SOLAR DEGRADATION OF THE METHYL TERT-BUTYL ETHER AT PROTOTYPE SCALE

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1. Introduction

Methyl tert-butyl ether (MTBE) is widely used as fuel additive. Due to accidental release or in production facilities it can occur in considerable concentrations in water. Although MTBE is not toxic, its removal from water is desirable as the compound affects the taste at concentrations as low as 15 µg/l. As MTBE is persistent to biological water treatment physicochemical measures have to be applied. As conventional approaches like UV oxidation, electrochemical treatment or ozonation afford high specific energy, solar photocatalytic treatment is an interesting option for MTBE removal in particular in the Mediterranean area.

Solar photocatalysis can serve as an energy efficient water treatment method in particular for non-biodegradable 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 seem to be technologically and economically feasible today.

2. Approach

In this study, the photochemical degradation of MTBE was examined with TiO_2 photocatalysis and the photo-Fenton reaction with laboratory experiments but also with sunlight at prototype scale (figure 1). A modular solar receiver system was applied that was recently also used for an automatically operating photo-Fenton treatment system at commercial scale [1, 2].

The batch experiments were analyzed with respect to MTBE (via GCMS) and total organic carbon (TOC).

Fig. 1: Solar prototype reactor with non-concentrating tubular receiver modules at DLR, Cologne.

3. Results

The solar prototype experiments started with a high MTBE concentration of 80 mg/l (as a model for process water e. g. for tank or pipe rinsing) in a scale of 160 l. With the photo-Fenton reaction the TOC was reduced in 5 hours solar irradiation (figure 2) by 75% whereas with TiO_2 photocatalysis a reduction of only 45% was achieved at 100 mg/l photocatalyst (Evonik P-25). With 200 mg/l TiO_2 the TOC reduction increased to 64%.

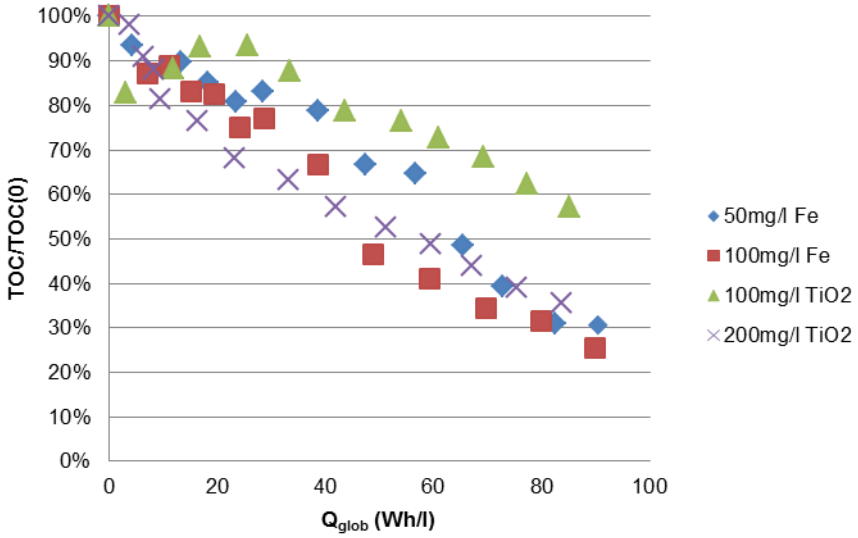

Fig. 2: TOC vs. global solar energy during MTBE degradation with photo-Fenton / TiO_2 photocatalysis.

Obviously, both reaction systems are able to degrade MTBE even at high concentrations. There is no evidence that the reaction slows down. According to qualitative GCMS measurements, most of the MTBE should has been eliminated in all experiments except for the one with 100 mg/l TiO_2. As intermediates tert-butyl formate and tert-butyl alcohol have been detected.

References

[1] C. Sattler, H.-J. Bigus, V. Dietrich, D. Graf, R. Huth, C. Jung, A. Müller, T. Olbrich, L. de Oliveira, R. Olwig, J.-P. Säck, Solar Photocatalytic Detoxification of Rocket Test Facility Waste Water with a Non Concentrating Tubular Receiver (NCTR) Pilot Plant, 14th Biannual SolarPACES Symposium, Las Vegas, NV (USA), 4.-7.03.2008.

[2] C. Jung, R. Olwig, C. Sattler, R. Huth, H.-J. Bigus, T. Olbrich, A. Sieck, V. Dietrich, The Non-Concentrating Solar Photocatalytic Water Treatment Plant in Lampoldshausen, 16th SolarPACES Symposium, Perpignan (France), 21.-24.09.2010.