The British Museum

Investigating the performance and suitability of various coatings as barriers to off-gassing from medium density fibreboard (MDF)

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THE CLOTHWORKERS' FOUNDATION

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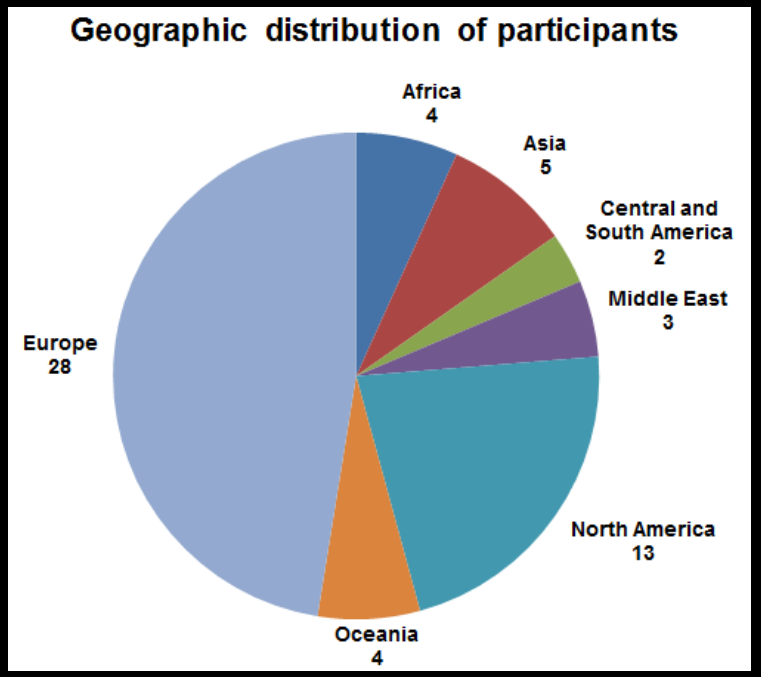
Outline

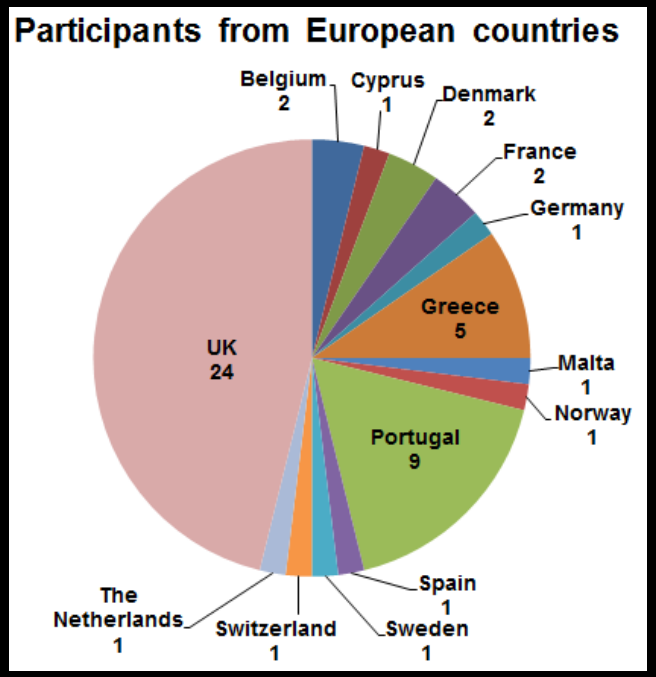
- Project background
- Selection of liquid “sealants” for MDF
- Testing methodology
- Preliminary results

Online survey about “sealing” MDF: current practices in cultural heritage institutions

Online Survey ‘Coatings for wood components inside museum showcases (in the same airspace of objects)’ July 10 – Sept 30, 2015

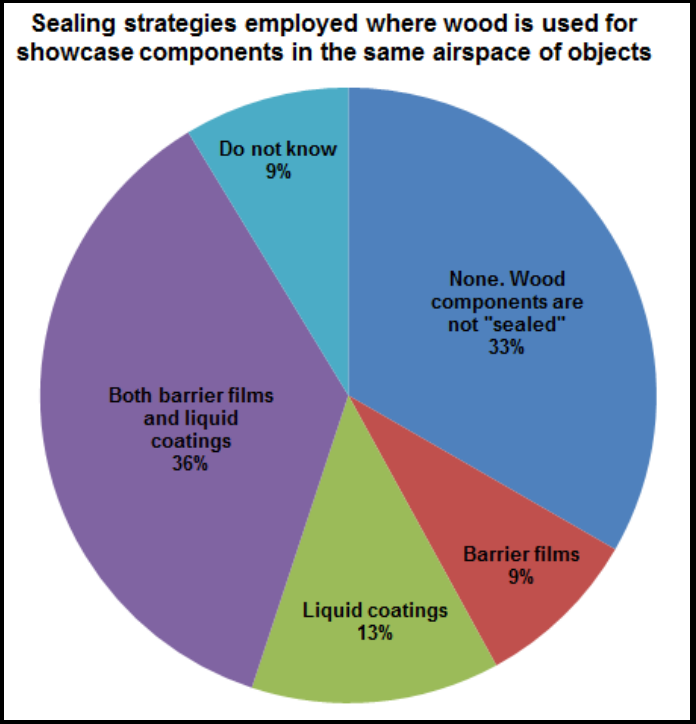
83 validated survey respondents



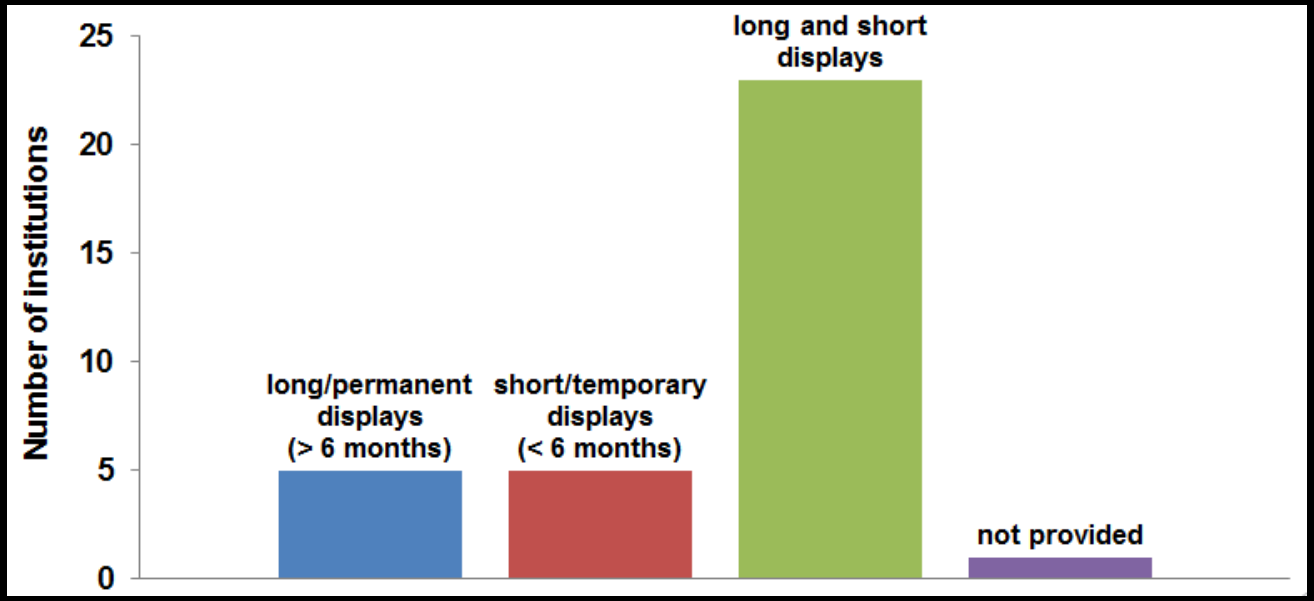


“Sealing” MDF: an unsolved problem that is still worth investigating

83% of respondents use wood components in showcases in the same airspace as the objects



Liquid sealants are used to seal wood in displays of different duration



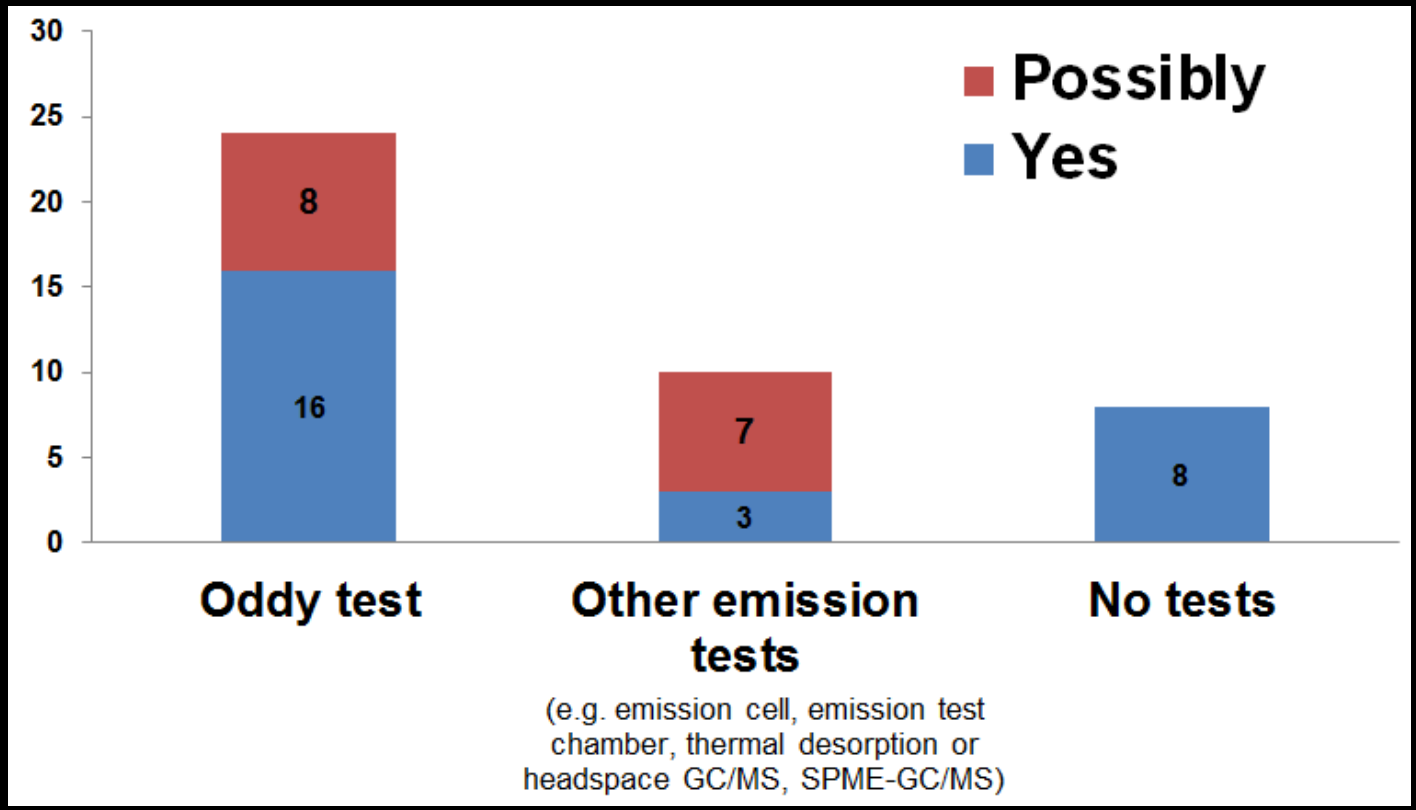
The majority of survey respondents employs acrylic coatings, known to be poor VOC barriers, to seal MDF

Chemical class	Number of respondents
ACRYLICS	**23**
Dacrylate 103-1	16
URETHANES	**5**
EPOXIES	**1**
Number of respondents using liquid coatings	**34**

Requirements for liquid sealants

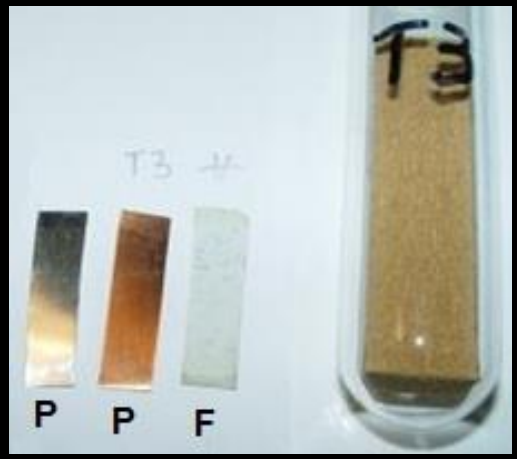
1. **No off-gassing**
2. **Good barrier** to MDF off-gassing
3. **Safe** for users
4. **Paintable**
5. Within the **budget** of temporary exhibitions, possibly also at institutions with limited financial resources
6. **Available** in a large number of countries

The Oddy test is the most popular way to assess sealant off-gassing

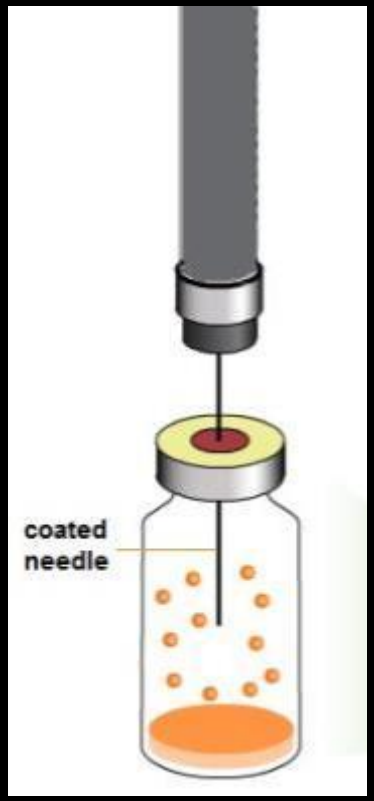


The Oddy test has many limitations:

- No identification of the VOCs
- Accelerated ageing
- Subjectivity of the evaluation
- Issues with reproducibility of results
- Limited sensitivity and range of VOCs



SPME-GC/MS allows the identification of the volatile compounds off-gassed



Solid Phase Micro Extraction

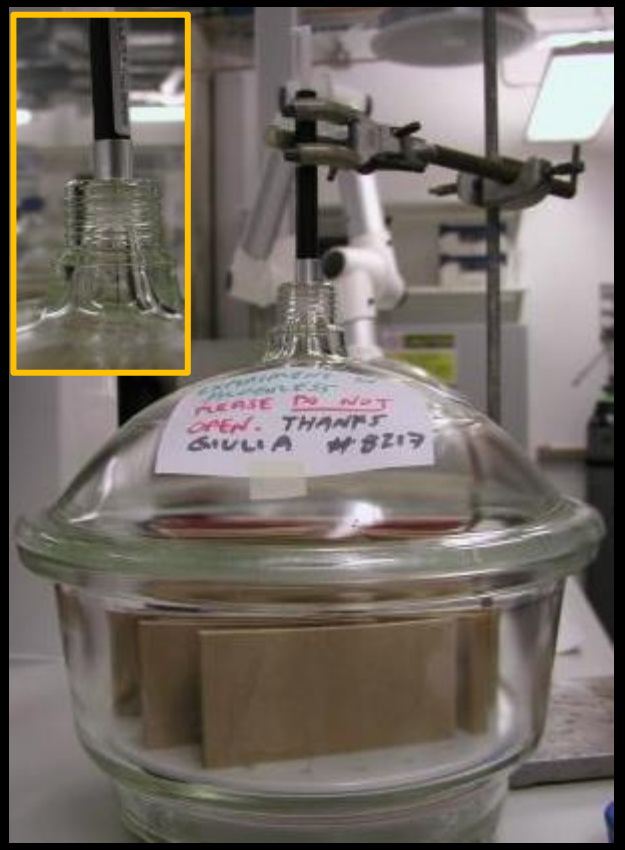
- solvent-free sampling, extraction, concentration and introduction into the GC

Gas Chromatography Mass Spectrometry

- Quantification
- Identification

SPME field samplers allow the measurement of the VOCs emitted by coated and uncoated MDF samples

CAR/PDMS-coated fiber:
sensitivity for acetic acid



Experimental procedure

1. Screening of the coatings
   1. Oddy test
   2. SPME-GC/MS (vials in autosampler)
2. Evaluation of the ‘sealing’ effectiveness

   Comparison of the emissions coated vs uncoated MDF by SPME-GC/MS (field sampling from desiccators)
3. Optimization of the application

Range of products tested

Chemistry	Number	Reasons for selection
Acrylic and acrylic copolymers	12 products	- Paintable, widely available, used in museums - Advertised as with low emissions and/or as able to block emissions from wood
2-pack solvent-based polyurethane-acrylic	2 products	- Manufacturers' recommendation
2-pack water-based polyurethane	4 products	- Expected good barrier - Manufacturers' recommendation
1-pack water-based polyurethane	1 product	- Expected good barrier - No mixing issues
Ethylene-vinyl acetate (EVA)	1 product	- Advertised as with low emissions and/or as able to block emissions from wood
2-pack epoxy	3 products	- Expected good barrier - Used by another museum

Powder-coated MDF: an option to investigate

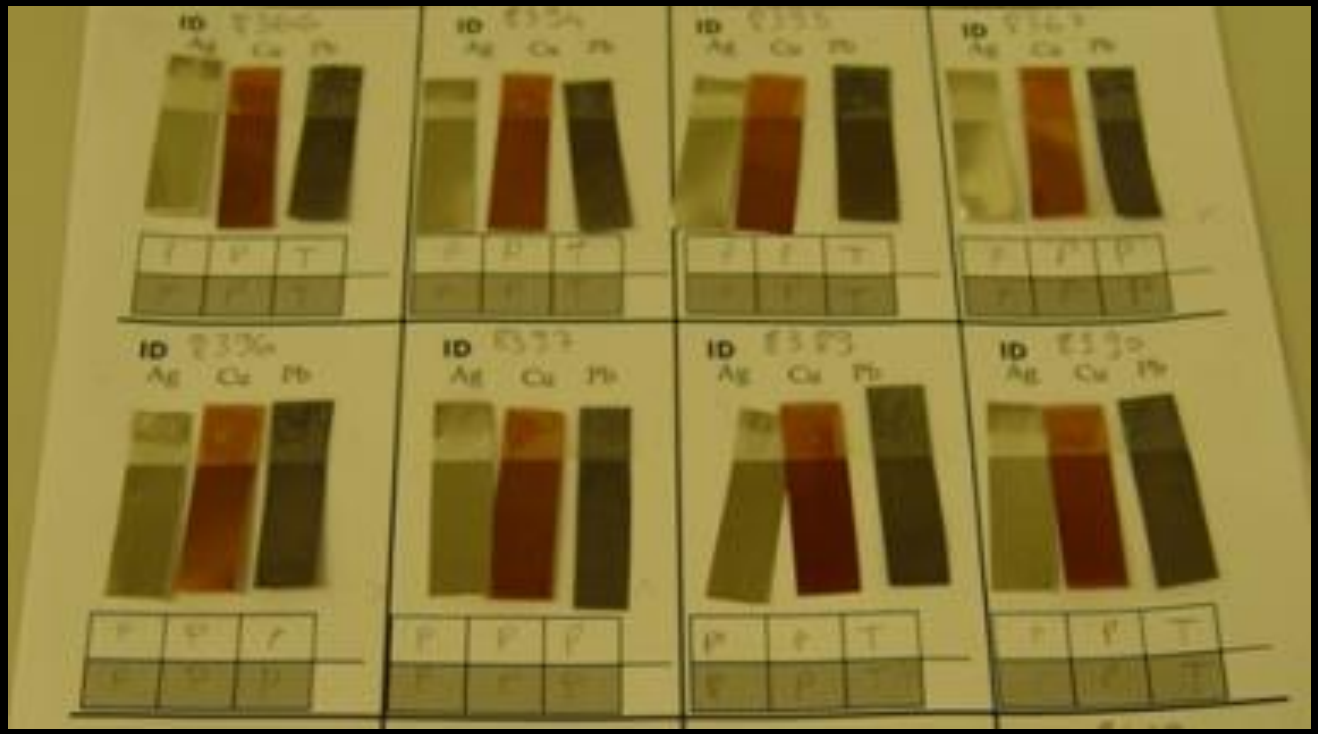
Epoxy powder-coating reduced MDF emissions of formaldehyde by 99%, total VOCs by 94%

Barry A, Corneau D (2004). Effectiveness of barriers to minimize VOC emissions including formaldehyde. http://www.ecobind.com/research/Effecitveness_of_Barriers_Phase_I.pdf

Product tested:
Epoxy-polyester hybrid

No restrictions on shape

All products passed the Oddy test except 2 water-based acrylics and 1 epoxy



The use of an autosampler improves the quality of the SPME-GC/MS screening of the sealants

- Precise extraction time
- Immediate exposure of the fibre in the injector after needle introduction (no peak splitting)
- Reproducibility of SPME fibre desorption in the GC injector

DVB-CAR/PDMS-coated fiber: wide range of VOCs

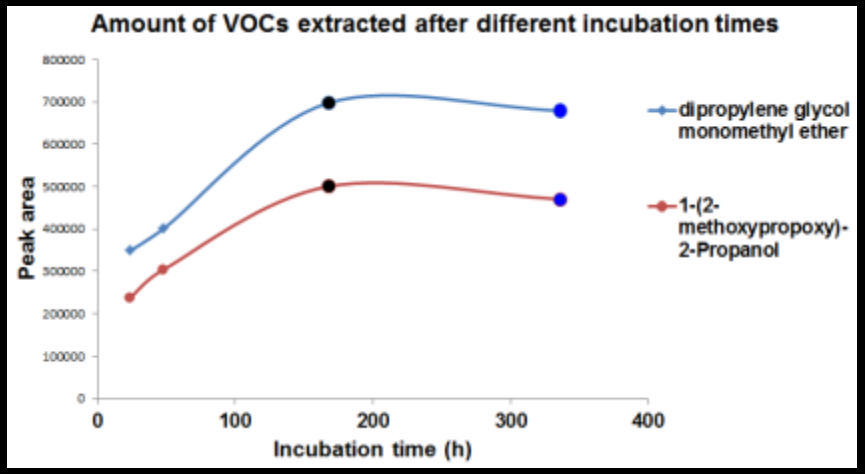
1 week is the optimal incubation time to screen the coatings by SPME-GC/MS (autosampler)

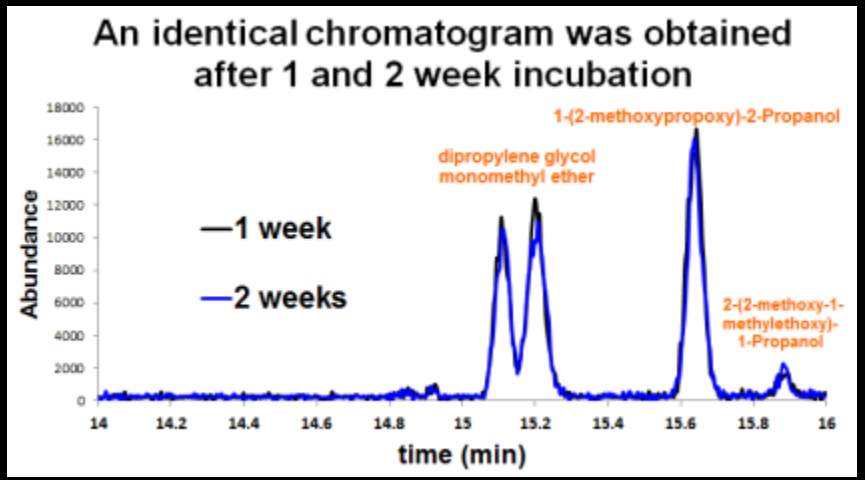
Self-crosslinking waterborne acrylic transparent sealer

Sprayed by supplier to c. 120-140 µm wet film thickness

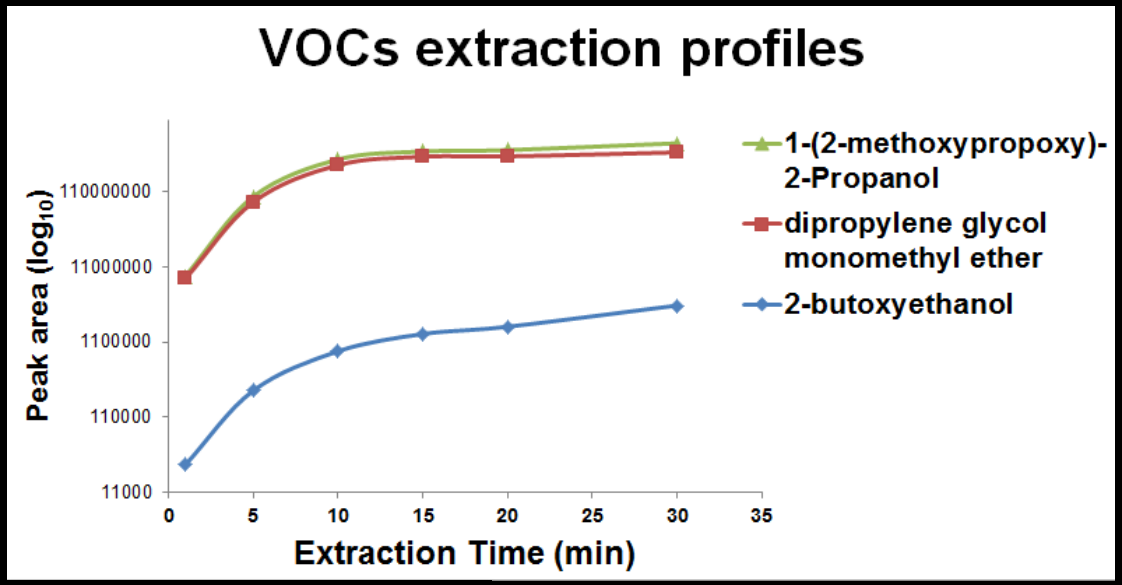
Passed the Oddy test

MSDS: (2-methoxymethylethoxy)propanol





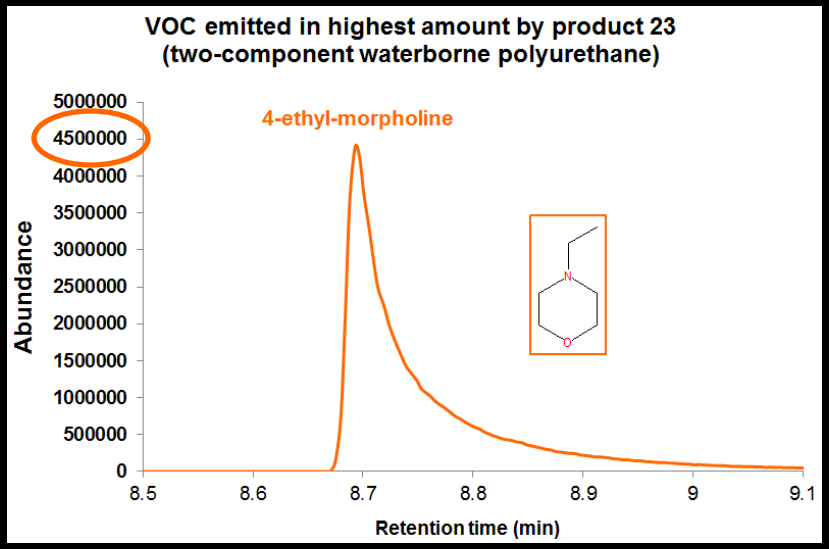
15 min seems the optimal extraction time to screen the coatings by SPME-GC/MS

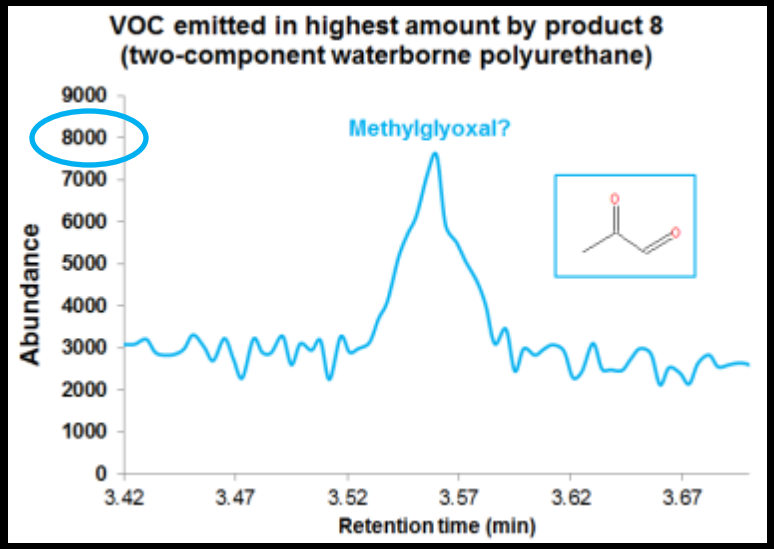


INLET	
Mode	splitless
Desorption T	**240°C**
Conditioning T	250°C
Conditioning time	**20 min**
Pressure	11.4 psi
Purge flow	20.0 ml/l
Desorption time	**1 min**
COLUMN	
Flow	**1.5 ml/min**

TRANSFER LINE	
Temperature	230°C
DETECTOR	
Temperature	250°C
MS ACQUISITION	
Mode	scan
Low mass	29
High mass	400
MS source	230°C
MS Quad	150°C

Products in the same class emit different compounds and in different amounts





Ingredients listed in the MSDS of product 23:

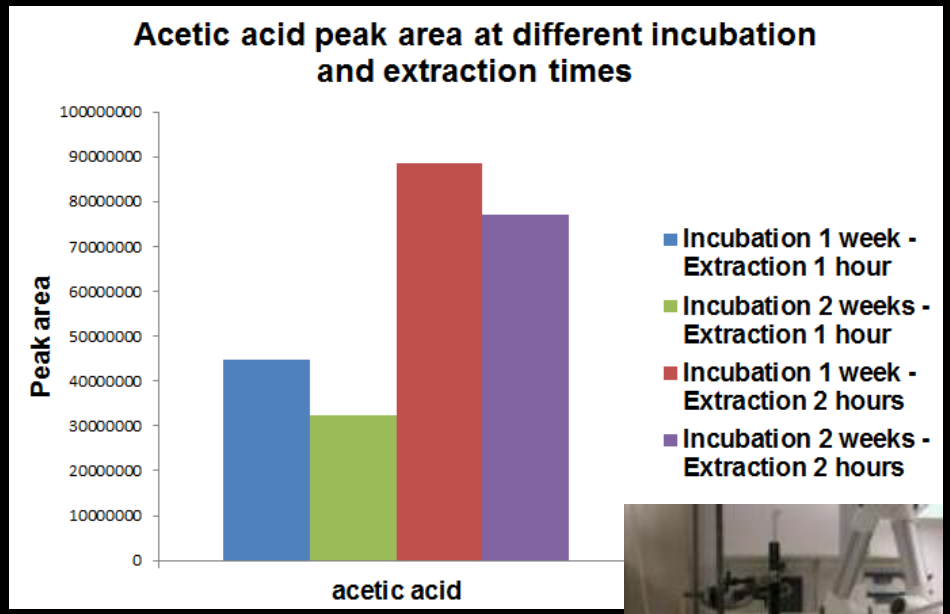
- 2-butoxyethanol 2.5-5%
- aliphatic polyisocyanate 50-100%
- 2-butoxyethyl acetate 5-10%
- hexamethylene diisocyanate <0.5%

Ingredients listed in the MSDS of product 8:

- 2-(2-butoxyethoxy)ethanol 1-5%
- hydrophilic, aliphatic polyisocyanate 60-80%
- n-methyl-2-pyrrolidone 2.5-10%
- paraffins (petroleum), normal C>10 1-2.5%
- polyfunctional isocyanate 50-75%
- hexamethylen-1,6-diisocyanate <0.1%

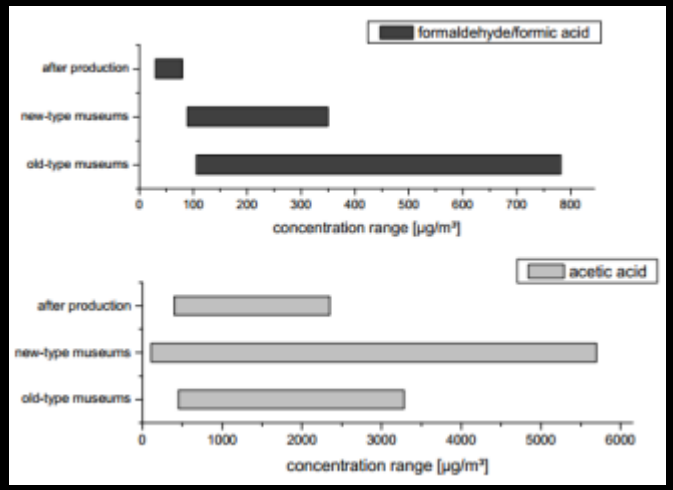
Optimal sampling and analysis method to assess the barrier effectiveness of the sealants

INLET	
Mode	splitless
Desorption T	**250°C**
Cleanup T	300°C
Cleanup time	20 min
Pressure	11.4 psi
Purge flow	20.0 ml/l
Desorption time	**1 min**
Total flow	24.0 ml/min
COLUMN	
Flow	**1.5 ml/min**
TRANSFER LINE	
Temperature	230°C
DETECTOR	
Temperature	250°C
MS ACQUISITION	
Mode	**SIM**
Ions m/z	**43 and 60**
Cycles/sec	4.53
Resolution	Low
EMV mode	Gain factor: 1
MS source	230°C
MS Quad	150°C

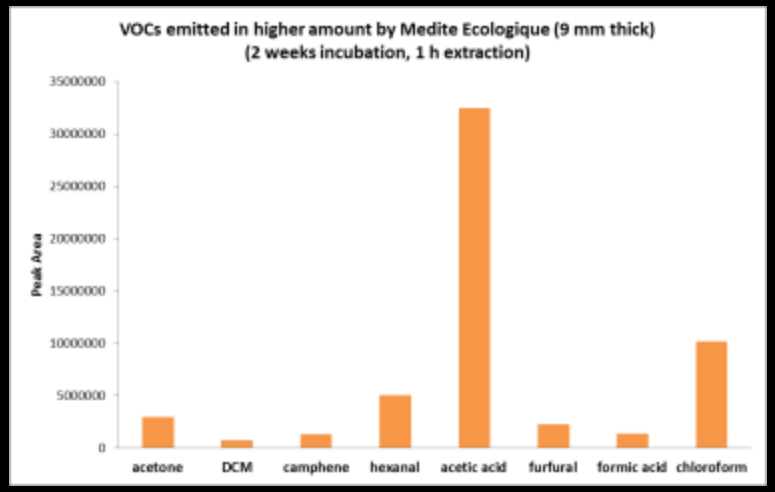


Incubation: 1 week
Extraction: 2 hours

Acetic acid was the compound selected to assess sealant barrier effectiveness



Schieweck A (2009). Airborne Pollutants in Museum Showcases – Material emissions, influences, impact on artworks . PhD thesis. Hochschule für Bildende Künste Dresden.



High acetic acid concentrations are detected in modern museum showcases

Acetic acid is the VOC off-gassed in the highest amount by the ZF-MDF used in this project

Methodology designed to evaluate of the barrier effectiveness of the coatings:

1 – cut, sand the edges of ZF-MDF samples, fit hook

2– pre-condition samples for 10 days (RH 50 ± 10%)

3– analysis of VOCs of uncoated MDF after 1 week incubation

4– application of the coating (3 layers by brush) and 30-day drying

5– analysis of VOCs of the coated samples after 1 week incubation

6– determination of the reduction of the acetic acid peak area coated/uncoated

Acknowledgements

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