# A Review of Current and Recent Practice in the Use of Adhesives by the Conservation Department at the British Library

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## Abstract

A systematic review of the range of adhesives used in the conservation of collection items in the British Library was carried out to assess their suitability with regard to established conservation criteria. Information was gathered through a questionnaire, research of articles and publications, and enquiries to individuals and institutions. Research and testing were also carried out by the Conservation Science department to investigate concerns associated with unrefined proteinaceous glue (animal glue) and certain synthetic adhesives.

We found that, on the whole, there is consensus in the conservation community about which adhesives are suitable for conservation. However, some areas need more research, especially in relation to animal glue. We discovered that a synthetic adhesive (based on ethylene vinyl acetate) commonly used in the United Kingdom off-gasses volatile organic compounds. We were able to recommend adhesives for use either directly on collection items, or in housings, and to suggest an ongoing program of research and development. The review has informed our work, allowing conservators to adapt treatments according to the latest research. Overall, it has proved to be an invaluable exercise with tangible benefits to the conservation of the British Library collection.

## Introduction

The British Library, was formed in 1973 and moved to St Pancras in central London in 1998, see Figure 1. It is home to an ever-growing collection of over 150 million physical items. It is one of six legal deposit libraries in the UK. The Library also has a purpose-built facility at Boston Spa, West Yorkshire, which stores print material in a low-oxygen, low-light environment.

Figure 1. The British Library, London


The British Library Centre for Conservation (BLCC) is the latest state-of-the-art addition to the St Pancras site, see Figure 2. The BLCC provides accommodation designed to meet the specific requirements of the majority of its conservators who work on a vast range of collection items and materials including; paper, books, leather, parchment, textiles, wood, papyrus, ivory, pigments, scrolls, seals, photographs, metal, plastics, maps and stamps.

Figure 2. The British Library Centre for Conservation opened in 2007

In accordance with professional practice, the Conservation department timetables regular reviews to promote best practice in its conservation approach (E.C.C.O. 2007). This gathering of collective knowledge ensures that Library resources are used efficiently and that our approach links into the wider conservation community professional practice.

> *'The Conservation Treatment Review is part of a package of projects that are being undertaken to ensure that the work done in Conservation meets the current and future needs of the British Library...' '...The aim is to develop a Conservation service that is world class, effectively managed and staffed by professionals who are equipped to make decisions about the best options for the treatment of the BL's Collections, with the chosen treatments carried out to consistently high standards.'* (Humphrey 2004).

Regular treatment reviews were implemented six years ago and began with the 'Iron Gall Ink Treatment Review 2005' (Beltran de Guevara 2006).

The project represented within this paper is a review of the use of adhesives in the British Library Conservation department which seeks to develop a consistent and appropriate use of adhesives in specific conservation treatments. This paper is an overview of the treatment review process, concentrating on the methodology employed and reporting on a selection of the most interesting findings.

Information gathered from the review has been compiled in a report held at the Library and relayed to staff via a Topic Talk. Topic Talks are held monthly in the BLCC's training facility. Collection Care staff can use these sessions to show current work, report about seminars and conferences or to discuss conservation issues. The wider conservation

community will be informed through a series of talks, workshops and publications. Should any future actions be identified these will be acted upon as part of the Conservation department's on-going strategy.

## Methodology

### Information gathering and research

Information gathered from the Library conservators was crucial to gauge the extent and specific use of adhesives within the department over the last five years. The team developed a 'tick-box' questionnaire and colleagues were invited to indicate which adhesives they would consider using for which conservation treatments.

We chose to review the 11 most widely used and familiar adhesives in the Conservation department consisting of four main adhesive types:

*Starch and polysaccharides*

- Wheat starch (BDH and Zin Shofu; powdered with gluten removed)
- JunFunori (red algae extract)
- Furu-nori (aged wheat starch - although the Library does not have a stock of aged starch, this was also investigated as a possible alternative to non-aged wheat starch paste for specific treatments)

*Cellulose ethers*

- Methyl cellulose (Methocel A4C; medium viscosity, 400mPas)
- Hydroxypropyl cellulose (Klucel G/E and Cellugel; hydroxypropyl cellulose in isopropanol)

*Proteinaceous*

- Gelatine (powdered, type B)
- Unrefined animal glue (crystalline, hide and bone)
- Isinglass (dried, sturgeon air bladder)

*Synthetic*

- Evacon-R (Conservation-by-Design; liquid, ethylene vinyl acetate with calcium carbonate)
- Adhesive tapes (due to the wide variety of adhesives on different carrier tapes we restricted our research to general recommendations on use and storage pending further investigations)
- Acrylics such as Particle Technology Conservation Adhesive AD20 (Particle Technology; liquid, acrylic in acetone) and Archibond Tissue (Conservation-by-Design; heat-set Paraloid acrylic adhesive).

The adhesive-related treatments we chose to review included; repairs, consolidation and lining, as well as the making of new bindings and conservation housings such as boxes, mounts and frames. The treatment list helped us identify the adhesives used in direct contact, close proximity and indirectly with collection items.

The results formed the basis of decision-making for the team. This questionnaire also informed our enquiries to professional colleagues and institutions around the UK and

internationally. When specific questions or issues arose the Conservation Distribution List (ConsDistList) provided a useful forum (ConsDistList 2010).

Information was gathered from up-to-date unpublished and published literature as well as articles on-line. This knowledge base provided us with valuable information on the chemical and physical aspects of adhesives as well as the current trends and thinking in the conservation community. Any gaps we found in specific areas were filled via empirical testing and practical work by members of the team.

**Current trends**

To establish the ethical trends in conservation we consulted guidelines provided by the Institute of Conservation (Icon), the leading professional body for cultural heritage in the UK. Their guidelines clearly illustrate the basic ethical approach for conservators; they state that conservators should have the:

> '*…training, knowledge, skills, experience and understanding to act with the aim of preserving cultural heritage for the future…'* and that *'Conservation consists mainly of direct action carried out on cultural heritage with the aim of stabilising condition and retarding further deterioration.'* (Icon 2007).

The European Confederation of Conservator-Restorers' Organisations' (E.C.C.O.) guidelines are specific, with regard to materials conservators use on cultural items.

> *'The Conservator-Restorer shall strive to use only products, materials and procedures which, according to the current level of knowledge, will not harm the cultural heritage, the environment or people. The action itself and the materials used should not interfere, if at all possible, with any future examination, treatment or analysis. They should also be compatible with the materials of the cultural heritage and be as easily and completely reversible as possible.'* (E.C.C.O. 2007).

Both guidelines espouse fundamental principles such as 'minimal intervention' and 're-treatability'. In order to keep the object's integrity and leave the possibility of re-treatment in the future it is clear that we, as conservators, have a responsibility and duty to evaluate, understand and apply our knowledge of processes and materials in our work (Applebaum 1987; Clarkson 1999).

**Suitability of adhesives for conservation**

Before an adhesive can be considered suitable for use on a collection item it must fulfill certain criteria. The review team established a set of criteria based on previous valuable work carried out by the American Institute for Conservation of Historic and Artistic Works (AIC 1988, chapter 46). These criteria form a list of characteristics applied to adhesives in the context of conservation, and allow materials to be assessed with respect to their suitability for particular applications or object. For example, the pH of the adhesive, both immediately after application and after ageing, must be compatible with objects in close proximity; the adhesive should not release potentially harmful volatiles; the physical properties (strength, flexibility, shrinkage, etc.) must allow it to provide sufficient adhesive support without introducing the risk of mechanical damage; it should ideally be removable, and this must be achievable in a way which will not damage the object itself; it must not discolour with age if this will mar the appearance of the object.

We also wanted to consider the additional complexities involved when additives are used in adhesives to alter properties or promote the ease of application, such as plasticizers. The addition of such chemicals may affect the suitability of that adhesive for use in conservation, and should be identified wherever possible. By the same reasoning, care should also be taken when deciding which solvents to use for making up adhesives. For example, the Library has a supply of reverse osmosis water which can be used to make up water-soluble adhesives, such as wheat starch paste.

## Results

### Scientific testing

The importance of the scientific testing carried out as part of this review cannot be emphasised enough. Testing our adhesive supplies directly saved time and resources as well as being a useful tool to focus on specific concerns. Where we were unable to find consistent or recent data in published material, our in-house testing provided some benchmark values, on which we could build our information and identify areas of concern.

Below are three examples of scientific investigations resulting from our enquiries. These examples illustrate concerns about the use of adhesives within the conservation community in the UK, but also reflect wider international concerns and issues.

It has been suggested by the AIC Book & Paper Group that *'Commercial preparations are recommended with caution because formulations can change without notice. Product literature may not fully disclose chemical composition or aging properties.'* (AIC 1988, chapter 46). The discovery of cellulose nitrate in a formulation of a material marketed as B72 (not pure Paraloid B72, produced by HMG paint manufacturer), has strengthened the cautious approach when selecting adhesives for conservation treatments (Nel and Lau 2009).

The British Library hold in stock a liquid acrylic adhesive which is sold as Particle Technology Conservation Adhesive AD20 and is said to contain *'Paraloid B72 acrylic in acetone.'* As this formulation was not supplied by Rohm and Haas, the manufacturers of Paraloid B72, and given the concerns raised regarding the HMG B72, it was considered worth testing for the presence of cellulose nitrate using Fourier transform infrared (FTIR) spectroscopy. The spectrum of the adhesive sample was not found to contain any cellulose nitrate contamination (FTIR spectrum acquired using a Perkin Elmer 'Spectrum One' spectrometer, fitted with an attenuated total reflectance [ATR] accessory, and running under Spectrum software, over the range 4000-400 $cm^{-1}$, with a resolution of 4 $cm^{-1}$ and 16 accumulations). Further testing will be carried out as part of the on-going testing strategy recommended by the review team.

As a result of our questionnaire we became concerned about the suitability and use of unrefined proteinaceous glue (animal glue) in conservation treatments of book and paper items. Gelatine is a commonly used refined form of proteinaceous glue for parchment repair and as a size or consolidant for paper especially where iron gall ink is present (Kolbe 2004, p34-36). However, animal glue used in traditional bookbinding was shown by our questionnaire to be considered by some as a suitable conservation adhesive. We thought it useful to research the use of animal glue; and although our investigations revealed the current trend is moving away from using this adhesive, the reasons given are based on observation and experience, not backed up by empirical testing or research. In fact there appears to be a lack of current research into animal glue in the context of book and paper

conservation. In order to seek some clarification we requested several experiments to help assess aspects of animal glue of particular concern to the review team; namely, its pH on ageing, its tendency to off-gas and how its stability is affected by repeated reheating. Although we were able to demonstrate that the repeated reheating of animal glue did not change its chemical properties the action of reheating altered the glue in several ways; we observed that it became more brittle, changed colour from amber to a grey-brown and became less efficient as an adhesive. An artificial ageing test demonstrated that animal glue tended to become more brittle and to discolour the paper substrate over time. An Oddy test also showed that animal glue has a tendency to off-gas and become acidic which was quantified by a surface pH reading, see Table 1 (Oddy 1973). These characteristics are a cause for concern and are consistent with the 'received wisdom' of conservation colleagues who witness the detrimental effects of animal glue on spines on a regular basis. The results directly informed our recommendations, which was that unrefined animal glue should not be used in book and paper conservation treatments; pure gelatine was suggested as the alternative adhesive for unrefined animal glue, where appropriate.

During the Oddy test of a commonly used adhesive in the UK, an unexpected result was revealed. Evacon-R is described on the supplier's website as an *'ethylene - vinylacetate copolymer emulsion...'* and includes *'...a small quantity of calcium carbonate…'* (Conservation-by-Design). It is preferred by conservators to the 'pure' homopolymer poly(vinyl acetate) (PVAC) as it possesses similar adhesive properties, but its copolymeric composition gives it 'reversibility' in water. Although it is normally used in conjunction with a barrier layer, its proximity to collection items is generally accepted and has been adopted by some conservators for use in conservation housings, new bindings and in some cases, on actual collection items.

However, under Oddy testing conditions, Evacon-R generated significant quantities of volatile organic acids, see Table 1. Further tests on two-week old (allowed to stand in open conditions) and aged (80°C, 60% RH, for four weeks) samples of Evacon-R showed that it produces volatile acids as it ages. The tests also showed that the acidic off-gassing of Evacon-R were most significant in a period roughly equivalent to the first few years after application and dropped off subsequently, although the surface acidity of the material continued to increase.

These results indicate that the Evacon-R formulation under test (currently used in the Library) fails the Lead Tarnish aspect of the Oddy Test, see Table 1. These results have instigated further work with the co-operation of the supplier to find ways of redressing the problem.

Table 1: Results of Oddy testing of Evacon-R and animal glues, immediately after drying and after roughly five years equivalent artificial (thermal) ageing, along with surface pH measurements. ('✓' indicates that no corrosion of the relevant metal token was observed; '(×)' denotes minor tarnishing or corrosion; '×' indicates heavy corrosion.)

| **Sample** | **Immediate** | | | | **Five Years** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Oddy Test** | | | **pH** | **Oddy Test** | | | **pH** |
| | **Cu** | **Ag** | **Pb** | | **Cu** | **Ag** | **Pb** | |
| **Evacon-R** | ✓ | ✓ | × | 6.5 | ✓ | ✓ | (×) | 4.5 |
| **Animal Glue** | × | × | (×) | 5.5 | × | × | ✓ | 4 |

## Discussion

As a result of the review we have been able to create guidelines based on current expertise at the Library and further afield, helping to provide consistent decision-making in our use of adhesives. In addition it has enabled concerns associated with the use of specific adhesives to be addressed and appropriate alternatives recommended, such as using gelatine instead of unrefined animal glue, and identified areas of future research, such as the investigation of adhesives commonly used in textile conservation.

On a practical level the review team have recommended that all unlabelled or non-archival adhesives be disposed of and that the testing of existing and new adhesives is implemented on a three year rolling programme.

The research into adhesive tapes and their use is still on-going due to the complexities of their construction and the many types available. The British Library Conservation Science department will also continue to research and test Evacon-R, working closely with the supplier to either refine it or find ways to mitigate the effects of off-gassing.

The responses generated by the questionnaire showed that the use of adhesives is not necessarily consistent between individuals, even those working for the same institution. However, by asking questions, discussing issues and raising awareness in this way, we believe that the treatment review process can be a valuable tool to influence practice in a positive way; encouraging a consistent approach to treatments.

It is inevitable that reviews raise more questions than they answer, so there must be flexibility within the strategy for reviews to develop, to incorporate new leads and discoveries. We aim to revisit the subject of adhesives on a regular basis, directing workshops to answer specific questions and needs and to reissue the questionnaire next year to assess any change in working practice.

The next treatment review proposed will investigate conservation book structures as a means of reducing the use of adhesives in original bindings and to study alternative options.

## Conclusion

Treatment reviews such as this have the potential to influence many areas within the Conservation department: conservators have the chance to question, adapt and hone their treatments according to the latest research; the Conservation Science department are given a focus to test adhesives and materials used in conservation; and the Management Team have the information they need to identify areas for future research.

The treatment review process embeds a professional attitude to continuing professional development both as an institution and as individuals. Overall, this review has proved to be an invaluable exercise with direct and tangible benefits to conservation of the British Library collection.

## Acknowledgements

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Bodleian Library; the British Museum; the National Archives of Scotland; Northumbria University; the Oxford Consortium; The National Archives, Kew; the University of Maryland Libraries, USA; the University of Pittsburgh, USA; Artlab, Australia and the many private conservators who participated in the questionnaire and responded to a ConsDistList posting and direct emails.

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Oddy, A. “An Unsuspected Danger in Display.” *Museums Journal* 73, 1 (1973), pp. 27-28.

## Materials and Suppliers

Adhesive tapes (archival, various): Conservation Resources.
http://www.conservation-resources.co.uk

Archibond Tissue (heat-set Paraloid acrylic adhesive on manilla spider tissue): Conservation-by-Design. http://www.conservation-by-design.co.uk

Cellugel (hydroxypropyl cellulose in isopropanol, gel): Preservation Equipment Ltd. (PEL).
http://www.preservationequipment.com

Evacon-R (ethylene vinyl acetate with calcium carbonate, liquid): Conservation-by-Design.
http://www.conservation-by-design.co.uk

Furu-nori (aged wheat starch, paste): Hayashibara Biochemical Laboratories, Inc.
http://www.hayashibara.co.jp/index.php?lg=en

Gelatine (type B, cell culture tested, powder): Sigma-Aldrich.
http://www.sigmaaldrich.com

Isinglass (sturgeon air bladder, dried): Kremer Pigmente GmbH & Co.
http://kremer-pigmente.de/en

Lascaux JunFunori (red algae extract, dried): Lascaux.
http://lascaux.ch/en/produkte/restauro/index.php

Klucel G/E (hydroxypropyl cellulose, powder): Conservation Resources.
http://www.conservation-resources.co.uk

Methyl cellulose (Methocel A4C – medium viscosity, 400mPas, powder): BDH, a chemical brand distributed by VWR International, LLC.
http://www.vwrsp.com

Paraloid B72 (acrylic beads): Rohm & Haas.
http://www.rohmhaas.com.

Particle Technology Conservation Adhesive AD20 (acrylic resin in acetone, liquid): Conservation Resources.
http://www.conservation-resources.co.uk

Texicryl 13/002 (acrylic resin dispersion, liquid): Archival Aids.
http://www.archivalaids.com

Wheat Starch (powder): BDH, a chemical brand distributed by VWR International, LLC.
http://www.vwrsp.com

Zin Shofu wheat starch (powder): Conservation-by-Design.
http://www.conservation-by-design.co.uk

## Biographies

**Ruth Stevens** originally trained as an illustrator and worked in graphic design for 15 years. She completed an MA in Conservation Studies, specializing in book conservation, at West Dean College (Chichester, United Kingdom) in 2005. Following graduation, she worked for institutions such as the National Trust, and with Elizabeth Neville Conservation. She joined the British Library as a Book Conservator in 2007, and was part of the Pamphlet Treatment Review team in 2009. Ruth is an accredited member of the Institute of Conservation (Icon), United Kingdom. She now runs Sussex Conservation Consortium Ltd. with Ian Watson ACR in Sussex, United Kingdom.

**Paul Garside** studied chemistry at the University of Southampton (United Kingdom), and carried out research there for a PhD (awarded in 2002) investigating the properties of natural polymer fibres. He subsequently joined the Textile Conservation Centre as a Research Fellow in Conservation Science, with a particular interest in plant fibres and weighted silks; he also taught the Conservation Science component of the Centre's MA course in Textile Conservation. He joined the British Library as a Conservation Scientist (Conservation and Preservation Research Officer) in 2009.

**Eleanor Russell** studied at Camberwell College of Arts (London, United Kingdom), graduating in June 2004 with a BA Honours in Conservation, specializing in paper and organic conservation. While still a student, she started work as a Conservator at St. Paul's Architectural Archives (London). She began her first full-time post at The National Archives in 2005 and then took up a position in the Western Art on Paper conservation studio at the British Museum. She joined the British Library in 2006, specializing in the conservation of papyrus, illuminated manuscripts, and works of art on paper. Eleanor led the Adhesives Treatment Review team at the British Library, and is currently an independent conservator. Eleanor is an accredited member of the Institute of Conservation (Icon), United Kingdom.