# Photocatalytic approaches to circular economy: $CO_2$ photoreduction to regenerated fuels and chemicals and $H_2$ production from wastewater

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## Abstract

The photoreduction of $CO_2$ is an unconventional process to regenerate fuels and chemicals storing solar radiation. A new photoreactor has been designed recently to achieve high productivity during the process, i.e. up to 16 mol/h $kg_{cat}$ of HCOOH or 1.4 mol/h $kg_{cat}$ of $CH_3OH$, which are unprecedented results with respect to literature, especially with a very simple commercial catalyst.
The production of hydrogen through photoreforming of aqueous solutions of organic compounds is also considered as a way to exploit solar energy storage in the form of hydrogen. Different sugars were selected as substrates derived from the hydrolysis of biomass or from wastewater (food or paper industry). A significant amount of $H_2$ was obtained with very simple catalyst formulations, e.g. 20 mol $kg_{cat}^{-1}$ $h^{-1}$ were obtained at 4 bar, 80 °C over commercial $TiO_2$ samples and using glucose as substrate. This result is very remarkable with respect to similar research in conventional photoreactors.
Both the routes represent a circular way to regenerate valuable products from gaseous or liquid wastes. Our attention was predominantly focused on the development of innovative reactors, possibly operating under unconventional conditions, with fine tuning of the operation parameters. Reactor modelling is also in progress, including the optimization of radiation distribution in the photoreactor to achieve suitable models for reactor scale up.

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