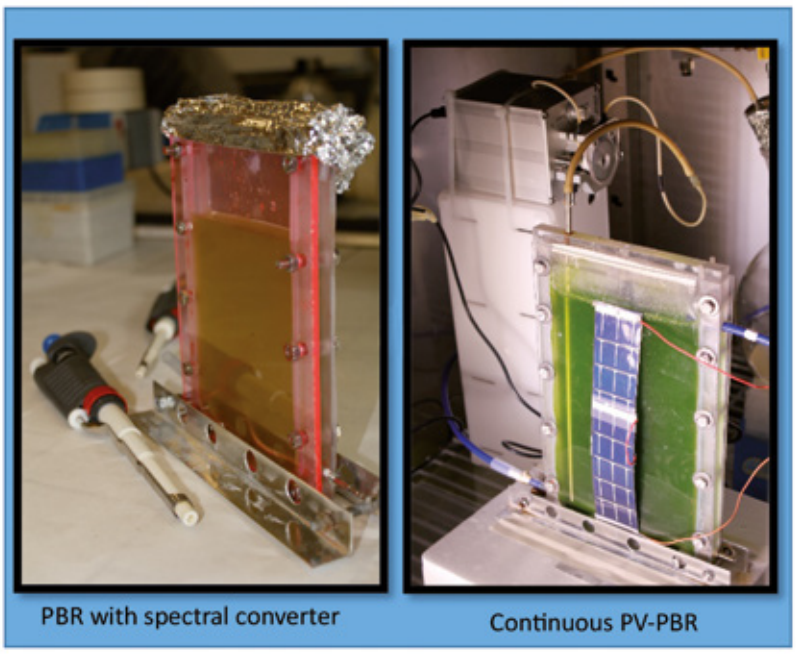
Improving the photoconversion efficiency in industrial photosynthesis: an integrated photovoltaic-photobioreactor system for microalgal cultivation

One of the main limitations to large-scale production of biofuels is the lower efficiency of sunlight conversion by photosynthesis of terrestrial plants. Microalgae show a faster growth, but also in this case, the maximum theoretical value for photosynthetic efficiency is hardly achieved in real outdoor cultivation systems, mainly due to inefficient light utilization, in addition to photosaturation and photoinhibition phenomena that take place at high irradiances. This work is focused on testing different possibilities aimed at improving the overall photo-conversion efficiency (PE) of microalgal production in photobioreactors (PBR). Two strategies were followed: the first one increases the portion of spectrum available for photosynthesis employing luminescent spectral-converter filters, the second one integrates microalgae reactors with photovoltaic panels, producing electrical energy together with biomass. Experiments were carried out both in batch and continuous laboratory scale flat-plate PBRs, at different light intensities and regimes, with two different species (N. salina and S. obliquus).
According to the first strategy, a commercially available spectral converter was applied to the surface of a flat panel reactor increasing the portion of spectrum available for photosynthesis. Even though the filter is able to efficiently absorb the green wavelengths and shifts this radiation to the red range, no significant effect was observed on algal growth, even under low irradiances.
On the other hand, integrating microalgae PBR with a photovoltaic (PV) panel, remarkably increased the overall PE of the system, by producing directly available electrical energy together with microalgal biomass. Moreover, under higher irradiances, a partial cover of the reactor surface resulted in reduced photosaturation and photoinhibition phenomena. Most importantly, under certain conditions, integrating microalgae cultivation in PBRs with PV allows to reach overall energy conversion values that exceed the theoretical maximum set by photosynthesis itself.



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Main research topics:

- Effect of light and operating variables on continuous cultivation of microalgae in Photobioreactors
- Optimization of sustainable nutrient and CO_2 supply for industrial autotrophic cultivation
- Exploitation of microalgae for Wastewater treatment and CO_2 capture
- Modelling of microalgae growth for process design and optimization
- Process simulation and techno-economic analysis of algal biomass production