Understanding Microclimates in Museums, Historic Houses, and Churches and their Impact on Heritage Materials

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Topic 4

Analysis and Interaction of Air Pollutants and Objects

Themes are monitoring in museum environments (Microclimate Studies) and the impact of these environments on selected heritage materials (Damage Assessment).

*In the **PROPAINT** project "Improved protection of Paintings during Exhibition, Storage and Transit", the aim was to monitor the air quality within microclimate frames, in the **SENSORGAN** project "Sensor System to Detect Harmful Environments" the aim was to monitor within lead-based organ pipes in contact with wooden parts of the organ.*

Impact on Heritage Objects

Studies of the effect of pollutants were made on parchment in the IDAP Improved Damage Assessment of Parchment" project , and on varnished strips exposed in frames for paintings in the PROPAINT project.

Microclimate Studies

Parameters which affect microclimatic conditions

RH,T, light,pollutants (inorganic and organic)

Monitoring

Methods for monitoring air quality in museums have not yet been standardised and are not extensively used. For microclimates it is more difficult due to limited volume for air sampling

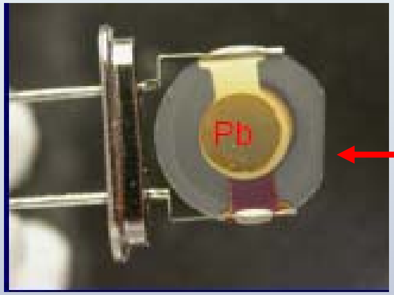
Limitations

High cost of some techniques

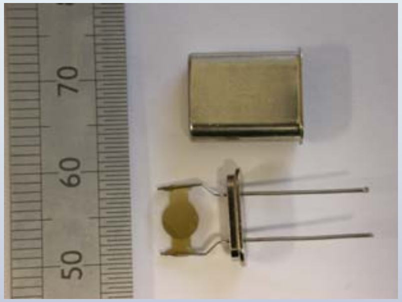
No clear correlation between level of pollutants and impact on collections ***have discouraged monitoring on a large scale.***

J.Tétreault "Airborrne Pollutants in Museums,Galleries and Archives: Risk Assessment,Control Strategies and Preservation Management" CCI (2003)

Dosimeter has enhanced sensitivity to the main cause of damage and the synergistic effect of contributing factors



Lead



The PQC-dosimeter responds to the cumulative dose received and can be responsive to (1) volatile organic acids or (2) photooxidising effects.

The change monitored is of a chemical nature and is irreversible. The larger the change monitored the greater the degradation of the material in the particular environment.

M.Ryhl- Svendsen Corrosivity Measurements of Indoor Museum Environments using lead coupons as dosimeters “Journal of Cultural Heritage” 9 (2008) 285-293

Impact on Heritage Materials   Damage Assessment

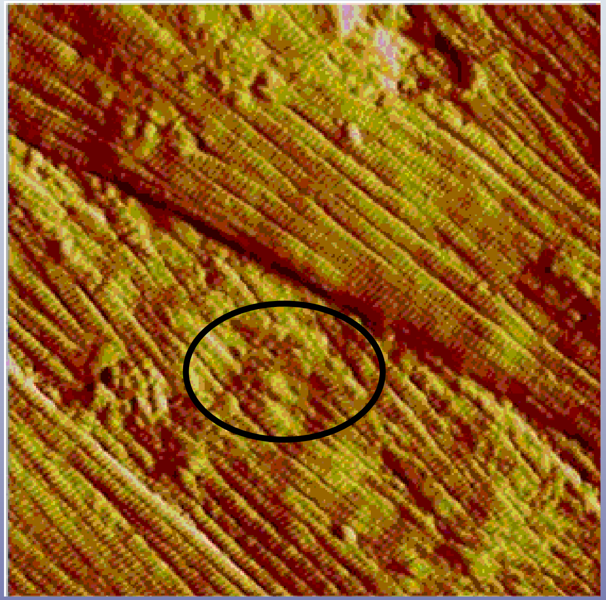
Courtesy D.Thickett English Heritage published in ICOM-CC Proceedings "Refitting old display cases" Vol 2 773 -782 (2008) Corrosion of lead tin solder (forms lead formate) in jet brooch in showcase Iveagh Bequest, Kenwood House, London English Heritage

Impact on Parchment   *Damage Assessment*

OPERA
Italian Project: Old Parchment Evaluating, Restoration and Analysis

Atomic Force Microscopy (AFM) images of modern parchment (goat) after exposure to selected levels of acetic acid vapour

5µmx5µm

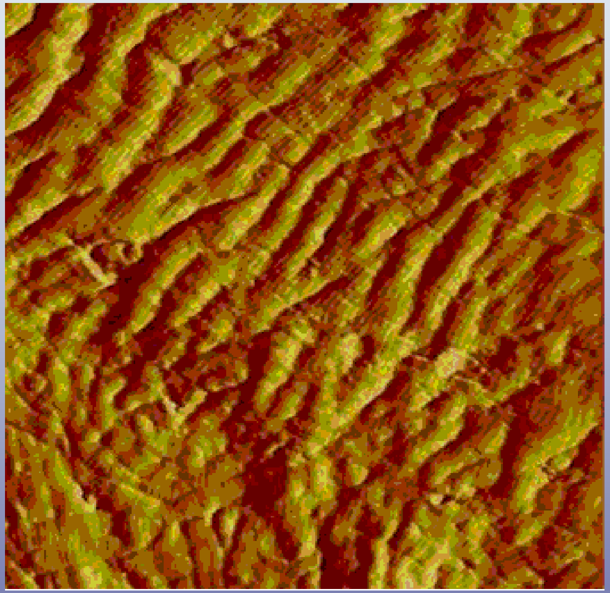


Exposed 15days to 0.6ppm (c1500ug/m3) HAc at 74%RH

D.Bradshaw M.Sc Analytical Chemistry

Thesis Birkbeck 2009

5µmx5µm



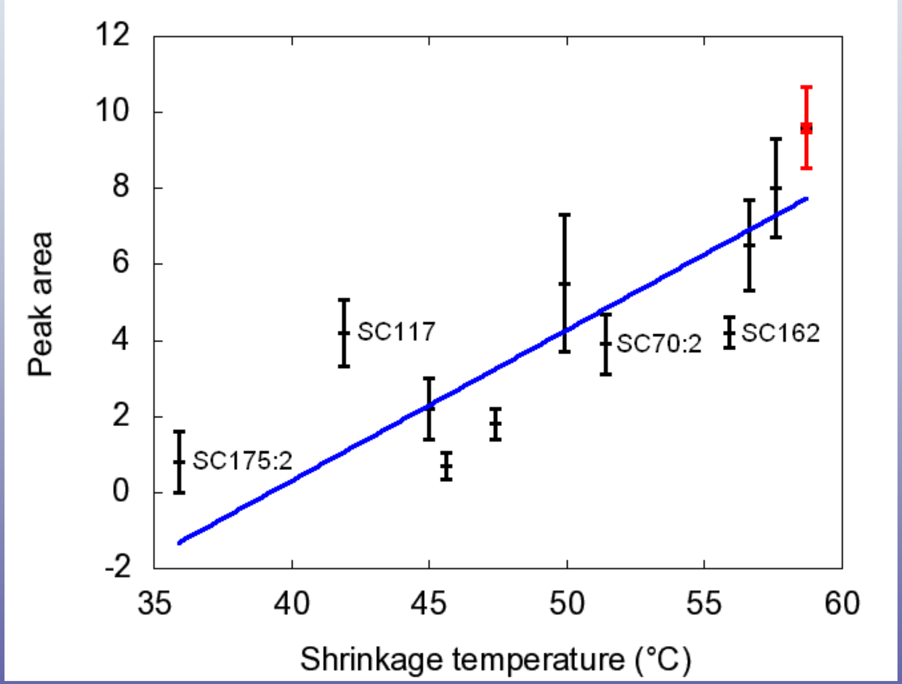
Exposed 33days to 0.6ppm HAc at 74%RH

Extreme wrinkling, loss of D-banding occurs

Impact on Parchment   Damage Assessment

Quantification of AFM images gives parameter (peak area) used to measure extent of intactness of D-banding of collagen

Correlates with Ts (shrinkage T) for some historical samples and change in mechanical properties on exposure to programmed RH of pre-dried samples



SC81:5(red) Control

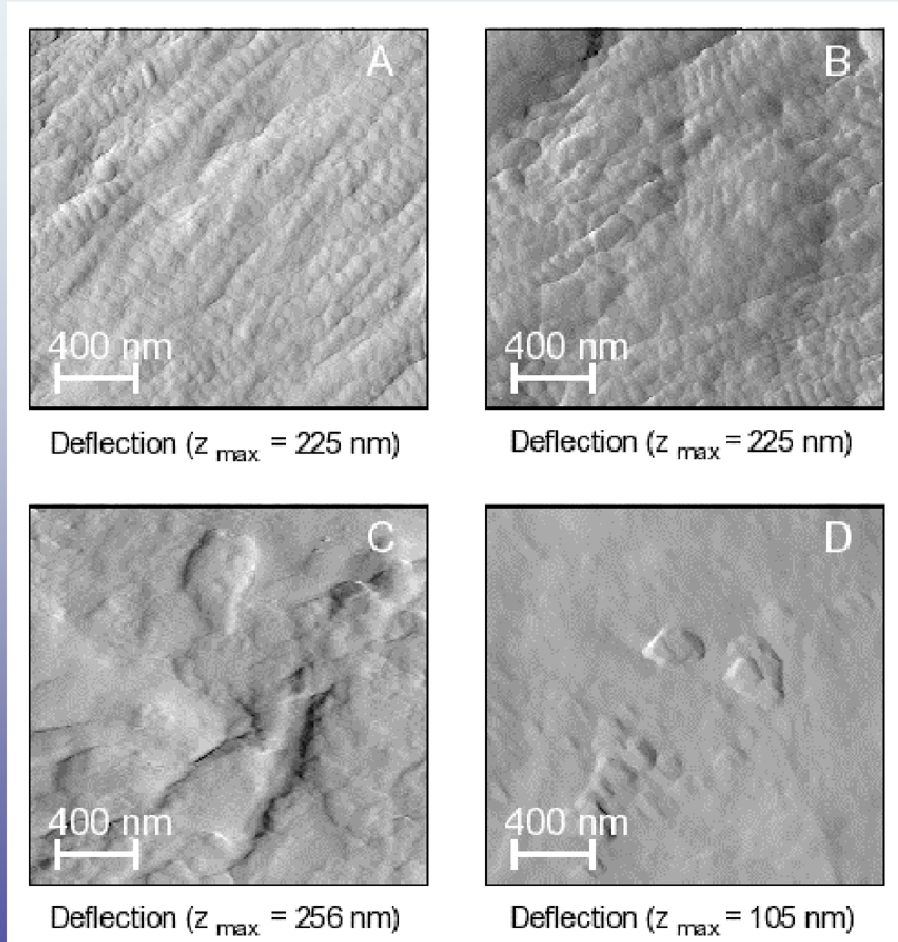
SC162 13th cent Segovia

SC175:2 (Florence)

J de Groot Ph D thesis (2007)

R.Larsen "Improved Damage Assessment of Parchment"   EC (2007)
ISBN 978-92-79-05378-8

Effect of pollutant ageing: AFM images of exposure of modern parchment (calf) to SO_2 (50ppm) for 2,4,8 and 16 weeks



Sample B (4 weeks) Extension (2%) on increase in RH

Sample C (8 weeks) Extension (1.1%) on increase in RH

J de Groot Ph D thesis (2007)

Materials Characterisation Case Studies   OPERA project

OPERA
Italian Project: Old Parchment Evaluating, Restoration and Analysis

"*Manuali del Senato*" State Archives of Genoa,Italy (end of XIVth-beginning of XVth) sample from water damaged bookbindings re-used in 1557

Extension (0.8%) on increase in RH

CHATELAIN'S FINANCIAL ACCOUNTS (CASTELLANIE) State Archives of Turin

ASTO 4-1: 1467-1469 (goat) sample from sewing border on the recto part
Extension (1.6%) on increase in RH

Impact on Artists' Varnishes *Damage Assessment*

EC PROJECT PROPAINT *Sample preparation for pollutant ageing*

"IMPROVED PROTECTION OF PAINTINGS DURING EXHIBITION, STORAGE & TRANSIT"

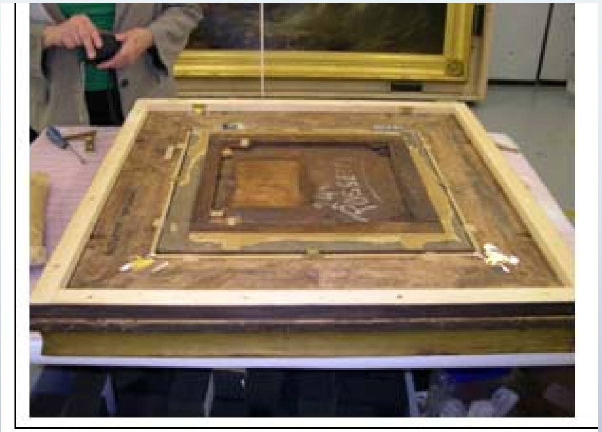
SSPI - 044254

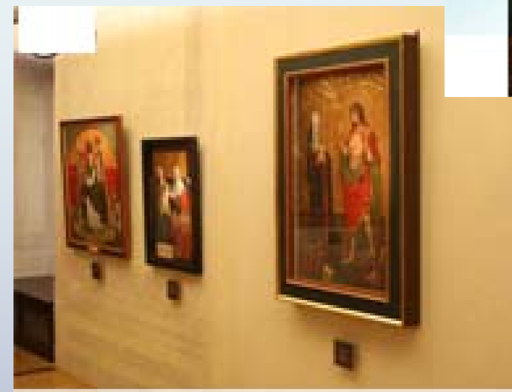
Varnishes selected

1. Resin Mastic
2. Dammar
3. Dammar and Tinuvin
4. MS2A
5. MS2A and Tinuvin
6. B72

Microclimate Studies

PRO PAINT





Impact of pollutants on properties of varnishes

Tate Store

National Museum Germany

National Museum Cracow

N.Museum Oslo

Statens (Dk)

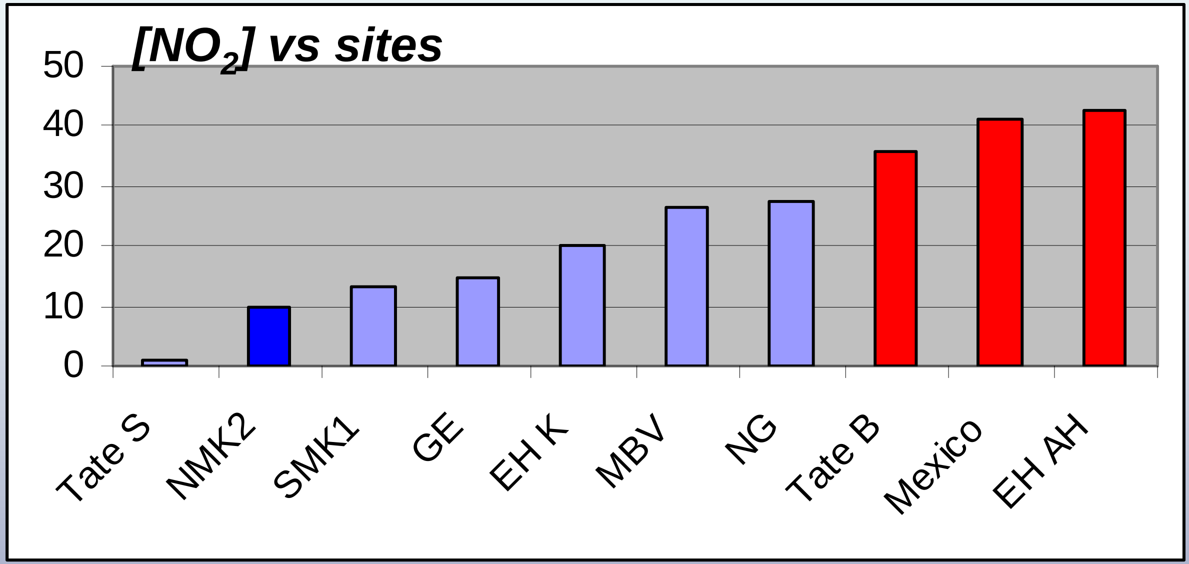
English Heritage (K)

Museum Fine Arts Valencia

Tate Britain

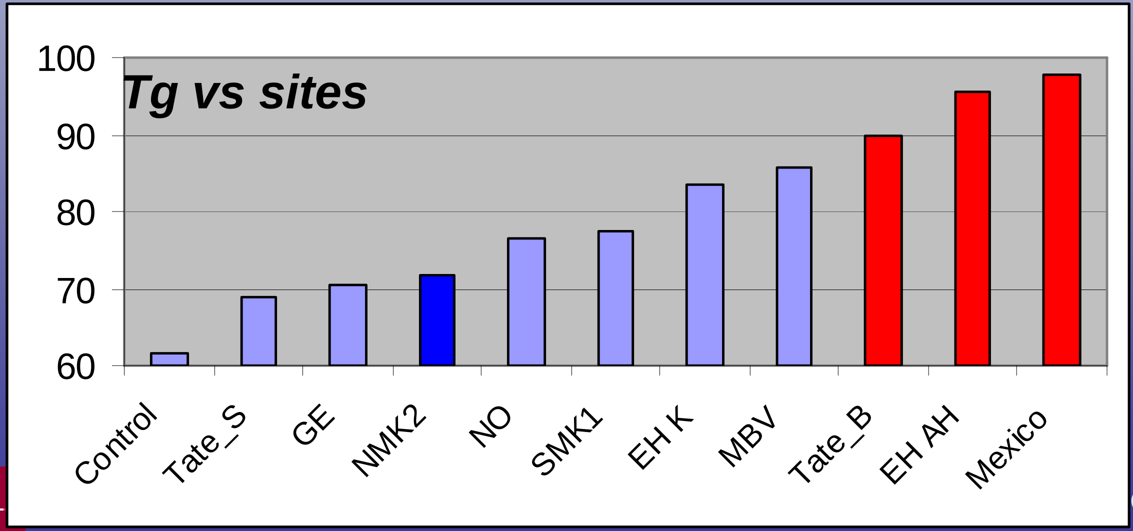
English Heritage (Apsley

Museum Mexico



Measured NO_2 concentrations ($\mu g/m^3$) in rooms

Tg values of resin mastic coated strips in museums



Tg

Site exposure

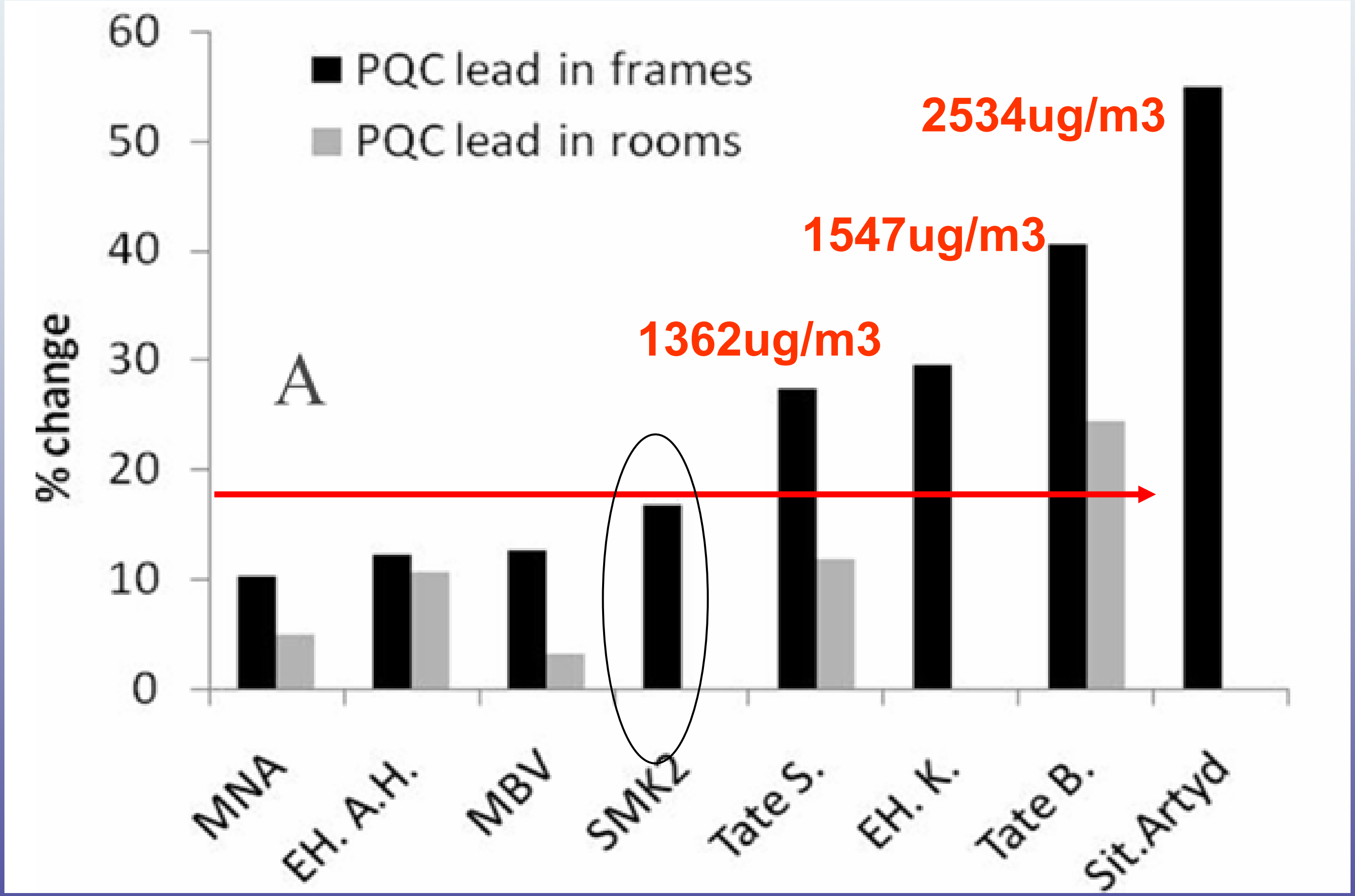
Resin Mastic Tg of strips in museums within frames (F) and in rooms (R) and measured NO_2, O_3,HAc values in frames and in rooms

	Tg / °C	NO_2	O_3	HAc
Tate B (F)	66	2	1	543
Tate B (R)	90	36	3	106
Cracow NF (F)	62	0	1	502
Cracow NF (R)	72	10	2	175
Valencia ES(F)	83	0	3	435
Valencia ES (R)	86	27	8	47
DK (F)	90	4	1	1070
DK (R)	78	13	13	43

Resin mastic in frame in Statens Museum (DK) shows Tg varnish in frame greater than Tg varnish in room. Levels of HAc in frame are higher. Frame offers no protection.

For Tate Britain Tg of varnish in room higher than in frame,possibly due to higher NO_2 in room. So protective action of frame containing painting.

L-PQC dosimeters exposed in Frames and Rooms..



Highest value is given by a prepared model painting in a mc-frame

HAc (red)

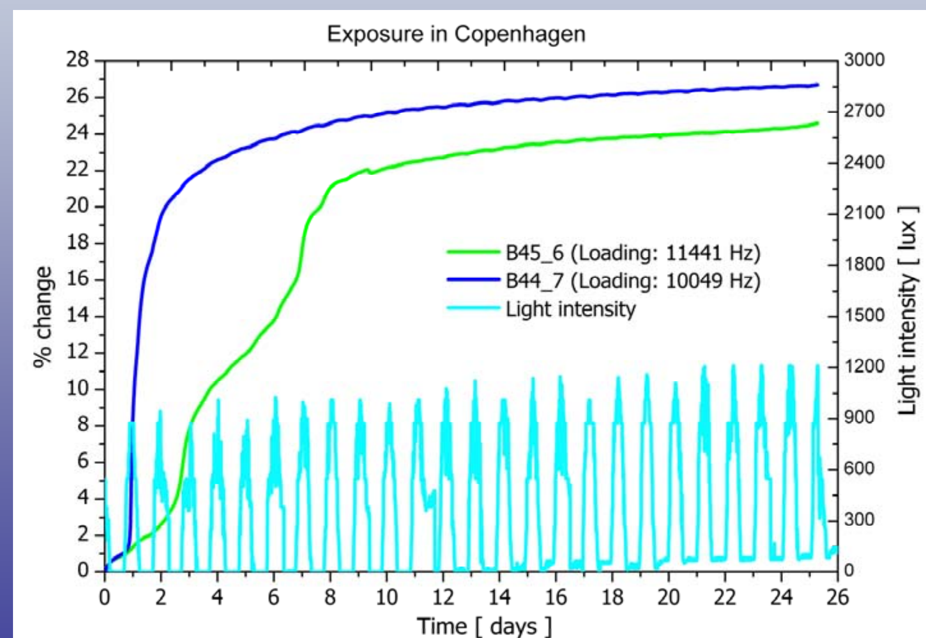
Above red line values are considered to be above acceptable values

PROPAINT “Improved protection of Paintings during Exhibition, Storage and Transit”

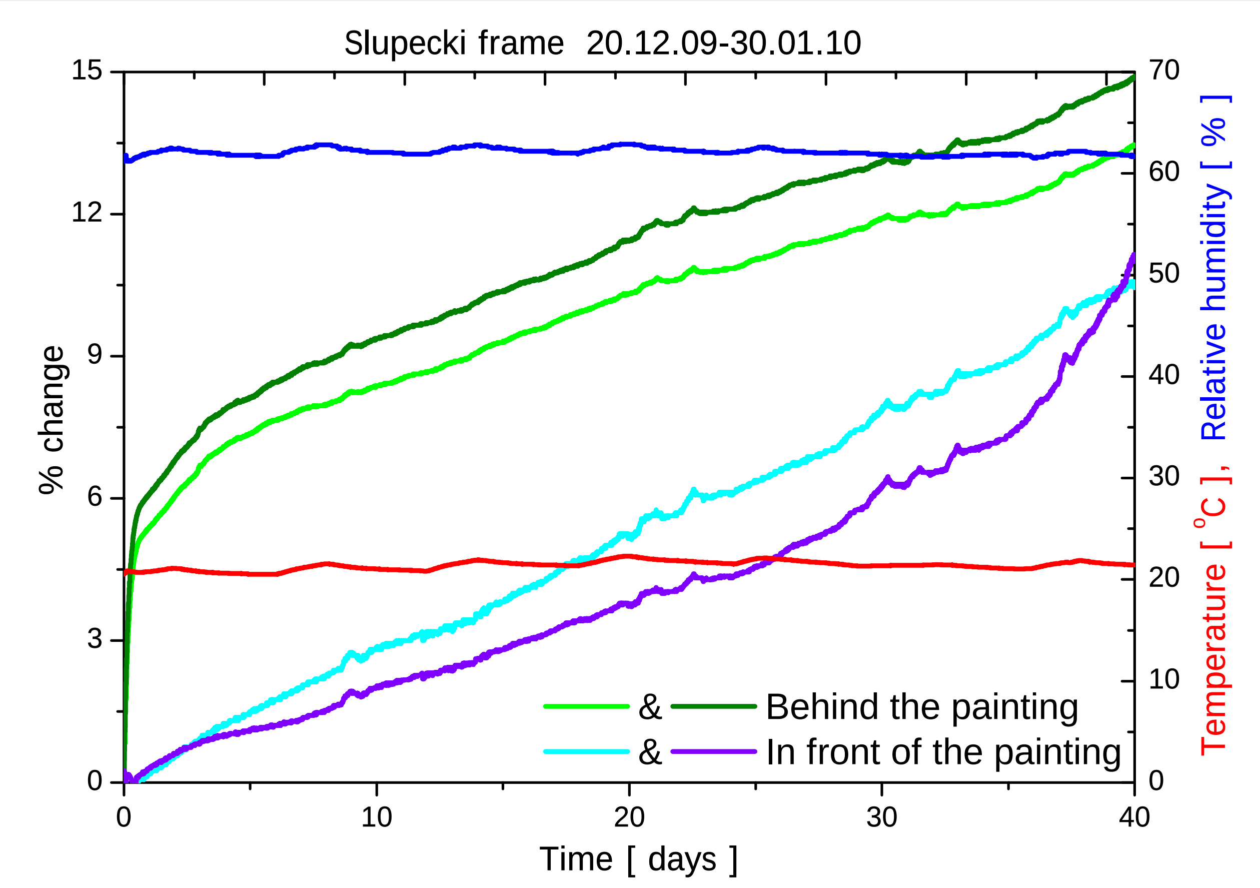
SSPI - 044254

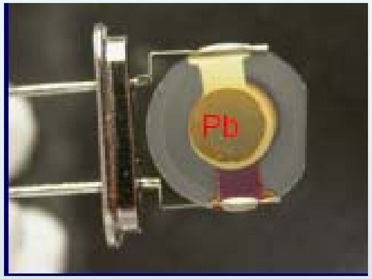
Lead coated PQC Dosimeters for continuous monitoring for volatile organic acids.

PQC dosimeter (battery powered) exposed at the Statens Museum for Art, Copenhagen



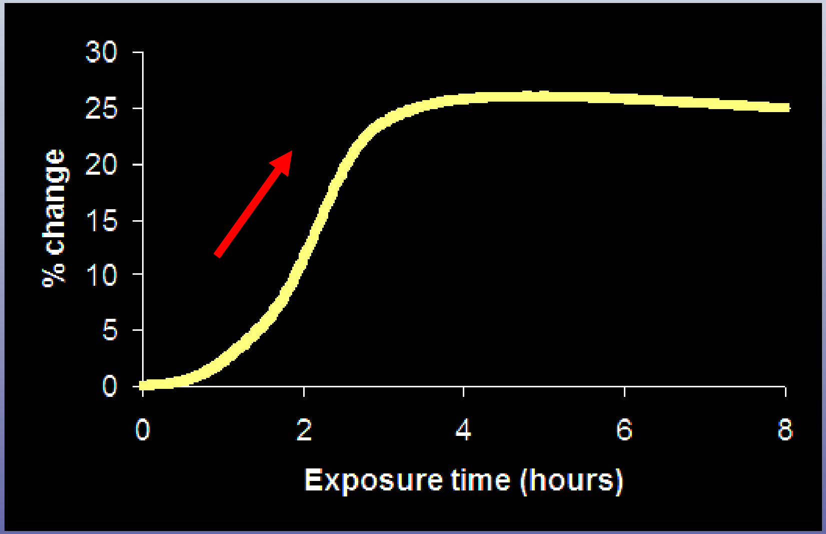
Difference in dosimeter response between front and back of painting in microclimate frame

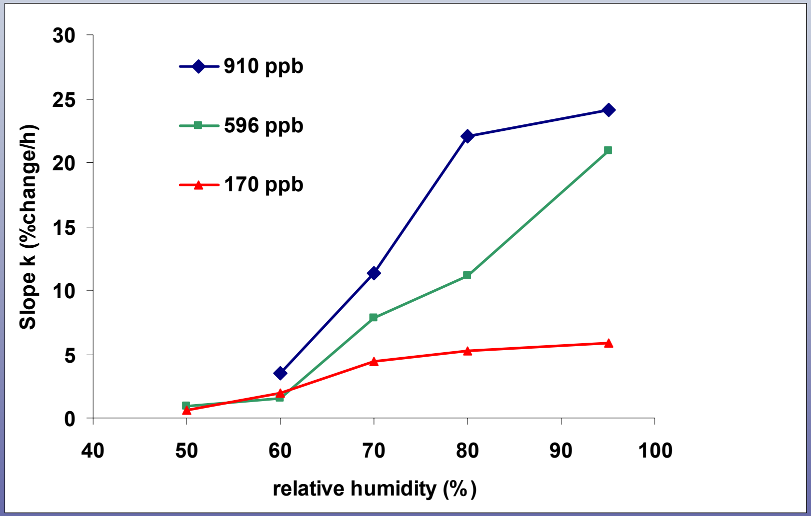




Change (%) is calculated from the frequency shift Δf(Hz) relative to the original frequency of the crystal (Fo(kHz) after coating

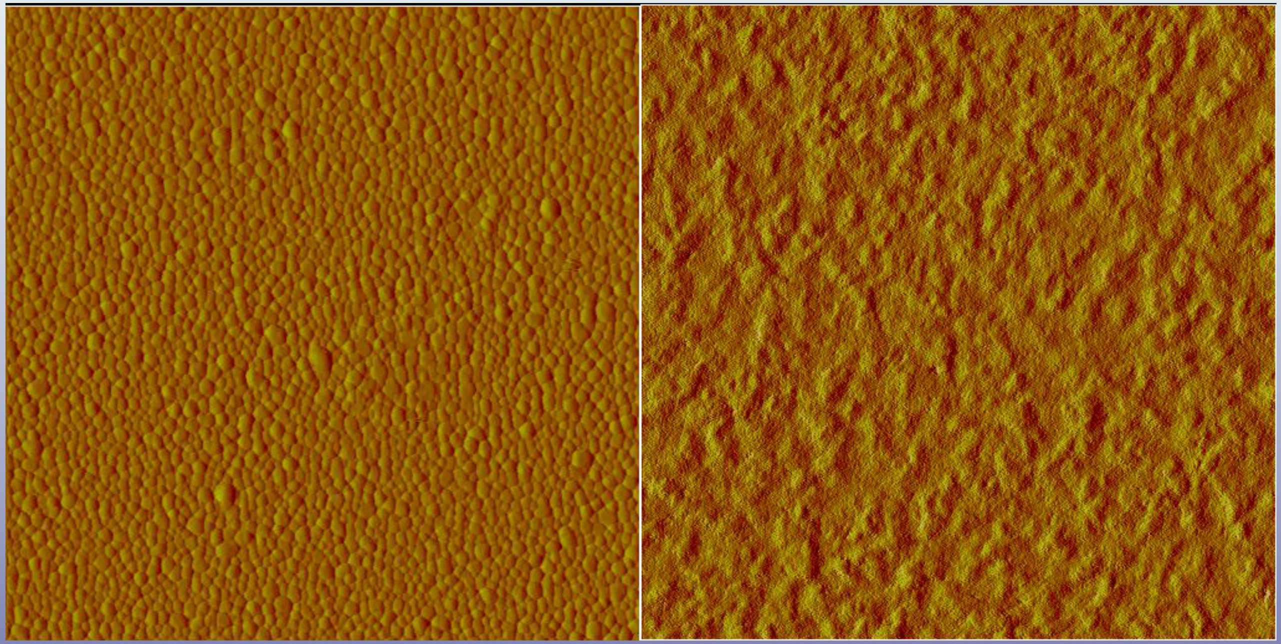
Change (%) (left) or Rate of change in lead (right) coated L-PQC crystal dosimeter on exposure to 596ppb HAc at 70%RH.





Piezoelectric Quartz Crystal dosimeter developed in MIMIC project (EVK4 -CT-2000-00040) and adapted to microclimate monitoring in the SENSORGAN project (Birkbeck)

Atomic Force Microscopy of lead coating on L-PQC Dosimeter



3.5 µm x 3.5 µm

before exposure

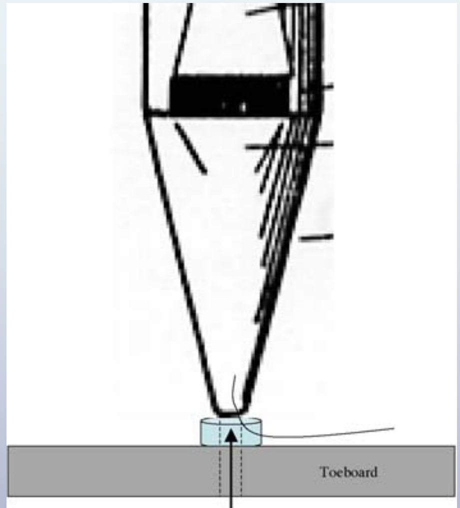
roughness: 18

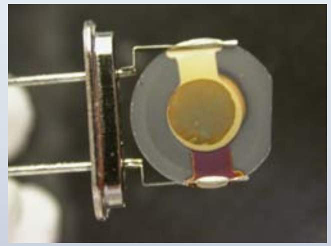
30 min. after exposure in oak cabinet

roughness: 28

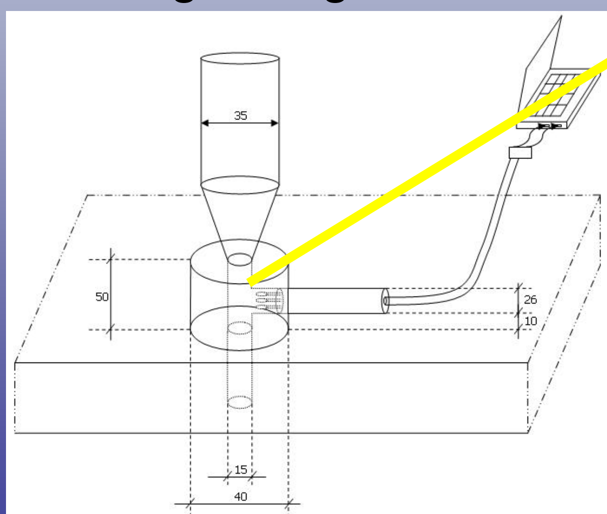
SENSORGAN

Miniaturisation for continuous monitoring in organ pipes





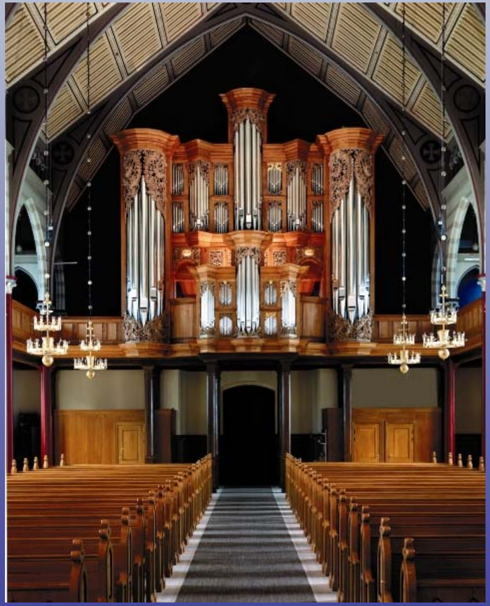
Monitoring of organic acids



SENSORGAN project (2008) Sensor system for detection of harmful environments for pipe organs. Contract no. 022695.

URL: *http://www.goart.gu.se/sensorgan*

SENSORGAN *“Sensor System to Detect Harmful Environments for Pipe Organs”.*



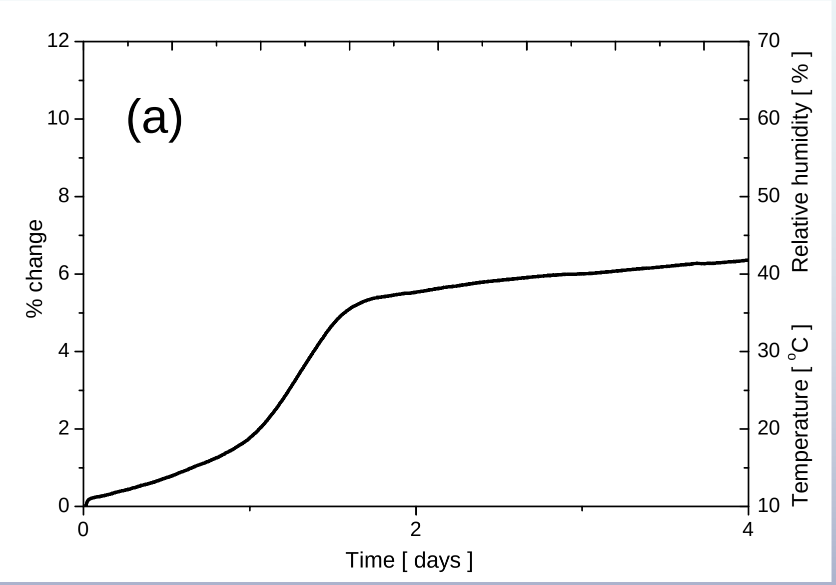
Wood (pine and oak) is used in the palette boxes of historical organs.

Emission of volatile organic acids is influenced by increases in relative humidity and T.

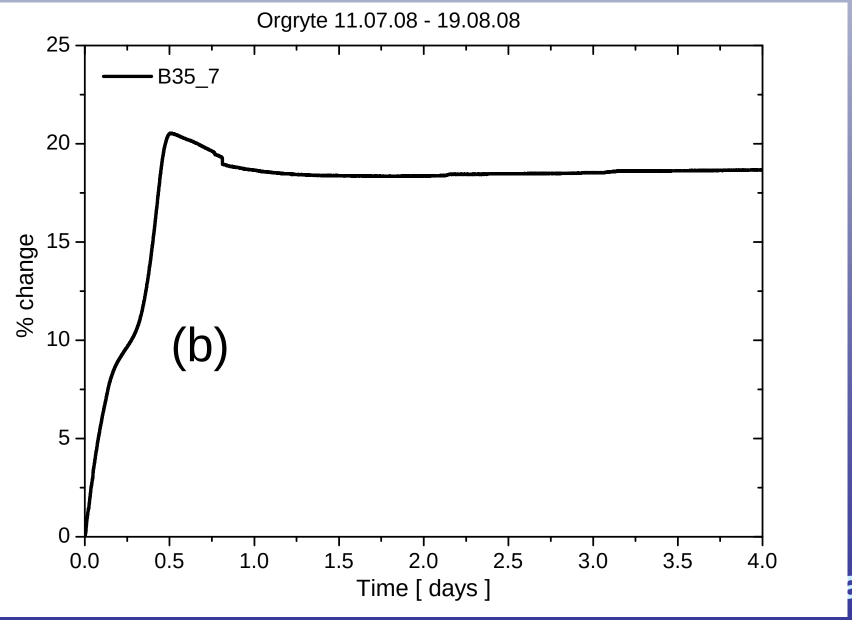
In SENSORGAN lead coated piezoelectric quartz crystal dosimeters (right) are used to monitor the volatile organic acids

http://www.goart.gu.se/sensorgan

Site testing using small holder
(a) St Botolph without Aldgate and (b) Orgryte

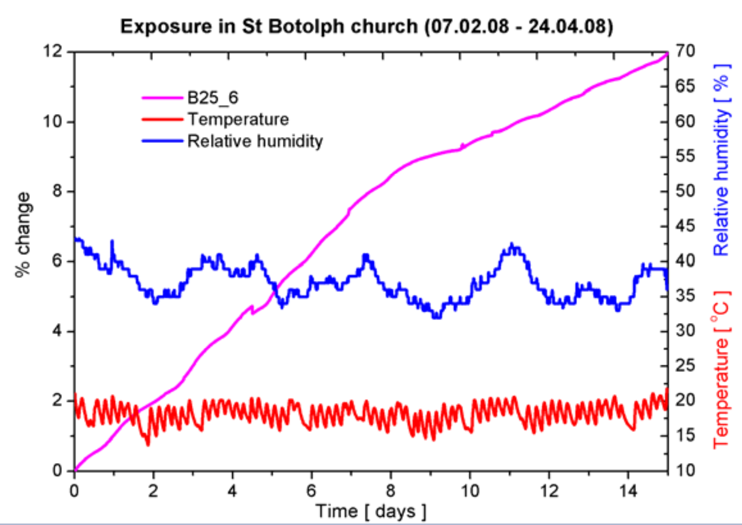


In St Botolph response is lower for period (8-10-2008 to 12-10-2008)

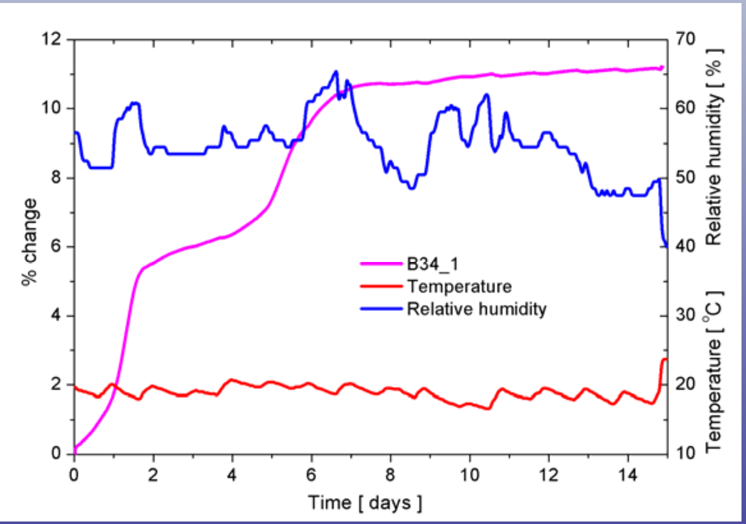


In Örgryte New Church (newly built baroque organ) response is much higher for period 11.07.08 and 15.07.08

Continuous monitoring in organ pipes at St Botolph without Aldgate,London

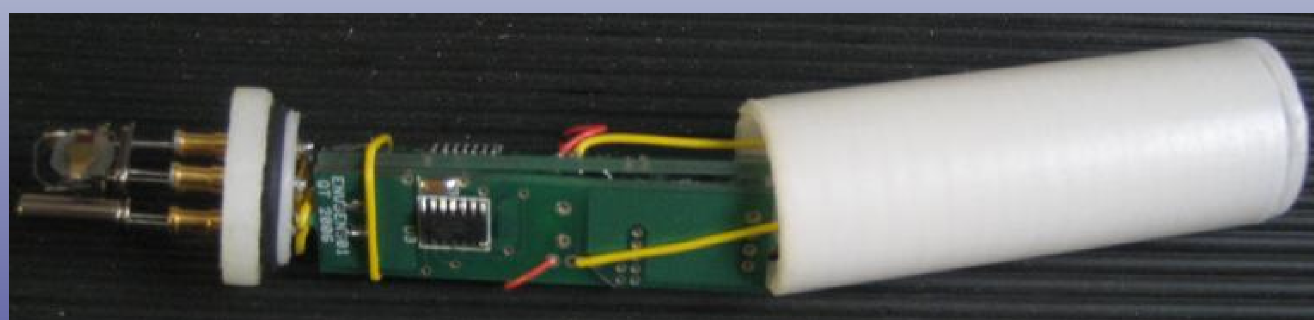


07-02-08 to 24-04-08
Pipe over new wood
RH 35-40% 15-20C
Rate of change 1%/day first 8 days



08-10-08 to 23-10-08
Pipe over old wood
RH 50-65% 17-20C
Rate of change 2.75%/day for first 2 days and slows down for 3 days

Miniaturisation of dosimeter



SME QuartzTec and Dr.S.Jakiela ICSC Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, Poland

Miniaturisation of dosimeter for use within paint frames

Holder and control box

Measures crystal f, RH,T,light

Control box contains

2 switches for power and usb download of data

Dr.S.Jakiela ICSC Institute of Catalysis and Surface Chemistry Poland

Conclusions

1. PQC L-dosimeter provides an assessment of the quality of the microclimate. A coating of lead on PQC crystals is responsive to volatile organic acids. Accelerated ageing and exposure at sites where volatile organic acids have been measured has demonstrated that the response is proportional to the dose received.

2. PQC L-Dosimeter can be used to rapidly test volatile organic acid levels in enclosures. Where air exchange values are low and acetic acid concentrations exceed c.1500ug/m3 then response occurs within a few hours.

3. If response in enclosure is rapid then this acts as an early warning signal. Ageing studies on parchment show that levels of this magnitude affect collagen structure and there are implications for mechanical properties and response to RH. For varnishes Tg values are also affected.

4. AFM provides information on changes in (1) surfaces of materials and DMA on glass transition temperatures of varnishes.

5. Correlation was found between changes in parchment structure (at nanoscale level) and shrinkage temperature and mechanical properties on response to programmed RH of pre-dried samples.

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