Indoor air quality within museum showcases

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Showcases – a problem?

Kind of nested prevention strategy: „box in a box-model“ [Camuffo et al., 2000]

The museum showcase as a „reaction vessel“ [Weschler and Shields, 1997]
Course of the project

**Main emission sources?**
- Building materials
  - Construction
  - Decoration

**showcases**
- Modern-type
- Traditional-type

**Similarities & differences**

**Emissions**
- Immissions
  - Evaluation
  - Interpretation
- Influences
  - Air exchange rates
  - Artificial lighting

**Impact on artifact materials?**

**Testing methods**
- Environmental chemistry

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Classification of pollutants
– emissions of indoor materials

<table>
<thead>
<tr>
<th>Inhalative</th>
<th>Oral</th>
<th>Dermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas phase</td>
<td>Airborne particles</td>
<td>Settled dust</td>
</tr>
<tr>
<td>VVOC</td>
<td>VOC</td>
<td>SVOC</td>
</tr>
<tr>
<td>60°C</td>
<td>290°C</td>
<td>400°C</td>
</tr>
<tr>
<td>formaldehyde</td>
<td>solvents, additives monomers</td>
<td>flame retardants plasticizers wood preservatives</td>
</tr>
</tbody>
</table>

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Active indoor air sampling techniques
Material emission analysis

Temperature [T]: 23°C-350°C  
Relative humidity: 50 ± 5%  
Air exchange rate [n]: 233 h⁻¹  
Loading factor [L]: 0,5 bzw. 0,03 m²/m³  
Sample sizes: 10 x 70 mm  
                      10 x 45 mm  
                      0,5 m² (plane samples)  
                      0,03 m³ (voluminous samples)
Material emission analysis

Temperature [T]: 23°C-350°C 23 ± 2°C
Relative humidity: 50 ± 5%
Air exchange rate [n]: 233 h⁻¹ 0,18 h⁻¹
Loading factor [L]: 0,5 bzw. 0,03 m²/m³
Sample sizes: 10 x 70 mm 0,5 m² (plane samples)
10 x 45 mm 0,03 m³ (voluminous samples)
Material emission analysis
Material emission analysis

- **Lacquers and coatings**
  - 24 h
  - 120/144 h
- **Adhesives and sealants**
  - 24 h
  - 120/144 h
- **Wood-based products**
  - 24 h
  - 72 h

Log chamber concentration [µg/m³]
Primary emissions – secondary emissions

- Production process
  - Chemical compounds
    - new material with primary products
      - material in use
        - primary emission
          - gas phase reaction
            - Indoor air
          - primary emission
          - secondary emission
            - Physical release
              - Chemical reactions

[Uhde and Salthammer, 2007]
Solvent-based lacquers versus powder coatings

Solvents/additives
(Di-)Carboxylic esters
Glycols
Aromatic hydrocarbons

[Schieweck and Salthammer, 2009]
Solvent-based lacquers versus powder coatings

Long-chained alkanes

[Schieweck and Salthammer, 2009]
Secondary emission of solvent-based lacquers

Ester hydrolysis

\[ R^1\text{CO}_2\text{O} + \text{H}_2\text{O} \rightarrow R^2\text{-OH} + R^1\text{CO}_2\text{H} \]

[Schieweck and Salthammer, 2009]
Silicone rubber sealants (RTV-1)

Decomposition products of cross linking agents:
- 2-butanone oxime (MEKO)  [Canc.Cat. 3]
- 4-methyl-2-pentanone oxime
- 2-propanone oxime
- cyclic siloxanes
- solvents

[CEC-Centre Européen des Silicones]
Wood-based products

Aldehydes
Terpenes
Organic acids
Formaldehyde

<table>
<thead>
<tr>
<th>Concentration [µg/m³]</th>
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</thead>
<tbody>
<tr>
<td>1000</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

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Wood-based products

**Fibre boards**

E1  equilibrium concentration in chamber air  HCHO: < 0.1 ppm
RAL-UZ 76 („Blue angel“)  equilibrium concentration in chamber air
  HCHO: < 0.05 ppm

**MDF**

ZF  „zero added formaldehyde“
Z0  no formaldehyde-based binder
Material safety data sheets etc. commonly do not provide any information regarding:

- emissions / emission potential (in time; composition)
- odorous compounds
- secondary emissions

Labelling systems: what do they mean? How is the test procedure?

Industrial product formulations might have a great impact on emissions

“emission-free” ↔ low-emissive
Investigated showcase types

- passive (no active air circulation)
- modern *versus* traditional
- sealed *versus* open
Traditional-type showcases

V: 0.5 m³ – 12 m³
Σ(VOC): 100 – 2800 μg/m³
HCHO: 70 – 760 μg/m³
HCOOH: 100 – 780 μg/m³
CH₃COOH: 450 – 2600 μg/m³
Modern-type showcases

\[ V: \quad 0.68 \text{ m}^3 - 1.45 \text{ m}^3 \]
\[ n: \quad 0.01 \text{ h}^{-1} - 0.02 \text{ h}^{-1} \]
\[ \Sigma(VOC): \quad 100 - 17000 \mu\text{g/m}^3 \]
\[ \text{HCHO:} \quad < \text{NG} - 150 \mu\text{g/m}^3 \]
\[ \text{HCOOH:} \quad < \text{NG} - 350 \mu\text{g/m}^3 \]
\[ \text{CH}_3\text{COOH:} < \text{NG} - 5700 \mu\text{g/m}^3 \]
Influence of air exchange rates on emissions

Luftwechsel

VOC, SVOC, H₂O, CO₂

Concentration

sample

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Local air flows around the lamps
No air circulation over the whole showcase
Negativ temperature gradient from the top to the bottom
Temperature difference: max. 4°C
The choice of building materials determines indoor air quality and pollution levels.

Main emission sources: solvent-based lacquers, silicone sealants, wood-based products.

Highly sealed showcases promote the accumulation of emissions inside.

Open constructed showcases show minor pollutant concentrations provided that background values are also low.

Now reduction of emissions due to shift in material selection.
Conclusions

Potential hazardous impact on cultural assets?

Hard to asset as no alterations yet can be traced back to impact of VOCs

ALARA-concept: emissions should be kept „as low as reasonably achievable“

NOEAL-values [Tétrault, 2003] should not be exceeded

This study provides a first basis regarding
- Evaluation concepts
- Labelling systems
Airborne pollutants in museum showcases – material emissions, influences, impact on artworks

The PhD-thesis is available online as full article:

www.hfbk-dresden.de
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Reduction of indoor air pollutions from museum showcases by the application of absorbent materials and “intelligent” material systems

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THANKS FOR YOUR ATTENTION