3D Microscopy for Monitoring Dynamic Environmental Impacts on Painted Wood

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Allowable microclimatic variations for polychrome wood

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Content

• introduction

• climatic stress on painted wood caused by microclimate attack

• moisture behavior of painted wood sorption isotherms

• dynamic environmental impacts monitored with 3D Microscopy

• outlook
Problems of heating in places of worship due to thermal comfort

field survey at the sculpture
Problems of microclimate impact on painted wood in museums caused by HVAC-system

Impacts due to uncontrolled outlet of air masses
Problems of microclimate impact on painted wood in museums caused by HVAC-system

Optimized control strategy with the help of a sensitive sensor network - target
Accumulation of damage due to fluctuation of microclimate

Materials of high moisture sensitivity:
most organics like timber, paintings, leather, glue

Deformation due to hygric expansion and contraction – shrinkage and swelling

![3D-Microscopy of painted wood](image)
Consequences to minimize risk of damage

Heating and HVAC: optimization climate conditions

Conservation: find out a suitable consolidation treatment
Environmental Impact on Painted Wood
- Strick-Building in Appenzell / Switzerland -
Exposed painting
Environmental Impact due to weathering attack

- Grisaille-Painting 1673
- lime-casein-tempera
- in a good situation
  → covered by wooden panels in the past (from ~ 1800 on)
  → façade oriented to the north
  → found in 2008
Owners demand: energy efficiency building
- owners interest: to bring in an inside insulation
- conservator: do this cause problems for the painting?
Prevailing microclimate and surface temperature of the painting
environmental conditions influenced by Lake Constance
Numerical simulation of the coupled heat and moisture problem
Distribution of relative humidity for a wet day in winter

- wooden wall
- foile
- OSB-boa
- insulation
- painting
- without insulation
Hygric expansion of materials

hygric deformation, $\varepsilon_h$

$$\Delta \varepsilon_h = \frac{\Delta l}{l_0} = \beta_h(\theta) \cdot (\theta - \theta_{ref})$$

hygric expansion function, $\beta_h$

- moisture content
- anisotropism
- kind of stone
- plaster composition
- temperature

$\Rightarrow$ Hygric deformation is related to the sorption behavior of materials!
Characterization of the sorption isotherms with Dynamic Vapor Sorption Analyses (DVS)

Advantage of the method:
- almost restraint-free deformation
- prevention of disturbing diffusion effects due to a very small size of the sample
Sorption Isotherms of painting and wood
Images of the DVS integrated microscopy of the grey painting on wood (magnification x 100)

40 % r.h.

99 % r.h.
New 3D Microscope to analyze the dynamic hygric deformation processes by fluctuation of the environmental conditions
Picture Correlation software to analyze the displacement and deformation of the painting on wood under climate impact
Picture Correlation software to analyze the displacement and deformation of the painting on wood under climate impact.
Relation between mass change and strain of the painting (30 – 99 % r.h.)
Cyclic fluctuation of moisture load
- grey painting on wood after treatment

consolidation treatments:
(natural and artificial glues)
- Methyl-Hydroxyethyl-Cellulose (MH 300)
- Störleim
- Funori-Leim
Conclusions and outlook

• There is a need in determination of hygric deformation functions for paintings and wood
  ➔ ongoing research with 3D Microscope and picture analyzing software
  ➔ characterization of the hygric deformation function in dependency of the orientation of the wood
  ➔ experiments to the behavior of cracked paintings before and after conservation treatment
    (Bonding behavior between painting and wood)

• Numerical study on the stress-situation in the surface near area due to fluctuation of microclimate