Solar Degradation of Methyl-*tert*-Butyl Ether at Prototype Scale

Background

The use of methyl *tert*-butyl ether (MTBE) as a fuel additive led to an increasing pollution of groundwater which refers to accidental release in petrochemical production sites and at filling stations. MTBE is not toxic but affects the taste of water at levels as low as 15 µg/l. The compound is persistent to biological degradation. Hence, physicochemical measures have to be applied for groundwater remediation as well as for water treatment in MTBE processing (water resulting e.g. from washing procedures of tanks and pipes).
Conventional approaches like electrochemical treatment, ozonation or UV oxidation afford high specific energy. In contrast, solar photocatalysis can serve as an energy efficient water treatment process. Solar photocatalysis provides most of the process energy by direct conversion of solar energy (figure 1). In particular, the method is applicable for non-biogradable contaminants.
While with titanium dioxide (TiO_2) as photocatalyst still some technological challenges like the catalyst separation and long-term behavior on reuse exist. Systems using the photo-Fenton principle are already technologically and economically feasible.

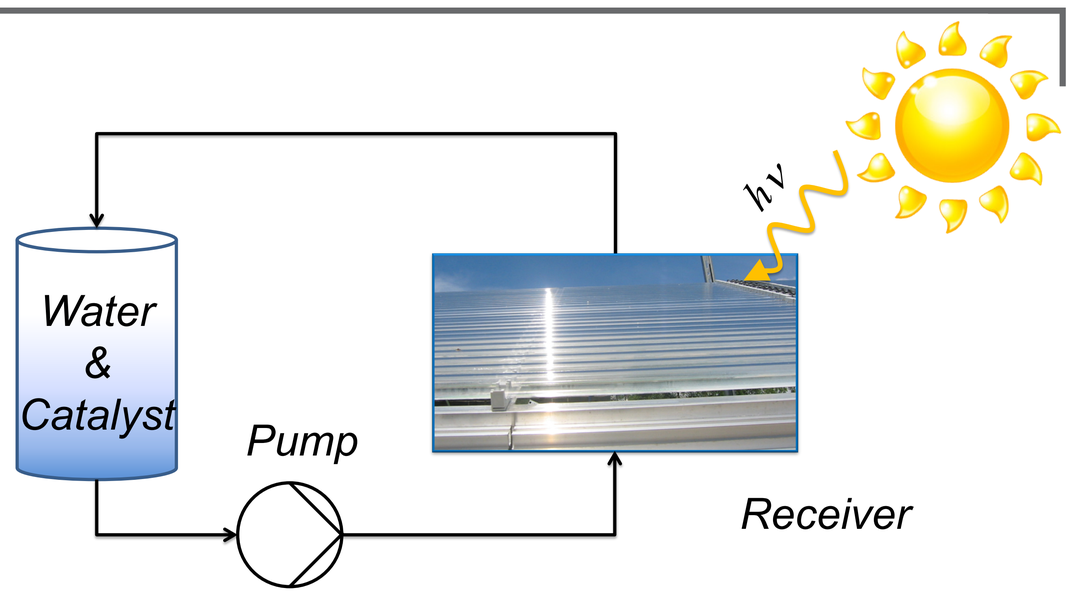

Fig. 1: Principle of a solar photocatalytic water treatment system

Fig. 2: Solar prototype reactor with non-concentrating tubular receiver modules at DLR, Cologne, Germany

Approach

In this study, the photochemical degradation of MTBE was examined with TiO_2 photocatalysis in comparison to the photo-Fenton reaction with sunlight at prototype scale (figure 2). A modular solar receiver design was applied that was recently also used for an automatically operating treatment plant at commercial scale.
The batch experiments were analyzed with respect to MTBE (via GCMS) and total organic carbon (TOC).

Results

High MTBE concentrations of 80 mg/l were tested in a scale of 160 l as a model for process water (e. g. from tank or pipe rinsing). With the photo-Fenton reaction, the TOC was reduced by 75 % with 90 Wh/l global irradiation (figure 3). When 100 mg/l TiO_2 (Evonik P-25) were applied, a reduction of only 45 % was achieved with the same specific energy. Increasing TiO_2 to 200 mg/l enhanced the TOC reduction to 64 %.
Both reaction systems are able to degrade MTBE even at high concentrations. According to qualitative GCMS measurements, most of the MTBE was eliminated in all experiments except for the one with 100 mg/l TiO_2. *Tert*-butyl formate and *tert*-butyl alcohol were detected as intermediates. As no slowing down of the reaction was observed, complete mineralization can be expected.

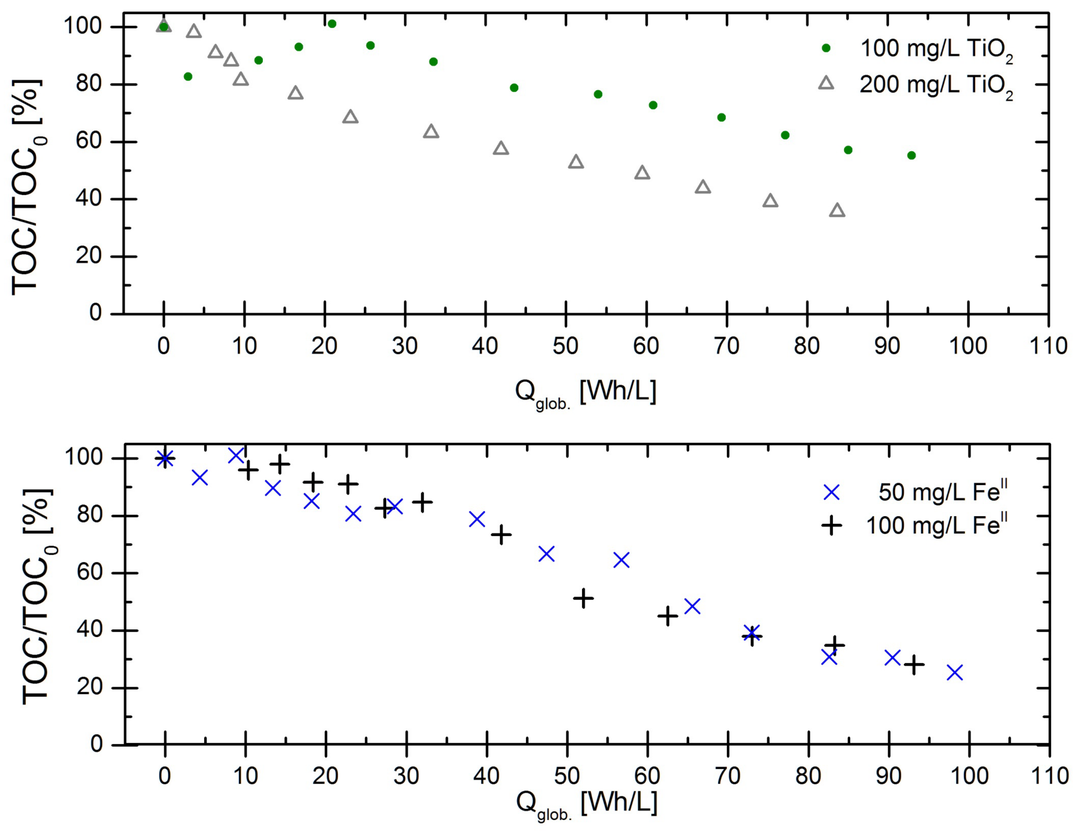

Fig. 3: TOC vs. specific global solar energy during MTBE degradation with photo-Fenton/ TiO_2 photocatalysis

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German Aerospace Center (DLR)
Institute of Solar Research | Solar Chemical Engineering | Linder Höhe | 51147 Köln
Christian Jung, Anke Nietsch, Christan Sattler, Marion Senholdt
Telefone +49 2203 601-2940 | Telefax +49 2203 601-4141 | christian.jung@dlr.de
www.DLR.de/sf www.DLR.de/energie

DLR Deutsches Zentrum für Luft- und Raumfahrt