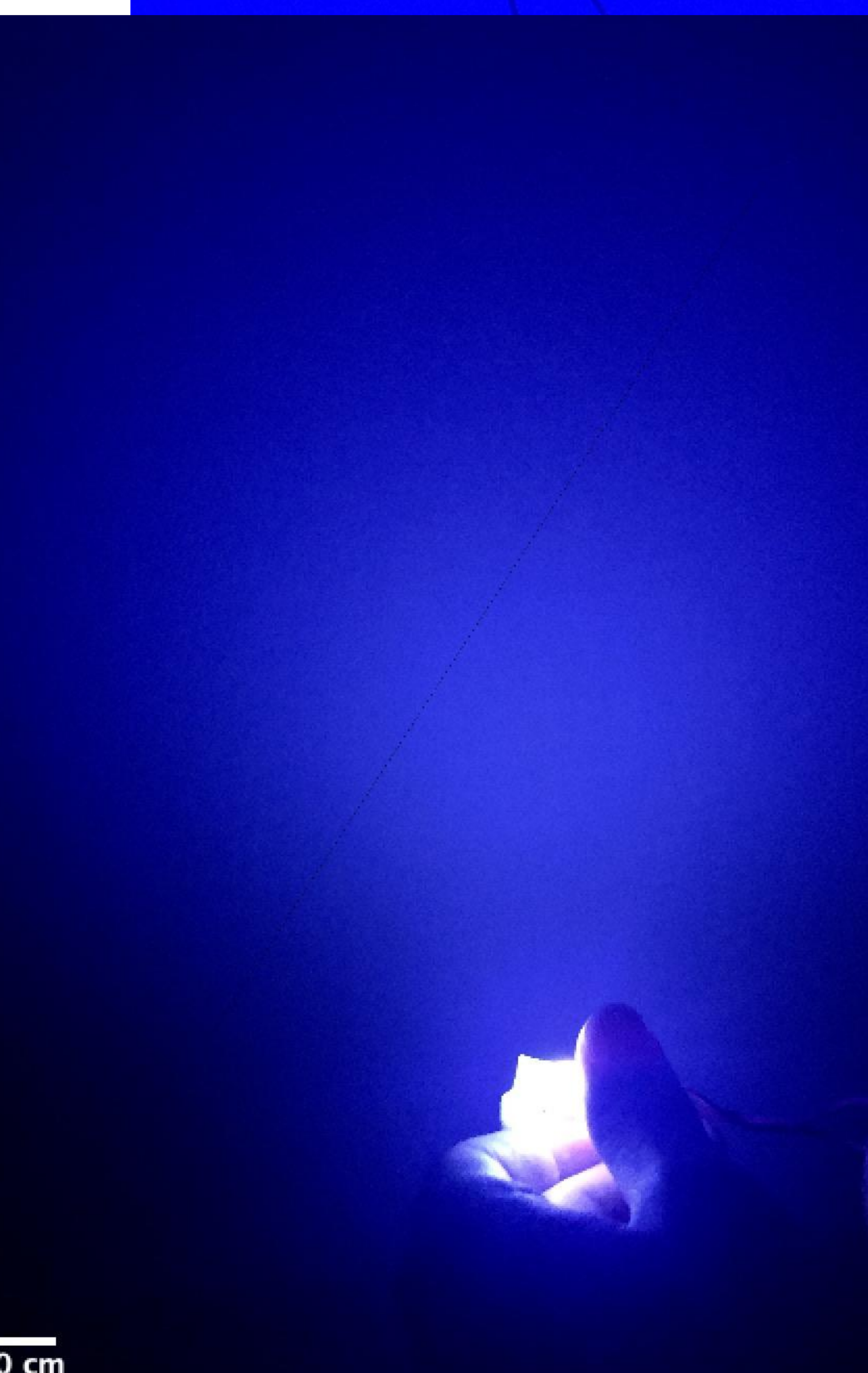


Diameter of the scattering:
95.5cm



Diameter of the scattering (roughly):
145.56cm