
Indoor Air Standards in Japan for Healthy Environment

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Do you think ?



* *The Last Samurai*, Warner Bros., 2003

** *Sayuri*, Columbia Pictures Industry, 2005

Modern Japan



Western style buildings



Economic power based on High-tech

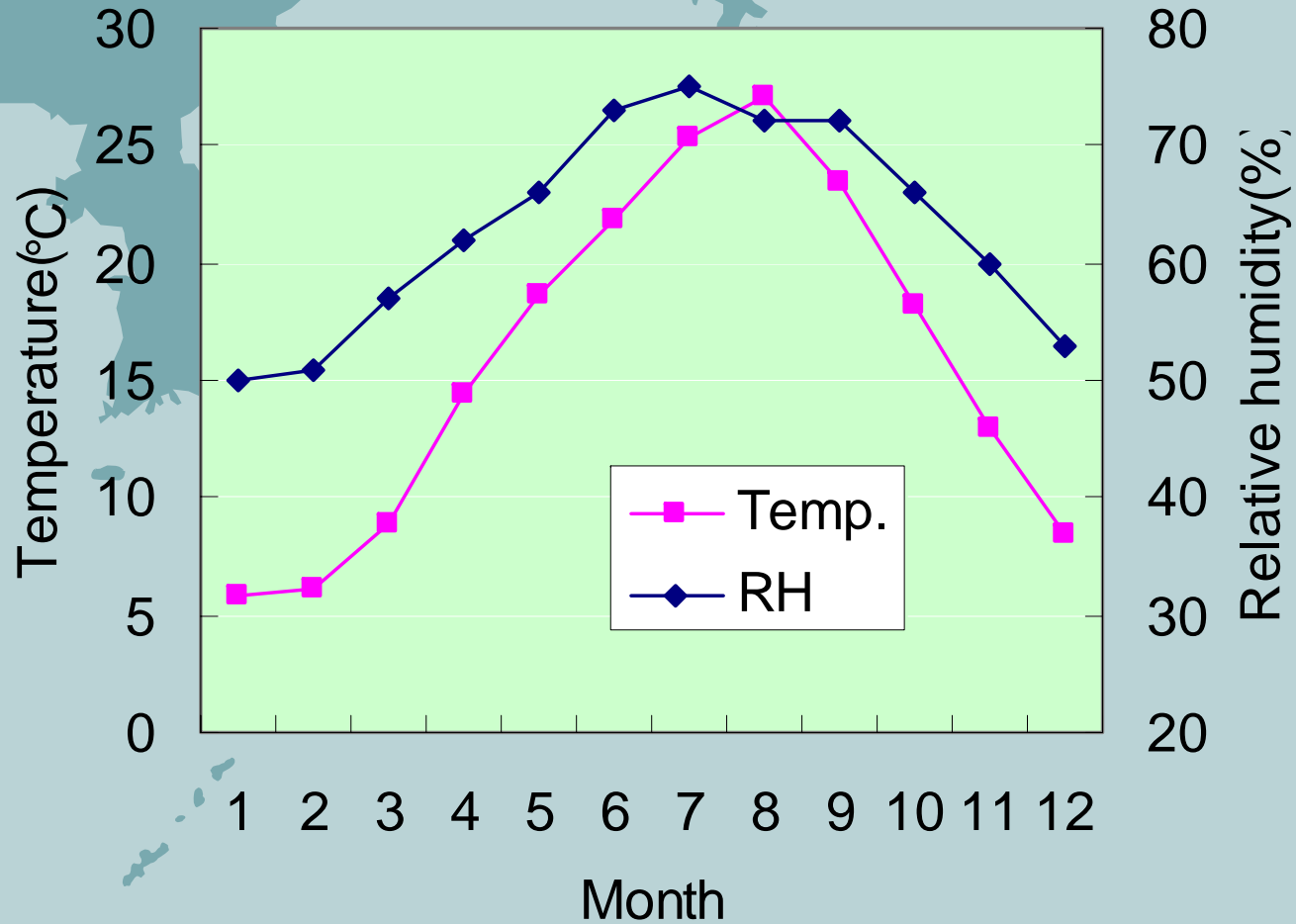


Why Japanese companies are so good at making microchips?

- M. Cross, *New Scientist* (1990)
- “...an important reason for Japan’s domination of the electronics market is that its people have a built-in “**clean-room**” **mentality**. It comes from the custom of changing shoes when stepping into another room.”



Japanese climate



SHOSO-IN Treasure House



An eighth century building specially constructed to prevent the natural damage caused by Japanese damp climate. The raised floor structure ensures sufficient ventilation underneath to keep the inside dry.

Raised floor structure in modern house



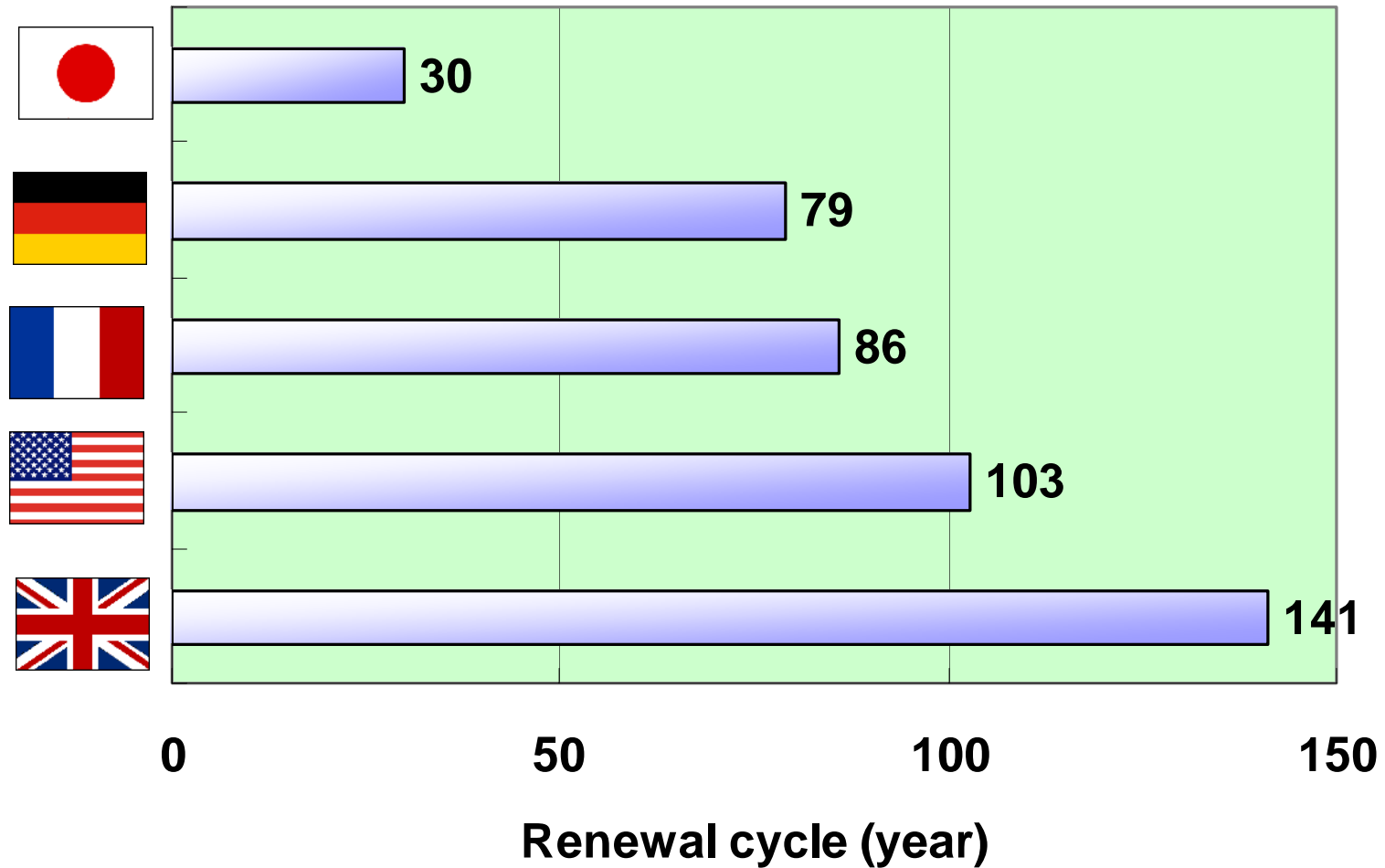
“Clean Room” mentality

*<http://www.misawa.co.jp/kodate/>

“Sick House Syndrome”

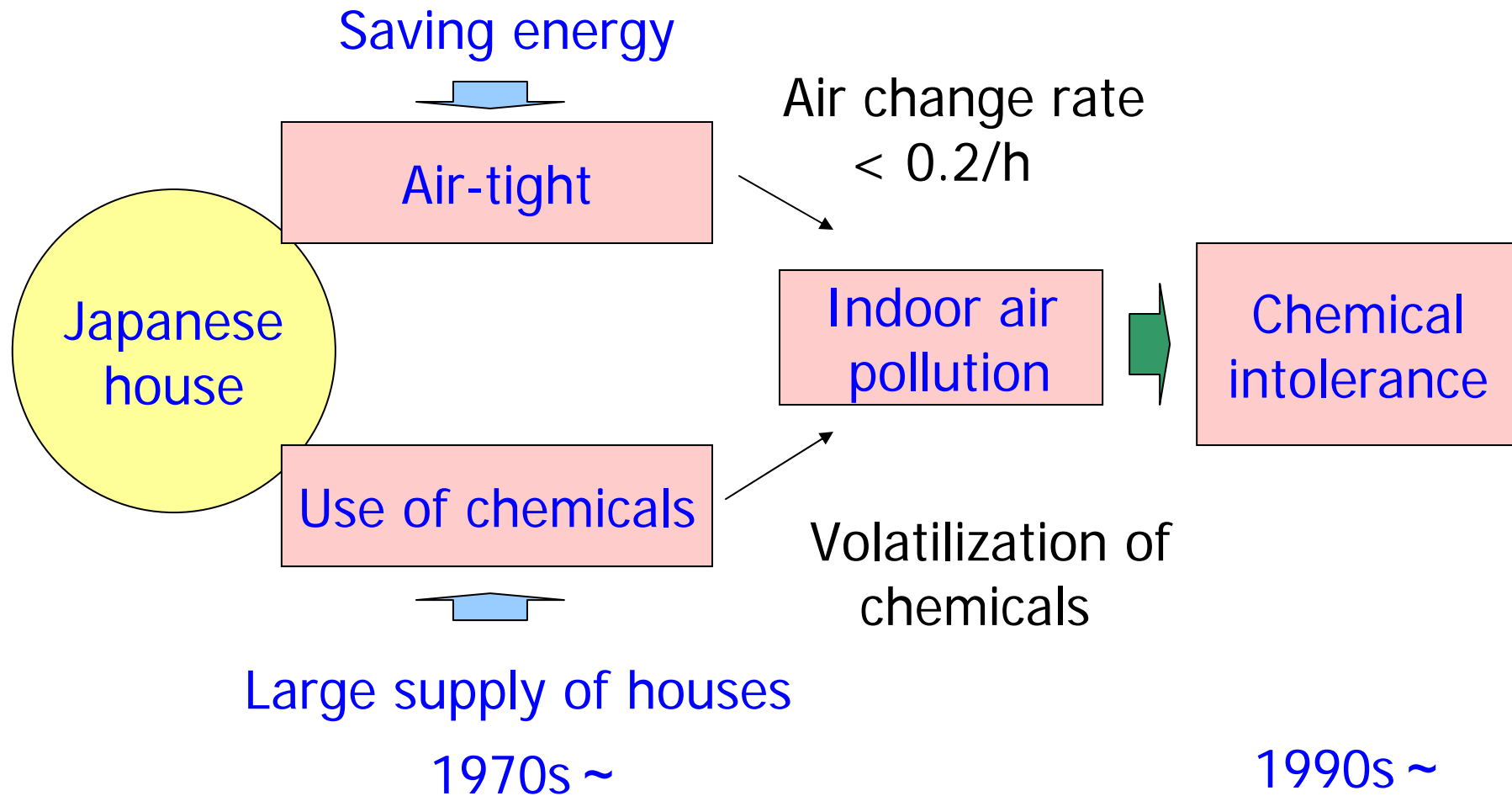
- “Sick Building Syndrome”
- Majority of patients: housewives and children in **newly-built houses**
- Typical air pollutants
 - Formaldehyde (HCHO)
 - Volatile Organic Compounds (VOCs)
- Why it happened in a house and invited a great social concern?

Renewal cycle of house



Renewal cycle= No. of present houses /No. of newly-built houses per year

Indoor air pollution by chemicals



Case of a victim in Tokyo

- Middle aged single woman
- In Apr.1999, moving to a newly built apartment house in Tokyo
- Health disorder
 - eye mucus, throat pain, bronchus irritation, headache, unpleasant feeling with muscles, diarrhea, fatigue and failure of memory
- Part-time librarian of a hospital
- In Mar.2000, diagnosis at hospital
 - Multiple Chemical Sensitivity



Multiple Chemical Sensitivity

- Medically unexplained symptom
 - different from allergy, acute poisoning
- Damage on nerve system etc.
- Repeated and intermittent exposure to chemicals (non-specific structure, property)
- Cross-sensitization
 - drugs, physical or psychological stress
- **In the case of Sick House Syndrome, most patients have been forced to move to another old house or replace building materials, sometimes at their expense.**

Efforts of reduction of chemicals



Bamboo charcoal



Air cleaners



Plants



Door with air pathway

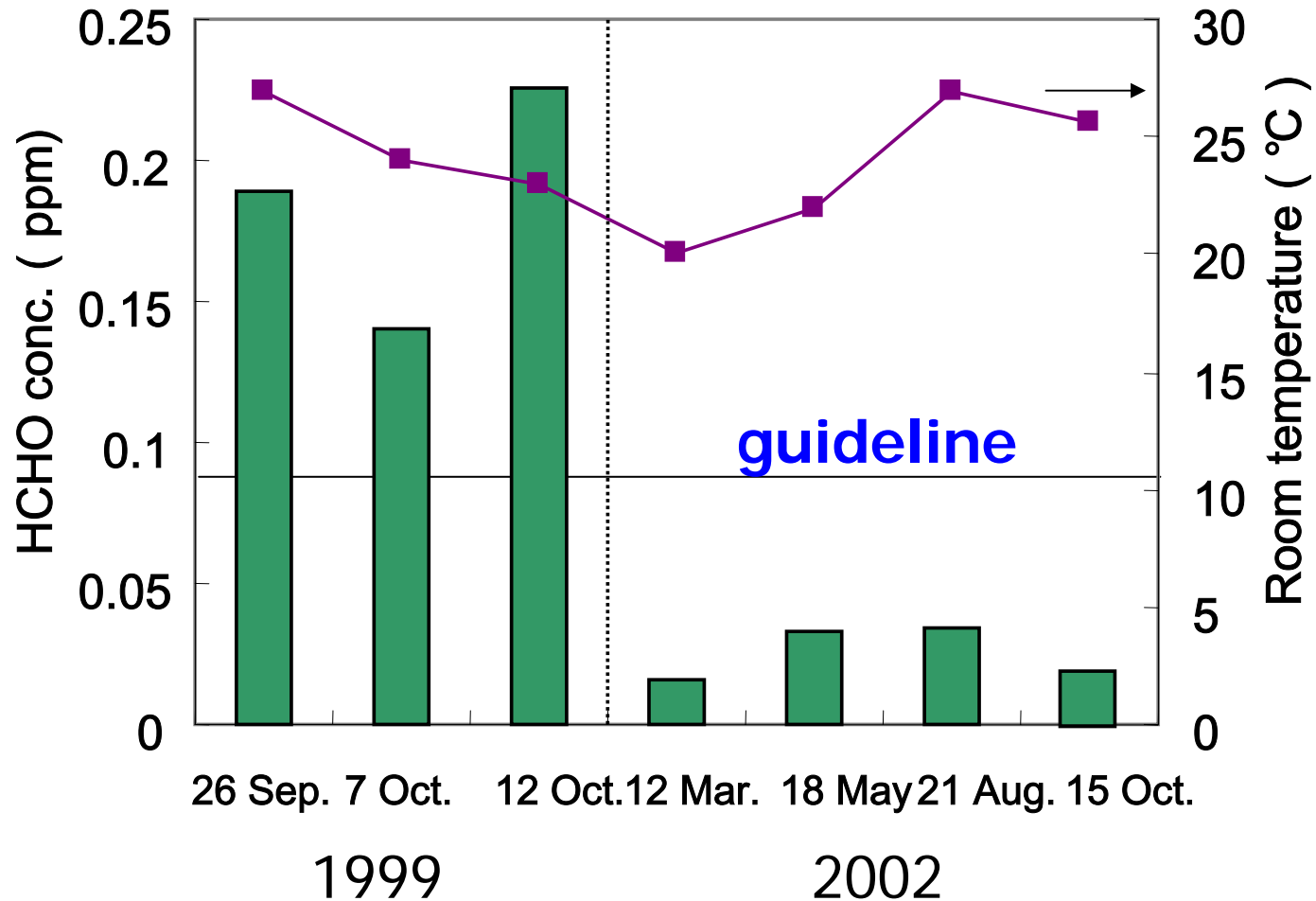


Pillow filled with charcoal



Passive sampler

Concentration of formaldehyde



Nation-wide survey

- Questionnaire study for Japanese 4,000 adults (> age 20) (Uchiyama,2003)
- Quick Environmental Exposure and Sensitivity Inventory (QEESI)
 - developed by C. Miller (1998)
- Results
 - respondents: 2,851
 - suspected as chemical sensitivity: **0.74%**
- Underestimate?
 - children: more sensitive to chemicals

Governmental countermeasures

- Setting Indoor Air Quality Guidelines of Chemicals (since 1997)
- Emission control and installation of ventilation system
 - Standard Building Law, 2003
- Monitoring of indoor air concentrations of chemicals in newly-built houses
 - Housing Quality Assurance Law , 2002
- formaldehyde in buildings and school
 - Building Sanitation Law,2002

Indoor Air Quality Guidelines

- Ministry of Health, Labour and Welfare, Japan

date	chemicals	CAS No.	concentration
1997.6	formaldehyde	50-00-0	100 $\mu\text{g} / \text{m}^3$ (0.08ppm)
2000.6	toluene	108-88-3	260 $\mu\text{g} / \text{m}^3$ (0.07ppm)
	xylene	1330-20-7	870 $\mu\text{g} / \text{m}^3$ (0.20ppm)
	<i>p</i> -dichlorobenzene	106-46-7	240 $\mu\text{g} / \text{m}^3$ (0.04ppm)
2000.12	ethylbenzene	100-41-4	3800 $\mu\text{g} / \text{m}^3$ (0.88ppm)
	styrene	100-42-5	220 $\mu\text{g} / \text{m}^3$ (0.05ppm)
	chlorpyrifos	2921-88-2	1 $\mu\text{g} / \text{m}^3$ (0.07ppb) 0.1 $\mu\text{g} / \text{m}^3$ (0.007ppb) for infant
	di-n-butylphthalate	84-74-2	220 $\mu\text{g} / \text{m}^3$ (0.02ppm)
	TVOC		400 $\mu\text{g} / \text{m}^3$ *
2001.7.5	tetradecane	629-59-4	330 $\mu\text{g} / \text{m}^3$ (0.04ppm)
	di-2-ethylhexylphthalate	84-66-2	120 $\mu\text{g} / \text{m}^3$ (7.6ppb)
	diazinone	33-41-5	0.29 $\mu\text{g} / \text{m}^3$ (0.02ppb)
	nonanal	124-19-6	41 $\mu\text{g} / \text{m}^3$ (7.0ppb)*
2002.1	acetaldehyde	75-07-0	48 $\mu\text{g} / \text{m}^3$ (0.03ppm)
	fenobucarb	3766-81-2	33 $\mu\text{g} / \text{m}^3$ (3.8ppb)

(): converted at 25 degC, *Draft value

Formaldehyde (HCHO)

- Emission source
adhesives used for
 - plywood, MDF, particle board,
 - vinyl wall paper
- Indoor concentrations
Survey for 4,600 housing units
in 2000 (by MLIT)
 - average 0.071ppm
 - 27.3% of the units
> the guideline



Plywood used for flooring

The amended Building Standard Law

- Enforced in July, 2003
- Applied to every habitable room of all buildings
- Regulation on Chlorpyrifos
 - The use of Chlorpyrifos is banned
- Regulation of Formaldehyde (HCHO)
 - Area size of HCHO-emitting materials used for interior finishing is restricted
 - Installation of 24h-ventilation system is mandatory to keep >0.5 ACH

HCHO-emitting materials

Formaldehyde emitting building materials	Emission rate	Restrictions on interior finishing materials
Type 4	up to $5\mu\text{g}/\text{m}^2\text{h}$	No restrictions
Type 3	$5 \sim 20\mu\text{g}/\text{m}^2\text{h}$	Limited area
Type 2	$20 \sim 120\mu\text{g}/\text{m}^2\text{h}$	
Type 1	over $120\mu\text{g}/\text{m}^2\text{h}$	Prohibited

Determined by a small chamber method (JIS A 1901,2003)

Housing Quality Assurance Law

- Ministry of Land, Infrastructure and Transport

- IAQ : One of the housing performance
- Measurement of indoor concentrations included in fields of the Housing Performance Indication System
- By request of the house purchaser, house builders have to make a monitoring of indoor air conc. of chemicals in a newly-built house.
- Sampling & analytical methods: Standard protocol prepared by MOHLW

Monitoring of Chemicals

- Target substances;
formaldehyde
toluene, xylene, styrene and
ethylbenzene
- Standard sampling methods
 - 1) Active samplings (30min)
 - 2) Passive samplings (24h)
- Passive samplers are commonly used for IAQ monitoring



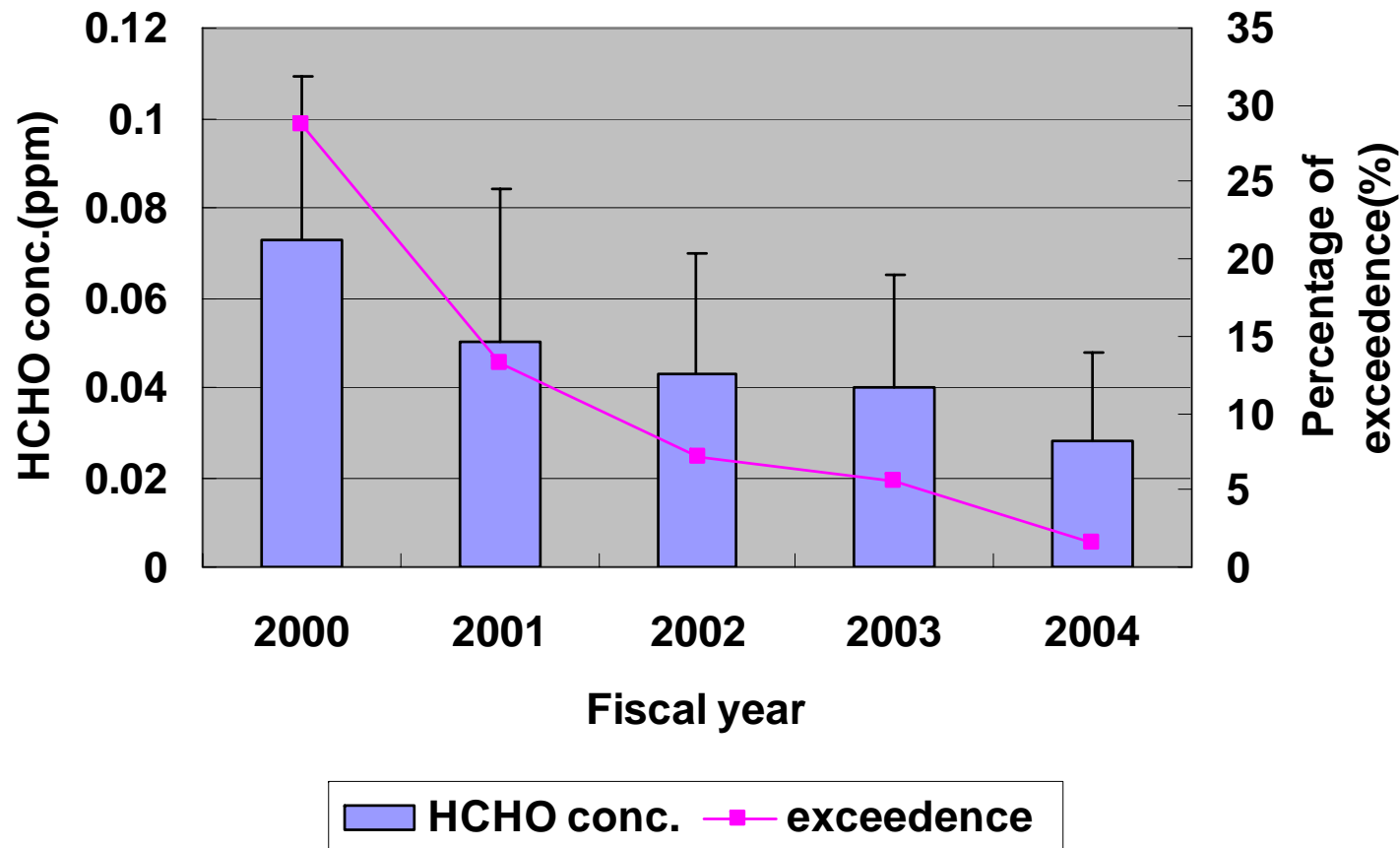
Passive samplers

IAQ standard for museum

substance	limit values	frequency
PM	0.15mg/m ³	bi-monthly
CO ₂	1000ppm	
CO	10ppm	
temperature	17 - 28°C	
relative humidity	40 - 70 %	
air stream	0.5m/s	
HCHO	0.1mg/m ³	in summer after being built, reformed and fitted up

*HCHO was added in 2002.

Yearly change of HCHO conc.



Indoor air concentrations of HCHO in newly-built houses ($n=2,000$)

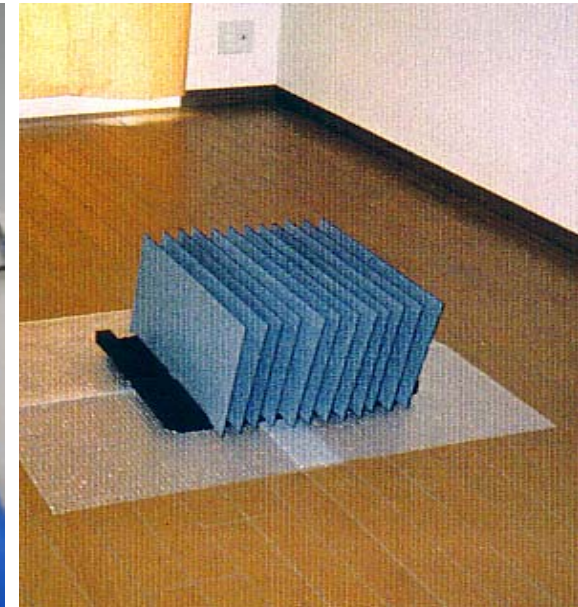
Air-cleaning materials based on “Clean-room” mentality



Air cleaner



Air cleaning paint



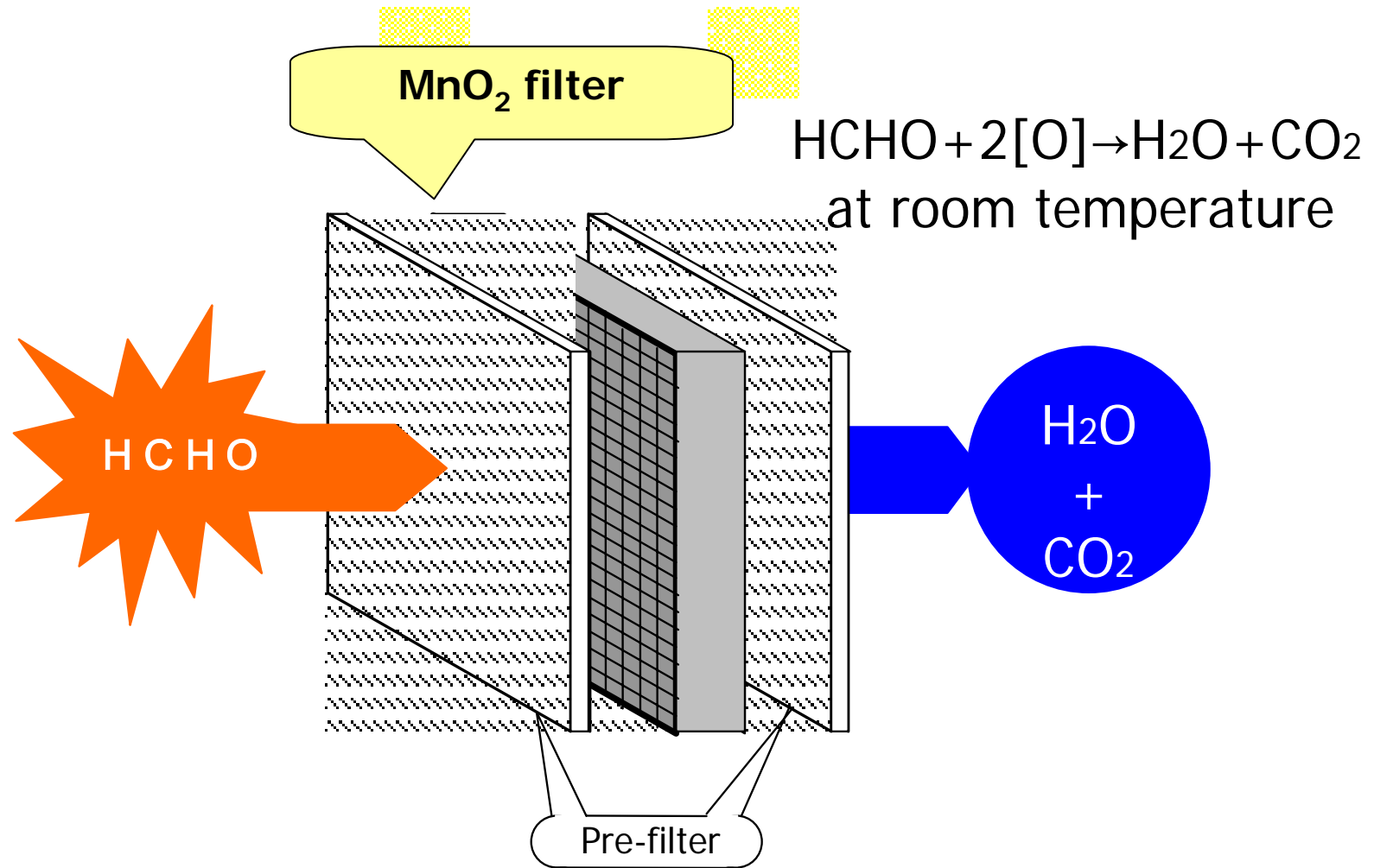
Air cleaning board

Removal of airborne chemicals

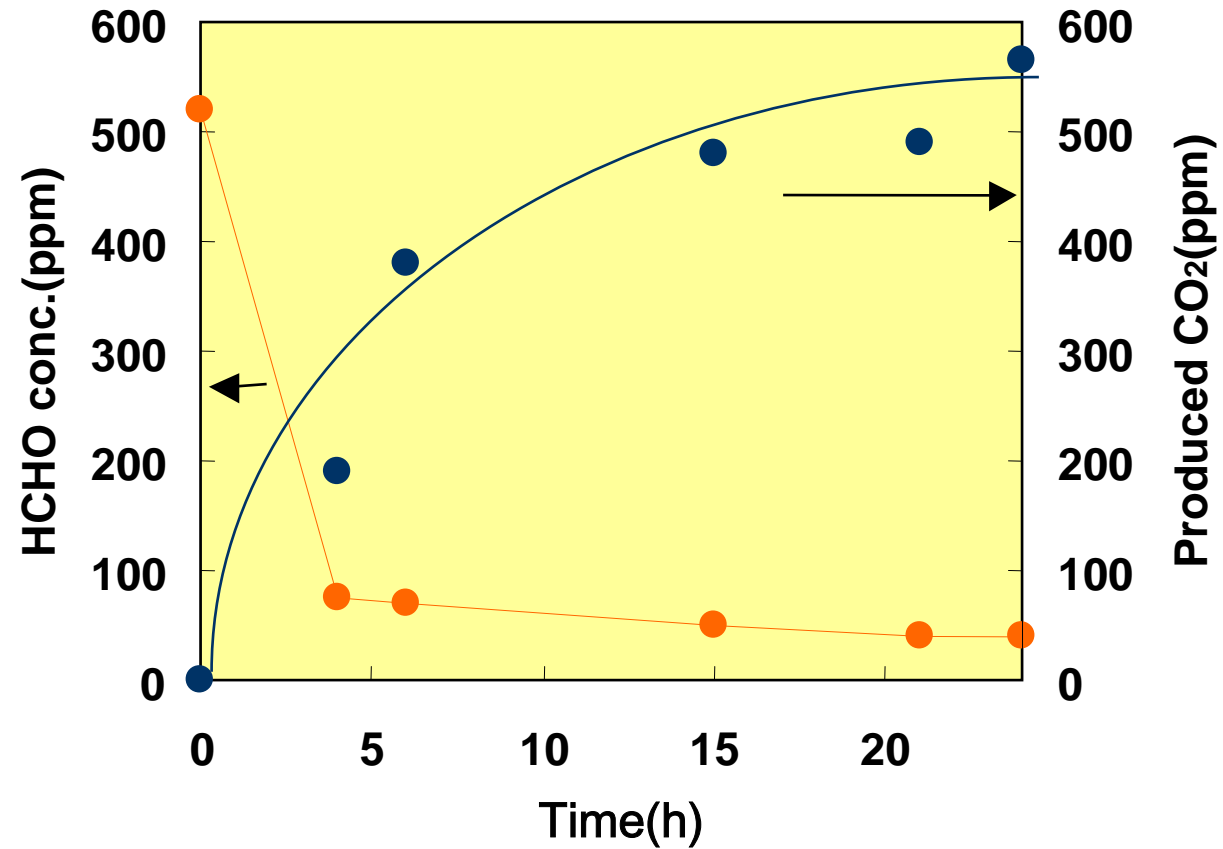
principle	methods/materials
physisorption	activated charcoal
	porous ceramics
	natural fibers
chemisorption	inorganic compounds
	organic compounds
	extracts
decomposition	photocatalyst
	ozonolysis
	catalytic decomposition
	modified charcoal
	plasma discharge
	minus ions
	activated oxygen
digestion	bacterial
blocking	resins



Passive air cleaning board

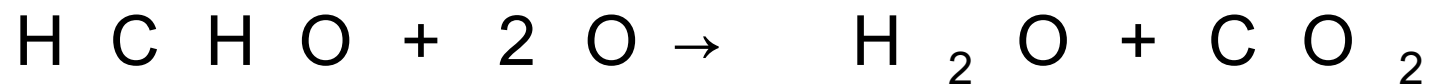
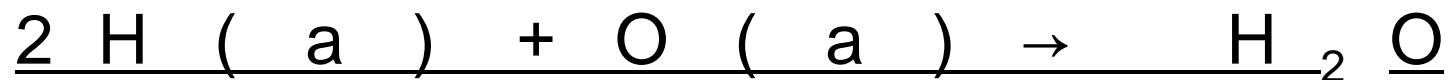


Manganese dioxide



(MnO₂:10g, PTFE Bag: 100L, 21°C)

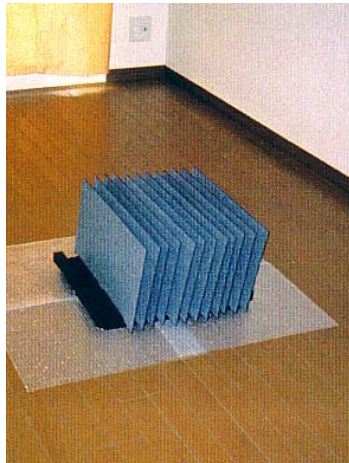
Possible pathways



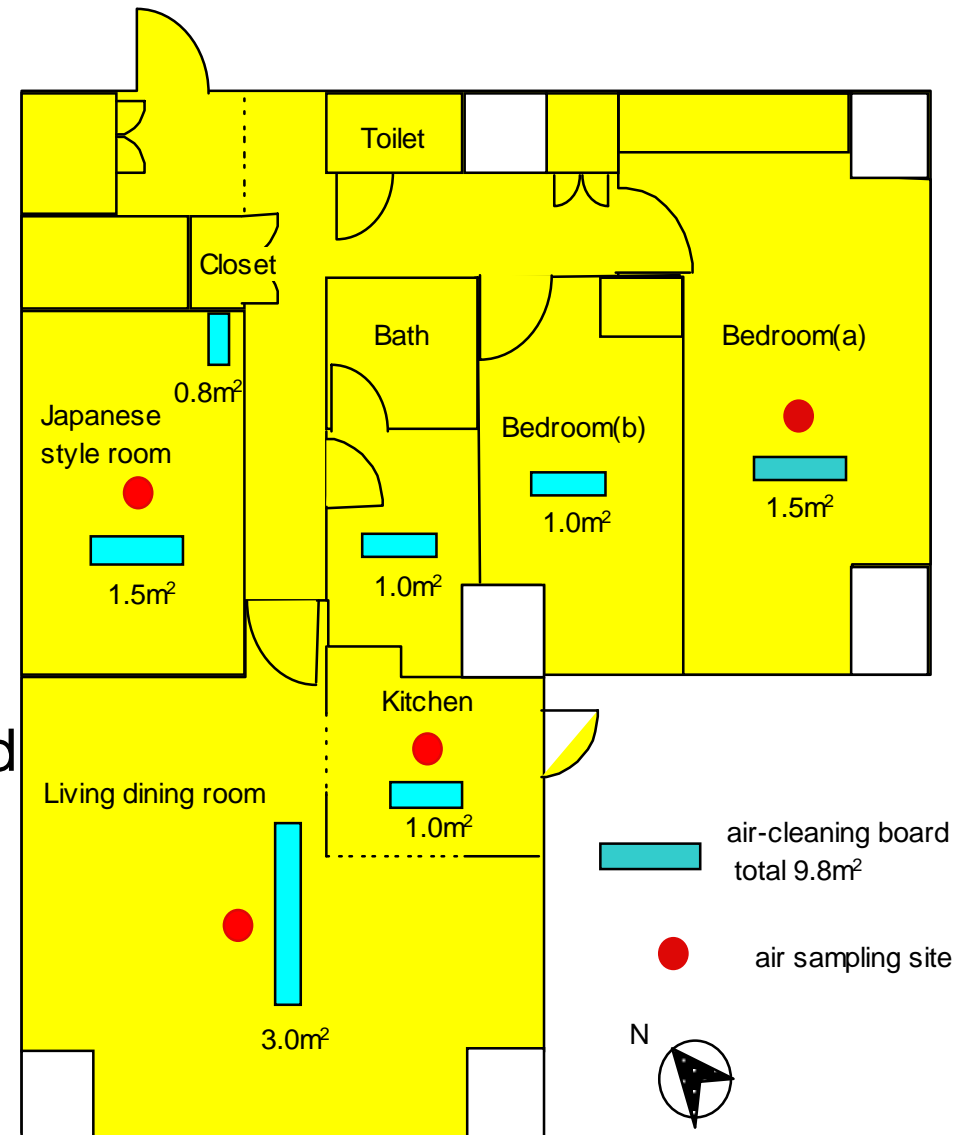
Sekine, Y, *Atmospheric Environment*, 36, 5543(2002) 5)

Field tests

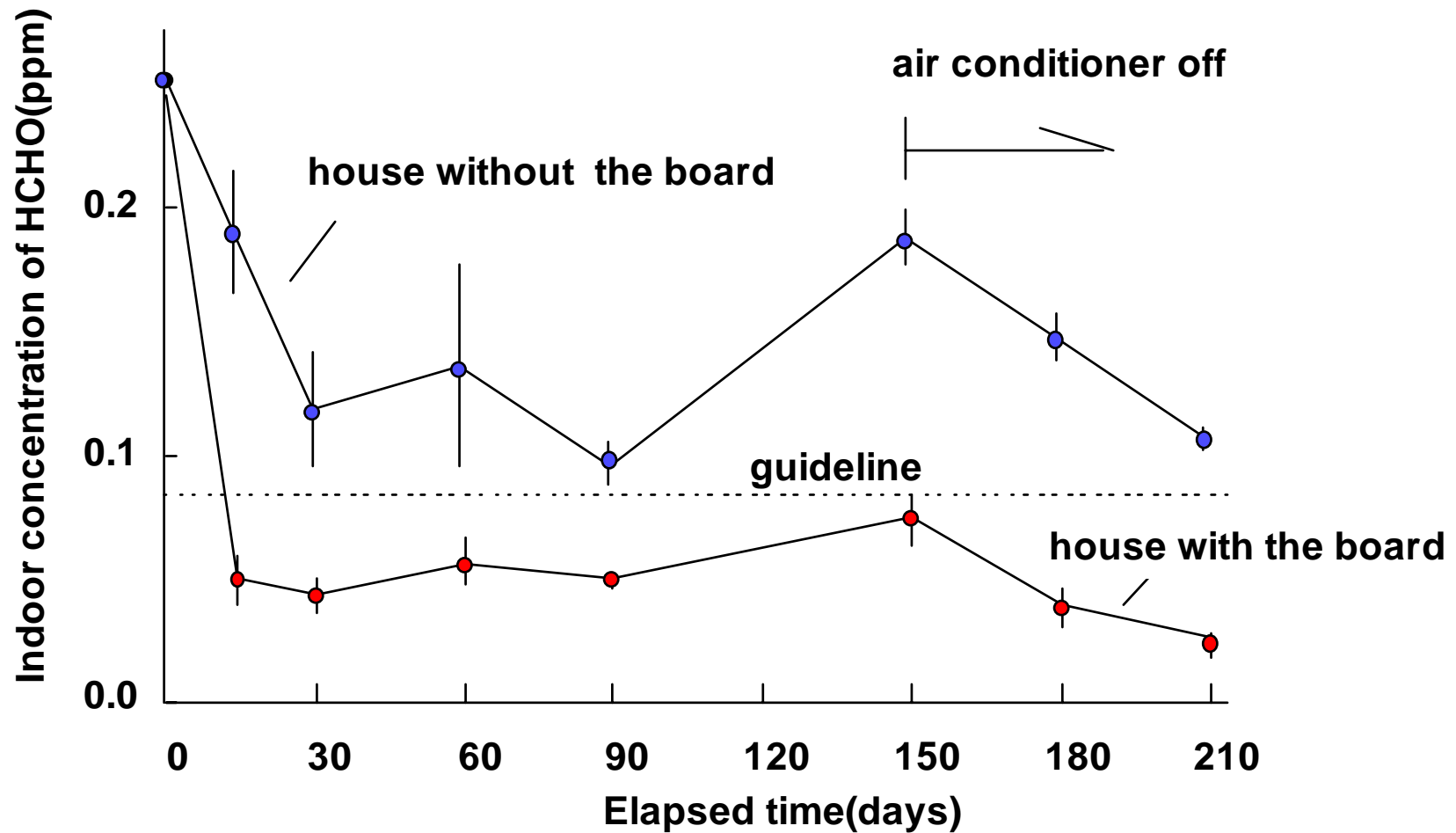
- Air-cleaning board



- Newly built and unoccupied apartment houses
- 3LDK(230m³)
- N=0.15/h
- May – Nov., 1998



Variation of HCHO concentration



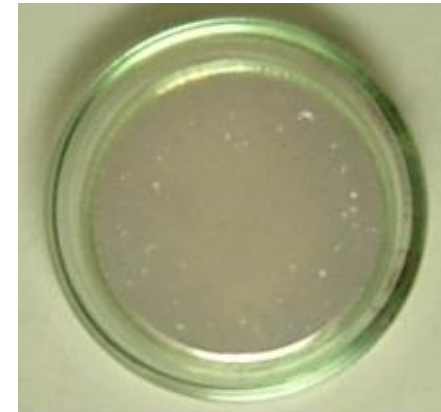
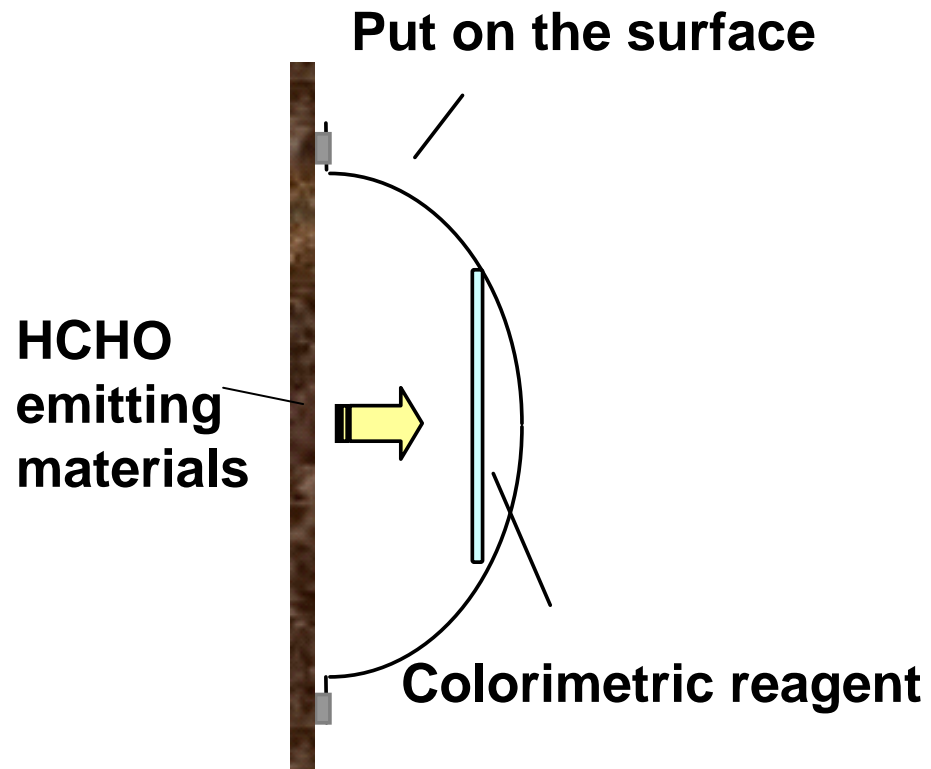
Air cleaning materials with legal basis

In the Standard Building Law,
Exemption from the restrictions for HCHO
Habitable room

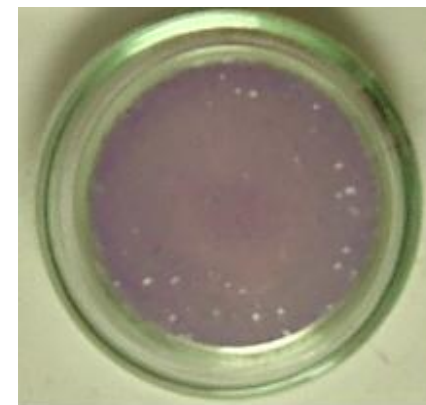
- equipped with centrally controlled air conditioner
- in which the HCHO concentration can be maintained at no more than 0.1mg/m^3

Air-cleaning materials can be used with approval of the Minister of MLIT

On-site colorimetric detector of HCHO



Virgin sample



Exposed to HCHO

User friendly technology



Find out Japanese businessman

