Evaluation of Selected Adhesive Tapes and Heat-set Tissues – A Final Update

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Evaluation of Selected Adhesive Tapes and Heat-set Tissues – A Final Update

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This paper is the final report on the tested properties of selected adhesive tapes and heat-set tissues which should help conservators understand their stability and their impact on paper. The tested properties include: the pH after 4 years of dark aging; the change in colour of the carrier side of the products and of paper substrates to which they were attached after oven aging and after 4 years of dark aging; the photographic activity test (PAT); and the mechanical and solvent removability of the products from 1870s commercial printed paper and a 1970s resin-coated (RC) photographic paper after oven aging and after 4 years of dark aging. The majority of the products were neutral (and remained so on aging), but some were slightly alkaline or acidic. Only one product discoloured the paper substrate on the reverse significantly after oven aging, while no product did so after 4 years of dark aging. However, the carrier side of several products discoloured substantially on oven aging, although only two on dark aging. Since only 40% of the products passed the PAT test, the results will be of interest to those using these products in the proximity of photographs. Generally, products were easier to remove from the RC paper than from the 1870s commercial printed paper. Aging tended to decrease removability, although it did not change the removability much for several products. Conservators can use the removability data to determine how difficult a specific product might be to remove mechanically and what solvents may be effective in its removal. Also, the results should help conservators make informed decisions on heat-set tissue choice. A few products exhibited good results across all tests.

Le présent article constitue le rapport final traitant des propriétés de certains rubans adhésifs et papiers de soie fixés à chaud mis à l'essai. Les résultats présentés aideront les restaurateurs à comprendre la stabilité de ces produits et leurs effets sur le papier. Les propriétés étudiées comprennent le pH (mesuré après 4 ans de vieillissement dans le noir), l'altération de la couleur du côté support des produits et des substrats de papier auxquels ils sont fixés (mesurée après le vieillissement au four et après 4 ans de vieillissement dans le noir), l'activité photographique, et la facilité d'enlèvement mécanique et d'enlèvement au moyen d'un solvant des produits fixés sur du papier imprimé commercial datant des années 1870 et sur du papier photographique plastifié datant des années 1970 (mesurée après vieillissement au four et après 4 ans de vieillissement dans le noir). Le pH de la plupart des produits était neutre et le demeurait après leur vieillissement, mais certains d'entre eux étaient légèrement alcalins ou légèrement acides. Un seul produit a entraîné une importante altération de la couleur du verso du substrat de papier après le vieillissement au four, mais aucun des produits mis à l'essai n'a eu cet effet après 4 ans de vieillissement dans le noir. Toutefois, le côté support de plusieurs produits a subi une importante altération de la couleur après vieillissement au four, bien que celui de seulement deux produits ait subi la même dégradation après vieillissement dans le noir. Seulement 40 % des produits ont réussi l'essai d'activité photographique; ces données sont intéressantes pour ceux qui utilisent ces produits à proximité de photographies. De manière générale, il a été plus facile d'enlever les produits fixés au papier plastifié que ceux fixés au papier imprimé commercial datant des années 1870. Le vieillissement a eu tendance à réduire la facilité d'enlèvement des produits, bien que pour plusieurs d'entre eux, cet effet n'était pas important. Les restaurateurs peuvent utiliser les données concernant la facilité d'enlèvement pour déterminer la difficulté de retirer mécaniquement un produit particulier et quels sont les solvants les plus efficaces pour l'enlever. Les résultats de l'étude peuvent aussi aider les restaurateurs à prendre des décisions éclairées en matière de choix de papiers de soie fixés à chaud. Quelques-uns des produits donnent de bons résultats pour tous les essais effectués.

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Introduction

Commercial adhesive tapes are not normally recommended for archival applications, but the sheer volume in use by the general public means they will inevitably find their way into museum and archival collections and cause concern for conservators with their appearance, degradation and/or removal. Heat-set tissues, on the other hand, are occasionally used in conservation treatments, but not without questions about suitability and safety on objects. Thus, research into the properties of tapes and heat-set tissues is important.

In 2001, the Canadian Conservation Institute (CCI) began a project on tapes and heat-set tissues. The purpose of the project was to study their chemical, mechanical and removability properties in order to understand their impact on paper and develop a reliable system for comparative evaluation. A program of research was devised which involved a screening procedure to reduce the number of products that would be tested in a subsequent aging/testing program. The project was first outlined in a paper in 2006[1] and an update on the progress and results after oven aging and 1 year of dark aging was given in 2011.[2] This paper presents the final results after 4 years of dark aging and attempts to clarify their implications.

Screening Program

A screening program was used to select 42 tapes and heat-set tissues from a sample of 146 products.[1,2] The products were analysed using Fourier transform infrared (FTIR) spectroscopy to identify major components. The pH of water extracts was also measured.[3] Products were classified according to chemistry of the carrier and the adhesive and the method of application. Products were rejected for further testing if they contained poly(vinyl chloride) (PVC), rubber, rosin or styrene butadiene (SBR), if they had a pH of less than 6 or greater than 8, or if they were coloured. The final selection was made following consultation with conservators. Token products containing PVC, rubber, rosin, or SBR, and one black tape were included as possible worst case scenarios. The 42 products are listed in **Table I**.

Preparation of Samples

Most of the tapes and heat-set tissues tested were commercial products that were used as supplied and did not require any initial preparation other than cutting to size. Heat-set tissues were prepared using Lascaux 360 HV, Lascaux 498 HV (and a mixture with 360 HV) and Vinamul 3252, while remoistenable tissues were prepared using homemade wheat starch paste. For these, wet adhesive was spread to an even film with a glass microscope slide into wells made with tape on thick Mylar. Before the adhesive dried, the tape was removed and strips of Kurotani tissue were laid on top of the adhesive and left to dry. The Library of Congress (LoC) Heat-set Tissue was made according to the procedure by Hey and Waters.[4] This involved applying the adhesive with a wide Japanese brush onto Mylar and laying Kurotani tissue on top which was then left to dry.

To make the samples used for testing colour change, removability and photographic activity, the commercial products and homemade heat-set or remoistenable tissues were cut to the desired size and attached to a paper substrate. The water-activated tapes were moistened with distilled water using a sponge and then adhered to the substrates using two passes of a Roll Down machine (ChemInstruments Inc.) that applied consistent pressure to each sample. The pressure-sensitive tapes were applied to the substrates by lightly tacking them at both ends of the strip with finger pressure and then adhering them along the strip using the Roll Down machine. Heat-set tissues were attached by tacking lightly at either end with a heated spatula before being heat-set in a Dritac 3442 Electro Laminating Press for 3 minutes at temperatures indicated in **Table I**. Super 77 spray adhesive was applied directly using two passes at a slow steady speed about 20 cm above the substrate masked by a Mylar cut-out template. The template was removed leaving a strip of adhesive to which Kurotani tissue was placed on top and left to dry.

Aging and Testing Programs

The testing program included assessment of pH upon dark aging, colour change after dark aging and oven aging, damage to photographs using a photographic activity test (PAT), and removability of the tape or heat-set tissue from two types of papers after dark aging and oven aging. The dark aging was carried out in an environmentally controlled dark aging room (22 ± 2°C, 45% ± 5% RH), while the oven aging was performed in a temperature and humidity controlled oven (Despatch Model LEA1-69) at 80°C, 65% RH for 28 days.[5]

pH

A modified pH standard was used to measure the cold-water-extracted pH of composite samples before and after dark aging.[3,6] The composite sample consisted of the adhesive on the tape or heat-set tissue along with the carrier, if there was one. Because several heat-set and remoistenable tissues were prepared using Kurotani tissue, the pH of the dried adhesive alone and with tissue were measured.

Colour Change

Samples for colour change were prepared using "Windsor" paper manufactured by Domtar (henceforth called Domtar paper)[7] as the substrate. Two strips (2 x 25 cm) of each tape or heat-set tissue were laid onto the Domtar paper. If the product was a remoistenable tissue, double-sided product, spray, or handmade heat-set tissue, Kurotani tissue was applied on top and was considered as the carrier. Prior to aging, a control colour measurement was taken at various points on the tape carrier side (henceforth called "tape side") as well as in the same location on the reverse where the adhesive of the tape or heat-set tissue meets the Domtar paper (henceforth called the "paper side"). Half of the samples were oven aged and re-measured. The remaining samples were dark aged for 4 years and then re-measured. Lab ΔE^*_{ab} measurements (i.e., colour change, henceforth called ΔE) were taken using a Minolta CM-2600d spectrophotometer.[8]

Evaluation of the colour change results was complicated by the fact that the Domtar paper substrate also changed colour on aging. On the paper side, colour change above and beyond that of the Domtar paper was of interest; i.e., the colour change from the adhesive coming through the Domtar paper. On the tape side, any colour change of the Domtar paper would be seen through a carrier that was transparent or semi-transparent, but not through the solid or semi-solid carriers. Consequently, to estimate the colour change caused by the tape or heat-set tissue, the ΔE of the Domtar paper was subtracted from the measured values as follows:

- *paper side, oven aging*: the ΔE for the Domtar paper alone after oven aging, 6.57 – a substantial visible colour change – was subtracted from all paper side ΔE oven-aged values;
- *paper side, 4 years dark aging*: the ΔE for the Domtar paper after 4 years of dark aging, 0.65 – considerably less than after oven aging – was subtracted from all dark-aged paper side ΔE values;
- *tape side, oven aging, transparent and semi-transparent carriers*: the ΔE for the Domtar "tape side" after oven aging, 5.91, was subtracted from the tape side ΔE oven-aged values for transparent and semi-transparent samples;
- *tape side, 4 years dark aging, transparent and semi-transparent carriers*: the ΔE for the Domtar "tape side"

after 4 years of dark aging, 0.72, was subtracted from the tape side ΔE oven-aged values for transparent and semi-transparent samples;

- *tape side, oven aging and 4 years dark aging, solid and semi sold carriers*: no subtraction was performed.

Generally, it is agreed that if ΔE is 1 or 2, then the colour change is perceptible to the eye (depending on the colour of the object in question and illumination, etc.) and if ΔE is greater than 5, then this would represent a definite substantial colour change.[9,10,11] The colour change results were assessed against this criteria.

Removability

For the removability tests, only 31 of the 42 products were selected for testing. These were chosen by paper and photograph conservators as products more likely to be in direct contact with a paper object than others, although a few non-contact products (i.e. products that are used for housings, matting, etc. and that are not in direct contact with a paper object) were also included. The removability tests were carried out before aging (i.e. on controls), after 1, 3 and 4 years of dark aging, and after oven aging.

For these tests, strips of the tape or heat-set tissue were adhered to two types of paper. The first paper was from two volumes of *Punch* periodicals dating from 1863 to 1878 (henceforth called Punch paper). The tape or heat-set tissue was positioned over the text areas on the page. The second paper used was a resin-coated photographic (RC) paper produced by Kodak. The photographic images on this RC paper were developed (i.e. photographically processed) in the mid 1970s. The tape or heat-set tissue was applied to the verso of the photograph, which is polyethylene.

Mechanical removal

Five conservators assessed ease of mechanical removal on all selected tapes and heat-set tissues using spatulas, heated spatulas, erasers (crepe, vinyl, mechanical) and scalpels. Assigned values for ease of mechanical removal were: 100% for very easy, 75% for easy, 50% for difficult, 25% for very difficult and 0% for impossible.[2] Three points were subtracted from the mechanical score if staining of the substrate following removal was assessed as high, two points if medium, and one point if low. The five conservators' results were averaged.

Solvent removal

Solvent removal was assessed by immersion in seven solvents (i.e. ethanol, acetone, heptane, ethyl acetate, toluene, distilled water and distilled water brought to a pH of 8.5 with saturated calcium hydroxide solution) combined with gentle scraping. The tapes and heat-set tissues were not assessed for ease of removal, but whether the carrier and adhesive were completely or partially removed or not removed. Staining of the substrate was also noted.

One conservator assessed removability of the selected tape or heat-set tissue for each solvent and assigned scores as follows: 100% for totally removed, 50% for partially removed**,** 0% for not removed. Three points were subtracted from the solvent removal score if a dark stain remained, two points if slightly stained, and one point if very slightly stained. For example, if the score is 100 or 50 then there was no staining; if 99 or 49 then it had a very slight stain; if 98 or 48 then it had a slight stain; and if 97 or 47 then it had a definite dark stain.

Photographic Activity Test

The photographic activity test (PAT)[12] was used to detect possible chemical interactions between an adhesive or carrier in the tape or heat-set tissue and photographic material (e.g. silver-gelatin or colour prints). The PAT consists of incubating the tape or heat-set tissue at 70°C and 86% RH for 15 days in a sandwich against the surface of two sensitive detectors – one for staining and one for image interaction. All products were adhered to Whatman #1 filter paper prior to testing. Staining, fading and mottling of detectors that had been incubated with the products were compared to those incubated with controls. If the product failed one of the three tests (staining, fading or mottling), then it failed the PAT test.

Overall Performance

Overall performance was evaluated giving equal consideration (i.e. weighting) to the pH, colour change, PAT and removability results.

Results and Discussion

The final results for each of the tests and overall performance is summarized in **Table I** and a discussion of these results follows.

pH

The majority of the control samples (i.e. 0 hours, unaged samples) were neutral, with four products being slightly alkaline (i.e. pH > 8: Perforated White Linen Tape, Framer's Tape II #S2000, Frame Sealing Tape FST 1000, filmoplast R) and six products being slightly acidic (i.e. pH < 6: Double-coated Film Tape #415, filmomatt libre, filmolux 609, Scotch Magic Tape #810, LoC adhesive alone, Unsupported Archibond).

After 4 years of dark aging, the majority of products were still in the neutral range (but with generally lower pH), but more had fallen into the acidic range when compared to the control samples (i.e. pH < 6: Homemade Wheat Starch Paste, filmoplast SH, Double-coated Film Tape #415, filmomatt libre, filmolux 609, Scotch Magic Tape #810, 3M Adhesive Transfer Tape #924, PH-70 Conservation ATG Tape Permanent, Crompton Tissue, Seal Colormount Dry Mounting Tissue, LoC adhesive alone, Lascaux 360 HV, Seal Fusion 4000 Dry Mounting Tissue and Unsupported Archibond). Filmoplast R was the only product still in the alkaline range after 4 years of dark aging (i.e. pH 8.35) which is slightly above the acceptable range for use with objects.

Colour change

Products that exhibited a colour change greater than 5, based on the corrected values, are highlighted in pink in **Table I**.

Paper Side

Oven Aging: After subtraction of the colour change of the Domtar paper, only BEVA 371 came close to showing a colour change in the range of 5 and this was likely due to the temperature of the oven aging being above the adhesive's softening point (60-65°C) causing it to sink into the paper. Frame Sealing Tape FST 1000 and Self-adhesive Frame Sealing Tape showed a colour change of about 1 or 2 when the Domtar ΔE was subtracted. Thus, these could indicate a perceptible colour change. No other product caused a significant colour change through the paper on oven aging.

4 Years Dark Aging: When colour change for the Domtar paper was subtracted from all dark-aged paper side ΔE values, no product showed a substantial or perceptible colour change through the paper after 4 years of dark aging.

Tape Side

Oven Aging: The oven-aged results indicate that there are many more products that show a substantial colour change on the tape side compared to the paper side, indicating that the carriers and/or adhesives are discolouring. A number of the heat-set tissues made with Kurotani tissue and water-activated paper carriers showed lower colour change values after the above subtraction indicating less discolouration.

4 Years Dark Aging: The 4 year dark aging results indicate that there are only two products that show a substantial colour change on the tape side. These are Duck General Purpose Masking Tape and Self-Adhesive Linen Hinging Tape.

Removability

Removability results in **Table I** can assist a conservator to determine how difficult a specific product is to remove mechanically, what solvents to use to remove it, and if the product gets more difficult or easier to remove after aging.

There are some general trends that can be seen by averaging various removability results in **Table I**. These are:

- It is generally more difficult to remove the products from the Punch paper than from the RC paper.
- Aging tends to make the products more difficult to remove as evidenced by:
  - the Punch paper average removability scores (i.e. all mechanical and solvent scores averaged together) which dropped by 9, 20, 17 and 27 points compared to the controls after 1, 3 and 4 years of dark aging and oven aging respectively.
  - the RC paper average removability scores which were not different compared to controls after 1 year dark aging, but dropped by 5, 11 and 17 points after 3 and 4 years of dark aging and oven aging respectively.

Of particular interest is whether any of the products became more difficult to remove with time. An example of this behaviour can be seen in **Table I** with filmoplast P90 for Punch paper using acetone or heptane. The P90 samples were totally removed (100%) from the Punch paper before aging (i.e. control samples), while after 1 year of dark aging the P90 was only partially removed (50%). After 3 and 4 years of dark aging or after oven aging, the P90 samples could not be removed from the Punch paper at all. Another example of this behaviour can be seen for mechanical removal of the Self-Adhesive Linen Hinging Tape adhered to the Punch paper. The samples were fairly easy to remove before aging (85%) and after 1 and 3 years of dark aging (74% and 73% respectively), but with further aging became increasingly difficult to remove (i.e. 63% after 4 years dark aging and 43% after oven aging).

Many of the water-activated products are quite removable mechanically and with water, while not so much with the other solvents. On the other hand, the products containing acrylic adhesives tend to be less removable mechanically and require more toxic solvents to remove them. This appears to be true after aging as well.

Twenty of the 31 products selected to undergo removability testing were acrylic-type products and the results of these were examined as a group. After oven aging, 75-80% of the samples changed their removability behaviour, becoming more difficult to remove, compared to 50-65% of samples after 4 years of dark aging. Clearly oven aging had a more detrimental effect on removability of the acrylic products than 4 years of dark aging, although dark aging was increasing the difficulty of removal in a number of products.

Lascaux 360 HV was applied to the substrates in three different ways (i.e. heat-set, pressure-sensitive, solvent-reactivated with ethanol), but the weighted average of all the removability scores did not indicate a difference between the application method and the removability even after 4 years of dark aging.

The mechanical and solvent removal results for the Punch and RC paper were averaged together in a weighted average (i.e. the mechanical score was given a weighting of 6, the water and pH 8.5 water scores were given a weighting of 5, ethanol and acetone a weighting of 3, heptane and ethyl acetate a weighting of 2 and toluene a weighting of 1). When this was done, the tapes and heat-set tissues with the highest overall weighted removability scores (i.e. the easiest to remove, weighted average score ≥70%) were Repa Tex G5, Homemade Wheat Starch Paste Tissue, BEVA 371 Film, filmoplast R, LoC Heat-set Tissue, Document Repair Tape, Self-Adhesive Linen Hinging Tape, Unsupported Archibond, Photo & Document Mending Tape #001 and Gummed Japanese Hinging Paper Hayaku. The most difficult product to remove (i.e. lowest overall removability score) was Seal Colormount Dry Mounting Tissue.

Photographic activity test

The full methodology, results and assessment of the PATs were given in the previous paper[2] and have not changed. For easy access and completeness, the results of the PAT are listed in **Table I** and have been included in the Overall Score.

Overall Performance of the Tapes and Heat-set Tissues

When all results and all aging data were evaluated with each test – pH, colour change, PAT and the weighted removability scores – given equal importance, the following products gave the highest scores (Overall Score, **Table I**):

- Water-activated: Repa Tex G5, Homemade Wheat Starch Paste and Gummed Japanese Hinging Paper Hayaku.
- Pressure-sensitive: filmoplast P and P90, Document Repair Tape, gudy 871 and Duck Masking Tape. Scotch 893 and 3M Magic Removable Tape #811 also fared well, but removability was not done.
- Heat-set: BEVA 371 film, LoC Heat-set Tissue, Seal Fusion 4000 Film and filmoplast R.

This is essentially the same list as that reported in 2011,[2] with the exception of a few more heat-set tissues whose scores increased after the new aging data was considered. Also, when the new aging data was assessed, the results for the token worst case scenario products did not change from that reported in 2011.

In reality, however, comparing the products in terms of overall score (i.e. giving each test equal importance) may not be the most helpful because some properties might be of more interest than others depending on the particular context. For instance:

- If you are removing an aged known tape from paper, you could go directly to the removability results for the Punch paper and get a fair idea of its ease of removability and what technique or solvent worked best.
- If you want to use a heat-set tissue, the data given on the various products may help you to make a good choice.
- If you want to use a product in proximity to a photograph such as sealing case structures, then the PAT results would be of great interest.

Conclusions

This paper presents considerable data on the pH, colour change, PAT and removability of various tapes and heat-set tissues after a period of oven aging and after 4 years of dark aging. It must be remembered, however, that this study was not designed to identify tape products for direct use on heritage materials, and should not be seen as providing evidence to encourage the use of one product over another as part of a conservation treatment without a case-by-case evaluation. Nevertheless, it is hoped that the information presented will assist conservators in their continuing quest to understand the stability, suitability and removability of these products.

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Materials

Acid-free Double-Stick Adhesive Pen #007, Double-Coated Film Tape #415, Photo & Document Mending Tape #001, Scotch 893, Scotch Adhesive Transfer Tape #924, Scotch Magic Tape #810, Scotch Magic Removable Tape #811, Spray Adhesive Super 77: 3M, Building 17, 10746 Innovation Road, Cottage Grove, Minnesota 55016-4600 USA; Tel.: 651-458-2047; Website: <http://solutions.3m.com/wps/portal/3M/en_US/CottageGrove/Plant>

BEVA 371 Film 1.0 mil: Conservator's Products Company, P.O. Box 601, Flanders, New Jersey 17836 USA; Tel: 973-927-4855; Website: <http://www.conservators-products.com>

Crompton Tissue, Hinged Cambric Cloth Tape, Lascaux 360 HV and 498 HV, Plextol B500, Wheat Starch Aytex P: Talas, 330 Morgan Avenue, Brooklyn, New York 11211 USA; Tel.: 212-219-0770; Website: <www.talasonline.com>

Document Repair Tape, Seal Fusion 4000 Dry Mounting Adhesive Film: Carr McLean, 461 Horner Avenue, Toronto, Ontario M8W 4X2 Canada; Tel.: 1-800-268-2123; Website: <www.carrmclean.ca>

Duck General Purpose Masking Tape: Canadian Tire, 2010 Ogilvie Road, Ottawa, Ontario K1J 8X3 Canada: Tel.: 613-748-0637; Website: <www.canadiantire.ca>

filmolux 609, filmomatt libre, filmoplast P, P90, R, SH and T, gudy 831 and 871: Neschen AG, Hans-Neschen-Str.1, 31675 Bückeburg, Germany; Tel.: +49 (0) 5722-20 70; Website: <www.neschen.com>

Frame Sealing Tape FST 1000: Gaylord, P.O. Box 4901, Syracuse, New York 13221-4901 USA; Tel.: 1-800-448-6160 or 315-634-8221; Website: <www.gaylord.com>

Framer's Tape II #S2000: Dick Blick Art Materials, P.O. Box 1267, Galesburg, Illinois 61402-1267 USA: Tel.: 1-800-828-4548; Website: <www.dickblick.com>

Gummed Japanese Hinging Paper Hayaku, Gummed Linen Hinging Tape, Gummed Paper Hinging Tape, Self-Adhesive Linen Hinging Tape, Perforated White Linen Tape, White Foil Back Frame Sealing Tape: Lineco (University Products), 517 Main Street, Holyoke, Massachusetts 01040 USA; Tel.: 1-800-322-7775; Website: <http://www.lineco.com>

Gummed Linen Tape, PH7-70 Conservation ATG Tape Permanent: UK Industrial Tapes, Brumwell House, Westway Industrial Estate, Throckley Newcastle Upon Tyne, NE15 9HW, UK; Tel.: 0191 269 7810; Website: <www.ukindustrialtapes.co.uk>

Kurotani #16 Small Tissue: The Japanese Paper Place, 77 Brock Avenue, Toronto, Ontario M6K 2L3 Canada; Tel.: 416-538-9669; Fax: 416-538-0563; Website: <http://www.japanesepaperplace.com>

Repatex G5: Gabi Kleindorfer, Aster Strasse 9, D-84186, Vilsheim, Germany; Tel.: 49 8706 1094; Website: <http://www.gmw-shop.de/shop/japanpapier---repatex/repatex/repatex-g5.php>

Rhoplex AC-73: Museum Services Corporation, South Saint Paul, Minnesota 55075 USA. Tel.: 651-450-8954; Website: <http://www.museumservicescorporation.com>

Seal Colormount Dry Mounting Tissue (SEC111425): B&H Photovideo Pro Audio, 420 9th Ave, New York, New York 10001 USA; Tel**.:** 1-800-606-6969 or 212-444-6615; Website: <http://www.bhphotovideo.com>

Unsupported Archibond: Conservation Resources International, Unit 2, Ashville Way, Off Watlington Road, Cowley, Oxford, OX4 5TU, England; Tel.: +44 (0) 1865 747755; Website: <http://www.conservationresources.com>

Vinamul 3252: Celanese Emulsions GmbH, Industriepark Hochst, Building E-416, 65926 Frankfurt, Germany; Tel.: 069 305 17701; Website: <http://www.celanese.com/htm>

Whatman filter paper: Fisher Scientific, 112 Colonnade Road, Ottawa, Ontario K2E 7L6 Canada; Tel.: 1-800-234-7437; Fax: 1-800-463-2996; Website: <https://www.fishersci.ca>

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J.CAC, vol. 38, 2013, pp. 14-25

Table I. Results of the Chemical Analysis, pH, Colour Change, PAT and Removability Tests.

Tape or Heat-set Tissue (THST)	Chemical Analysis	pH (pH 6-8; <6 or >8; (pH Kurotani Tissue alone = 7.18±.02)) 0 hours: THST Alone	pH 0 hours: THST with Tissue	pH Dark Aged 4 yrs: THST Alone	pH Dark Aged 4 yrs: THST with Tissue	Colour Change (No substantial colour change; Substantial colour change) Transparency	Colour Change Dark Aged 4 yrs: ΔE Tape Side	Colour Change Dark Aged 4 yrs: ΔE Paper Side	Colour Change Oven Aged: ΔE Tape Side	Colour Change Oven Aged: ΔE Paper Side	PAT (Pass; Fail): Adhesive Side	PAT: Carrier Side	PAT: Overall PAT	Removability (For Mechanical >70 is easier to remove; 40-69 more difficult; <39 very difficult. For Solvent 97-100 is removable; 47-50 is partially removable; 0 is not removable.) Punch Paper: Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	RC Paper: Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	Overall Score (all tests equal)
WATER-ACTIVATED – Paper Carriers																																
Gummed Paper Hinging Tape	Protein	7.24 ±.03		7.13 ±.03		ST-S	1.39 ±.60 (0.67)	0.99 ±.10 (0.34)	3.79 ±.22 (-2.12)	5.63 ±.20 (-0.94)	F	F	F	C	75	100	100	0	0	0	0	0	C	80	100	100	0	0	0	0	0	63
														1	75	100	100	49	0	0	0	0	1	74L	100	100	0	0	0	0	0	
														3	74L	100	100	0	0	0	50	0	3	74L	100	98	0	0	0	0	0	
														4	74L	100	100	0	0	0	0	0	4	80	100	100	0	0	0	0	0	
														O	43M	47	47	0	0	0	0	0	O	70	100	100	0	0	0	0	0	
Repa Tex G5	Protein + methyl cellulose	7.71 ±.20		7.02 ±.02		ST	1.14 ±.17 (0.42)	0.87 ±.07 (0.22)	8.85 ±.50 (2.94)	6.89 ±.29 (0.32)	P	P	P	C	95	100	100	50	100	100	100	0	C	100	100	100	100	100	100	100	0	97
														1	85	100	100	49	100	100	0	0	1	85	100	100	100	100	100	0	47	
														3	95	100	100	50	48	50	0	0	3	100	100	100	100	0	0	0	0	
														4	100	100	100	100	100	100	100	100	4	100	100	100	100	100	100	100	100	
														O	100	100	100	50	50	100	0	0	O	100	100	100	100	100	0	100	0	
Gummed Japanese Hinging Paper Hayaku	PVOH / PVAC	6.98 ±.04		6.50 ±.03		ST	0.73 ±.26 (0.01)	0.71 ±.07 (0.06)	6.60 ±.29 (0.69)	6.21 ±.06 (-0.36)	P	P	P	C	50	100	100	100	100	0	100	100	C	90	100	100	50	100	0	100	100	93
														1	35	100	100	100	100	50	100	100	1	85	100	100	50	100	50	100	100	
														3	55	0	0	50	100	0	100	100	3	85	100	100	50	100	0	100	100	
														4	75	50	98	100	100	0	100	100	4	85	100	100	50	100	0	100	100	
														O	20	0	0	0	100	0	98	100	O	40	50	50	50	100	0	100	100	
Homemade Wheat Starch Paste **with Kurotani Tissue**	Starch	6.04 ±.04	7.01 ±.05	5.97 ±.08	7.08 ±.03	ST	0.80 ±.10 (0.08)	0.79 ±.09 (0.14)	6.15 ±.46 (0.24)	6.05 ±.29 (-0.52)	P		P	C	100	100	100	100	100	100	100	100	C	100	100	100	0	50	50	0	0	89
														1	95	100	100	99	97	100	100	100	1	75	100	100	50	50	100	50	0	
														3	90	100	100	50	100	0	100	100	3	80	100	100	50	0	0	100	0	
														4	95	100	100	100	100	100	100	100	4	95	100	100	0	0	0	0	0	
														O	90	100	100	100	100	100	100	99	O	100	100	100	0	50	50	50	0	
WATER-ACTIVATED – Cloth Carriers																																
Hinged Cambric Cloth Tape	Protein + Starch >8:1	6.78 ±.02		6.49 ±.01		SS	2.21 ±.20	0.69 ±.06 (0.04)	7.71 ±.25	5.98 ±.51 (-0.59)	F	F	F	removability not done																			58
Gummed Linen Hinging Tape	Protein + Starch >8:1 (carrier slightly different)	7.57 ±.10		7.84 ±.02		SS	0.92 ±.39	0.82 ±.09 (0.17)	3.89 ±.16	5.98 ±.17 (-0.59)	F	F	F	C	90	100	100	100	50	100	100	100	C	90	100	100	0	0	0	99	0	66
														1	50	100	100	100	0	0	0	50	1	80	100	100	100	50	0	0	50	
														3	45	100	98	50	50	100	100	50	3	59L	100	100	48	0	0	0	0	
														4	55	100	100	0	0	0	0	0	4	75	100	100	0	0	0	0	0	
														O	80	100	100	0	50	50	100	100	O	75	100	100	0	0	0	0	0	
Perforated White Linen Tape	Protein + Starch >8:1	8.12 ±.01		7.79 ±.03		SS	1.37 ±.23	0.62 ±.09 (-0.03)	5.49 ±.25	5.82 ±.17 (-0.75)	F	F	F	C	85	100	100	0	0	0	0	50	C	90	100	100	0	0	0	0	0	46
														1	70	100	100	100	100	100	100	50	1	90	100	100	48	100	100	100	100	
														3	60	100	100	50	0	0	0	0	3	65	100	100	50	0	0	0	0	
														4	70	100	100	0	0	0	0	0	4	85	100	100	0	0	0	0	0	
														O	65	0	0	0	0	0	0	48	O	75	100	100	0	100	0	50	0	
Gummed Linen Tape	Modified Starch (carrier different)	6.43 ±.04		6.46 ±.01		SS	0.38 ±.05	0.82 ±.06 (0.17)	2.98 ±.16	5.93 ±.15 (-0.64)	F	P	F	removability not done																			67

Table I. Results of the Chemical Analysis, pH, Colour Change, PAT and Removability Tests (con't).

Tape or Heat-set Tissue (THST)	Chemical Analysis	pH (pH 6-8; <6 or >8; pH Kurotani Tissue alone = 7.18±.02)				Colour Change (No substantial colour change; Substantial colour change)				PAT (Pass; Fail)			Removability (For Mechanical >70 is easier to remove; 40-69 more difficult; <39 very difficult. For Solvent 97-100 is removable; 47-50 is partially removable; 0 is not removable.)																Overall Score (all tests equal)
		0 hours		Dark Aged 4 yrs			Dark Aged 4 yrs		Oven Aged																				
		THST Alone	THST with Tissue	THST Alone	THST with Tissue	Transparency	ΔE Tape Side	ΔE Paper Side	ΔE Tape Side	ΔE Paper Side	Adhesive Side	Carrier Side	Overall PAT	Punch Paper								RC Paper								
														Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	
PRESSURE-SENSITIVE – Paper Carriers																														
filmoplast P	PnBA + $CaCO_3$ + UN	7.06 ±.11		7.19 ±.10		ST	1.82 ±.14 (1.10)	0.78 ±.07 (0.13)	11.14 ±.25 (5.23)	6.67 ±.23 (0.10)	P	P	P	C	45	50	50	100	99	99	100	100	C	75	100	50	0	0	100	100	100	82
														1	49L	100	100	48	100	50	100	100	1	70	100	100	0	0	50	50	0	
														3	29L	0	0	100	98	50	100	98	3	60	0	100	50	50	0	48	100	
														4	38M	50	50	47	48	0	100	100	4	55	100	100	0	0	0	50	50	
														O	25	0	0	0	0	50	99	99	O	65	50	50	0	0	50	100	100	
filmoplast P90	PEHA + $CaCO_3$	6.93 ±.07		7.07 ±.01		ST	0.76 ±.18 (0.04)	0.77 ±.10 (0.12)	7.94 ±.15 (2.03)	5.99 ±.18 (-0.58)	P	P	P	C	55	0	0	0	100	100	100	100	C	75	100	100	100	100	100	100	100	88
														1	50	0	0	98	50	50	100	100	1	60	100	100	100	50	50	100	100	
														3	55	0	0	48	0	0	100	50	3	55	50	50	100	48	0	100	100	
														4	54L	50	0	0	0	0	100	50	4	65	100	100	0	50	0	100	100	
														O	25	0	0	0	0	0	50	100	O	50	0	48	50	49	100	100	100	
gudy 831 **with Kurotani Tissue**	PEHA + PVAC + soap	7.16 ±.13		7.80 ±.02		ST	1.57 ±.17 (0.85)	0.71 ±.07 (0.06)	10.66 ±.44 (4.75)	6.65 ±.20 (0.08)	F		F	C	60	0	50	0	100	100	100	100	C	85	100	100	50	100	100	100	100	59
														1	48M	0	0	98	50	99	100	50	1	60	100	100	50	100	100	100	100	
														3	48M	0	0	48	98	100	100	98	3	75	100	100	48	98	100	100	100	
														4	48M	50	50	0	0	100	100	48	4	70	100	100	0	50	100	100	100	
														O	28M	0	0	0	99	50	48	99	O	75	0	0	50	99	100	100	100	
Document Repair Tape	PVAC -vinyl maleate	7.35 ±.08		6.98 ±.01		ST	2.34 ±.25 (1.62)	1.24 ±.06 (0.59)	11.74 ±.47 (5.83)	6.50 ±.09 (-0.07)	P	P	P	C	90	0	0	100	100	100	100	100	C	90	100	100	100	100	100	100	100	88
														1	74L	0	0	98	100	100	100	100	1	85	100	100	100	100	100	100	100	
														3	70	0	0	100	100	100	100	100	3	100	100	100	100	100	100	100	100	
														4	65	50	0	100	100	100	98	100	4	80	100	100	100	50	100	100	100	
														O	53M	0	0	98	99	50	98	100	O	69L	100	100	100	100	100	100	100	
Duck General Purpose Masking Tape	Rubber + Tackifier (carrier with acrylic coating)	6.64 ±.03		6.79 ±.06		ST	6.64 ±1.34 (5.92)	0.91 ±.07 (0.26)	16.90 ±.25 (10.99)	6.97 ±.53 (0.40)	P	P	P	C	75	0	0	0	100	100	100	100	C	85	100	100	100	50	100	100	100	77
														1	70	0	0	100	50	100	100	100	1	85	100	100	100	100	100	100	100	
														3	74L	0	0	50	0	100	97	98	3	95	0	0	50	0	100	100	100	
														4	70	50	0	0	48	98	50	97	4	95	100	100	50	50	100	50	100	
														O	47H	0	0	47	97	50	97	97	O	70	0	0	50	0	50	100	100	
PRESSURE-SENSITIVE – Cloth Carriers																														
filmoplast SH	PEHA + PVAC	6.12 ±.03		5.80 ±.04		SS	0.55 ±.09	1.00 ±.09 (0.35)	6.99 ±.13	6.75 ±.10 (0.18)	F	F	F	C	70	50	50	100	100	100	100	100	C	75	100	100	100	100	100	100	100	47
														1	64L	0	0	98	50	100	100	100	1	75	0	100	50	50	100	100	100	
														3	59L	0	0	50	98	100	98	100	3	70	50	50	50	100	100	97	100	
														4	48M	50	0	47	47	100	100	98	4	75	100	50	50	100	100	100	100	
														O	25	0	0	47	98	99	100	100	O	65	0	0	100	100	100	100	100	
filmoplast T Tape (Black)	PEHA + PVAC + talc / mica	6.85 ±.04		6.46 ±.01		S	0.48 ±.59	0.54 ±.08 (-0.11)	1.15 ±.09	6.12 ±.18 (-0.45)	F	P	F	removability not done																	67
Self-Adhesive Linen Hinging Tape	PnBA	6.54 ±.04		6.26 ±.06		SS	4.45 ±.21	0.79 ±.04 (0.14)	9.21 ±.24	6.12 ±.10 (-0.45)	F	P	F	C	85	50	50	100	50	50	99	100	C	95	100	100	100	100	100	100	100	56
														1	74L	50	50	98	0	59	100	100	1	75	100	100	100	100	50	100	100	
														3	73M	0	0	100	98	50	100	100	3	75	50	100	100	100	100	100	100	
														4	63M	50	50	47	98	0	100	100	4	75	100	100	50	100	0	100	100	
														O	43M	0	0	47	98	47	98	98	O	80	100	100	100	100	100	100	100	

Table I. Results of the Chemical Analysis, pH, Colour Change, PAT and Removability Tests (con't).

Tape or Heat-set Tissue (THST)	Chemical Analysis	pH (pH 6-8; <6 or >8; (pH Kurotani Tissue alone = 7.18±.02))				Colour Change (No substantial colour change; Substantial colour change)				PAT (Pass; Fail)			Removability (For Mechanical >70 is easier to remove; 40-69 more difficult; <39 very difficult. For Solvent 97-100 is removable; 47-50 is partially removable; 0 is not removable.)																	Overall Score (all tests equal)
		0 hours		Dark Aged 4 yrs			Dark Aged 4 yrs		Oven Aged																					
													Punch Paper									RC Paper								
		THST Alone	THST with Tissue	THST Alone	THST with Tissue	Transparency	ΔE Tape Side	ΔE Paper Side	ΔE Tape Side	ΔE Paper Side	Adhesive Side	Carrier Side	Overall PAT	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	
PRESSURE-SENSITIVE – Polyester Carrier																															
Double-coated Film Tape #415 **with Kurotani Tissue**	PnDA (+PAA)	5.93 ±.16		5.54 ±.04		ST	0.70 ±.14 (-0.02)	0.46 ±.13 (-0.19)	11.00 ±.47 (5.09)	6.58 ±.18 (0.01)	F		F	removability not done																	25
Photo & Document Mending Tape #001	PnDA + PIB ++	7.49 ±.47		6.50 ±.20		T	1.06 ±.05 (0.34)	0.76 ±.04 (0.11)	8.26 ±.29 (2.35)	6.60 ±.28 (0.03)	F	P	F	C	85	50	50	100	100	100	100	100	C	100	100	100	100	100	100	100	100	68
														1	65	0	0	100	100	100	100	100	1	95	50	100	100	100	100	100	100	
														3	50	0	0	50	97	100	98	98	3	80	50	50	50	100	100	97	100	
														4	60	50	50	48	97	100	100	100	4	90	100	50	50	100	100	100	100	
														O	54L	0	0	98	48	99	98	98	O	85	50	100	100	100	100	100	100	
Scotch 893	Rubber + PP	7.49 ±.07		6.68 ±.06		ST	3.20 ±.75 (2.48)	0.80 ±.32 (0.15)	10.62 ±.22 (4.71)	6.18 ±.10 (-0.39)	P	P	P	removability not done																	92
PRESSURE-SENSITIVE – Polypropylene Carriers																															
Framer's Tape II #S2000	PnBA	8.07 ±.02		6.99 ±.12		T	1.96 ±.07 (1.24)	0.63 ±.10 (-0.02)	10.51 ±.24 (4.60)	6.85 ±.13 (0.28)	F	P	F	C	49L	0	0	100	100	99	100	100	C	90	100	100	100	100	100	100	100	47
														1	58M	0	0	98	100	50	100	100	1	75	100	100	50	100	50	100	100	
														3	52H	0	0	98	100	100	98	98	3	79L	0	0	100	100	100	100	100	
														4	53M	0	0	47	100	100	100	100	4	70	100	50	50	0	100	100	100	
														O	23M	0	0	47	98	0	47	97	O	85	100	100	100	50	100	100	100	
filmomatt libre	PEHA + PVAC	5.48 ±.06		4.73 ±.03		T	3.28 ±.04 (2.56)	0.65 ±.05 (0)	9.90 ±.28 (3.99)	6.40 ±.25 (-0.17)	F	P	F	C	60	0	0	100	100	100	100	100	C	90	100	100	100	100	100	100	100	42
														1	58M	0	0	98	100	50	100	100	1	90	100	100	100	100	50	50	50	
														3	38M	0	0	48	98	100	100	98	3	85	100	100	50	100	100	98	100	
														4	43M	0	0	98	98	50	100	100	4	85	100	100	100	100	100	100	100	
														O	23M	0	0	0	47	0	48	100	O	75	100	100	100	50	100	100	100	
PRESSURE-SENSITIVE – Poly(vinyl chloride) (PVC) Carriers																															
filmolux 609	PEHA + PVAC + phthalate PVC Carrier	5.61 ±.05		4.79 ±.17		T	2.21 ±.11 (1.49)	0.86 ±.05 (0.21)	16.93 ±.29 (11.02)	6.97 ±.16 (0.40)	F	P	F	removability not done																	25
PRESSURE-SENSITIVE – Cellulose Acetate Carrier																															
3M Magic Tape #810	PnDA	5.45 ±.26		5.04 ±.32		T	1.89 ±.06 (1.17)	0.75 ±.11 (0.10)	11.44 ±.17 (5.53)	6.60 ±.19 (0.03)	P	P	P	C	100	0	0	100	100	100	100	100	C	100	100	100	100	100	50	50	100	59
														1	60	0	0	98	100	100	50	100	1	55	100	100	50	100	100	50	100	
														3	53M	0	0	50	98	100	100	98	3	75	50	50	50	100	50	100	100	
														4	59L	0	0	48	98	100	100	100	4	60	100	100	50	100	100	100	100	
														O	38M	0	0	48	47	98	98	98	O	89L	0	0	50	100	50	50	97	
3M Magic Removable Tape #811	PnDA	6.93 ±.06		7.42 ±.03		T	1.44 ±.16 (0.72)	0.67 ±.11 (0.02)	11.68 ±.31 (5.77)	6.36 ±.18 (-0.21)	P	P	P	removability not done																	92

Table I. Results of the Chemical Analysis, pH, Colour Change, PAT and Removability Tests (con't).

Tape or Heat-set Tissue (THST)	Chemical Analysis	pH (pH 6-8; <6 or >8; pH Kurotani Tissue alone = 7.18±.02)				Colour Change (No substantial colour change; Substantial colour change)				PAT (Pass; Fail)			Removability (For Mechanical >70 is easier to remove; 40-69 more difficult; <39 very difficult. For Solvent 97-100 is removable; 47-50 is partially removable; 0 is not removable.)																	Overall Score (all tests equal)
		0 hours		Dark Aged 4 yrs			Dark Aged 4 yrs		Oven Aged					Punch Paper								RC Paper								
		THST Alone	THST with Tissue	THST Alone	THST with Tissue	Transparency	ΔE Tape Side	ΔE Paper Side	ΔE Tape Side	ΔE Paper Side	Adhesive Side	Carrier Side	Overall PAT	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	
PRESSURE-SENSITIVE – Foil Carriers																															
Frame Sealing Tape FST 1000	PnBA	8.23 ±.08		7.72 ±.06		S	2.17 ±.14	0.45 ±.07 (-0.20)	4.13 ±.19	7.96 ±.21 (1.39)	P	F	F	removability not done																	50
Self-Adhesive Frame Sealing Tape (White)	PEHA	7.94 ±.06		7.68 ±.01		S	0.49 ±.04	0.63 ±.06 (-0.02)	4.74 ±.20	8.69 ±.37 (2.12)	F	P	F	removability not done																	58
PRESSURE-SENSITIVE – No Carrier																															
3M Adhesive Transfer Tape #924 **with Kurotani Tissue**	PnDA + sm PAA	6.29 ±.08		5.54 ±.61		ST	1.16 ±.10 (0.44)	0.65 ±.08 (0)	10.51 ±.39 (4.60)	7.23 ±.15 (0.66)	F		F	removability not done																	42
Acid-Free Db-Stick Adhesive Pen #007 **with Kurotani Tissue**	PnDA + PIB ++	7.95 ±.19		6.32 ±.26		ST	0.68 ±.25 (-0.04)	0.74 ±.04 (0.09)	6.10 ±.34 (0.19)	6.78 ±.27 (0.21)	F		F	removability not done																	67
PH7-70 Conservation ATG Tape Permanent **with Kurotani Tissue**	PEHA + UN	6.52 ±.13		5.61 ±.19		ST	2.68 ±.29 (1.96)	1.12 ±.09 (0.47)	19.17 ±1.80 (13.26)	7.19 ±.19 (0.62)	F		F	C	75	50	50	0	100	100	98	99	C	95	100	100	50	100	100	100	100	48
														1	63M	0	0	50	100	99	100	100	1	75	100	100	48	100	100	100	100	
														3	48M	0	0	48	100	100	50	100	3	75	100	100	50	100	100	100	100	
														4	58M	0	0	0	98	100	100	97	4	70	100	50	0	100	100	100	100	
														O	43M	47	47	0	47	97	97	97	O	74L	48	50	47	97	97	98	98	
gudy 871 **with Kurotani Tissue**	PEHA + PVAC + soap	7.29 ±.12		7.11 ±.12		ST	0.76 ±.23 (0.04)	0.67 ±.06 (0.02)	7.72 ±.23 (1.81)	5.63 ±.12 (-0.94)	P		P	C	44L	50	50	100	100	100	100	100	C	80	100	100	50	100	100	100	100	91
														1	49L	0	0	48	100	100	50	100	1	70	100	100	100	100	100	50	100	
														3	48M	0	0	50	98	100	100	100	3	75	100	100	50	98	100	100	100	
														4	53M	0	0	0	47	100	100	100	4	75	100	50	50	100	100	100	100	
														O	43M	0	48	0	47	99	49	99	O	75	50	50	50	100	100	100	100	
PRESSURE-SENSITIVE – Spray																															
Spray Adhesive Super 77 **with Kurotani Tissue**	SBR + Rosin	6.80 ±.08		6.35 ±.05		ST	1.01 ±.22 (0.29)	0.76 ±.07 (0.11)	9.32 ±.73 (3.41)	6.94 ±.21 (0.37)	F		F	C	38M	50	50	50	99	100	100	99	C	85	0	0	50	100	100	100	100	63
														1	58M	0	0	0	0	100	48	100	1	55	100	100	0	50	100	100	100	
														3	57H	0	0	48	47	100	100	98	3	58M	100	100	48	100	100	100	100	
														4	57H	0	0	47	47	100	100	97	4	53M	0	50	0	100	100	100	100	
														O	27H	47	47	0	47	47	97	47	O	74L	0	0	47	99	98	99	97	

Chemical Analysis: $CaCO_3$ = calcium carbonate; EVA = ethylene vinyl acetate; NaCMC = sodium carboxymethyl cellulose; PAA = poly(acrylic acid); PEA = poly(ethyl acrylate); PEHA = poly(ethylhexyl acrylate); PEMA = poly(ethyl methacrylate); PIB = polyisobutylene; PMA = poly(methyl acrylate); PMMA = poly(methyl methacrylate); PBA, PnBA = poly(butyl acrylate); PnDA = poly(decyl acrylate); PODA = poly(octadecyl acrylate); PVAC = poly(vinyl acetate); PVOH = poly(vinyl alcohol); SBR = styrene butadiene; sm = small amount; UN = unidentified; VAC = vinyl acetate; VAE = vinyl acetate ethylene; VAL = vinyl alcohol; ++ = other components or additives present

Abbreviations for Transparency: T = transparent; ST = semi-transparent; S = solid; SS = semi-solid.

Colour Change: Domtar Paper alone: Tape Side – ΔE = 0.72 ±.07 (Dark Aged 4 yrs), ΔE = 5.91 ±.11 (Oven Aged); Paper Side – ΔE = 0.65 ±.05 (Dark Aged 4 yrs), ΔE = 6.57 ±.07 (Oven Aged).

These colour values for the Domtar paper were subtracted from results except for tape side of products that were semi-solid or solid (difference in brackets).

Removability: Age: C = Controls; 1, 3, 4 = 1, 3, 4 years dark aging; O = Oven Aging. Staining: L = low; M = medium; H = high.

The point score for Removability in the Overall Score was determined by weighting the mechanical and solvent scores in the following manner: mechanical was given a weighting of 6; water and pH 8.5 water were given a weighting of 5; ethanol & acetone a weighting of 3; heptane & ethyl acetate a weighting of 2; and toluene a weighting of 1, only if the score was >70. This was done to give more emphasis to the mechanical and water removal scores and less emphasis to the more toxic solvents.

Table I. Results of the Chemical Analysis, pH, Colour Change, PAT and Removability Tests (con't).

Tape or Heat-set Tissue (THST) (heat-set temperature)	Chemical Analysis	pH (pH 6-8; <6 or >8; (pH Kurotani Tissue alone = 7.18±.02))				Transparency	Colour Change (No substantial colour change; Substantial colour change)				PAT (Pass; Fail)			Removability (For Mechanical >70 is easier to remove; 40-69 more difficult; <39 very difficult. For Solvent 97-100 is removable; 47-50 is partially removable; 0 is not removable.)																		Overall Score (all tests equal)
		0 hours		Dark Aged 4 yrs			Dark Aged 4 yrs		Oven Aged					Punch Paper								RC Paper										
		THST Alone	THST with Tissue	THST Alone	THST with Tissue		ΔE Tape Side	ΔE Paper Side	ΔE Tape Side	ΔE Paper Side	Adhesive Side	Carrier Side	Overall PAT	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	
HEAT-SET – Paper Carriers																															
Crompton Tissue (84-87°C)	PMA / PEMA	6.10 ±.04		5.55 ±.07		ST	1.01 ±.04 (0.29)	0.73 ±.10 (0.08)	10.28 ±.18 (4.37)	6.19 ±.21 (-0.38)	F	P	F	C	45	0	0	100	100	0	98	99	C	60	100	0	100	100	0	100	100	46
														1	25	0	0	98	100	50	100	100	1	80	100	100	100	100	50	100	100	
														3	25	0	0	100	100	0	100	100	3	50	100	100	100	100	0	100	100	
														4	24L	50	0	48	100	0	100	100	4	90	100	0	100	100	0	100	100	
														O	43M	0	0	98	100	0	98	99	O	34L	50	0	100	100	0	100	100	
filmoplast R (88-94°C)	PODA + UN	8.97 ±.03		8.35 ±.03		ST	0.99 ±.07 (0.27)	1.00 ±.09 (0.35)	8.27 ±.39 (2.36)	6.10 ±.91 (-0.47)	P	P	P	C	75	0	0	100	100	100	100	100	C	90	100	0	100	100	100	100	100	70
														1	50	100	100	98	0	100	100	100	1	90	100	100	100	100	100	100	100	
														3	65	0	0	50	100	100	100	100	3	75	100	100	100	100	100	100	100	
														4	74L	97	100	98	97	100	100	100	4	80	100	100	100	100	100	100	100	
														O	60	0	0	100	100	100	100	100	O	80	100	0	98	100	100	100	100	
Seal Colormount Dry Mounting Tissue **with Kurotani Tissue** (84-87°C)	EVA + UN	6.11 ±.04		5.88 ±.15		ST	1.60 ±.10 (0.88)	0.81 ±.02 (0.16)	10.65 ±.51 (4.74)	6.44 ±.29 (-0.13)	P		P	C	39L	0	50	0	100	98	100	98	C	25	0	0	0	0	100	50	0	63
														1	30L	0	0	100	0	100	100	100	1	24L	0	0	0	0	50	0	0	
														3	34L	0	0	0	50	100	100	100	3	33M	0	0	50	48	100	98	50	
														4	24L	0	0	0	0	0	100	98	4	25	50	0	0	0	0	100	0	
														O	37H	0	0	0	0	97	97	97	O	25	0	0	0	0	100	0	0	
Vinamul 3252 **with Kurotani Tissue** (78-81°C)	VAE +VAL/VAC + NaCMC	6.71 ±.19	7.70 ±.11	6.98 ±.02	7.30 ±.04	ST	1.18 ±.32 (0.46)	0.81 ±.04 (0.16)	6.44 ±.29 (0.53)	5.80 ±.19 (-0.77)	F		F	C	45	50	50	0	100	0	100	99	C	70	100	100	50	100	100	100	100	64
														1	30	0	0	100	100	0	50	50	1	95	100	100	50	100	0	100	50	
														3	30	0	0	50	50	0	100	100	3	50	100	100	50	100	100	100	100	
														4	30	0	0	98	98	0	100	100	4	80	100	100	0	100	0	100	100	
														O	32H	0	0	0	0	0	98	99	O	35	100	100	0	100	0	100	100	
LoC Heat-set Tissue (Plextol B500, Rhoplex AC-73, water) **with Kurotani Tissue** (86-91°C)	PEA / PMMA	4.90 ±.11	7.01 ±.01	3.74 ±.09	7.09 ±.03	ST	0.98 ±.17 (0.26)	0.87 ±.07 (0.22)	8.09 ±.33 (2.18)	6.12 ±.36 (-0.45)	P		P	C	70	100	100	100	100	100	100	100	C	90	100	100	100	100	100	100	100	82
														1	55	50	50	100	100	0	100	100	1	95	100	100	50	100	100	100	50	
														3	40	0	0	50	0	0	100	100	3	85	100	100	100	100	0	100	100	
														4	100	100	100	100	47	0	100	100	4	90	100	100	0	100	0	100	100	
														O	60	100	100	100	100	0	100	100	O	60	0	0	100	100	100	100	100	
Lascaux 498 HV **with Kurotani Tissue** (72-77°C)	PBA / PMMA	7.29 ±.11	7.09 ±.09	6.45 ±.06	6.79 ±.18	ST	1.16 ±.20 (0.44)	0.98 ±.03 (0.33)	9.79 ±2.44 (3.88)	6.88 ±.59 (0.31)	F		F	C	49L	0	0	100	100	0	100	100	C	100	100	100	100	100	100	100	100	65
														1	40	0	0	100	50	0	100	100	1	80	100	100	50	100	0	100	100	
														3	40	0	0	100	100	0	100	100	3	90	100	100	100	100	0	100	100	
														4	40	0	0	100	47	0	100	100	4	75	100	100	0	50	0	100	100	
														O	35	0	0	100	100	0	100	98	O	45	50	50	100	100	0	100	100	
Lascaux 360 HV MADE AS HEAT-SET TISSUE **with Kurotani Tissue** (48-51°C)	PBA / PMMA	6.87 ±.04	7.38 ±.04	5.46 ±.12	7.24 ±.15	ST	0.96 ±.20 (0.24)	1.00 ±.10 (0.35)	9.92 ±.89 (4.01)	6.43 ±.22 (-0.14)	F		F	C	80	0	0	100	100	50	100	100	C	85	100	100	100	100	100	100	100	60
														1	49L	0	0	100	100	0	100	100	1	80	100	100	100	100	0	100	100	
														3	49L	0	0	98	100	0	100	100	3	75	100	100	50	100	0	100	100	
														4	50	0	0	100	50	0	98	100	4	80	100	100	100	100	0	100	100	
														O	53M	0	0	48	100	50	100	99	O	80	50	50	100	100	50	100	100	

Table I. Results of the Chemical Analysis, pH, Colour Change, PAT and Removability Tests (con't).

Tape or Heat-set Tissue (THST) (heat-set temperature)	Chemical Analysis	pH (pH 6-8; <6 or >8) (pH Kurotani Tissue alone = 7.18±.02)				Colour Change (No substantial colour change; Substantial colour change)				PAT (Pass; Fail)			Removability (For Mechanical >70 is easier to remove; 40-69 more difficult; <39 very difficult. For Solvent 97-100 is removable; 47-50 is partially removable; 0 is not removable.)																		Overall Score (all tests equal)
		0 hours		Dark Aged 4 yrs		Dark Aged 4 yrs		Oven Aged					Punch Paper									RC Paper									
		THST Alone	THST with Tissue	THST Alone	THST with Tissue	Transparency	ΔE Tape Side	ΔE Paper Side	ΔE Tape Side	ΔE Paper Side	Adhesive Side	Carrier Side	Overall PAT	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	Age	Mechanical	Water	pH 8.5 Water	Ethanol	Acetone	Heptane	Ethyl Acetate	Toluene	
HEAT-SET – Paper Carriers (con't)																															
Lascaux 360 HV MADE AS PRESSURE-SENSITIVE TISSUE **with Kurotani Tissue**	PBA / PMMA	6.87 ±.04	7.38 ±.04	5.46 ±.12	7.24 ±.15	ST	0.96 ±.20 (0.24)	1.00 ±.10 (0.35)	9.92 ±.89 (4.01)	6.43 ±.22 (-0.14)	F		F	C	49L	0	0	100	100	0	100	100	C	88	100	100	100	100	0	100	100	60
														1	44L	0	0	100	100	0	100	100	1	95	100	100	100	100	0	100	100	
														3	44L	0	0	50	98	0	100	100	3	80	100	100	50	100	0	100	100	
														4	55	0	0	100	98	0	98	100	4	85	100	100	100	100	0	100	100	
														O	48M	0	0	98	100	0	99	99	O	88	50	50	100	100	0	100	100	
Lascaux 360 HV MADE BY SOLVENT REACTIVATION WITH ETHANOL **with Kurotani Tissue**	PBA / PMMA	6.87 ±.04	7.38 ±.04	5.46 ±.12	7.24 ±.15	ST	0.96 ±.20 (0.24)	1.00 ±.10 (0.35)	9.92 ±.89 (4.01)	6.43 ±.22 (-0.14)	F		F	C	63	0	0	100	100	100	100	100	C	88	100	100	100	100	0	100	100	60
														1	49L	0	0	100	100	0	100	100	1	95	100	100	100	100	0	100	100	
														3	44L	0	0	50	98	0	100	98	3	80	100	100	50	100	0	100	100	
														4	74	0	0	48	98	0	100	100	4	95	100	100	0	100	0	100	100	
														O	49L	0	0	99	99	0	99	99	O	75	50	50	100	100	0	100	100	
Lascaux 498/360 (2:1) **with Kurotani Tissue** (55-60°C)	PBA / PMMA	6.78 ±.01	7.29 ±.06	6.19 ±.04	7.02 ±.05	ST	1.06 ±.07 (0.34)	0.99 ±.07 (0.34)	8.44 ±.63 (2.53)	7.05 ±.27 (0.48)	F		F	C	69L	0	0	100	100	100	100	100	C	90	100	100	100	100	100	100	100	66
														1	49L	0	0	100	98	0	100	100	1	80	100	100	100	100	0	100	100	
														3	44L	0	0	50	48	0	100	100	3	70	100	100	100	100	0	100	100	
														4	60	0	0	100	97	0	100	100	4	60	100	100	100	100	0	100	100	
														O	43M	0	0	100	100	0	100	100	O	80	0	0	100	100	100	100	100	
BEVA 371 Film 1 mil **with Kurotani Tissue** (60-62°C)	EVA + Ketone Resin N ++	6.73 ±.21		6.16 ±.03		ST	0.95 ±.10 (0.23)	0.73 ±.06 (0.08)	16.60 ±.39 (10.69)	10.83 ±.82 (4.26)	P		P	C	48M	0	0	100	100	100	97	100	C	90	100	100	100	100	100	100	100	83
														1	48M	0	0	100	100	100	50	100	1	80	100	100	50	100	100	100	100	
														3	43M	0	0	50	100	100	98	98	3	75	100	100	100	100	100	100	100	
														4	64L	0	0	100	100	100	100	100	4	80	100	100	100	100	100	100	100	
														O	48M	47	47	97	47	47	97	100	O	84L	0	100	100	100	100	100	100	
Seal Fusion 4000 Dry Mounting Adhesive Film **with Kurotani Tissue** (78-81°C)	EVA	7.11 ±.18		5.85 ±.31		ST	0.67 ±.07 (-0.05)	0.70 ±.06 (0.05)	7.54 ±.47 (1.63)	6.47 ±.26 (-0.10)	P		P	C	60	50	50	0	0	50	48	100	C	95	100	100	100	100	100	100	100	77
														1	38L	0	0	50	0	0	0	50	1	95	100	100	100	100	100	100	100	
														3	40	0	0	50	0	0	50	50	3	85	100	100	100	100	100	100	100	
														4	79L	0	0	0	0	0	0	50	4	89L	100	100	100	100	100	100	100	
														O	47H	48	48	0	0	0	0	98	O	64L	0	0	100	0	100	50	100	
Unsupported Archibond **with Kurotani Tissue** (74-80°C)	PMA / PEMA	5.06 ±.08		4.49 ±.14		ST	0.74 ±.07 (0.02)	0.88 ±.04 (0.23)	7.00 ±.17 (1.09)	6.73 ±.11 (0.16)	P		P	C	50	50	50	99	100	50	98	100	C	90	100	100	100	100	50	100	100	68
														1	44L	100	100	100	100	0	100	98	1	85	100	100	100	100	0	100	100	
														3	49L	0	0	100	100	0	100	98	3	70	100	100	100	100	0	100	100	
														4	55	0	0	100	100	0	100	100	4	75	100	100	100	100	0	100	100	
														O	43M	48	48	99	99	49	98	99	O	44L	100	50	100	100	0	100	100	

Chemical Analysis: $CaCO_3$ = calcium carbonate; EVA = ethylene vinyl acetate; NaCMC = sodium carboxymethyl cellulose; PAA = poly(acrylic acid); PEA = poly(ethyl acrylate); PEHA = poly(ethylhexyl acrylate); PEMA = poly(ethyl methacrylate); PIB = polyisobutylene; PMA = poly(methyl acrylate); PMMA = poly(methyl methacrylate); PBA, PnBA = poly(butyl acrylate); PnDA = poly(decyl acrylate); PODA = poly(octadecyl acrylate); PVAC = poly(vinyl acetate); PVOH = poly(vinyl alcohol); SBR = styrene butadiene; sm = small amount; UN = unidentified; VAC = vinyl acetate; VAE = vinyl acetate ethylene; VAL = vinyl alcohol; ++ = other components or additives present

Abbreviations for Transparency: T = transparent; ST = semi-transparent; S = solid; SS = semi-solid.

Colour Change: Domtar Paper alone: Tape Side – ΔE = 0.72 ±.07 (Dark Aged 4 yrs), ΔE = 5.91 ±.11 (Oven Aged); Paper Side – ΔE = 0.65 ±.05 (Dark Aged 4 yrs), ΔE = 6.57 ±.07 (Oven Aged).

These colour values for the Domtar paper were subtracted from results except for tape side of products that were semi-solid or solid (difference in brackets).

Removability: Age: C = Controls; 1, 3, 4 = 1, 3, 4 years dark aging; O = Oven Aging. Staining: L = low; M = medium; H = high.

The point score for Removability in the Overall Score was determined by weighting the mechanical and solvent scores in the following manner: mechanical was given a weighting of 6; water and pH 8.5 water were given a weighting of 5; ethanol & acetone a weighting of 3; heptane & ethyl acetate a weighting of 2; and toluene a weighting of 1, only if the score was >70. This was done to give more emphasis to the mechanical and water removal scores and less emphasis to the more toxic solvents.