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Erlangen, 03.06.2012

Your contract dated September 2011

Dear Ms. Reger,

Please find the concluding report and documentation concerning the photocatalytic reduction of acetaldehyde in two samples of tile material. In accordance with your samples sent on 22.09.2011, the reduction was measured both with and without a cut-off filter (455 nm).

Yours sincerely,



Prof. Dr. Horst Kisch

Documentation of the photocatalytic reduction in acetaldehyde on tiles with HT coating

Task set

Two different tiles of production dates **05.07.2011 (Sample 5810)** and **15.07.2011 (Sample 5811)** were to be tested in a sealed system for their characteristics of photocatalytic reduction of acetaldehyde.

The experiment and its implementation

Tiles 5810 and 5811 in their dimensions, 12 x 3 cm were each exposed to a gaseous atmosphere consisting of air and acetaldehyde and irradiated for 3 hours with UV light both without a cut-off filter and with a 455 nm cut-off filter respectively. The reduction in the acetaldehyde concentration was determined at hourly intervals by gas chromatography (GC FID). Acetaldehyde concentrations in the regions of approx. 5 ppm (vol.) and 4,000 mg/m³ respectively were selected as the initial concentrations.

Gas samples were taken by means of a septum seal (see Fig. 1)



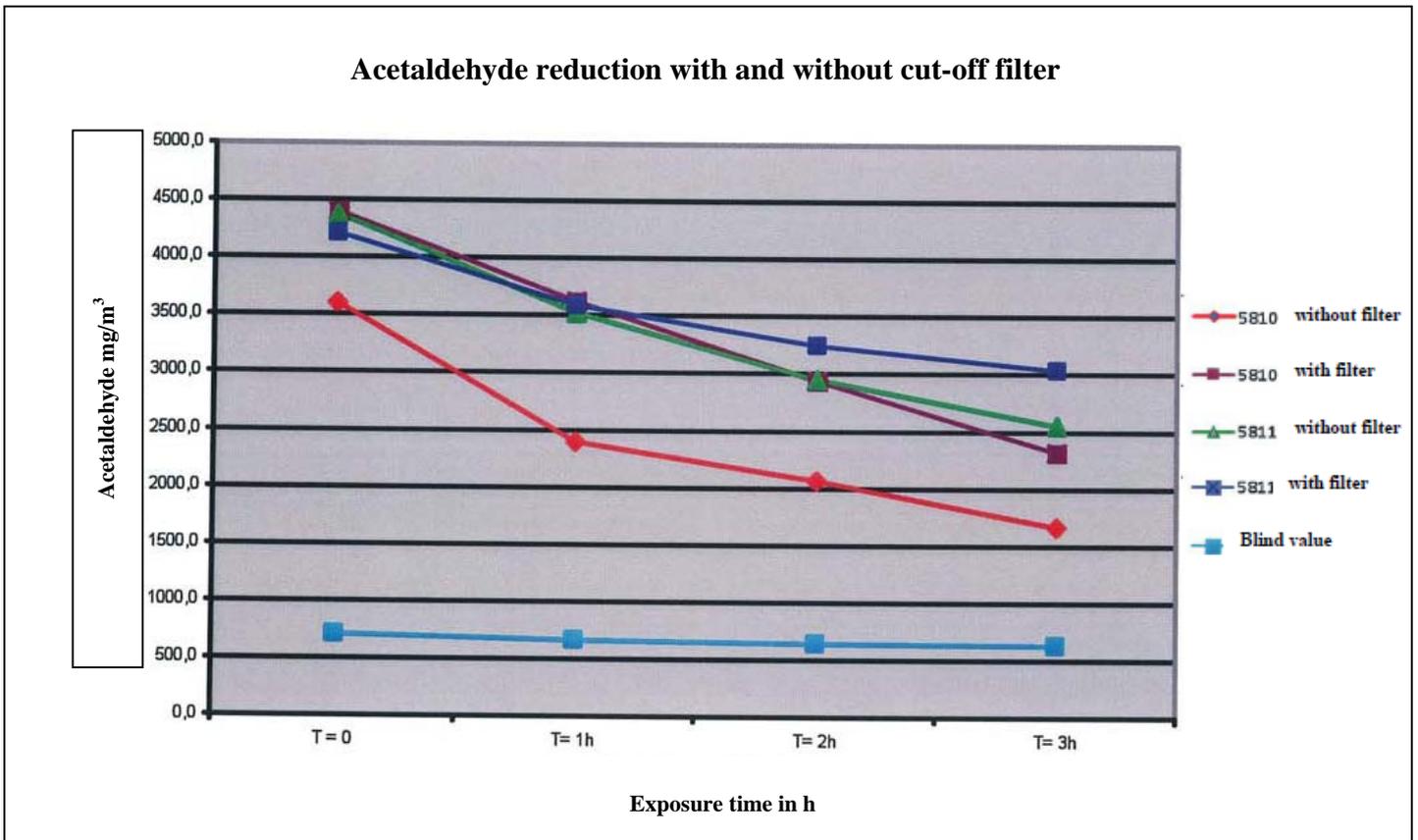
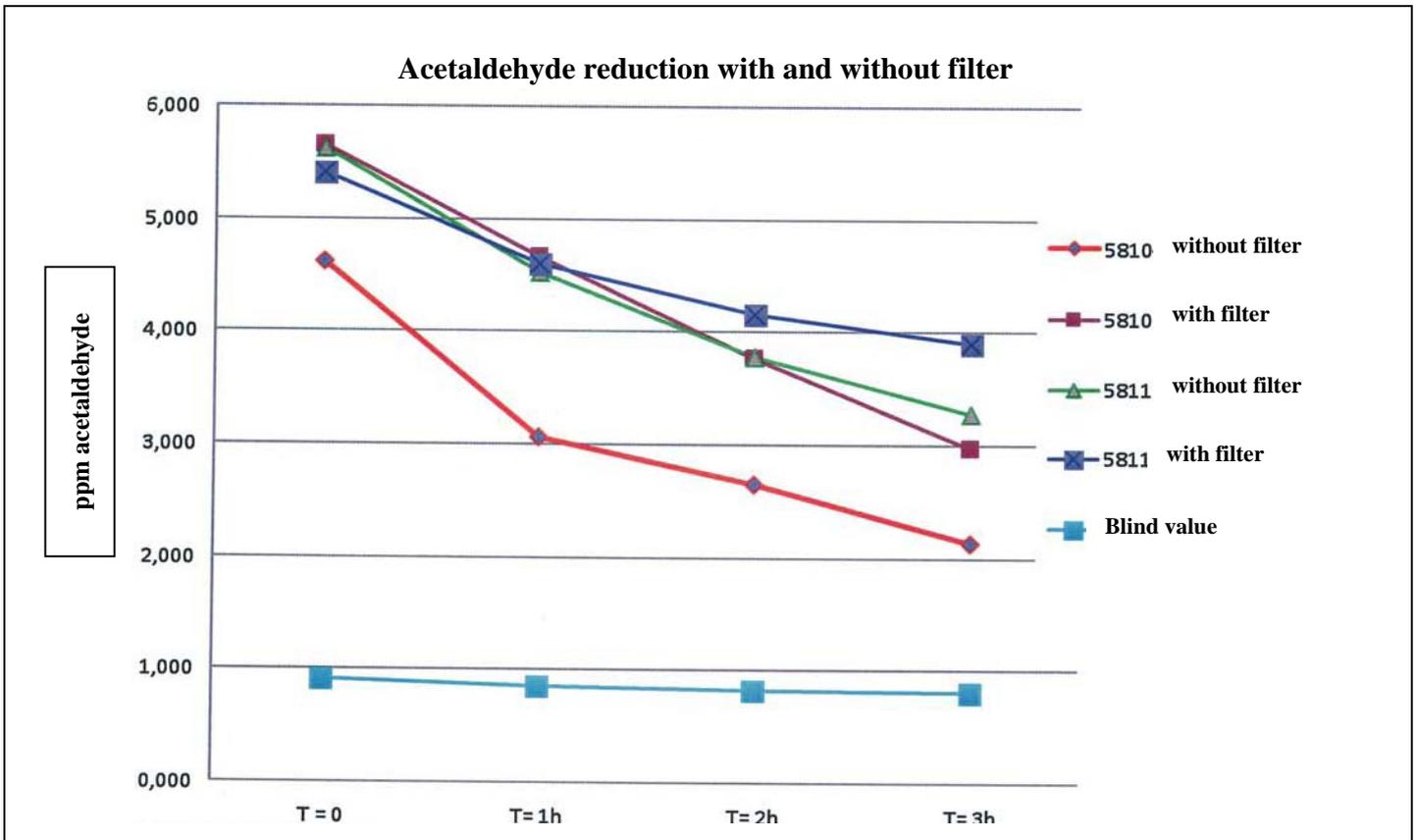
Fig.1: Photoreactor with water filter for the removal of infrared rays (centre).
The lamp - not illustrated - is located to its left.

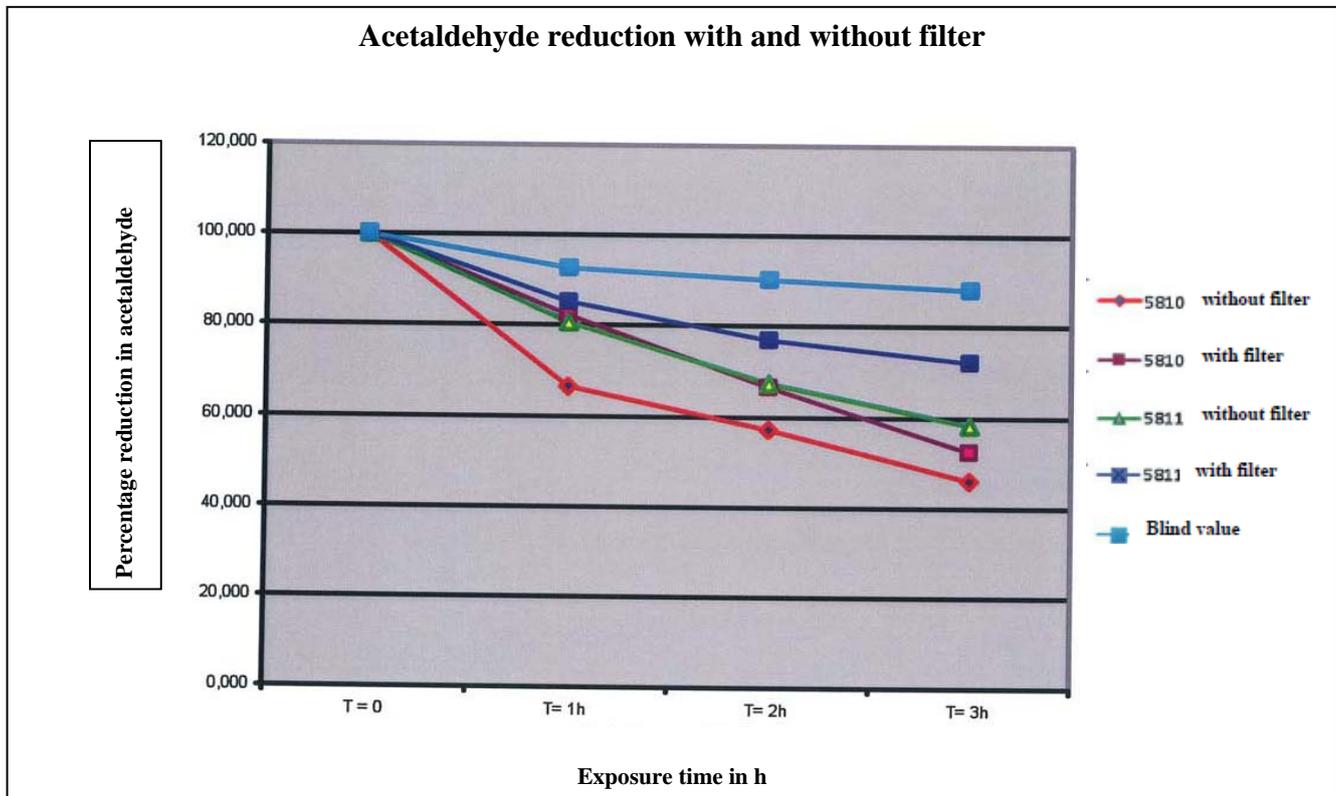
Exposure to acetaldehyde gas was effected by injecting the appropriate volume. After an equilibration time of 15 minutes in darkened conditions, the samples were exposed for 3 hours to a 150w Xe lamp without and with an upstream 455 nm cut-off filter. A gas-tight septum was used to take samples for analysis at the beginning, after 1 hour, after 2 hours and after 3 hours.

1. Measurement results

Exposure for 3 h without and with 455 nm cut-off filter

No.	5810	5810	5811	5811	
Description	HT tiles	HT tiles	HT tiles	HT tiles	Blind test without tile
PN date	22.09.2011	22.09.211	22.09.2011	22.09.2011	
Dimensions	10 x3 cm	10 x 3 cm	10 x 3 cm	10 x 3cm	
Colour	white	white	white	white	
Gassing	Acetaldehyde	Acetaldehyde	Acetaldehyde	Acetaldehyde	Acetaldehyde
Cut-off-filter	without	455 nm	without	455 nm	without
Lamp	Xe 166 w				
Equilib.time	15 min.				
Gas collection tube vol. in ml	211	211	211	211	211
Acetaldehyde in mg/cm ³					
t = 0	3597.9	4406.7	4377.4	4213.3	714.1
t = 1h	2390.8	3628.8	3530.9	3588.5	661.6
t = 2h	2061.2	2936.7	2951.3	3243.2	643.7
t = 3h	1659.0	2313.9	2551.2	3036.8	628.4
Acetaldehyde in ppm (vol.)					
t = 0	4.61	5.65	5.61	5.40	0.92
t = 1h	3.07	4.65	4.53	4.60	0.85
t = 2h	2.64	3.76	3.78	4.16	0.83
t = 3h	2.13	2.97	3.27	3.89	0.81
Relative acetaldehyde reduction in %					
t = 0	100.0	100.0	100.0	100.0	100.0
t = 1h	66.4	82.3	80.7	85.2	92.6
t = 2h	57.3	66.6	67.4	77.0	90.1
t = 3h	46.1	52.5	58.3	72.1	88.0





Test conclusions

The two tile types (5310 and 5311) significantly catalyse the reduction of acetaldehyde under the influence of light. In both tile samples, the reduction progresses rather “more quickly” with UV + vis. light as is illustrated in the example of 5810 with filter (————) (vis. only, i.e. visible light) and 5810 without filter (—————) (UV + vis. light).

In contrast, acetaldehyde alone shows no reduction or only a very weak reduction under the influence of light - which is however, caused by the oxidation of the acetaldehyde due to the oxygen content of the air in the gas collection tube.

Erlangen, 28.11.2011

Prof. Dr. Horst Kisch

Catalytic effectiveness of the HT coating on ceramic tiles

1. Approach to the experiment

2 ceramic tiles were placed in each of 2 emission test chambers. A continuous flow of humidified neutral air enriched with the testing substance (NO) was passed through the test chambers. Two “Eversun” fluorescent lamps, whose emission spectrum included an increased proportion of UV light, were mounted on inert supports within the test chambers. An emission test chamber with fluorescent tubes but without ceramic tiles served as a reference.

2. Results

In the absence of tiles, the effect of UV light on the test gas atmosphere averaged over the testing period reduced the NO concentration by 12.3 ppb. The combination of HT coating and UV light showed a reduction in the NO concentration amounting to 28.5 ppb. The use of non-coated tiles led to a reduction in the ppb concentration under UV light in the test chamber amounting to 24.4 ppb. The development of NO concentrations over time is shown in Fig.1. Fig. 2 shows the average concentrations calculated over the testing period and the respective scatter widths.

Translator's notes:

1. To the left of the graph, y-axis, “c (NO) [ppb]”
2. In the top left hand corner of the graph, “t = 0 d is equivalent to the start of the addition of NO test gas”.
3. Inside the graph, on the right hand side, “Blank value, lighting off”
“Blank value, lighting on”
4. Below the graph, x-axis, “time [d]”
5. To the right of the graph, y-axis, -“□ with UV, without ceramic tiles”
- □ with UV, with HT
- ▲ with UV, without HT”

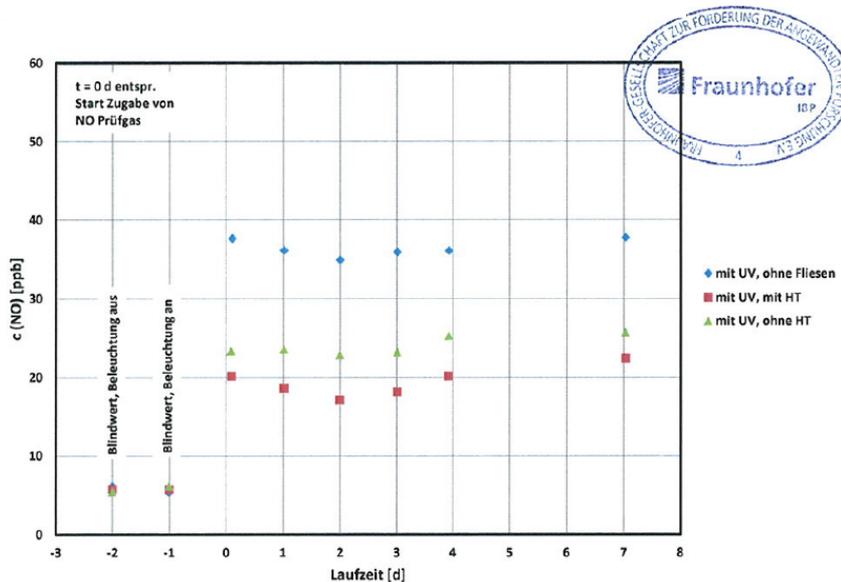


Fig. 1:
Time dependent course of NO concentrations in the test chambers.

Translator's notes:

1. To the left of the graph, y-axis, "NO concentration [ppb]"
2. Below the graph, Column 1, "without ceramic tiles"
3. "Coating and light source [-]"

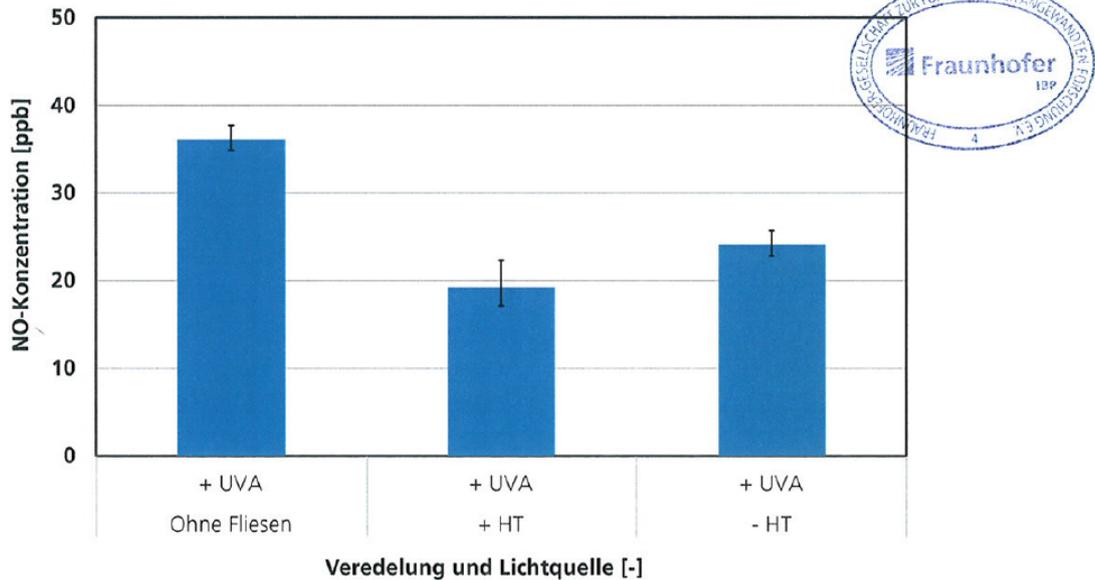


Fig. 2:
Average values and NO concentration scatter in the test chambers.

The NO(x) concentrations in the test chambers tended to follow the course of NO concentration. Hereby, the effect is less pronounced however (Fig. 3). The formation of NO₂, a product of the oxidation of NO, can be assumed to be the cause of the less pronounced reduction in concentration under the influence of UV light.

Translator's note:
All texts as in Fig. 1

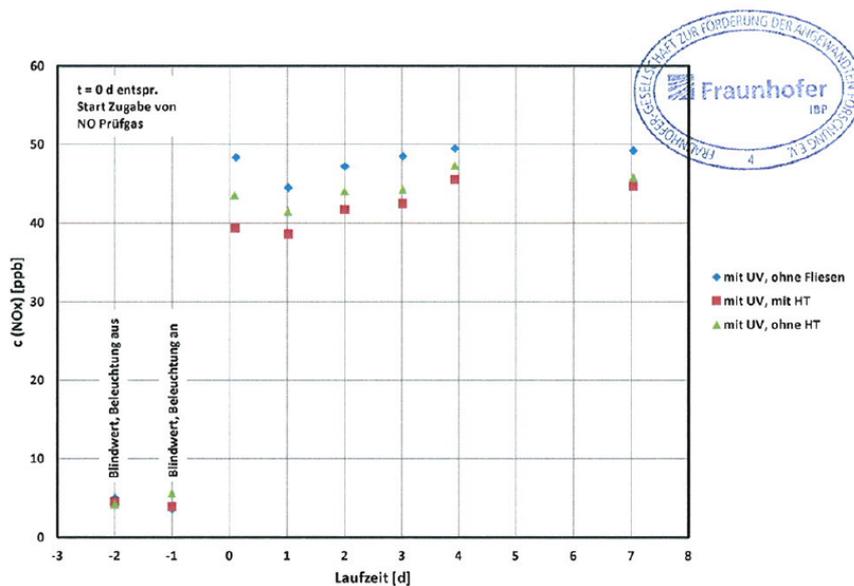


Fig. 3:
Time dependent course of the NO(x) concentrations in the test chambers.

3. Summary

The results can be summarised as follows:

- The combination of HT coating and UV light showed a significant reduction in the NO concentration.
- The reduction in NO(x) concentration was significantly less pronounced than the reduction in the NO concentration. The reason for this can be assumed to be the fact that part of the nitric oxide (NO) is oxidised to form nitrogen dioxide NO₂ and that this is also recorded in the NO(x) measurement.
- The effect of UVA light on the test gas without the presence of ceramic tiles already resulted in a reduction in the NO concentration.
- Within the measuring accuracy, the effect of UV light and HT coating remained almost constant over the test period.