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Photocatalytic activity of FN1, FN2, FN3 and P25 using ISO 22197-4:2013 standard

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Contents

Test equipment

Samples were measured using ISO 22197-4:2013 standard method. This method is based on photocatalytic degradation of formaldehyde of initial concertation 1 ppm. Schematic diagram of the test equipment is shown on Fig. 1. It is the same as that used in the method for removal nitric oxide (ISO 22197-1) and consists of the gas supply, a photoreactor, a light source and GC analyzer. The test gas supply provides air polluted with formaldehyde (c=1 ppm, relative humidity 50%).The total flowrate was 3dm^3/min. Concertation of the test gas was determined using Agilent 7890B GC analyzer.

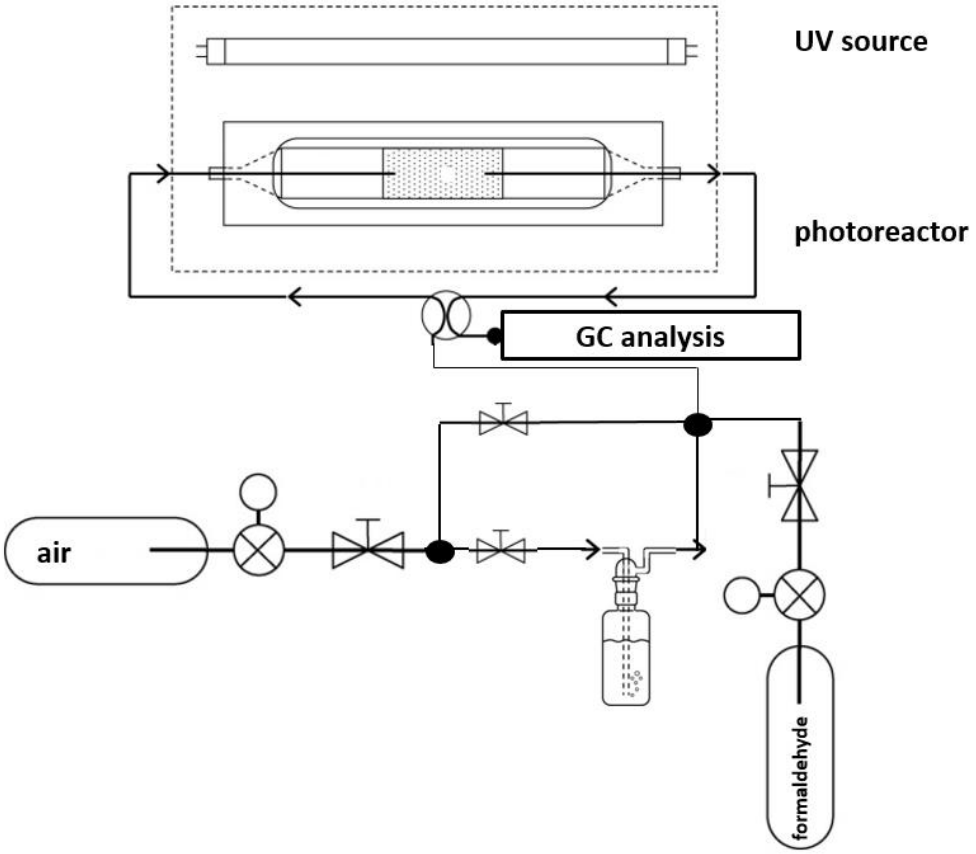


Fig 1: Schematic diagram of the test equipment

1 Procedure

Mass controllers were adjust to achieve the initial concentration of formaldehyde of 1 ppm at a total flowrate 3dm^3/min. By changing the flow rate of dry and wet air respectively, the relative humidity of gas supply was set to 50% (temperature (25±2,5)℃. Before photocatalytic experiment samples were pretreated by UV A light (2,5 mW/cm^2) to decompose residual organic matter.

The intensity of UV light during photocatalytic experiment was set at 1 mW/cm^2 by changing the optical length (UV source 2x fluorescent tubes Eiko, emission maximum at 351 nm). At first the test gas was loaded outside the reactor (by pass) to achieve stable concentration of formaldehyde. After than the gas was introduced into photoreactor which was covered by aluminum foil to observe the absorption process of the test piece. If the formaldehyde concertation matches the initial concertation of formaldehyde, at that point the light irradiation started by removal of aluminum foil.

After starting light phase, concentration of formaldehyde was continuously measured for 3 hours. After 3 hours UV lamp were turned off and the increase of formaldehyde concentration was recorded.

The result of this test is amount of photocatalytic removed formaldehyde (n_F) in last hour of the test calculated using formula 2.

R_F is the removal percentage, by test piece, of formaldehyde (%)

φ_{F0} is the supply volume fraction of formaldehyde (ppm)

φ_F is volume fraction of formaldehyde at reactor exit (ppm)

f is the flow rate of test gas converted into that at the standard state (dm^3/min)

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

(formula 2)

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

(formula 3)

When R_F is below 5%, the quantity of formaldehyde removed (n_F) is calculated by formula 4

$$n_F = 0{,}136 \varphi_{F0} f$$

(formula 4)

2 Results

2.1 FN1-3L (coated on glass)

date	9.2.2016
temperature (°C)	24,5
RH in laboratory (%)	20,9
by pass	9:17
adsorption phase	9:54
UV on	10:27
UV off	13:31

Fig. 3.1.1: Test conditions

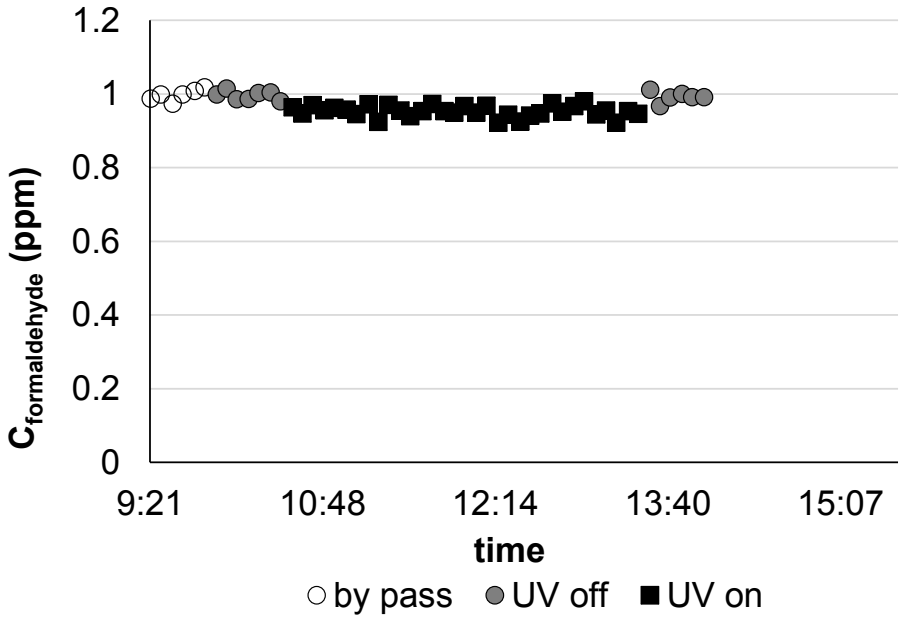


Fig. 3.1.2: Dependence of formaldehyde concentration depending on time – FN1-3L

R_F	4,6 %
n_F	0,4 µmol

Fig. 3.1.3: The removal percentage (R_F) and removal quantity of formaldehyde (n_F) – FN1-3L

2.2 FN2-3L 3L (coated on glass)

date	8.2.2016
temperature (°C)	24
RH in laboratory (%)	34,5
by pass	9:14
adsorption phase	9:35
UV on	10:03
UV off	13:03

Fig. 3.2.1: Test conditions

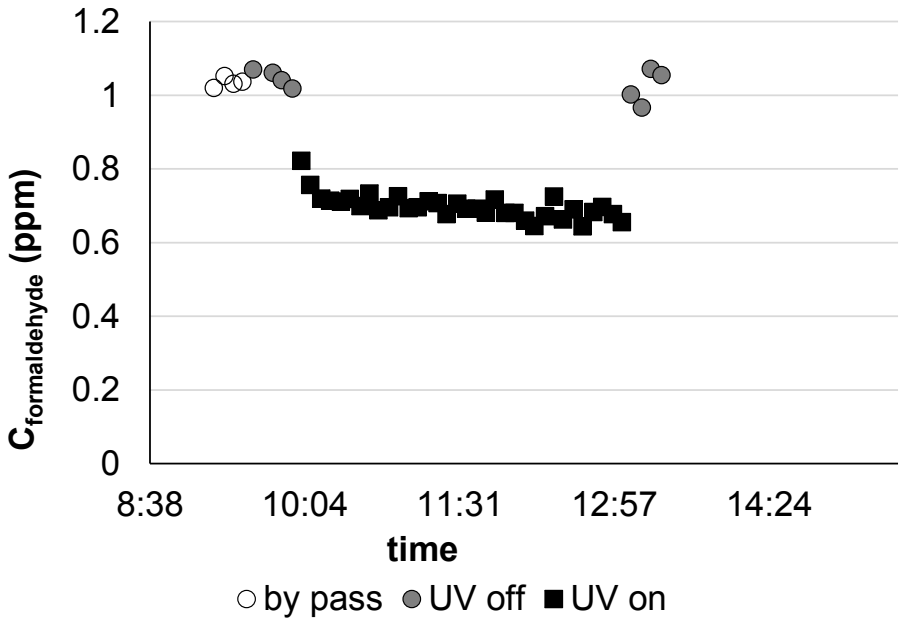


Fig. 3.2.2: Dependence of formaldehyde concentration depending on time -FN2-3L

R_F	35,7 %
n_F	3 µmol

Fig. 3.2.3: The removal percentage (R_F) and removal quantity of formaldehyde (n_F) – FN2-3L

2.3 FN3-3L (coated on glass)

date	16.2.2016
temperature (°C)	24,7
RH in laboratory (%)	28,9
by pass	9:28
adsorption phase	10:28
UV on	10:55
UV off	13:54

Fig. 3.3.1: Test conditions

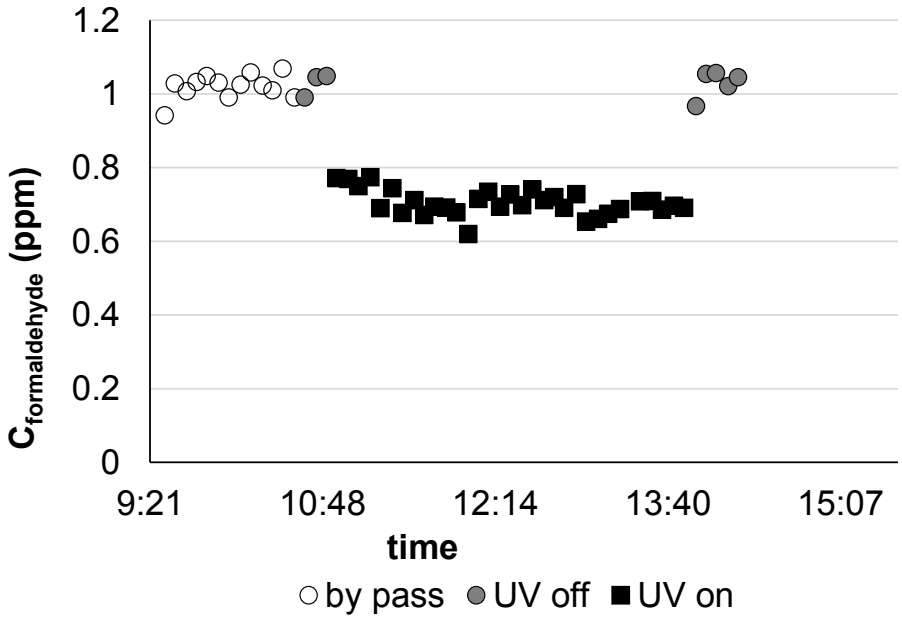


Fig. 3.3.2: Dependence of formaldehyde concentration depending on time – vzorek FN3-3L

R_F	33,2 %
n_F	2,8 µmol

Fig. 3.3.3: The removal percentage (R_F) and removal quantity of formaldehyde (n_F)– vzorek FN3-3L

2.4 P25-3L (coated on glass)

date	23.2.2016
temperature (°C)	23,4
RH in laboratory (%)	33,2
by pass	9.27
adsorption phase	10.11
UV on	10.43
UV off	13.43

Fig. 3.4.1: Test conditions

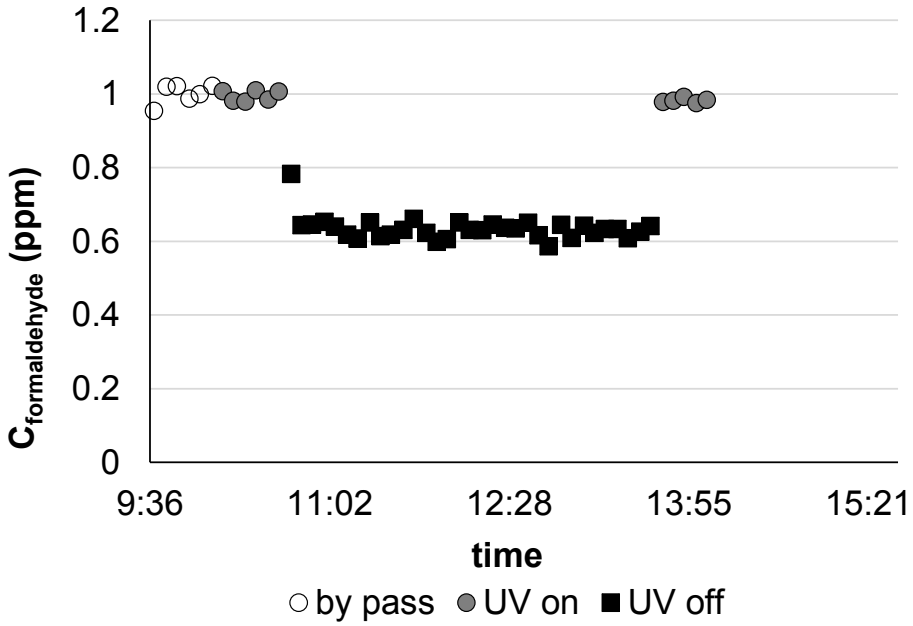


Fig. 3.4.2: Dependence of formaldehyde concentration depending on time – P25-3L

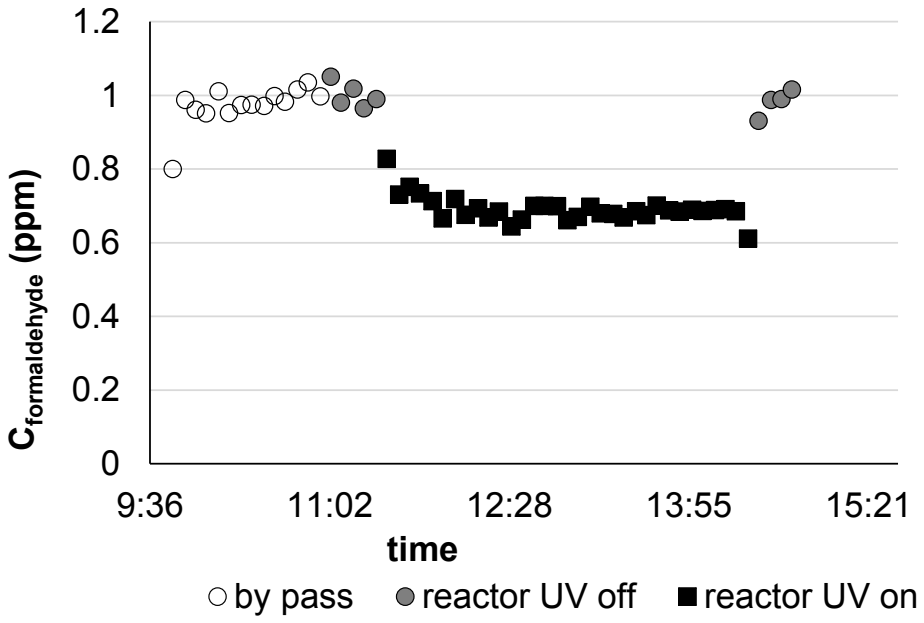
R_F	36,9 %
n_F	3 µmol

Fig 3.4.3: The removal percentage (R_F) and removal quantity of formaldehyde (n_F) – P25-3L

2.5 FN1-3L (coated on glass) - rinsed with water and re-measured

The same sample (FN1-3L) whose photocatalytic activity was determined in Section 2.1, were rinsed with 50 ml distilled water, then was pretreated using UV and photocatalytic activity were re-measured

date	18.4. 2016
temperature (°C)	24,5
RH in laboratory (%)	30
by pass	9:47
adsorption phase	10:59
UV on	11:29
UV off	14:29



R_F	32,1
n_F	2,6 micromol

3 Conclusions

In Fig. 4, there is illustrated comparison of photocatalytic activity expressed as a quantity of removal formaldehyde in last hour of the test. It results, that FN2 and FN3 coatings show similar photocatalytic activity as the reference sample P25. On the other hand FN1 exhibit much lower photocatalytic activity with the removal percentage of formaldehyde lower than 5%. This sample was rinsed with water (50 ml) and photocatalytic activity was re-measured. After this operation sample exhibit similar photocatalytic activity compared to reference sample containing P25.

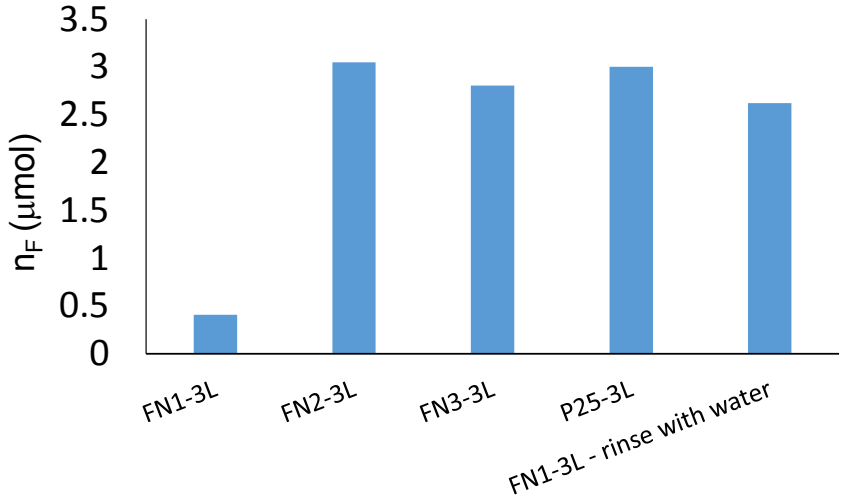


Fig. 4: Results of photocatalytic activity expressed as a quantity of removal formaldehyde (n_F)