QUANTIFICATION OF VOC EMISSON IN THE LOW ppb-RANGE

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Abstract

Car interiors consist of different components made of various materials, such as plastics, glue, lubricants or paint, exhibiting the potential for outgassing of volatile organic compounds (VOCs), which can be harmful to human health. Several studies depicted the appearence of VOCs in new cars, which is commonly known as "new car smell". Typical harmful compounds found in new car interiors are: acetaldehyde, acrolein, benzene, toluene, ethylbenzene, o-, m-, p-xylene and styrene, e.g. With its GC-IMS device G.A.S. makes a novel approach for detection and quantification of VOC outgassings by using the combination of automated analyte enrichment & desorption, gas chromatography (GC) and ion mobility spectrometry (IMS) combining excellent selectivity with extraordinary sensitivity within one measuring device. The developed system detects and quantifies all the afore-mentioned VOCs down to a concentration level of 5 ppb and lower, whereas the cycle time is ~15 minutes only.

Objective

- Simultanous quantification of gaseous emissions of acetaldehyde, acrolein, benzene, toluene, ethylbenzene, o-, m-, p-xylene and styrene in the low ppb-range
- Automated sampling system of ambient air, interior of cars, sampling chambers, e.g.
- Short cycle time
- Easy in use

Set-Up & Workflow
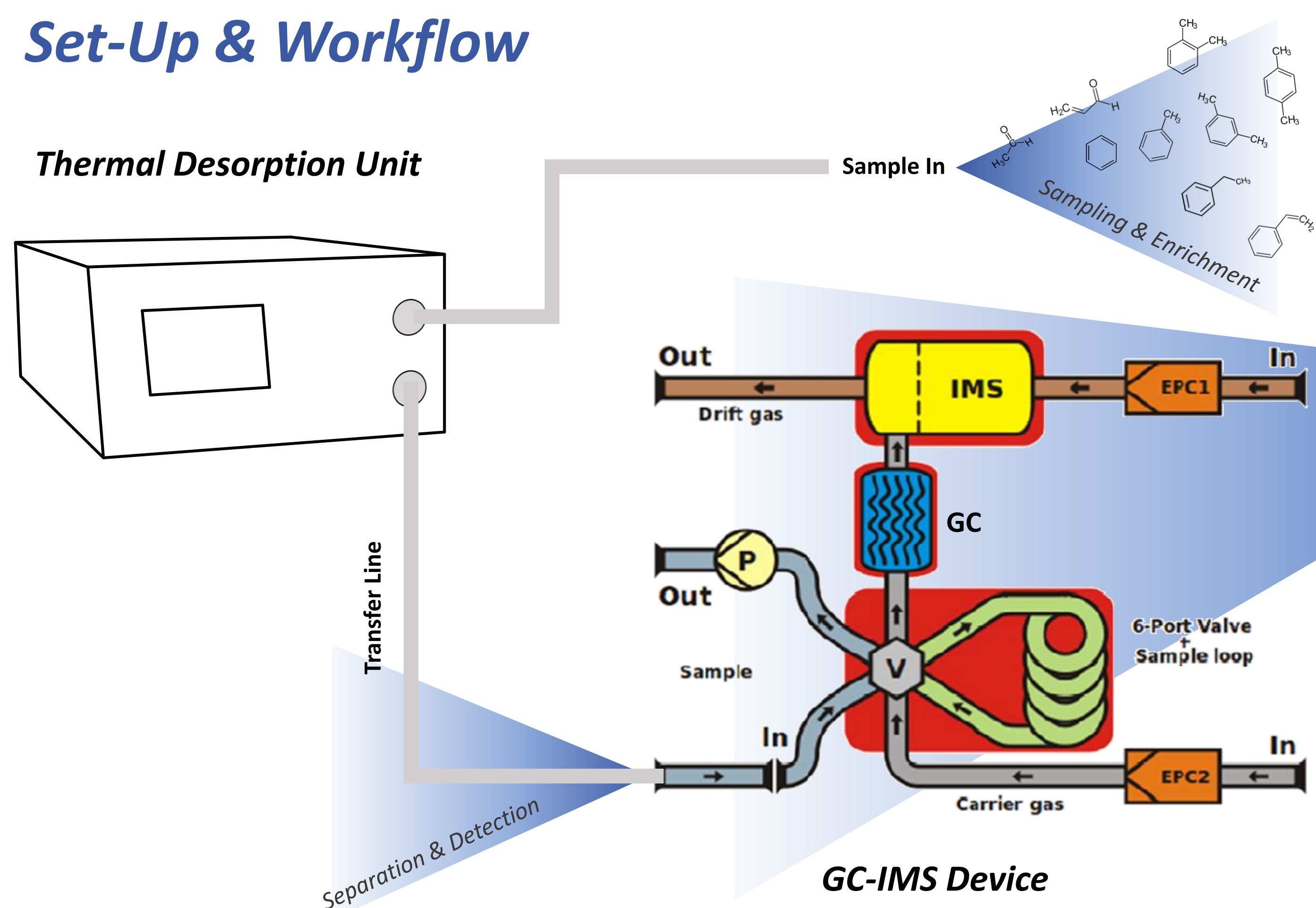
Combination of thermal desorption and GC-IMS technology (TD-GC-IMS).

In a first step (*Sampling & Enrichment*) the gaseous sample is sucked into the thermal desorption unit for several minutes. During this phase the introduced compounds are focussed onto an adsorption tube at relatively low temperatures (slightly above ambient temperature). Afterwards the temperature of the adsorption tube is increased (>200 °C) in order to desorb the afore adsorbed compounds within a small volume. Then the pre-concentrated sample is directly injected into the GC-IMS device (*Separation & Detection*). While the sample is analyzed by the GC-IMS the thermal desorption unit is cleaned/cooled down and afterwards ready for a next cycle.
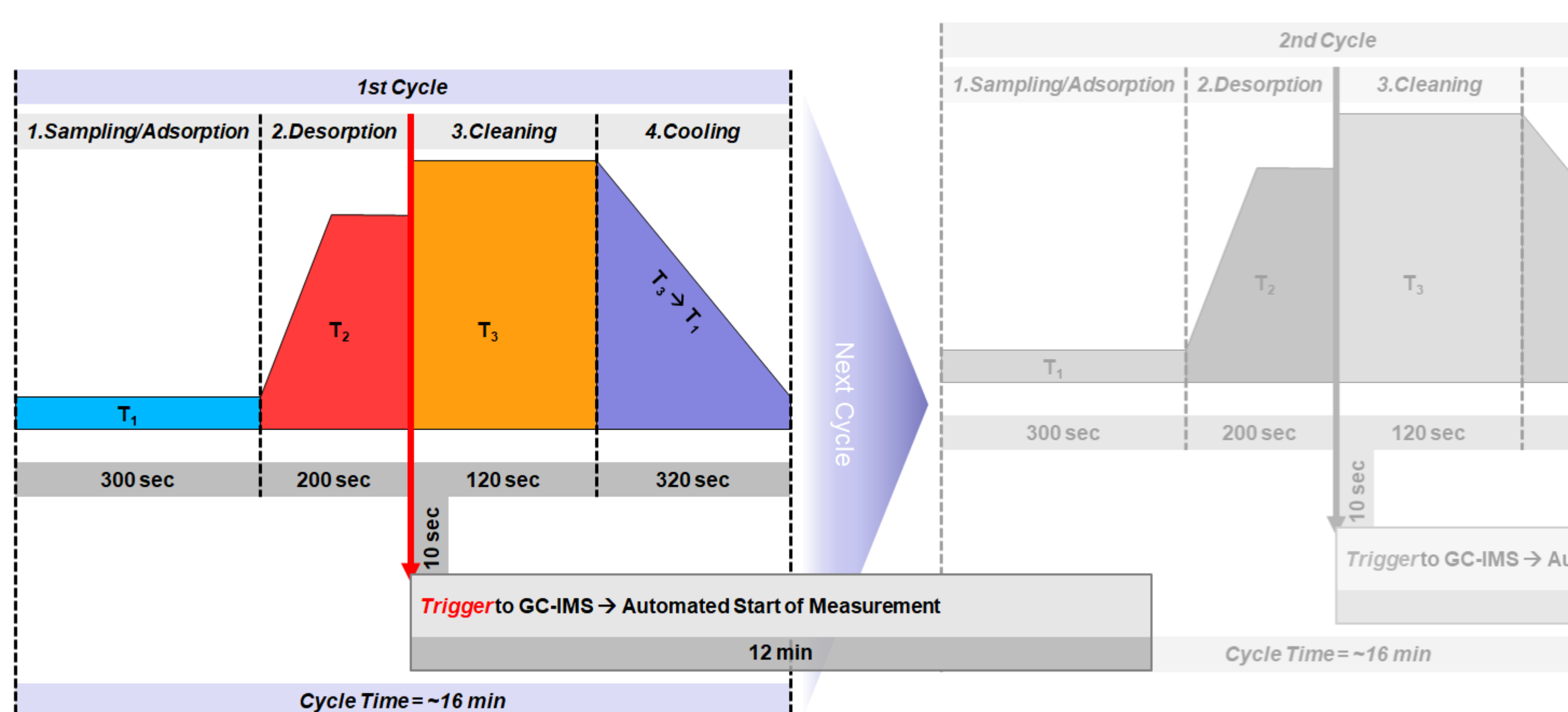

Workflow of the combination of the thermodesorber and GC-IMS. After the pre-concentration step the sample gets injected into the GC-IMS device, where the compounds are separated by gas chromatography in a first step. Afterwards the second separation is based on IMS technology.

After separation by gas chromatography and ion mobility spectrometery the compounds are measured (*Data Collection*). Based on implemented calibration curves and ranges for each substance incoming data are evaluated and the substances are quantified (*Automated Data Evaluation*). Calculated results are depicted on the devices display after each measurement. If requested, the results can be sent to a process control system (PCS) via Modbus-TCP 2 protocol (*Results Output*). Export of the data to USB-Stick or automated transfer to a PC is also possible.
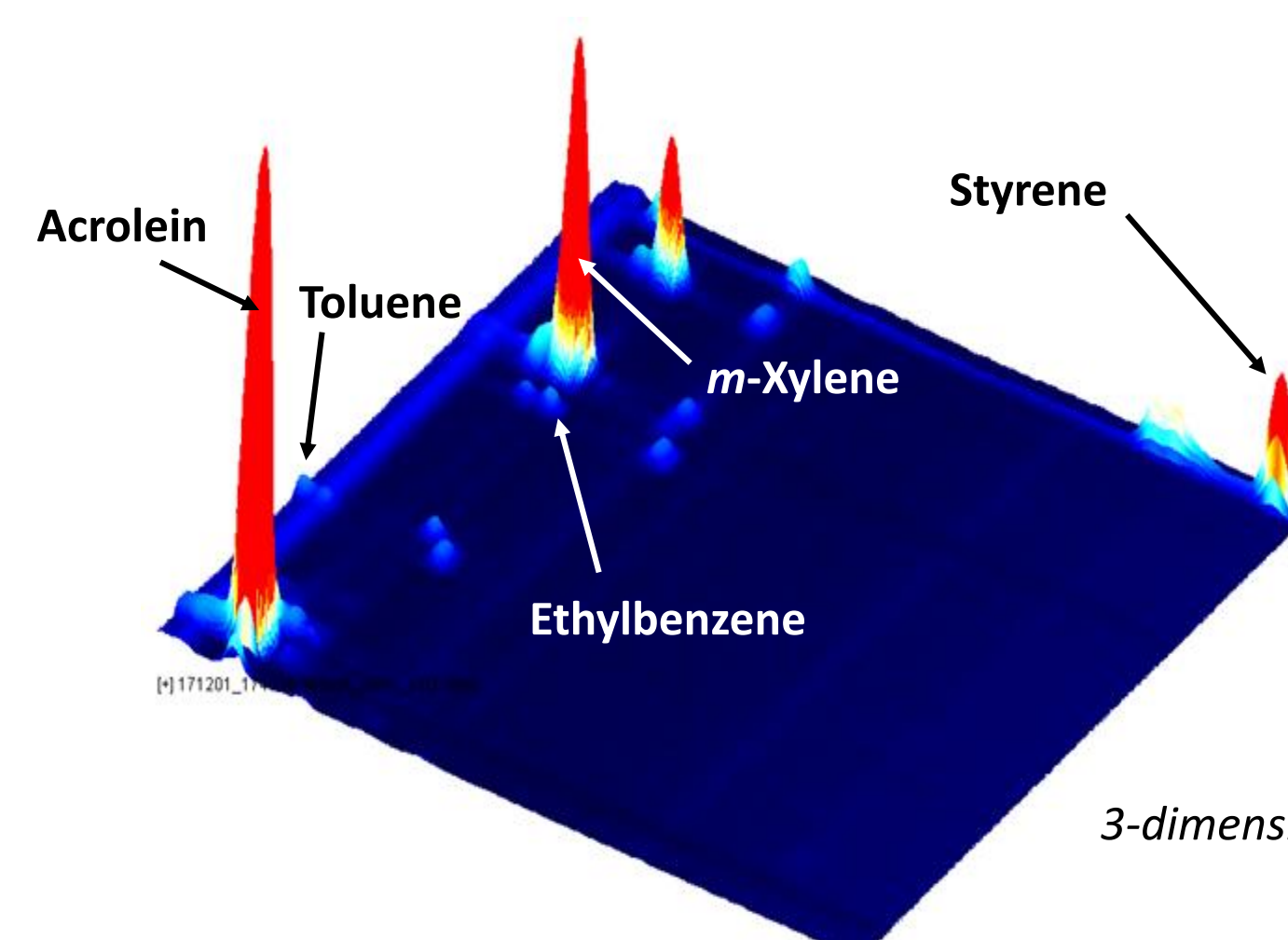
Results

A measurement system for simultanous quantification of acetaldehyde, acrolein, benzene, toluene, ethylbenzene, o-, m-, p-xylene and styrene in the low ppb-range was evaluated. All substances were detectable down to a concentration of 5 ppb, whereat systems sensitivity is higher in case of certain substances (acrolein, acetaldehyde, e.g. → ppt-level).
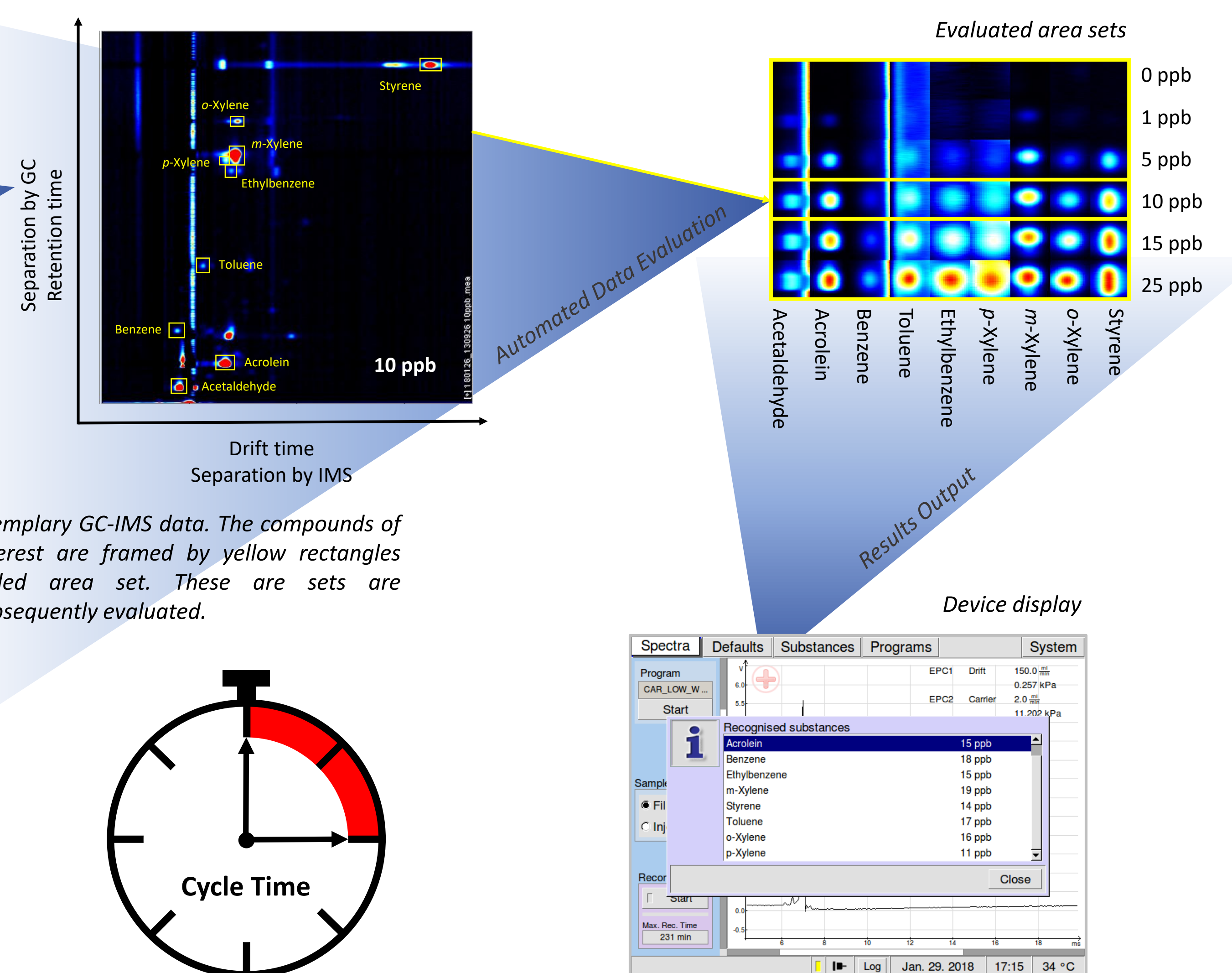
Exemplary GC-IMS data. The compounds of interest are framed by yellow rectangles called area set. These are sets are subsequently evaluated.
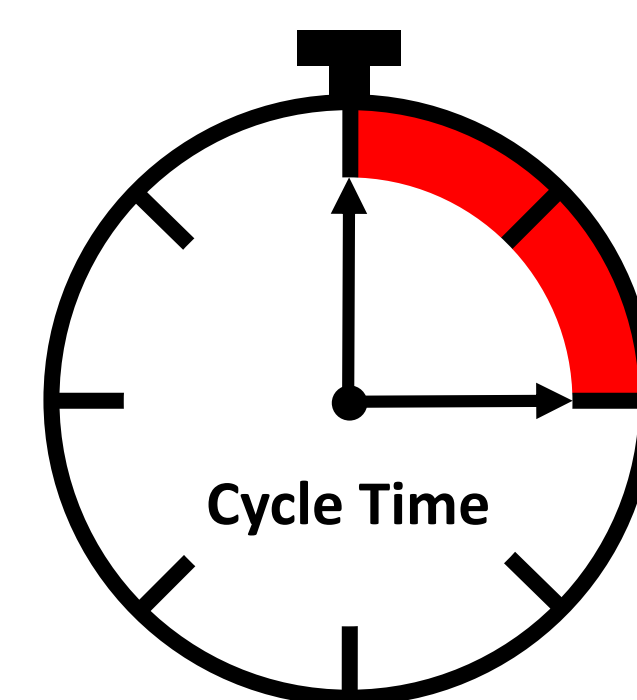
All mentioned substances are detected and quantified within a cycle time of ~15 minutes. The calibrated concentration range was 1 to 200 ppb in this application development. The standard deviation of the evaluated signals intensity is about ~2 % for all compounds down to a concentration of 5 ppb.

Exemplary statistics of toluene signal (n=10).

Signal of 20 ppb Toluene	Intensity/V	Integral/V*s
Mean Average	3.86E-01	1.77E+00
Standard Deviation	8.01E-03	3.82E-02
Standard Deviation/%	2.07	2.16

3-dimensional representation of GC-IMS data.

Conclusion

- Based on thermal desorption and GC-IMS technology a stable and reproducible measurement system for the detection and quantification of the desired compounds in concentrations down to 5 ppb was evaluated and optimized.
- Due to the comprehensive 2-dimensional separation technique a simultaneous detection and quantification of the mentioned compounds is possible within a short cycle time, even in complex matrices.
- The cycle time for detection/quantification using the TD-GC-IMS device is ~15min (incl. all needed steps: pre-concentration → GC separation → IMS separation/detection → cleaning step of the GC-IMS).
- Different calibration ranges can be realized (LOD ~5ppb).

Perspective

- Real-life measurements at-site (car interior, e.g.)
- Coupling of the measuring system to sample chambers/tedlar bags
- Comparison with standard technologies