Green Syntheses of Efficient Organic Dyes for Organic Hybrid Light-Emitting Diodes

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Intro: Organic Hybrid LEDs

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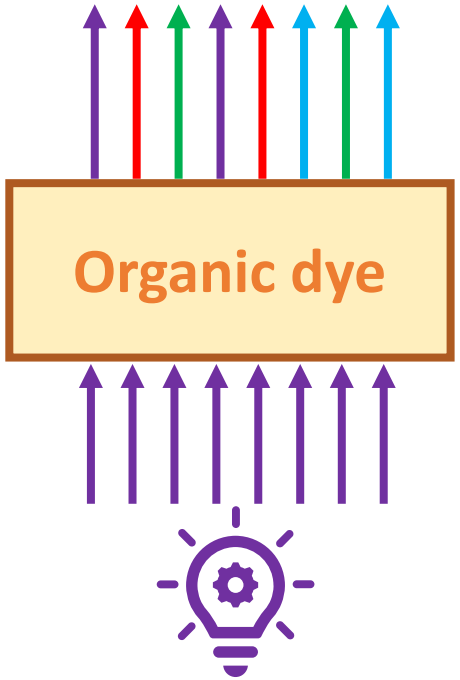
What is an organic hybrid LED and why is it appealling?

Organic Hybrid LED



405 nm
Inorganic LED

Light down-conversion

Electricity to light conversion

Uniting the advantages of LEDs and OLEDs

- **Potentially bio-sourced**
- **Good light quality**
- **Aesthetics**

- **High efficiency**
- **Inexpensive**

Cost of commercial fluorescent dyes

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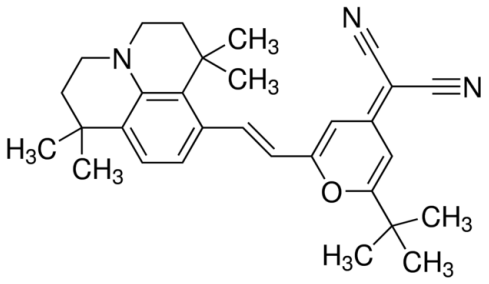
High-performance organic dyes are relatively expensive compared to LED chips.

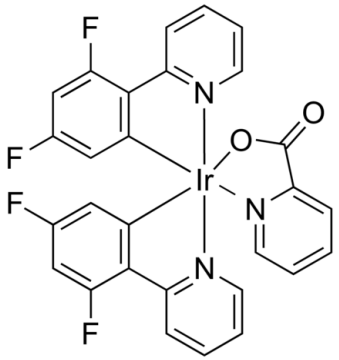
Fluorescent emitter



DCJTB

$348 / 250 mg

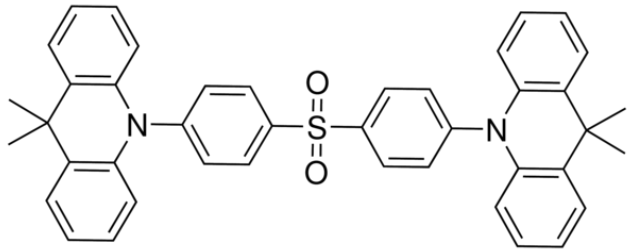
Phosphorescent emitter



F_2Irpic

$352 / 250 mg

TADF emitter



DMAC-DPS

$400 / 250 mg

Challenges:

- Relatively long syntheses
- Requiring noble metals (e.g., Ir, Pd, Pt.)
- Using organolithium and Grignard reagents **Air-sensitive**

Prices adopted from Sigma Aldrich or TCI

TADF: thermally activated delayed fluorescence

Low cost by green and streamlined syntheses

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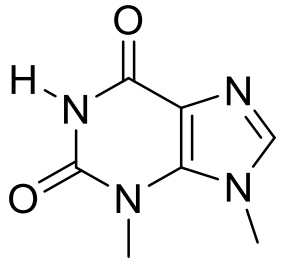
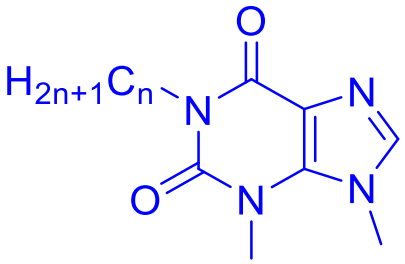


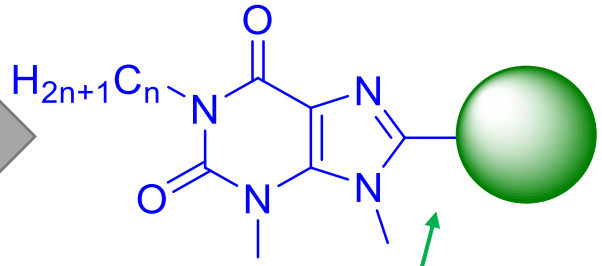
Theobromine, an abundant commodity originally found in cacao beans

Enhance solubility



Enhancing fluorescence and solubility of final product

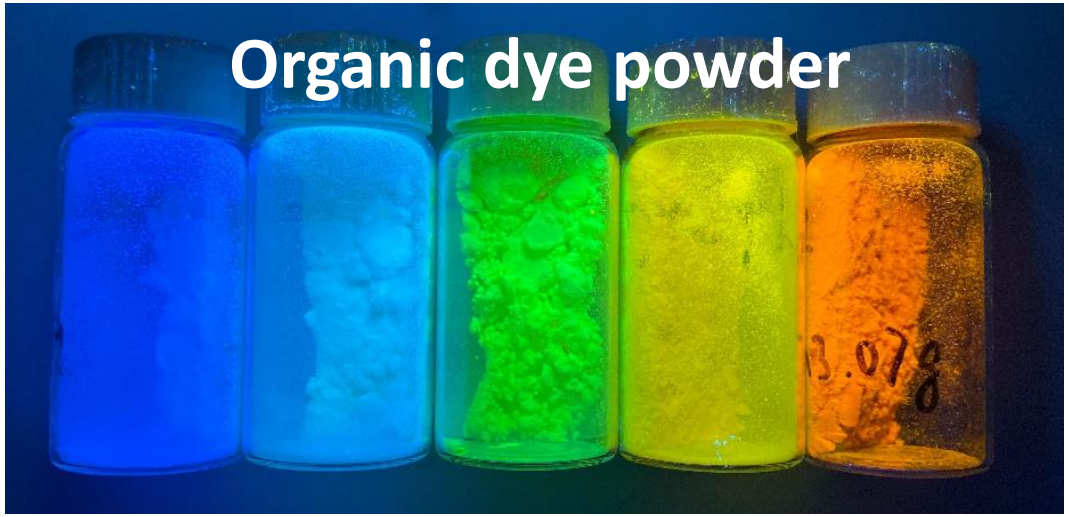
Tuning emission



Luminophore of choice for desired emission

No hazardous materials applied

Green Chem., **2019**, *21*, 6600-6605.



Cost estimation based on lab production: **$ 2–13 / 250mg**

The introduction of theobromine increases the photostability of organic dyes, because it is electron withdrawing and decelerates photooxidation.

Huang et al. **2021**, *submitted*

Patent pending.

Low cost from low material consumption

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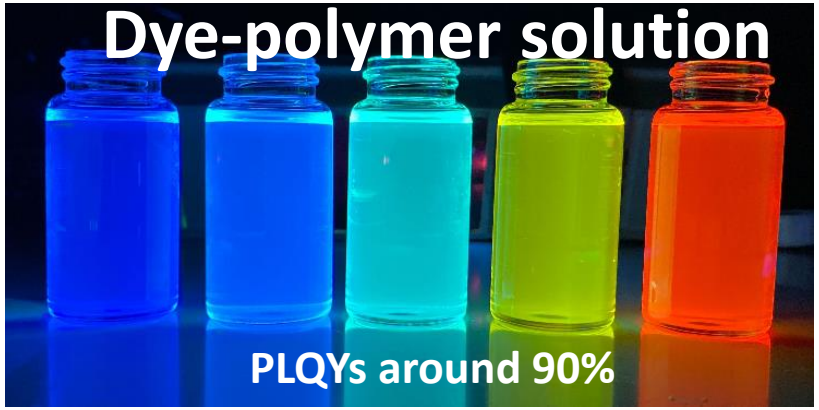
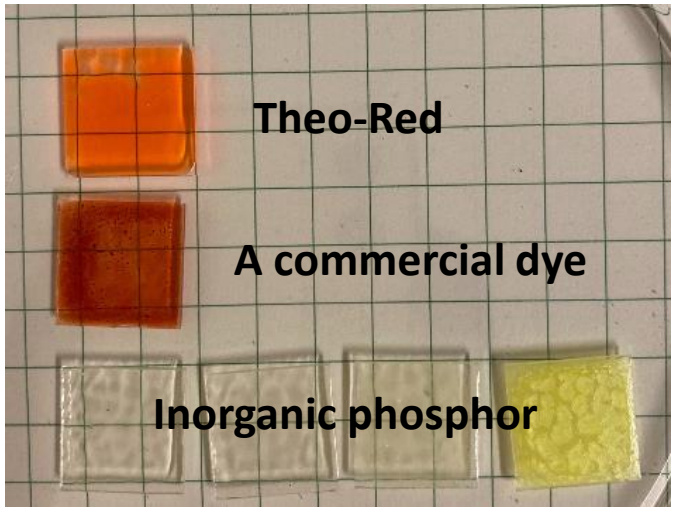
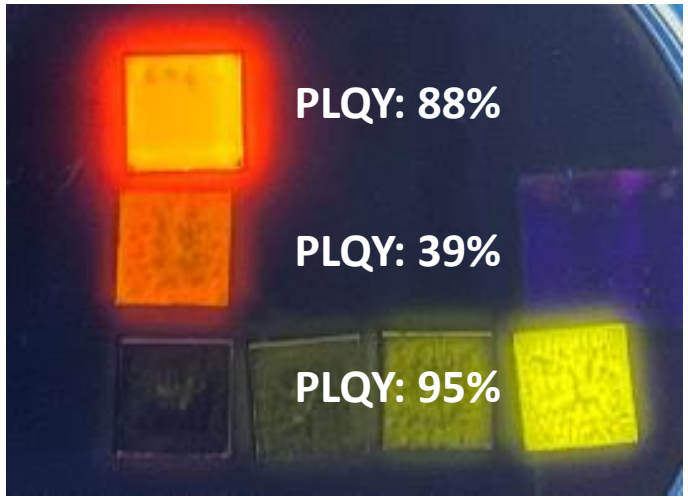
Dissolve and blend with
a common polymer



Solution processing





Dye:polymer ratio **1:100** **10:100** **20:100** **100:100**

PLQY: Photoluminescence quantum yield

Patent pending.

Good color quality

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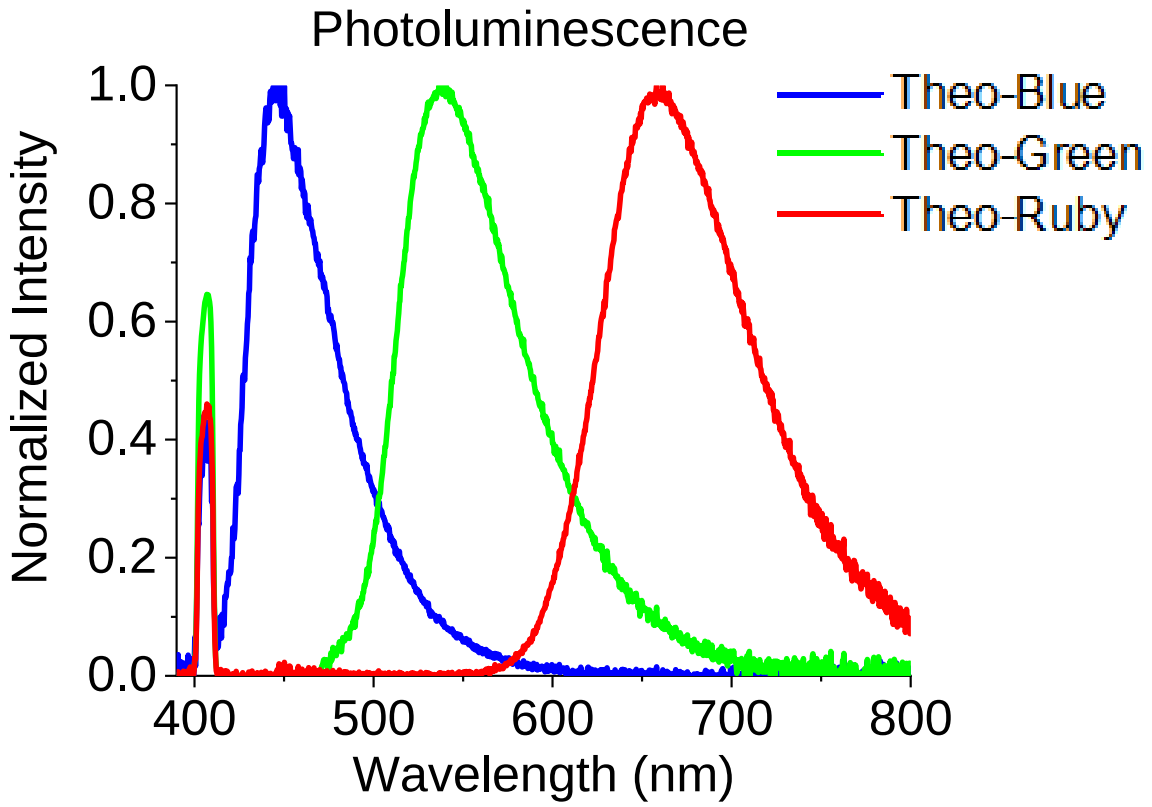
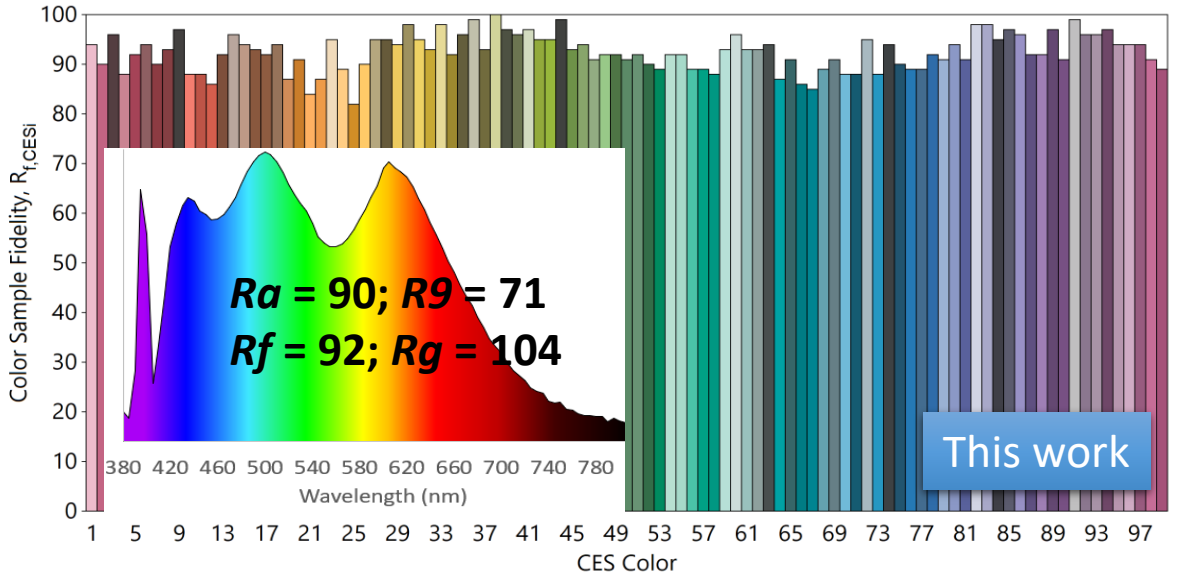
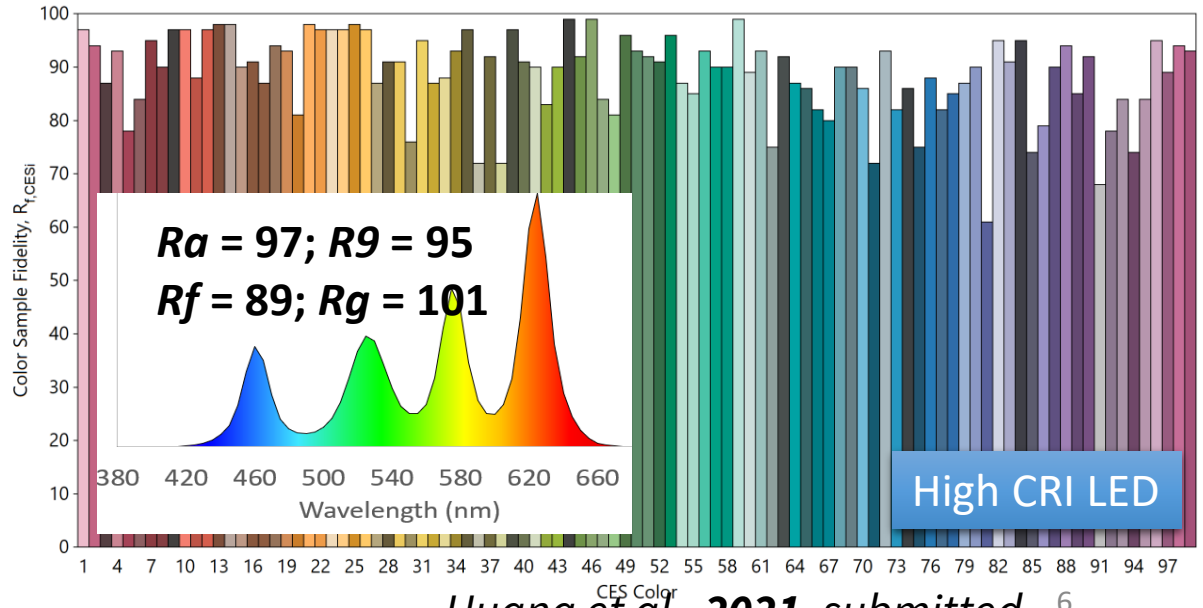
High CRI (*Ra*) and CFI (*Rf*) values.







CRI: Color Rendering Index

CFI: Color Fidelity Index

*Huang et al., **2021**, submitted.*

Aesthetics

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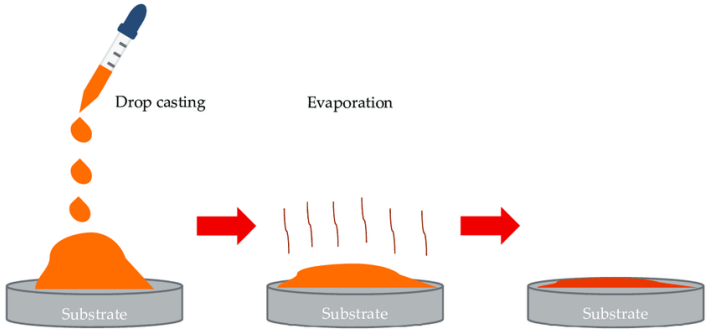
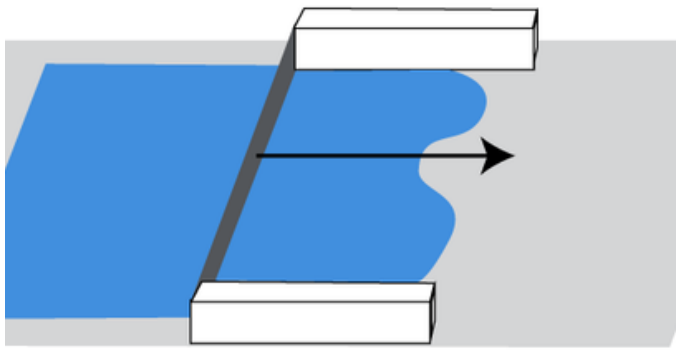
Solution processed waveguides

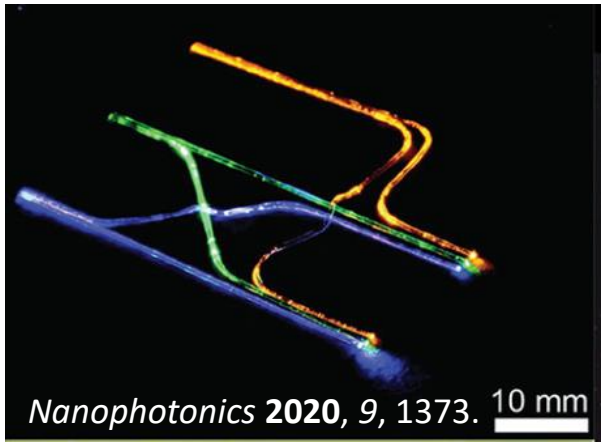
Organic dye solution



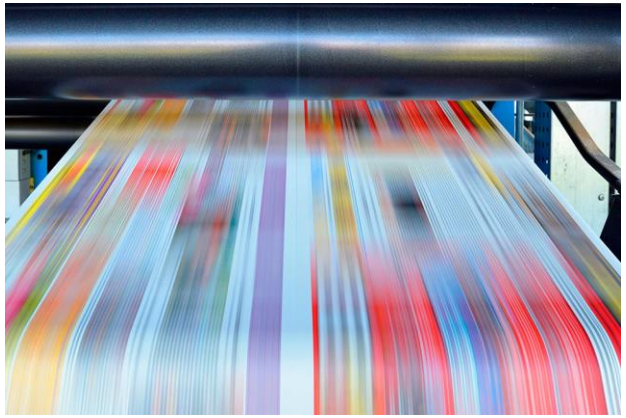
Drop casting



Blade coating



Inkjet printing



Roll-to-roll printing

Aesthetics

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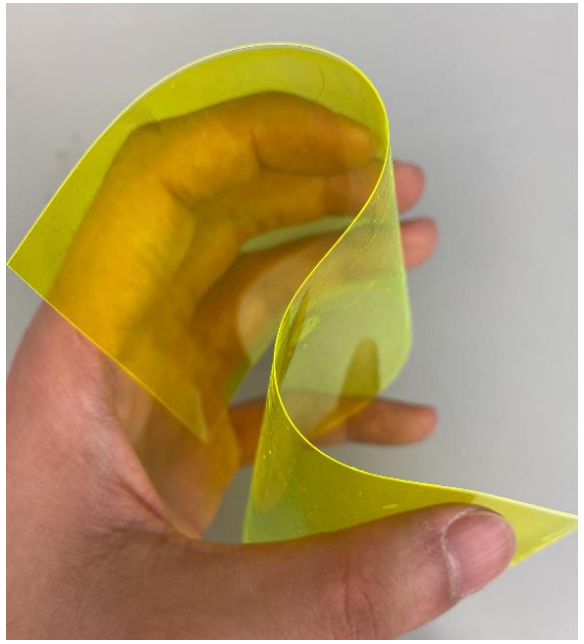
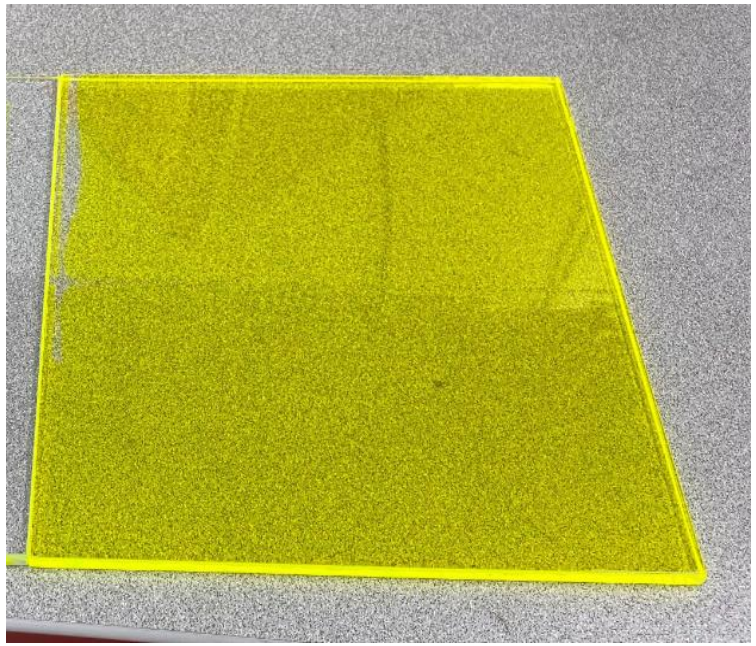
Different waveguides fabricated via solution processing for different requirements





Edge-lit device from the glass waveguide

Patent pending.

Summary

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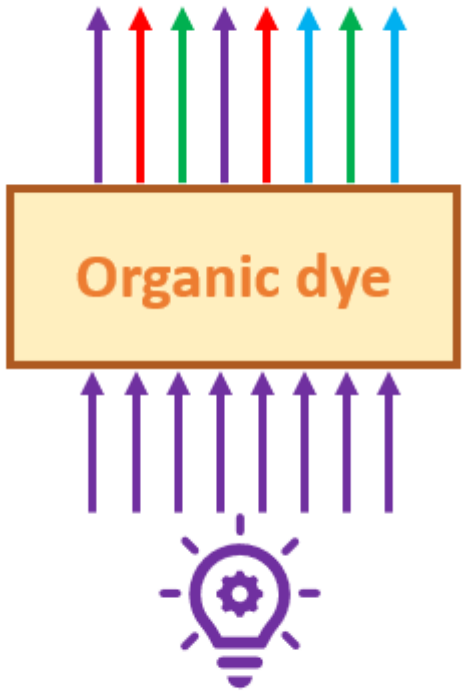
Organic Hybrid LED



1. Low-cost and bio-sourced from theobromine
2. Good light quality with high CFI value of 92
3. Stretchable waveguide for non-glare devices

Acknowledgements

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