UNIVERSITY OF TWENTE.

Advanced Materials and Reactors for Photocatalytic Conversion of CO_2 into Fuels

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Introduction

Convert thermal-dynamically stable CO_2 into valuable hydrocarbons under mild condition by photocatalysis.

$CO_2 + H_2O \rightarrow CH_4 + O_2$
$CO_2 + H_2O \rightarrow CH_3OH + O_2$
$XCO_2 + ½\ yH_2O \rightarrow C_xH_y + (x+2y)O_2$

Approach

Catalyst development
Ti-based mesoporous materials (e.g. Ti-SBA-15) and Ti-nanotube have been reported in the literature to be more efficient in the CO_2 reduction reaction than dense phase TiO_2 particles.

Mechanism investigation (in-situ DRIFTS)
In-situ DRIFTS (Diffuse and Reflectance Infrared Fourier Transform Spectroscopy) experiments are means to obtain mechanistic information and can be carried out by using a three-window cell. Two windows (ZnSe) allow IR transmission, and the third (Quartz) the introduction of UV/Vis light into the reactor. IR signals can thus be collected when catalysts in presence of CO_2 and water vapor. Carbonyl, (bi)carbonates and carboxylates can be during UV/Vis illumination (100Watt Hg lamp, λ: 280-650nm).

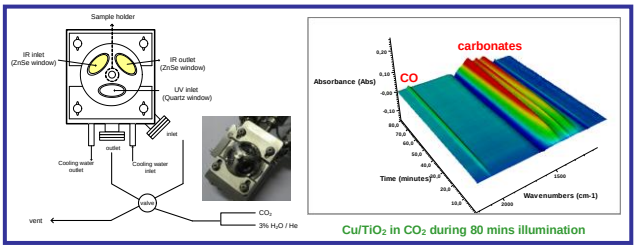

Fig. 1 (a) three-window cell; (b) time profiled DRIFT spectra of Cu/TiO_2 in presence of CO_2 during 80mins illumination

Photoreactor development
(combinatorial photoreactors - catalyst screening)
Different semiconductors, porous materials with isolated metal centers, and Ti-nanotubes have been tested in the target reaction and described in the literature. It is still difficult to compare the catalyst performance, since they have typically been tested under specific reaction conditions. In particular, comparison on basis of the quantum efficiency is impossible. We have developed a photocatalyst screening device for heterogeneous photocatalysis application (such as CO_2 reduction and H_2O oxidation). A multi-batch reactor coupled to a compact gas chromatograph, and fully automated sampling program, enables photocatalyst screening, quick product analysis and fair comparison of photo-activity performance.

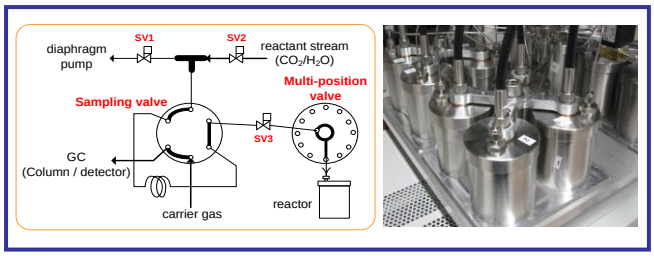

Fig. 2 Principle of combinatorial photoreactors for CO_2 reduction or H_2O oxidation

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