HUMIDIFICATION WITH MOISTURE PERMEABLE MATERIALS

Sebastian Dworsky*, Hannes Singer**, Gerhard Banik*

Abstract

Humidification is an essential part in the conservation of paper, parchment and photographic prints. Especially when dealing with water sensitive objects the application of moisture creates problems that are usually solved with expensive high-tech equipment like a humidification chamber. The use of moisture permeable materials for this purpose, which allow humidity to reach the object without wetting it, offers easy and inexpensive techniques for the humidification of water sensitive objects. These investigations into the use of moisture permeable materials for humidification led as well to the development of new techniques which allow the removal of residual adhesive, old linings and stains from water sensitive objects.

HUMIDIFICATION, STAIN REMOVAL, LINING, PAPER, PARCHMENT, PHOTOGRAPHS, GORE-TEX, SYMPATEX®

Introduction

In many cases of paper conservation it is necessary to treat paper documents or works of art on paper using humidification. Major tasks are relaxing, removal of linings and stains, swelling of residual adhesive, etc. Modern textile and strip developed membrane coated fabrics which allow the migration of water vapor but prevent water in liquid form to penetrate.

One laminate is manufactured using membranes with defined porosity, which are sold under the trade name GORE-TEX®[1]. Some of these products are suitable for conservation treatments. Due to its porous structure and the hydrophobic character of the GORE-TEX membrane it prevents water and mixtures of water with polar solvents in liquid form from penetrating, but it is permeable for gases like water vapor and solvent vapor. This characteristic of GORE-TEX laminates enables the conservator to treat graphic art objects with water vapor in a very controlled way.

SYMPATEX®[2] is another laminate that was developed for the textile industry. Its main difference to GORE-TEX is that it consists of a non-porous membrane which still allows the penetration of moisture. Since SYMPATEX® is a quite new material for art group, only preliminary examinations on its usability in paper conservation could be performed. According to these investigations SYMPATEX showed similar results compared to humidification treatments with GORE-TEX laminates. Due to our limited experience with humidification using SYMPATEX the following treatments refer to GORE-TEX laminates only.

* State Academy of Fine Arts, Paper Conservation Course, Am Weißenhof 1, D-W-7000 Stuttgart 1, Germany.

** Graphische Sammlung Albertina, Conservation Department, Augustinerstraße 1, A-1010 Vienna, Austria

Material description

GORE-TEX

W.L. Gore & Associates Inc. is specialized on manufacturing of membranes and their lamination on a variety of support materials. The membrane, a special treated, so called expanded polytetrafluoroethylene (PTFE), is a material with similarities to teflon. These membrane laminates, sold under the trade name GORE-TEX are mainly used in textile industry, but filter membranes for technical use and products for medical application are available as well.

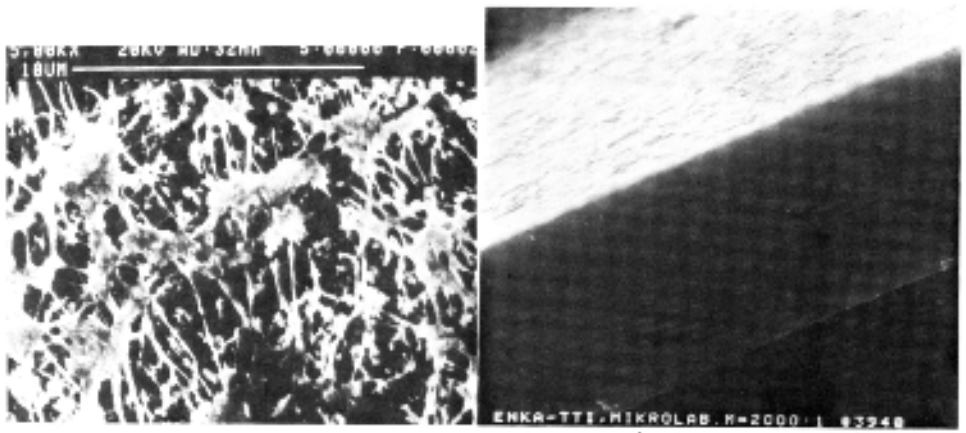
There are two types of GORE-TEX laminates, which can be used for conservation treatments:

GORE-TEX Barrier Polyester Nonwoven Laminate
GORE-TEX Barrier Polyester Knit Laminate

These GORE-TEX laminates consist of 2 layers, a polyester support and the membrane itself. The expanded PTFE membrane is produced with pores of approximately 0.2 µm in diameter.[3]

GORE-TEX membrane polyester laminates show a high chemical resistance, are hydrophobic and stay stable up to temperatures of 135 °C (275 °F). According to accelerated aging tests, their aging characteristics are excellent. The membrane is permeable for gases, but prevents – due to its hydrophobic character and its small pore size – penetration of water in liquid form. Some organic solvents like ethanol and acetone penetrate the membrane in liquid form. The penetration can be suppressed by adding an appropriate amount of water.

Figure 1
The porous GORE-TEX membrane (left) at high magnification in comparison with the non-porous SYMPATEX membrane (right).



SYMPATEX

SYMPATEX is another laminate, which was developed by the textile industry for the fabrication of waterproof, but water vapor permeable clothing. For this purpose a 15 µm thick extruded non-porous membrane made of modified polyester is used. A 10 µm thick membrane is available as well, which allows even more water vapor to pass. This polyester is modified with dicarbonic acids, di-alcohols and polyether in order to create a hydrophilic character of the membrane. When liquid water is in contact with the membrane, the polymer swells and allows the transport of water vapor[4]. The swelling of the polyester membrane causes dimensional expansion of about 5 %. The polyester membrane allows, unlike GORE-TEX no penentration of liquid solvents, but vapors of polar solvents migrate through the membrane. SYMPATEX membranes are sensitive to strong alcaline solutions, but these should not be used in paper conservation anyway. Akzo / Enka produces only the plain membrane itself, while the laminates are manufactured by other companies which call these laminates SYMPATEX, in spite of different support materials and lamination processes. Depending on the support material and the type of adhesive the laminates can be sensitive to certain solvents.

Table I
Technical data of the above mentioned membranes. The values are either taken from the product information sheets supplied by W.L. Gore & Associates[5] and Akzo[6] or through communication with H. Marxmeier (Enka)[7]; some data are converted to European units. Since no information on SYMPATEX laminates could be obtained, data of SYMPATEX membranes are displayed. Please note that this table compares laminates versus plain membranes.

	GORE-TEX barrier Polyester Nonwoven Laminate	GORE-TEX barrier Polyester Felt Laminate	SYMPATEX Membrane 10 µm	SYMPATEX Membrane 15 µm
Weight	1.7 - 1.9 oz/yd² 40.30 - 45.04 g/m²	5.1 - 5.4 oz/yd² 120.89 - 128.00 g/m²	12.7 g/m²	19.1 g/m²
Thickness	7.0 - 10.0 mils 0.178 - 0.254 mm	43.0 - 46.0 mils 1.092 - 1.168 mm	10 µm	15 µm
Moisture vapor transmission rate, dry (minimum)*	25,000 g/m²/24h 0.10 ml/cm²/h	10,000 g/m²/24h 0.04 ml/cm²/h	28,000 g/m²/24h 0.12 ml/cm²/h	25,000 g/m²/24h 0.10 ml/cm²/h
Heat resistance (maximum)	275 °F 135 °C	275 °F 135 °C	200 °C	200 °C
Pore size	0.2 µm	0.2 µm	non-porous	non-porous

* It has to be considered that W.L. Gore & Associates and Akzo / Enka use different standards to define the moisture vapor transmission of their products (GORE-TEX: QCTM 301; SYMPATEX: ASTM E 96-66, method B, modified).

Water permeability of GORE-TEX

The special feature of GORE-TEX to allow water to penetrate in gas form only offers its use as conservation tool for controlled humidification. Based on our examinations at the National Library of Austria it can be assumed that the relative humidity on top of the membrane will rise after some minutes to approximately 90 % [8]. The humidity flow towards the paper object will continue until the paper has absorbed its maximum humidity - an equilibrium is reached. No condensation due to over saturated air is possible, as long as the temperature is stable. The humidification with GORE-TEX sandwiches is dependant on the temperature, since the evaporation of water is temperature dependant.

Fig. 2 illustrates how small water droplets are stopped by the GORE-TEX membrane from penetrating and wetting the paper, but water vapor is migrating through the membrane. The cellulose fibers of the paper are absorbing this water vapor and are able to bind it in a semi liquid state. This enables water soluble matter in the paper felt to be swollen and under appropriate conditions it is possible to transport them as well.

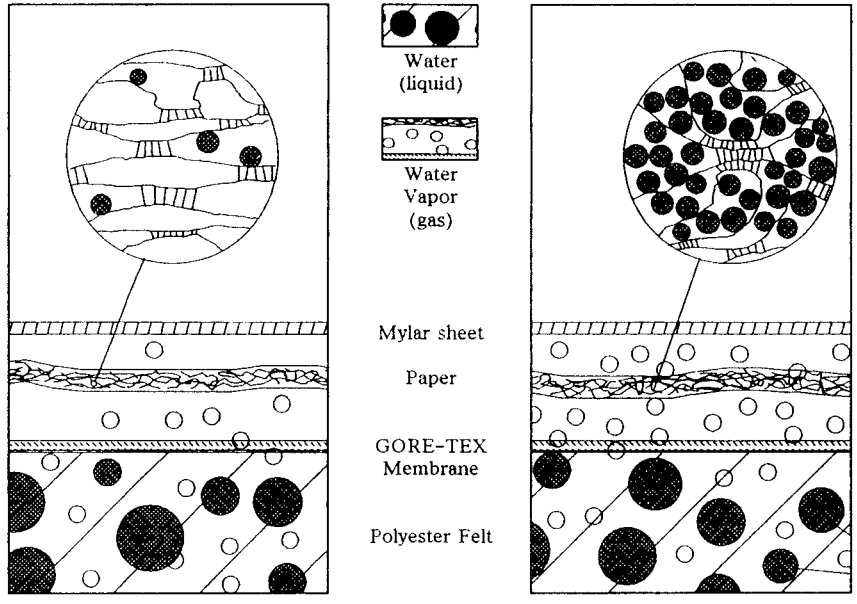
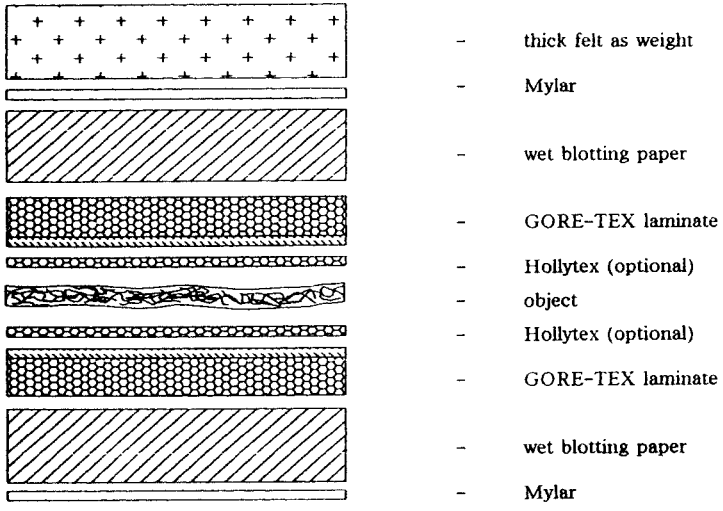


Figure 2
Schematic cut through a simple GORE-TEX sandwich. The left drawing illustrates the beginning of the humidification treatment, while on the right side the paper is fully saturated with water, the equilibrium is reached and no more humidity will penetrate through the membrane. The enlarged sections are showing the swelling in the molecular cellulose structure as described by Jakes[9].

GORE-TEX sandwiches

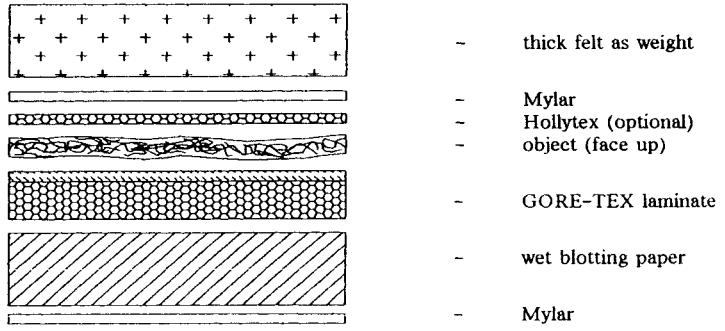
For humidification treatments it is advisable to build up sandwiches using other materials which are used in paper conservation, e.g. Mylar sheets, felts, blotting paper, etc.. Similar sandwiches were presented by Keiko Keyes in 1988 in Ottawa[10]. The configuration of the sandwich has to correspond with the planned conservation treatment. In fig. 3-5 three GORE-TEX sandwich variations are shown which may be modified according to the specific problems of the object that has to be treated.

Figure 3
Schematic cross section of a GORE-TEX sandwich for double-sided humidification.



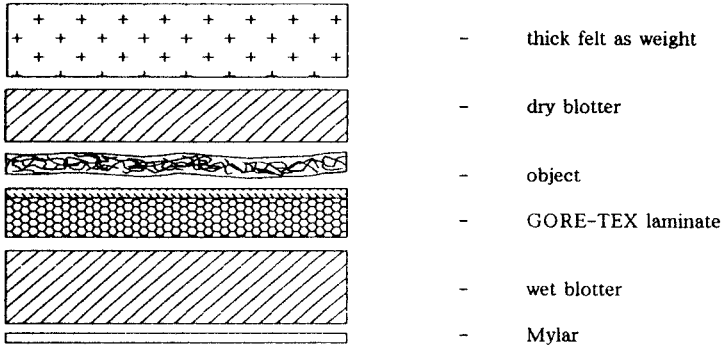
This GORE-TEX sandwich is the standard modification for humidification. The humidity can penetrate into the object equally from both sides and migration of soluble matter is kept to a minimum. The humidification is relatively rapid and strain during treatment caused by un-equal expansion of the object is prevented. Extremely water sensitive colors may be covered with Hollytex or equivalent.

Figure 4
Schematic cross section of a GORE-TEX sandwich for single-sided humidification.



The GORE-TEX sandwich shown in fig. 4 can be used for the removal of old linings with water soluble adhesives. It is suitable for humidification of objects with extremely water sensitive colors on one side, e.g. gouache. Those objects are placed face up (the sensitive side is *not* showing to the GORE-TEX membrane) into the GORE-TEX sandwich. It is advisable to stop humidification before the object is completely saturated, because not only the support will absorb moisture, but to a certain degree the color will absorb humidity as well. This might result in a transfer of the color to the covering sheet. An additional layer of Hollytex or equivalent material will prevent adhesion of tacky color to the Mylar sheet and it eliminates the danger of condensation which might occur because of temperature changes or minor defects of the membrane.

Figure 5
Schematic cross section of a GORE-TEX sandwich for the removal of soluble matter, e.g. stains.



This sandwich allows the transport of soluble matter from the paper felt into the dry blotter using capillary forces. It is advisable to place the object face down onto the GORE-TEX membrane, because in this way the solved substances are moving away from the image side. Addition of polar solvents (e.g. ethanol) to the humidification liquid showed good results.

In opposite to the product information sheets from W.L. Gore & Associates Inc. or Lascaux we cannot recommend the application of humidification liquid directly onto the polyester felt. It is much safer to use a thoroughly wetted blotting paper instead. This has the advantage to guarantee a more uniform humidification and to reduce the risk of liquid penetration through creases in the membrane. Please note, that the blotter has to be smaller than the GORE-TEX laminate to avoid migration of liquid from the sides.

Relaxing

Planar distortions, undulations and creases in sensitive graphic art objects may cause loss of the paint layer. In many cases these distortions are caused by rapid change of climatic conditions (e.g. exhibition, transport, disfunction of air conditioner, etc.). To avoid loss of paint or ink these objects have to be relaxed by humidification and dried under light pressure or strain. In case of water sensitive paint layers or inks the treatment of those objects is quite difficult or even impossible, if no humidification chamber is available.

The use of a GORE-TEX sandwich according to fig. 3 and 4 allows the treatment of such delicate objects in a controlled way, without the need of expensive high-tech equipment. Humidification in a GORE-TEX sandwich avoids the risk of formation of small water drops on the object's surface or condensation.

The speed of the humidification procedure is dependant on the type of GORE-TEX laminate used. The GORE-TEX barrier Polyester Nonwoven Laminate humidifies 2½ times faster than the GORE-TEX barrier Polyester Felt Laminate. Therefore it takes much more time for the latter to reach the humidification equilibrium but this is sometimes advantageous when treating delicate objects. Besides the type of GORE-TEX laminate used, the absorption characteristic of the treated paper is of great importance.

Some photographic prints are quite water sensitive as well, especially certain painted photographs or some silver-gelatin prints with high gloss surface. A flattening treatment developed by the Academy of Fine Arts in Copenhagen[11] was modified according to fig. 4 in order to allow humidification of those water sensitive photographic prints. When treating photographic prints it is very important to use only acid free, but unbuffered blotting paper with neutral pH.

Removal of water soluble stains

Degradation products of cellulose and residual adhesives can increase acidity and discoloration of the paper. The removal of this matter enhances the permanence of the treated object and its aesthetical appearence. In case of objects with water sensitive colors or inks an aqueous treatment induces a high risk to the original, but the application of a GORE-TEX sandwich facilitates in most cases an aqueous treatment with reduced risk.

The first step is to place the work of art, image side down*, into a GORE-TEX sandwich according to fig. 3. This treatment will relax the work of art and will cause the deterioration products to absorb moisture and to swell.

In the second step the covering Mylar is replaced with a slightly moistened blotting paper which will start to absorb moisture from the work of art. Humidity will continuously move from the GORE-TEX membrane through the work of art into the almost dry blotting paper; dissolved degradation products will as well migrate into it. This procedure will take some time. Its speed is depending on the type of GORE-TEX laminate used, the temperature, the paper quality and the solubility of the matter to be removed.

* This is important, since the dissolved substances should move away from the image side of the paper.

Extremely water sensitive paints may start to migrate into the paper structure, especially when the treatment is very long. To avoid this it is advisable to remove the work of art from the GORE-TEX sandwich when it is completely relaxed and swollen and to treat the paper on the suction table. The use of a fine airbrush enables selective treatment of the object. The combination of both techniques will shorten the treatment considerably.

Removal of linings

In many cases graphic art objects suffer from improper linings (e.g. wood pulp containing linings, acidic linings). Treatments which were conducted at the National Library of Austria showed that improper linings of objects with water sensitive paint layer could be removed without problems after their adhesive was swollen in a GORE-TEX sandwich according to fig. 4. The application of moderate heat (≤45 °C) to the sandwich was found to be helpful in cases were animal glue had to be swollen[12 13]. The reason for this behavior is the accelerated evaporation of the water in combination with the enhanced swelling of animal glue under warm conditions.

In cases where the work of art is adhered to very thick or solid supports (e.g. wood panels) the use of a GORE-TEX sandwich according fig. 4 was found to be appropriate as well. The only difference to fig. 4 is that the object has to be inserted face down. This variation might be used as well for badly stained linings, to avoid migration of yellow degradation products into the original.

According to the composition, the GORE-TEX sandwich can be very thin. In case the humidification of only one page of a book is desired, the sandwich can be inserted in the bound book without taking it apart.

Lining

For aqueous lining of water sensitive objects a method developed by C. Baker[14] was enhanced, using a GORE-TEX sandwich. A Japanese tissue is prepared with sodium carboxy methylcellulose (NaCMC) by pasting it to a Mylar sheet. After drying, the precoated tissue can be easily stripped off the Mylar sheet. This tissue is cut in size, inserted, the glossy side up, between two Hollytex sheets and put into a GORE-TEX sandwich according to fig. 4. Depending on the time of exposure of the tissue to the humidity, the tackiness of the adhesive can be controlled. The object to be lined is positioned onto the tissue while it is still on the GORE-TEX laminate. Immediately the object is covered by another Hollytex sheet and inserted between two blotting papers. This sandwich (blotter/Hollytex/object/lining tissue/Hollytex/ blotter) is dried for a few minutes under pressure to assure good contact.

The Hollytex sheet prevents the adhesion of uncovered lining tissue to the blotting paper. The slight adhesion of the tissue to the Hollytex is sufficient to perform a stretching effect during drying. To prevent high tension after drying, it is advisable to humidify the object in another GORE-TEX sandwich before lining. In case the object can not withstand this treatment the tension can be limited by using Tengujo or another Japanese tissue with little tendency to expand when wetted.

This technique enables the conservator to apply linings with week adhesion for securing the object, which can be removed mechanically. To achieve stronger bonds for permanent lining the precoated tissue has simply to be left in the GORE-TEX sandwich for a longer period of time.

Conclusion

GORE-TEX laminates can be used very well for various humidification treatments in conservation of paper, tracing paper, parchment[15] and photographs[16]. Its use in other conservation sections like paintings conservation might be an interesting subject. Comparing GORE-TEX and SYMPATEX laminates, the latter seems to have certain advantages. It is less expensive than GORE-TEX and its disposal is not critical. The disposal of GORE-TEX is problematic, since it develops fluoric gases when burned under normal conditions. One disadvantage of SYMPATEX might be its tendency to develop an "orange skin" surface when moistened. This is due to the swelling of the polyester membrane.

Further studies on the use of GORE-TEX and SYMPATEX in paper conservation are necessary and will be performed during a conservation project of the Graphische Sammlung Albertina, Vienna in collaboration with the Academy of Fine Arts in Stuttgart. This project is financed by Henkel-Austria GmbH.

Acknowledgement

We would like to thank Mrs. Birgit Schwarz (Gore & Associates) and Dr. Harald Marxmeier (Akzo/Enka) for their material support and their valuable help. We would like to thank as well the National Library of Austria, the Graphic Collection Albertina and the Academy of Fine Arts in Stuttgart since their support made this work possible.

Manufacturer and Distributors:

GORE-TEX laminates

W.L. GORE & Associates Inc.
P.O.B. 1550
100 Airport Road
Elkton, MD 21921
U.S.A.

W.L. Gore & Associates GmbH
Wernher-v.-Braun-Straße 18
D-W-8011 Putzbrunn
Germany

Alois Diethelm AG
Lascaux Restauro
CH-8306Brütisellen
Switzerland

SYMPATEX membranes

Akzo / Enka AG
Textiltechnisches Institut
Postfach 10 01 49
D-W-5600 Wuppertal 1
Germany

SYMPATEX laminates

Carl Freudenberg
Industrial Products
Postfach 1369
D-W-6940 Weinheim
Germany

Erba AG
Postfach 1740
Äußere Bucker Straße 51
D-W-8520 Erlangen
Germany

NINO AG
Postfach 2029
Bentheimer Straße 122
D-W-4460 Nordhorn
Germany

C.F. Ploucquet GmbH & Co.
Postfach 1740
Plouquetstraße 11
D-W-7920 Heidenheim
Germany

References:

1 GORE-TEX® is a registered trade name of W.L. Gore & Associates Inc.

2 SYMPATEX® is a registered trade name of Akzo / Enka AG.

3 Gore & Associates, Inc.
Art Humidification, Product Information, Elkton, MD: Gore & Associates, Inc., 1986.

4 H. Marxmeier
Wetterschutzbekleidung mit einer wasserdampfdurchlässigen Membran, Kunststoffe, Vol. 78, No. 6, Munich: Carl Hanser Verlag 1988.

5 W.L. Gore & Associates, Inc.
Physical Properties of GORE-TEX barrier for Art Conservation, Product Information, Elkton, MD: W.L. Gore & Associates, Inc., 1986.

6 Akzo / Enka AG
SYMPATEX - Eigenschaften, Funktion, Einsatz in Wetterschutzbekleidung (Technische Produktinformation), Wuppertal, Akzo/Enka 1988.

7 Information by Dr. Harald Marxmeier, Textiltechnisches Institut, Enka AG, Wuppertal.

8 V. Flamm, C. Hofmann, S. Dobrusskin, G. Banik
Conservation of Tracing Papers, ICOM Committee for Conservation - 9th Triennial Meeting Dresden - Preprints, p. 465-467, 1990.

9 K.A. Jakes, J.H. Howard
Replacement of Protein and Cellulosic Fibres by Copper Minerals and the Formation of Textile Polymorphs, Historic Textile and Paper Materials - Conservation and Characterization, H.L. Needels, S.H. Zeronian Eds., Advances in Chemistry Series 212, Amer. Chem. Soc., Washington DC: 1986, p. 277-287.

10 K.M. Keyes
Some Practical Methods for the Treatment with Moisture of Moisture-Sensitive Works on Paper, Symposium 88 - Abstracts, Talk: 6. 10. 1988, Ottawa, Ontario: Communications Canada / Canadian Conservation Institute 1988.

11 M.S. Koch
Photographic Conservation: Flattening Waterdamaged Prints. Handout, Grafisk Restaureringslinie, Det Kongelige Danske Kunstadademi, Konservatorskolen.

12 C. Mackay
Goretex, Paper Conservation News, No. 54, p. 12, Worcester, 1990.

13 H. Singer, S. Dobrusskin, G. Banik
Behandlung wasserempfindlicher Objekte mit GORE-TEX - Anwendungen, Möglichkeitenund Grenzen, Restauro, Vol. 97, No. 2, pp. 102-111, Munich: Callwey 1991.

14 C. Baker, R. Espinosa
Working Across the Conservation Disciplines: New Techniques and Materials, American Institute for Conservation (AIC) Preprints, p. 205, Washington D.C.: AIC 1988.

15 H. Singer
Safer Methods in the Conservation of Parchment Objects using GORE-TEX Laminates. The Paper Conservator, in press.

16 K.B. Hendriks, S. Dobrusskin
Identification, Conservation and Restoratin of Hand Coloured Photographs. Unpublished Project Report, Picture Conservation Division, National Archives of Canada, Ottawa, Ontario 1989.

Zusammenfassung

Die wichtigsten Behandlungsmethoden der Papierrestaurierung basieren alle auf der Anwendung von Wasser. Dies führt jedoch bei feuchtigkeitsempfindlichen Objekten - z.B. Malerei mit Gouachefarben - zu Problemen, die bisher meist unter Verwendung von teurer high-tech Ausrüstung wie Ultraschallbefeuchter oder Feuchtigkeitskammer gelöst wurden. Die Anwendung von Wasserdampf durchlässigen Membranen bietet dem Restaurator eine kostengünstige Möglichkeit Objekte kontrolliert zu befeuchten, ohne sie mit Wasser in flüssiger Form in Berührung zu bringen - eine Methode, die sogar das Befeuchten von höchst wasserempfindlichen Objekten erlaubt. Gleichzeitig wurden Methoden entwickelt, die das Entfernen von Klebstoffresten, Verbräunungen und alten Kaschierungen von wasserempfindlichen Blättern erlauben.

Diese Arbeit basiert hauptsächlich auf Versuchen die mit GORE-TEX® Membranen durchgeführt wurden. Erste Experimente mit SYMPATEX® Membranen, die sich durch einen wesentlich unterschiedlichen Aufbau von GORE-TEX unterscheiden, erbrachten vielversprechende Ergebnisse.