Report following the order dated 07.12.2016 placed by DEHTOCHEMA TN a.s., Prague, Czech Republic

Photocatalytic activity test of one bi tumen sampl e

One bitumen sample (Technonicol Enviro Air) has been tested concerning the photocatalytic degradation of NO in the gas phase under illumination of UV(A)-light. The sample has been pre-illuminated with 1 mW/cm^2 UV-A light for 6 days.

Degradation of NOx

The photocatalytic NO-Oxidation is measured with an apparatus in which synthetic air (relative humidity 50%) containing 1 ppm NO is flowing at a rate of 3 L/min across the surface of a sample with an illuminated surface area of 50 x 100 mm^2. The measurement is performed employing a NO/NO_2-Analyser equipped with a fluorescence detector that has a detection limit of 1 ppb NO. The illumination is performed with UV(A) light at an intensity of 1.0 mW/cm^2 measured at the surface of the samples.

D-TOX
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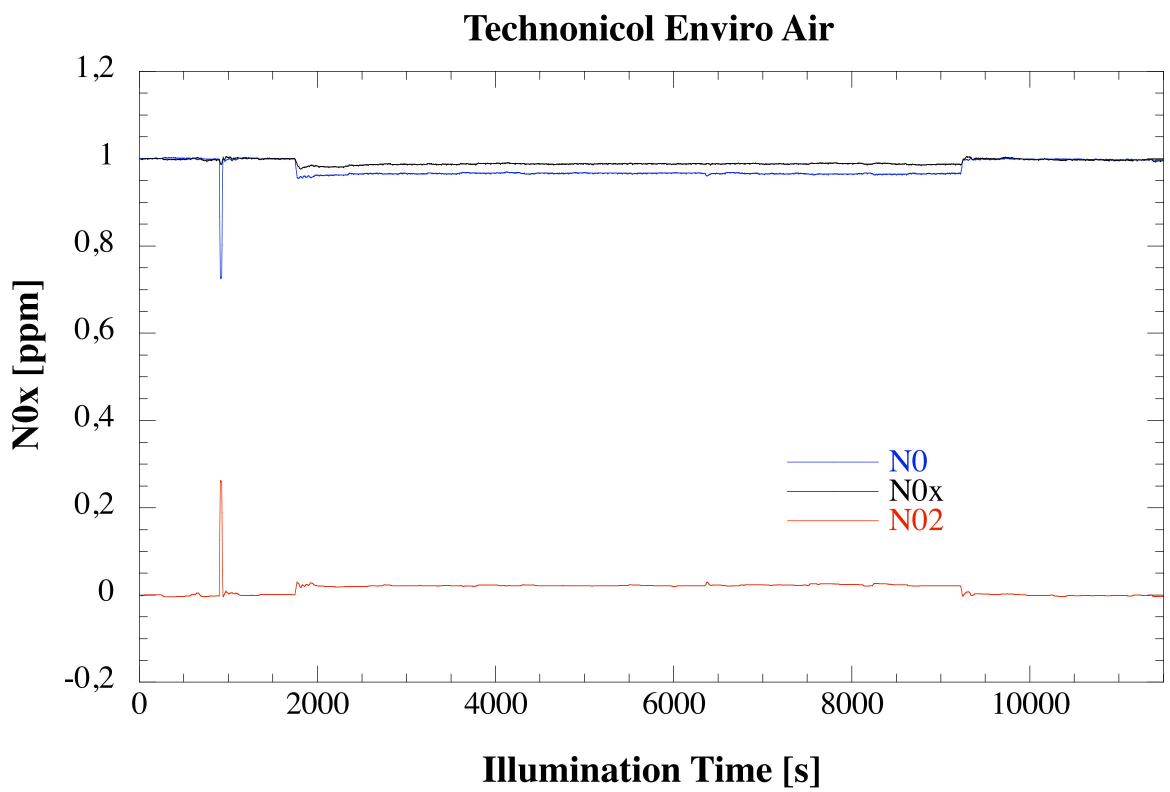
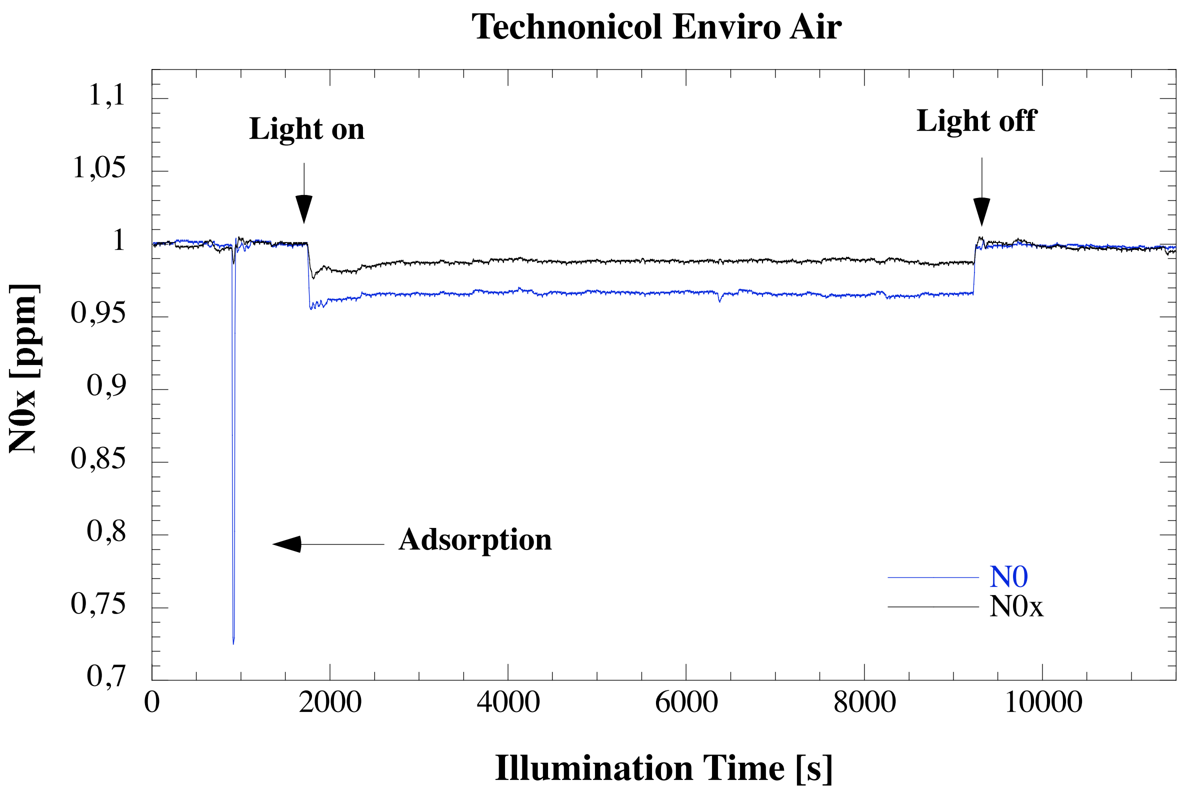
Results:


Technonicol Enviro Air
1,2
1
0,8
0,6
0,4
0,2
0
-0,2
N0x [ppm]
0
2000
4000
6000
8000
10000
Illumination Time [s]
N0
N0x
N02


Technonicol Enviro Air
Light on
Light off
Adsorption
1,1
1,05
1
0,95
0,9
0,85
0,8
0,75
0,7
N0x [ppm]
0
2000
4000
6000
8000
10000
Illumination Time [s]
N0
N0x

Data Analysis:

The employed UV(A) illumination intensity is 1 mW/cm^2, with an illuminated sample area of 50 cm^2 the total power is 50 mW. Taking an average illumination wavelength of 350 nm this can be converted to:

50 mW = 1.47×10^{-7} *molhν/ s*

The continuous test apparatus operates with a flow rate of 3 L/min. Assuming an ideal gas the following holds:

24 L Gas = 1 mol (at p = 1 bar and 25°)

i.e., it takes 8 min for 1 mol gas to pass the sample. The gas flow contains 1 ppm NO, hence 10^{-6} mol NO flow across the sample within 8 min. During the same time the sample is illuminated with

1.47×10^{-7} *molhν / s x 60 s/min x 8 min =* 70×10^{-6} *molhν .*

If total oxidation (loss) of the 1 ppm NO is observed, the Photonic Efficiency ζ will be:

$\zeta = 10^{-6}$ *mol NO /* 70×10^{-6} *molhν = 0.0143 = 1.43 %*

For a measured degraded amount of x ppm NO the Photonic Effiency can consequently be calculated with the following formula:

ζ_x = x (ppm) * 1.43 (% / ppm)

Results:

Technonicol Enviro Air:

NO-Degradation: 0.046 ppm (initial)
Photonic Efficiency ζ = **0.066%**
NO-Formation: 0.0343 ppm (final)
Photonic Efficiency ζ = **0.05**%
NOx-Degradation: 0.024 ppm (initial)
Photonic Efficiency ζ = 0.034%
NOx-Formation: 0.01 ppm (final)
Photonic Efficiency ζ = 0.014%
NO_2-Formation: 0.022ppm (initial)
Photonic Efficiency ζ = 0.031%
NO_2-Formation: 0.0243 ppm (final)
Photonic Efficiency ζ = 0.035%

The test conditions employed here are identical to those suggested by the ISO 22197-1 standard, i.e., 1ppm NO, 3L/min air flow, 50% Relative Humidity (RH), 1 mW/cm^2 UV(A) illumination. According to the mathematical data treatment described in ISO 22197-1 the data obtained here can be used to calculate the amount of removed NO in μmol as follows:

$n_{NO} = 3L\ min^{-1} / 22.4\ L\ mol^{-1}\ x\ (C_{NO,in} - C_{NO,out})\ x\ 300\ min$

*For "**Technonicol Enviro Air**"* $C_{NO,in} - C_{NO,out} = 0.0343$ *ppm, i.e., 0.0343* $\mu L/L$
$n_{NO} = (3/22.4)\ x\ 0.0343\ x\ 300\ \mu mol$
$n_{NO} = 1.38\ \mu mol$ *(in 5 hours illumination time)*

In analogy, the amount of NO_x degraded is calculated via
$n_{NOx} = 3L\ min^{-1} / 22.4\ L\ mol^{-1}\ x\ (C_{NOx,in} - C_{NOx,out})\ x\ 300\ min$

*For "**Technonicol Enviro Air**"* $C_{NOx,in} - C_{NOx,out} = 0.01$ *ppm, i.e., 0.01* $\mu L/L$
$n_{NOx} = (3/22.4)\ x\ 0.01\ x\ 300\ \mu mol$
$n_{NOx} = 0.40\ \mu mol$ *(in 5 hours illumination time)*

Finally, the amount of formed NO_2 is calculated via
$n_{NO2} = 3L\ min^{-1} / 22.4\ L\ mol^{-1}\ x\ (C_{NO2,in} - C_{NO2,out})\ x\ 300\ min$

*For "**Technonicol Enviro Air**"* $C_{NO2,in} - C_{NO2,out} = 0.0243$ *ppm, i.e., 0.0243* $\mu L/L$
$n_{NO2} = (3/22.4)\ x\ 0.0243\ x\ 300\ \mu mol$
$n_{NO} = 0.98\ \mu mol$ *(in 5 hours illumination time)*

These results can be directly compared with the test data shown in Annex A of ISO 22197-1.

Alternatively, the following calculation is often used:
The molecular weight of NO is *30 g mol*$^{-1}$, the illumination surface area is *0.005m*^{2}.
The degradation of 1μmol is equal to *30* μ*g* or *6 mg/m*^{2}.

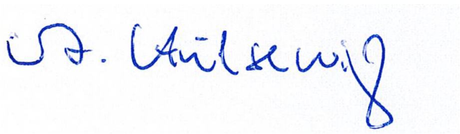
The sample "***Technonicol Enviro Air***" degrades *1.38* μ*mol* in 5h, i.e., 0.28 μmol/h or ***1.68 mg NO/m***^{2}***h***.

A value more than 5.0 mg NO/m^{2}h can be regarded as a very good degradation efficiency. The German Photocatalysis Association has recently defined a threshold value of 0.6 mg NO/m^{2}h to discriminate between photocatalytically inactive and active samples.

Data Interpretation

With an efficiency of ζ = 0.05% (NO-Degradation, final value) the sample "***Technonicol Enviro Air***" tested here exhibits a satisfying activity for the photocatalytic degradation of NO in the gas phase (Our Ranking Scale is as follows: sufficient: 0.01%< ζ < 0.05%, satisfying: 0.05%< ζ < 0.1%, good: 0.1%< ζ < 0.2%, very good: 0.2%< ζ < 0.5%, excellent: ζ > 0.5%).

Hannover, 15.12.2016



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