



From an increasing demand to a field solution : all steps of a formaldehyde micro-analyzer development; collaboration between a public research organization and a start-up company

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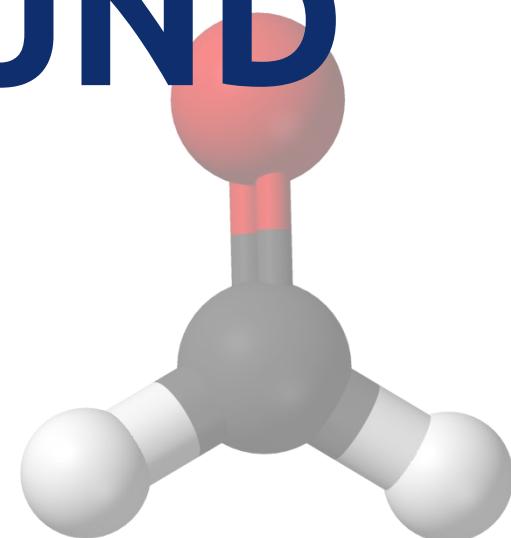
Outline





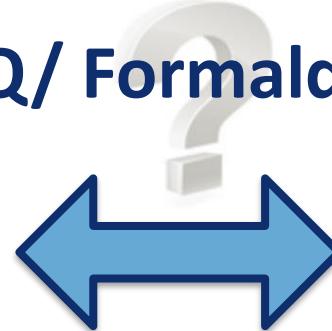
GENERAL BACKGROUND

How's Your Indoor
Air Quality?



IAQ/ Formaldehyde

Indoor air quality (IAQ) is responsible of more than 4 millions of premature deaths per year^[1]



Time spends in enclosed environment could reach 90%

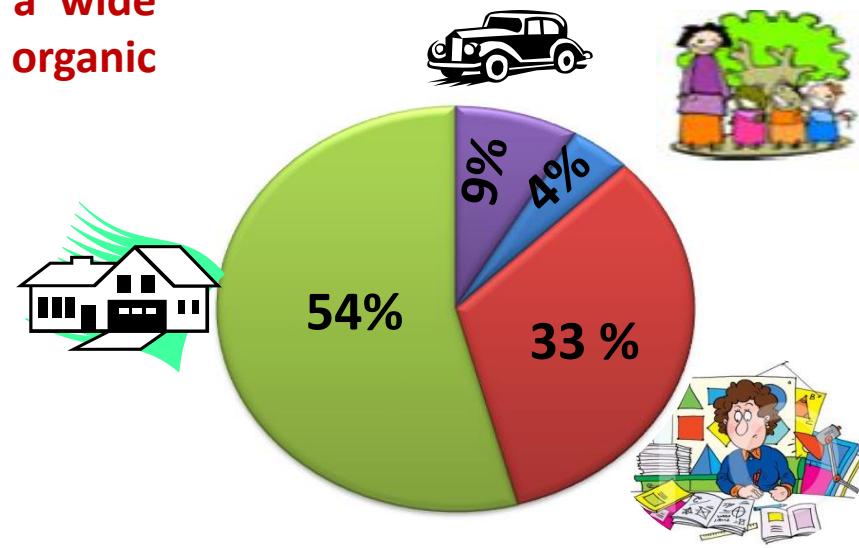
IA is contaminated by a wide variety of Volatile organic compounds (VOCs)



Sick building syndrome [2]:

- Eyes burning
- Nose and skin irritation
- Headache and drowsiness

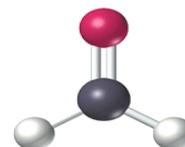
- ✓ Asthma
- ✓ Cancer



[1] World Health Organisation

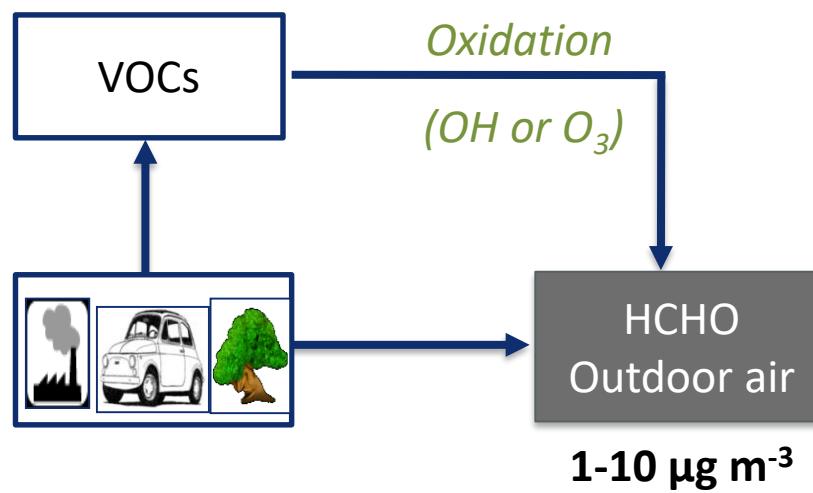
[2] R. Kostiainen, Volatile organic compounds in the indoor air of normal and sick houses, *Atmos. Environ.* 29 (1995) 693–702

HCHO: Formaldehyde

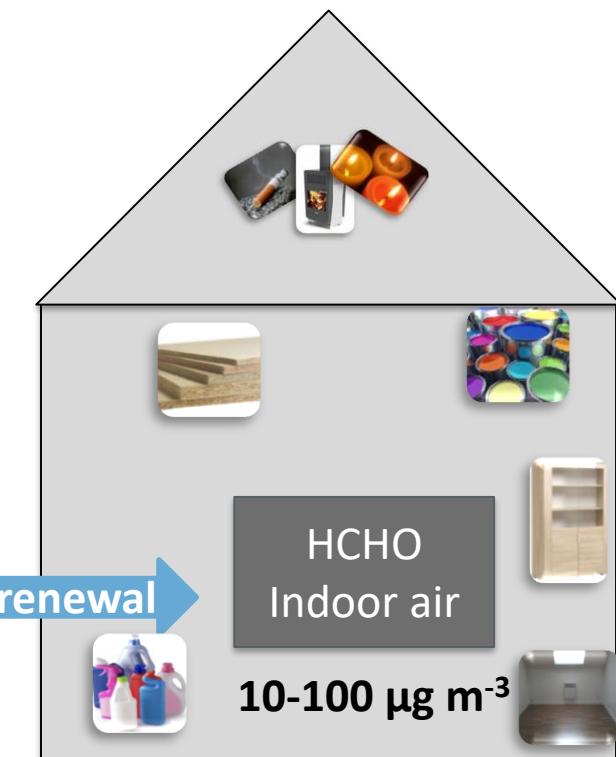


Formaldehyde Sources [3]

Secondary sources



Primary sources



[3] Toda et al., *Analytica Chimica Acta*, 2004; Hak et al., *Atmos. Chem. Phys.* 2005; Junkermann et al., *J. Atmos. Oceanic Tech.* 2005; Salthammer, *Chem. Rev.*, 2010

Compound	Effect ^[4]	Guide values ^[5]	2013	2018
		Concentration ($\mu\text{g m}^{-3}$)	5 (1.6 ppb)	2 (0.6 ppb)
Benzene	Human carcinogenic class A (leukaemia)			
Toluene	Harmful to Nervous central system			
Ethylbenzene	Pneumonitis			
Xylenes	Liver and kidney disorder			
Formaldehyde	<ul style="list-style-type: none"> <input type="checkbox"/> Irritation of eyes and respiratory tract <input type="checkbox"/> Human carcinogenic <input type="checkbox"/> Co-factor of allergic asthma 	Guide values ^[5]	2018	2023
		Concentration ($\mu\text{g m}^{-3}$)	30 (24 ppb)	10 (8 ppb)

These new regulations make necessary the development of **portable and sensible instruments** for formaldehyde and BTEX monitoring in public buildings.

[4] World Health Organisation

[5] Décret n°2011-1727 of December 2011 for Indoor air French guides values

LABORATORY RESEARCH

Temporal resolution
 $< 10 \text{ min}$

Development of an analytical method based on **microfluidic devices**

Reagent autonomy
Very low consumption

Limit of detection
 $< 1.5 \mu\text{g m}^{-3}$

HCHO selectivity

Ultra portable
Size $< 4 \text{ kg}$

Formaldehyde monitoring in public indoor air starting 2018^[6]

- Thesis ADEME / région Alsace – 2007-2010 – Thesis supervisor: S. Le Calvé
- PRIMEQUAL – 2008-2010 – Coordinator : S. Le Calvé



Results :

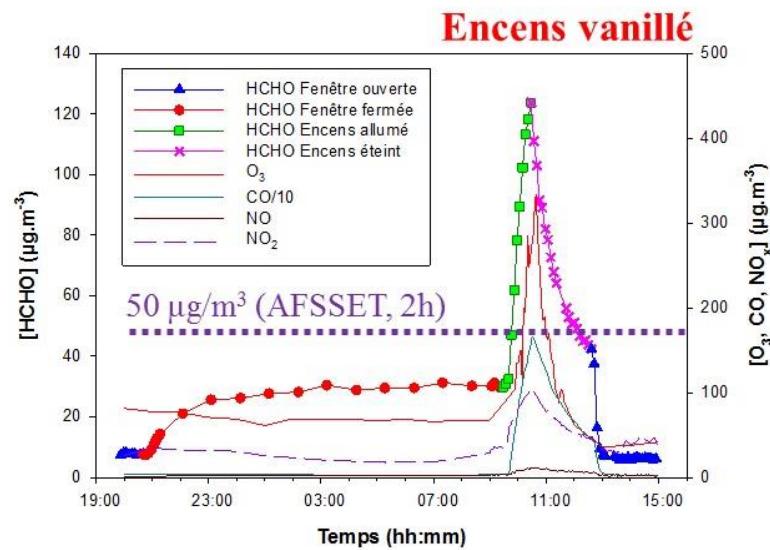
- Analytical method: continuous monitoring
- Near real time detection
- Accurate and repeatable
- Compact and transportable device
- LD < 0.2 µg m⁻³



28 × 23 × 38 cm ~ 12 Kg

Drawbacks:

- Reagent consumption: 60 mL h⁻¹
- Transportable but not portable device



Le Calvé et al., patent, dec. 2010 (extended PCT, juin 2011)

Objective: method based on microfluidic device to

- Increase autonomy (decrease reagent consumption)
- Reduce weight



- REALISE – 2012 – Coordinator : S. Le Calvé
- MINI-FORMALAIR – CONECTUS – 2012 & 2013 – Coordinator : S. Le Calvé
- Thèse ADEME / région Alsace – 2012-2014 – Thesis supervisor: S. Le Calvé
- CAPFEIN – ANR ECOTECH – 2012-2015 – Coordinator : S. Le Calvé

Results : comparison between the two analytical method

Features	Method 1	Method 2
Weight	12 kg	x 1/2 → 5.5 kg
Reagent consumption	60 000 µL h ⁻¹	x 1/50 → 600 – 1200 µL h ⁻¹
Response time	10 min	10 min
Temporal resolution	10 min	x 1/50 → 2 – 120 s
LD	< 0,2 µg m ⁻³	1 µg m ⁻³ (2s) < 0,5 µg m ⁻³ (30s) < 0,2 µg m ⁻³ (120s)
Linearity range	1 – 200 µg m ⁻³	1 – 200 µg m ⁻³



33 × 45 × 15 cm ~ 5.5 Kg



Le Calvé et al., patent, jan. 2014 (extended PCT, jan 2015)

Second Mermaid campaign : 16th February – 6th March 2015

Maubeuge, FRANCE



Main objective : characterization of IAQ and description of processes responsible for pollutants occurrence in indoor air of low energy public buildings.

Delivery date	August 2011
Region	North
Type of public access building	College
Energetic performance level	VHEP
Primary energy consumption ¹ (kW m ⁻² an ⁻¹)	70
Standard Primary energy consumption (kW m ⁻² an ⁻¹)	135

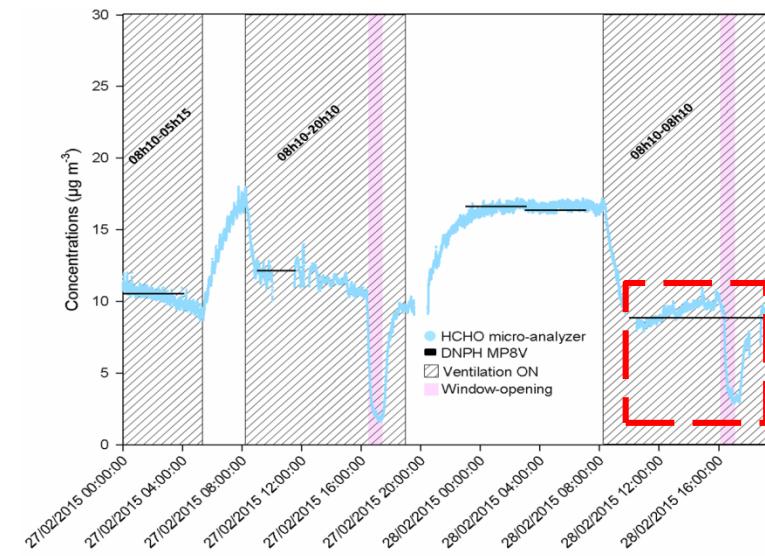
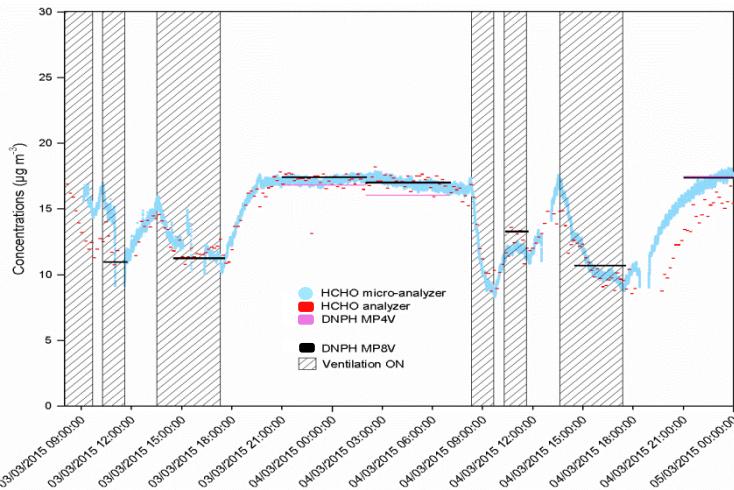


Low energy high school

HCHO objective :

- Determination of temporal variations of formaldehyde concentrations, using the micro-analyzer
- Comparison with two other analytical method for gaseous formaldehyde quantification
- Comparison of Indoor and Outdoor levels to discriminate formaldehyde origins

Results : comparison between the two analytical method



INDUSTRIALIZATION



L'EQUIPE



NOS DOMAINES
D'EXPERTISE



NOS VALEURS



NOS RÉFÉRENCES



In'Air Solutions, the smart air analysis

Vers une meilleure qualité de l'air intérieur!



UNIVERSITÉ DE STRASBOURG



Institut de Chimie et
Procédés pour l'Énergie,
l'Environnement et la Santé

Issued from Strasbourg University and CNRS research,

**In'Air solutions is specialized on products solutions
for Innovative technology for Air pollution detection.**

**In'Air solutions is always collaborate with
Strasbourg University to accelerate research valorisation
and industrial application**



in'air **solutions**
the smart air analysis

Beginning of R&D works

University of Strasbourg & CNRS

Creation of In'Air Solutions

- 4 people Board founder providing complementary vision
- 3 patents with exclusive rights
- Laboratory prototypes

1st Funding Raising of 1.2 M€

- Beginning of Design, Proof of concept & prototype
- BTEX & HCHO Analyzer
- Industrial prototype in 2016

Market Launch

- France & Europe market priorities
- Business Strategy
- Beginning of sales

2011

2014

2016

2017/2018

2006

2013

2015

2017

Lauréat du concours national d'entreprises innovantes en catégorie "Emergence"



Prix de l'innovation



Lauréat du concours national d'entreprises innovantes en catégorie "Création développement"



CLEAN TECH OPEN FRANCE

Finaliste Trophée Cleantech Open France



Lauréat du trophée SILICON VALLEY INNOVATION TOUR

CCI ALSACE EUROMÉTROPOLE

Lauréat concours TANGO & SCAN



Lauréat du trophée PME INNOV ECO

POLLUTEC 2016

Finaliste du trophée de l'innovation



Lauréat du trophée "Mesures QAI innovantes"

Fundraising campaign

- US & Canada targets
- New products on portfolio
- Campaign of internal recruitment



Expertise



Conviction



Responsability



Humanism

Director & CEO

Stéphanette Englaro

Research & Innovation Center

Senier scientific advisor

Stéphane Le Calvé

R&D Project Manager

Claire Trocquet

PhD student (CIFRE)

Florian Noel

PhD student (Marie Curie European project)

Irene Lara Ibeas

Ali Sharifi

Sulaiman Kahn

Gustavo Coehlo

Ricardo Brandner



Product Development & Customer Service

Project Manager

Vincent Person

Project Manager

Pierre Bernhardt

Customer service and logistic operation

XXX

Sales & Marketing Department

Technical Business Developer Manager

Khalid El Gersifi

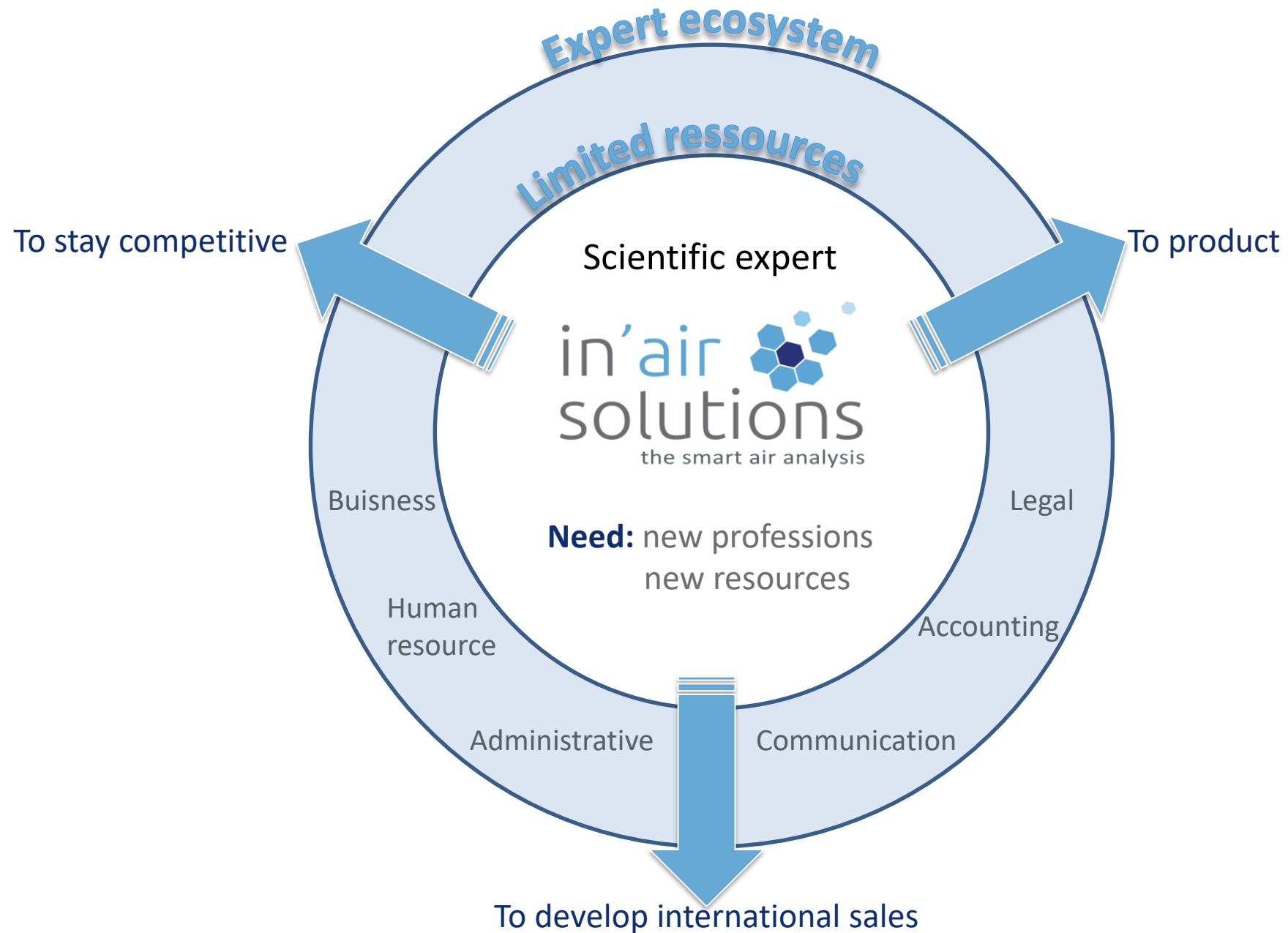
Junior Marketing and communication

Mathias Brabant

External Experts

Financial and administrative Manager

Thierry Mignot







3. Industrialization

Industrial ecosystem: Manufacturer

TRONICO

TRONICO

ALCEN

FOUNDATION

1973

LOCATION

Saint-Philbert-de-Bouaine
France

ACTIVITY

Electronic
Manufacturing
Services

EMPLOYEES

720
60 – R&D dpt

SALES REVENUE

63 Million EUR

INFORMATION

Part of ALCEN



AEROSPACE
DEFENCE &
SECURITY



MEDICAL



BIOTECHNOLOGY



ENERGY



TRANSPORT



INDUSTRY

THURMELEC



FOUNDATION

2004

LOCATION

Pulversheim
France

ACTIVITY

Study Development
Manufacturing
Electronics systems

EMPLOYEES

50

SALES REVENUE

6.8 Million EUR

INFORMATION

Unit production
2500 m²



MEDICAL



INDUSTRY



SECURITY



TRANSPORT

Laboratory prototype 1



28 × 23 × 38 cm
~ 12 Kg
No battery
Computer software
Reagent consumption 60 ml.h⁻¹

Commercial instrument

Manufacturer Tronico



32 x 28x 15 cm
~ 6 kg
Battery
Smart embedded software
Reagent consumption 1.2 mL.h⁻¹
Vial built-in support
Remote communication

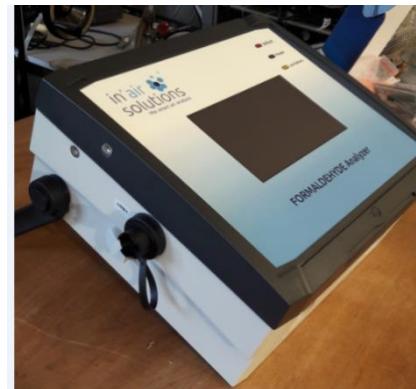
Laboratory prototype 2



33 x 45x 15 cm
~ 5.5 kg
No battery
Computer software
Reagent consumption 1.2 mL.h⁻¹

Industrial A-prototype

Manufacturer Tronico



32 x 28x 15 cm
~ 6 kg
Battery
Smart Embedded software
Reagent consumption 1.2 mL.h⁻¹
No vial built-in support
No remote communication



In'Air μF-1

- Continuous Formaldehyde detection down to **1 ppb**
- No Interference
- **Real time** monitoring of Formaldehyde, Temperature and Humidity
- Low maintenance & easy & fast field implementation
- Smart embedded programmable software



In'Air μBTEX-1

- Real time BTEX detection down to **1 ppb**
- **High autonomy** of carrier gas
- Easy & quick calibration
- Smart embedded programmable software



In'Air 4WAYS-1

- Compatible with most market cartridge
- **Secured** collecting samples
- Easy calibration of Pressure & Flow
- Smart embedded programmable software

Objectives are:

- Continuous measurement of indoor air in three different homes
 - In 2 new and unoccupied homes;
 - In one home for several weeks;
- Determine concentrations of pollutants
 - Formaldehyde;
 - Benzene, Toluene, Ethylbenzene, m/p/o-xylene;
- Identify if one of the building materials contributes mostly to the emission of these pollutants



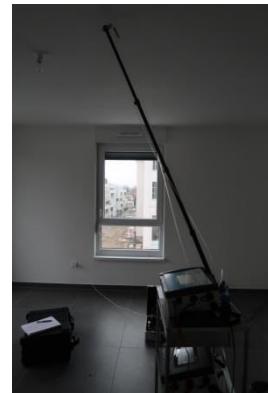
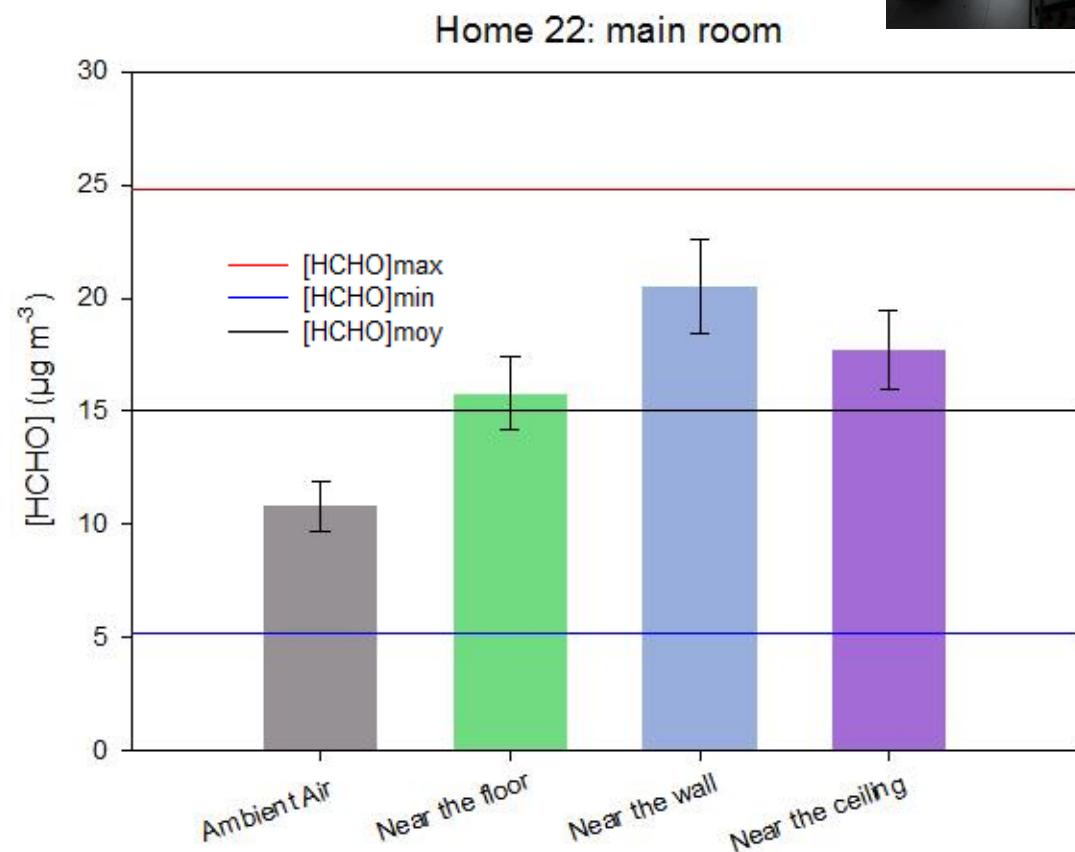
Equipment used:

- Formaldehyde measurement:
 - Formaldehyde micro-analyzer: **In'Air μF-1**, Industrial A-prototype
 - Reference method ISO 16000-3;
 - => Sampling on DNPH cartridges with our sampler **In'Air 4WAYS-1**, laboratory prototype;
 - => Cartridges analyses in laboratory with **HPLC-UV**.
- BTEX measurement :
 - BTEX micro-analyzer: **In'Air μBTEX-1**, Industrial A-prototype (field measurement) and Industrial Q-prototype (materials analysis)
 - Reference method ISO 16017-2;
 - => Sampling on Tenax cartridges with our sampler **In'Air 4WAYS-1**, laboratory prototype;
 - => Cartridges analyses in laboratory with **ATD-GC-FID**.

Formaldehyde measurement during 65 minutes in the room:

Concentration ($\mu\text{g m}^{-3}$)	
Mean	15.0
Max	24.8
Min	5.2

Sample line position	Mean Concentration ($\mu\text{g m}^{-3}$)
Ambient Air	10.8
Near the floor	15.8
Near the wall	20.5
Near the ceiling	17.7



Wall paint analysis during 75 min:

➤ Emission Rate calculation T :

$$T = \frac{C_{cell} \times D_{air}}{S_{cell}}$$

T : Emission rate ($\mu\text{g m}^{-2} \text{ h}^{-1}$)

S_{cell} : Material surface studied with the FLEC (m^2) = 0,01767 m^2

D_{air} : Flow rate applied in the FLEC (m^3/h) = 0.018 m^3/h

HCHO	
Mean concentration ($\mu\text{g m}^{-3}$)	7.7
Emission rate ($\mu\text{g m}^{-2} \text{ h}^{-1}$)	7.8

➤ Exploitation:

Computational tools

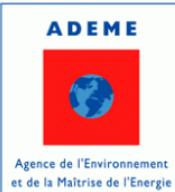
Room Volume	30.00 m^3
Door Surface	2.10 m^2
Window Surface	1.68 m^2
Ceiling and Floor Surface	12.00 m^2
Wall Surface	31.22 m^2
Air change rate	0.50 h^{-1}

In a characteristic room with a wall surface of 31 m^2
 => 16 $\mu\text{g m}^{-3}$ of HCHO are potentially generated in the room

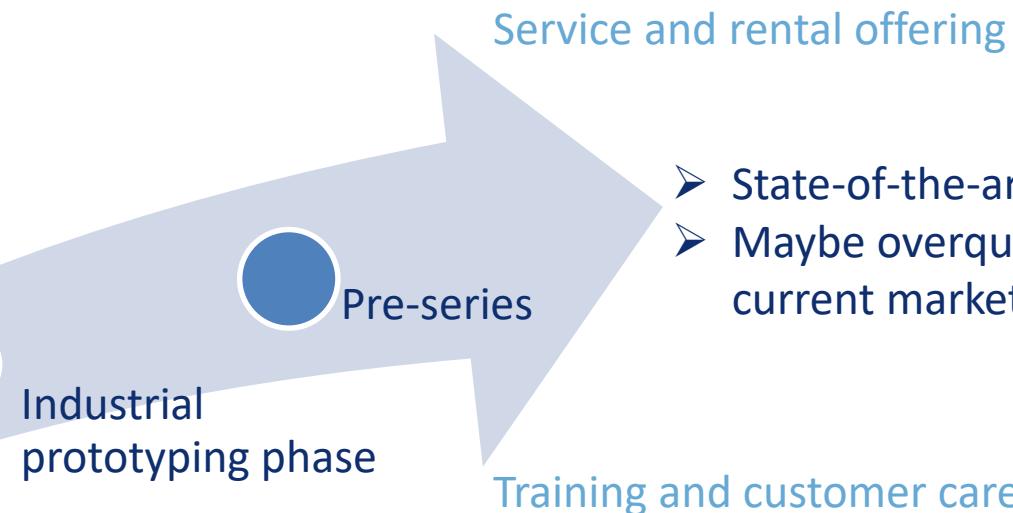
5. Conclusion



Proof-of-concept



bpi**france**



in'air
solutions
the smart air analysis



Thank you for your attention!



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