Trapping of VOCs and carbonyl compounds emitted by particleboards used in furniture industry.

N. PIAZZON, G. Freund , H. Nouali, B. Lebeau, J. Patarin, T. Miclo

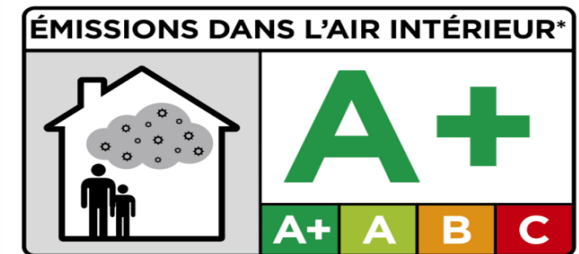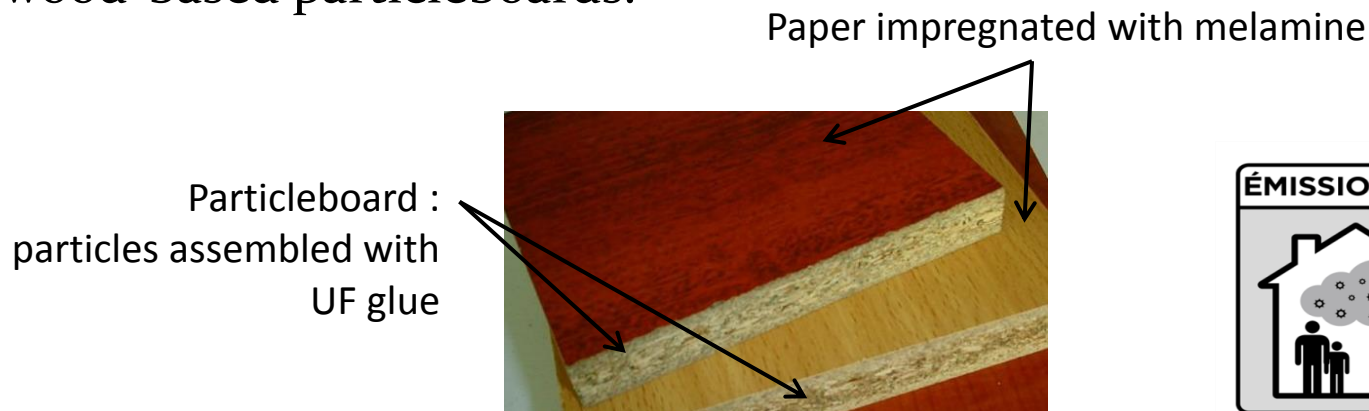Inovame, 4 rue de Bruxelles, F-67520 Marlenheim, France
Equipe Matériaux à Porosité Contrôlée (MPC), Institut de Science des Matériaux de Mulhouse (IS2M), UMR 7361, Institut JBD, 3 bis rue Alfred Werner, F-68093 Mulhouse, France.

Context and objective

The quality of indoor air has became a public health question. One source of indoor pollution is the modern furniture made of particleboards. In order to regulate these emissions, a regulation similar to the one concerning new building products (decret of 23rd March, 2011) will be in application in 2020 for furniture.

The objective of this project is to find a way to reduce VOCs and carbonyl compounds (particularly formaldehyde) emitted by furniture made with wood-based particleboards.

Paper impregnated with melamine

Particleboard :
particles assembled with
UF glue

ÉMISSIONS DANS L'AIR INTÉRIEUR*

A+

A+ A B C

Outline

- VOCs and carbonyl compounds emitted by particleboards

- Adsorption of VOCs and carbonyl compounds by zeolites

- Evaluation of formaldehyde and VOCs adsorbents
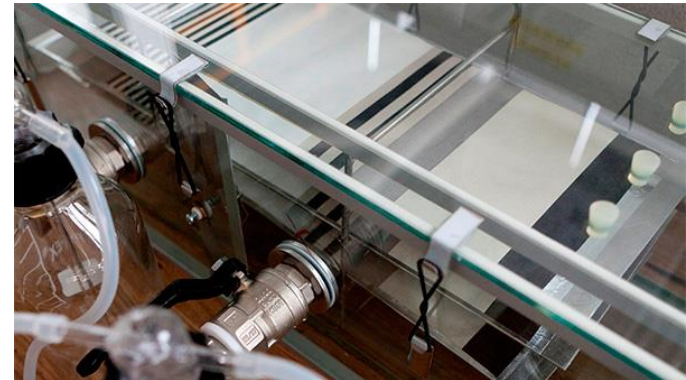
directly incorporated in furniture

- Conclusions

VOCs and carbonyl compounds emitted by particleboards

Identification of VOCs and carbonyl compounds emitted by particleboards (EN-717-1):

  Humidity rate = 50%

  Temperature : 19°C

  Charge rate : $(1 \pm 0{,}02)m^2/m^3$

HPLC-UV (DNPH cartridge)
- **Carbonyl compounds**: formaldehyde, acetaldehyde, aceton, propanal, butanon, butyraldehyde, benzaldehyde, tolualdehyde

TD-GC-MS (Air Toxic cartridge)
- **Wood essence**: α-pinène, β-pinène, camphene, 3-carene, limonene, carenol
- **Alkanes, alcenes, esters**

The formaldehyde concentration increases with the temperature and humidity rates:
- UF glue degradation under the influence of temperature
- UF glue hydrolysis under the influence of humidity

VOCs and carbonyl compounds emitted by particleboards
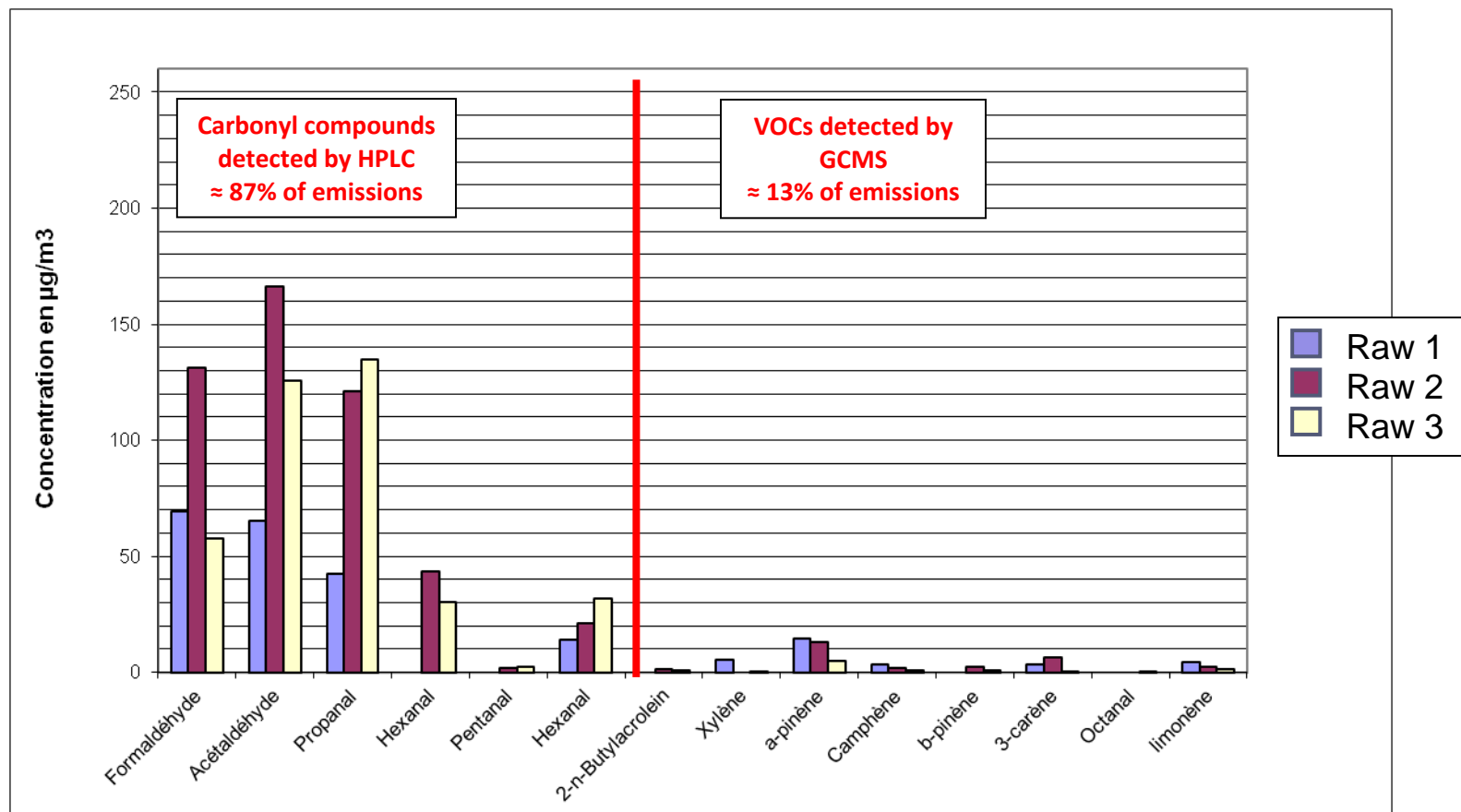
VOCs and carbonyl compounds emitted by particleboards

Comparison of VOCs and carbonyl compounds emission rates

Particleboards	Raw	Melaminated	Finish foil
Carbonyl compounds *	466 μg/m^3	280 μg/m^3	140 μg/m^3
VOCs **	68 μg/m^3	85 μg/m^3	78 μg/m^3
% VOCs	13%	23%	36%
% carbonyl compounds	87%	77%	64%

* Carbonyl compounds: Total concentration of species detected by HPLC/UV
** VOCs: Total concentration of species detected by GC/MS

Limit concentration of formaldehyde (OMS) = 100 μg/m^3 in 30 min

VOCs concentration similar for the three particleboards

Tendency of carbonyl compounds content:

Raw >> Melaminated > Finish Foil

Adsorption of VOCs and carbonyl compounds by zeolites

Zeolitic materials

- MFI-structure type (zeolite Silicalite-1)
- 3D channel system: 5.3 x 5.6 Å et 5.5 x 5.1 Å
- Pore volume : 0.18 cm^3/g
- Hydrophobic

- *BEA-structure type (zeolite β -Si)
- 3D channel system: 6.6 x 7.7 Å et 5.6 x 5.6 Å
- Pore volume: 0.23 cm^3/g
- Hydrophobic

- FAU structure type (zeolite 13X and EMC-1)
- 3D cage structure: 7.4 x 7.4 Å
- Pore volume : 0.30 cm^3/g
- Hydrophilic

Kinetic diameter of formaldehyde~ 2,8 Å

Adsorption of VOCs and carbonyl compounds by zeolites

Zeolites sprinkled on shelves of furniture made by particleboards

Zeolites	% Mass loss*	% water	% VOCs and carbonyl compounds	Concentration (mg/g)
Silicalite-1	3%	2%	1%	10
β-Si	4%	1%	3%	30
13X	18%	17%	1%	10
EMC-1	15%	15%	0%	0

*Measured by TGA

Adsorption capacities of VOCs and carbonyl compounds by zeolites:

$$\beta\text{-Si} > \textbf{Silicalite-1} \approx 13X$$

➢ Silicalite-1 was retained because the product is industrialized

➢ Trapping of carbonyl compounds: very low
➢ Trapping of VOCs: good

On the 1% of VOCs and carbonyl compounds adsorbed by silicalite-1, there are 99% of VOCs and 1% of carbonyl compounds.

➢ Solution to trap formaldehyde: chimisorption using an amide

Evaluation of formaldehyde and VOCs adsorbents directly incorporated in furniture

<u>Two measurement campaigns</u>

➢ Each measurement campaign is constituted by 6 pieces of furniture:
  3 references + 3 samples with an adsorbent-based formulation.

➢ Samples of the first measurement campaign contain:
  zeolite-based formulation.

➢ Samples of the second measurement campaign contain:
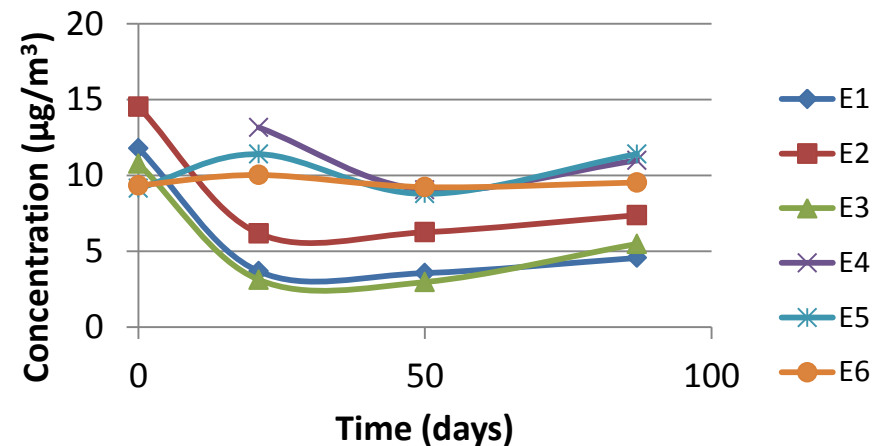 amide-based formulation and zeolite-based formulation.

Evaluation of formaldehyde and VOCs adsorbents directly incorporated in furniture

Zeolite-based formulation (First campaign)

Evolution of tolualdehyde concentration
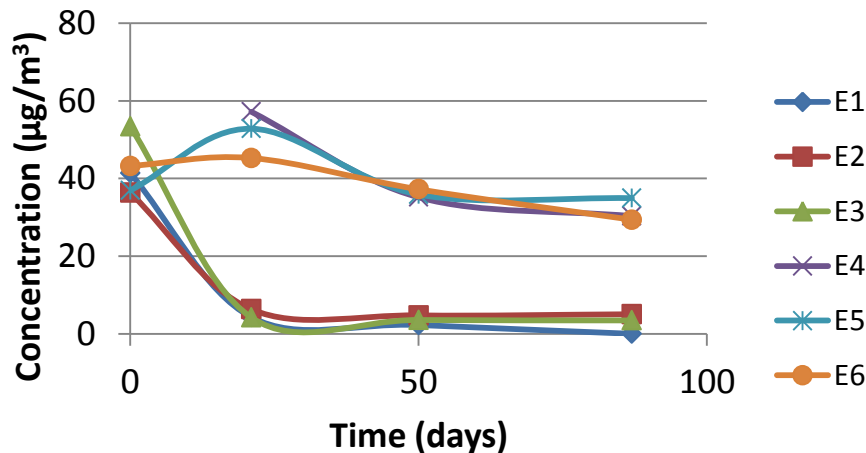
Evolution of benzaldehyde concentration

Adsorbents are in furniture during 80 days. References : E4, E5, E6

- **Decrease of tolualdehyde (88%) and benzaldehyde (65%) concentrations** in furniture atmosphere containing the zeolite-based formulation.
- **Formaldehyde is not trapped.**

Evaluation of formaldehyde and VOCs adsorbents directly incorporated in furniture

Zeolite-based formulation (First campaign)

Evolution of VOCs concentration

After 80 days in furniture

Peak surface area (counts/min)

References: E4, E5, E6
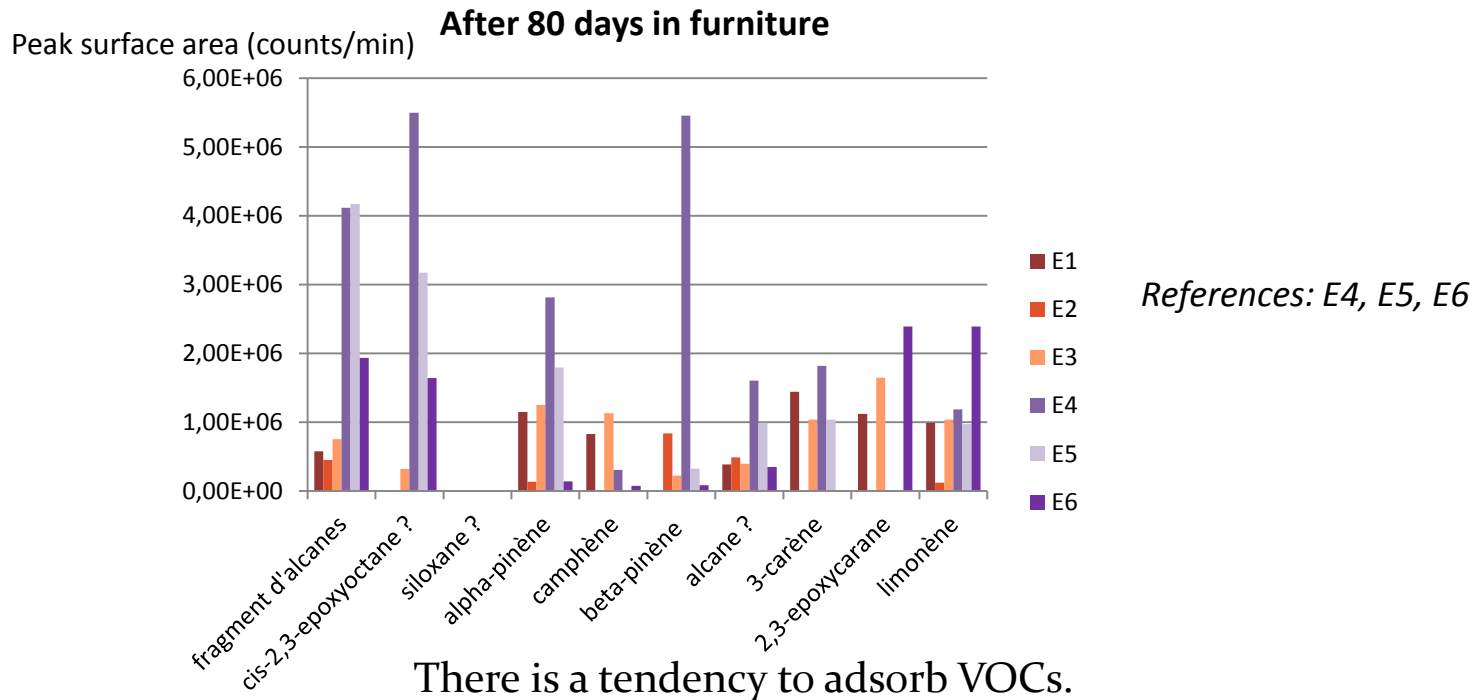
There is a tendency to adsorb VOCs.

The analyzes of VOCs adsorbed by a formulation which was three months in furniture show that about 2 wt% were adsorbed. **Identified adsorbed VOCs are mainly wood essence, like limonen known as an allergen compound.**

Evaluation of formaldehyde and VOCs adsorbents directly incorporated in furniture

Amide-based and zeolite-based formulations
(Second campaign).

Evolution of formaldehyde concentration

References: D1, D5, D6
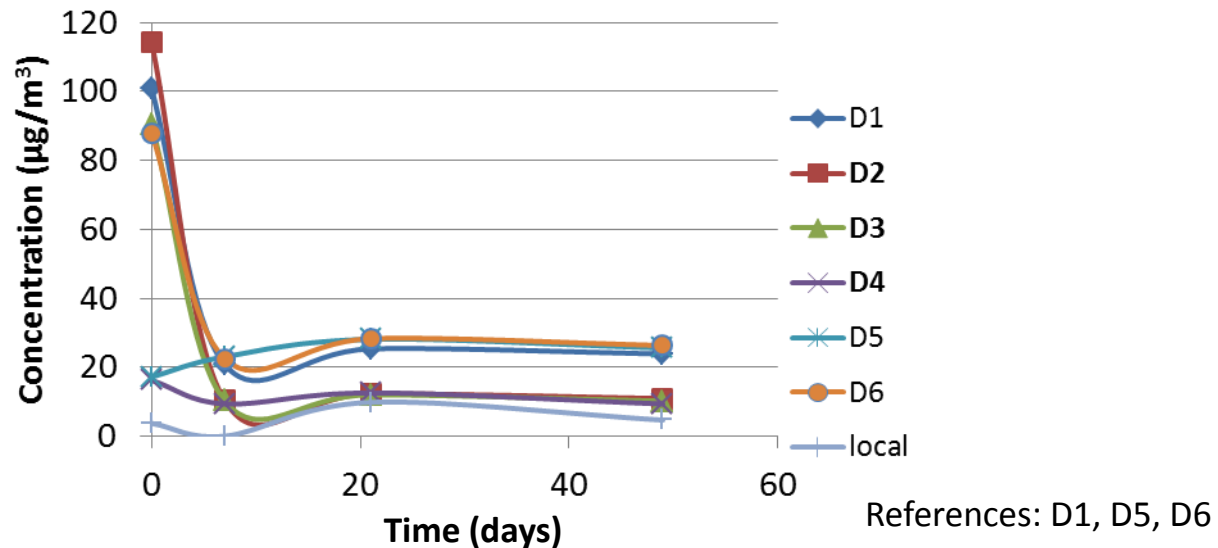
➢ **The formaldehyde concentration decreases of 60%.**
➢ **Tolualdehyde is totally trapped.**

Conclusions and prospects

- **Silicalite-1 zeolite was retained:**
    - produced at industrial scale
    - pore size diameter similar to kinetic diameter of some VOCs and carbonyl compounds
    - hydrophobic: no competition with water for the VOCs and carbonyl compounds adsorption.

- **Amide-based formulation allows to reduce the formaldehyde concentration of 60%.**
- **Zeolite-based formulation adsorbs 2 wt% of VOCs, decreases the concentration of tolualdehyde (-88%) and of benzaldehyde (-65%).**

- **A patent was submitted.**

In the future, trials will be performed in a measurement room simulating the environment of a classical room (17m³, control of temperature and humidity rate).

Acknowledgements

Thank you for your attention