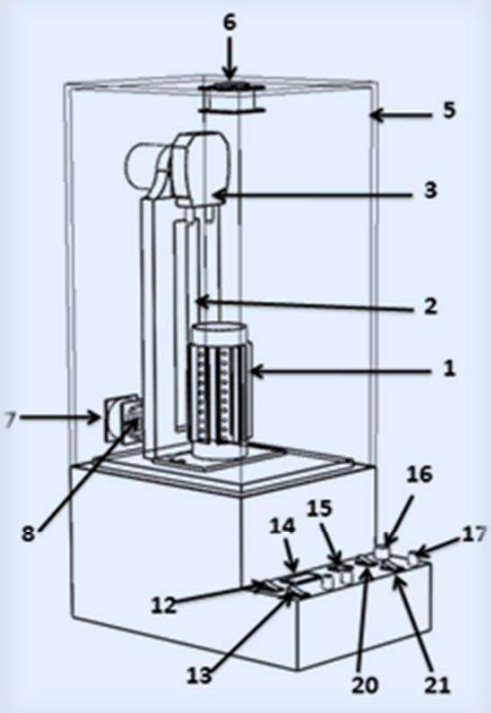
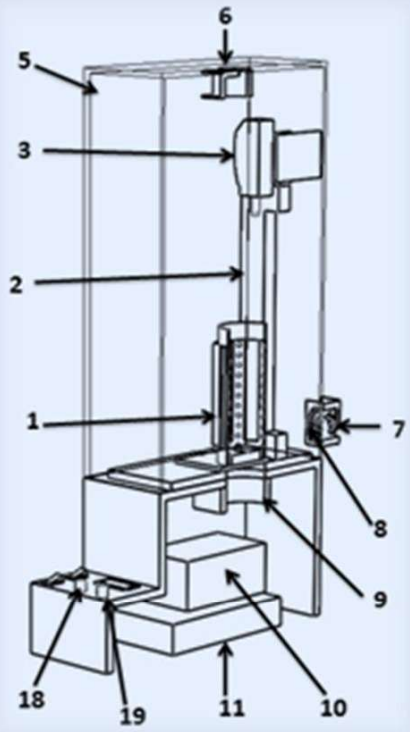
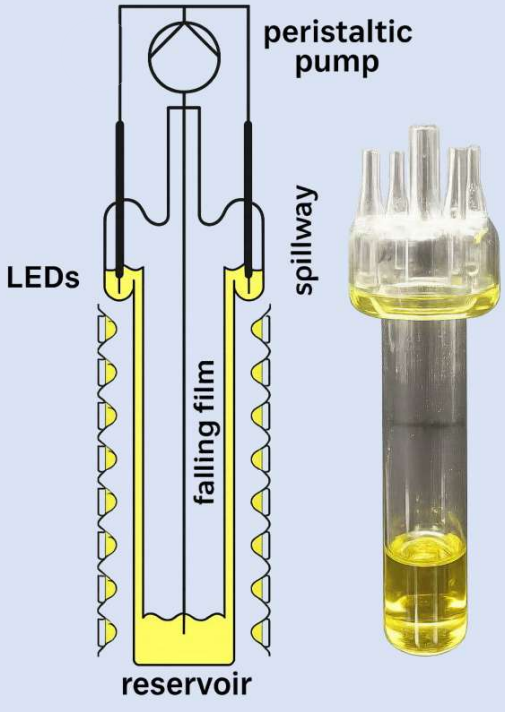
Batch-Flow Photoreactor

A Modular, Scalable System for Light-Driven Photochemistry





1) Integrated light assembly
2) Adjustable Pump Stand.
3) Peristaltic Pump.
4) Uniquely designed glass container.
5) Outer cover.
6) Cooling fan.
7) Cooling fan
8) Cooling Coil.
9) Magnetic stirrer.
10) Battery unit.
11) 12 V power supply.
12) Switch for the magnetic stirrer
13) Switch for integrated light assembly.
14) Volt amp display unit.
15) Temperature display unit.
16) Pump flow rate controller.
17) Cooling fan speed controller.
18) amp controller.
19) Magnetic Stirrer speed controller.
20) Switch for Pump.
21) Switch for cooling fan.



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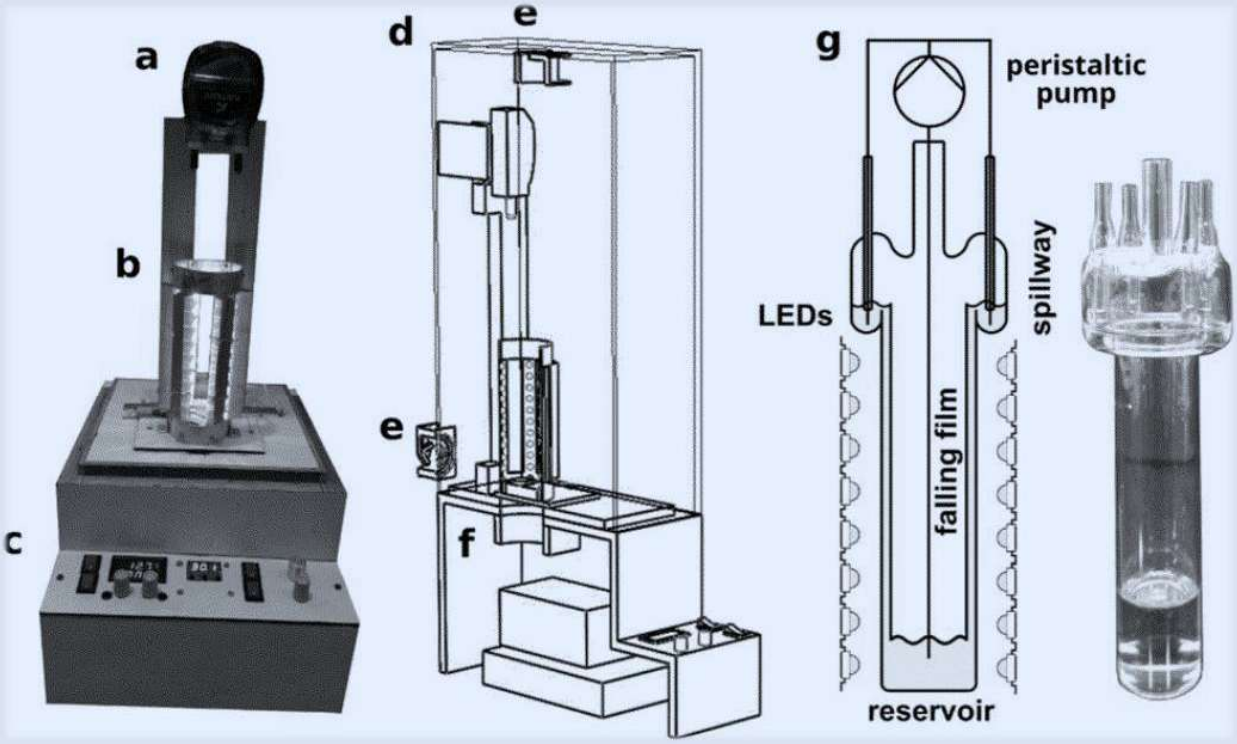
About Us

At PhotonicR, we're pioneering a new era in photochemical engineering. Our team of innovators, chemists, and engineers is driven by a singular goal: *to make scalable, high-efficiency photoreactors accessible for both research and industry*. We combine scientific insight with practical design to create advanced tools that simplify complex processes. The Batch-Flow Photoreactor is the embodiment of this mission—delivering reliable, reproducible results without the scale-up headaches.

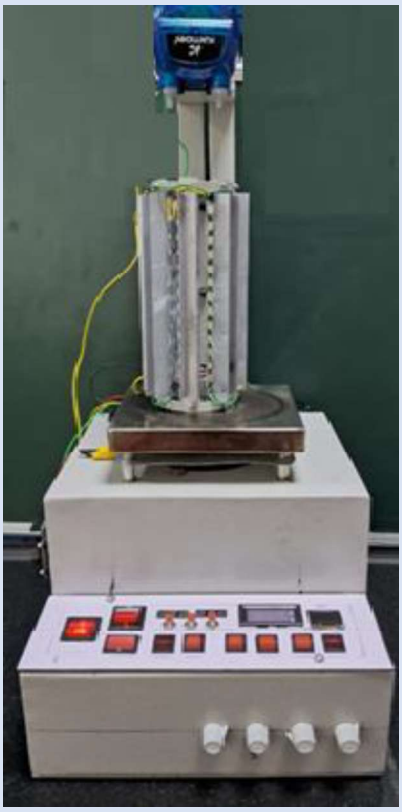


Overview

The batch-flow photoreactor (BFPR) developed by our group represents a modular, scalable platform for photochemical synthesis, enabling consistent photon-to-reactant ratios from milligram to gram scales. This reactor integrates seven functional modules—including a pump module (a) peristaltic pump, (b) an irradiation module, (c) a control unit, (d) reactor casing, (e) fans, (f) a magnetic stirrer and (g) photoreactor glassware with a spillway and working principle of the falling film looping photoreactor --- to generate a uniform falling film (~200–300 µm) over a vertical cylindrical surface. The system supports both batch and looped flow operation, with scalability achieved by proportionally increasing the wetted surface area (1×A to 4×A) and LED count while maintaining constant film thickness, irradiance (60–131 mW/cm²) and photon flux ranges from 21 to 185 µmol s^{-1} across scales, ensuring linear productivity. Benchmark reactions such as benzylic bromination and trifluoromethylation confirmed excellent scalability, with space-time yields rising from 27.9 to 1765.1 g/day with very good photonic efficiency (ξ_{ext}).

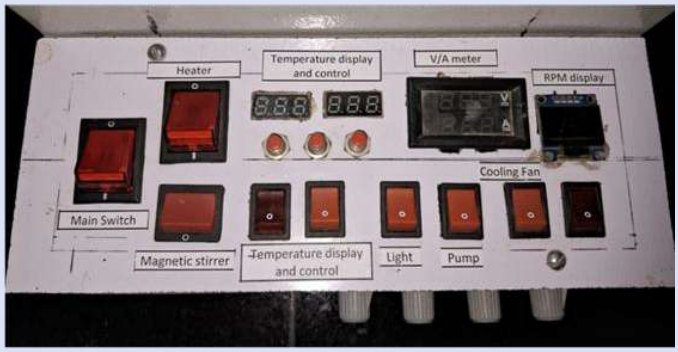
The reactor's compact design, precise photonic control, and robust material compatibility (including inert conditions) make it a powerful tool for process intensification and translational photochemistry. Its capacity for modular expansion, short residence times, and energy-efficient operation positions it as a benchmark for future development in industrial photochemical reactors.

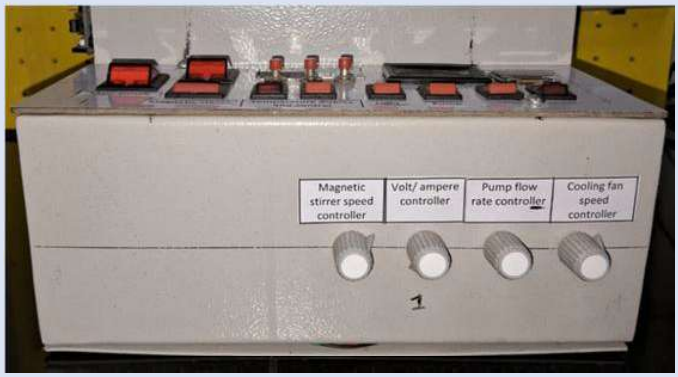
Product Details



A batch-flow photoreactor was designed as a tool for photoreaction optimization and scale-up from a milligram to the gram scale under comparable irradiation and reaction conditions. Therefore, a modular design was implemented to ensure easy adaptation of the reactor components to a changing reaction scale and the needs of experimentalists within photochemical laboratories.

The control unit of the A batch-flow photoreactor was designed as a tool for photoreaction optimisation photoreactor was designed for easy lab use. It includes a magnetic stirrer for batch mode and a battery backup to keep the reactor running during power failures. The reactor mainly runs on a 12 V, 10 A DC power supply, with current controllers and a display to adjust and monitor LED power. A flow rate controller ensures steady liquid flow, and heating is available when needed. Tubing size and pump efficiency vary with reactor size (1×A, 2×A, 4×A) to handle different reaction volumes and flow conditions.





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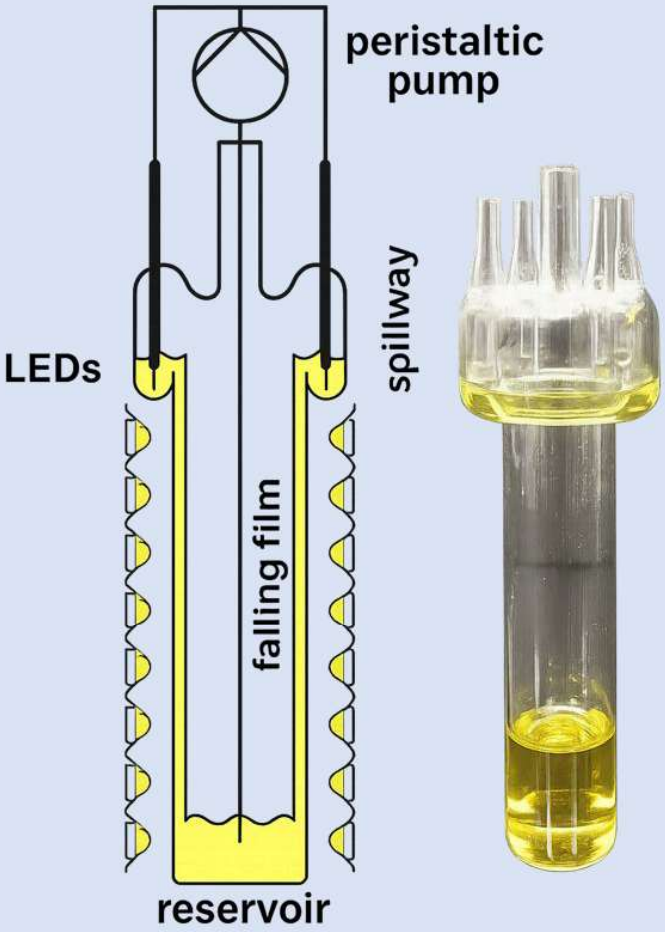
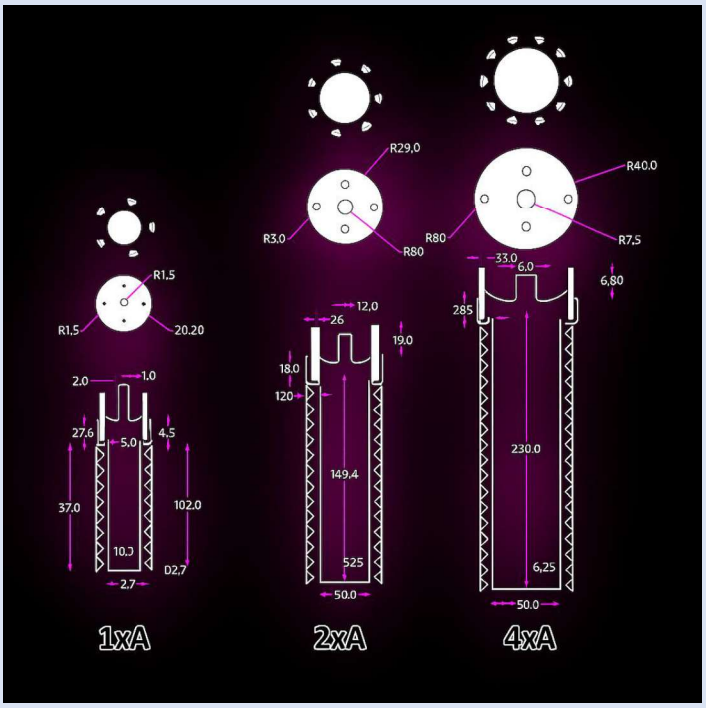


Three different-sized reactor modules (1×A, 2×A, and 4×A), made of borosilicate glass, were designed to fit inside matching LED irradiation modules with a fixed 5 mm gap between the glass and LEDs. Each reactor includes a built-in spillway at the neck that evenly distributes the reaction solution to create a uniform falling film along the inner glass surface. The liquid is pumped from the bottom reservoir to the top distributor, then flows through four inlets into the spillway, forming the falling film and returning to the reservoir in a continuous loop.

Very easily scaled up by keeping the **photon-to-reactant ratio** constant, achieved by maintaining constant **film thickness** and **irradiance**. As the **film area** increased, so did the liquid volume and photon flux, allowing linear scaling. Three reactor sizes were used—1×A (78.5 cm^2), 2×A (179.1 cm^2), and 4×A (314.2 cm^2)—with the number of LEDs adjusted to ensure equal irradiance across all sizes.



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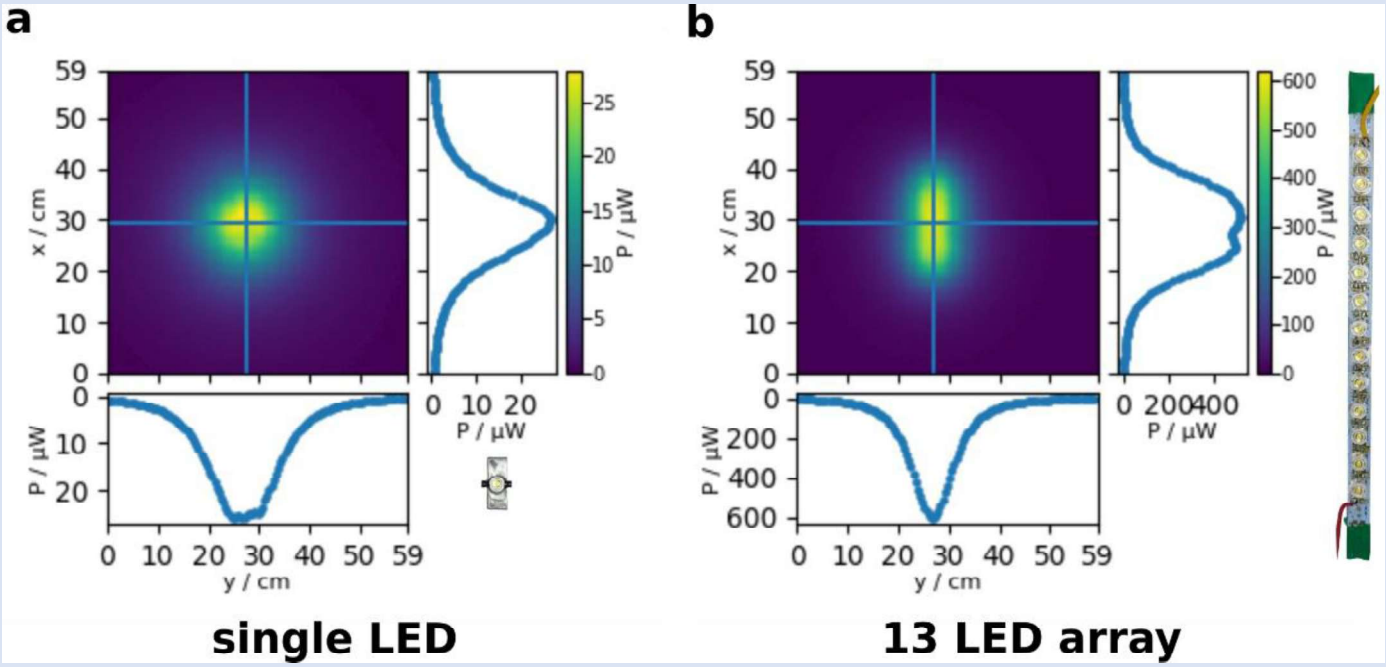

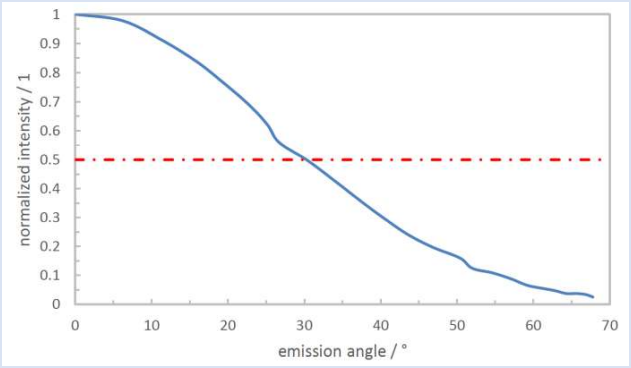

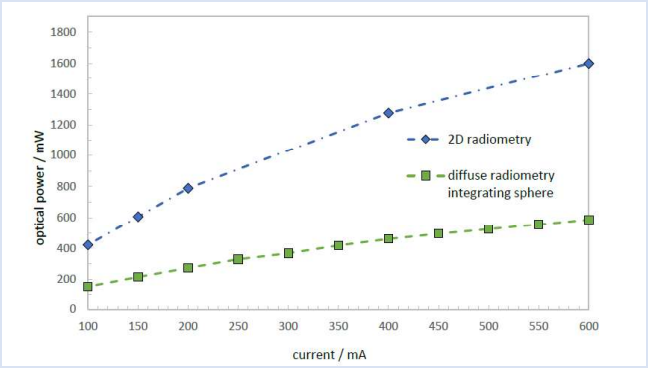

The integrated light assembly used in our reactor is photonically well characterized. Using **2D Radiometric Measurements**, we mapped the spatial and angle-dependent light intensity of both a single white LED and an array of 13 LEDs. These relative intensity maps were calibrated to absolute optical power using data from **Diffuse Radiometric Measurements using an Integrating Sphere**, which involved measuring the LED output at various electrical currents (50–600 mA) with a calibrated reference light source. Together, these experiments provided accurate information on the LEDs' absolute optical power and emission distribution—**crucial for reliably performing and analyzing photochemical reactions.** The photonic characterization of the light sources was conducted at the Institute of Chemical Engineering at **Ulm University, Germany.**

Publication details:

1) Journal Papers

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ii.DOI:https://doi.org/10.1039/D4RA05774K

iii.DOI:https://doi.org/10.1016/j.jphotochem.2024.116076

2) Patents

Patent No: 412866 (Granted)

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Prototype 1

Prototype 2

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