A luminescent solar concentrator-based photomicroreactor for energy efficient continuous-flow photocatalysis

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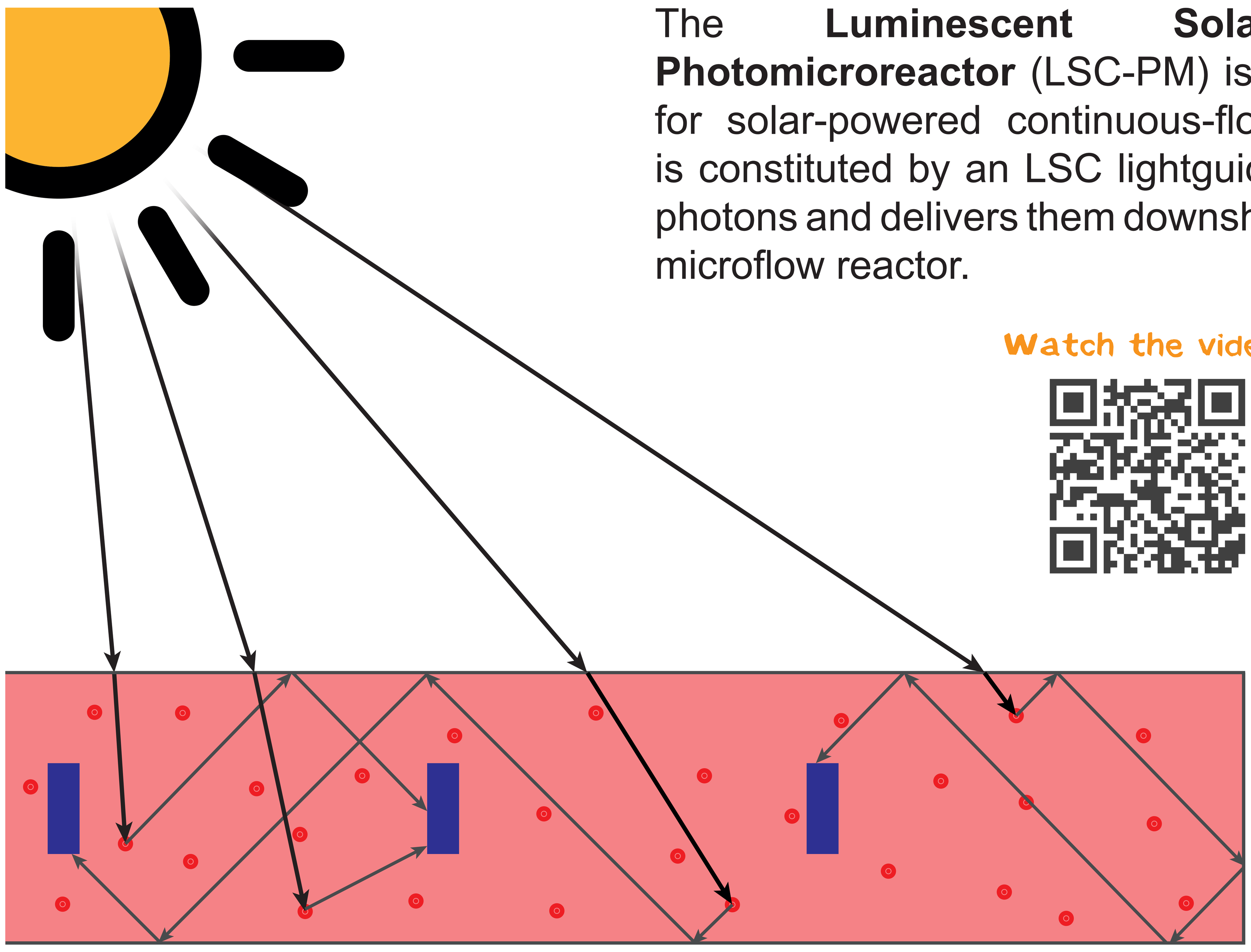
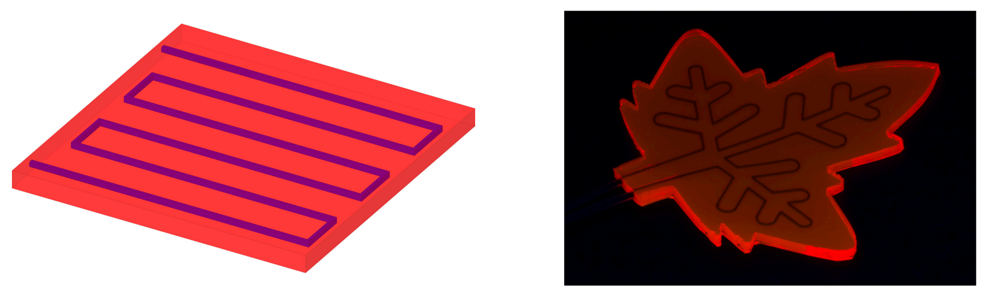
The **Luminescent Solar Concentrator-Photomicroreactor** (LSC-PM) is an innovative device for solar-powered continuous-flow photochemistry. It is constituted by an LSC lightguide that harvests solar photons and delivers them downshifted to the embedded microflow reactor.



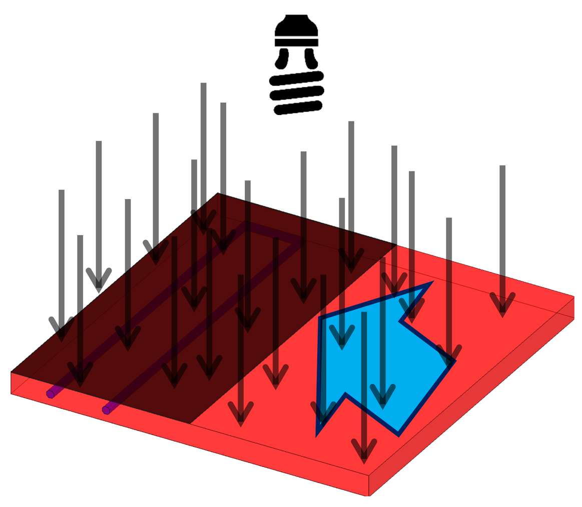
A schematic representation of the LSC-PM working principle. The luminescent photons emitted by the dispersed luminophore are trapped in the lightguide until they eventually reach a reaction channel.

Watch the video!

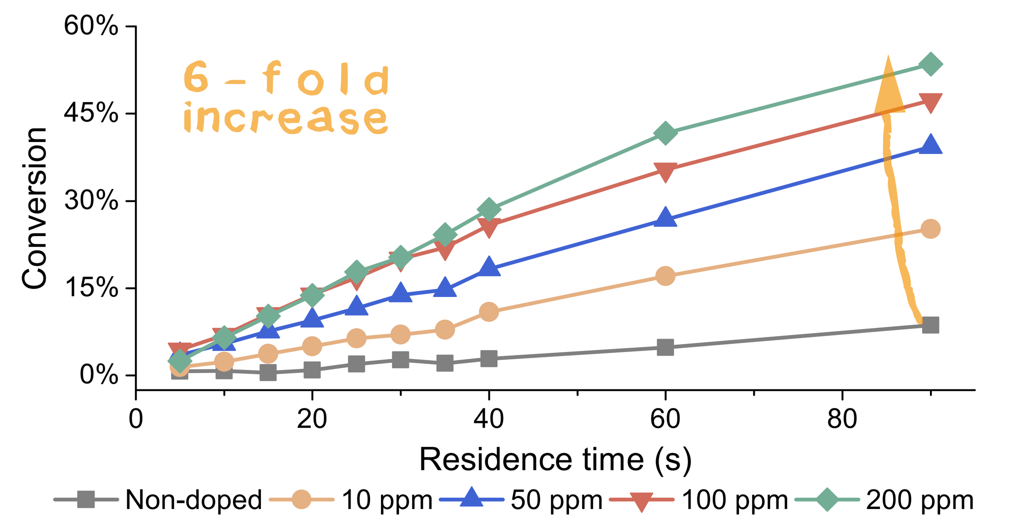


3D-model of the standard device and photograph of a leaf-shaped LSC-PM.

Light transport

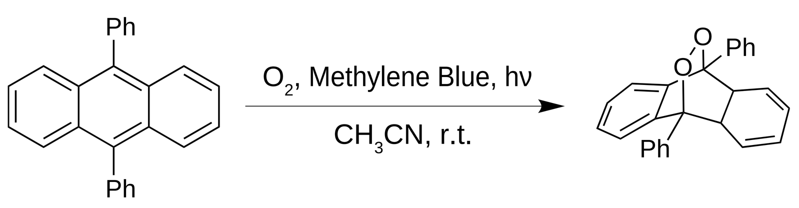


3D model of the modified LSC-PM employed for the light-transport experiments. The incident light is absorbed in the irradiated half and transported via waveguiding to the dark half, where the channels are situated.

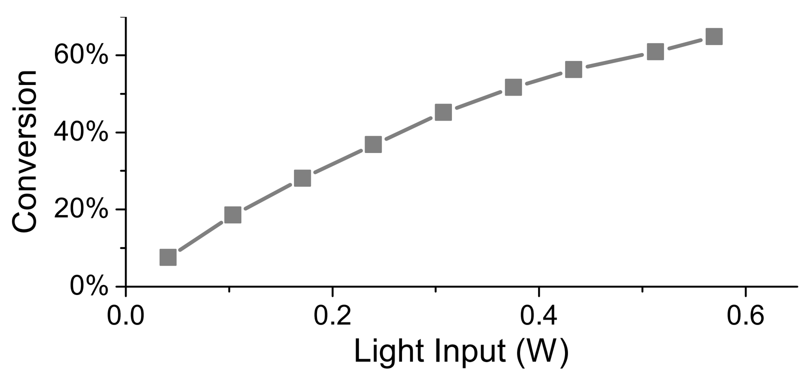


Conversion profile for the model reaction in the modified LSC-PM design to verify the light transport. The reaction acceleration in the LSC-PM with respect to the non-doped analogue is due to the waveguiding of the luminescent photons toward the non/irradiated half of the reactor.

Model reaction



The photon flux in the device channels is indirectly measured with the photooxygenation of diphenylanthracene (DPA) employing methylene blue (MB) as singlet oxygen photosensitizer.



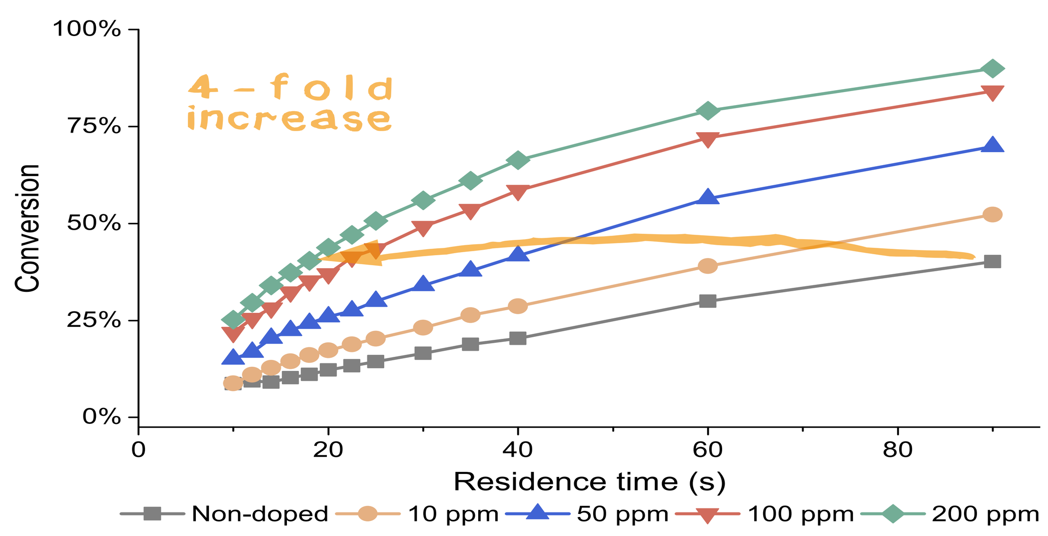
Light-dependency in DPA photooxygenation. The reaction apparent kinetics is strictly light limited.

Solar simulated contidions

The LSC-PM performances were characterized in solar-simulated conditions.

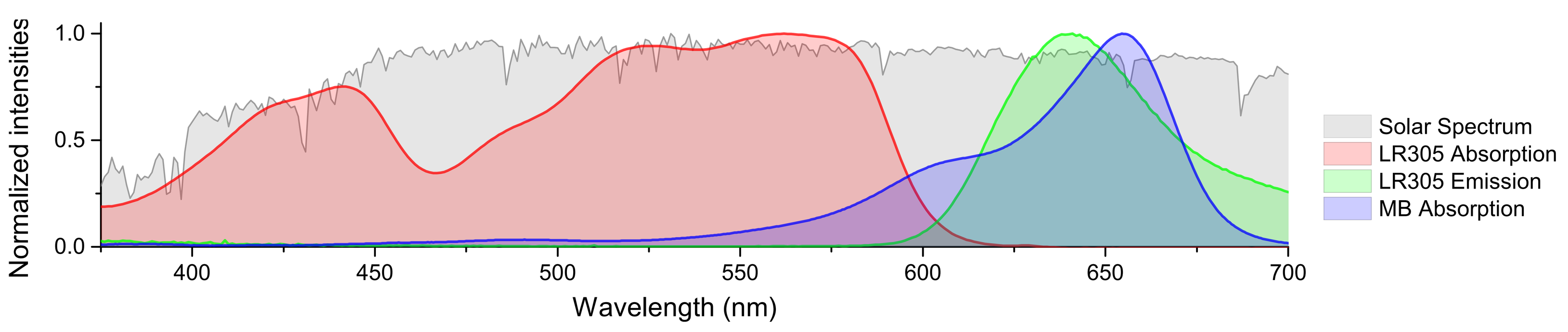
With the highest dye doping the reaction channels witnessed a 4-fold intensified photon-flux.

This is the combined results of the light transport and wavelength conversion contributions.

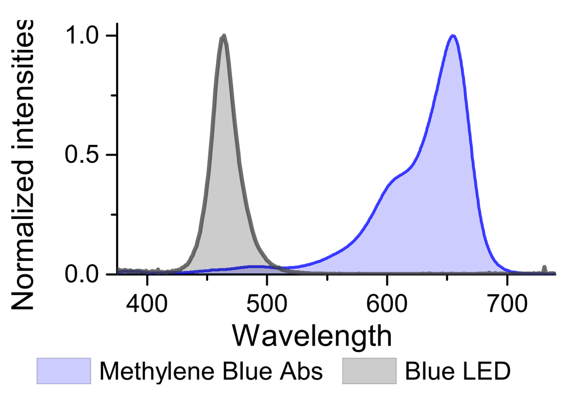


Conversion profile for the model reaction in LSC=PMs and non-doped reactor, when irradiated with solar-simulated conditions.

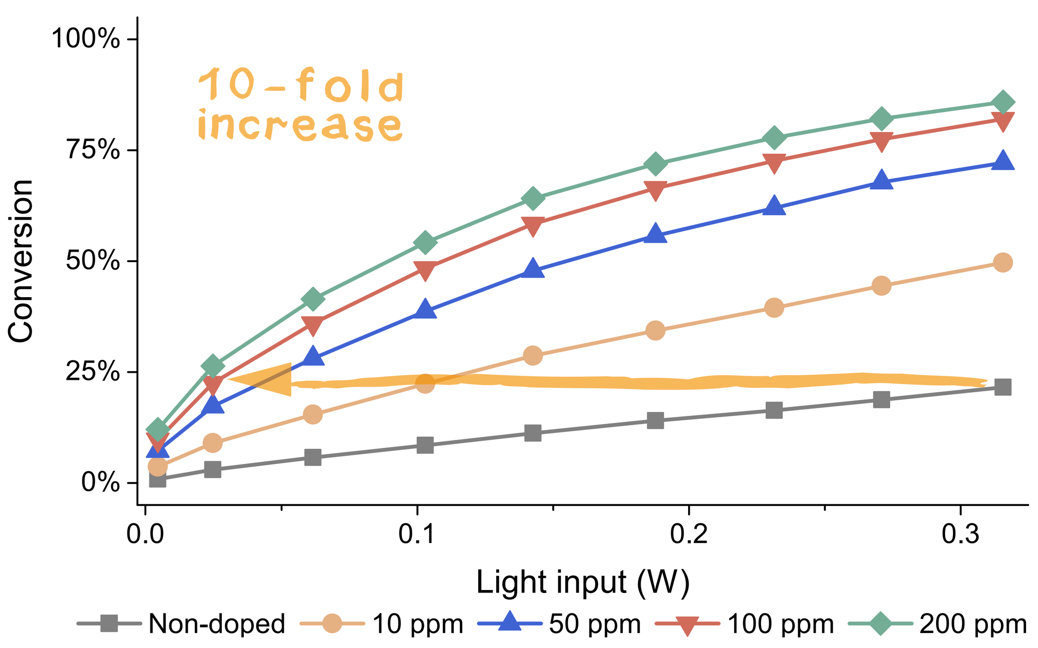
Wavelength conversion



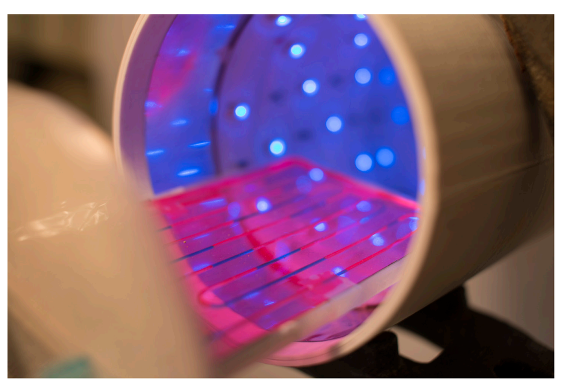
Blue LED irradiation was used to prove the wavelength conversion properties of the LSC-PM.
The LSC-PM spectral downconversion makes the 200 ppm reactor 10 times more photon efficient than the non-doped analogous under blue light irradiation.



The mismatch between light source used and methylene blue absorption spectrum.

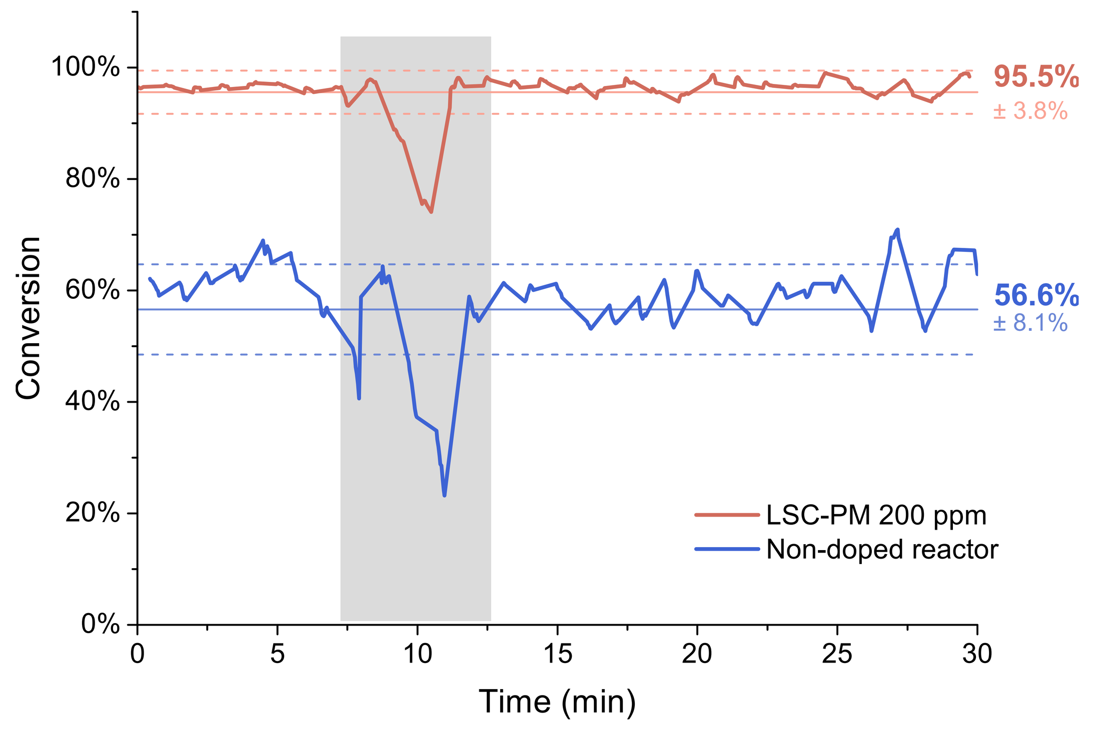


Conversion profile for the metylene blue sensitized DPA-photooxygenation in LSC-PMs with increasing dye doping, irradiated with blue light. The reaction acceleration in the LSC-PMs is due to the spectral conversion of the incident light into fluorescent down-converted red light, as evidencied by the dye-doped dependent nature of the effect.



A 3D-printed box with blue-LEDs was used as irradiation setup for the wavelength conversion experiments.

Outdoor experiment

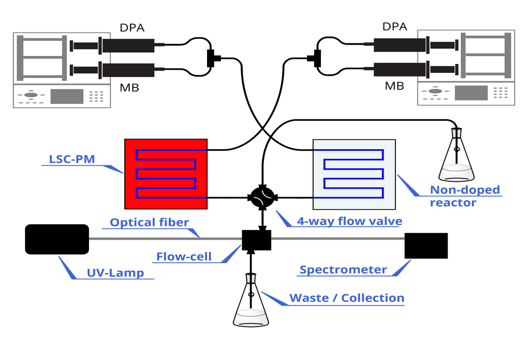


Reaction conversion over time in the LSC-PM and a non-doped reactor during the outdoor experiment. In the area highlighted in gray the cloud coverage was significantly increased.

Finally, to prove the LSC-PM ability to perform sunlight-powered chemical reaction with increased efficiency, a direct comparison between doped and non-doped reactors was performed in outdoor condition.

Higher and more stable reaction conversion are the results of the device efficiency and ability to make productive use of diffuse light.

A photo of the experimental setup for the outdoor experiment.



Flow-scheme for the continuous monitoring of converion in both the LSC-PM and the non-doped reactor during the outdoor experiment

Sky conditions during the outdoor experiment. Unlike PV panels, LSC are capable of collecting light also under cloudy sky conditions.

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