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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Atmos'*fair* 2017 - Lyon - 10 & 11 October 2017

Outline

Views

and

1. General Background

5. Conclusion

2. Laboratory Research

3. Industrialization

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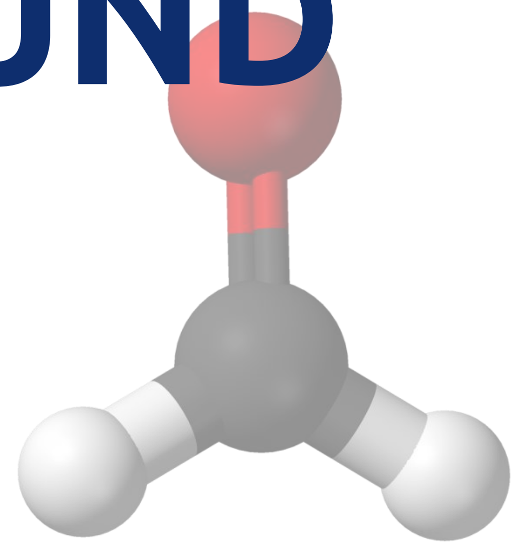
GENERAL BACKGROUND

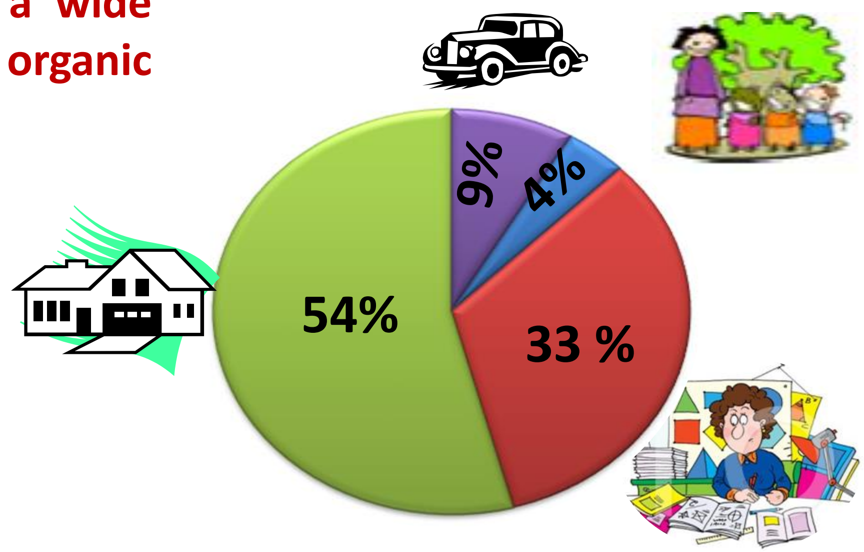


IAQ/ Formaldehyde

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)



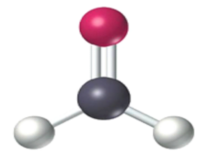
Sick building syndrome [2]:

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

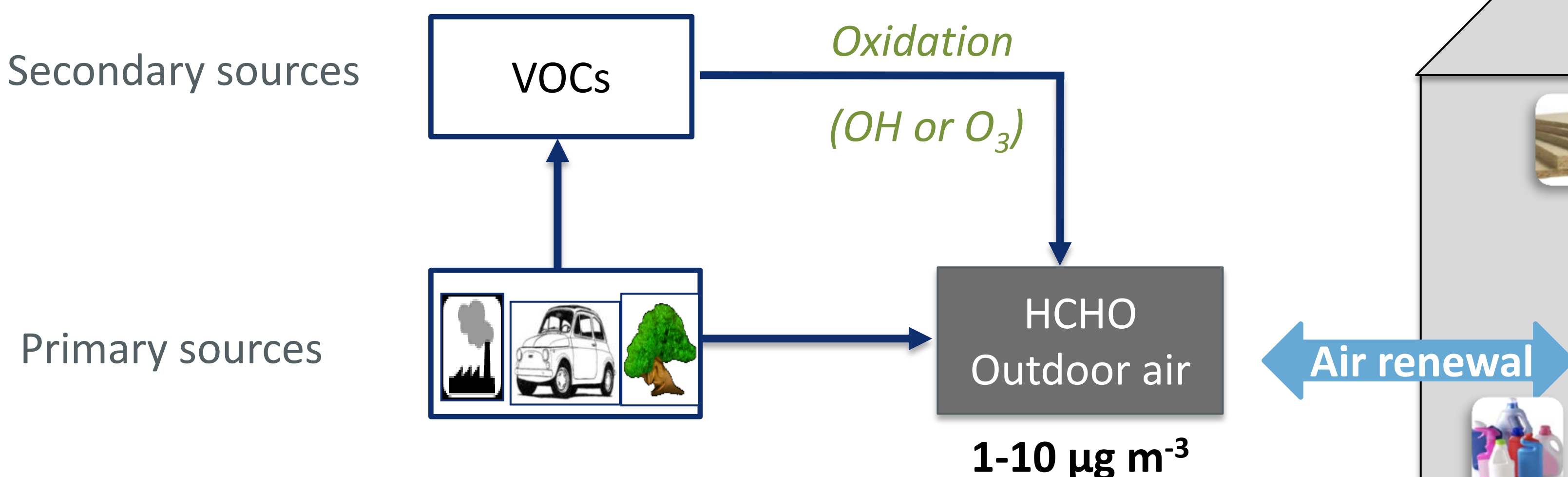
- ✓ **Asthma**
- ✓ **Cancer**

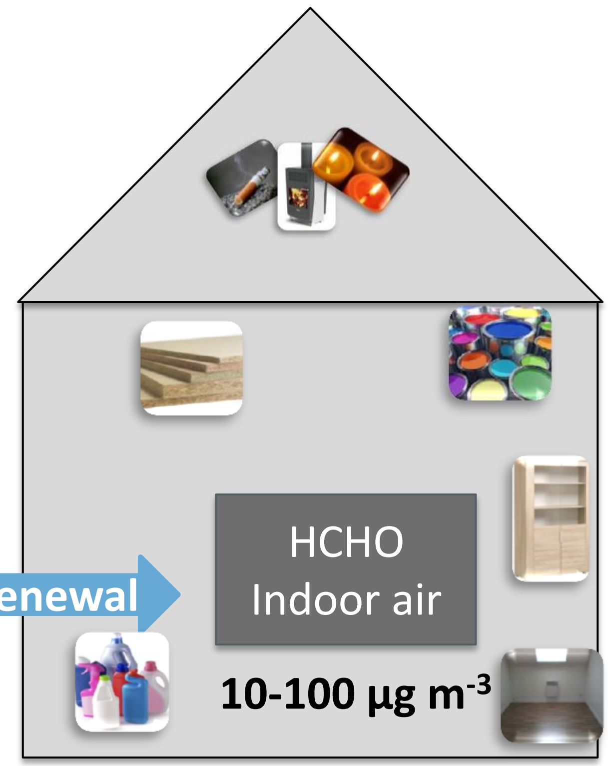
[1] World Health Organisation
[2] R. Kostiainen, Volatile organic compounds in the indoor air of normal and sick houses, Atmos. Environ. 29 (1995) 693–702

HCHO: Formaldehyde



Formaldehyde Sources [3]





[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]
Benzene	Human carcinogenic class A (leukaemia)
Toluene	Harmful to Nervous central system
Ethylbenzene	Pneumonitis
Xylenes	Liver and kidney disorder
Formaldehyde	❑ Irritation of eyes and respiratory tract ❑ Human carcinogenic ❑ Co-factor of allergic asthma

Guide values[5]	2013	2018
Concentration ($\mu g\ m^{-3}$)	5 (1.6 ppb)	2 (0.6 ppb)

Guide values[5]	2018	2023
Concentration ($\mu g\ m^{-3}$)	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] Decret n°2011-1727 of December 2011 for Indoor air French guides values

LABORATORY RESEARCH

Objectives

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

- Temporal resolution < 10 min
- Reagent autonomy: Very low consumption
- Limit of detection < 1.5 µg m^{-3}
- HCHO selectivity
- Ultra portable: Size < 4 kg

Formaldehyde monitoring in public indoor air starting 2018[6]

[6] Decret n°2011-1728 of December 2011 for Indoor air monitoring-French government

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

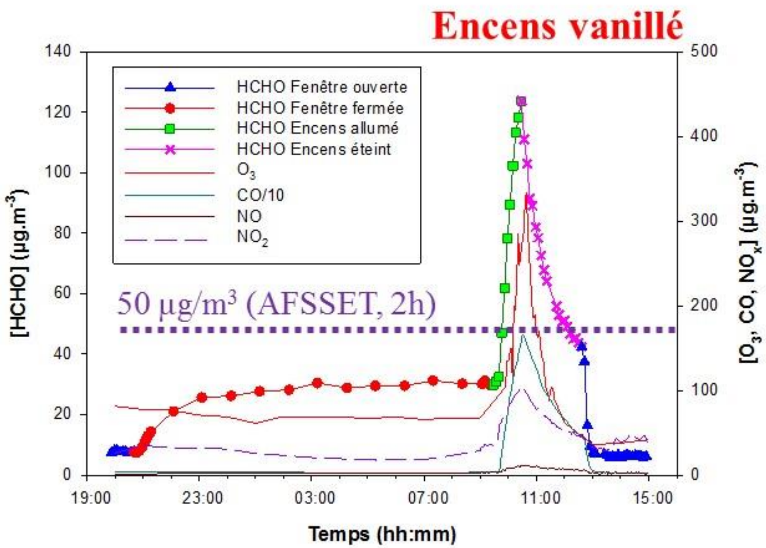
Results :

- 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)

2nd real time method for formaldehyde analysis

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

Low energy high school

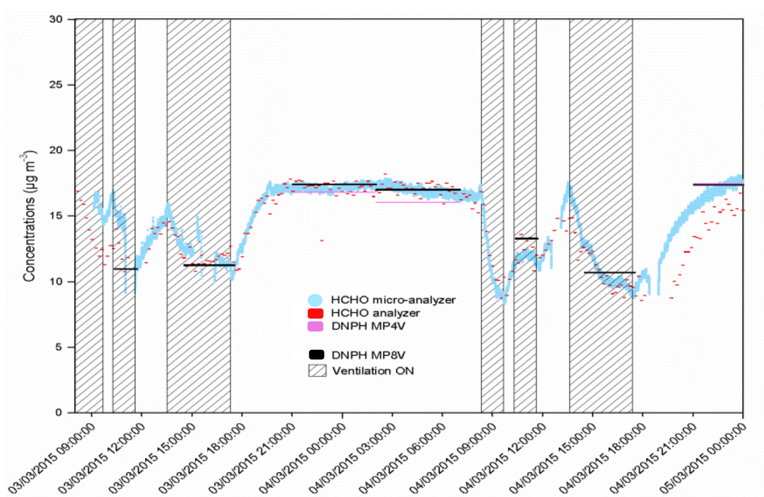
Main objective : characterization of IAQ and description of processes responsible for pollutants occurrence in indoor air of low energy public buildings.

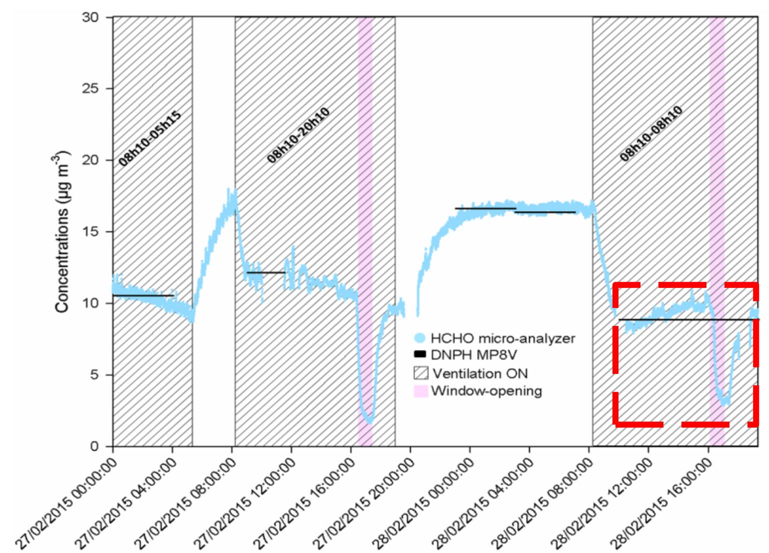
Delivery date	August 2011
Region	North
Type of public access building	College
Energetic performance level	VHEP
Primary energy consumption[1] (kW m^{-2} an^{-1})	70
Standard Primary energy consumption (kW m^{-2} an^{-1})	135

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

3. Industrialization

Who we are?

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

2006

Beginning of R&D works

University of Strasbourg & CNRS

2011

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

Prix de l'innovation

2013

Creation of In'Air Solutions

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

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

2014

1st Funding Raising of 1.2 M€

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

Finaliste Trophée Cleantech Open France

Lauréat du trophée SILICON VALLEY INNOVATION TOUR

Lauréat concours TANGO & SCAN

Lauréat du trophée PME INNOV ECO

2015

Finaliste NOVA INNOVATION (WASHINGTON)

2016

Market Launch

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

POLLUTEC 2016

Finaliste du trophée de l'innovation

2017

Lauréat du trophée "Mesures QAI innovantes"

2017/2018

Fundraising campaign

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

Value

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

migrate microfluidics

Clean Sky

Product Development & Customer Service

Project Manager
Vincent Person

Project Manager
Pierre Bernhardt

Customer service and logistic operation
XXX

Sales & Marketing Department

Technical Business Developper Manager
Khalid El Gersifi

Junior Marketing and communication
Mathias Brabant

External Experts

Financial and administrative Manager
Thierry Mignot


Expert ecosystem
Limited ressources
To stay competitive
To product
Scientific expert
in'air solutions
the smart air analysis
Buisness
Legal
Need: new professions
new resources
Human resource
Accounting
Administrative
Communication
To develop international sales

Bronkhorst® FRANCE

flow TECHNIQUE

interchim

Swagelok

HAMAMATSU Photon is our business

postnova analytics

Farnell element14

Cil

Hellma® Analytics High Precision in Spectro-Optics

AIR MONITORS Quality - Service - Innovation

SP Schwarzer Precision

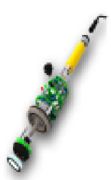
IDIL FIBRES OPTIQUES

Industrial ecosystem: Manufacturer

TRONICO

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

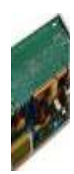

AEROSPACE DEFENCE & SECURITY


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 m^2


MEDICAL


INDUSTRY


SECURITY


TRANSPORT

3. Industrialization — *HCHO prototype evolution*

Laboratory prototype 1

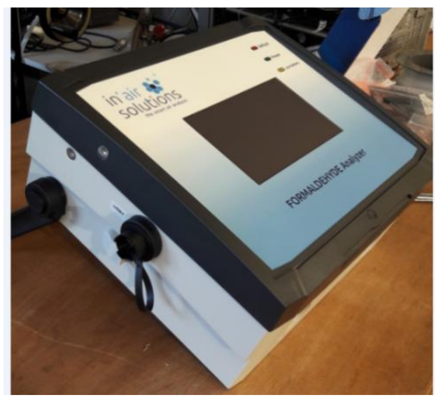
28 × 23 × 38 cm
~ 12 Kg
No battery
Computer software
Reagent consumption 60 ml.h^{-1}

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

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

3. Industrialization — *Portfolio*

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 differents home
  - In 2 new and unoccupied home;
  - In one housing for several weeks;
- Determine concentrations of polluants
  - 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**.

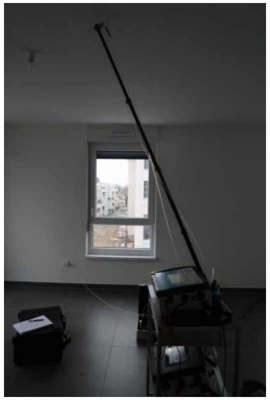
- BTEX measurement :
  - BTEX micro-analyzer: **In'Air µBTEX-1**, Indutrial A-protoype (field measurement) and Indsutrial Q-prototype (materials analysis)
  - Reference method ISO 16017-2;

    => Sampling on Tenax cartridges with our sampler **In'Air 4WAYS-1**, laboratory prototype;

    => Cartridges analyses in laboratory with **ATD-GC-FID**.

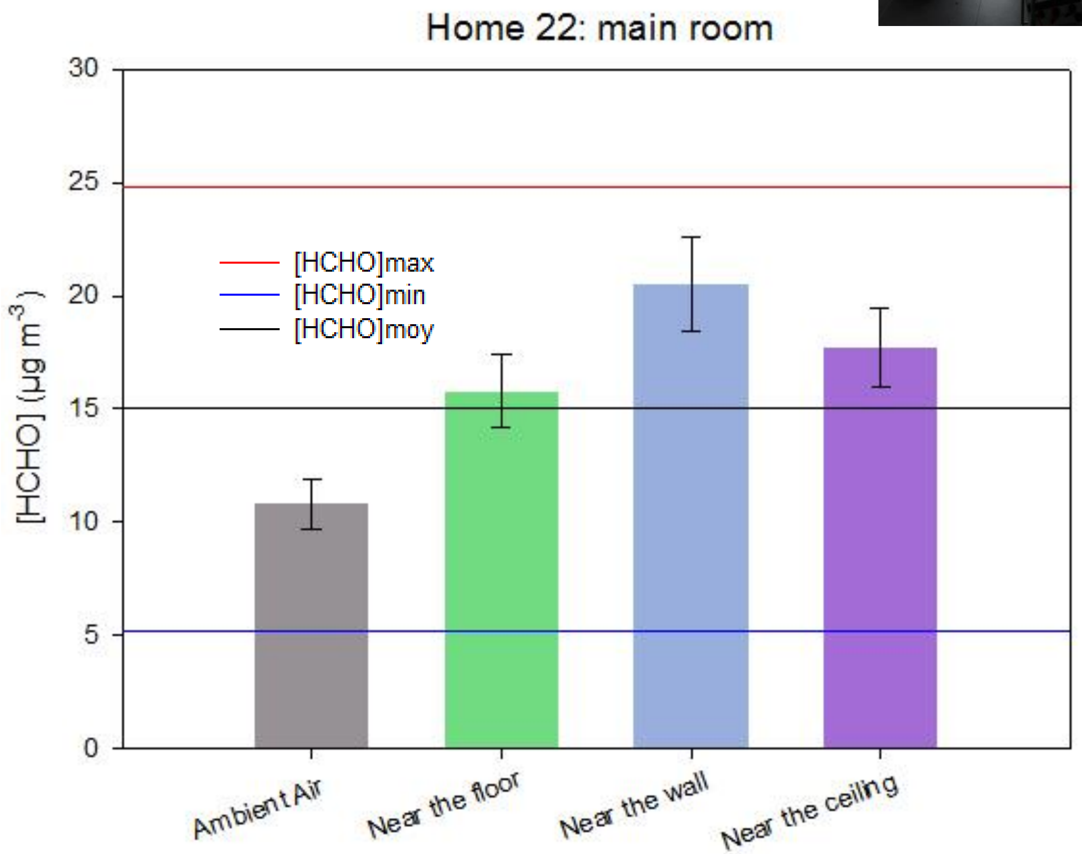
Study performed in february 2017 with ALCYS and ILLIOS as part of EkO_2 project.

Formaldehyde measurement during **65** minutes in the room:



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

Sample line position	**Mean Concentration ($\mu g\ m^{-3}$)**
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 (µg m^{-2} 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 (µg m^{-3})	7.7
Emission rate (µg m^{-2} 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 Suface	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 µg m^{-3}** of HCHO are potentially generated in the room

5. Conclusion

Laboratory R&D

Proof-of-concept

Industrial prototyping phase

Pre-series

Service and rental offering

- State-of-the-art equipment
- Maybe overqualified for current market needs

Training and customer care

Grand Est ALSACE CHAMPAGNE-ARDENNE LORRAINE

CONECTUS RECHERCHE COLLABORATIVE & TRANSFERT DE TECHNOLOGIES SATT ALSACE

cnrs

UNIVERSITÉ DE STRASBOURG

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

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RÉPUBLIQUE FRANÇAISE Ministère de l'Écologie, du Développement durable et de l'Énergie

ADEME Agence de l'Environnement et de la Maîtrise de l'Energie

SEMIA INCUBATEUR D'ALSACE

in'air solutions the smart air analysis

Thank you for your attention!

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