

**Impact case study (REF3b)**

<b>Institution:</b> University College London / Birkbeck College
<b>Unit of Assessment:</b> 5 - Biological Sciences
<b>Title of case study:</b> Application of advanced analytical methods for damage assessment of cultural artefacts in museums and historic buildings
<b>1. Summary of the impact</b>  Research by Marianne Odlyha and her group at the Department of Biological Sciences, Birkbeck, University of London, has led to the development of minimally invasive analytical methods and portable tools (dosimeters) for assessing damage to historical artefacts. These dosimeters are now in use at locations around the world, including the Tate Gallery's store rooms, English Heritage properties (Apsley House) and museums in Ghent, Cracow and Mexico. Methods for assessing damage, and for mitigation of pollutant impact on objects in museum enclosures, have been disseminated to conservation professionals through workshops and training courses held across Europe. The assessment and prevention of damage is vital to conserve the cultural as well as the monetary value of artefacts.
<b>2. Underpinning research</b>  The main theme of our research over the last 20 years has been the assessment of damage to heritage materials, developing new ways of detecting damage, analysing what is causing it, and finding the best way of preventing further damage. We have focussed on the microclimates around objects, for example inside enclosures such as painting frames and museum display cases. Working with collaborators in many European countries, we have adapted and optimised minimally invasive analytical methods for assessing damage.  Our early research, beginning in the mid-90s, developed paint dosimeters to assess the effect of environmental factors, including pollutants, on canvas-supported paintings, combining this with characterisation of physicochemical alterations in paintings. This work was undertaken as part of a research consortium (co-ordinated by Odlyha at Birkbeck) working with curators, conservation scientists and conservator-restorers, including at the Tate Gallery in London. It was the first time that changes in paint media and artists' varnishes were characterised at the macro and molecular levels in accelerated aged paint films prepared according to traditional techniques [1].  Following on from this work, we began development of an electronic dosimeter to assess possible damage to historical artefacts. We collaborated with QuartzTec, a small UK company, to modify their existing commercial instruments for suitability of operation in museum environments and for continuous electronic recording of data. Novel coatings were applied to piezoelectric quartz crystals (PQC). These were based on artists' paint media and were found to be sensitive to the presence of photo-oxidizing agents. These devices were tested through an EU-wide project, entitled 'Monitoring of Indoor Environments for Cultural Heritage Preservation' (MIMIC), with devices being placed in seven major European museums, castles and historic houses, including the Petrie Museum at UCL, and English Heritage and National Trust properties. Research groups interacted with the conservators and arranged for exposure and documentation of the dosimeters together with monitoring of climate and pollutant data. This enabled determination of dose-response functions for the coatings and estimation of damage threshold levels [2].  In 2006 we collaborated on a further EU project (SENSORGAN) to examine corrosion in lead-based organ pipes. Due to the size of the pipes, and the need to monitor the air flowing into the pipes, we had to further adapt our electronics, in particular by miniaturising the device. Also, another coating was developed which was sensitive to the volatile organic acids emitted from the wooden components of the organ and which were identified as the cause of corrosion. Our main collaborators were Chalmers University, Gothenburg, who provided support for calibrating the coated PQC dosimeters and analytical information on the coatings. The new model dosimeters were trialled in St Botolph's in London and in churches in Sweden and Cracow. Concurrently, we

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collaborated on another EU project (PROPAINT) with the University of Pisa on assessment of damage to varnished paintings in microclimate frames. We further adapted our devices to monitor conditions within the enclosed microclimate frames which are used to protect paintings and also modified the electronics to allow for battery operated devices. The overall research prototype included two calibrated coatings sensitive to photooxidising agents and to volatile organic acids [3].

We have played key roles in the research consortia of two projects looking at damage to historical parchment (IDAP) and to historic tapestries from collections at Hampton Court and in the Royal Palace in Madrid (MODHT). In the former, we collaborated with Dr Laurent Bozec at the UCL Eastman Dental Institute to develop methods for assessing damage in collagen-based materials. This introduced for the first time the use of atomic force microscopy (AFM) and micro-thermal analysis for characterising changes in collagen at the nano-scale level, and mechanical testing in controlled environments. A method for quantification of AFM images of collagen was developed; this provided a measure of the extent of intact ordered structure present in the imaged surface and hence damage [4,5]. Similar techniques were also applied to textiles (wool and silk) to evaluate the extent of damage in historical tapestry samples [6].

**3. References to the research**

- [1] Odlyha M, Cohen NS, Foster GM, West RH. Dosimetry of paintings: determination of the degree of chemical change in museum exposed test paintings (azurite tempera) by thermal and spectroscopic analysis *Thermochimica Acta*. 2000;365(1):53-63. <http://doi.org/cg3nsg>
- [2] Odlyha M, Theodorakopoulos C, Thickett D, Ryhl-Svendsen M, Slater JM, Campana R. Dosimeters for Indoor Microclimate Monitoring for Cultural Heritage. In: Padfield T, Borchersen K, editors. *Museum Microclimates*. Copenhagen: National Museum of Denmark. 2007. p. 73-9. [http://natmus.dk/fileadmin/user\\_upload/natmus/bevaringsafdelingen/billeder/far/Museum\\_Microclimate/Contributions\\_to\\_the\\_conference/odlyha.pdf](http://natmus.dk/fileadmin/user_upload/natmus/bevaringsafdelingen/billeder/far/Museum_Microclimate/Contributions_to_the_conference/odlyha.pdf)
- [3] Grønthoff T, Odlyha M, Mottner P, Dahlin E, Lopez-Aparicio S, Jakiela S, Scharff M, Andrade G, Obarzanowski M, Ryhl-Svendsen M, Thickett D, Hackney S, Wadum J. Pollution monitoring by dosimetry and passive diffusion sampling for evaluation of environmental conditions for paintings in microclimate frames. *Journal of Cultural Heritage*. 2010;11(4):411-9. <http://dx.doi.org/10.1016/j.culher.2010.02.004>
- [4] Odlyha M, Cohen NS, Foster GM, Aliev A, Verdonck E, Grandy D. Dynamic mechanical analysis (DMA), C-13 solid state NMR and micro-thermomechanical studies of historical parchment. *Journal of Thermal Analysis and Calorimetry*. 2003;71(3):939-50. <http://dx.doi.org/10.1023/A:1023346814391>
- [5] Odlyha M, Theodorakopoulos C, Groot de J, Bozec L, Horton M. Fourier Transform Infra-red Spectroscopy (ATR/FTIR) and Scanning Probe Microscopy of Parchment. *e-Preservation Science*. 2009;6:138-44. <http://www.morana-rtd.com/e-preservation-science/2009/Odlyha-05-08-2008.pdf>
- [6] Odlyha M, Wang Q, Foster GM, de Groot J, Horton M, Bozec L. Thermal analysis of model and historic tapestries. *Journal of Thermal Analysis and Calorimetry*. 2005;82(3):627-636. <http://dx.doi.org/10.1007/s10973-005-6882-6>

**Selected research grant support**

Monitoring of Indoor environments for Cultural Heritage Preservation (MIMIC). 2001-4, extended to 31/3/05. Sponsor: 4th Framework EC DG-RTD. Coordinator and PI: M Odlyha (Birkbeck). Total awarded: €484,926. Birkbeck allocation: €145,566.

Sensor system for detection of harmful environments for pipe organs (SENSORGAN). 2006-9. Sponsor: 6th Framework EC DG-RTD. PI: M Odlyha (Birkbeck). Birkbeck allocation: €278,959.

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Improved Protection of Paintings during Exhibition, Storage and Transit (PROPAIN). 2007-10. Sponsor: 6th Framework EC DG-RTD. PI: M Odlyha (Birkbeck). Birkbeck allocation: €189,000.

Damage Assessment of Historical Parchments Parchment (IDAP). 2002-5. Sponsor: 5th Framework EC DG-RTD. Coordinator: School of Conservation Copenhagen. PI: M Odlyha (Birkbeck). Total awarded: €1,644,300. Birkbeck allocation: €395,600.

Monitoring of Damage in Historic Tapestries (MODHT). 2002-5. Sponsor: 5th Framework EC DG-RTD. Coordinator: Hampton Court Palace Conservation Department. PI: M Odlyha (Birkbeck). Total awarded: €1,640,956. Birkbeck allocation: €395,639.

**4. Details of the impact**

The underpinning research described above has had an impact both on indoor monitoring of microclimates in museums and on damage assessment of cultural heritage materials. It has succeeded in raising awareness to risks of damage to objects on display in showcases and in enclosures during storage or in transit. The dosimeter that we have developed is a small portable tool with a fast response time that is practical for use in museums and galleries. The dosimeter is easy for conservators to use in order to evaluate whether inappropriate materials have been used in showcases and as backboards for paintings, and the effect of different air exchange rates.

**Use of dosimeters in museums**

Throughout our research programme, we have worked with the Tate Gallery to develop and test our devices so that they are useful and relevant to professional conservators. The Tate now uses our dosimeters to monitor levels of air pollution in its store rooms and identify effects on paintings and sculptures. The Conservation Department at the Tate report that: "*The Piezoelectric quartz crystal dosimeter PQC has provided a means of gaining a much better idea of the extent of air pollution in store rooms and, more importantly, identifying its effect on the collection of paintings and sculpture...We can now start putting into practice new routines, where necessary using better (and more expensive) materials, and prioritise our decisions for a remedial process that will take many years to complete*" [a].

Other museums have changed their practices as a result of using our dosimeters. The Museo Bellas Artes in Valencia, for example, used dosimeters to monitor the conditions within microclimate frames. As a result of these tests, the museum now only uses acid-free materials inside the frames, and avoids certain materials, such as chloroform which was previously used in the joints of the frames. The dosimeters have also been used to identify pollutants from cleaning products used in regular maintenance in the museum [b].

Our dosimeters were used in 2007-8 by English Heritage to assess the oxidising potential of the atmosphere in two of their properties: Apsley House and Kenwood House, both of which house internationally important painting collections. The analyses allowed important management decisions to be taken on refitting the air filtration system and the impact of dust from the gravel at the entrance to Kenwood House. The lead-coated PQC crystals determined the risk to paintings from microclimate frames used to protect them against relative humidity fluctuations and internally generated pollutants. The research has increased the use of such frames that are now a standard approach to displaying vulnerable paintings in historic house environments [c].

**Use of dosimeters in art transport: the Lady with an Ermine**

In 2011, our dosimeters provided vital information during the transport and exhibition of Leonardo da Vinci's *Lady with an Ermine*. There had been considerable controversy about whether the painting should be able to leave its permanent home in Poland [d] but, as part of a monitoring programme, our dosimeters were placed within the micro-climate showcase in which the painting was exhibited at the Royal Palace in Madrid to monitor the level of corrosiveness of the air within the frame. Art transport company SIT-Artyd report that this monitoring showed: "*good results that*

warranted the continuity of the tour to London and Berlin, before the return to home in Poland” [e]. As a result of this successful experience, SIT are now promoting and including the dosimetry in their exhibition, storage and transport services for museums in Madrid, Valencia and Barcelona.

### Dissemination of our research to professional conservators

We have disseminated our research findings to professional conservators across Europe and beyond, through our collaborative work, and through presentation of our results at a series of workshops and conferences aimed at professionals. For example, through the IDAP project we developed an algorithm for processing AFM images to allow damage assessment of collagen fibres. Damage to collagen at the fibre and fibril level is now taught at regular workshops held by the School of Conservation in Denmark [g]. Odlyha herself has presented at many conferences, including in Turin, Vienna, Evora, Portugal, and recently in Madrid and has participated in workshops held in London and Madrid. These were well attended by conservation professionals from many organisations including the British Museum the National Gallery in London, and the Musée National Picasso (Paris) [i]. Odlyha has also edited, and written an introduction to, a chapter on cultural heritage in the Journal of Thermal Analysis and Calorimetry (May 2011).

### 5. Sources to corroborate the impact

- [a] Letter from Conservation Department, Tate Britain. Available on request.
- [b] Letter from Chemist Conservator, Museo Bellas Artes de Valencia. Available on request.
- [c] Letter from Senior Conservation Scientist, English Heritage. Available on request.
- [d] <http://artdaily.com/news/46703/Poland-s-Most-Precious-Painting---Lady-with-an-Ermine--by-Leonardo-da-Vinci-to-Hit-the-Road>
- [e] Letter from SIT Departamento Tecnico, SIT-Artyd, Madrid, Spain. Available on request.
- [f] Corroborating testimony available from Associate Professor at the Royal Danish Academy of Fine Arts, School of Conservation. Contact details provided.
- [g] Professional Education - courses during the period 2008-13:
  - Sep 2008 3-day practical course on Improved Damage Assessment of Parchment, Turin
  - May 2009 5-day EC Cost Action D42 Training School on “Indoor Air Quality in Museums, Galleries and Archives: Analytical Methods and Preventive Conservation Strategies.” Vienna, Austria.
  - Sep 2009 4-day workshop on dosimetry and damage assessment, Criaova, Romania.
  - 2010 3-day postgraduate course to conservation scientists/conservators at the School of Conservation, Copenhagen.
  - 2010, 2011 RSC TAC (Thermal Analysis and Calorimetry) short courses, including applications to analysis of cultural heritage objects
  - April 2013 Seminar held at UCL Centre for Sustainable heritage: “Towards remotely assessing heritage environments and materials”. Attended by 10-15 people, including conservation professionals (e.g. from National Trust, English Heritage)
  - May 2013 MEMORI project workshop held at Birkbeck College. 32 participants from museums and galleries around the UK, and private conservators.  
<http://www.thepicturerestorer.co.uk/memori-free-workshop/>