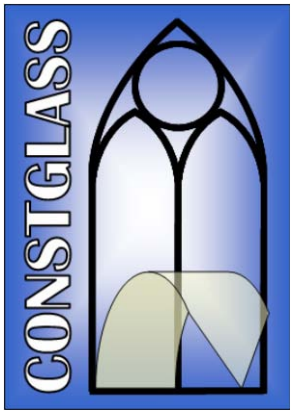


Project reporting in FP6

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

Product Matrices

Ablebond® 342-1. Bonding and gap-filling

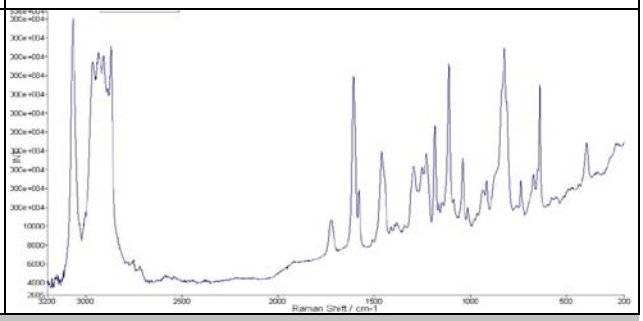
Pilot objects	GLASGOW
Bay (date)	Burrell Collection: Swiss roundel depicting the Life of St Francis
Exposure - protective glazing	Internal, artificially-lit gallery
Composition of the product	Epoxy resin : diglycidyl ether of Bisphenol A resin plus trimethylenetriamine hardener
Application : date (age of product) ; studio ; protocol	Applied at the Burrell collection conservation studios in *c.*1978
Morphology	
Direct observation	Epoxy resin bonds and fills have shown excellent durability and good non-yellowing behaviour
SEM observation	
Desktop Xrays tomography	
Synchrotron tomography	
Chemical behaviour	
FTIR	
Raman spectroscopy	
Mechanical behaviour	
Contamination	
Fungi	
Bacteriae	
Active infestation	
Biological activity	
Microbiological susceptibilty	
Reversibility	
Product 1	
Product 2	
Retreatability	
Product 1	
Product 2	
General observations	
	This use of Ablebond 342-1 represents the first application of this epoxy resin for stained glass conservation. The documentation of the resin application and the subsequent display conditions are very complete.
Recommendations	
Safety/healthy	
Preparation	
Application	
Future conditions of conservation	

Araldite® coating

Pilot objects	BURGDORF	FRESH MATERIAL
Bay (date)	Vestry south of the choir Panel of fragments	samples: Ugent/Aral/1 Ugent/Aral/Kontur/1 LBW/Aral/1 LBW/Aral/2 LBW/Aral/3
Exposure - protective glazing	South	-
Composition of the product	Araldite® binder AY103 by 100 parts Hardener HY951 by 9 parts (Astorit AG, Einsiedeln).	epoxy resin (bisphenol-A) with hardener (cyclic aliphatic amine)
Application : date (age of product) ; studio ; protocol	1971, Konrad Vetter, treatment description	2008 Cologne Cathedral (protocol), application 1 time
Morphology		
Direct observation	Observation of the consolidant: We observe today that the resin used for fracture mending and back plating has sometimes heavily yellowed, is bristled and partly looses adhesion. We identified 8 phases of epoxy deterioration and detachment process in back-platings with Araldite®.	good and stable
SEM observation	-	-
Desktop Xrays tomography	-	-
Synchrotron tomography	The plating glass has been detached, its surface seems to have been smoother than the surface of the original. The crack in the epoxy layer occurs at the border between parts of different thickness. This confirms an observation on larger samples: The effect could be due to shrinking, but also to the different mechanical stresses due to thermal expansion (glasses, but especially the resin itself). In the crack, the well adhering epoxy infill has stripped off a part of the adjacent glass – evidence for the risks of de-restoration.	-
Chemical behaviour		
FTIR	-	-
Raman spectroscopy		-
Mechanical behaviour		
	-	stable
Contamination		
Fungi	-	high
Bacteriae	-	no
Active infestation		
Biological activity	-	high
Microbiological susceptibilty		
		considerably under moist conditions
Reversibility		
Product 1	-	-
Re-treatability		

Product 1	In this case, we don't re-treat the panel.	-
General observations		
		-
Recommendations		
Safety/healthy	Maske, glove and air exhaust for safety applicaation.	-
Preparation	Araldite® binder AY103 by 100 parts, hardener HY951 by 9 parts (Astorit AG 8840 Einsiedeln). Hardening at 22 ^{0}C during 24h.	-
Application	Single fractures were scotch taped on the painted surface. Then the crack was opened for inserting the Araldite®. The remaining Araldite® was removed with acetone. Doubling method: A thin carrier glass was cut and sometimes reheated in a plaster mould taken from the original fragment. Araldite® was poured on the carrier glass, the fragment was then put on top and left under pressure with a weight, for 24 hours/22 °C. The resin coming out all around the doubled glass has been removed with a sharp blade after 6-7 hours.	-
Future conditions of conservation	Type of Araldite® 2020 still used for single fractures.	-

Araldite® AY103/HY951. Bonding and gap-filling

Pilot objects	GLASGOW
Bay (date)	Burrell Collection: English panel depicting Princess Cecily
Exposure - protective glazing	Internal, artificially-lit gallery and subsequently off display
Composition of the product	Epoxy resin : diglycidyl ether of Bisphenol A resin plus polyoxypropylenediamine hardener
Application : date (age of product) ; studio ; protocol	Applied at the Burrell collection conservation studios in *c.*1975
Morphology	
Direct observation	Epoxy resin bonds and fills have shown excellent durability and good non-yellowing behaviour
SEM observation	
Desktop Xrays tomography	
Synchrotron tomography	
Chemical behaviour	
FTIR	
Raman spectroscopy	
Mechanical behaviour	
Contamination	
Fungi	
Bacteriae	
Active infestation	
Biological activity	
Microbiological susceptibilty	
Reversibility	
Product 1	
Product 2	
Retreatability	
Product 1	
Product 2	
General observations	
Recommendations	
Safety/healthy	
Preparation	
Application	
Future conditions of conservation	

Pilot objects	COLOGNE	COLOGNE
Bay (date)	s XXII, south side aisle, "Adoration of the Magi" (1846)	N VI, choir clerestory, "Cycle of Kings" (ca.1300)
Exposure - protective glazing	South	North
Composition of the product	Methyl silicone resin (50% Toluene + 2% hardener TU 2); to prolong the setting time ethyl acetate was added	Methyl silicone resin (50% Toluene + 2% hardener TU 2); to prolong the setting time ethyl acetate was added.
Application : date (age of product) ; studio ; protocol	BS 31 was applicated in 1981; carried out by an outside company (no protocol). It was used for the stabilisation of damaged paint- layers and of fresh retouches. The application was either partial or all over the surface (internal + external face).	Between 1978-1982 paint-layer consolidation with BS 31 took place; it was used on internal faces for the stabilisation of damaged paint layers and fresh retouches; the treatment was carried out by the stained glass studio of Cologne Cathedral (protocol).
Morphology		
Direct observation	The BS 31-coatings seems to be in a good condition. But several parts (thick application) have a milky aspect, as if air bubbles were enclosed. Under the microscope crizzeld areas are visible.	The BS 31-coating of the paint partly starts to delaminate. These areas look milky.
SEM observation	for organic materials this analytic device is not suitable	-
Desktop Xrays tomography	The compact glass, the silicone, the paintlayer and the tape is visible	-
Synchrotron tomography	The compact glass with traces of metal, the silicone and the tape is very good visible	-
Chemical behaviour		
FTIR	no reference spectrum of BS31 is availible and the product is no availible anymore	-
Raman	no reference spectrum of BS31 is availible and the product is no availible anymore	-
Mechanical behaviour		
	The mechanicle behaviour seems to be stable in the thinner applied areas. But in the thicker parts of the BS 31-coating, the behaviour is not satisfying. The BS 31 can flake off when being touched with a scalpel.	The mechanical behaviour seems to be good and stabil.
Contamination		
Fungi	-	-
Bacteriae	-	-
Active infestation		
Biological activity	-	-
Microbiological susceptibilty		
	Not tested (BS 31 is out of market; no fresh material available)	Not tested (BS 31 is not on the market any more; no fresh material available)
Reversibility		
Product 1	**Ethanol (gel with 5% Klucel® M),** good results (tests were not carried out on the investigated sample but on an comparable segment!)	**Ethanol (as gel)** good results, but remains in the paint (tests were not carried out on the investigated sample but on an comparable segment!).
Re-treatability		
Product 1	not intended	not intended

BS31 Coating

General observations		
	From the conservator's point of view there is no need to remove BS 31 at the moment,	
Recommendations		
Safety/healthy	BS 31 is out of market; no fresh material available	
Preparation		
Application		
Future conditions of conservation		

Pilot objects	FRESH MATERIAL
Bay (date)	samples: LBW/Fyn/gestr/1 LBW/Fyn/gestr/2 LBW/Fyn/gestr/3
Exposure - protective glazing	-
Composition of the product	Epoxy resin (two components),
Application : date (age of product) ; studio ; protocol	2008 Cologne Cathedral, application 1 times, only at sand blasted glasses
Morphology	
Direct observation	at blank surfaces the material contract themself in the middle of the glass, at the rough surfaces good results
SEM observation	-
Desktop Xrays tomography	-
Synchrotron tomography	-
Chemical behaviour	
FTIR	-
Raman	-
Mechanical behaviour	
	stable at rough surfaces
Contamination	
Fungi	medium
Bacteriae	no
Active infestation	
Biological activity	high
Microbiological susceptibilty	
	eventually under moist conditions and roughness increases suszeptibility
Reversibility	
Product 1	
Product 2	
Re-treatability	
Product 1	
Product 2	
General observations	
Recommendations	
Safety/healthy	
Preparation	
Application	
Future conditions of conservation	

Pilot objects	FRESH MATERIAL
Bay (date)	samples: LBW/Hxtal/gestr/1 LBW/Hxtal/gestr/2 LBW/Hxtal/gestr/3
Exposure - protective glazing	-
Composition of the product	Epoxy resin (two components), resin: based on Epichlorhydrin; hardener: Alkyletheramin, Imidirole
Application : date (age of product) ; studio ; protocol	2008 Cologne Cathedral, application 1 times, also at sand blasted glasses
Morphology	
Direct observation	at blank surfaces the material contract themself in the middle of the glass, at the rough surfaces good results
SEM observation	-
Desktop Xrays tomography	-
Synchrotron tomography	-
Chemical behaviour	
FTIR	-
Raman	
Mechanical behaviour	
	stable at rough surfaces
Contamination	
Fungi	medium
Bacteriae	no
Active infestation	
Biological activity	high
Microbiological susceptibilty	
	eventually under moist conditions and roughness increases suszeptibility
Reversibility	
Product 1	
Product 2	
Re-treatability	
Product 1	
Product 2	
General observations	
Recommendations	
Safety/healthy	
Preparation	
Application	
Future conditions of conservation	

Pilot objects	COLOGNE	FRESH MATERIAL
Bay (date)	**NVI** (panel 4bL), choir clerestory ; "Cycle of Kings" (ca. 1300)	samples: Ugent/Orm/1 LBW/Orm/1 LBW/Orm/2 LBW/Orm/3
Exposure - protective glazing	North – protective glazing	-
Composition of the product	Multiple-layered protective system with glass flakes: - base lacquer (50% Ormocer® + 50% Paraloid B 72, solved in ethyl acetate 1:3), twice applied; - protective lacquer (50% Ormocer® + 50% Paraloid, solved in ethyl acetate 1:10), three times applied; in each single layer inorganic pigments (glass flakes) were inserted; - covering layer: Paraloid® B 72, solved in Toluene 1:9, one time applied.	inorganic-organic hybrid polymer, a heteropolysiloxane mixed with Paraloid® B 72.
Application : date (age of product) ; studio ; protocol	1989 ; Cologne Cathedral (protocol)	2008 Cologne Cathedral (protocol), application 3 times
Morphology		
Direct observation	The external surface was completely coated with the Ormocer® protective system. Visibly the coating is is a stable condition. Partial the material has some bubbles and several parts of the coating (thickly applied) has a milky aspect. The putty around the glass segments was coated with Ormocer®, too.	good and stable
SEM observation	good adhesion to glass, no fissures between glass and ORMOCER® detectable, no flakes detectable	-
Desktop Xrays tomography	It was possible to detect the ORMOCER®-layer with CT. The retreatment with doped Paraloid® was not truely detectable.	-
Synchrotron tomography	n/a	-
Chemical behaviour		
FTIR	ORMOCER® didn't change in the 22 years of aging	-
Raman	No chemical changes of the ORMOCER® during over 20 years of exposure are observable.	-
Mechanical behaviour		
	Solid; slightly elastic.	stable
Contamination		
Fungi	n/a	medium
Bacteriae	n/a	no
Active infestation		
Biological activity	n/a; investigations done with fresh ORMOCER®	low
Microbiological susceptibilty		
		neglegtible
Reversibility		

Product 1	MEK gel (5% Klucel G) / compress (only tests). Duration: 4 times (10 and 15 min) together 45 minutes + secondary cleaning with cotton swab (MEK) and brush (dry). Results: Ormocer® was removed by the compress; some remains of the embedded glassflakes were additionally removed with a MEK-soaked cotton swab, but there were still rests of the flakes on the surface.	-
Re-treatability		
Product 1	only for the tests of reversibility/retreatment: Paraloid B72®	-
Product 2	ORMOCER®	-
General observations		
	From the conservator's point there is no necessity to remove Ormocer® at the moment.	-
Recommendations		
Safety/healthy	The solvent part of SZA and Ormocer® is highly flammable; the mixtures are also classed as irritants. Vapours may cause drowsiness and dizziness so use in a properly ventilated area is recommended.	-
Preparation	Both are ready to use solutions; if necessary Ormocer® can be diluted in the workshop with methylethylcetone, toluene or butoxyethanol	-
Application	It can be applied by brush. In most cases several treatments are recommended. Depending on the solvent / mixture of solvents a drying time of about 12 to 24 hours between every step of application is recommended	-
Future conditions of conservation	no action has to be done for the moment	-

Pilot objects	KLAUSEN
Bay (date)	I, choir axis "Crucifixon and Flight to Egypt" (1878)
Exposure - protective glazing	East
Composition of the product	Mixture of: ORMOCER® / Paraloid® B 72 / Plexigum PM 381 (80 / 10 / 10), 6% solution in ethylacetate; applied several times (varied).
Application : date (age of product) ; studio ; protocol	1991 Cologne Cathedral (protocol)
Morphology	
Direct observation	The ORMOCER® treatment was applied on the fired contours; the treatment is visible (darker appearance). During application the ORMOCER® sunk sufficiently into the contours and the overlaying film of unfired pigmentd oil-lacquer. Today's condition of the ORMOCER®-treatment seems stable.
SEM observation	The mix of fired glass paint and unfired paint, dust particles and conservation material cannot be distinguished in detail by SEM-investigation
Desktop Xrays tomography	n/a
Synchrotron tomography	n/a
Chemical behaviour	
FTIR	The roughness of the sample was too high, so µ-ATR or FTIR was not possible.
Raman	n/a
Mechanical behaviour	
	solid
Contamination	
Fungi	low contamination
Bacteriae	low contamination
Active infestation	
Biological activity	normal
Microbiological susceptibilty	
	none
Reversibility	
Product 1	tests of reversibility only done at Cologne NVI
Product 2	-
Re-treatability	
Product 1	not necessarry, but it might be possible with ORMOCER®, Paraloid® and other materials
Product 2	
General observations	
	From the conservator's point there is no necessity to remove ORMOCER® at the moment.
Recommendations	
Safety/healthy	The solvent part of SZA and Ormocer is highly flammable, the mixtures are also classed as irritants. Vapours may cause drowsiness and dizziness so use in a properly ventilated area is recommended.
Preparation	Both are ready to use solutions; if necessary Ormocer can be diluted in the workshop with methylethylcetone, toluene or butoxyethanol
Application	It can be applied by brush. In most cases several treatments are recommended. Depending on the solvent / mixture of solvents a drying time of about 12 to 24 hours between every step of application is recommended
Future conditions of conservation	It is recommended, at the moment, to keep the consolidant as it is.

Pilot objects	KLAUSEN	CANTERBURY	FRESH MATERIAL
Bay (date)	I, choir axis "Crucifixon and Flight to Egypt" (1878)	CAN N XVII 7	samples: Ugent/Para/1 Ugent/Para/Kontur/1 LBW/Para/1 LBW/Para/2 LBW/Para/3
Exposure - protective glazing	East	North	-
Composition of the product	EMA/ MA 70/30; 1% Toluol	Microcristalline wax 1129 re-treated with Paraloid® B72	methacrylate/ethyl methacrylate (70/30), 5% in Toluene
Application : date (age of product) ; studio ; protocol	1991 Cologne Cathedral	1992 (18 years) Re-treatment of ancient consolidation with wax	2008: Cologne Cathedral (protocol), application 3 times
Morphology			
Direct observation	Paraloid® B72 was used for the stabilisation of damaged paint layers. The treatment of the contours is visible. During the application it sunks well into the contours. The today's condition of the Paraloid® B72 seems to be stable.	Paraloid B-72: remains stable and clean.	good, stable, a little bit flexible
SEM observation	-		-
Desktop Xrays tomography	-		-
Synchrotron tomography	-		-
Chemical behaviour			
FTIR			-
Raman			-
Mechanical behaviour			
	The treated areas are more stabil in comparison to the untreated areas.		stable, a little bit flexible
Contamination			
Fungi			medium
Bacteriae			no
Active infestation			
Biological activity	n/a; investigations done with fresh Ormocer®		medium
Microbiological susceptibilty			
		no microbial activity under the microscope	scarcely under moist conditions
Reversibility			
Product 1	it is possible with different solutions, but it is riky because of the oil-laquer	Complete and safe removal of Paraloid B72 possible.	-
Product 2	-		-
Re-treatability			
Product 1	it might be possible with all usual materials		-
Product 2			-

Paraloïd B72® Consolidant

General observations			
	From the conservator's point there is no necessity to remove Paraloid® B72 at the moment.	No delamination of the Paraloid over 18 years with internally ventilated protective glazing.	-
Recommendations			
Safety/healthy	-	Fume extraction during application of Paraloid B72.	-
Preparation		Solid Paraloid B72 was dissolved in acetone until correct liquid consistency was achieved. Before application glass surface must be free of dust.	-
Application		Applied with a small brush.	-
Future conditions of conservation	-	Continue to monitor. Protective glazing works well.	-

Pilot objects	FRESH MATERIAL
Bay (date)	samples: Ugent/SH1/1 LBW/SH1/1 LBW/SH1/2 LBW/SH1/3
Exposure - protective glazing	-
Composition of the product	thermoplastic colourless 2-component epoxy resin, darkened with black pigment; out of market.
Application : date (age of product) ; studio ; protocol	2008 Cologne Cathedral (protocol), application 1 time
Morphology	
Direct observation	good and stable
SEM observation	-
Desktop Xrays tomography	-
Synchrotron tomography	-
Chemical behaviour	
FTIR	-
Raman	-
Mechanical behaviour	
	stable
Contamination	
Fungi	medium
Bacteriae	no
Active infestation	
Biological activity	medium
Microbiological susceptibilty	
	scarcely under moist conditions
Reversibility	
Product 1	
Product 2	
Re-treatability	
Product 1	
Product 2	
General observations	
Recommendations	
Safety/healthy	
Preparation	
Application	
Future conditions of conservation	

Pilot objects	CHARTRES			CANTERBURY
Bay (date)	37, Aisle (ca 1205-1215) The Christ's Passion	42, Aisle (ca 1205-1215) Virgin Mary's death and Assumption	50, West facade (ca 1145-1155) Jesus childhood and public life of the Christ	SXXVIII 8h
Exposure - protective glazing	North, between 2 buttress	South	West	South
Composition of the product	Silicone CAF 3 :mixture of polydimethylsiloxanes, silica and curing agents	Silicone CAF 3	Silicone CAF 3	Silicone CAF 3
Application : date (age of product) ; studio ; protocol	1988 (21 years) ; Alliou	1988 (21 years) ; Petit	1976 (33 years) ; Gaudin	1975-78 (35 years)
Morphology				
Edge bonding : Direct observation	No visible alteration of the silicon (flexible), good adherence between two edges, partial loss of adherence on the surface of some pieces	No visible alteration of the silicon (flexible), good adherence between two edges	No visible alteration of the silicon (flexible), good adherence between two edges	Excess silicone remains on the surface of the glass.it appears firm and translucent. No visible deterioration since application
Back plating : Direct observation	-	No visible alteration of the silicon (flexible), good adherence between two edges, light milky aspect of the recent glass	No visible alteration of the silicon, light milky aspect of the recent glass	
SEM observation	-	-	-	
Desktop Xrays tomography	good adherence of the glue on the edge of healthy glass	-	-	
Synchrotron tomography	-	-	-	
Chemical behaviour				
FTIR	-	-	-	
Raman	-	-	-	
Mechanical behaviour				
	good maintaining when hand strain in different directions ?	good maintaining when hand strain in different directions	good maintaining when hand strain in different directions	
Contamination				
Fungi	None	None	None	
Bacteriae	None	Not forseen	None	
Active infestation				
Biological activity	Low	Low	None	
Microbiological susceptibilty				
	-	-		

Reversibility			
Product 1	Mechanical removal and scouring with a rubber	-	
Re-treatability			
Product 1	Silicone without acetic acid: good adherence	-	
Product 2	Araldite 2020, epoxy resin: good adherence	-	
General observations			
	Good flexibility, good adherence, good reversibility		
Recommandations			
Safety/healthy	Slightly irritating to eyes, respiratory system and skin. On contact with humidity: irritating vapors are released. Combustible. Ventilation, manipulation with gloves. Work outside or in a well-ventilated room.		Gloves should be worn.
Preparation	Make sure surfaces to be bonded are cleaned and free from grease.		Make sure surfaces to be bonded are cleaned and free from grease.
Application	Edge bonding: apply along break edges before placing firmly together. Back plating: after placing face to face ancient and new glasses together, apply along the edges.		Apply along break edges before placing firmly together.
Future conditions of conservation	No need for a re-treatment		No need. No treatment necessary. The window from which the panel is has externally ventilated protective glazing

Pilot objects	KLAUSEN	FRESH MATERIAL
Bay (date)	I, choir axis "Crucifixon and Flight to Egypt" (1878)	samples: Ugent/SZA/1 UGent/SZA/ gestr/1 LBW/SZA/1 LBW/SZA/2 LBW/SZA/3 LBW/SZA/ gestr/1 LBW/SZA/ gestr/2 LBW/SZA/ gestr/3
Exposure - protective glazing	East	-
Composition of the product	Si / Zr (9:1), 14% solution in iso-butyl-alcohol	inorganic material based on silicion-zirkon-alkoxide
Application : date (age of product) ; studio ; protocol	1991 Cologne Cathedral	2008: Cologne Cathedral (protocol), application 3 times, also on sand blasted glasses
Morphology		
Direct observation	SZA was used for the stabilisation of damaged paint layers. The treatment of the contours is not visible. During the application SZA sunk well into the contours. But due to its highly fluid character, the SZA inevitably spread out onto the surrounding area, including the overlaying film of unfired pigmented oil-lacquer. The today's condition of the SZA seems to be stable.	during drying-process the material contracted in the centre of glossy surfaces; on rough (sandblasted) surfaces good adhesion
SEM observation	SEM was done at KLA_SZA_1 after cleaning and retreatment with doped Paraloid®. It was not possible to see after cleaning wether SZA was removed or not. Only the new application with Paraloid® was visible.	-
Desktop Xrays tomography	The application of SZA wasn't possible to detect. SZA is anorganic and near to glass. A layer of glass on a surface of glass has the same resolution.	-
Synchrotron tomography	not for seen	-
Chemical behaviour		
FTIR	Almost not detectable with FTIR. Layers of SZA are very thin.	-
Raman	not forseen	-
Mechanical behaviour		
	The treated areas are more stabil in comparison to the untreated areas.	stable at rough surfaces
Contamination		
Fungi	low contamination	On smooth glass low On sand blasted glass (gestr).: high
Bacteriae	low contamination	no
Active infestation		
Biological activity	normal	On smooth glass low On sand blasted glass (gestr).: high
Microbiological susceptibilty		
	none	negligtible, but roughness increases suszeptibility
Reversibility		
Product 1	Treatment only for tests: MEK-gel (5 % Klucel® G) / compress Duration: 180 minutes	

	Result:The exposure time of the MEK-gel was decided to be long enough (by Constglass consortium). Whether SZA has been removed or not, can visibly not be detected.	
Re-treatability		
Product 1	it might be possible with all usual materials	-
General observations		
	From the conservator's point there is no necessity to remove SZA at the moment.	-
Recommendations		
Safety/healthy	The solvent part of SZA and Ormocer is highly flammable, the mixtures are also classed as irritants. Vapours may cause drowsiness and dizziness so use in a properly ventilated area is recommended.	-
Preparation	Both are ready to use solutions; if necessary Ormocer can be diluted in the workshop with methylethylcetone, toluene or butoxyethanol	-
Application	It can be applied by brush. In most cases several treatments are recommended. a setting time of 3-5 days between every step of application is recommended, for optimum setting the relative humidity has to be higher than 50%r.H. during setting time	-
Future conditions of conservation	No action has to be done for the moment	-

Pilot objects	BOURGES	LE MANS
Bay (date)	**4**, Choir (Ca 1210-1215) The Last judgement	**XVI**, Nave (Ca 1120) The Ascension
Exposure	East - no protective glazing	South - no protective glazing
Composition of the product	80% Viacryl VC 363 + 20% Desmodur N 75	80% Viacryl VC 363 + 20% Desmodur N 75
Application : date (age of product) ; studio ; protocol	1981 (28 years) ; Mauret ; glasses + leads	1974 (35 years) ; Gruber ; glasses
Morphology		
Direct observation	Flaking, chipping, partial or total detachment, yellowing with a milky aspect, hard and brittle	Flaking, chipping, general detachment, yellowing with a milky aspect, hard and brittle
SEM observation	Alteration product = gypsum + gel layer. The gel layer is pulled out by the flakes.	Alteration product = gypsum + gel layer. The gel layer is pulled out by the flakes.
Desktop Xrays tomography	Adherence of the Viacryl on gel layer. These techniques highlight the detachment of the gel layer by Viacryl flakes.	-
Synchrotron tomography		-
Chemical behaviour		
FTIR	Chemical degradation : - decreasing of the secondary amides functions - increasing of the primary amides functions.	Chemical degradation : - decreasing of the secondary amides functions - increasing of the primary amides functions.
Raman	*No need - information obtained with FTIR*	
Mechanical behaviour		
	-	-
Contamination		
Fungi	Medium infastation	None
Bacteriae	Low	None
Active infestation		
Biological activity	Medium (459 RLU/25 cm²)	None
Microbiologicalsusceptibilty		
	not tested (no fresh product available)	
Reversibility		
Product 1	**Ethanol (gel)** good results, good swelling and loss of adherence	**Water-ethanol mixture** good results on surface, but remains in the craters
Product 2	**N-pyrrolidone (gel)** Good results, needs brushing near leads	**N-pyrrolidone** good for elimination into the crater
Re-treatability		
Product 1	*no need*	*no need*
Product 2		
General observations		
	Insufficient durability, partial damage to gel layer when deteriorated	
Recommendations		
Safety/healthy	**No more available** **Not to be employed**	**No more available** **Not to be employed**
Preparation		
Application		
Future conditions of conservation	isothermal glazing installation	isothermal glazing installation

Pilot objects	LE MANS	CHARTRES	
Bay (date)	**XVI**, Nave (Ca 1120) The Ascension	**37**, Nave (ca 1205-1215) Typological Passion	**42**, Nave (ca 1205-1215) Death and Assumption of the Virgin
Exposure	South	North, between 2 buttress	South
Composition of the product	80% Viacryl® VC 363 + 20% Desmodur® N 75	80% Viacryl® SM 564 + 20% Desmodur® N 75	80% Viacryl® SM 564 + 20% Desmodur® N 75
Application : date (age of product) ; studio ; protocol	**1974** (35 years) ; Gruber ; paint and glasses	**1988** (21 years) ; Alliou ; paint + glasses	**1988** (21 years) ; Petit ; paint
Morphology			
Direct observation	Observation of the consolidant is easy: the paint is glossy and under UV, it's fluorescent. Good maintaining of the glass paint except some which are frail (5%), restart of corrosion on the paints and the glasses, cracked Viacryl® on glass.	Observation of the consolidant is easy: the paint is glossy and there are rests of Viacryl® around grisaille and near leads. Sometimes, Viacryl® is coated on all the surface of the piece. No visible alteration, except some grisailles which are frail because of scratches.	Observation of the consolidant is difficult with binocular microscope and raking light, slight fluorescence under UV light. Only visible after dust cleaning (cotton swab with water). No visible alteration. Protection still effective.
SEM observation	Corrosion products = gypsum + gel layer.	Micro-cracks on coated Viacryl®, and when it is scratched macro-cracks bare gel layer and paints. Corrosion products = gypsum + gel layer	No micro-cracks on the consolidant, some gaps revealing unprotected grisaille on the edges of some trace lines. Corrosion products = gypsum + gel layer
Desktop Xrays tomography	-	Good adherence of the Viacryl on gel layer and grisaille. Permits also to see the good reversibility of Viacryl®.	-
Synchrotron tomography	-		-
Chemical behaviour			
FTIR	-	-	-
Raman	-	-	-
Mechanical behaviour			
	-	good behaviour (tested with a cotton rolled around a stick)	good behaviour (tested with a cotton rolled around a stick)
Contamination			
Fungi	-	None (rough surface : Low)	None
Bacteriae	-	None (rough surface: Low)	None
Active infestation			
Biological activity	None	Low	Low
Microbiological susceptibilty			
	-	Microbiological susceptibility supported by dust and dirt in cracks and fissures due to a rough surface	
Reversibility			
Product 1	**Water-ethanol mixture** on weathered glass around paints : good results ; to be made under binocular microscope, with cotton rolled around a stick.	**Water-ethanol mixture** on excess of Viacryl®: very long and repeated applications are needed because of the good preservation of the coating	-
Re-treatability			
Product 1	-	ORMOCER: easy to apply, good penetration in the glass paint, good visual aspect	-
Product 2		Paraloïd® B72: easy to apply, good penetration in the glass paint, good visual aspect	
General observations			
Recommandations			

Safety/healthy Preparation Application	**No more available Not to be employed**	**No more available Not to be employed**	**No more available Not to be employed**
Future conditions of conservation	Protective glazing installation, with internal ventilation	Protective glazing installation, with internal ventilation	Protective glazing installation, with internal ventilation

Pilot objects	CANTERBURY	
Bay (date)	**CAN N XVII 7**	**CAN N II 7**
Exposure - protective glazing	North	North
Composition of the product	Microcristalline wax 1129 diluted with white spirit	Microcristalline wax 1129 diluted with white spirit
Application : date (age of product) ; studio ; protocol		
Morphology		
Direct observation	**in 1992** Wax: various degrees of flaking, delamination, surface deposits (after 6-8 years exposure without protective glazing) **in 2009** Wax remnants and Paraloid B-72: sound, clean.	Wax is stable, no visible deterioration
SEM observation		microcrystalline wax appears solely on sample sent to fraunhoffer institute
Desktop Xrays tomography		
Synchrotron tomography		
Chemical behaviour		
FTIR		
Raman		
Mechanical behaviour		
Contamination		
Fungi	-	-
Bacteriae	-	-
Active infestation		
Biological activity		
Microbiological susceptibilty		
		Negative results from LBW. Possible re-test
Reversibility		
Product 1	Complete and safe removal of flaking wax possible; well adhering wax only thinned down - danger of damage to substrate. (mechanical with scalpel)	Removed the wax after 2 minutes
Product 2		Removed after 30 seconds
Re-treatability		
Product 1	Paraloid B-72 good result, no delamination over 18 years with internally ventilated protective glazing	
General observations		
Recommendations		
Safety/healthy	Fume extraction during applicatin of Paraloid-B72	Reversibility Tests were taken under fume extraction and handled with gloves
Preparation		Ensure glass and paint are stable before attempting removal of wax.
Application		In Klucell G gel compress / on cotton swabs
Future conditions of conservation	Continue to monitor. Protective glazing works well.	Window nII has externally ventilated protective glazing; ideally this should be turned to internal ventilation, but is working well as is.