Photocatalytic Conversion of Methanol to Formaldehyde in a Continuous Laboratory Plant

F. Stubenrauch[1]; M. Schörner[1]; Y. Mahayni[1]; A. Bösmann[2]; P. Schühle[2]; P. Wasserscheid[1,2]
[1]Forschungszentrum Jülich GmbH, Helmholtz-Institut Erlangen-Nürnberg for renewable Energy (IEK-11)
[2]Lehrstuhl für chemische Reaktionstechnik, Friedrich-Alexander-Universität Erlangen-Nürnberg

Abstract

In this work we present the highlights of two approaches for the photocatalytic conversion of methanol into formaldehyde under mild conditions using a narrow peak UV-A LED light source in a continuously operated reactor set-up (Figure 1). In the first study, we selectively oxidized methanol to formaldehyde under aerobe conditions using Titanium (IV) oxide (TiO_2) Aeroxide® P25 as photocatalyst. Next to the formation of formaldehyde also methyl formate and CO_2 could be observed as by-products. We evaluated the influence of the catalyst temperature, the residence time, the catalyst load and the irradiation intensity on the reaction selectivity and activity. As a result, the formaldehyde selectivity increased with higher temperature and lower residence time, while the catalyst amount and the irradiation strength did not affect the selectivity significantly. A maximum formaldehyde selectivity of 80% could be achieved. The methanol conversion increased with an increase of all varied parameters.

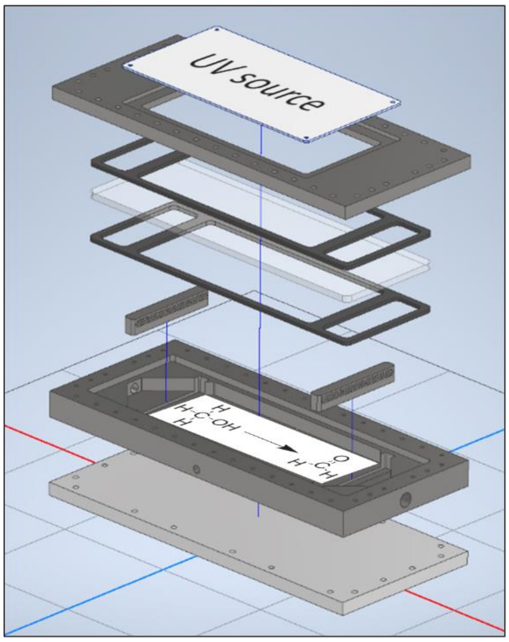

Figure 1: Explosion view of the continuous photoreactor used in this work.

In the second part we added Pt nanoparticles as co-catalyst to the photocatalyst Aeroxide® P25 and conducted methanol dehydrogenation experiments. In this process, methanol is converted into an equimolar amount of formaldehyde and hydrogen. In a consecutive reaction methyl formate is formed as the only by-product in small amounts. As a result, no CO_2 is formed in this process. In this study we varied the irradiation strength, the residence time and the temperature. The formaldehyde selectivity increased with increasing temperature and decreased with increasing residence time. Again, the irradiation strength did not affect the selectivity significantly. At a temperature of 120 °C a carbon-based formaldehyde selectivity of 95% could be achieved showing the high potential of this promising approach for the formation of formaldehyde from methanol.