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Determination of photocatalytic activity of samples FN1, FN2, FN3 and P25 according to the methodology ISO 22197-4:2013

Developed on the basis of order No. VSCHT 17-12-15 for Advanced Materials-JTJ sro

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Content

Experimental equipment

The coatings were tested according to the ISO 22197-4: 2013 standard based on the photocatalytic degradation of formaldehyde in an air stream with an input concentration of 1 ppm. A diagram of the apparatus is shown in FIG. 1. The air stream is passed through a mass flow meter (AALBROG with a range of 0-5dm ^{3} / min) and divided into two streams, one of which is passed through a washing flask with water. Needle valves control the flow of wet resp. dry air in order to achieve a relative humidity of 50%. The formaldehyde stream is passed through a mass flow meter (AALBORG with a range of 0-200 ml / min) and is connected to the resulting humidified air stream to achieve an initial formaldehyde concentration of 1 ppm. The total gas flow is 3 dm ^{3} / min (STP). The gas flow is led through a two-way valve allowing the gas to be led out of the photoreactor (so-called by pass). From the photoreactor, part of the gas is sucked by a pump into a gas chromatograph (Agilent 7890B) for analysis and part of the gas is discharged in a waste stream into a fume hood.

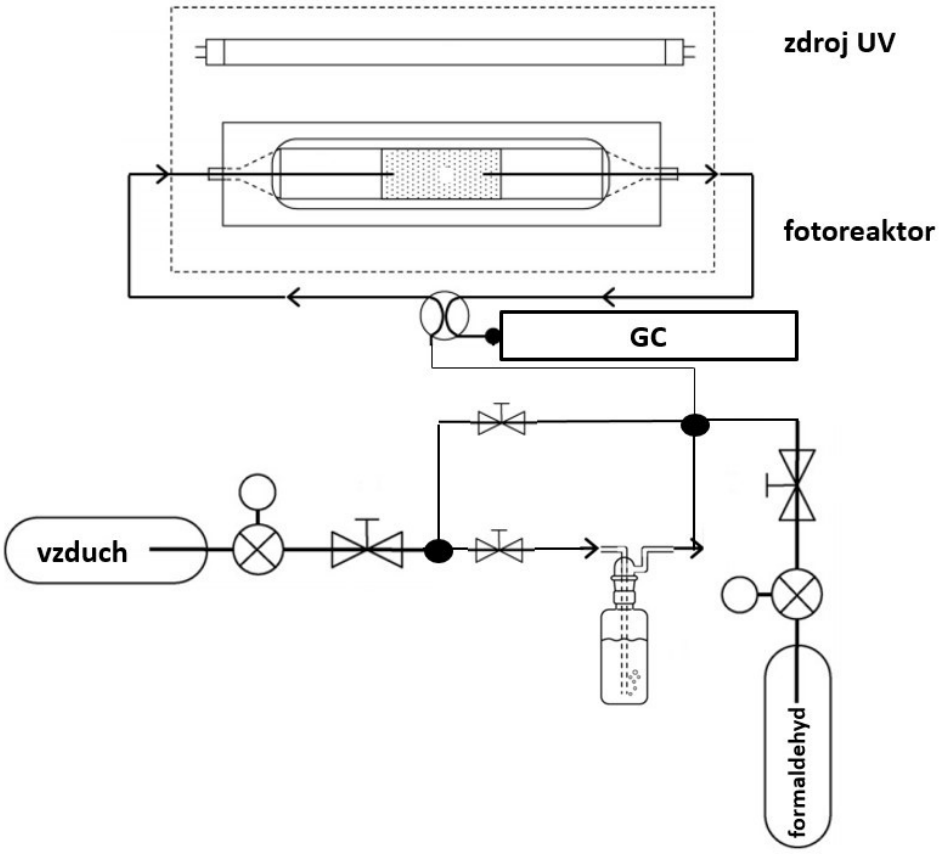

Image 1: Scheme of experimental apparatus

1 WORKFLOW:

The required flow rates are set on the mass flow meters to achieve an input formaldehyde concentration of 1 ppm at a total gas flow of 3dm ^{3} / min (STP). The needle valves are used to set such a dry flow or humid air to achieve a humidity of 50%. Prior to the actual experiment, the samples were preactivated by UV radiation for 20 hours (2x Eiko fluorescent lamp, emission maximum 351 nm, UV A intensity 2.5 mW / cm ^{2}).

Prior to the actual photocatalytic experiment, the required UV intensity was set to 1 mW / cm ^{2} by changing the distance from the source (radiation source: 2x Eiko fluorescent lamp. emission maximum 351 nm). In the first phase, the gas was led out of the reactor (by a so-called bypass) until a stable initial formaldehyde concentration of 1 ppm was obtained. The reactor was covered with aluminum foil to prevent the penetration of UV radiation and the gas supply was introduced into the reactor through a valve. Due to the possible adsorption of the pollutant, the output concentration of the model pollutant is reduced, the experiment is run in this arrangement for 30 minutes to reach an output concentration of 1 ppm. If, after 30 minutes, the formaldehyde output concentration is less than 90% of the initial concentration value, the adsorption experiment is continued until 90% of the formaldehyde input concentration value (1 ppm) is reached.

After the adsorption phase, the actual photocatalytic experiment is started by exposing the photoreactor with aluminum foil. In this arrangement, the experiment is run for 3 hours, the photocatalytic activity being quantified by the amount of degraded formaldehyde during the last hour of the test. At the end of the photocatalytic experiment, the UV source is switched off and the increase in the formaldehyde concentration to the initial value is monitored.

The amount of degraded formaldehyde in micromoles in the last hour of the test (n $_F$) is calculated according to Equation 2, where:

R_F represents the conversion of formaldehyde (calculated according to Equation 3) (%) φ_{F0} initial formaldehyde concentration (ppm) φ_F formaldehyde concentration at the reactor outlet (ppm) f total gas flow in dm ^{3} / min at standard conditions (dm ^{3} / min)

$$n_F = R_F \frac{\varphi_{F0}\, f \cdot 1{,}016 \cdot 60}{100 \cdot 22{,}4}$$

(equation 2)

$$R_F = 100 \cdot \frac{\varphi_{F0} - \varphi}{\varphi_{F0}}$$

(equation 3)

for the case of formaldehyde conversion (R $_F$) <5%, the amount of degraded formaldehyde is calculated according to Equation 4.

$$F_F = 0.136 \varphi_{F0} f$$

(equation 4)

2 Results

2.1 Sample FN1-3L (substrate glass)

test date:	9.2.2016
laboratory temperature (° C)	24.5
relative humidity lab (%)	20.9
The beginning of the experiment	9:17
Switch to reactor	9:54
UV on	10:27
UV off	13:31

Tab. 3.1.1: Test conditions

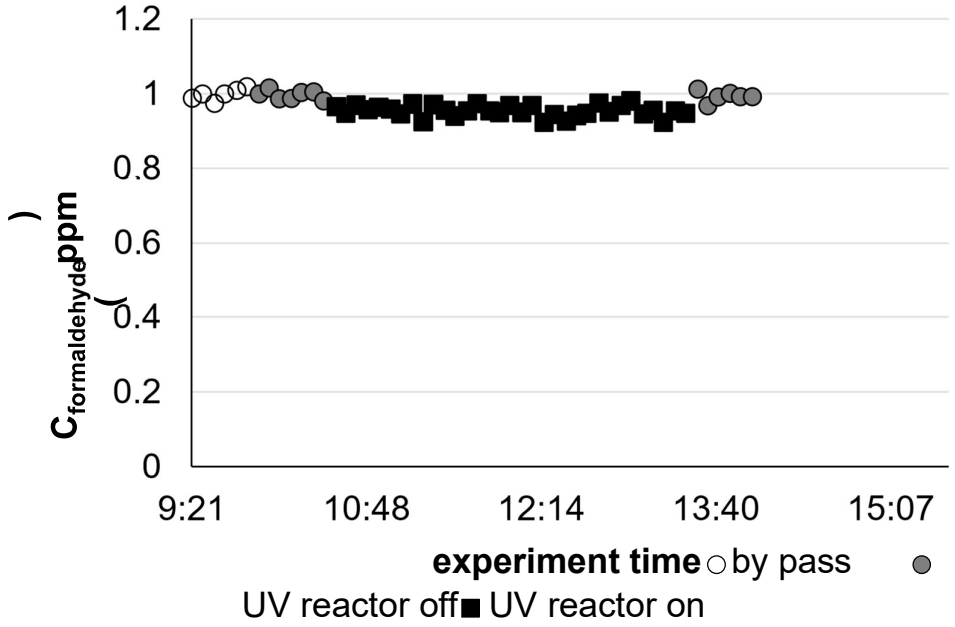

Image 3.1.2: The course of the photocatalytic experiment - sample FN1-3L

R_F	4.6%
n_F	0.4 micromolar

Tab. 3.1.3: Conversion (R_F) and amount of formaldehyde degraded (n_F) - sample FN1-3L

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2.2 Sample FN2 3L (substrate glass)

test date:	2/8/2016
laboratory temperature (° C)	24
relative humidity lab (%)	34.5
The beginning of the experiment	9:14
Switch to reactor	9:35
UV on	10:03
UV off	13:03

Tab. 3.2.1: Test conditions

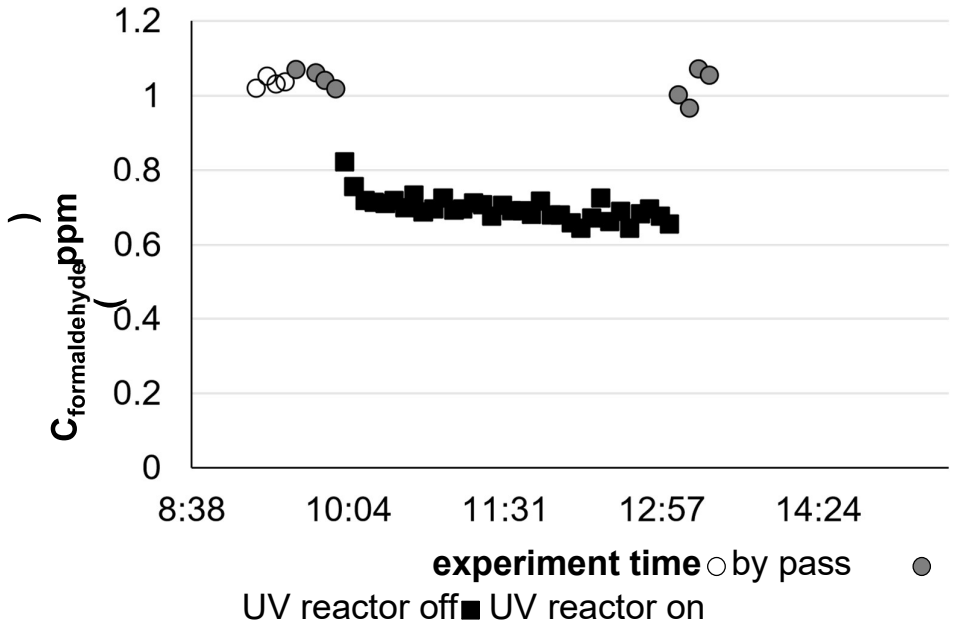

Image 3.2.2: The course of the photocatalytic experiment - sample FN2-3L

R_F	35.7%
n_F	3 micromolar

Tab. 3.2.3: Conversion (R_F) and amount of formaldehyde degraded (n_F) - sample FN2-3L

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2.3 Sample FN3 3L (substrate glass)

test date:	2/16/2016
laboratory temperature (° C)	24.7
relative humidity lab (%)	28.9
The beginning of the experiment	9:28
Switch to reactor	10:28
UV on	10:55
UV off	13:54

Tab. 3.3.1: Test conditions

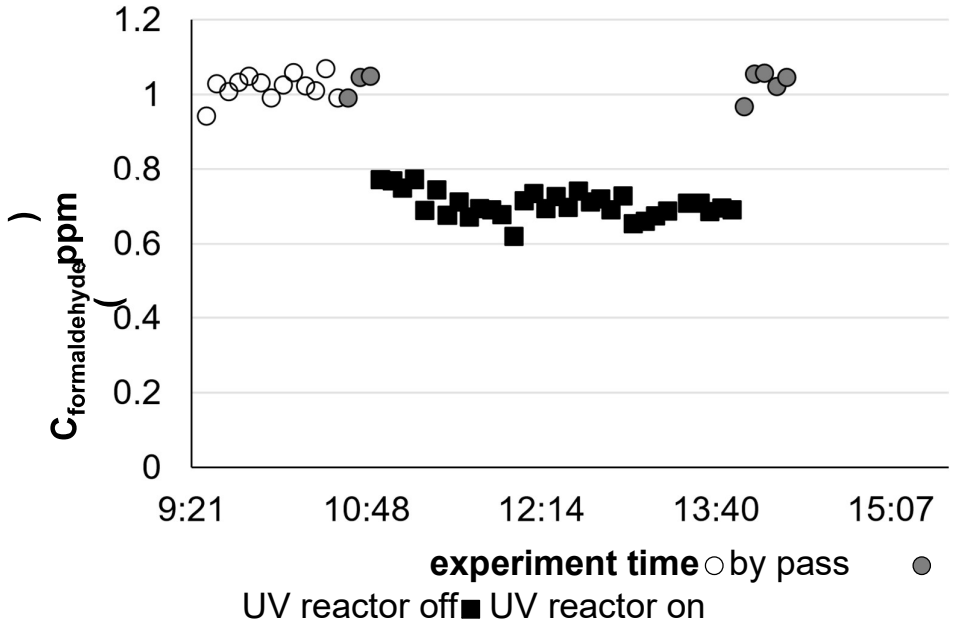

Image 3.3.2: The course of the photocatalytic experiment - sample FN3-3L

R_F	33.2%
n_F	2.8 micromolar

Tab. 3.3.3: Conversion (R_F) and amount of formaldehyde degraded (n_F) - sample FN3-3L

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2.4 Sample P25 3L (substrate glass)

test date:	23.2.2016
laboratory temperature (° C)	23.4
relative humidity lab (%)	33.2
The beginning of the experiment	9.27
Switch to reactor	10.11
UV on	10.43
UV off	13.43

Tab. 3.4.1: Test conditions

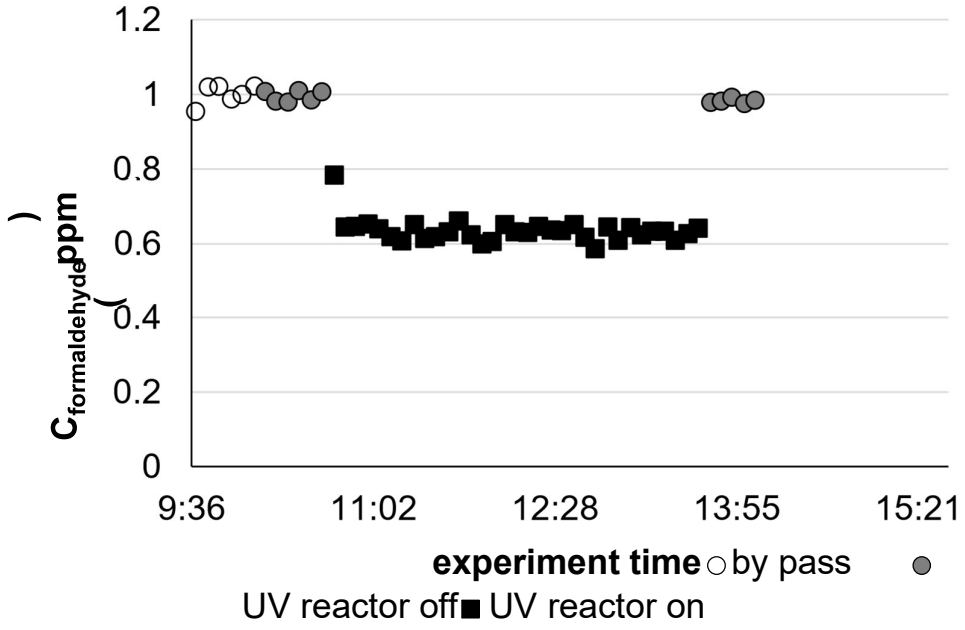

Image 3.4.2: The course of the photocatalytic experiment - sample P25-3L

R_F	36.9%
n_F	3 micromolar

Tab. 3.4.3: Conversion (R_F) and amount of formaldehyde degraded (n_F) - sample P25-3L

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3 Conclusions

In the graph of FIG. 4: a comparison of the photocatalytic activity of individual samples evaluated by the amount of degraded formaldehyde (n_F) is shown. The results show that the layers formed by FN2 and FN3 show comparable photocatalytic activity with the layers formed by the reference photocatalyst P25. In contrast, in the case of the FN1 layer, the formaldehyde conversion was less than 5% - this sample showed the lowest photocatalytic activity.

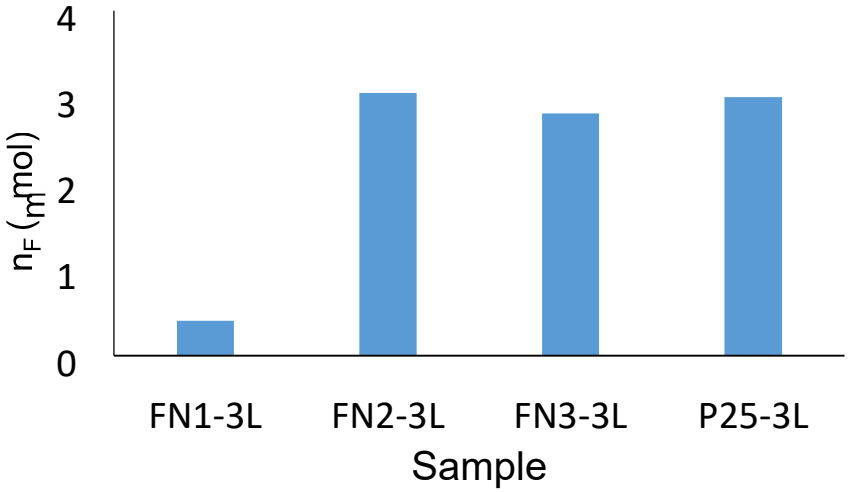

Image 4: Comparison of photocatalytic activity of individual samples evaluated by the amount of degraded formaldehyde (n_F)