SUITABILITY OF COMMERCIAL VOC SENSORS FOR AIR QUALITY MONITORING FOR EC REGULATORY PURPOSES

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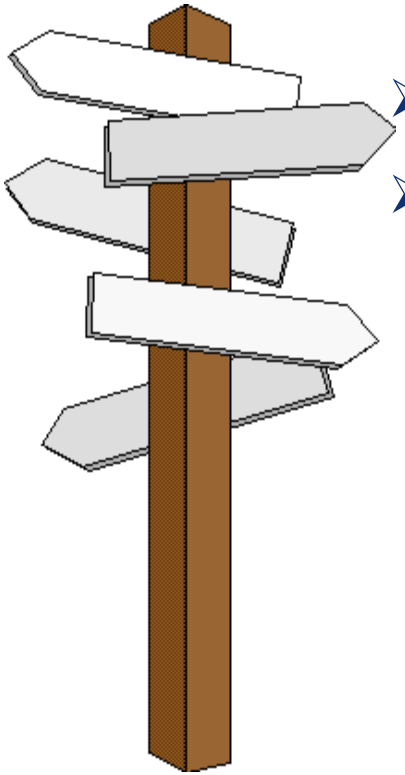
COST Action TD1105 - New Sensing Technologies for Air-Pollution Control and Environmental Sustainability -
Fourth Scientific Meeting, organized by Linkoping University, Linkoping, 3-5 June 2015



- **The reference/indicative benzene measurements**
- **The Euramet Key-VOC project**
- **Sensitivity of commercial sensors for benzene measurements**
  - **PID (OEM + hand held instruments)**
  - **MOs (OEM)**
  - **Amperometric sensors (OEM)**
  - **Portable GC**
  - **e-Nose**
  - **Prototypes**
- **Selection of benzene sensors for tests**

Fixed/indicative measurements: definition

'fixed measurements' measurements taken at fixed sites, to determine the levels in accordance with the relevant Data Quality Objectives (DQO);

'indicative measurements' measurements which meet DQOs that are less strict than those required for fixed measurements;

European DIRECTIVE 2008/50/EC on ambient air quality and cleaner air for Europe, art. 2

AQD: Data Quality Objectives (DQO)

	Benzene
Uncertainty for **fixed measurements**	25 %
Uncertainty for **indicative measurements**	**30 %**

KEY-VOCs

EMRP
European Metrology Research Programme
Programme of EURAMET
The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

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KEY-VOCs Objectives

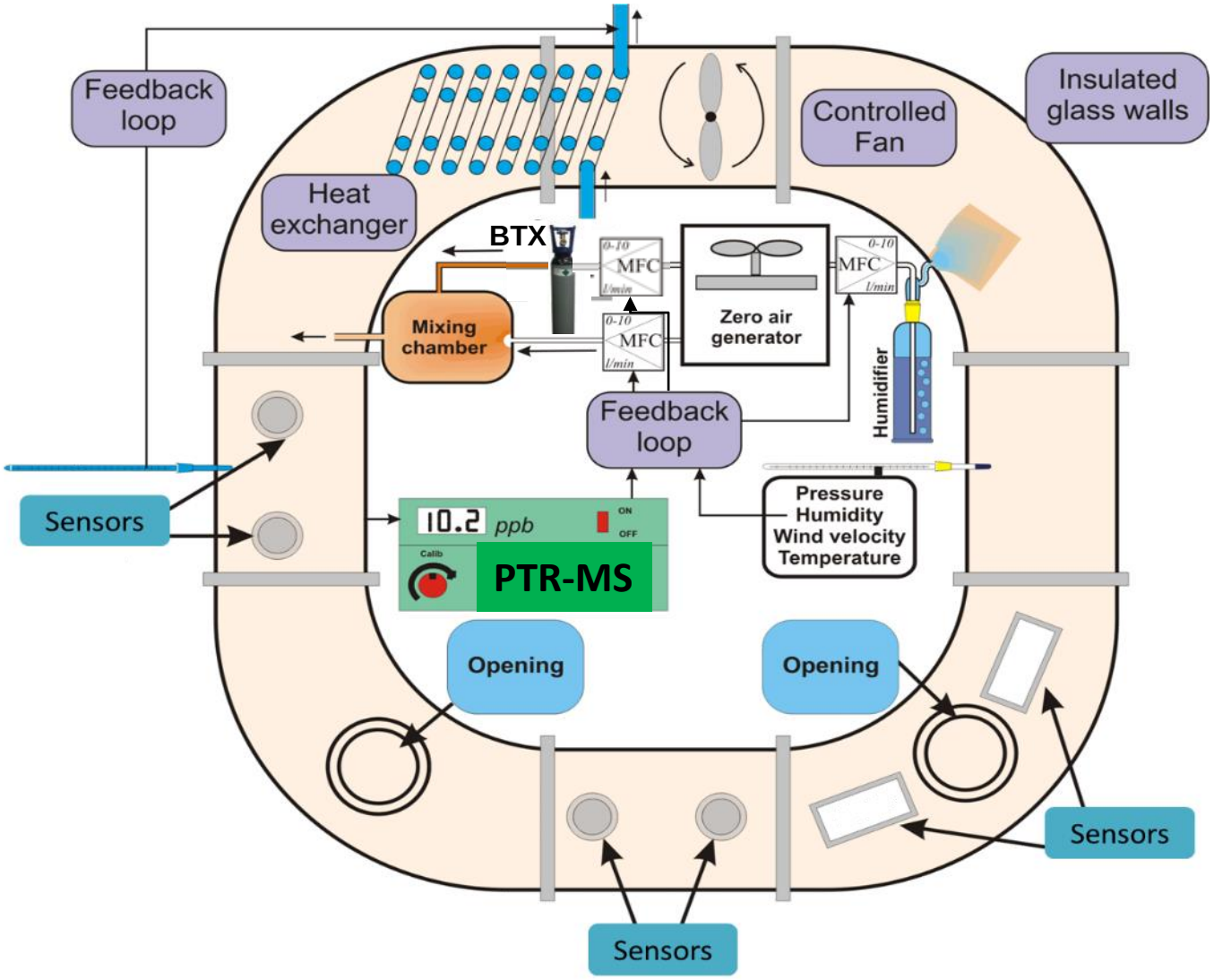
1- providing traceable and comparable VOC reference gas standards

2- validating new measurement systems (sensors-based) for benzene

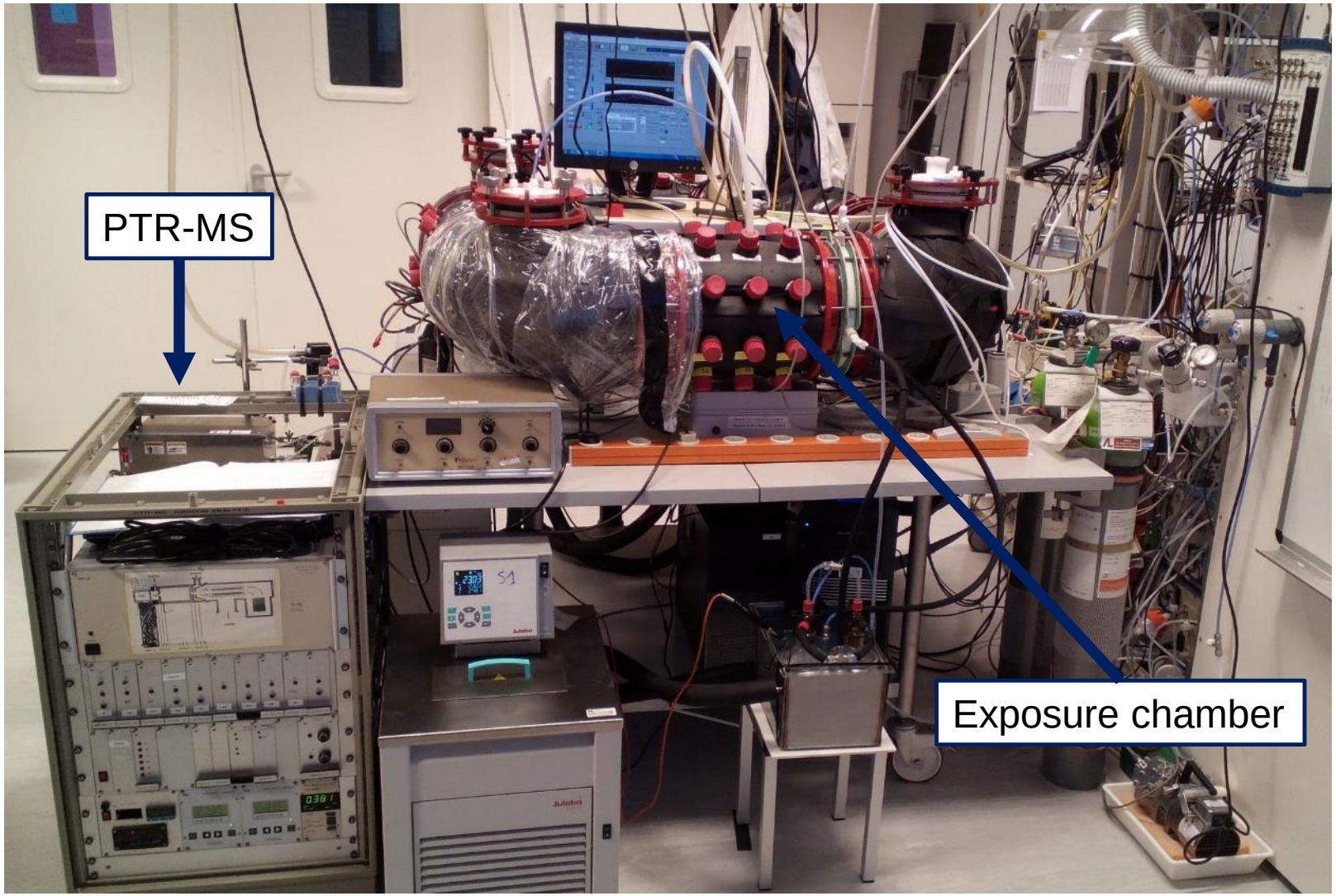
WP4: Validation of low–cost VOC Measurement sensors

- **<u>state of the art</u>** for low-cost sensors for benzene
  - the most sensitive (ppb) and selective sensors (MOx, PID, e-nose, micro GC …)
- to run an extended programme of **<u>laboratory and field validation</u>**
- compare the **<u>performances of selected models</u>** of sensor responses

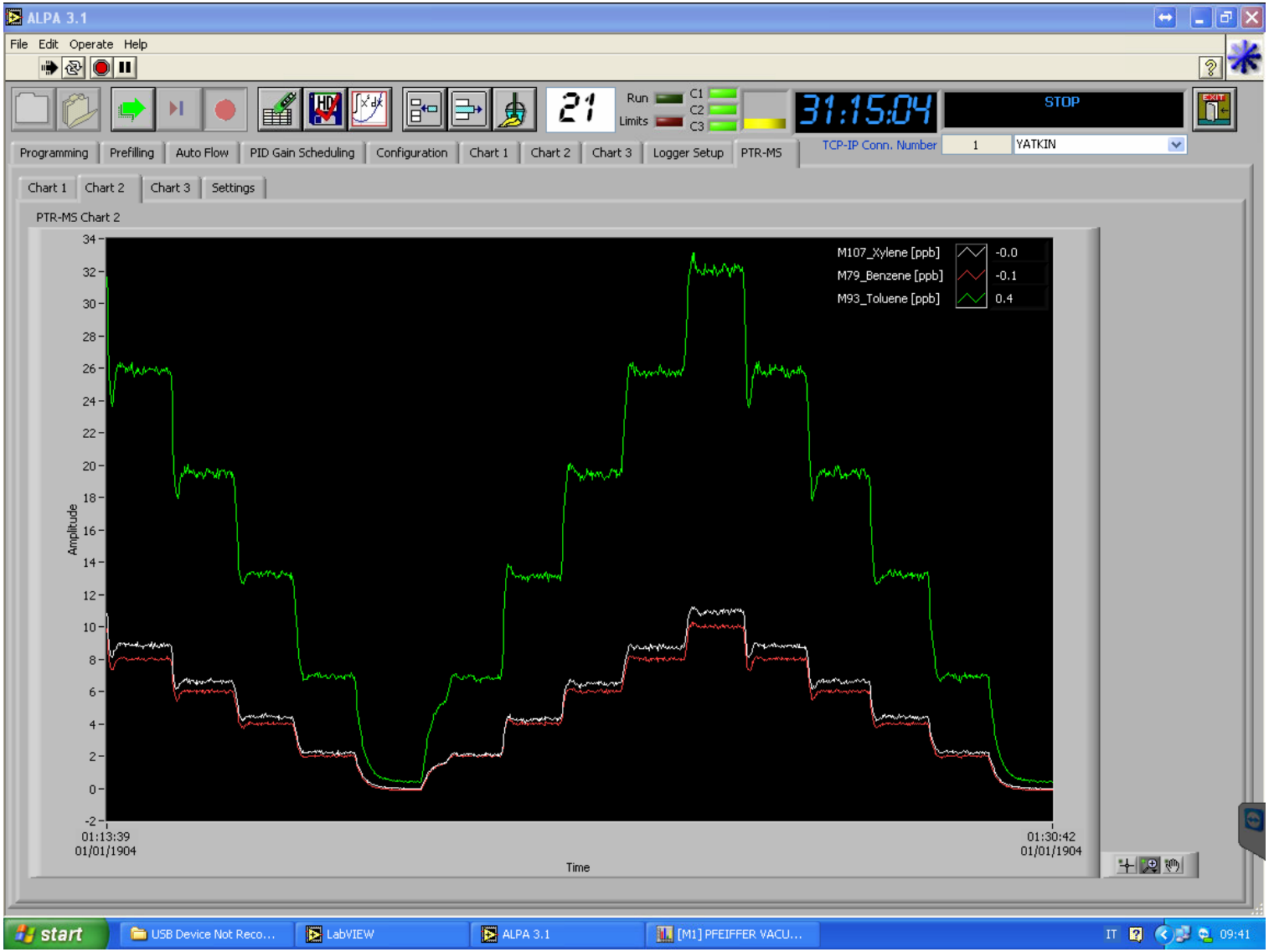
WP4: Flow chart of the exposure chamber with BTX control system based on PTR-MS



WP4: Integration of a PTR-MS in the exposure chamber

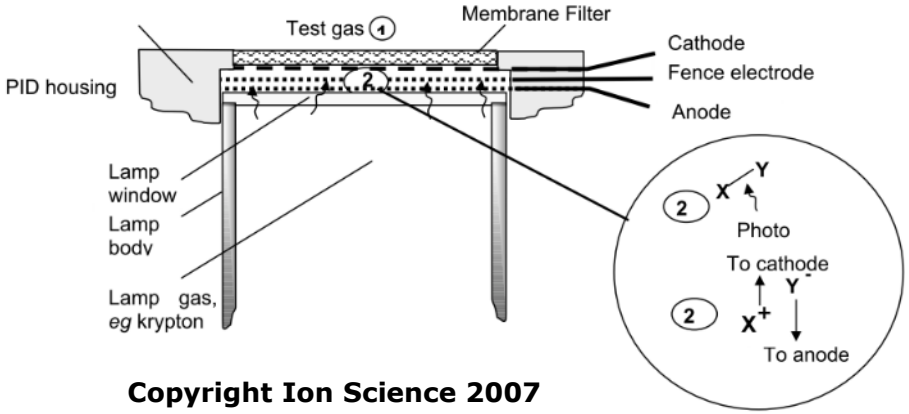


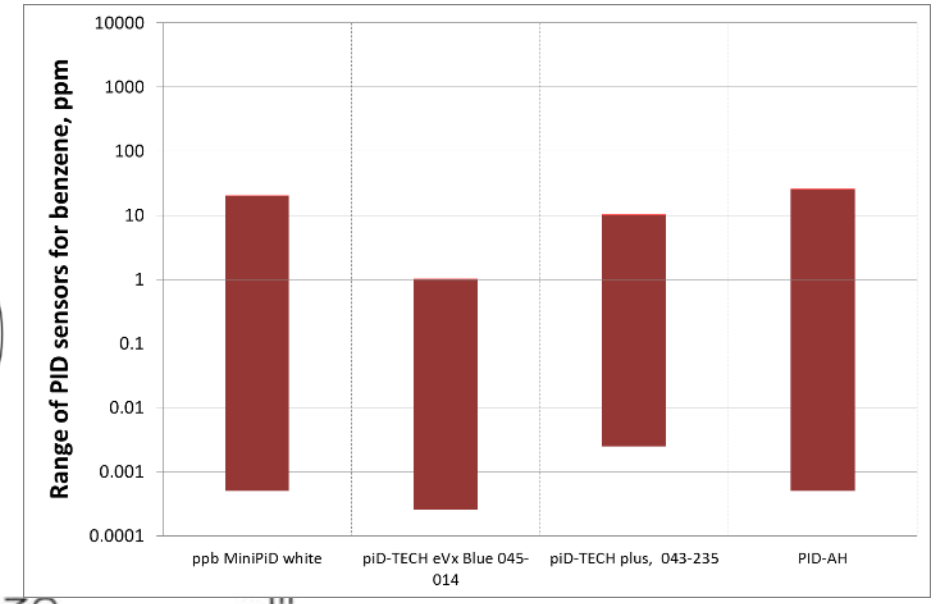
WP4: Example of automatic control of BTX in the exposure chamber using PTR-MS

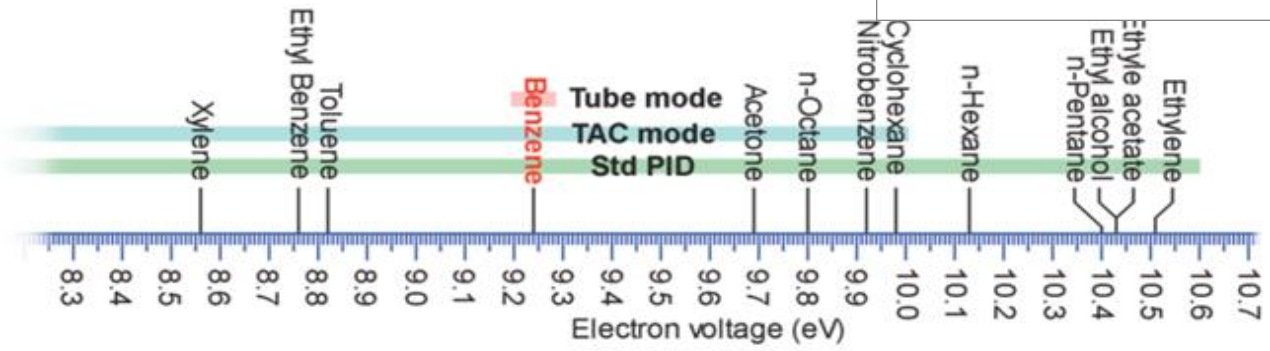


Selection of suitable commercial sensors

Photo-Ionisation Detectors (OEM)

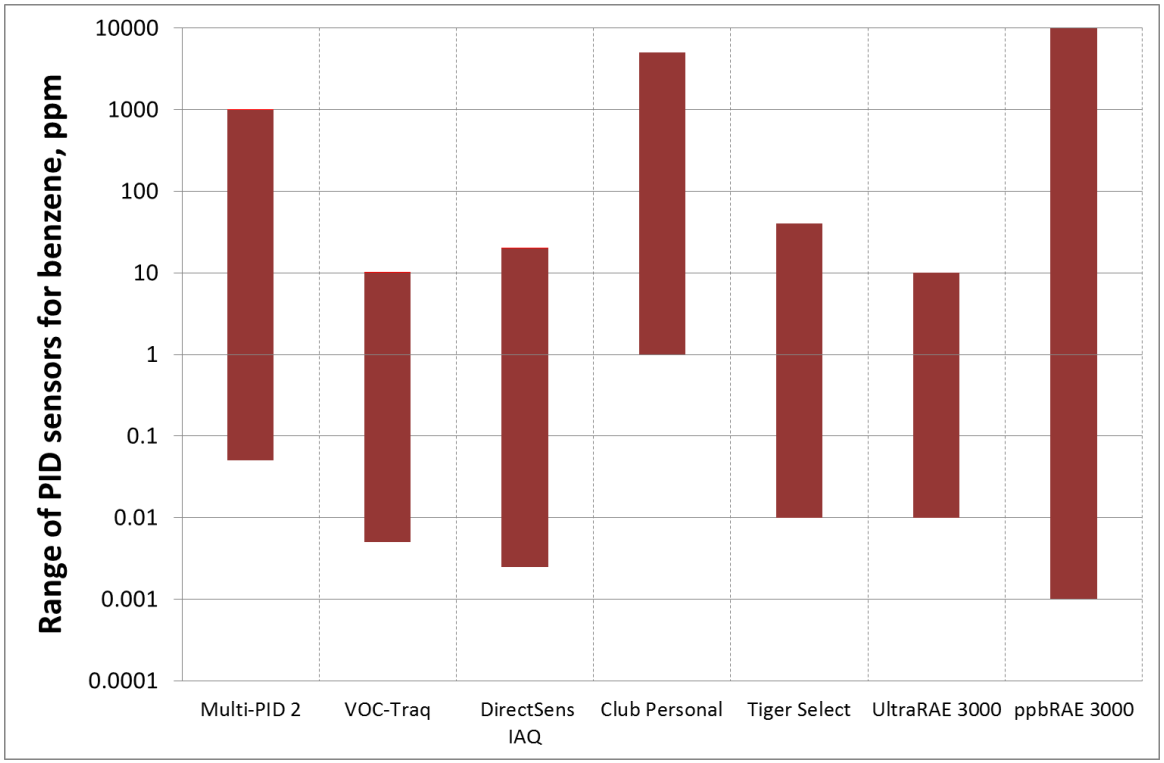






Sens Sel Sta Cost

Portable PID sensors



An extremely sensitive toxic gas detector designed for monitoring many toxic gases in real time or for logging long term event data. Picture is almost actual size.

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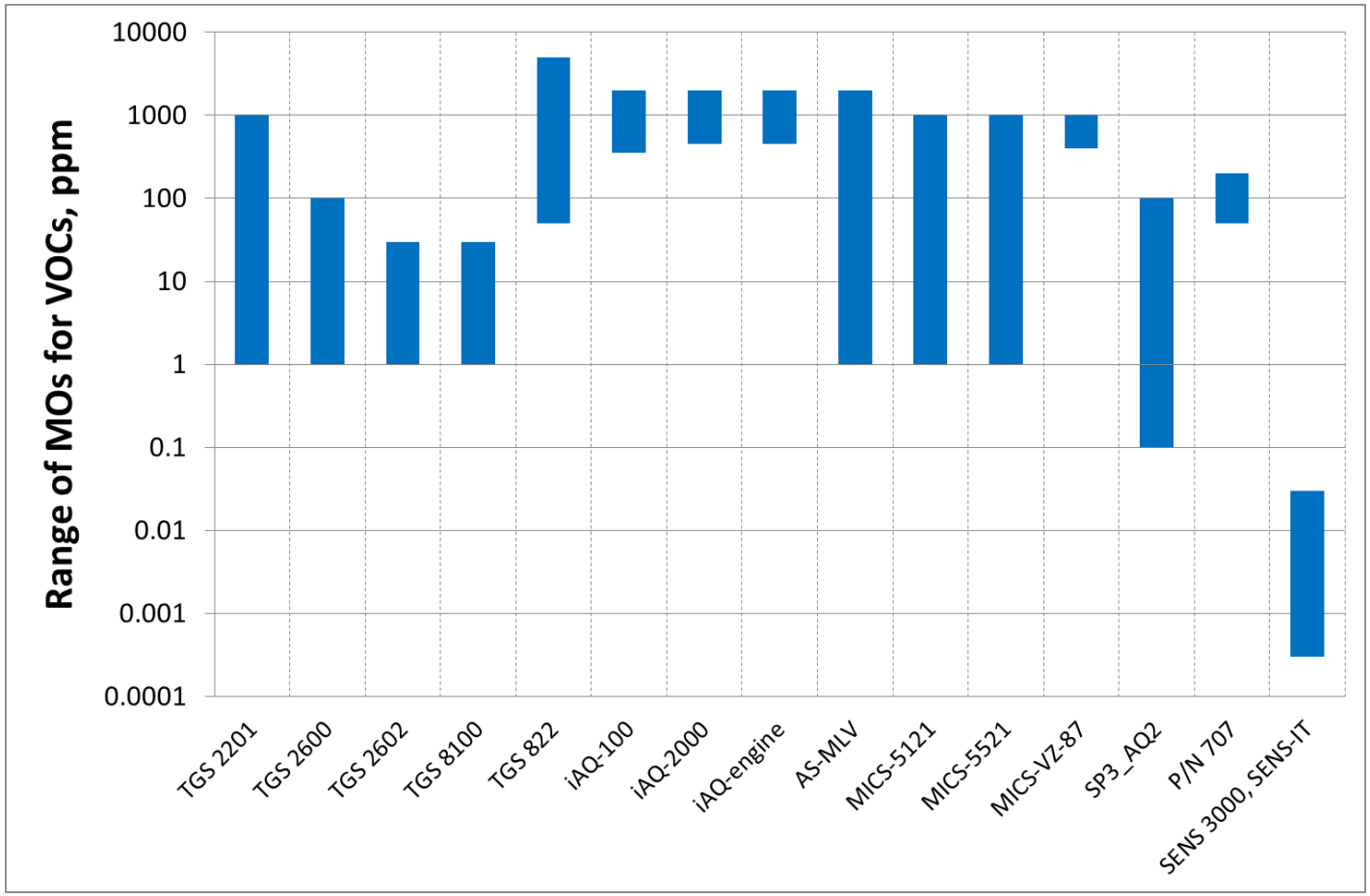
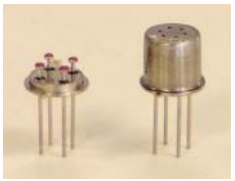
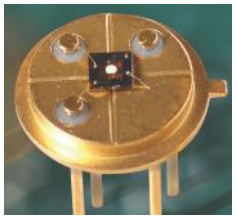
Metal oxide sensors (OEM)







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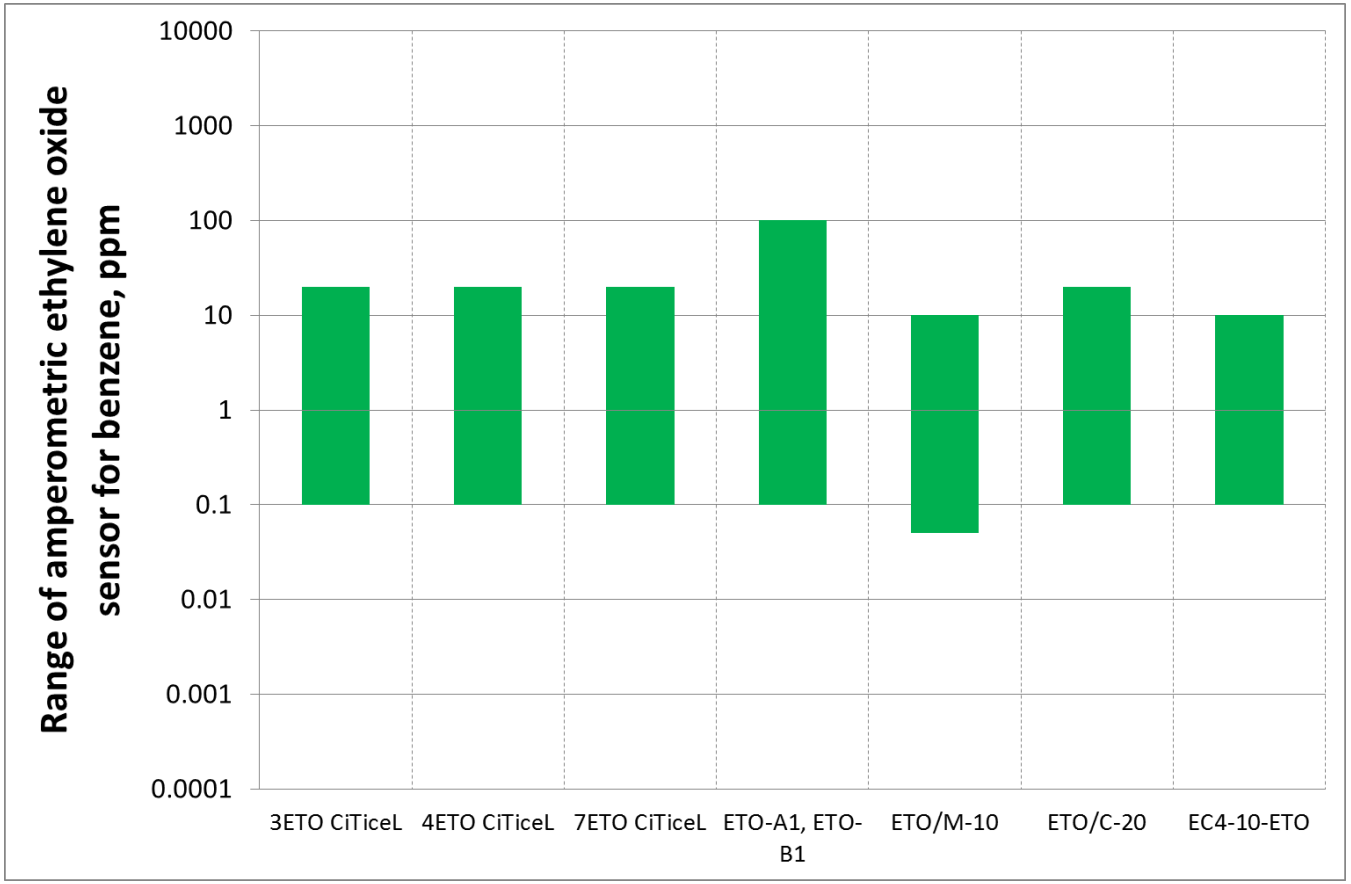
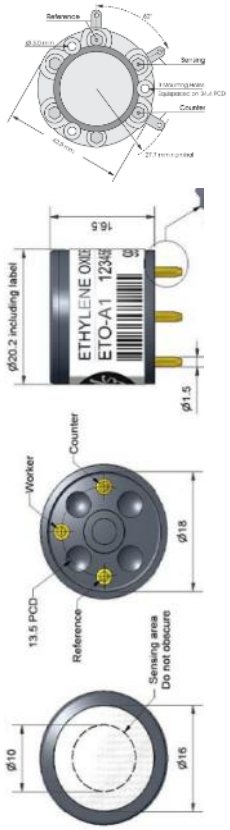
Amperometric sensors (OEM)





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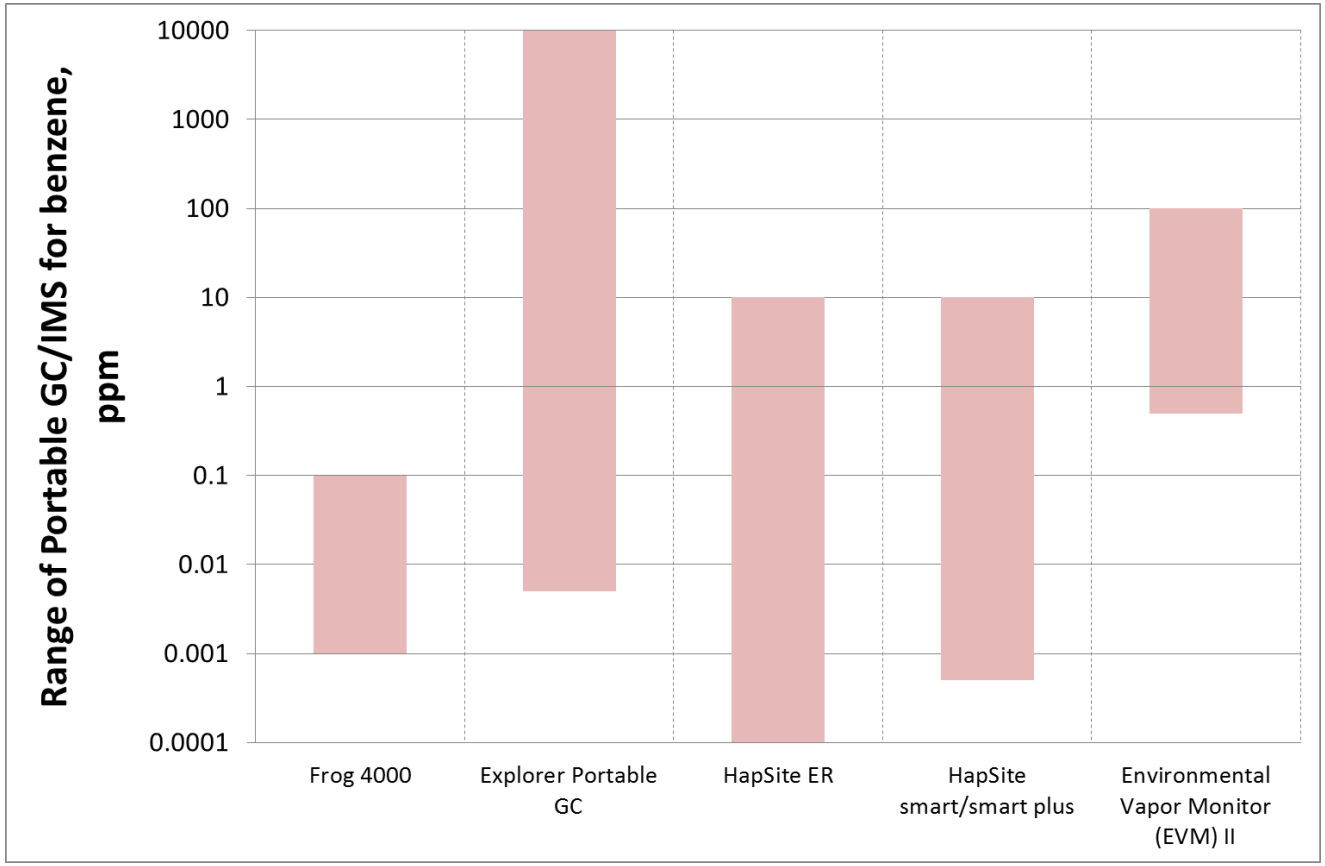
20-100 kE

Portable GC/IMS



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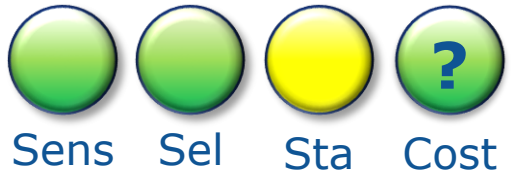
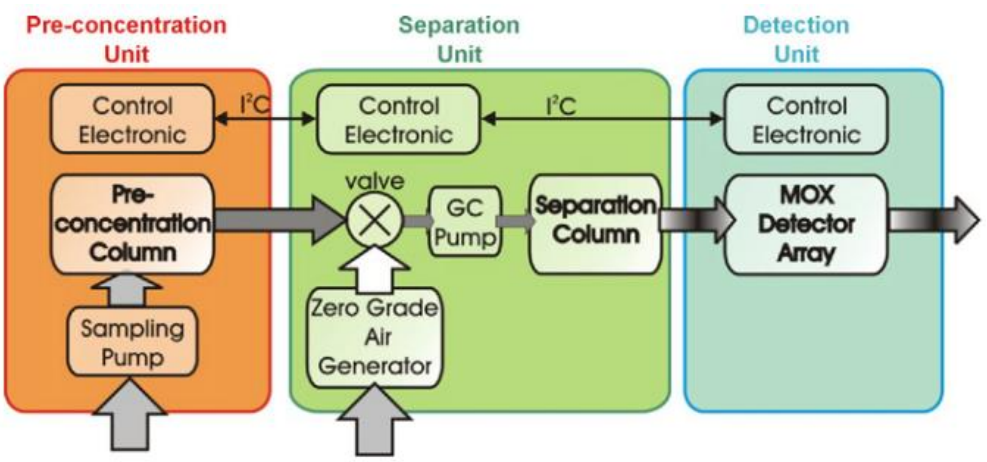
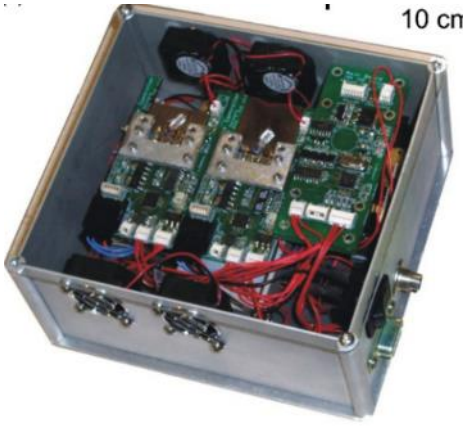


Prototype of miniaturized GC

Target gas	Principle	Limit of detection	Response time, min	Year
Aromatic VOCs	Pre-concentrator, column separation, MOs detector	0.0001 ppm	60	2009

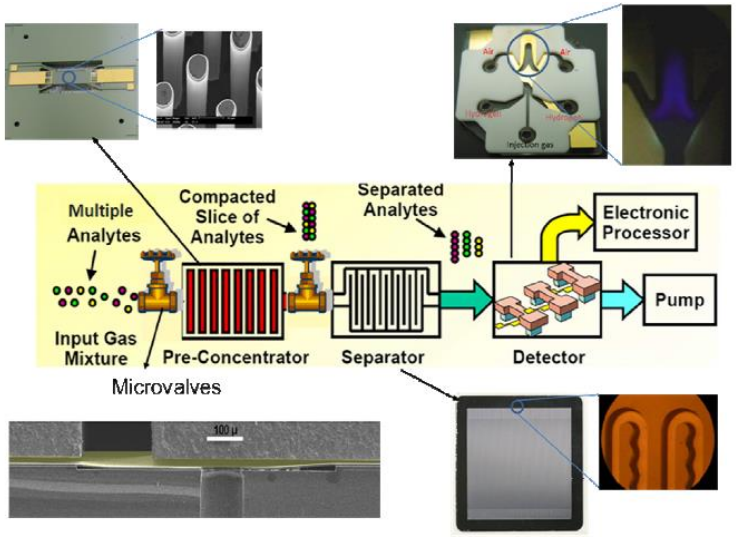


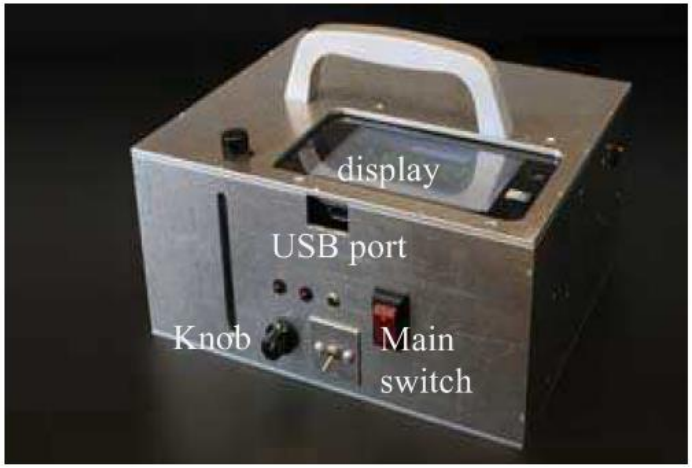


S. Zampolli, et al., 2009. Real-time monitoring of sub-ppb concentrations of aromatic volatiles with a MEMS-enabled miniaturized gas-chromatograph. Sensors and Actuators B: Chemical 141, 322–328.

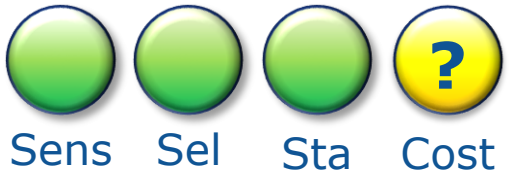
Prototype of portable GC

Target gas	Principle	Limit of detection	Response time, min	Year
17 VOCs including BTEX (benzene, toluene, ethylbenzene, and xylenes).	Pre-concentrator, column separation, FID detector	Not clear, low enough with FID (ng?)	60	2012



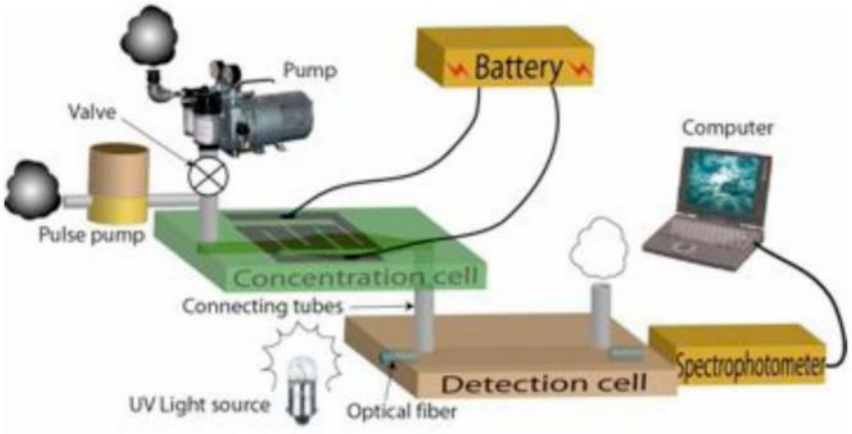


Bae et al., 2012. Development of a portable gas analyzer using a micro-Gas Chromatograph/Flame Ionization Detector (micro-GC/FID) for NASA's environmental missions. American Institute of Aeronautics and Astronautics.



Prototype spectroscopic sensor

Target gas	Principle	Limit of detection	Response time, min	Sensitivity factor, (ppm.min)	Year
Benzene, toluene xylene	Absoption/desorption /UV detec.	1 and 0.3 ppb	30	0.030	2006, 2012



S. Camou, T. Horiuchi, and T. Haga, "Ppb Level Benzene Gas Detection by Portable BTX Sensor Based on Integrated Hollow Fiber Detection Cell," Proc. of IEEE Sensors 2006, Daegu, Korea, 2006

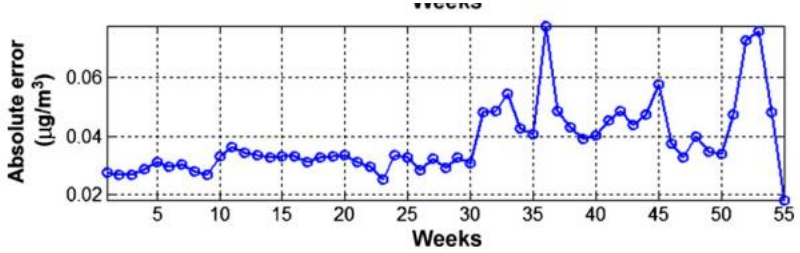
Commercially available e-nose

Manufacturer	Model	Principle of operation
Comon-Invent	e-Nose	Sensor array with 4 semi-conductor sensors, pattern recognition software
The eNose Company	Aerekaprobe	System with 1 to 12 non-specific sensors and pattern recognition software. Micro-hotplate metal-oxide sensors, temperature modulated

Prototype of E-nose

Target gas	Principle	Limit of detection	Response time, min	Sensitivity factor, (ppm.min)	Year
Benzene	Multi-sensor + neural network	<1 ppb	30	0.030	2006, 2012

- multi sensor with 7 MOs (Pirelli Labs)
- 13-month field calibration vs reference monitoring station values (on-line GC)
- calibration by neural network: solve also the lack of selectivity and stability of MOs
- 10 days training: no drift observed for more than 6th months, influences at low-concentrations suggested the need for a further calibration.

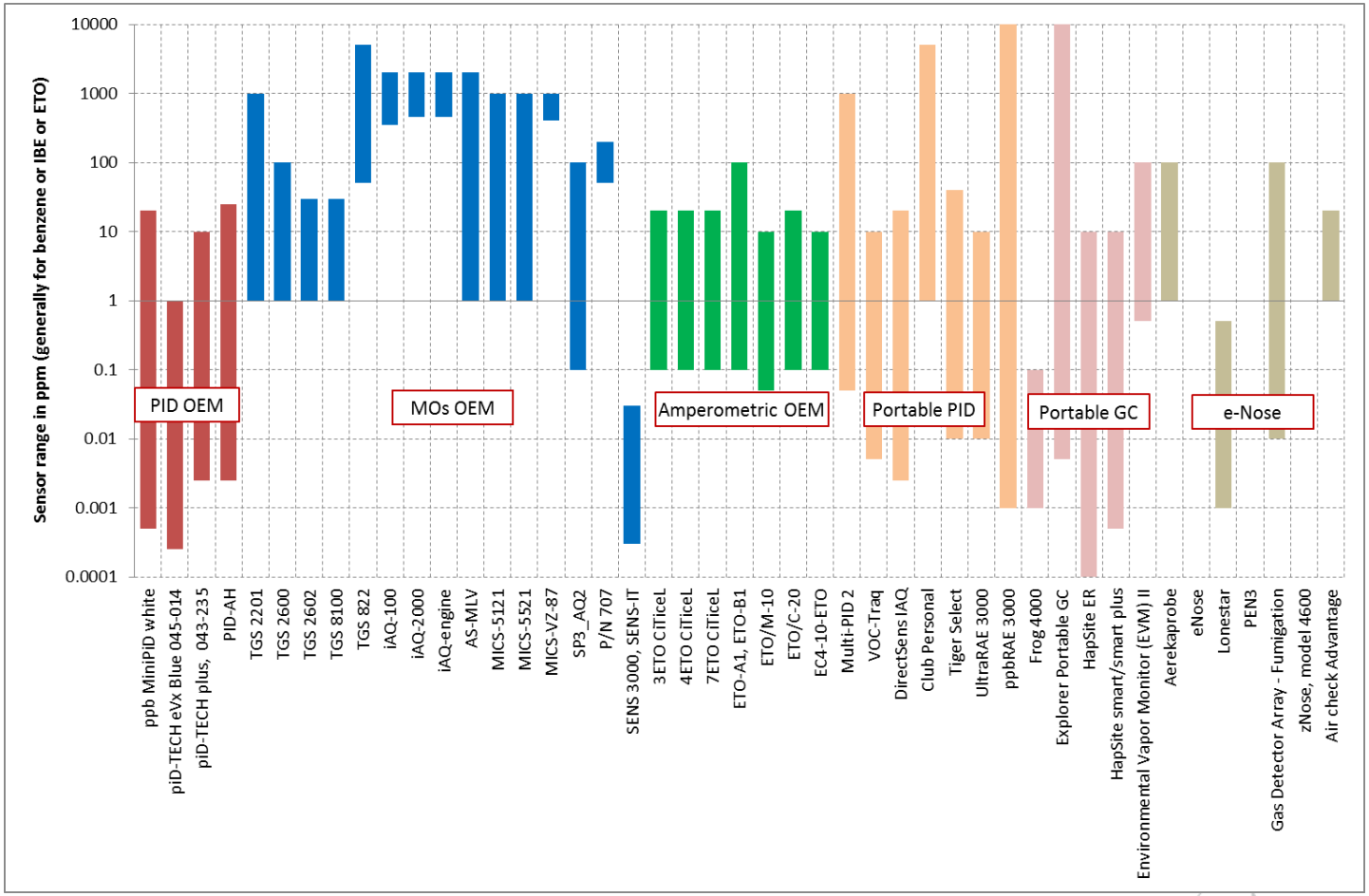


De Vito et al., 2008. On field calibration of an electronic nose for benzene estimation in an urban pollution monitoring scenario. Sensors and Actuators B: Chemical 129, 750–757. doi:10.1016/j.snb.2007.09.060

Conclusions

- *PID, MOs and amperometric sensors (OEMs) are not enough selective (PID) or sensitive (MOs + amperometric) for measuring levels of ppb to 100' of ppts. Except: It may be worth to test Unitec Sens3000/SensIT?*
- *Portable PID may be an alternative (Tiger Select Benzene and UltraRAE3000), the ones including filtering or absorbing cartridges. Portable GC/IMS are too expensive*
- *Investigate if prototypes (miniaturized GC – Zampolli et al. and portable UV spectometer – Camou et al.) are commercially available*
- *e-nose (de Vito et al.,) ?*

Thank you for your attention!



KEY VOCs

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Secretariat to CEN/TC 264 "Air quality"

our date 2014-12-19

our reference Dr. Ne/pe

CEN/TC 264 N **2275**

For action:
To the members of CEN/TC 264

For information:
To the Chairman and Vice-Chairman of CEN/TC 264
To the CEN/CENELEC Management Centre

Dear Sir or Madam

New work item proposal "Gas sensors"

Please find enclosed a new work item proposal dealing with adoption of the following preliminary work item:

prCEN/TS xxxxx *Air quality – Performance evaluation of sensors for the determination of concentrations of gaseous pollutants and particulate matter in ambient air* (Doc. **N 2274**)

All members of CEN/TC 264 are kindly asked to let us know whether they agree to the adoption of this preliminary work item by making use of the **CEN eBalloting portal (Committee Internal Balloting)**.

In case of adoption Mr. Michel Gerboles, JRC Ispra, has been kind enough to accept project leadership. **Any members who would be willing to take over the secretariat of the new WG are kindly invited to inform the TC secretariat accordingly (by e-mail to perschau@vdi.de).**

Deadline for voting is **2015-03-20**.

Thank you in advance for your kind co-operation!

Yours sincerely

Dr. Rudolf Neuroth

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The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union
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