Detection of volatile organic compounds (□□ Formaldehyde emissions) in wood based materials by using photoacoustic infrared spectroscopy

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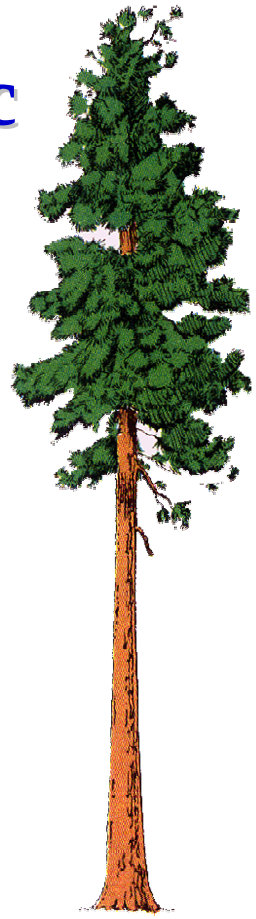

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- Conclusions

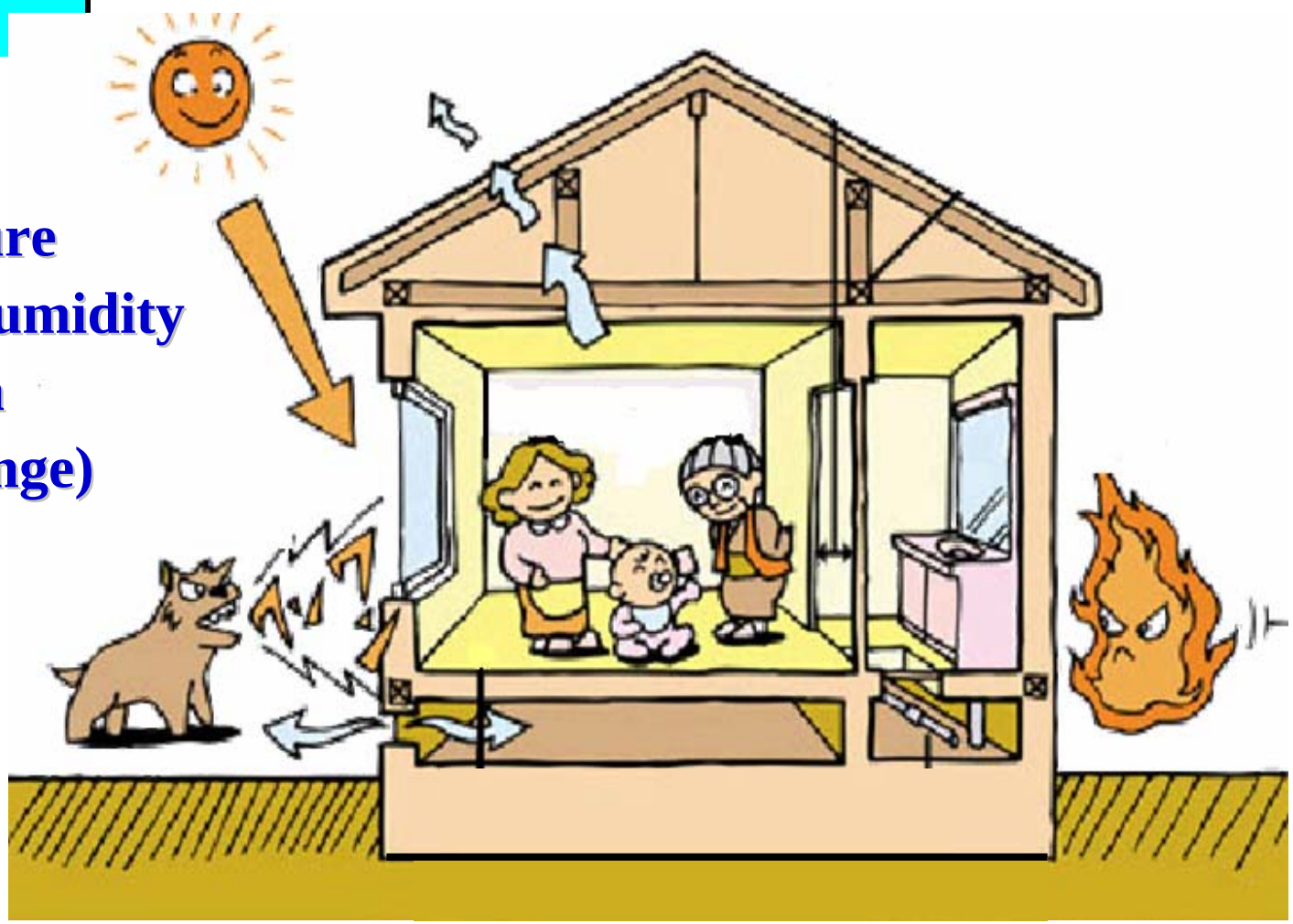
Introduction

Wood is a porous material that has an ability to modulate the moisture and thermal performances. Therefore, wood based materials are often used as constructive and decorative materials in building. However, the effects of volatile organic compounds (VOCs) (eg formaldehyde) from wood based materials have become a great concern of indoor air quality.

This study is to investigate the VOCs/formaldehyde by using the photoacoustic analysis to monitor and detect the wood based materials. In order to understand how to prevent the formaldehyde emissions and the related impacts of the concentrations to the indoor environment. Furthermore, to reduce the formaldehyde concentration is using the charcoal adsorbent (activated carbon) in the indoor.

Indoor Environment Quality

- Air
- Noise
- Lighting
- Temperature
- Relative Humidity
- Ventilation (Air exchange)



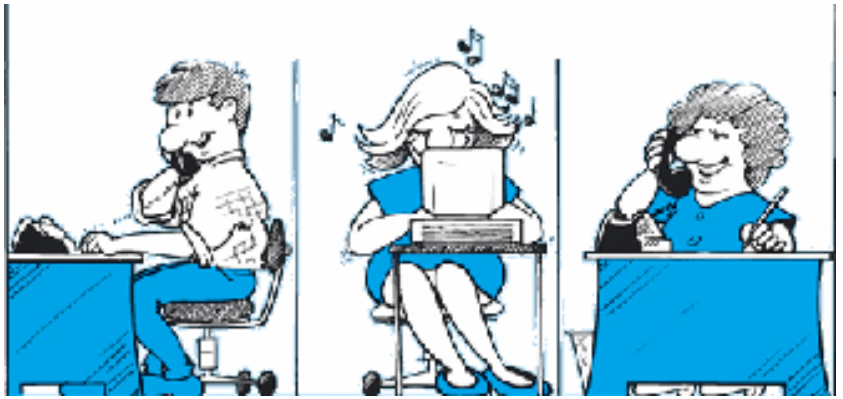
Why is indoor air quality a concern today?

High exposures indoor environment **(WHO1999;US EPA2000)**

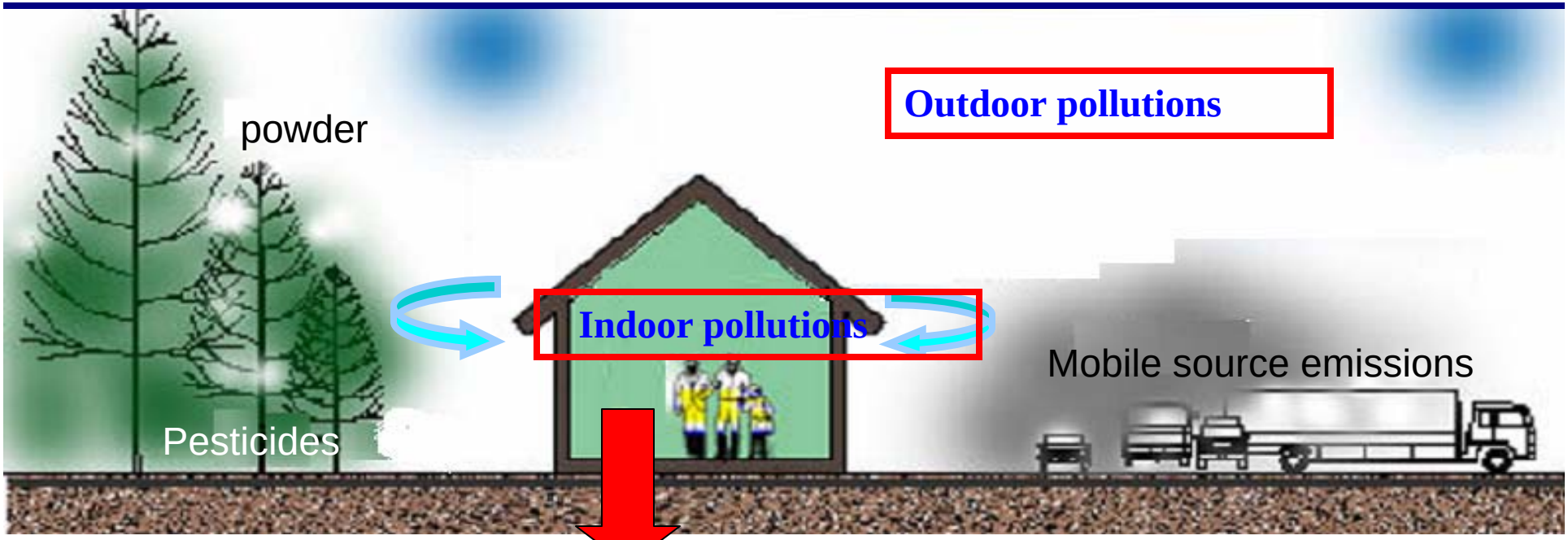
Typically up to 90% of time spent indoors

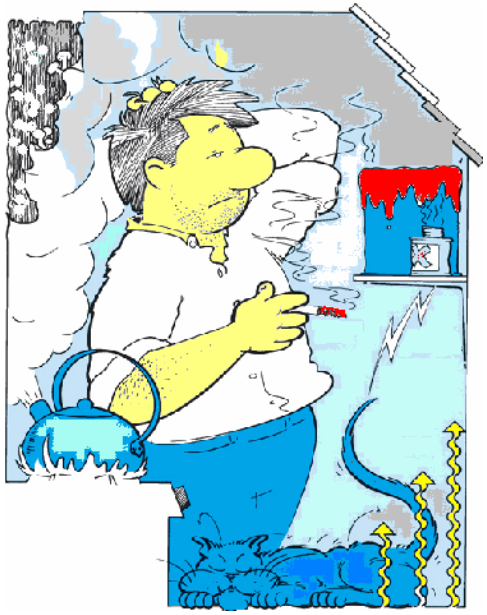
- **Unhealthy Indoor Air Problems**
  - **Illness (Sick symptom)**
  - **Injuries**
  - **Deaths**
  - **Increased medical costs**

- **healthy Indoor Air environments**
  - **Well-being**
  - **High productivity**
  - **Lower medical costs**



Indoor Air Pollutants Sources





- Tobacco Smoke
- Combustion Products
- Biological Contaminants
- Volatile Organic Compounds
- Formaldehyde
- Soil gases
- Pesticides
- Particles and Fibers

Objectives

The aim of this study is to detect formaldehyde(HCHO) emitted in the wood based materials, so that the technique can improve the indoor air quality.

Photoacoustic Analysis

- ✓Photoacoustic
- ✓LASER (light source)
- ✓Acoustic (receiver)
- ✓HITRAN

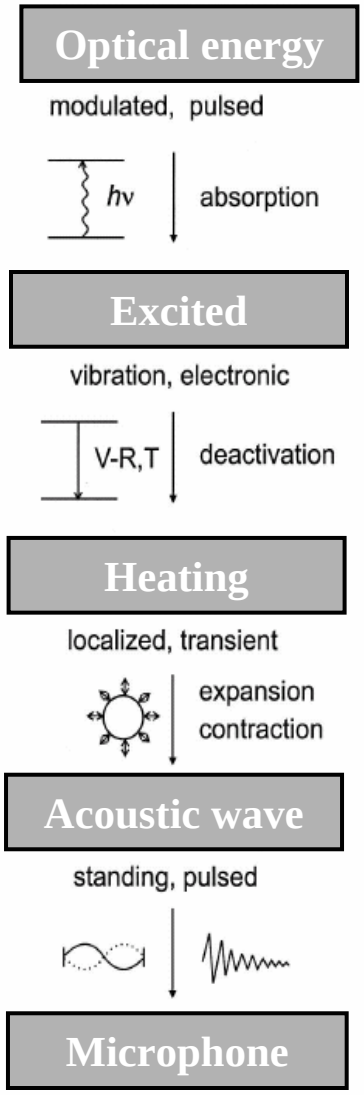
- •Setup Laser
- •Calculation
- •Background test

Formaldehyde Emissions vs. Environment

- ✓HCHO Emissions
- ✓Materials Emissions
- ✓Temperature & RH

Theory & Modeling

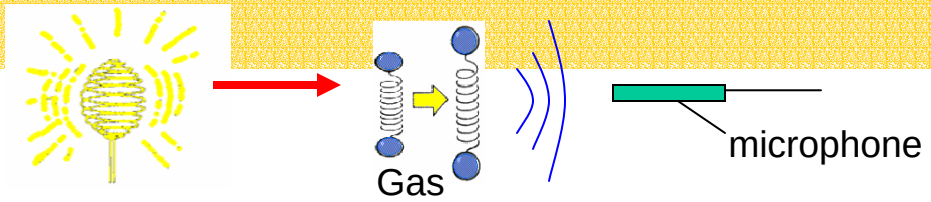
What's Photoacoustic



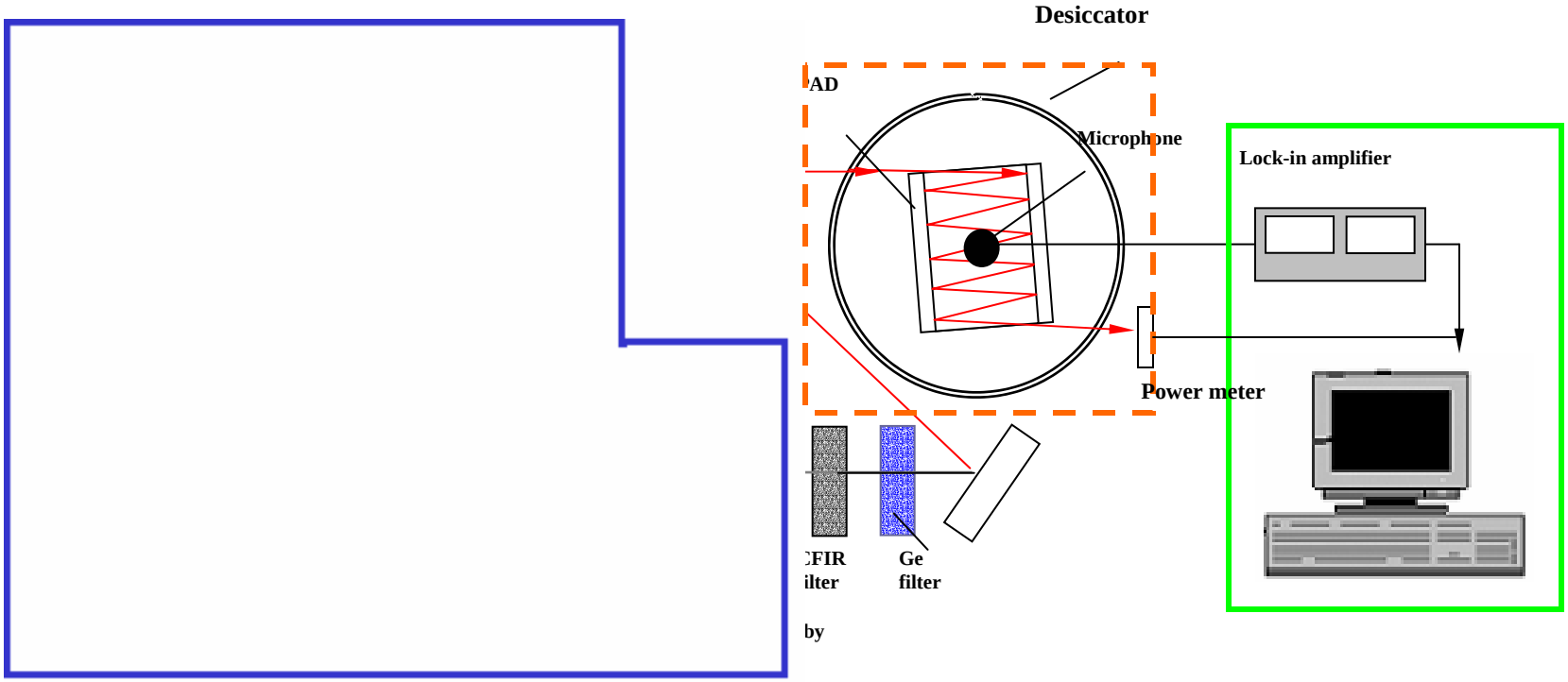
- ✓ The photoacoustic is a translation of *optical energy* in to *mechanical energy* by the sample (molecule).
- ✓ When illuminated by light of *specific wavelength*, the molecules become *excited*.
- ✓ The excitation process produces *kinetic energy* or *heat*.

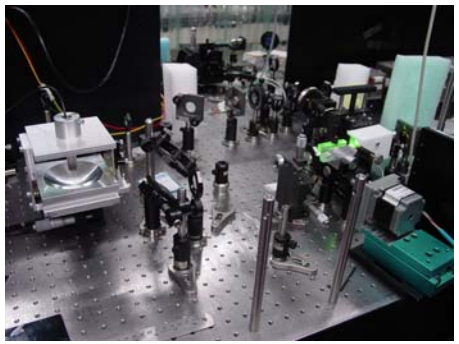
(The heating air expansion obtains the pressure variation as acoustic wave)

- ✓ The detector measures the acoustic wave produced by the sample (molecule).



The Photoacoustic Measurement Setup

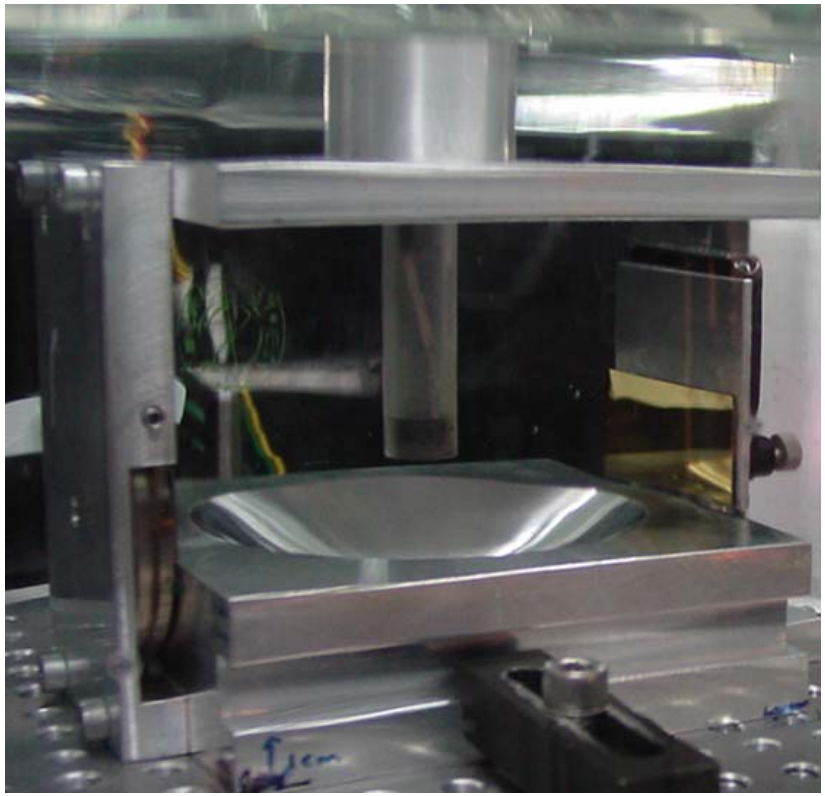


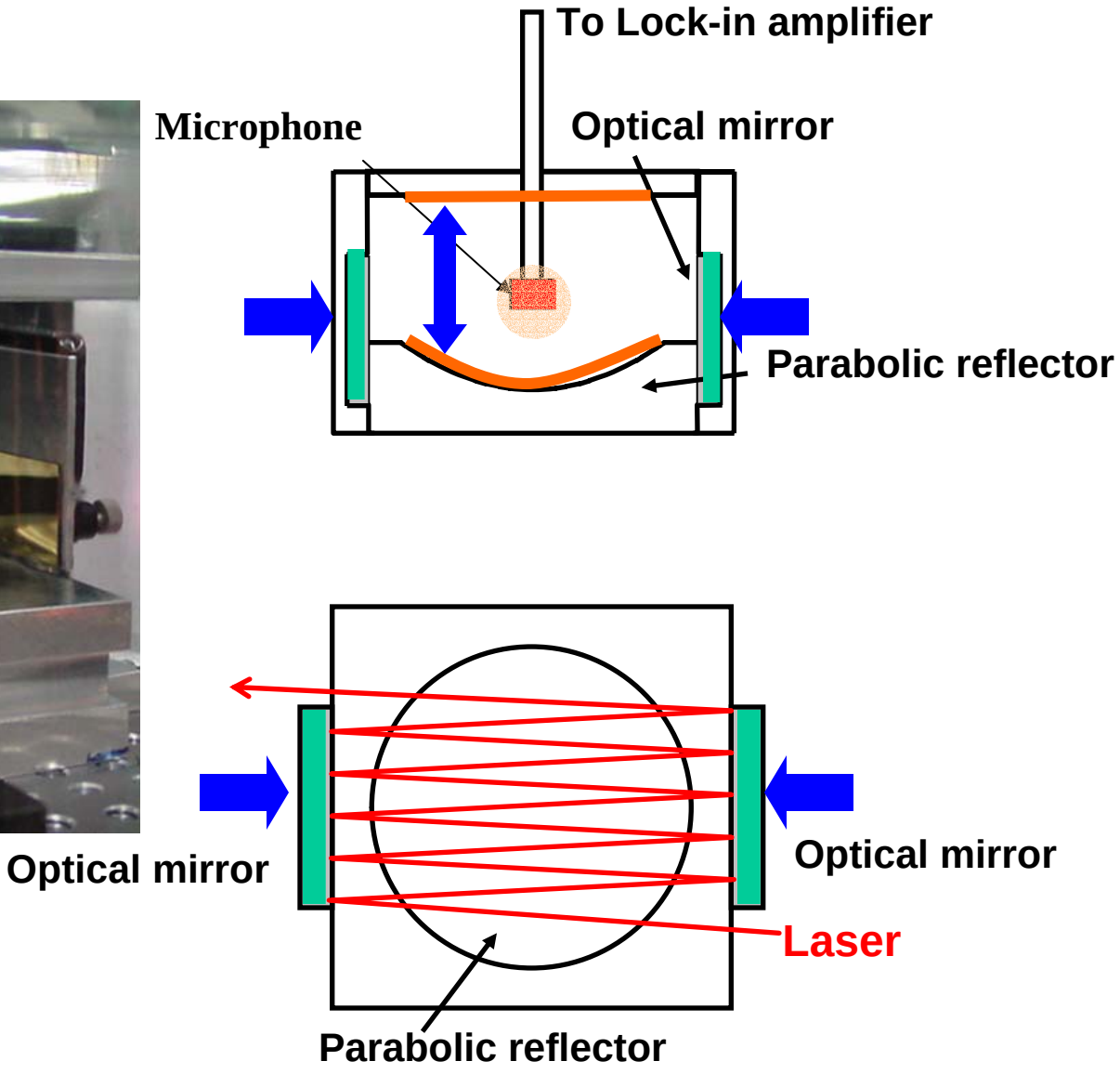


Using Laser Condition:

- ✓ Laser frequency: 2790 ~ 2810 cm^{-1}
- ✓ Laser power: 90mW (in front)
- ✓ Laser light path: 1.0 m (in MOPAD)
- ✓ Room temperature : 22°C±5°C
- ✓ Relative humidity: 60%± 5%

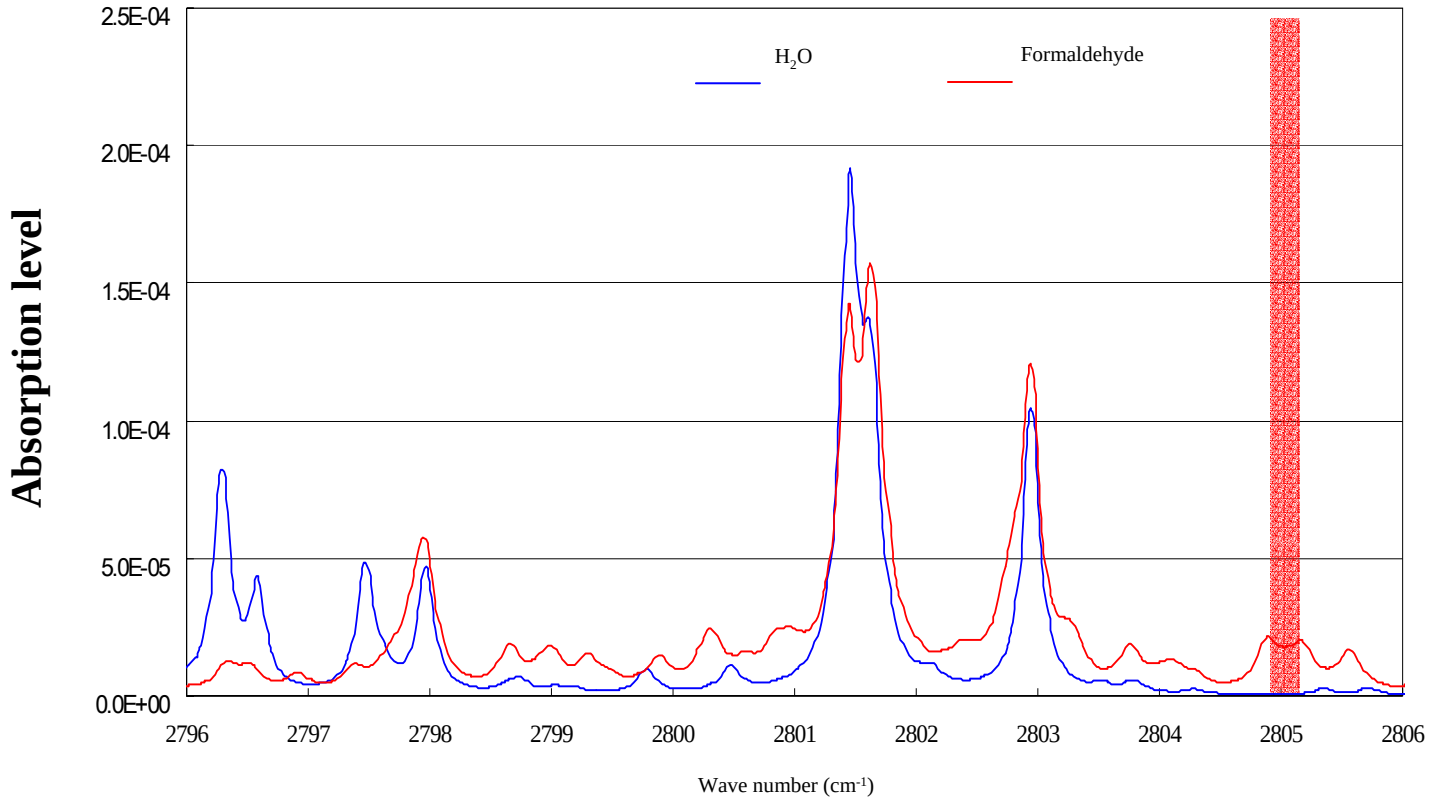
Multipass Acoustically Open Photoacoustic Detector (MOPAD)



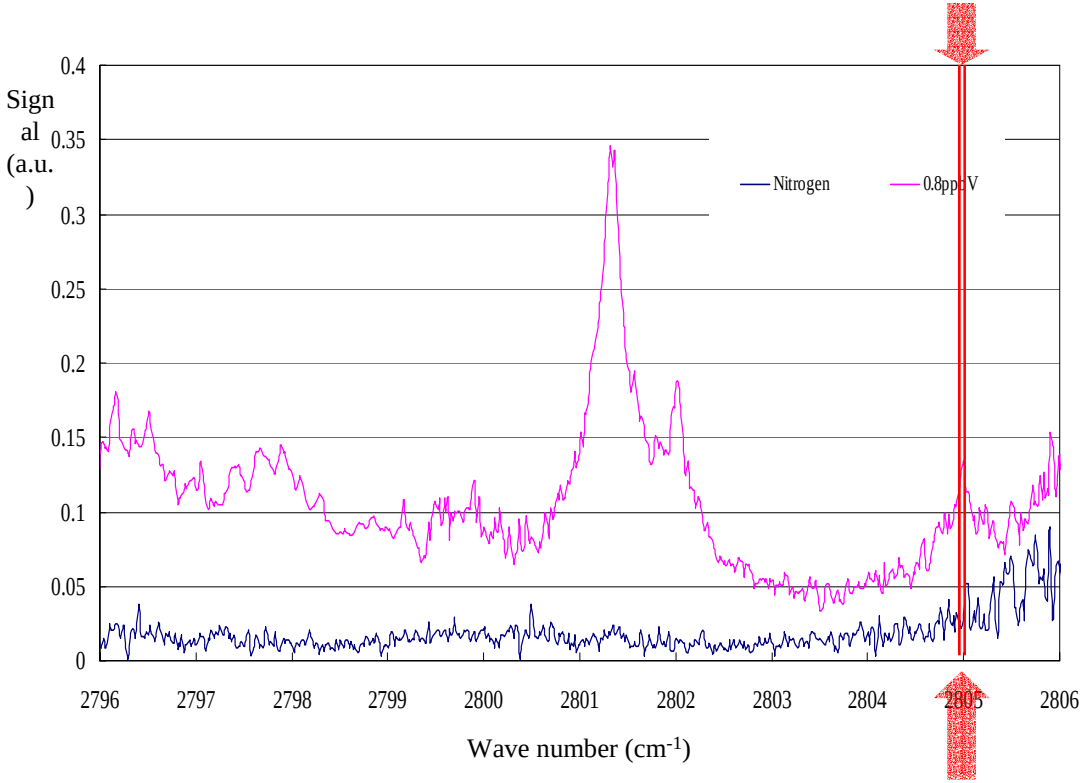


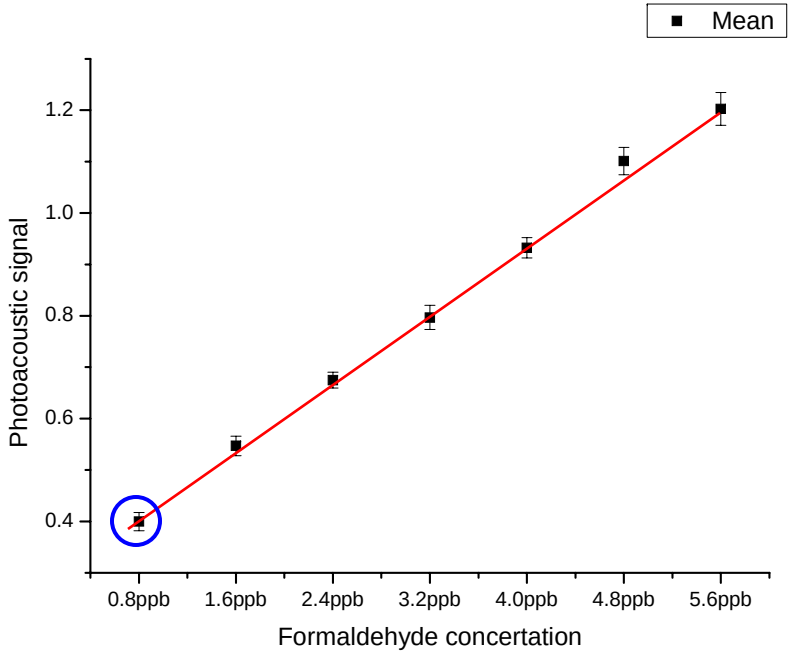
HITRAN vs. concentration levels (H_2O, H_2O with formaldehyde)

HITRAN (high-resolution transmission molecular absorption database)
--- is a compilation of spectroscopic parameters that use to predict and simulate the transmission and emission of molecular light.



Formaldehyde Test





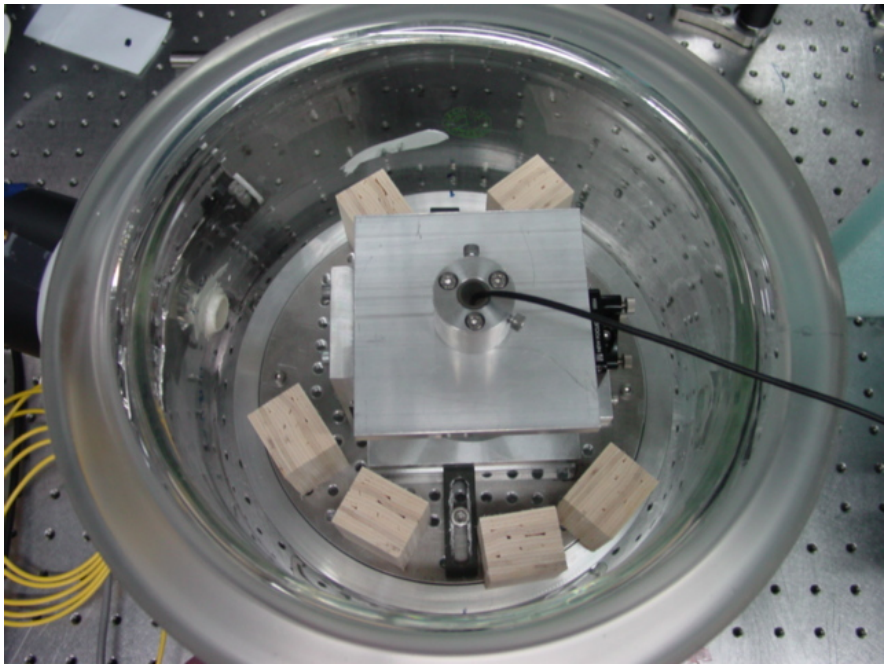
Time constant (τ)= 3 min. (200 meas.), laser power ~ 90 mW

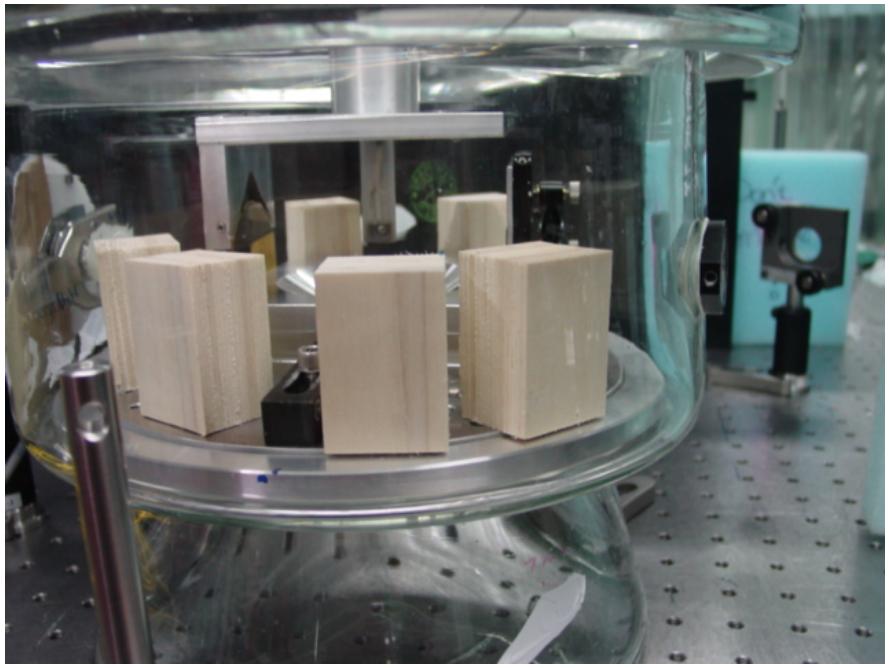
Total pressure 1 ATM, $\Rightarrow$ noise-equivalent sensitivity k=8.1×10^{-9} cm^{-1}W (Hz)$^{-1/2}$

The setting wave number for formaldehyde = 2805 cm^{-1}

The lowest level is 0.8 ppbV (10^{-3} mg/m^3)

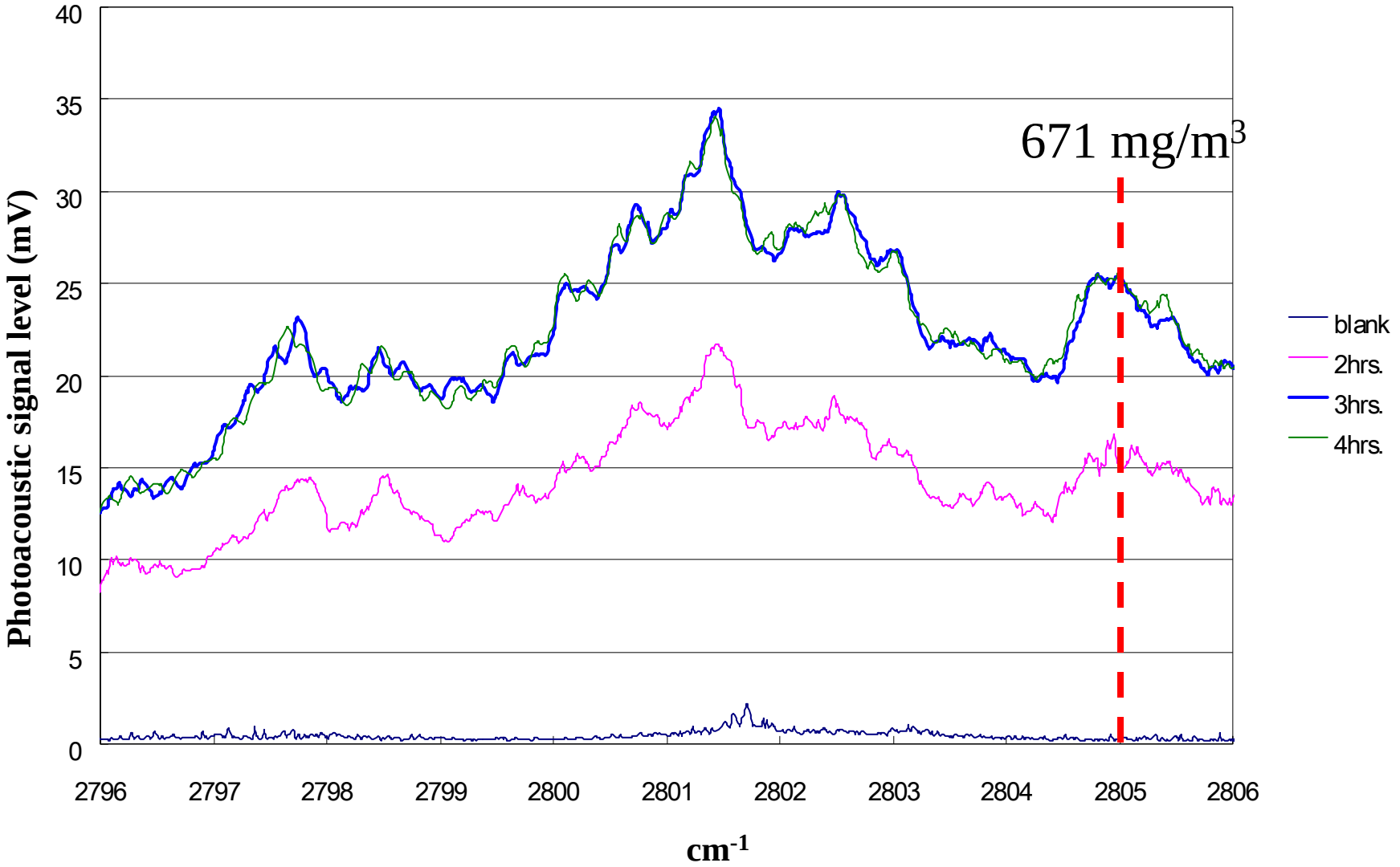
Laminated venner lumber samples



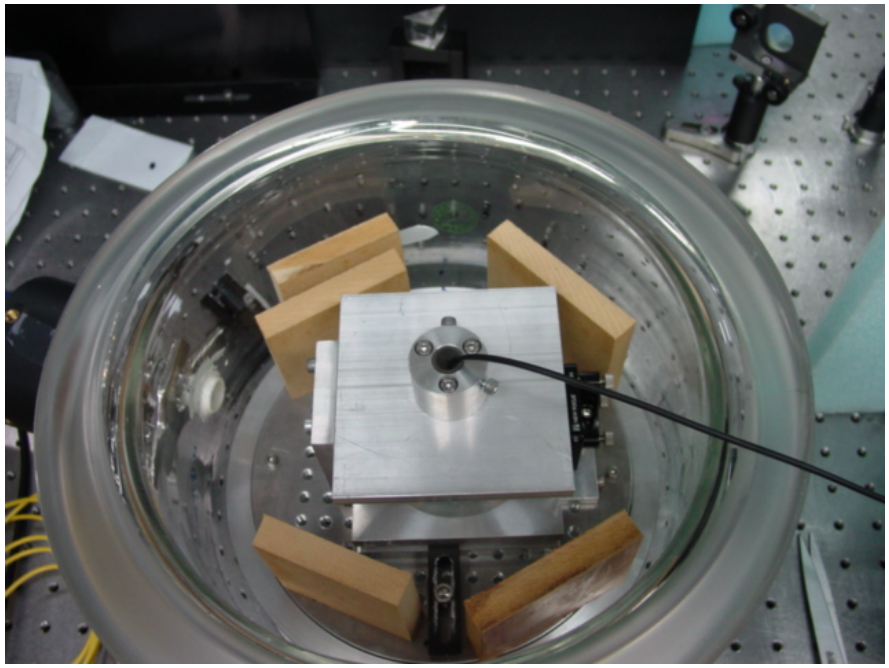


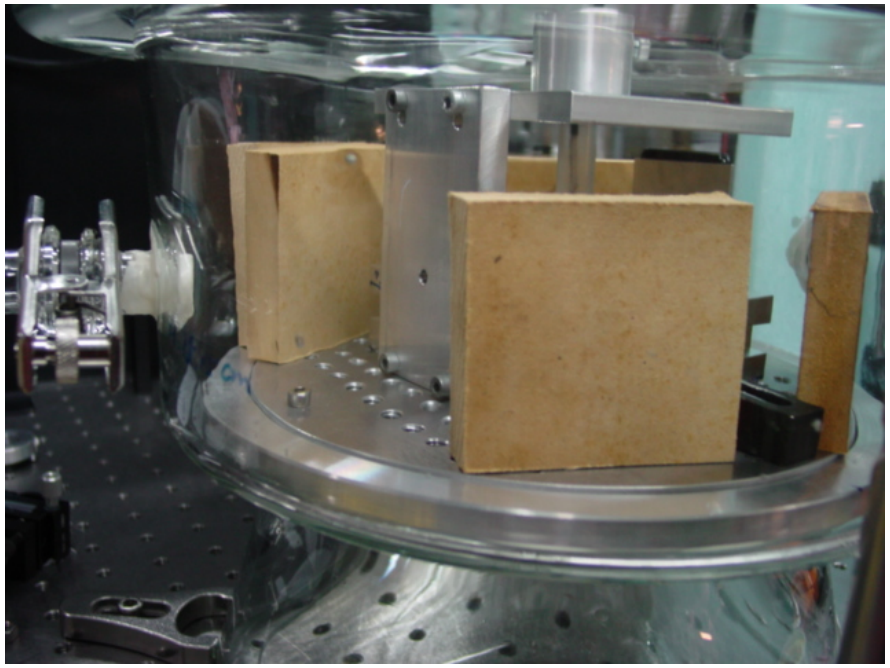
LVL sample
Load factor: 3.6 m^2/m^3
Room temperature : 22^{o}C$\pm$5^{o}C
Relative humidity: 60%$\pm$ 5%

Formaldehyde level of laminated venner lumber samples



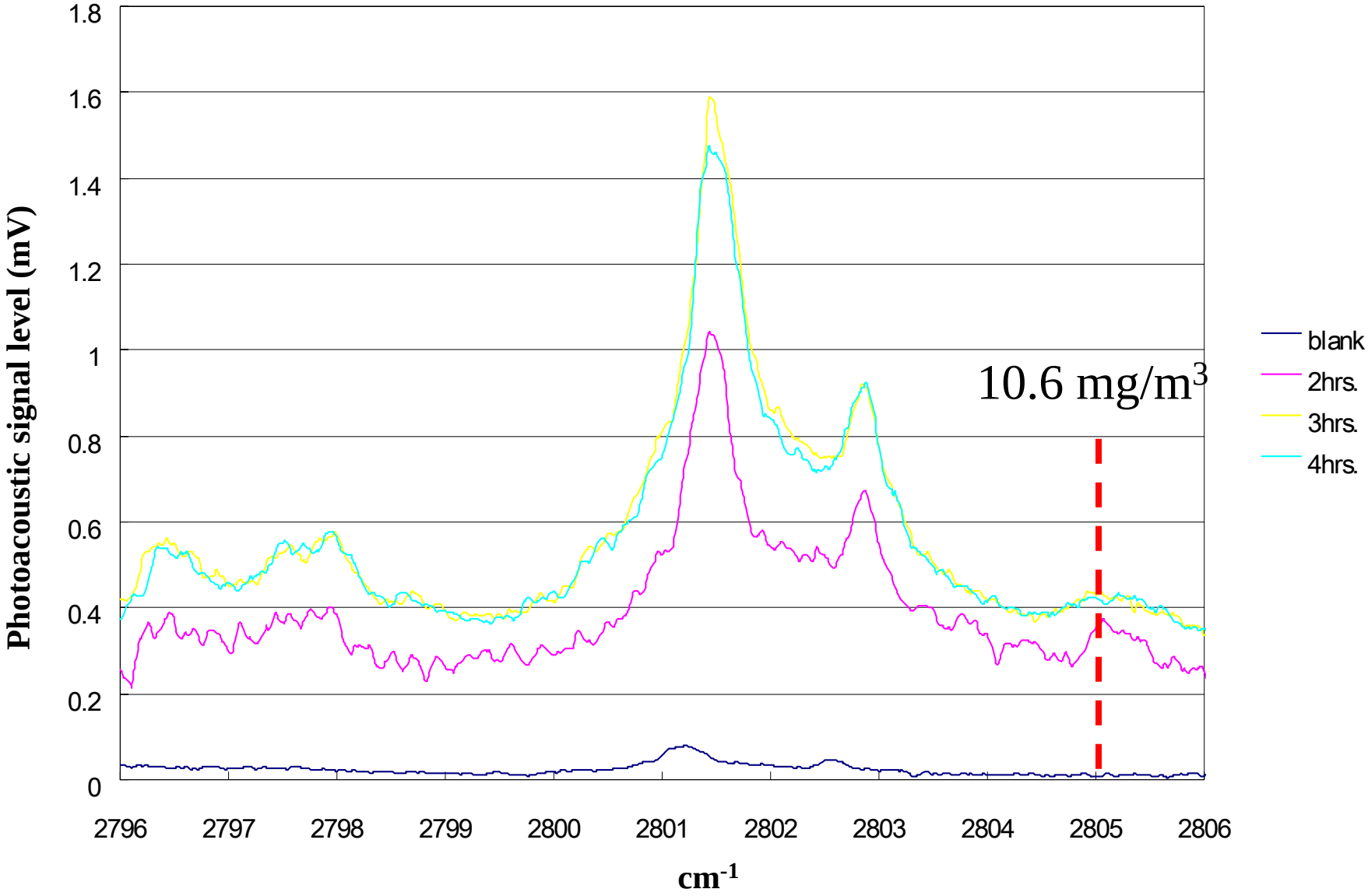
Middle density fiberboard samples





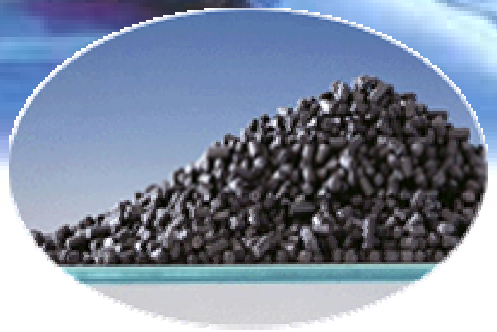
MDF sample (aging over 10 years)
Load factor: 6.17 m^2/m^3
Room temperature : $22^oC \pm 5^oC$
Relative humidity: $60\% \pm 5\%$

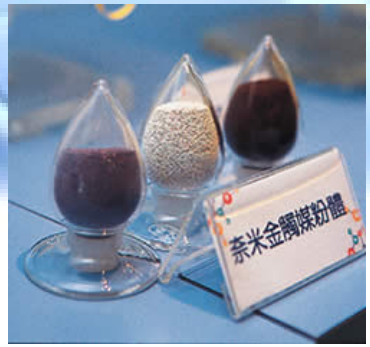
Formaldehyde level of MDF samples



Formaldehyde abatement strategies

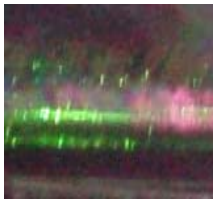
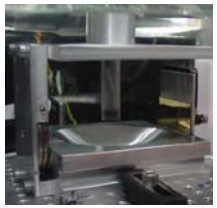
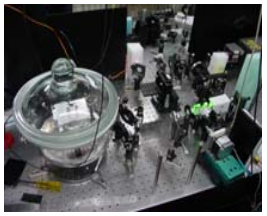
- Low-emission materials
- Good ventilation
- Humidity & microbial control
- Adsorbent materials
- Biologically based evaluations

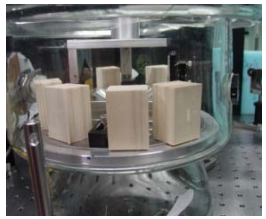




Conclusions

- ✓ **The formaldehyde concentration is increased with photoacoustic signal level increasing.**
- ✓ **The measurement lowest level is 0.8 ppbV (10^{-3} mg/m^3)**
- ✓ **The method can neglect the moisture influence.**
- ✓ **The open test cell can be used as both Lab. and field testing .**
- ✓ **The photoacoustic as a dynamic analysis system that can be utilized as VOCs monitor and detection tool.**




Thank You