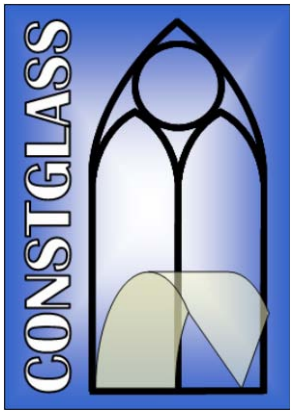


Project reporting in FP6

Project no. 044339

CONSTGLASS

Conservation materials for stained glass windows – assessment of treatments, studies on reversibility and performance of innovative restoration strategies and products

Specific Targeted Research Project

FP 6 Thematic Priority 8.1: Policy-oriented research

Final object report

Part III of IV

Canterbury Cathedral (England)

The structure of this **final object report** is:

Part I:

1 Bourges, Cathédrale St. Etienne (France)

2 Chartres, Cathédrale Notre-Dame (France)

3 Le Mans, Cathédrale St. Julien (France)

Part II:

4 Cologne Cathedral (Germany)

5 Klausen, Parish and Pilgrimage church St. Maria Himmelfahrt (Germany)

6 Hannover, Marktkirche St. Georgii et Jacobi (Germany)

Part III:

7 Canterbury Cathedral (England)

Part IV:

8 The Burrell Collection, Glasgow (Scotland)

9 Burgdorf (Canton Bern, Switzerland)

10 Academy of Fines Arts, Krakow (Poland)

CONSTGLASS

Final Activity Report

Léonie Seliger
Cathedral Studios

Introduction

Canterbury Cathedral's stained glass conservation department, The Cathedral Studios, was established in 1973, with the stained glass artist Frederic Cole as its first director, to preserve the cathedral's internationally important stained glass windows. The studio's work was supported from the outset by an advisory panel composed of art historians, scientists and artistic advisors. One of the most influential members of the committee was Professor Roy Newton, who wrote the first modern textbook on stained glass conservation in the English language. With the help of this advisory committee, research was carried out on a wide range of conservation issues in order to establish conservation strategies.

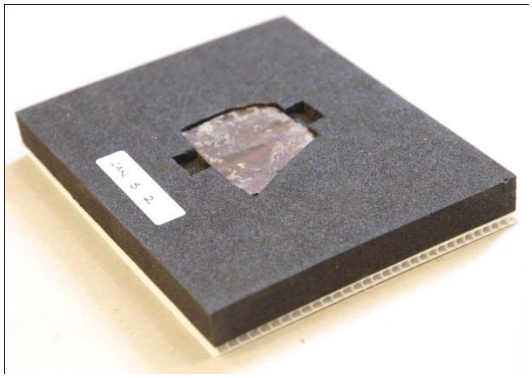
The Cathedral Studios is a division of Cathedral Enterprises Ltd., and not only works on glass from Canterbury Cathedral, but also takes on conservation projects in many churches around England and Wales. The work of the studio continues to have a major influence on stained glass conservation in Britain.

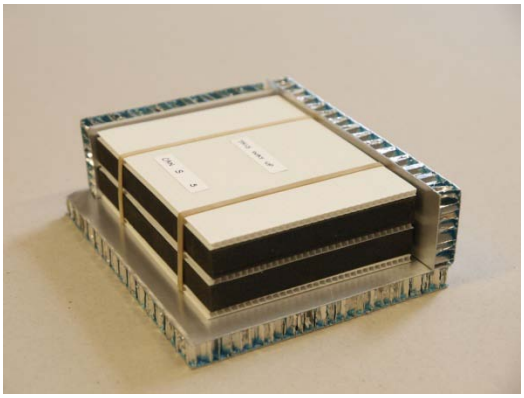
The overruling principle adopted for the preservation of the cathedral's windows was to install protective glazing on all conserved windows. Although the design of this protective glazing system evolved over the decades to reflect emerging knowledge, the principle remains unchanged to this day.

For CONSTGLASS, the studio was able to choose pilot objects that were treated with a range of materials from several locations in Canterbury Cathedral. A main focus was the application of artificial waxes for paint consolidation in the mid-1980s on 12th and 13th century glass. The use of this material ceased at the end of the decade, to be replaced with Paraloid® B72. Silicone rubber was used from the start for edge-bonding and for sealing backing plates. In 1992, in conjunction with the Fraunhofer Institute a trial application of SZA and Ormocer® was carried out on a single panel in the 12th century North Oculus window. Polymer coatings were also found to be present in the Great South Window, used as external coatings as well as for paint consolidation.

WP1

Packaging development





During the first meeting of the consortium, the necessity to develop a safe and reliable method of packaging samples was revealed.

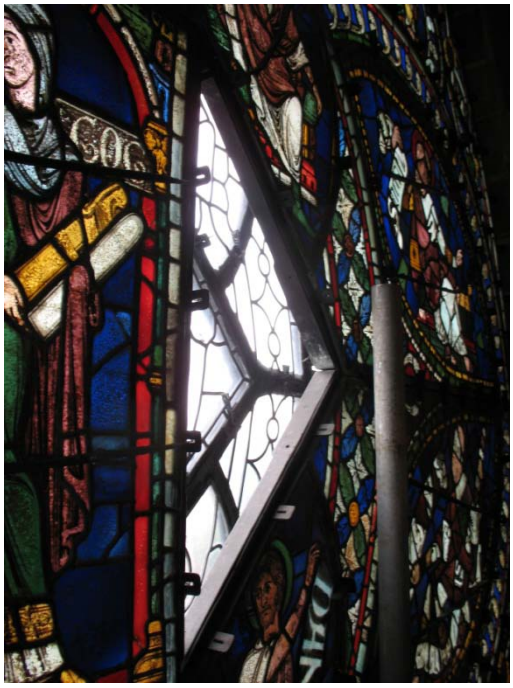
The Cathedral Studios was tasked to develop a method and to source the materials for such a packaging system. The packaging had to be adaptable to any size of sample, easy to manufacture from conservation-grade and easily accessible materials, sturdy and re-usable.

The materials and surfaces under investigation had to be suspended in such a manner that packaging and transporting would not in any way alter their morphology. This packaging system was developed successfully. The Cathedral Studios proceeded to supply pre-fabricated kits to all partners upon demand, which could then be adapted to the individual samples by the curators.

Pilot Objects

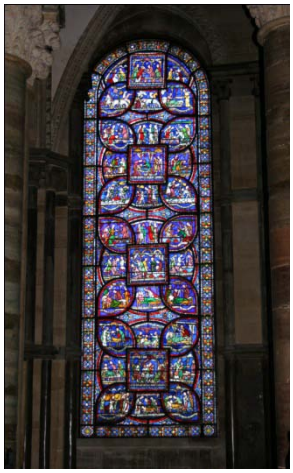
Pilot objects were chosen from several windows within Canterbury Cathedral. Permission to carry out investigation on the objects was granted by the Cathedral Fabrics Commission for England with the restriction that all interventions must be non-destructive and reversible.

An initial inspection was carried out in situ from scaffolding erected for the purpose by the Cathedral's Works Department. Individual panels were chosen and dismantled from the windows for further inspection and sample taking in the studio. Criteria for selection were: representative use of material, accessibility for



Panel NXVII 3 after removal from window. The protective glazing is visible through the gap.

sampling, exposition within the building, level of available documentation and relative importance of the object within the window. Risk assessments were carried out repeatedly during the selection and sampling period.



Window nII

Each pilot object comprises investigation on several panels within the same window.

Pilot Object 1 – nII, panels 6, 7, and 33
(paint consolidation with artificial wax)

Window nII in the Trinity Chapel of Canterbury Cathedral dates to the early 13th century and shows scenes of miracles attributed to Saint Thomas Becket. It is at ground level and faces north-east, in a climatically relatively stable position. The window was treated in 1984 by The Cathedral Studios. All glass was dismantled from the lead matrix, cleaned and re-leaded. The internal surface of many glass pieces was entirely coated with wax as a paint consolidant. The wax was applied with a brush in solution with white spirit and then mechanically polished. The window was re-installed behind externally ventilated protective glazing.

Wax application in 1984

Window sVII

Pilot Object 2 - sVII, panels 1, 4, and 10
(paint consolidation with artificial wax)

Window sVII is part of the same series of 13th century Miracle Windows as window nII. It is at ground level and faces due south. It is exposed to full sunlight and to the climatic extremes resulting from this. The window was treated in 1983 by The Cathedral Studios. All glass was dismantled from the lead matrix, cleaned and re-leaded. The internal surface of many glass pieces was entirely coated with wax as a paint consolidant. The wax was applied either by melting it onto the surface with a heat spatula, or with a brush in solution with

Window NXVII

white spirit, and was then mechanically polished. The window was re-installed behind externally ventilated protective glazing.

For both pilot objects 1 and 2, the behaviour of the wax consolidation was of interest in the context of CONSTGLASS.

Pilot Object 3 – NXVII, panels C1, C2, and 3

(paint consolidation with artificial wax, re-treatment with Paraloid®B72, silicone rubber edge-bonding, trial applications of SZA and Ormocer®)

The North Oculus window NXVII is a late 12th century window depicting the Old Covenant. It is at clerestory level and faces due north.

Panel NXVII C2

In the late 1980s wax was applied in situ onto un-cleaned flaking painted decoration. The window remained without protective glazing until 1992, when the glass was taken to the studio for conservation. The wax was found to have de-laminated and become brittle in many places, while in other places it seemed to adhere well to the substrate. It had also darkened and gathered dust. It was therefore decided to remove the loose areas of wax with a scalpel, and to thin down well adhering areas by shaving off the excess. The loose and fragile painted decoration was then consolidated with Paraloid® B72 ca 7% in acetone, often on top of a remaining wax layer.

NXVII, condition in 1992, and re-treated area, acrylic resin on artificial wax

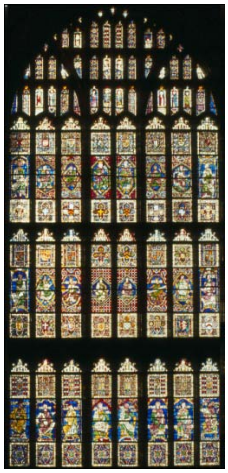
During the 1992 conservation, silicone rubbers were used to edge-bond glass fractures and to seal backing plates.

Also in 1992, a trial application of SZA and Ormocer® was carried out on panel C1.

The window was then set into an internally ventilated isothermal glazing system.

Panel NXVII C1

For CONSTGLASS, the validity of the re-treatment of wax coated surfaces with Paraloid®B72 was of the utmost interest. Hitherto re-treatment of wax coatings has been deemed to be impossible with materials other than wax. Paint consolidation with wax was used not only in England, but also in Germany, and the results from CONSTGLASS give new insight into the



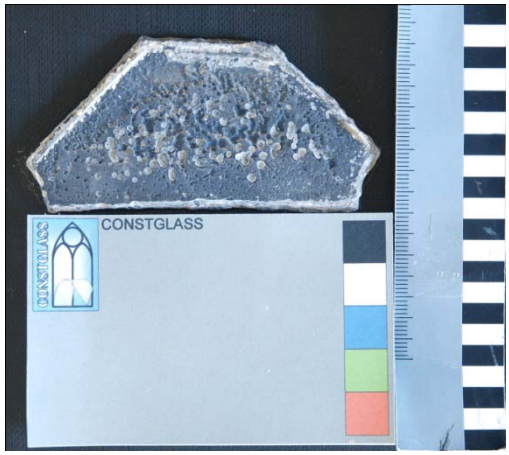
Window SXXVIII

possibility of re-treatment. The performance of silicone rubbers and their effect on surrounding lead, and the behaviour of SZA and Ormocer® were also investigated.

Pilot object 4 – SXXVIII, panels 8h, A16, C1 and D8
(application of polymer coating, silicone rubber edge-bonding)

In July 2009, a stone fall raised structural concerns which made the removal of the medieval stained glass from the Great South Window SXXVIII necessary. Several panels showed the application of polymer coatings both internally and externally. There was no documentary evidence for this application, but correspondence between Professor Newton and Frederic Cole indicates that the use of Viacryl® was discussed for this window. The window was set into an externally ventilated protective glazing system, which was found during the de-installation in 2009 to have significant failures, with a very small interspace and signs of water penetration onto the historic glass. The consortium decided to include the identification of the polymer in the CONSTGLASS project.

Panel SXXVIII A16



Panel SXXVIII A16, decayed polymer coating on original sample

Research methodology

Apart from the SZA and Ormocer® trial in 1992, the level of recording of interventions carried out in the past presented some difficulties. The documentary evidence was not always complete, sometimes patchy, contradictory or even entirely absent. The information in the conservation records on each window had to be augmented with information from the minutes of the advisory committee, from exchanges of letters between the scientific advisor and the studio director, and from contemporary published material on conservation methods and materials. Previous employees of the studio were contacted and interviewed. An inventory of all archived conservation materials kept in the studio was carried out, which revealed five different artificial waxes.

Obtaining reliable and detailed information is a very typical challenge in dealing with past interventions on stained glass windows. The work carried out during the CONSTGLASS project in identifying materials will therefore be applicable across the field.

Recording

All pilot object panels were examined closely under optical magnification and re-recorded to current studio standards as well as on the data sheets developed for CONSTGLASS.
High resolution photographs were taken in transmitted and reflected light.

Samples

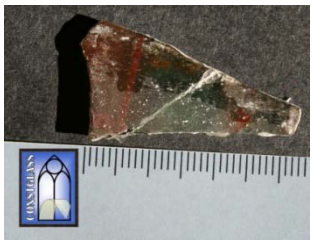
<u>Wax</u>

Before original glass samples were removed from the pilot objects, the conservators had to be satisfied that such intervention was going to produce meaningful data. It was therefore decided to manufacture sets of 'dummy' samples replicating as closely as possible the applications to be investigated.

The documentary research had indicated that a mixture of two waxes, Microcrystalline wax and Polythene 'A' wax, was used on the windows, but their ratio and the reliability of the recording were in question. Samples of all waxes found in the studio archive were sent to the Fraunhofer Institute for analysis via FT/IR and Raman spectroscopy. Wax shavings from windows nII and sVII were compared with the archived wax samples.

1st set of 'dummy' samples:

Trials were carried out on specifically prepared modern glass 'dummies' to determine the application characteristics of different ratios of wax mixtures and application techniques. Sample shavings of those mixtures were also sent to the Fraunhofer Institute to establish whether these known mixtures and their ratios could be identified.



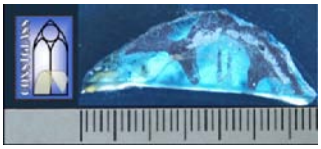
'Dummy' sample of wax and Paraloid® B72on medieval glass

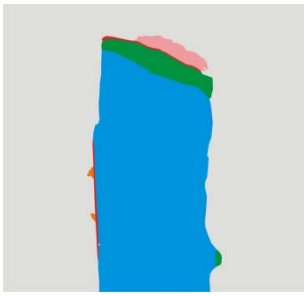
The results showed that only two waxes (Microcrystalline wax and Polythene 'A' wax) were actually present on the pilot objects, and that no mixtures were used, but only pure waxes. This tallied with the studio experiments, which found that mixtures of waxes had poorer application characteristics than pure waxes.

2nd set of ‘dummy’ samples:

Another set of ‘dummy’ samples on medieval glass pieces from the studio’s fragment archive was prepared, simulating the different recorded application techniques. These were sent to Ghent University and Sincrotrone Trieste to establish the ability of optical coherence tomography and of phase-contrast tomography respectively to visualise the interface between wax and substrate.

The results showed that these techniques are able to visualise wax coatings on glass.





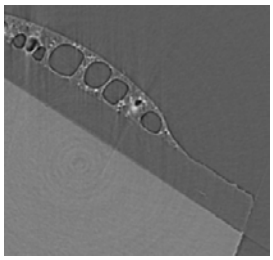
Panel nII 7, original glass samples and coloured optical coherence tomography scan of a section, showing wax coating (in red)

1st original glass samples:

Two samples of 13th century glass coated with wax were removed from nII 7 and sent to Ghent University and Sincrotrone Trieste. The extreme thinness of the wax application made visualisation difficult, but no de-lamination between coating and substrate was detected.

3rd set of ‘dummy’ samples:

The interface between Paraloid® B72 and wax was of the utmost interest. A new set of ‘dummy’ samples was prepared on medieval glass pieces from the studio’s fragment archive. These samples were thinly coated with wax in the original manner, with another thin coating of Paraloid® B72 applied to the wax surface. The aim was to visualise the interface between wax and Paraloid® B72, but the two materials were indistinguishable via computer tomography, and although no separation could be seen - indicating that the adhesion between the two materials was excellent - another set of samples was prepared to validate that finding and to visualise the interface.



Doped ‘dummy’ samples, and phase contrast computer tomography image of interface in section

4th set of ‘dummy’ samples:

This last set of ‘dummy’ samples purposely deviated from replicating the original application technique. Both wax and Paraloid® B72 were applied much more thickly than on the pilot object to give a greater

target. In addition to that, the materials were doped with umber pigment, on one set the wax, on another the acrylic resin, to create a visible contrast between the two materials. The results were surprising, in that no clear division between the two coatings was visible, indicating that a) the adhesion was excellent, and b) that there may even be a degree of interdiffusion between acrylic resin and wax. The agent for this possible interdiffusion would be the acetone in which Paraloid® B72 was dissolved.

Silicone rubber

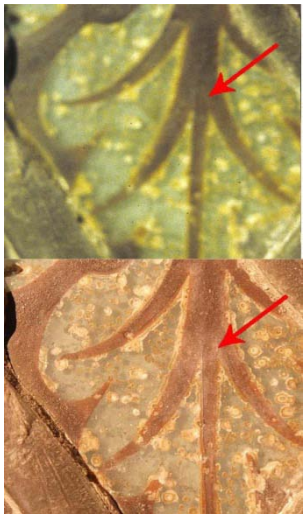
Silicone rubber with acetic acid content was used since the 1970s and continues to be used by the studio, both for edge-bonding and for sealing the edges of plated pieces. The specific product is Rhodorsil® CAF 3 and 33, a product marketed as being low in acid content. The use of acid-containing silicones is generally rejected by the European stained glass conservation community on the grounds that the off-gassing of acetic acid may deteriorate the surrounding lead. The Cathedral Studios have had occasion in the past to examine its own previous repairs, where lead had been in long-term contact with silicone seals and bonds. In no case was lead carbonate, or any other deterioration phenomena, observed.

Panel sVII 1, silicone edge-bonding, 1984

In the context of CONSTGLASS, the performance of silicone bonds was examined via light microscopy on all pilot objects. All bonds were found to be stable and in good condition, and no colour change was observed. There were no visible signs of lead deterioration associated with silicone.

To investigate the rate of off-gassing from the silicone rubber used by the studio, fresh product was tested by Professor Norman Tennent by a tube diffusion process which is able to detect parts per million. The results show that off-gassing occurs largely within the first two days, and drops below levels detectable by this method within four days. This supports the validity of the studio's procedure of only re-introducing edge-bonded pieces and sealed plates into the lead matrix after a period of ca 4 – 5 days.

Since silicone rubber has excellent long-term durability, these findings add silicone as a choice for reliable materials for the conservation of stained glass – if off-gassing is allowed to take



Panel NXVII C1, SZA trial. Comparison of condition 1992 with 2009

place sufficiently.

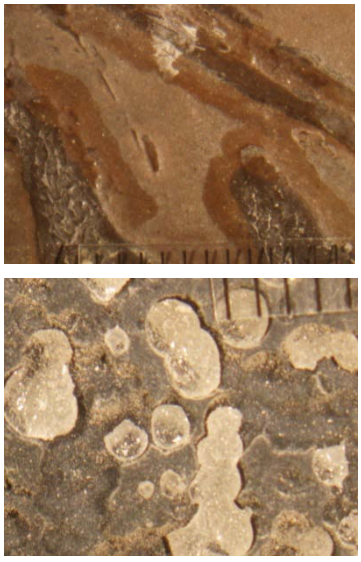
SZA and Ormocer®

The trial applications of SZA and Ormocer® on panel C1 in NXVII were examined very closely via light microscopy. A set of colour transparencies was obtained from the archive of the Fraunhofer Institute, which, together with the conservation records made at the time of application, allowed for clear identification of the test areas.

A new set of photographs was produced replicating as closely as possible the original lighting conditions for the transparencies. The two sets of photographs were then compared under magnification. Apart from a very slight white alteration in the surface appearance of one area consolidated with SZA, no alterations were found. The risk assessment for the removal of original samples from this panel decided against this action; consequently no samples other than surface swabs for microbiological investigation were taken.

Polymer coatings

The polymer coatings found on panels at the apex of window SXXVIII showed a wide range of phenomena. They were used internally to consolidate paint decoration and externally as an overall coating. The internal application was found to be in perfectly sound condition, whereas the external coatings varied in appearance from near perfectly preserved to laminating to only remaining in some corrosion pits.



SXXVIII, different states of preservation of polymer coating

Samples of original glass illustrating all preservation conditions were removed from three panels and investigated via FT/IR and SEM by the LRMH.

The FT/IR provided no firm conclusion on the composition of the polymers as it does not correspond with LRMH reference spectra. The composition of the coating corresponds to an aliphatic amide.

SEM observation revealed microcracks, delamination, loss of transparency and discoloration in the externally applied coating. No detachment of glass surface was observed where the coating had delaminated from the glass surface.

Swabs

All pilot objects were swabbed for investigation through cultures, ATP and rapd/FISH by LBW Bioconsult. Since some panels had been removed from their settings in the cathedral weeks or even months before swabs were taken, both the panels in storage and panels left in situ were sampled. No significant microbiological activity was detected on any of the samples.

Reinstallation

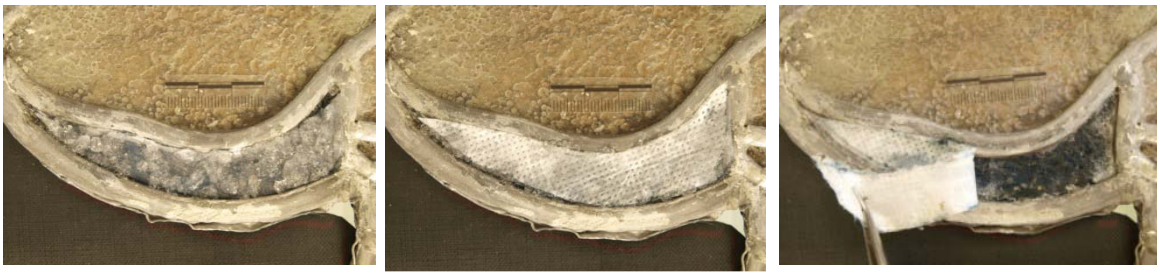
After all investigations were successfully carried out the unaltered glass samples taken from the pilot objects were reinserted into the panels, and the panels reinstalled into the windows.

Product Performance Picture Gallery

The studio supplied a wide range of images for the website developed and designed by the Dombauhütte Cologne.

WP3

Reversibility test



Panel SXXVIII C1, reversibility test

Two of the studio's conservators took part in the reversibility workshop at Artesis University College in Antwerp. The knowledge gained during this workshop was then applied to carry out reversibility tests on two pilot objects, sVII (wax) and SXXVIII (polymer). The tests showed that the coatings can be removed safely, with dichloromethane swabs in the case of wax, with ethanol gel in the case of the polymer, the risk analysis showed that removal of the coatings found on any of the pilot objects was not necessary. The wax coatings were in sound condition and were not giving reasons for concern. The polymers were either in reasonable condition, or were so decayed that they could be left to fall off in their own time.

WP4

Re-treatability

The risk assessments of all pilot objects showed that no re-treatment on original glass was advisable. The evaluation of the 1992 re-treatment of microcrystalline wax with Paraloid® B72 was a major part of the CONSTGLASS project for the studio. Initial trials had shown that original samples from the window would not be suitable for visualisation via tomography. The re-treatment therefore had to be repeated in a carefully considered method on 'dummy' samples to make investigation possible. The results showed that the new treatment was successful. The transferability of these results to the behaviour of the aged materials on the actual pilot object is supported by the very detailed visual investigation under maximum magnification with the optical microscope. No new damages were observed on the pilot object since re-treatment in 1992.

WP5

Table of results and product matrices were produced for each pilot object panel and for each sample of original material.

WP6

Dissemination of Results

During the final conference in Romont, the studio gave two Powerpoint presentations, one on the work carried out on the pilot objects in Canterbury Cathedral, and the other giving guidelines for sampling and for packaging.

A packaging manual was produced, which is available on the CONSTGLASS website as a PDF file.

Conclusions

The results of CONSTGLASS indicate that the materials used by the studio on the early medieval glass in Canterbury Cathedral have not had any adverse effects on the objects.

All but the undocumented polymer on window SXXVIII are in sound condition.

Although the application techniques used for the artificial wax coatings would not be considered appropriate within modern guidelines, and were discontinued decades ago, the waxes themselves continue to perform well behind protective glazing.

The silicone rubber has been shown to be a reliable and safe material if used correctly.

The re-treatment of wax with Paraloid® B72 has been shown to be entirely successful and will be recommended for use in similar cases.

The trial applications of SZA and Ormocer® have not altered significantly.

Compared to some of the results from other pilot objects, the materials in Canterbury Cathedral have performed exceedingly well. One major factor for this good behaviour must be the protective glazing that was installed on all treated windows immediately following conservation.

This underlines the importance of protective glazing as a preventive conservation measure, both in terms of conservation performance and in terms of cost effectiveness.

Canterbury, 15 June 2010

Léonie Seliger
Head of Studio

The Cathedral Studios