European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

WGs and MC Meeting at LINKOPING, 3 - 5 June 2015

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

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involved in WG2, SIG 1 & 3, STSM

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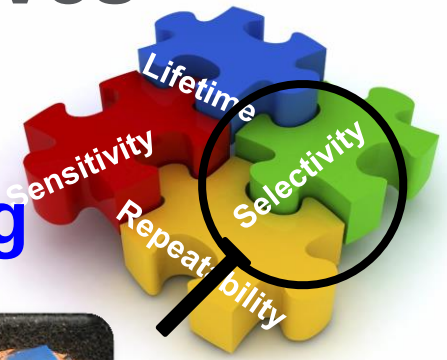
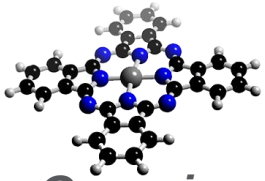
COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Scientific context and objectives

Sensitive and selective sensor-systems for gaseous outdoor pollutants monitoring





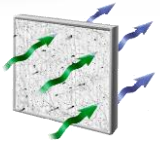
Organic

Mineral

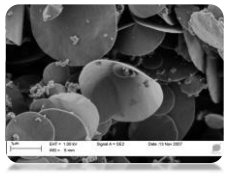
Acoustic

Microwave
(ICB-Dijon)

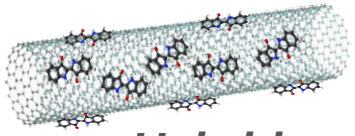
Sensors



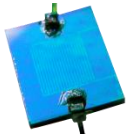
Chemical filters



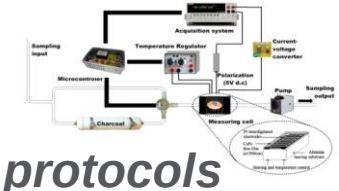
Nanocarbons



Hybrid



Conductimetric



Working protocols

Materials **Transducers** **Sensor-systems**

- ⇨ Functionalized nanostructures for enhanced gas detection at ppb level, stability and selectivity (WG1 objective)
- ⇨ Relevant sensitive material/transducer association (SIG3 objective)

Involved in WG2, SIG1, SIG3 and STSM committee

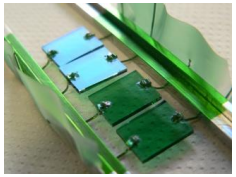
Skills & expertise

Our team ? Multidisciplinary !

System & Microsystem Gas Sensor group

- **Electronics**
  1 Professor
  1 Associate Professor
- **Physicist**
  1 PhD student
- **Physical chemist**
  1 Associate Professor
- **Chemist**
  1 Research Engineer

Thin layers realization



Electrical characterizations of semiconductors

Development of electronic units

Sensors & sensor-systems development

cost
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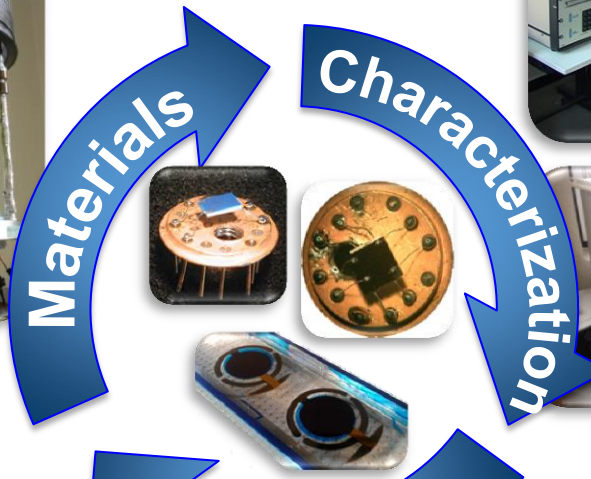
Research facilities for sensor development

Thin film deposition

Electrical measurements



Gas exposures & Calibration

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Measurement of monocyclic hydrocarbons by phthalocyanine-based QCM sensors: Results and Outlooks

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involved in WG2, SIG 1 & 3, STSM

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Societal and scientific context

Outdoor air pollution ⟷ **Established !** ⟷ **Public health trouble**

2010 223 000 deaths from lung cancer worldwide resulted from air pollution

2012 7 millions premature deaths annually linked to air pollution

World Health Organization

2013

Outdoor air pollution classified as carcinogenic for humans at worldwide scale

2015 **Project call "CANC'AIR"**

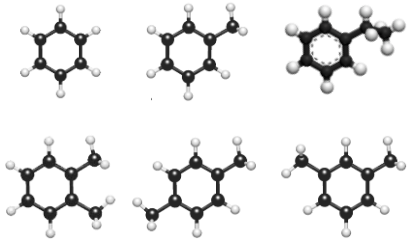
FONDATION ARC POUR LA RECHERCHE SUR LE CANCER

Better characterization of air pollutant exposures linked to cancer
Innovative prevention methods

Special focus on monocyclic hydrocarbons

International Agency for Research on Cancer

World Health Organization



Benzene	Group 1	Carcinogenic to humans
Ethyl-benzene	Group 2B	*Possibly* carcinogenic to *humans*
Toluene	Group 3	*Not classifiable as to its carcinogenicity to humans*
Xylenes	Group 3	

Guidelines

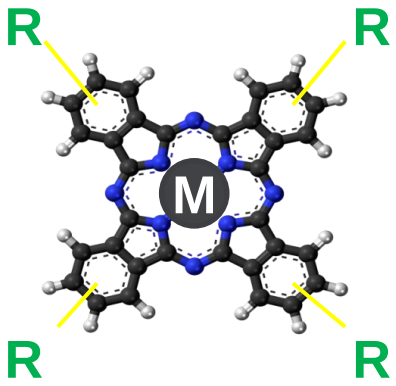
	Non-occupational			Occupational
	ATSDR	EPA	World Health Organization	OSHA
Benzene	3-6 ppb	9-10 ppb	≈ 1.5 ppb	10 ppm
Ethyl-benzene	0.06-5 ppm	230 ppb	≈ 90 ppb	100 ppm
Toluene	0.08-1.3 ppm	1.3 ppm	≈ 265 ppb	200 ppm
Xylenes	0.05-2 ppm	26.5 ppb	≈ 1 ppm	100 ppm
	MRL TWA-8h	*RfC*	*Odor threshold -1/2h*	*PEL TWA-8h*

Ubiquitous pollutants

Daily exposed

A priority for health prevention

Scientific approach for sensor development



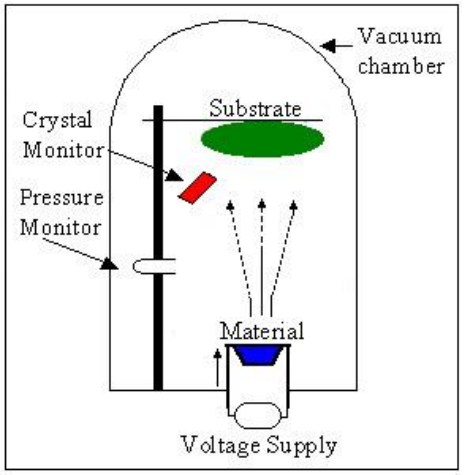
Metallophthalocyanines

- π-electron delocalization
- High aromaticity
- Easy functionalization at periphery

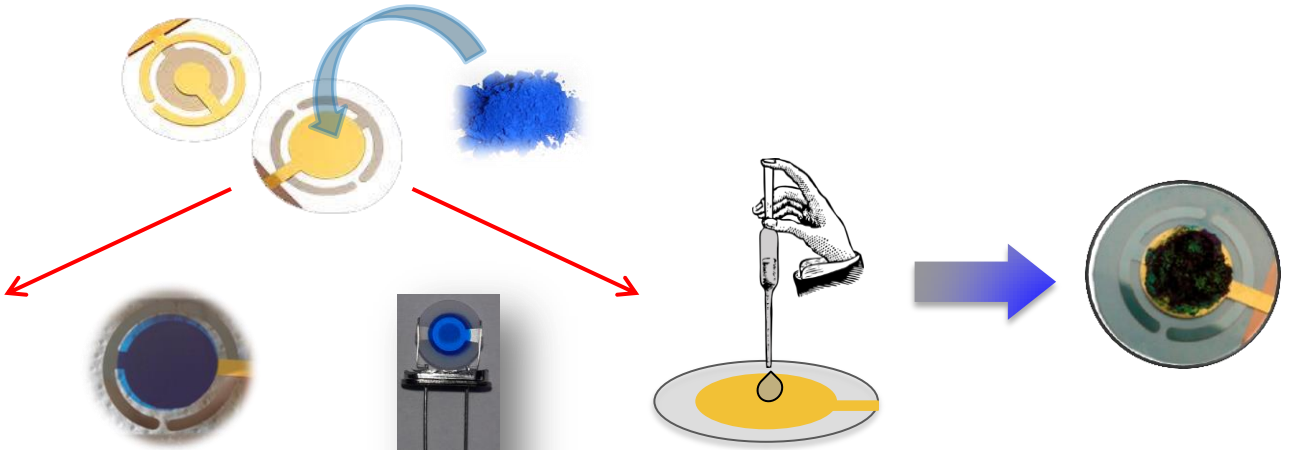
Aromatic properties ⇒ **pi-stacking interactions with analytes**

Processability ⇒ **Compatible with several transducing modes**

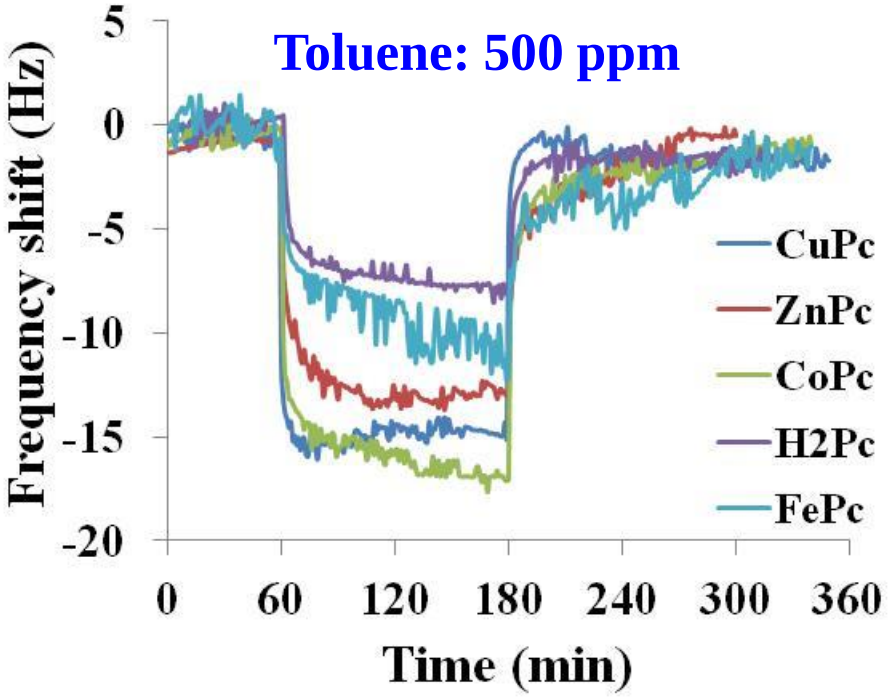
Nature of interaction ⇒ **Quartz Crystal Microbalances**

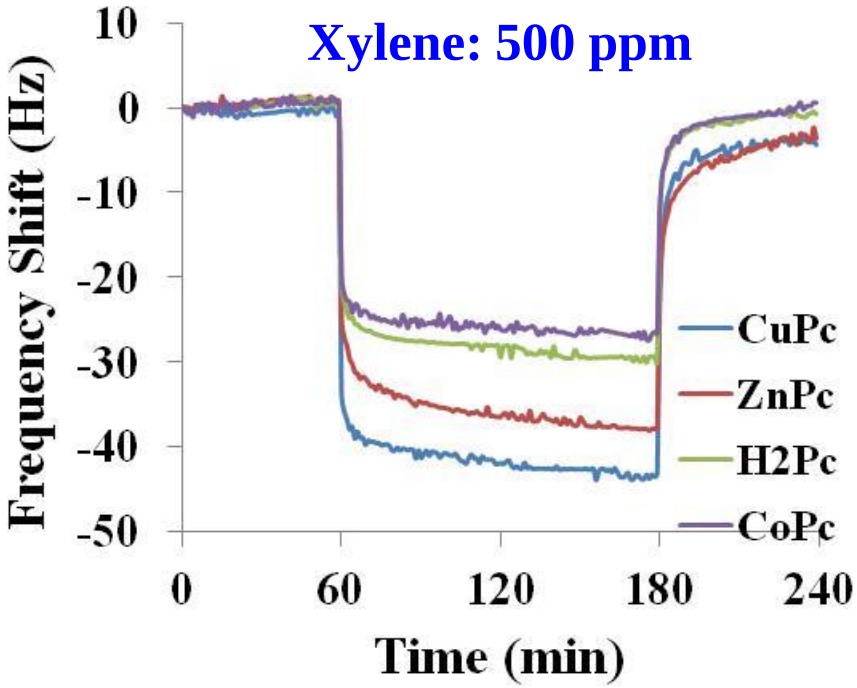


Thermal evaporation



Phthalocyanines: effect of metal





Benzene → Low sensitivity, low signal/noise ratio

Low sensitivity

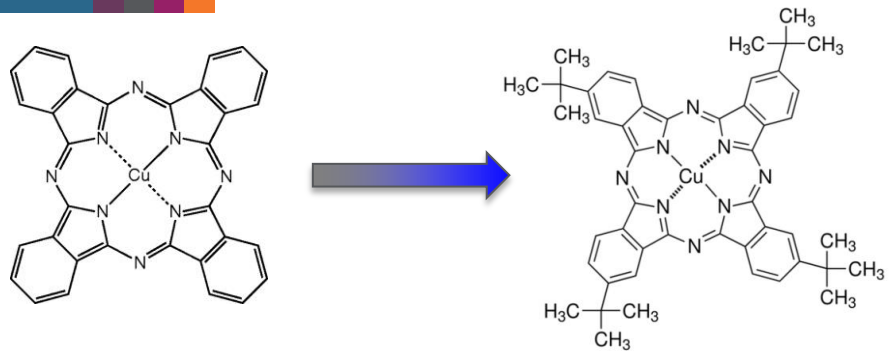
No significant effect of metal on sensor response

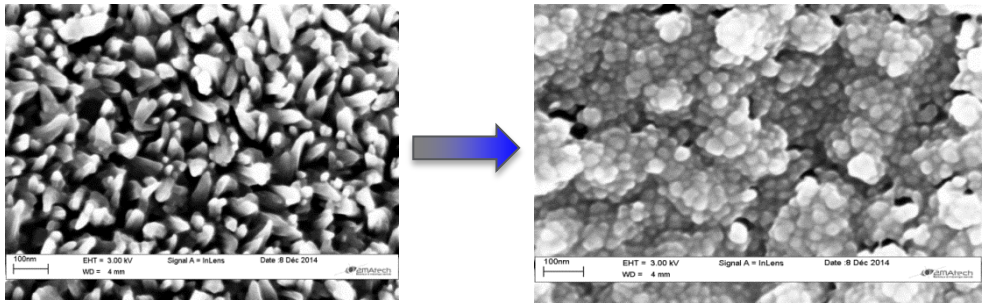
Electro-donor peripheral groups

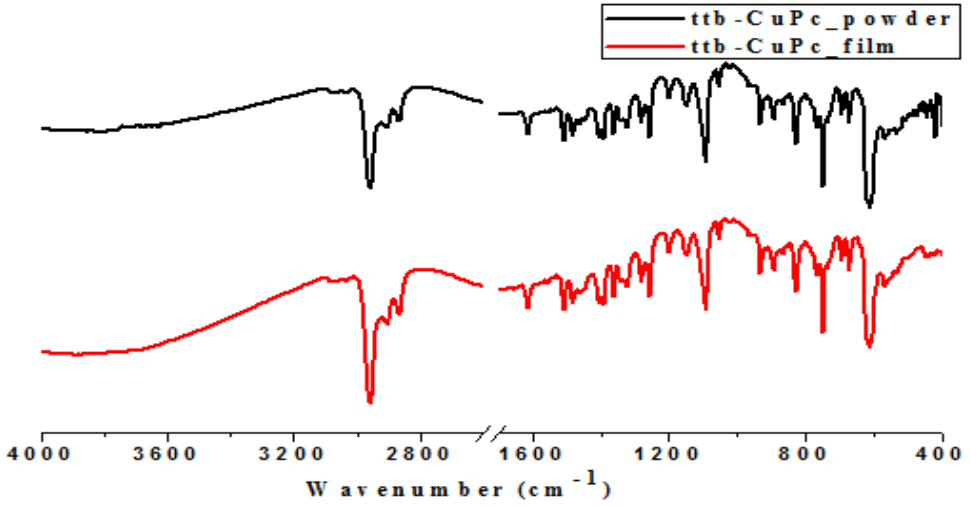
↓

pi-stacking interactions strengthened

Phthalocyanines: effect of peripheral groups



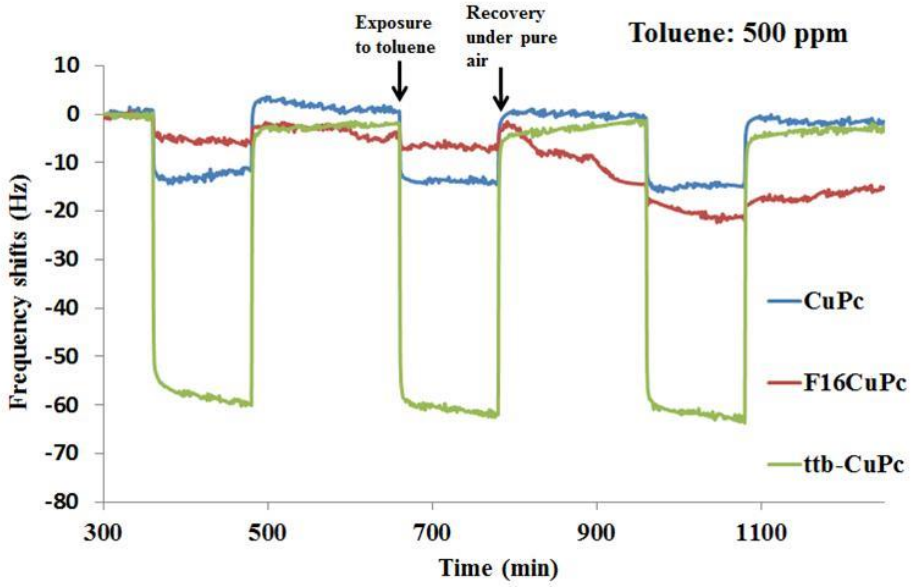




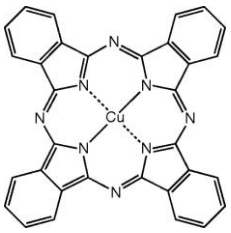
Same results with ttb-ZnPc

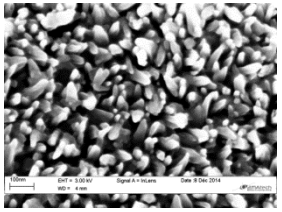
Strong influence of peripheral groups on gas/material interactions

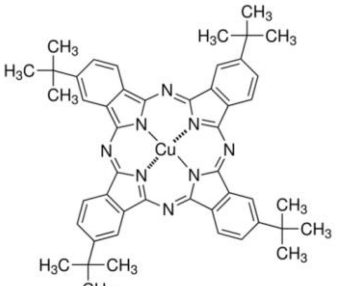
Higher sensitivity to BTX

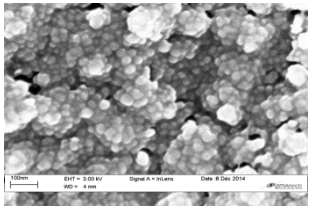


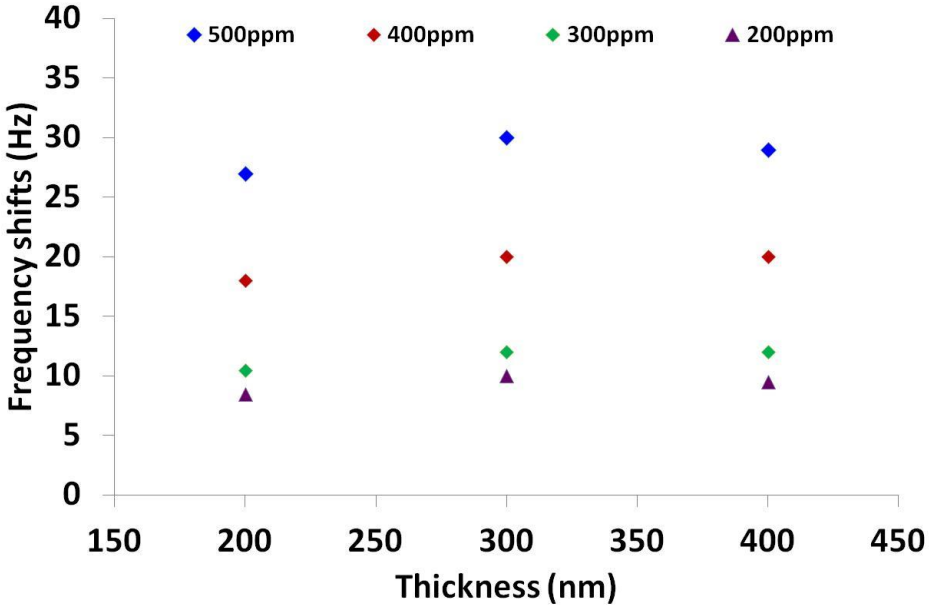
Effect of layer thickness

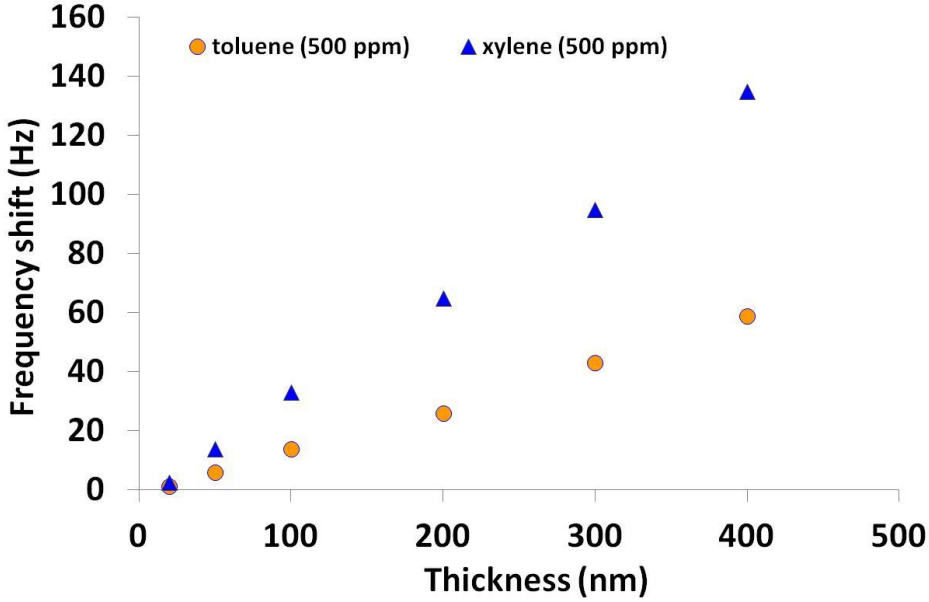












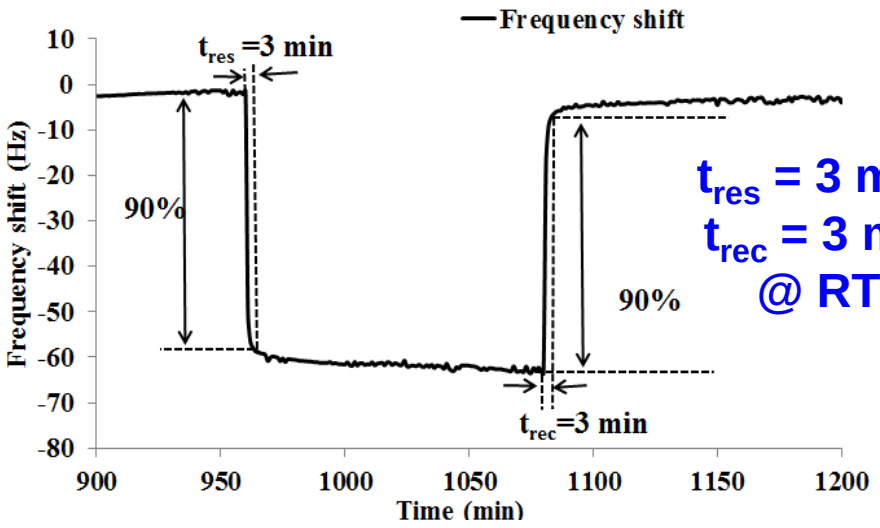
No thickness influence

Adsorption localized at layer surface

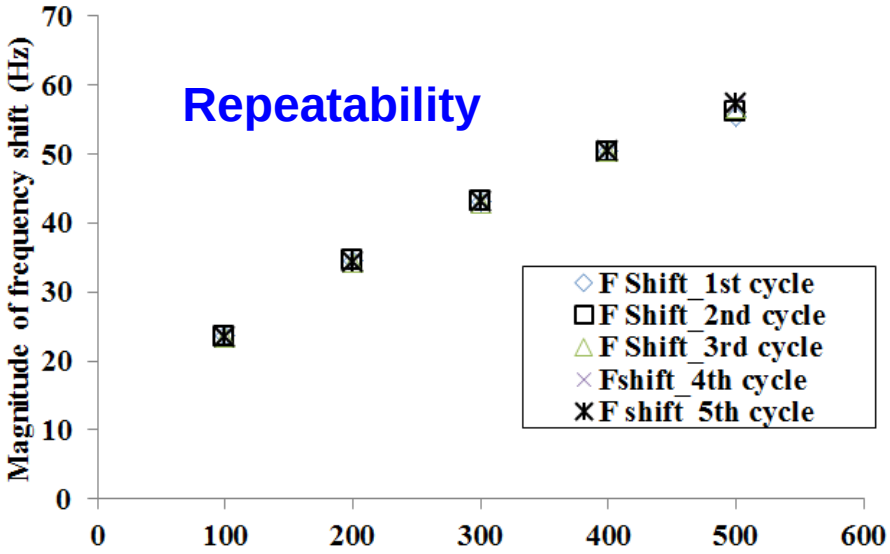
Linear dependence

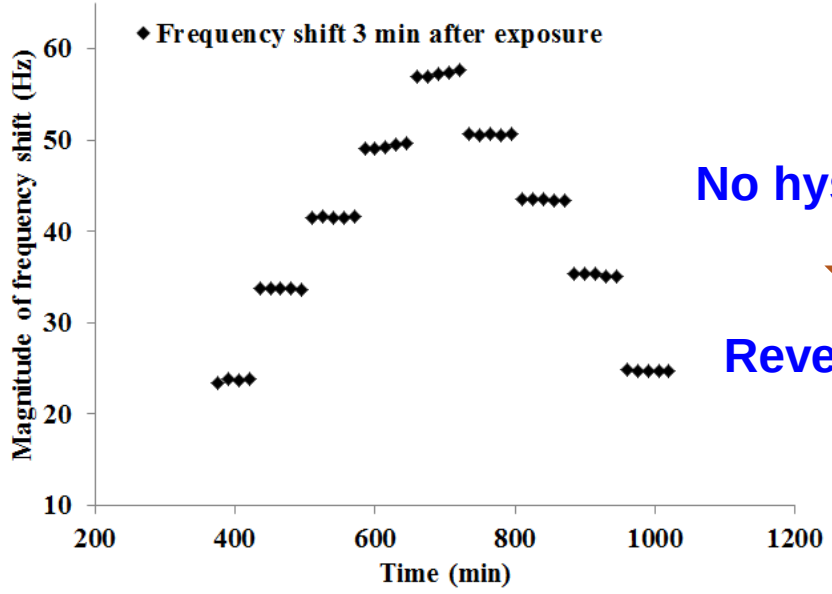
Interactions distributed into the layer volume

Sensing performances



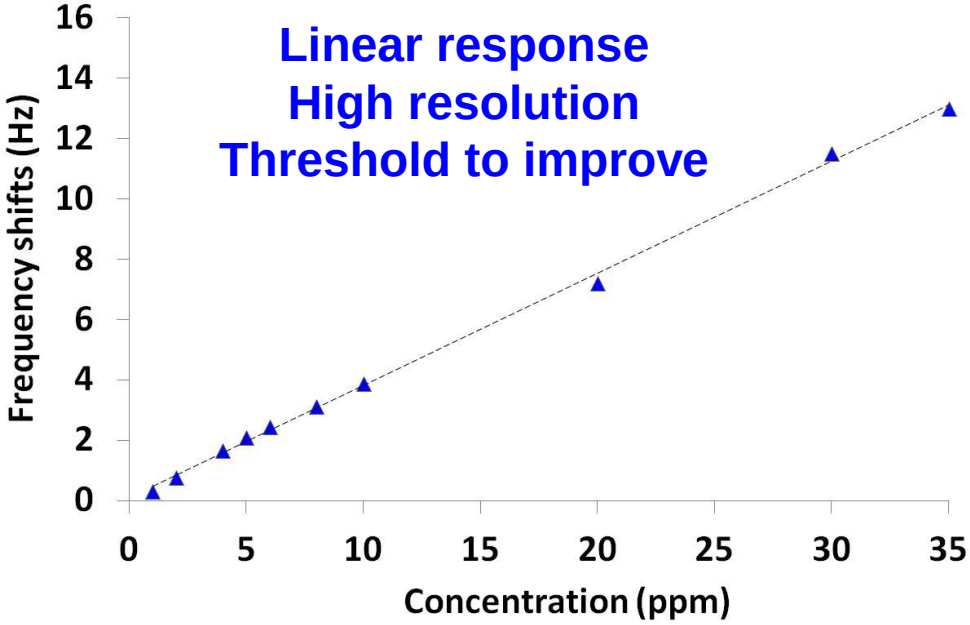
t_{res} = 3 min
t_{rec} = 3 min
@ RT





No hysteresis

Reversibility



What about the selectivity?

No significant response toward CO, H_2S and NO_2 !

Sensor partially selective to BTX compounds

INSTITUT PASCAL
sciences de l'ingénierie et des systèmes

STSM

ENEA

Sensors and Actuators B 210 (2015) 398–407

Contents lists available at ScienceDirect

Sensors and Actuators B: Chemical

journal homepage: www.elsevier.com/locate/snb

Tetra-tert-butyl copper phthalocyanine-based QCM sensor for toluene detection in air at room temperature

A. Kumar[a,b,*], J. Brunet[a,b], C. Varenne[a,b], A. Ndiaye[a,b], A. Pauly[a,b], M. Penza[c], M. Alvisi[c]

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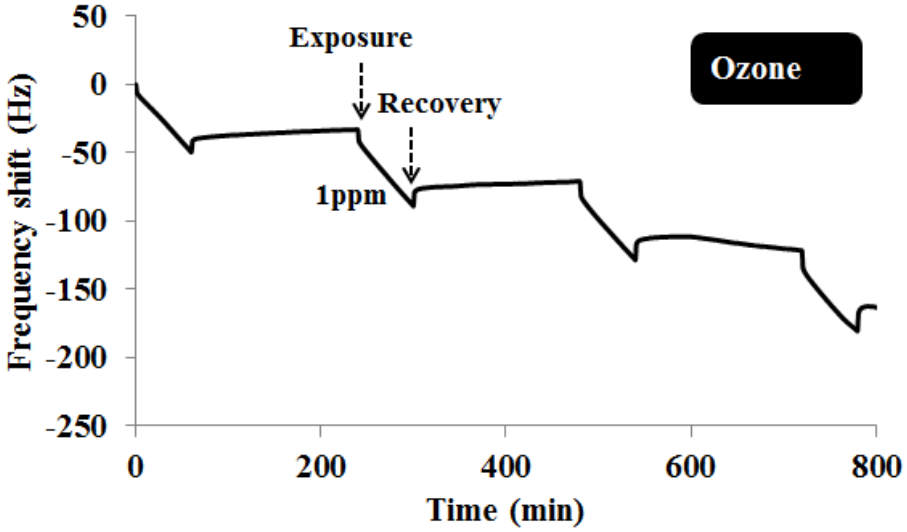
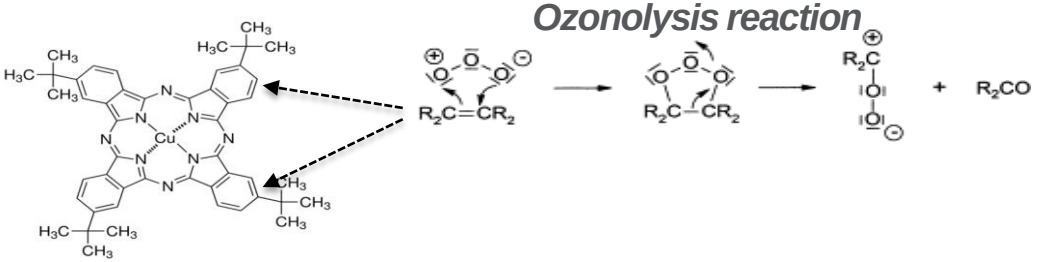
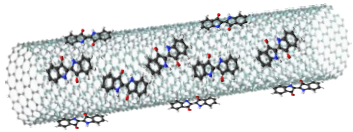
[c] ENEA, Brindisi Technical Unit of Technologies for Materials, PO Box 51-Br4, I-72100 Brindisi, Italy



Ozonolysis reaction



Selective chemical filter for O_3 removal



cost
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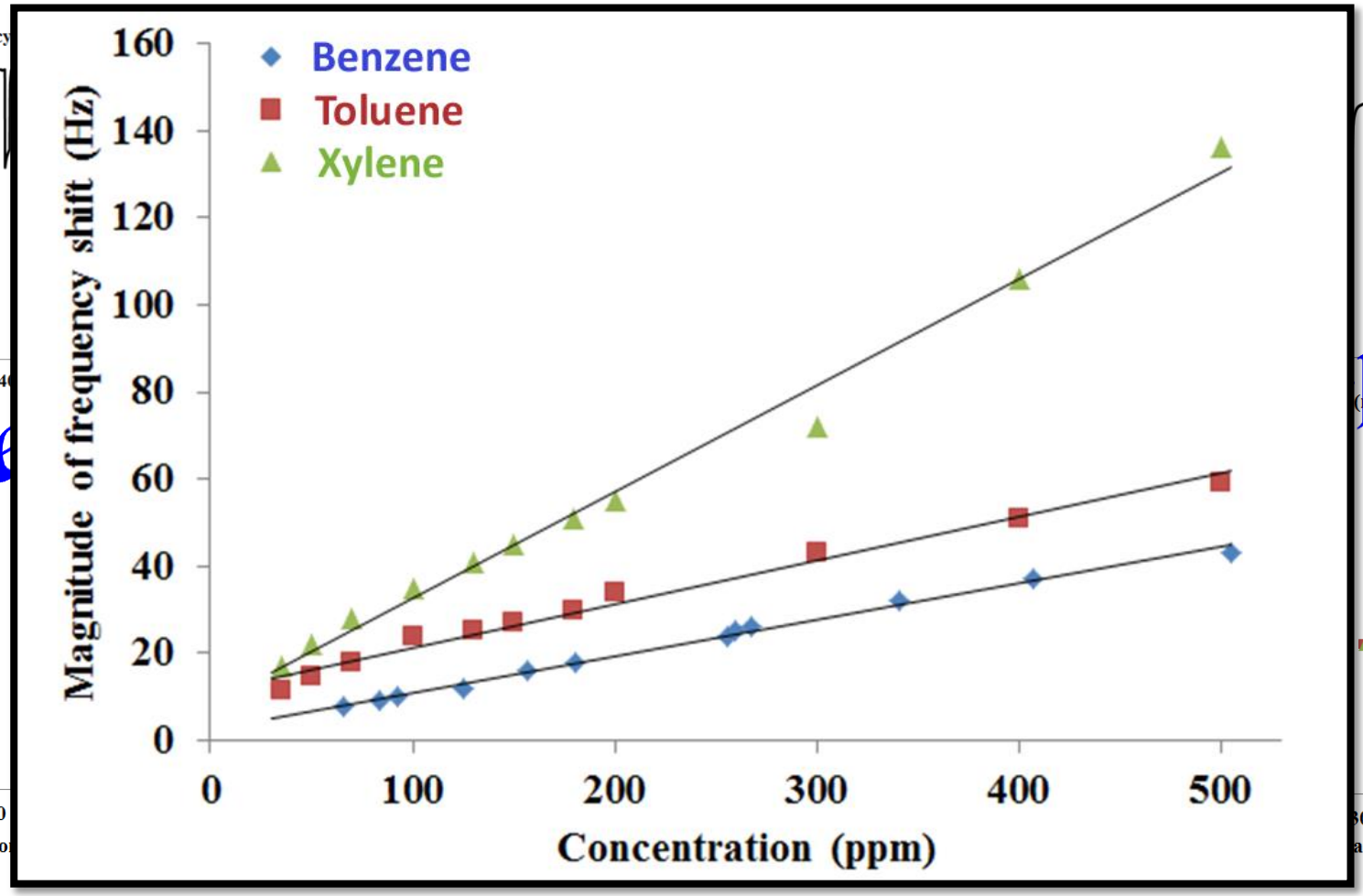
What about the selectivity?



Challenge ? → Discrimination !

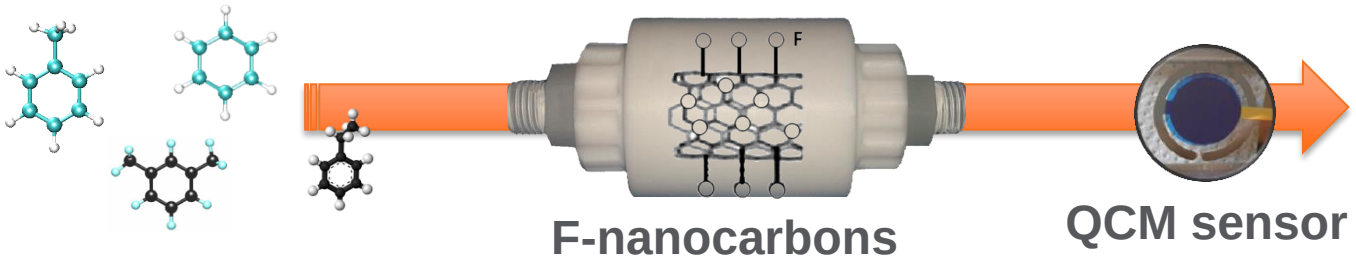
Ongoing research activities

❶ Sensor-system for VOCs monitoring

ASTHMAA exploratory project (granted)

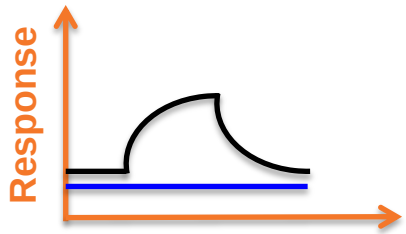
advancing the frontiers

Scientific strategy:

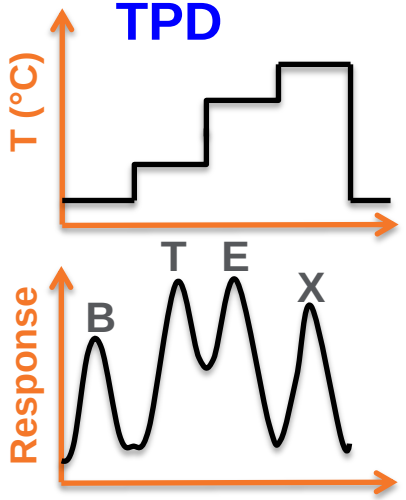


Discriminated responses

Selective filter



TPD



Partners:

IS2M

Institut de Chimie de Clermont-Ferrand

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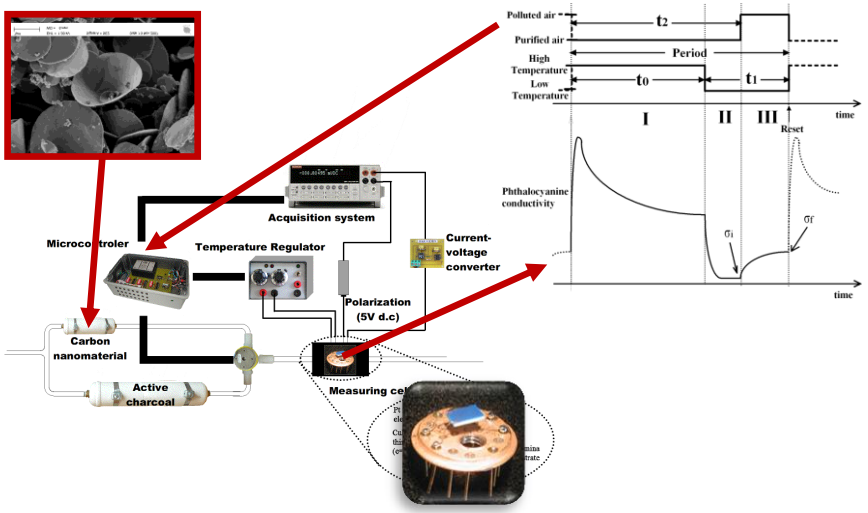
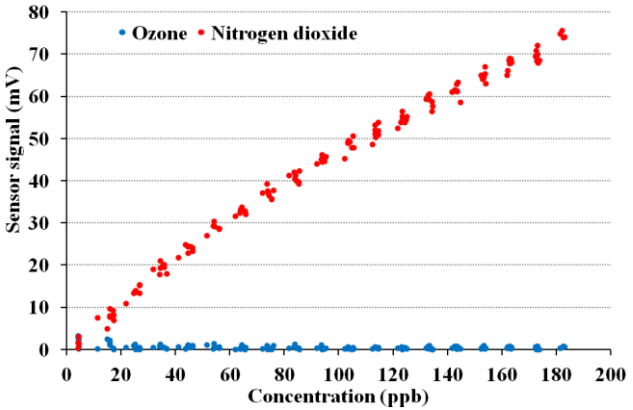
Ongoing research activities

❷ Sensor-system for the selective metrology of NO_2





From patent to…

Use of carbon nanomaterial as a filtration material impervious to O_3

Blaise Pascal University / CNRS

Published as FR2931701, WO2010000956, EP2291230, US2011124112

…transfer of technology

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Suggested R&I Needs for future research

R&I needs for sensing devices

- **Selectivity, resolution, threshold and stability: high level and in agreement with the target application**

- **Low-power, low cost and flexible sensors able to be integrated into new technological devices**
  - ✓ **Integration to mobile phones, clothes or cycles**
  - ✓ **Citizen contribution to pollution monitoring**
  - ✓ **Safety working and living conditions**

- **Environment-friendly materials and technologies**
  - ✓ **No hazard for environment and health, limited wastes**
  - ✓ **What about nanomaterials?**

Suggested R&I Needs for future research

Innovations in AQC

- Sensor-systems as decision support
  - ✓ Adapted commuting / street air quality
  - ✓ Innovative mobility

- Sensor-systems for real-time personal exposure
  - ✓ Complementary to air monitoring stations
  - ✓ Health prevention

- Making citizens, policymakers and authorities aware of the potential decrease in public heath expenses by AQC
  - ✓ Individual actions for health prevention


Gracias
Merci
Thank you
Danke
Merci
Gracias
Dziękuję
Gracias
Obrigado
Danke
Chacuбo

thank you