Wilhelm-Klauditz-Institut Holzforschung

7th Indoor Air Quality 2006 Meeting

IAQ in museums and archives

Braunschweig,Germany 15-17 November 2006

Dosimetry with spectroscopy and impedance analysis for cumulative damage monitoring of historical pipe organs

M. Odlyha[1], C. Theodorakopoulos[1], J.M.Slater[1],

A.Cavicchioli[2], D.L.A. de Faria[2], J-E. Svensson[3] A. Niklasson[3]

1.School of Biological & Chemical Sciences, Birkbeck College

2. School of Arts,Sciences and Humanities, University of Sao Paolo Brazil,

3.Chalmers,University of Technology,Dept. of Environmental Inorganic Chemistry

Carl Johan Bergsten & Alf Aaslund
GÖTEBORG ORGAN ART CENTER, GÖTEBORG UNIVERSITY, SWEDEN

Marianne Odlyha & Jonathan Slater
SCHOOL OF BIOLOGICAL AND CHEMICAL SCIENCE, LONDON

Lukasz Bratasz & Roman Kozlowski
INSTITUTE OF CATALYSIS AND SURFACE CHEMISTRY, KRAKOW, POLAND

Dario Camuffo
INSTITUTE OF ATMOSPHERIC SCIENCES AND CLIMATE, PADOVA, ITALY

Grazyna Praszelik-Kocjan & Lech Skoczylas
THE MUNICIPAL CULTURAL CENTRE, OLKUSZ, POLAND

Andrea Cavicchioli & Dalva L.A. De Faria
UNIVERSITY OF SÃO PAULO, SÃO PAULO, BRAZIL

Jan-Erik Svensson & Annika Niklasson
CHALMERS UNIVERSITY, GÖTEBORG, SWEDEN

CONSORTIUM

SENSORGAN

Detection System for Harmful Environments for Pipe Organs

- European heritage of more than 10 000 historical instruments.
- Organic acids and condensation phenomena lead to pipe corrosion
- Harmful humidity conditions are related to cracks in the wooden parts of organs

Objectives of the project

MAKE AVAILABLE NEW INSTRUMENTATION FOR MONITORING AND DETECTION OF HARMFUL ENVIRONMENTS FOR ORGANS THROUGH DEVELOPMENT OF SENSORS FOR REAL TIME MEASUREMENTS

- Development of a piezoelectric quartz-based dosimeter for detection of organic acids
- Development of an acustic emission sensor related microcracks appearing in wood
- Development of a sensor for detection of dew formation inside and outside organ pipes
- Definition of mitigative strategies
- Support to CEN Standardisation

SENSORGAN

"Sensor Systems for Detection of Harmful Environments for Pipe Organs"
SENSORGAN

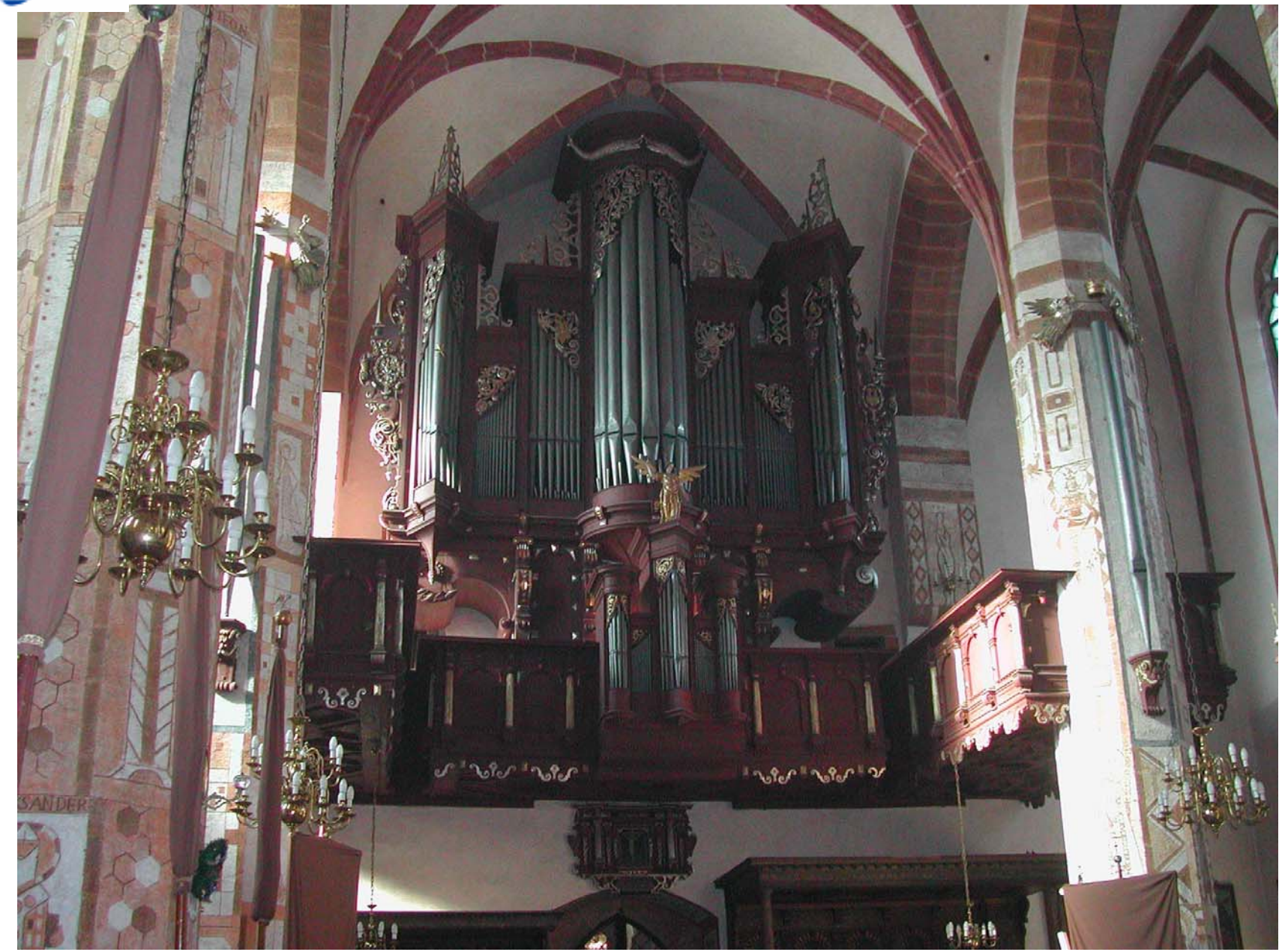
http://www.goart.gu.se/sensorgan

The results from three previous EC research projects:

COLLAPSE (EVK4-CT-2002-00088)
MIMIC (EVKV-CT-2000-00040)
FRIENDLY HEATING (EVK4-CT-2001-00067)

are important for SENSORGAN.

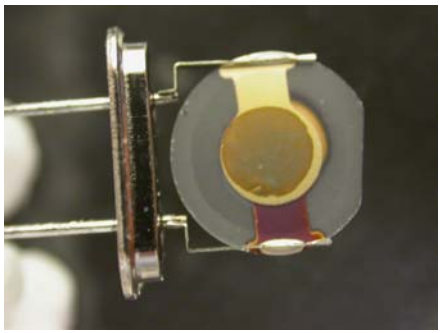
SENSORGAN

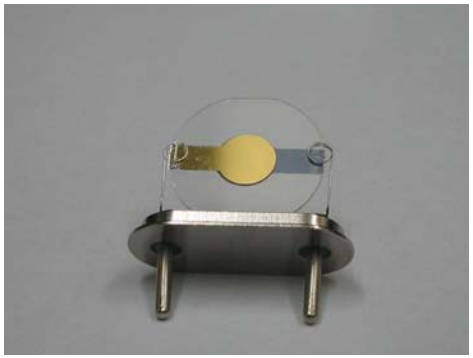


SENSORGAN

WP1 Sensor for detection of organic acids corrosive to organ pipes

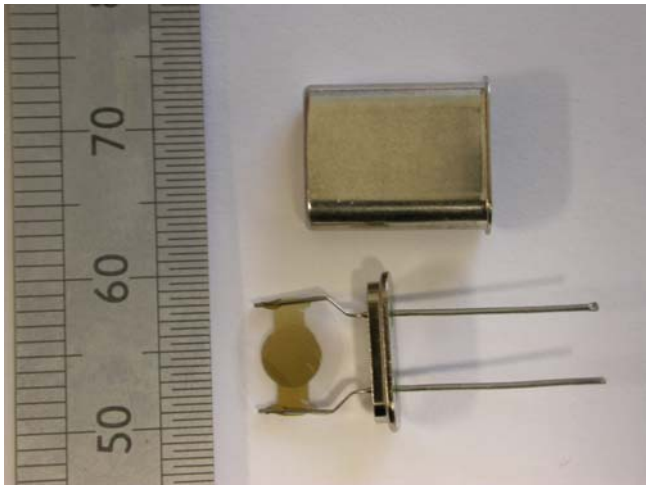
Birkbeck College, Chalmers University of Technology, and the University of Sao Paolo, Brazil.





1. Deposition of lead onto 10MHz piezoelectric quartz crystals
2. Monitoring of behaviour post deposition (dataloggers developed in MIMIC project for continuous monitoring of change)
3. Exposure of lead coated crystals to accelerated ageing.
4. Exposure at test sites Olkulsz (organ) and Kenwood House (English Heritage). In the latter exposure was made in a showcase where levels of acetic acid have been measured.
5. Testing and characterisation of lead coupons exposed at English Heritage sites and accelerated aged samples (Chalmers).

WP1 Sensor for detection of organic acids corrosive to organ pipes



Sauerbrey equation

$$\Delta m = \frac{\Delta f.\ A}{2.3*10^{6}.\ F^{2}}$$

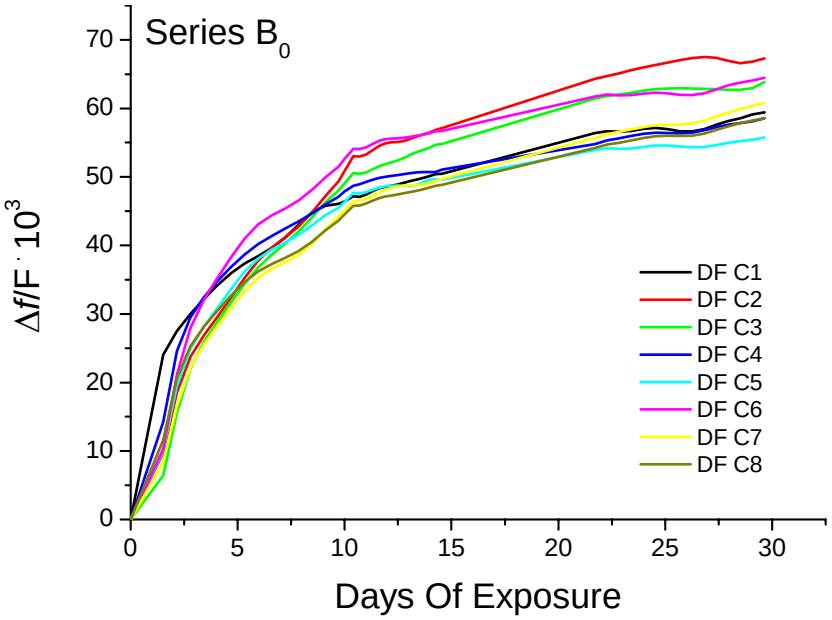
Where $A(cm^2)$, F =10 MHz

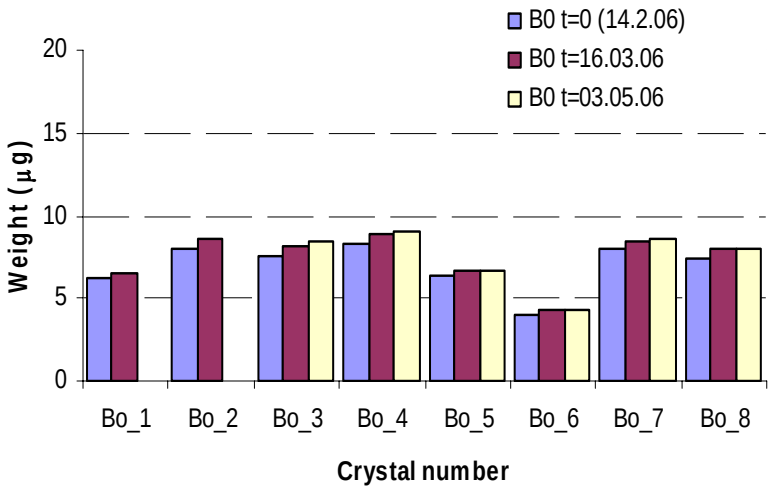
Surface area r=0.16cm $A=\pi r^2$ [2 sides2x$(3.14x0.16^2)$] =0.161cm^2

Thickness of film =delta m / V= delta m/ ρ*A

Bo Series

	delta f 14.02.06		delta f 16.03.06			delta f 03.05.06		
		M t=0		**M t=30d**	**%Mincrease**		**M t=48d**	**%Mincrease**
	(Hz)	(μg)	(Hz)	(μg)	(%)	(Hz)	(μg)	(%)
Bo_1	8863	6.20	9355	6.55	5.55	Sao Paolo		
Bo_2	11416	7.99	12292	8.60	7.67	Sao Paolo		
Bo_3	10854	7.60	11720	8.20	7.98	11962	8.37	10.21
Bo_4	11908	8.34	12631	8.84	6.07	12808	8.97	7.56
Bo_5	9070	6.35	9599	6.72	5.83	9600	6.72	5.84
Bo_6	5618	3.93	6050	4.24	7.69	6156	4.31	9.58
Bo_7	11369	7.96	12105	8.47	6.47	12361	8.65	8.73
Bo_8	10659	7.46	11325	7.93	6.25	11416	7.99	7.10



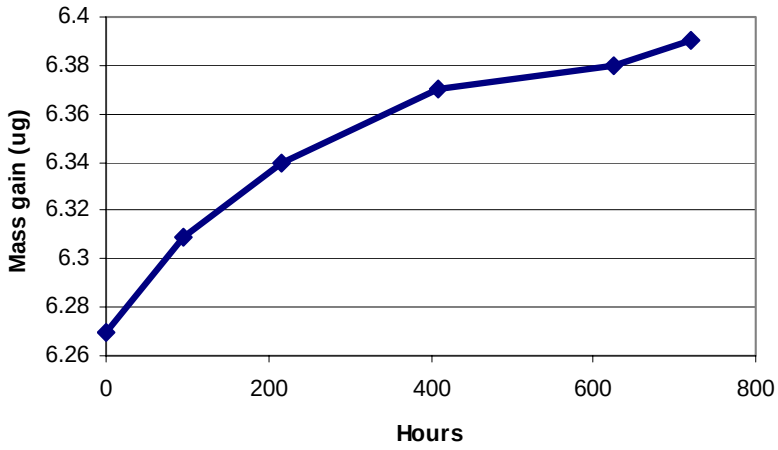


Bo_6 remained in lab canned. Re-measured 8.10.06 and % wt gain has increased from 9.6% to 13.7%

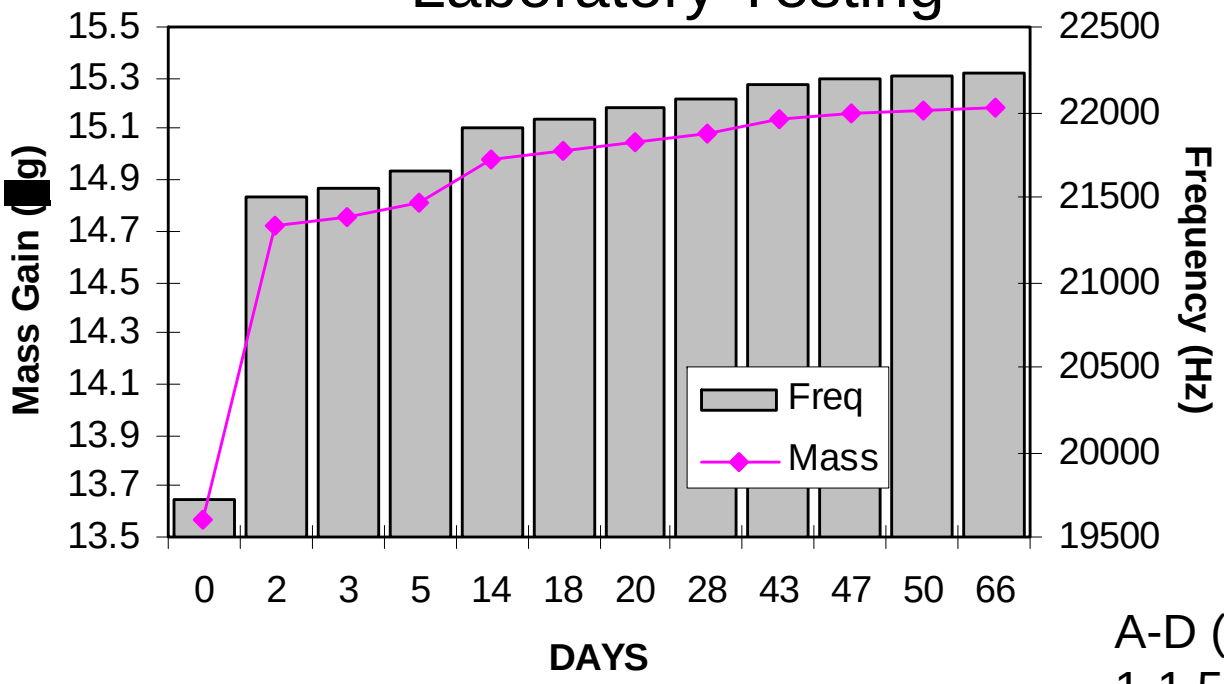
Laboratory Testing

QTS-2					
		delta F	delta F	Mass (ug)	Mass (ug)
	Days	B2_7	B1_4	B2_7	B1_4
09.09.06	0	8958	10741	6.27	7.51
13.09.06	4	9025	10795	6.31	7.54
18.09.06	9	9063	10830	6.34	7.58
26.9.06	17	9097	10898	6.37	7.63
05.10.06	26	9118	10947	6.38	7.66
9.10.06	30	9134	10965	6.39	7.68

B2_7 %wt. inc. 1.91%



Laboratory Testing

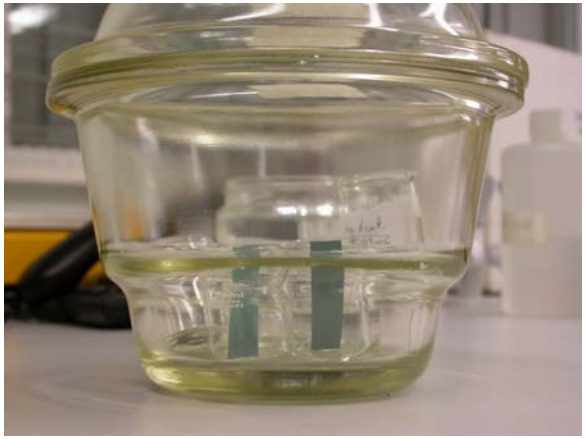


Exposure to saturated $Mg(acac)_2$

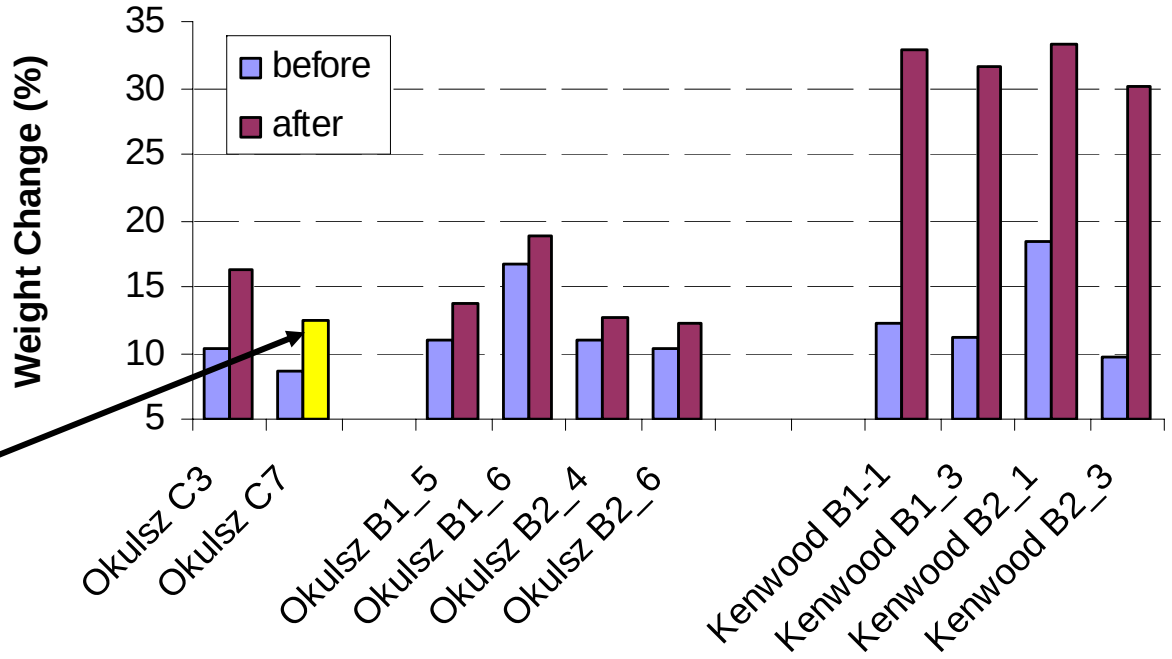
HAc 0.65 ppm and 74%RH

Exp Time Days	RH (%)	Temp (oC)	DF	Mass (µg)
0	25.0	23.8	19610	13.6
2	38.0	22.1	21323	14.8
3	33.0	23.9	21379	14.9
5	28.0	22.5	21474	14.9
14	22.0	23.6	21712	15.1
18	24.0	24.1	21767	15.1
20	20.0	25.0	21819	15.2
28	27.0	22.8	21878	15.2
43	32.0	24.3	21962	15.3
47	29.0	27.0	21987	15.3
50	29.0	25.2	22005	15.3
66	45.0	23.8	22029	15.3

A-D (Acid Detecting) strips (level 1-1.5) Film base deterioration monitors- Test strips for atmospheric acidity



Testing at Sites (Olkusz ,PL and Kenwood House (English Heritage)

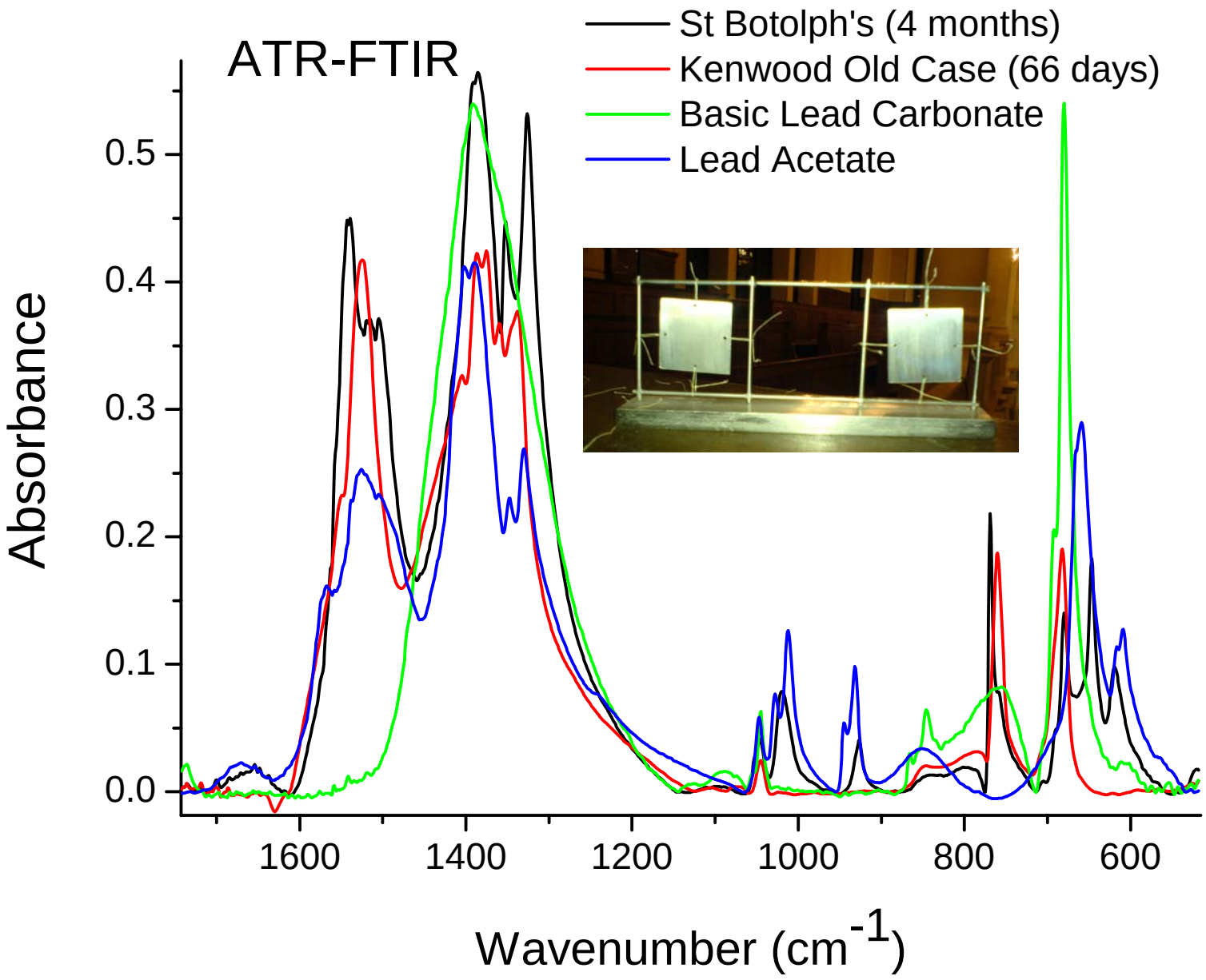


Okulsz (B0_3,B0_7) open and canned 28.06.06 to 29.07.06

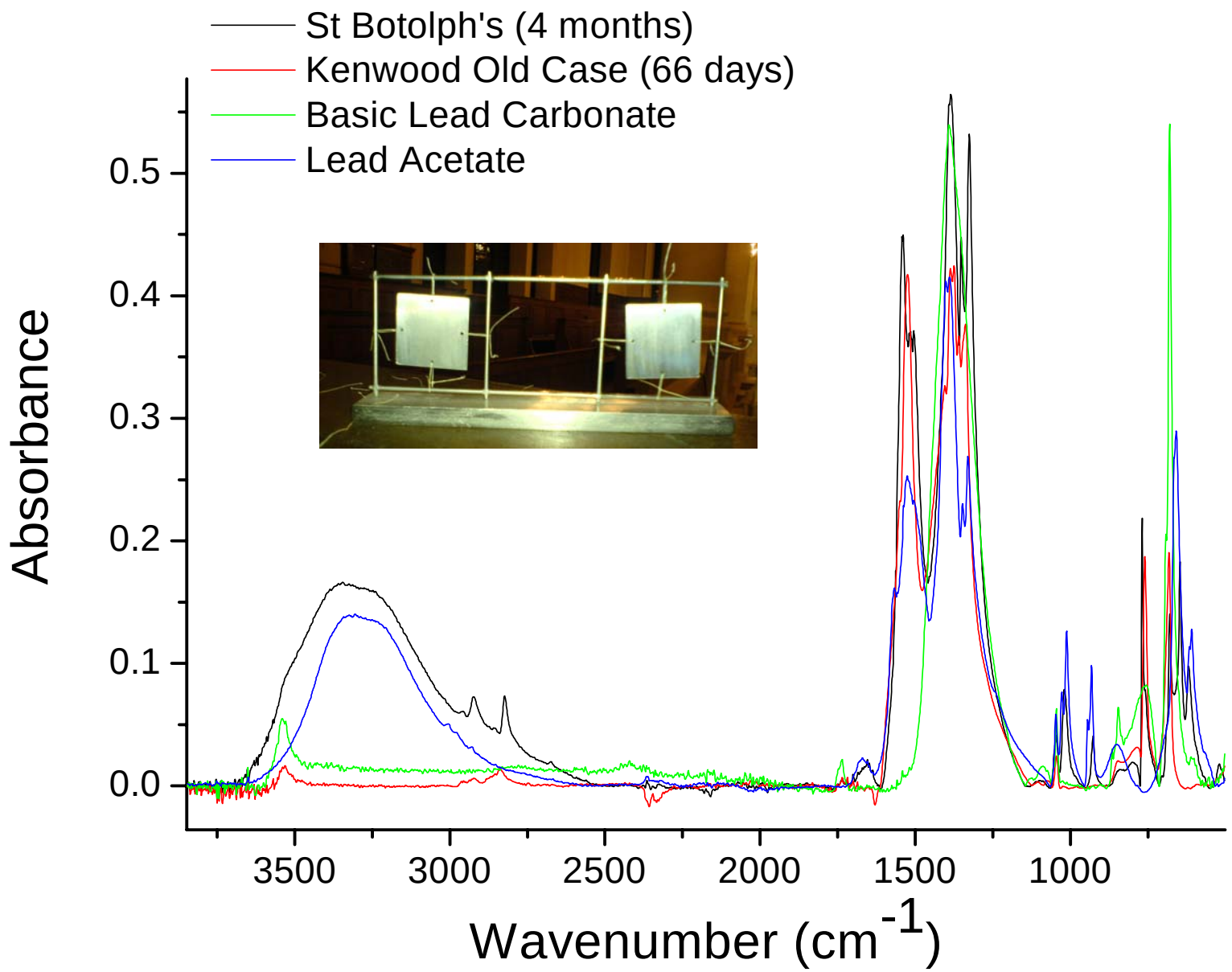
Okulsz B1_5,B1_6,B2_4,B2_6 25.08.06 to 26.09.06

Kenwood B1_1,B1_3,B2_1,B2_3 11.08.06 to 30.08.06 in show case
(HAc levels c.3850ug/m3 or 1540ppb) (1ppb=2.5ug/m3)

Testing at Sites with Lead Coupons (Olkusz ,PL) and Kenwood House (English Heritage)



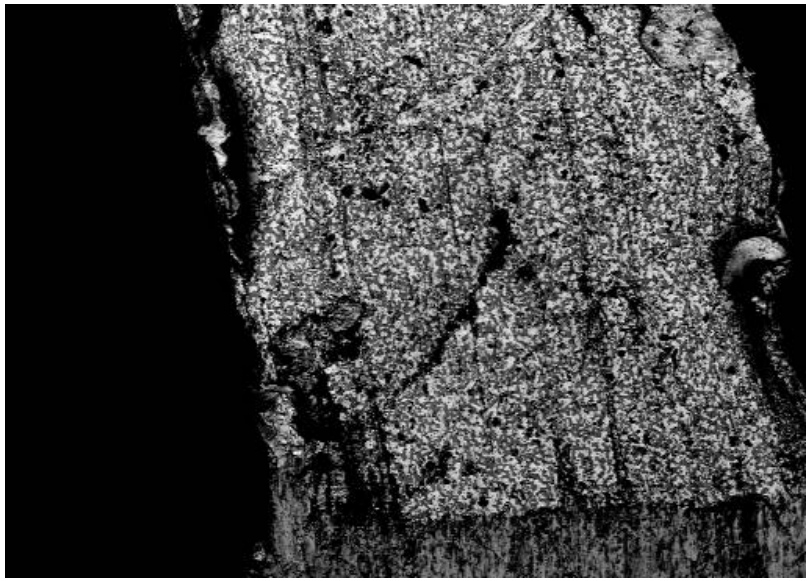
Testing at Sites with Lead Coupons (Olkusz ,PL) and Kenwood House (English Heritage)



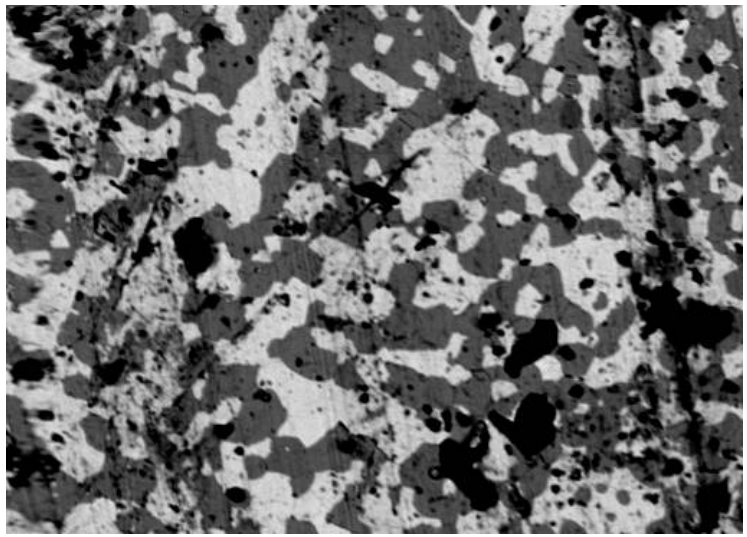
St Botolph without Aldgate,London

Organ builders Martin Goetz and Dominic Gwynn responsible for restoration of organ at St.Botolph (oldest in England, 1704). RH,T data loggers at St.B (from March) as in Olkusz (from Jan).

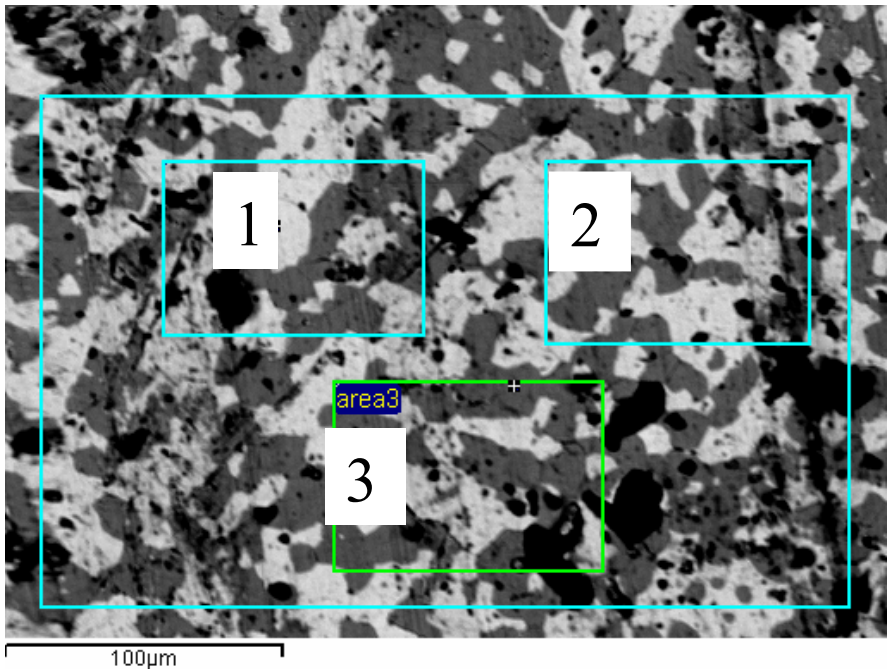
SEM/EDX



BSE Sample A Mag x40



Sample A Mag x400



Pb rich 96.3

Sn rich 96.6

Overall area Pb 45.2

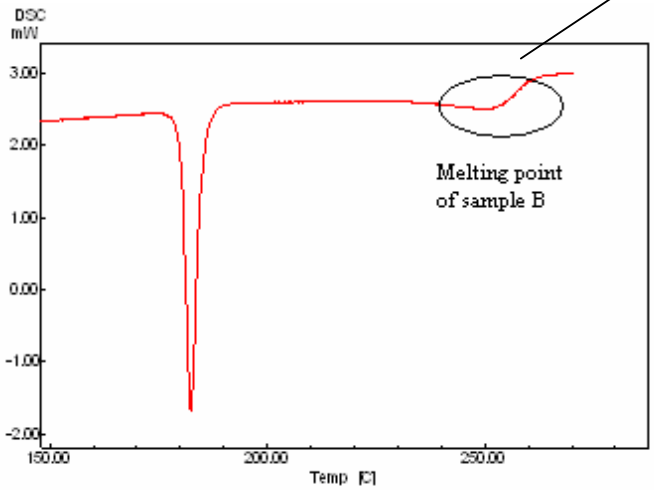
A1 48.9

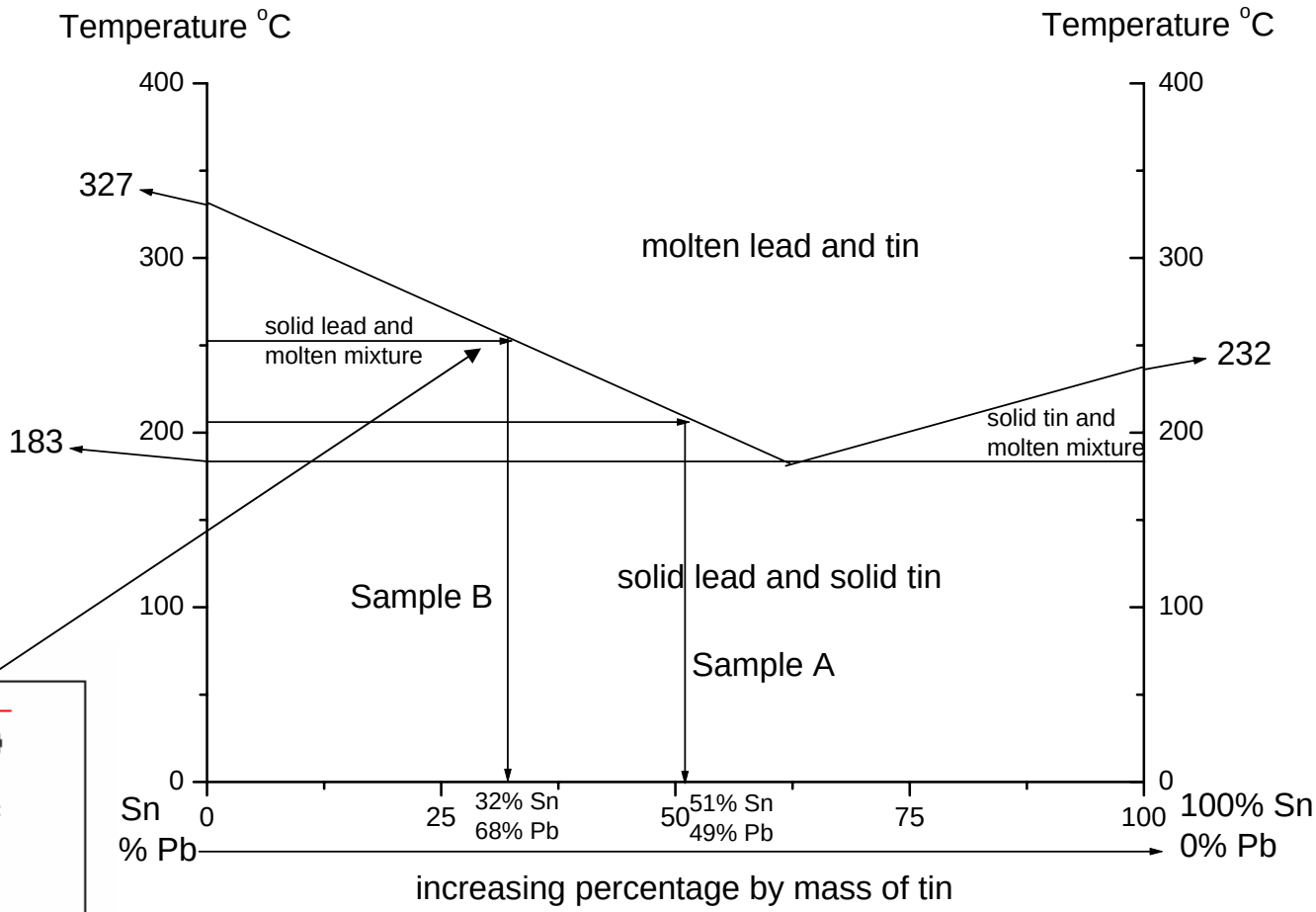
A2 47.7

A3 41.1

Composition of pipes in relation to Pb-Sn phase diagram

Differential Scanning Calorimetry

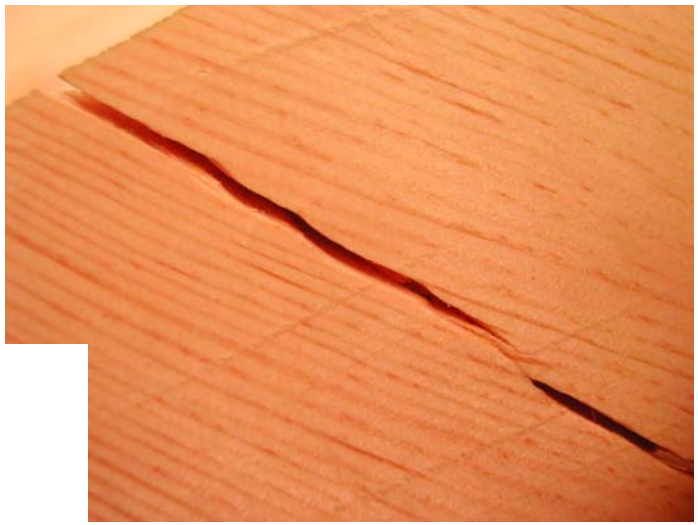




SENSORGAN

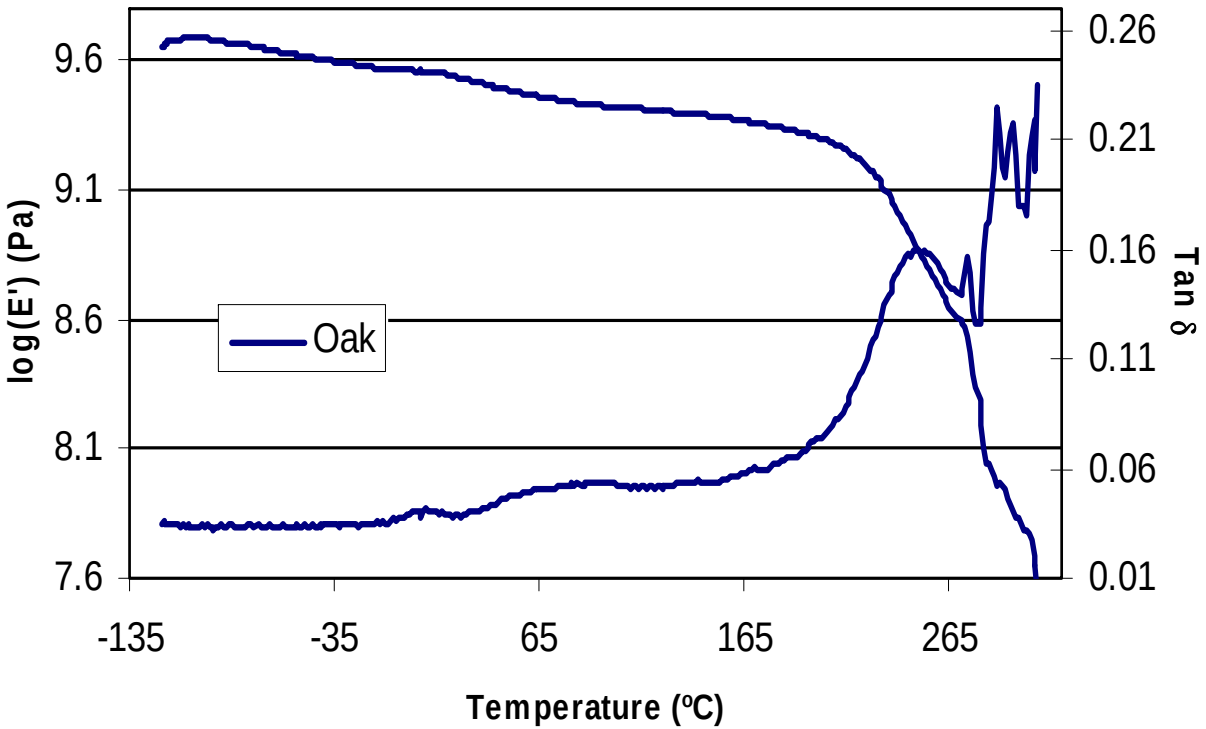
WP2 Acoustic Emission Sensor

Institute of Catalysis and Surface Science,Polish Academy of Sciences



Bbk measures viscoelastic properties

of wood & variation with RH



Acknowledgements

EC 6th Framework programme **PRIORITY 8.1 Policy-oriented research Scientific Support to Policies**

J.Neal, University of Bath, Physics Dept. for thermal deposition of lead on PQC crystals.

Organ builders Martin Goetz and Dominic Gwynn for providing samples from restoration work . This contributed to M.Sc student project at Bbk.

Senior conservation scientist David Thickett (English Heritage) for exposure of dosimeters at Kenwood House and providing data on levels of acetic acid and climate data (RH,T).

Partners (Institute of Catalysis and Surface Chemistry) for exposures in Okulsz.

Institute of Air Quality (Rome) for pollutant levels in Okulsz (3 months)