



Department of Inorganic Technology
UCT PRAGUE

Determination of photocatalytic activity using removal of benzene

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1 Objective

The objective was to determine photocatalytic activity of samples FN2, FN3 and P25 which were coated on glass by the customer JTJ Advanced Materials.

2 Methodology

Samples were tested according to standard ISO 22197-3 (removal of toluene). The conditions of the test were slightly modified. The initial concentration of benzene was 5 ppm and the total flowrate was 1 dm³/min. Experimental equipment is illustrated in Fig. 1. Mass controllers were adjusted to achieve the initial concentration of test gas equal to 5 ppm. The ratio of wet/dry air is set using needle valves to obtain the humidity 50%. Before photocatalytic experiment, sample is pre-treated by UV irradiation (24 hours, emission maximum 351 nm, intensity of UV light 3 mW/cm²).

The intensity of UV light during photocatalytic experiment was set to 1 mW/cm² by changing the distance of UV source (2x fluorescent tubes Eiko, emission maximum at 351 nm) from the sample surface. At first the test gas was conducted outside the reactor (by pass) to achieve stable concentration of pollutant. After this the testing gas was introduced into photoreactor which was covered by aluminium foil to observe the absorption process of the test piece under dark. When the concentration reached the initial concentration of benzene the light irradiation started by the removal of aluminium foil.

After the start of irradiation, concentration of test gas was continuously measured for 3 hours. Photocatalytic activity is then expressed as removed amount of benzene in last hour of the test.

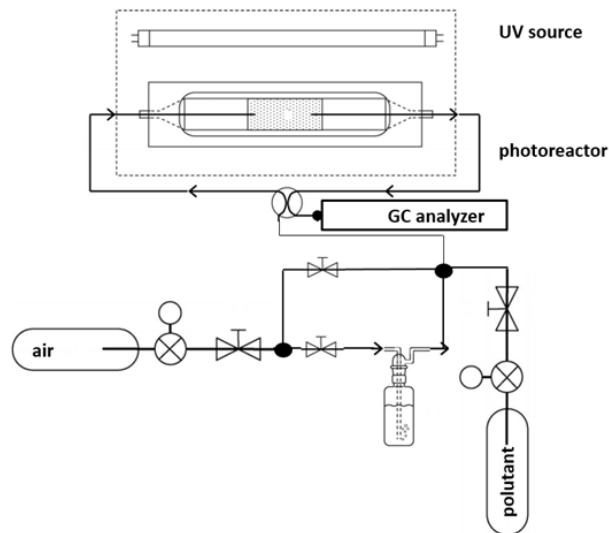


Fig 1: Experimental setup

The conversion removal of benzene (R_B) (%) is calculated using equation (2), where:

φ_{B0} is the volume fraction of benzene at the reactor input (ppm),

φ_B is the volume fraction of benzene at the reactor exit (ppm),

$$R_B = 100 \cdot \frac{\varphi_{B0} - \varphi_B}{\varphi_{B0}} \quad (2)$$

When R_B is either below 5% or more than 95%, R_B is not expressed as number but it is stated that R_B is below 5% or more than 95%, respectively.

The amount of benzene removed by photocatalytic oxidation on the surface of the test piece (n_B) (mol/hour) in the last hour of the test is calculated using equation (3a):

$$n_B = 1 \times 10^{-6} R_B \frac{\phi_{B0} f \cdot 1.016 \cdot 60}{100 \cdot 22.4} \quad (3a)$$

f is the flow rate of the test gas at standard conditions (l/min, 25°C, 101,3 kPa, dry gas basis).

ϕ_{B0} is the volume fraction of benzene at the reactor input (ppm)

The molar amount of benzene removed by photocatalytic oxidation on the surface of the test piece ($n_{B(A)}$) in the last hour of the test related to photoactive area (mol/hour/m²) is calculated using equation (3b), where n_B is removed amount of benzene in the last hour of the test (mol/hour) and S is geometrical photoactive area (m²).

$$n_{B(A)} = \frac{n_B}{S} \quad (3b)$$

The mass of benzene removed by photocatalytic oxidation on the surface of the test piece in the last hour of the test related to photoactive area ($m_{B(A)}$) (mg/hour/m²) is calculated using equation (3c), where n_B is removed molar amount of benzene in the last hour of the test (mol/hour), S is photoactive area (m²) and M_B is molar mass of benzene (78,11 g/mol).

$$m_{B(A)} = 1 \times 10^3 \frac{n_B M_B}{S} \quad (3c)$$

3 Results and discussion

3.1 TiO₂ P25 (standard sample)

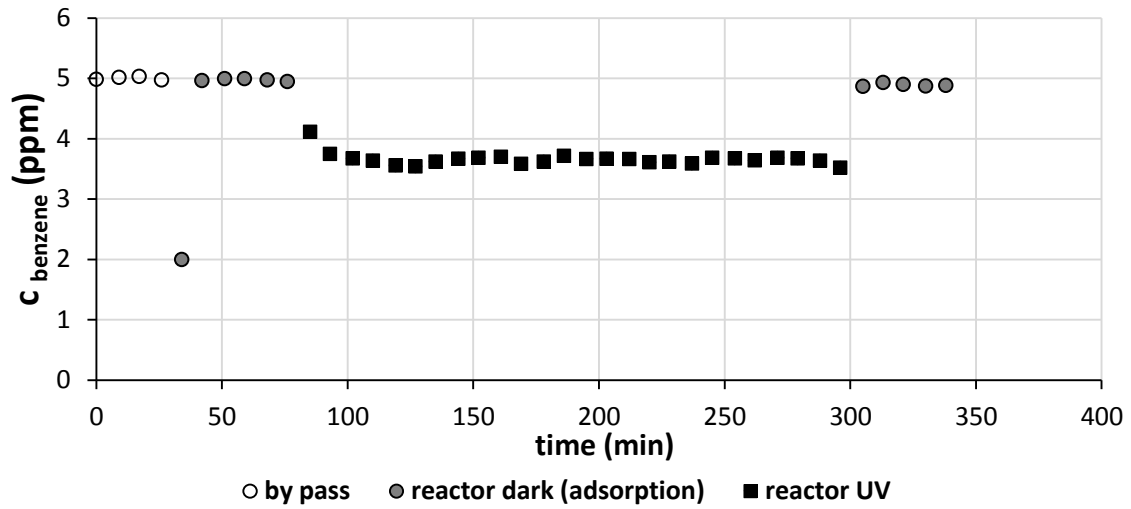


Fig. 4: Time dependence of benzene concentration during photocatalytic experiment – sample TiO₂ P25

Table 5: Results of the test (sample TiO₂ P25, 1mg TiO₂/cm²)

conversion of benzene (%)	27%
amount of removed benzene related to time and irradiated area (mol/hour/m ²)	7,45·10 ⁻⁴
amount of removed benzene related to time and irradiated area (mg /hour/m ²)	58

3.2 FN2

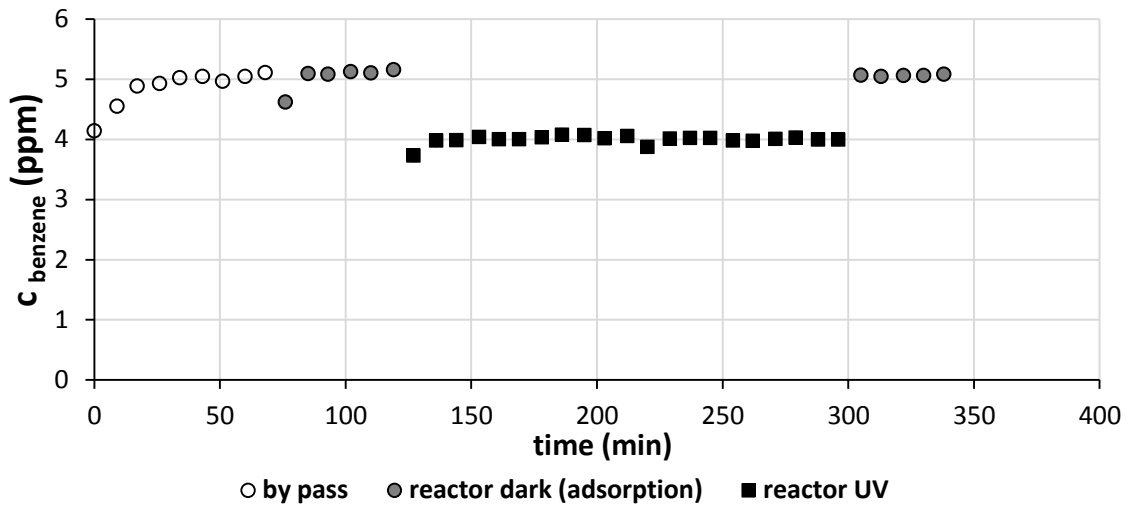


Fig. 6: Time dependence of benzene concentration during photocatalytic experiment – FN2

Table 7: Results of the test (sample FN2)

conversion of benzene (%)	21
amount of removed benzene related to time and irradiated area (mol/hour/m ²)	$5,66 \cdot 10^{-4}$
amount of removed benzene related to time and irradiated area (mg /hour/m ²)	44
conversion of benzene related to TiO ₂ P25 (%)	75

3.3 FN3

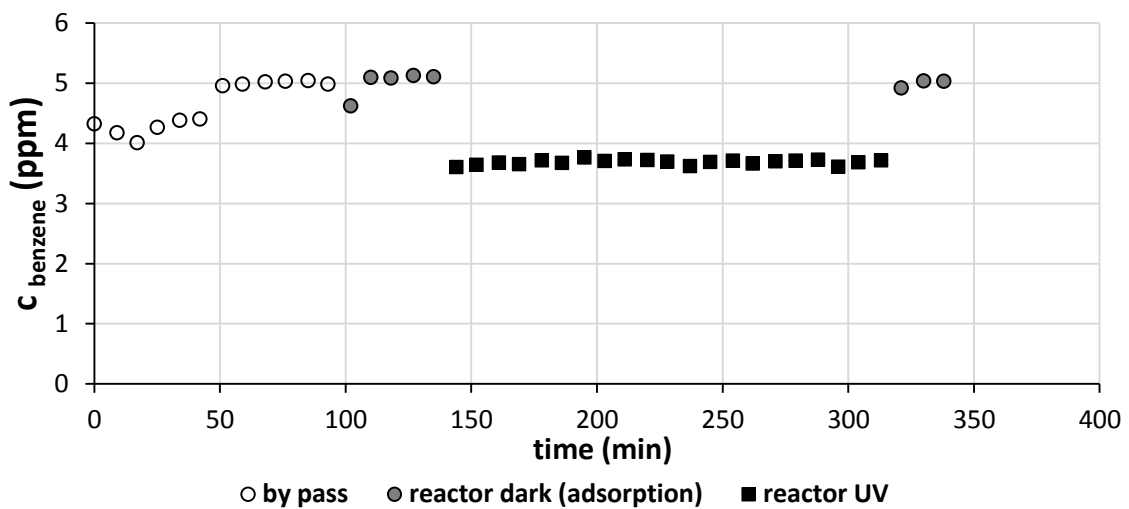


Fig.8: Time dependence of benzene concentration during photocatalytic experiment - sample FN3.

Table 9 Results of the test (sample FN3)

conversion of benzene %	27%
amount of removed benzene related to time and irradiated area (mol/hour/m ²)	$7,24 \cdot 10^{-4}$
amount of removed benzene related to time and irradiated area (mg /hour/m ²)	57
Conversion of benzene related to TiO ₂ P25 (%)	97

4 Conclusions

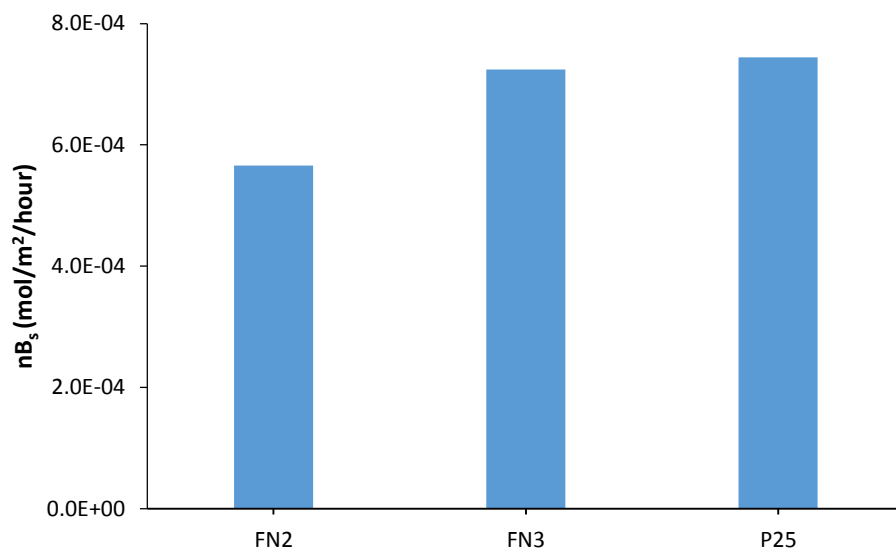


Fig. 10: Comparison of removed amount of benzene related to area and time

In Fig. 10, there is comparison of removed amount of benzene on studied samples. We can see that FN3 exhibit similar activity compared to P25. FN2 exhibit slightly lower photocatalytic activity which corresponds to 75% of TiO₂ P25 standard.