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# Photocatalytic tests with devices from F. Peterka

## Results with 4 VOCs according to the standard XP B44-013

## (16/12/2013)

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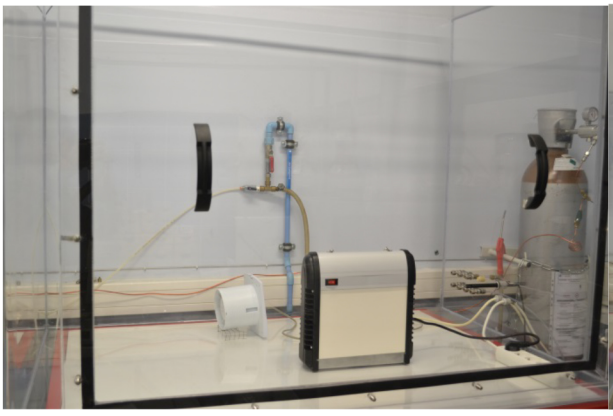
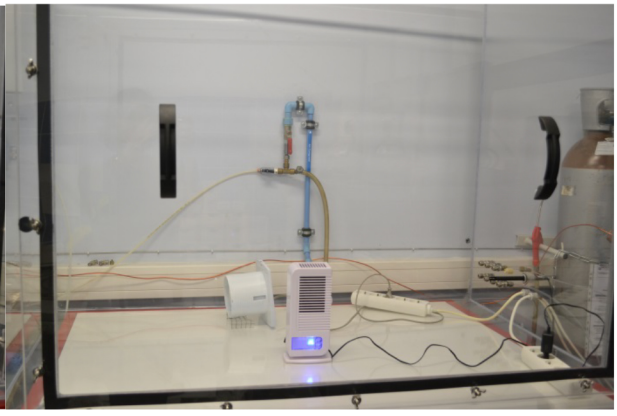
# TABLE OF CONTENTS

# 1. Protocol

- Flushing of the closed chamber with humid air without $CO_2$ and dry air successively all the night, until about 50±5 % relative humidity (HR) at 22°C is reached, with device ON.
- Control test with system ON without added VOCs to follow $CO_2$ and VOCs possibly released by the device.
- Test with VOCs: Injection of the 4 VOCs mixture at about 1 ppmv for each compound in the chamber
- Monitoring of VOCs, $CO_2$, RH and T during all the test



**Picture 1 : Device 1 (prototype)**



**Picture 2 : Commercial device 2**

# 2. Results for device 1 (prototype)

## 2.1 Releasing test without added VOCs, with device ON

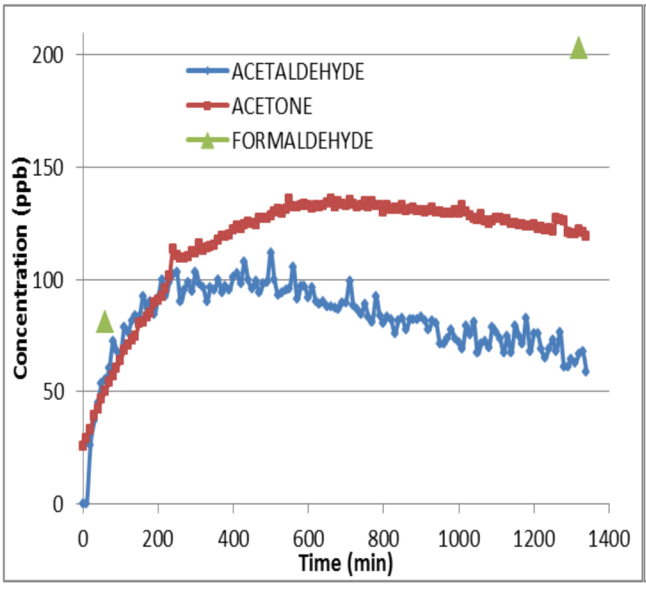



**Fig. 1: Monitoring of VOCs**

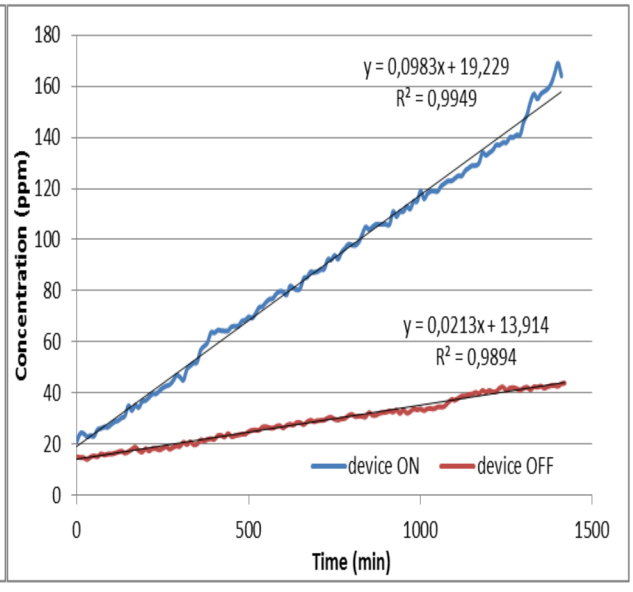



**Fig. 2: Monitoring of $CO_2$, with GC-methanizer-FID**

Without added VOCs in the closed chamber, formaldehyde (DNPH/HPLC-UV analysis) acetaldehyde and acetone (GC-PID analysis) production was noticed (Fig.1). Moreover, a significant $CO_2$ increase was monitored with the device ON. The low $CO_2$ increase with device OFF was due to $CO_2$ inlet (leaks) from outside air inside the chamber (fig. 2).
Temperature and relative humidity were relatively stable during the test (fig. 3)

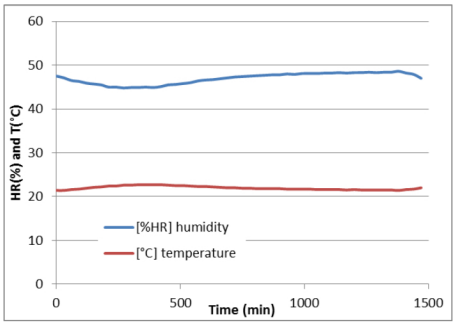



**Fig. 3 : Relative humidity and temperature during blank test-device ON**

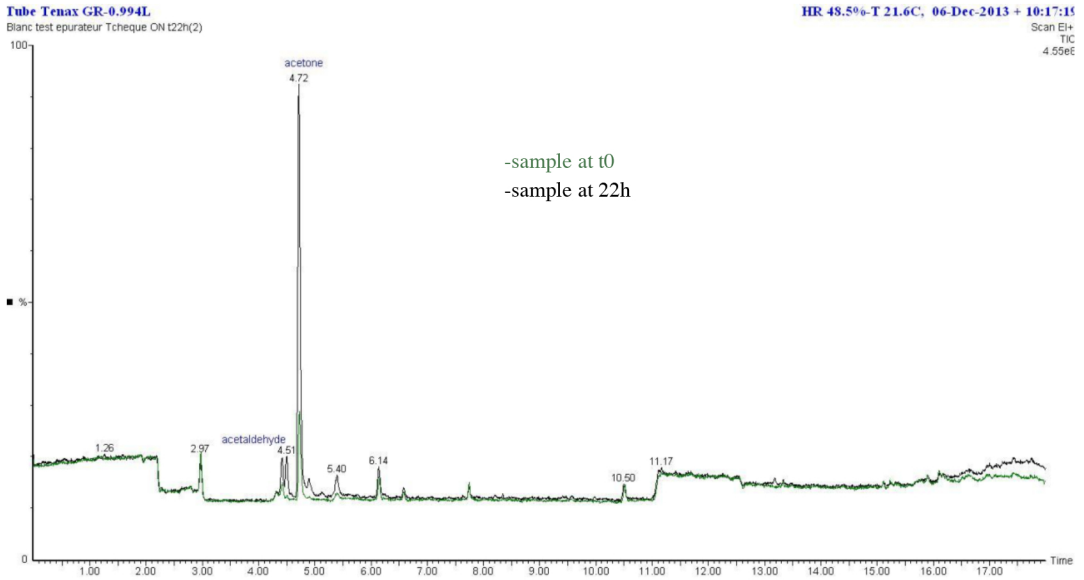



**Fig. 4: Monitoring of VOCs with ATD-GC-MS**

Figure 4 shows that acetone was the major compound produced in the air chamber after 22 hours, with the device ON, without VOCs added in the chamber. It should be noted that formaldehyde is not detectable by this method.

## 2.2 Test with VOCs, with device ON

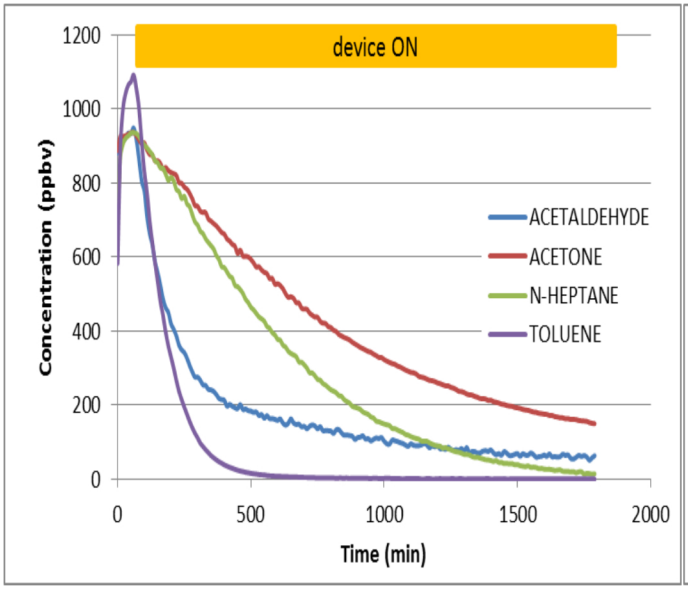



**Fig. 5: Monitoring of VOCs with GC-PID**

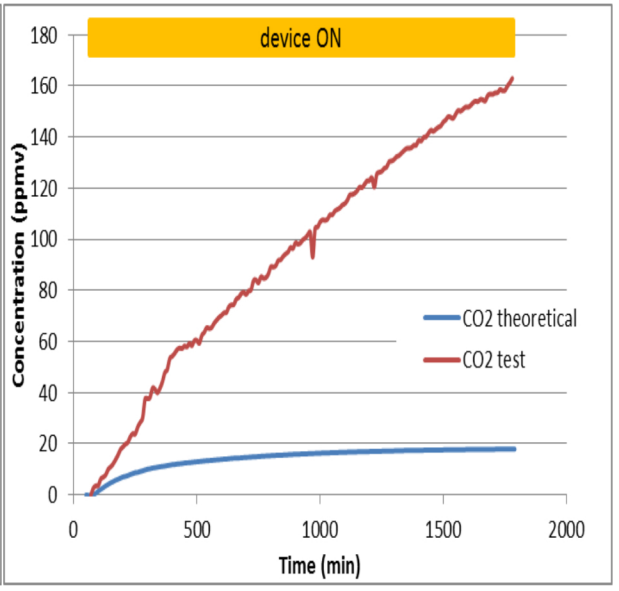



**Fig. 6: Monitoring of $CO_2$, with GC-methanizer-FID**

The test with 4 VOCs showed an almost complete decrease of heptane and toluene concentrations. However, residual concentrations of acetaldehyde and acetone remained after about 24h (Fig. 5). The variation of the concentrations of each VOC is indicated in table 1.
As for the control test without VOCs, an important $CO_2$ increase was monitored. This increase was more than 9 times higher than the theoretical $CO_2$ expected from VOCs mineralization (blue curve in Fig. 6). This result indicated a considerable $CO_2$ production by the device itself.

| Compound | Acetaldehyde | Acetone | n-heptane | Toluene |
|---|---|---|---|---|
| Concentration decrease in 24h | 93 % | 80 % | 96 % | > 99 % |

**Table 1 : Variation of the concentration of each VOC during the test.**

A by-product control during this test showed the production of new transient compounds. An analysis of a sample made during photocatalytic test (after 3 hours) indicated a **formaldehyde concentration of 467 ppbv**. Other low levels of by-products were detected by ATD-GC-MS during the photocatalytic test (annex 1).

Moreover, temperature and relative humidity were stable during the test (Fig. 7).

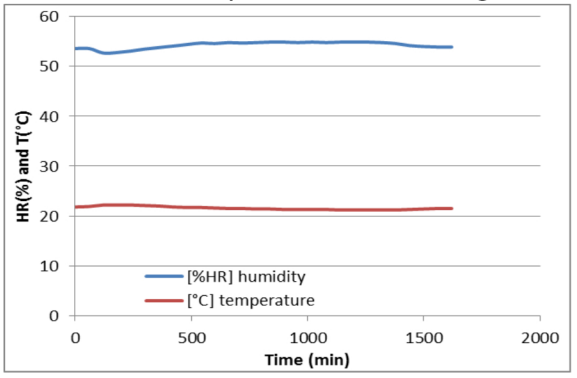



**Fig. 7: Relative humidity and temperature during test with VOCs**

## 3. Results for commercial device 2

### 3.1 Releasing test without added VOCs, with device ON

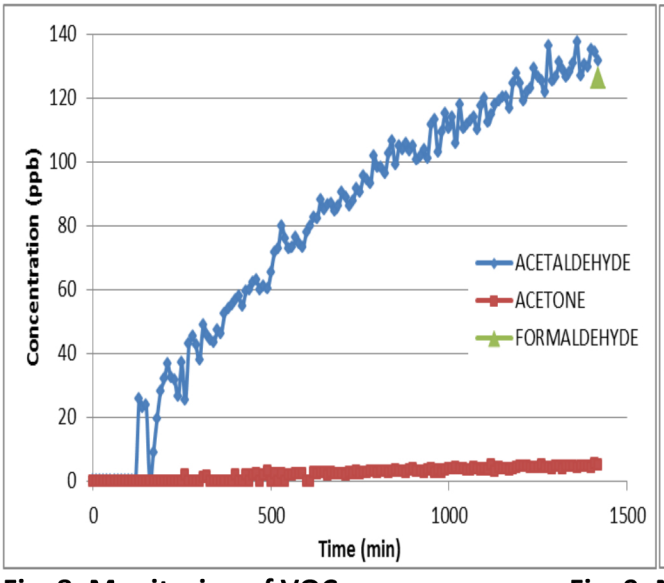



**Fig. 8: Monitoring of VOCs**

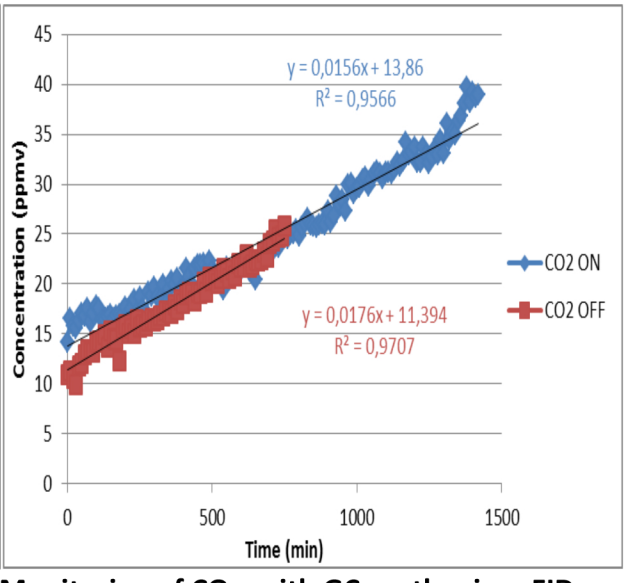



**Fig. 9: Monitoring of $CO_2$, with GC-methanizer-FID**

Without added VOCs in the closed chamber, formaldehyde (DNPH/HPLC-UV analysis) acetaldehyde and acetone (GC-PID analysis) production was noticed (Fig. 8). Moreover, no significant $CO_2$ production was monitored with the device ON. The low $CO_2$ increase obtained with device OFF was due to $CO_2$ inlet (leaks) from outside air inside the chamber (fig. 9) and was similar to that obtained with device ON.
Temperature and relative humidity were relatively stable during test (fig. 10)

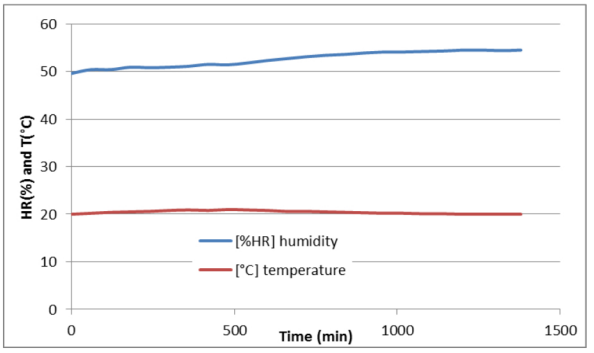



**Fig. 10 : Relative humidity and temperature during blank test-device ON**

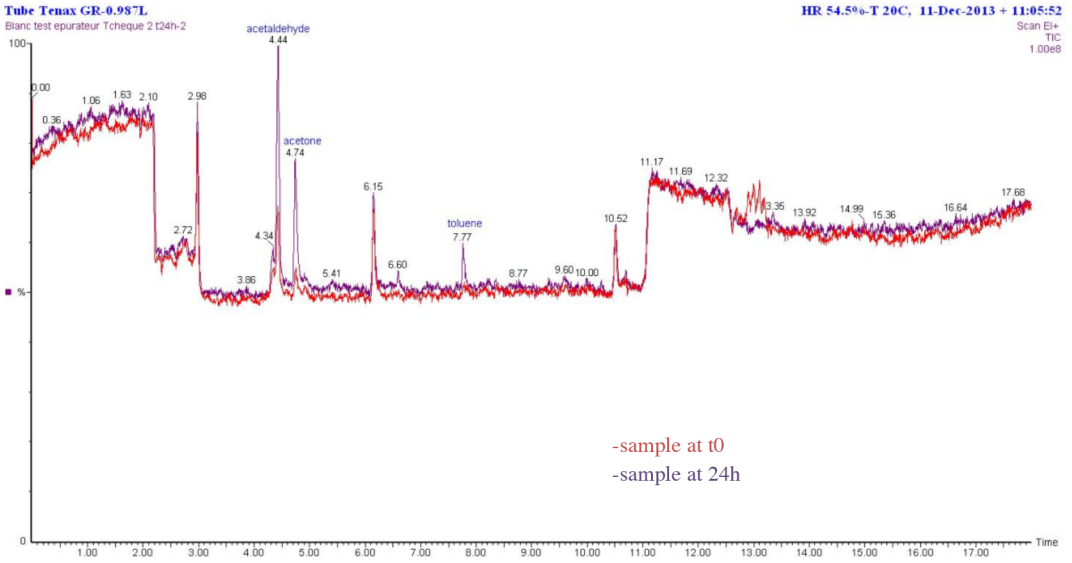



**Fig. 11: Monitoring of VOCs with ATD-GC-MS**

Figure 11 shows that acetaldehyde and acetone were the major compounds produced in the air chamber after 24 hours, with the device ON, without added VOCs . The pics at t=6.15 min and 10.52 min were detected with the same intensity for sample at $t_0$ and sample at $t_{24h}$ (maybe attributed to siloxane ?).

### 3.2 Test with VOCs, with device ON

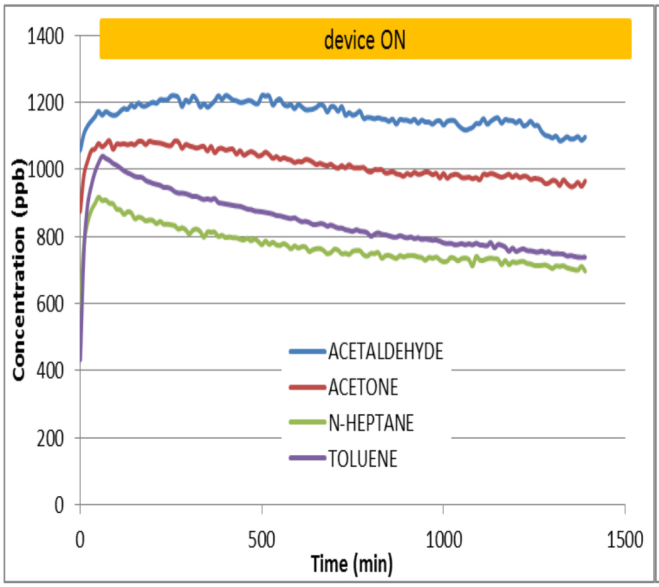



**Fig. 12: Monitoring of VOCs with GC-PID**

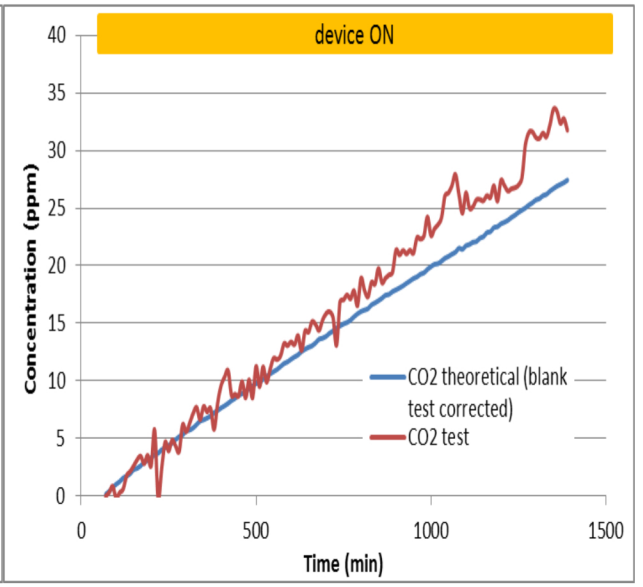



**Fig. 13: Monitoring of $CO_2$, with GC-methanizer-FID**

The test with 4 VOCs showed a very low decrease of the 4 VOCs concentrations after 24 hours (Fig. 12). The variation of the concentration of each compound is indicated in table 2.
A comparison of $CO_2$ variation during the test with calculated $CO_2$ (taking into account VOCs mineralization and $CO_2$ increase monitored from blank test –Fig. 9) shows a quite good agreement (Fig. 13).

| Compound | Acetaldehyde | Acetone | n-heptane | Toluene |
|---|---|---|---|---|
| Concentration decrease in 24h | 9 % | 13 % | 23 % | 30 % |

**Table 2 : Variation of the concentration of each VOC during the test.**

A by-product control during this test showed the production of new transient compounds (such as formaldehyde): an analysis of a sample made during the photocatalytic test (after 3 hours) indicated a **formaldehyde concentration of 184 ppbv.** Few levels of paraldehyde were also detected by ATD-GC-MS (annex 2).

Moreover, temperature and relative humidity were stable during the test (Fig. 14).

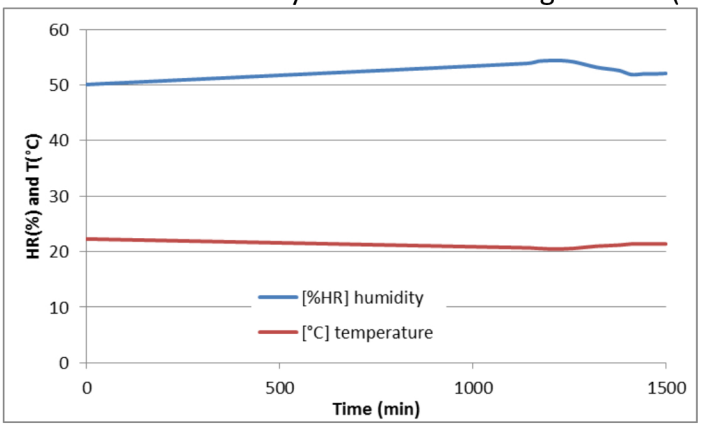



**Fig. 14: Relative humidity and temperature during test with VOCs**

## 4. Conclusion

These experiments indicated that:

- the device 1 released VOCs (formaldehyde, acetaldehyde, acetone), as well as a lot of $CO_2$ in the absence of any pollutant. This device allowed an almost complete decrease of heptane and toluene concentrations, but an incomplete elimination of acetaldehyde and acetone. Formaldehyde was detected in significant amounts.
- the device 2 released VOCs (mostly formaldehyde, acetaldehyde, but also acetone) in the absence of any pollutant. This device was not efficient to reduce significantly the concentrations of the 4 VOCs (acetaldehyde, acetone, n-heptane and toluene). New unidentified by-products were also detected by concentration on sampling cartridges. Formaldehyde was not checked during the test with the four VOCs but was also probably present, as in the previous control without added VOCs (confirmed by the detection of paraldehyde by ATD-GC-MS).

# Annex 1: Results with device 1 for the test with 4 VOCs,

**ATD-GC-MS RESULTS**

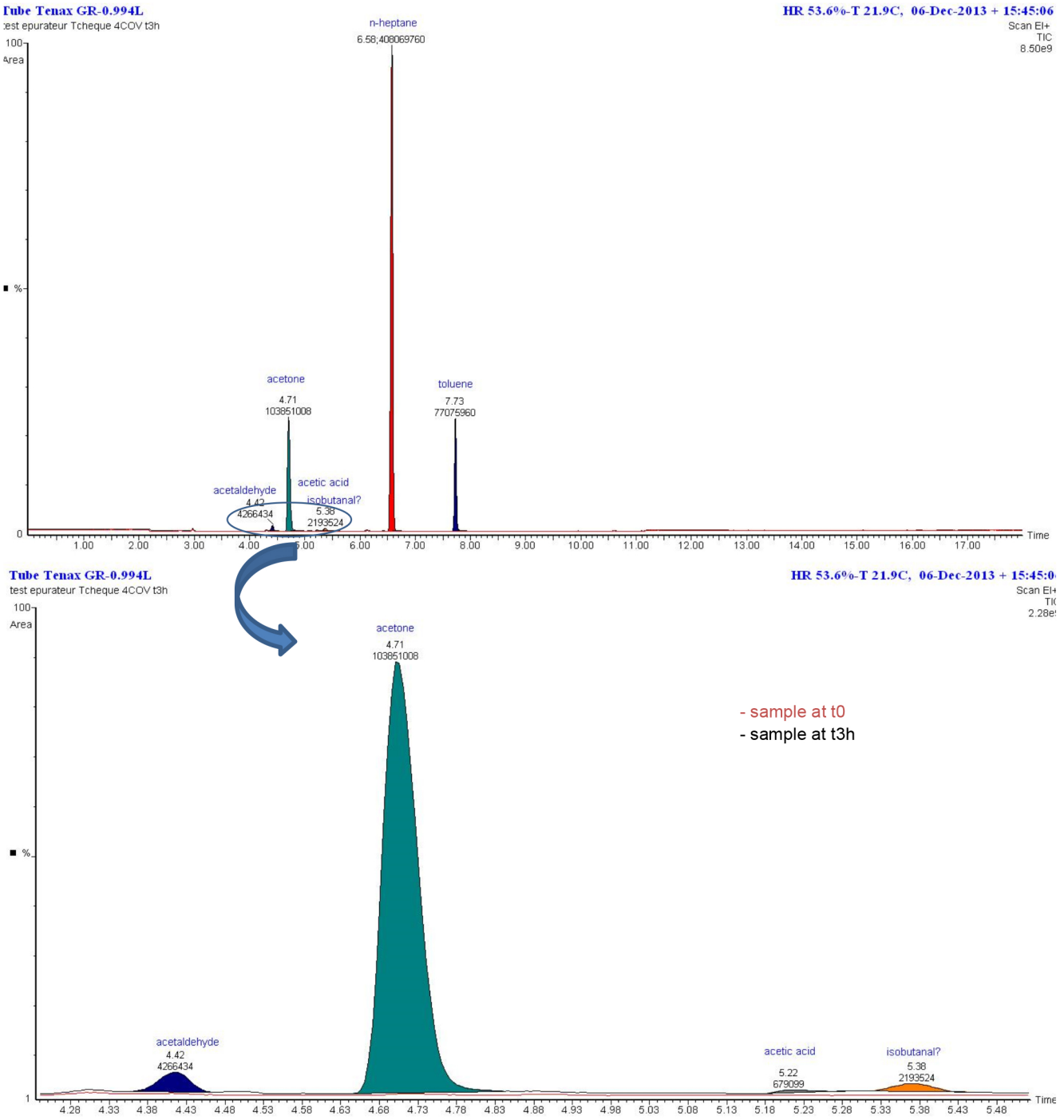



**Fig. 1A**: Top-analysis at $t_{3h}$ after switching on the device (sample volume 0.984L)
Bottom-zoom of selected area

The 4 initial VOCs were mostly detected in the chamber after 3h. Furthermore low levels of new compounds were detected: acetic acid and isobutanal.

# Annex 2: Results for the test, with 4 VOCs, with device 2

**ATD-GC-MS RESULTS**

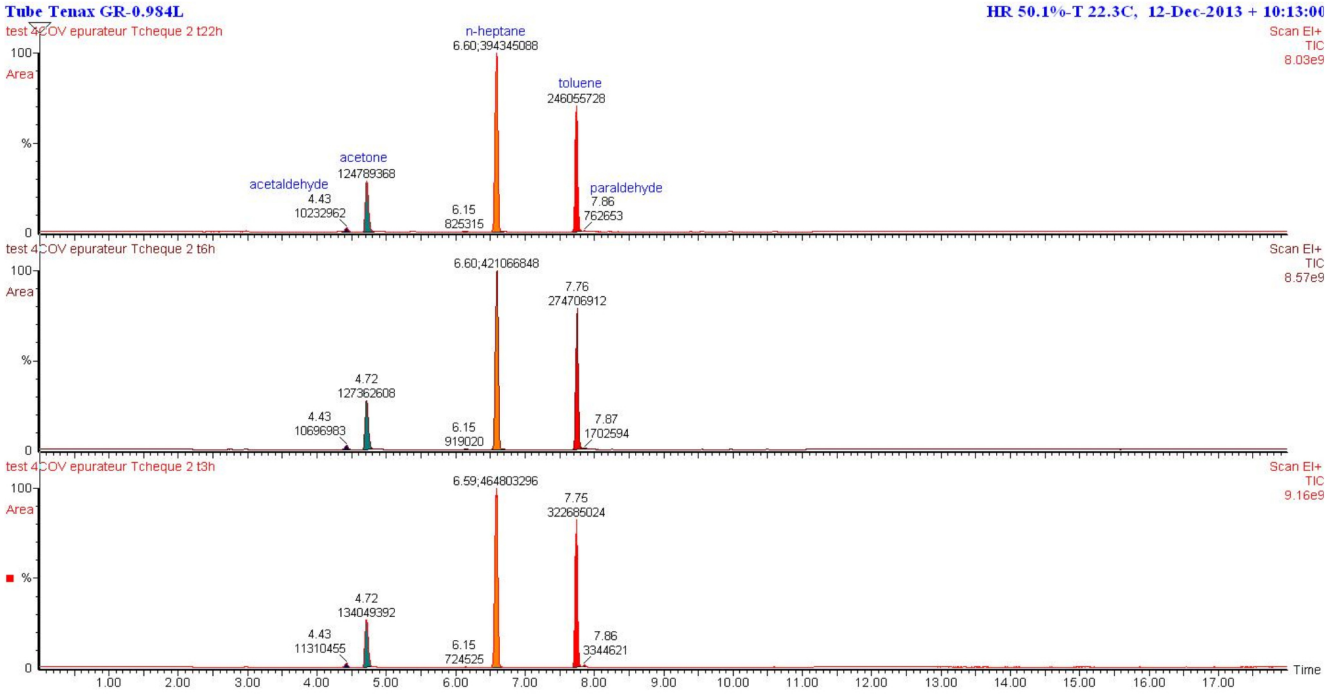



**Fig. 2A**: Top-analysis at $t_{22h}$ after switching on the device (sample volume 0.984L)
Middle-analysis at $t_{6h}$ after switching on the device (sample volume 0.984L)
Bottom-analysis at t3h after switching on the device (sample volume 0.981L)

The 4 initial VOCs were mostly detected in the chamber after 3, 6 and 22 hours. Furthermore few levels of a new compound were detected: paraldehyde (t=7.86 min) was identified.