Light ageing of discoloured manganese stained glass from Uppsala Cathedral

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Introduction

During the recent conservation work on Sweden's largest church window, The Son's window from 1892 in Uppsala Cathedral, questions were raised about the type of protective glass that should be installed. Some of the stained glass was noticeably discoloured and the concern was that the process of discolouration would continue if not appropriately protected from sunlight.

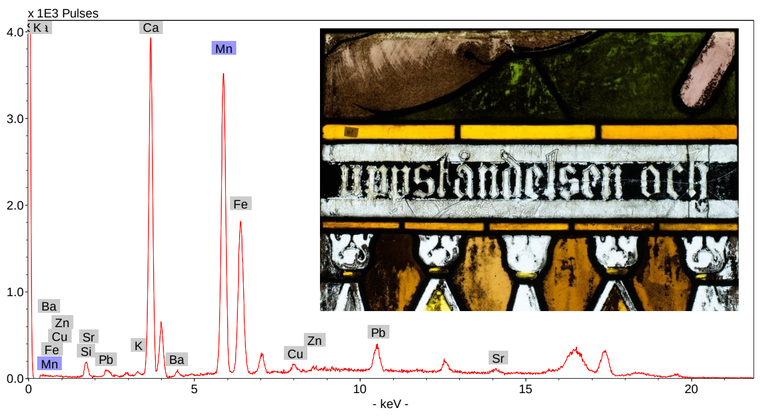
Uppsala Cathedral (photo by Mark Wilson: Wikimedia commons)

Conservators at Uppsala Cathedral Stained Glass Studio working on a panel of The Son's window (photo: Johan Nilsson)

Manganese stained glass

The chemistry of a "browning" phenomenon of manganese compounds in glass (present as either colourant, decolourant, impurity or contaminant) has been studied extensively by other researchers [1-4].

The presence of manganese in the discoloured glass was confirmed by non-destructive X-ray fluorescence spectroscopy (XRF).

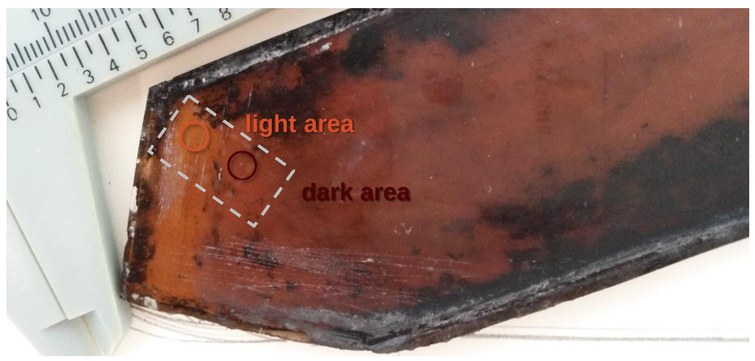


Along the upper part of the image is an area that had been shielded from sunlight by a synthetic mastic and the lug bar (which secured the panel in the window), now showing that the colour has changed from pinkish brown to a darker brown. The XRF spectrum was obtained from a discoloured area of the pink-brown stained glass piece (top right in image)

Accelerated light ageing

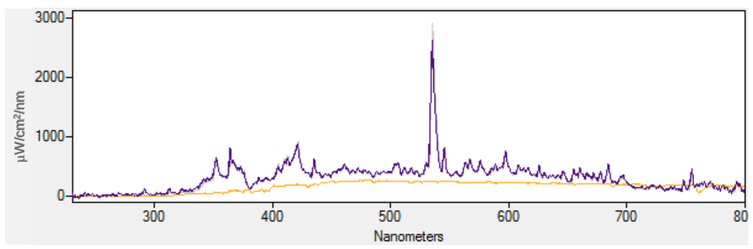
At the Swedish National Heritage Board a small area (2 cm^2) with both original "light" and discoloured "dark" stained glass was exposed to accelerated light ageing under a high UV metal halide lamp. The exterior side of the glass piece was directed towards the light source.

The discolouration process was followed spectrophotometrically through regular reflectance measurements of the "light" and "dark" areas from both the interior and the exterior sides of the glass piece.



Pink-brown stained glass piece showing the area that was exposed to accelerated light ageing (grey) and the "light" and "dark" areas used for colour measurements.

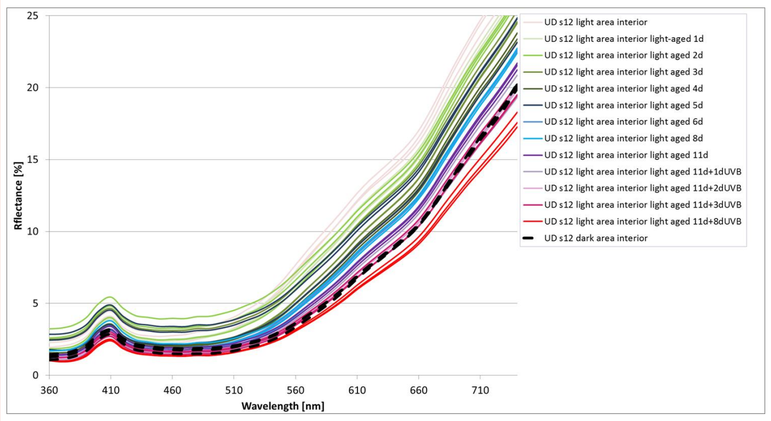
Accelerated ageing was carried out for a total of nineteen days, of which eleven were with a UV filter installed and eight without. The filter cut nearly all radiation < 295 nm) and reduced the UVA part of the lamp spectrum.



Sol lamp spectrum (with H2 filter, grey; without filter, purple) and sunlight spectrum as measured on a sunny day in May in Visby, Sweden

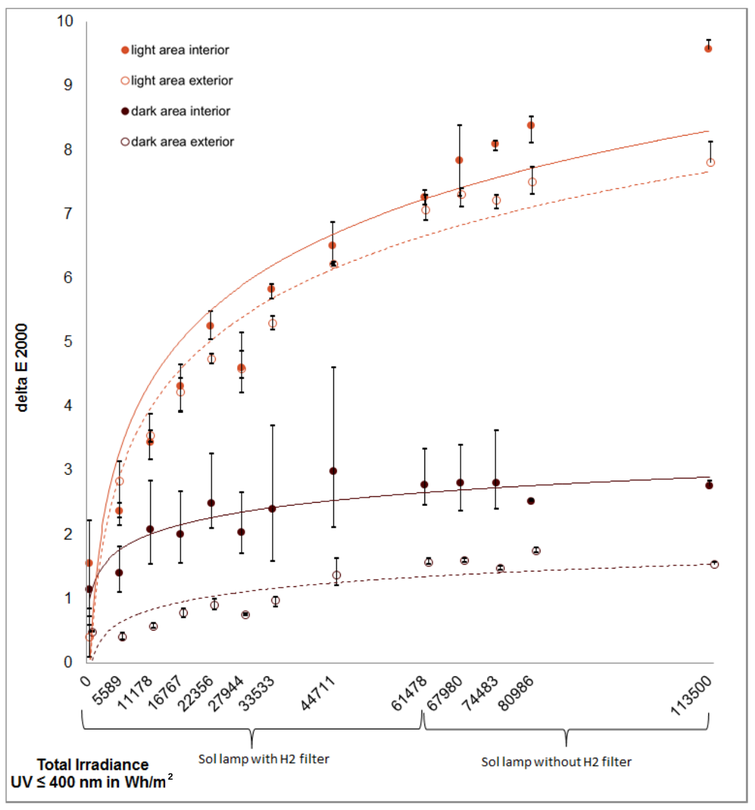
Results

After eleven days of accelerated light ageing the lighter area had discoloured to nearly the same level as the naturally aged dark area.



Spectral reflectance curves of the light area measured from the interior side of the glass piece. Upon light ageing the curves decrease in reflectance to approximately the same level as the naturally dark area and a bit further.

Accelerated ageing was carried on for another eight days with the UV filter removed, causing both the light and dark areas to discolour further. However, despite the addition of UVB and UVC light, the discolouration continued at a slower rate. The further "browning" was measurable by spectrophotometry but it was not visible by eye.



Spectrophotometric measurements expressed in units of colour change (delta E 2000) and plotted againts the total irradiance of UV light received by the glass piece during nineteen days of accelerated ageing.

The logarithmic trendlines in the graph above show that the rate of change starts to level off.

The colour change for the previously unexposed light area was significant and reached ~7-8 ΔE values after eleven to fourteen days of ageing which represented the natural colour change "browning" that had occurred over the entire glass piece where it had been exposed to sunlight.

The additional ~1-2 ΔE values caused by further light ageing up to nineteen days were not noticeable by eye. Similarly, the colour change of ~1-2 ΔE values induced in the already sunlight exposed dark area was measurable but not noticeable by eye.

Conclusions

The accelerated ageing investigation on a manganese containing stained glass from the late 19th century showed that the greatest extent of colour change had already occurred and that any additional colour change would most probably not be noticeable by eye. Following this project, it was decided to install one of the more aesthetic protective glasses, slumped float glass with a thin wash, rather than the more expensive option of a full UV protective glass.

References

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3. S. Cagno, G. Nuyts, S. Bugani, K. De Vis, O. Schalm, J. Caen, L. Helfen, M. Cotte, P. Reischig and K. Janssens, 2011. Evaluation of manganese-bodies removal in historical stained glass windows *via* SR-µ-XANES/XRF and SR-µ-CT , *Journal of Analytical Atomic Spectrometry*, 26, pp 2442-2451.

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