

Active Archival Housing

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INTRODUCTION

It was in the investigation of W. J. Barrow, who published six volumes of data in the 1960s, that the causes of inherent vice in paper deterioration were initially identified.¹ Increased deterioration rates of paper cellulose were determined to be the result of acidic reactions, which appeared to result from a variety of efforts to produce less expensive papers. Papers made from ground wood or unbleached fibers that contained lignin and the use of aluminum sulfate ($\text{Al}_2(\text{SO}_4)_3$) to adhere sizing (acid resins) to paper fibers were among the primary causes, although there were others of a similar nature. As these issues were isolated, commercial papers that display improved characteristics of permanence were developed for publishing, fine arts and records documentation applications. This was done in the context of traditional conservation treatments intended to remove or neutralize acids generated as papers deteriorate. Quality original-use papers are now frequently made in an alkaline process and include an alkaline reserve placed into the paper during manufacture.

Placing an alkaline reserve in original-use papers was thought to have resolved one aspect of a problem recognized and defined by earlier researchers. Subsequently, alkaline reserves were incorporated into housing materials as an extension of their role in original-use papers. Thus equipped, housing papers and boards, many of which had been previously subject to the same degenerative cycles as collections materials, would no longer exacerbate the problem of acidity.² At that time, the addition of alkaline reserves to housing components was largely corrective, designed to elevate the intrinsic archival properties of enclosure materials.

Subsequent development efforts of this company³ resulted in the introduction of boards designed specifically as structural elements for archival enclosures.

One such material, patented and introduced in the 1980s, is a triplex board in which the exterior layer is lignin and sulfur-free and contains a traditional alkaline buffering, the middle layer comprises a sheet of archival polyester and the other side of the board is a neutral pH, non-buffered and lignin- and sulfur-free paper. With the introduction of products such as this, modified boxboards with alkaline reserves were supplanted, in this case by a special-purpose archival housing board with inert enclosure surfaces designed to not exacerbate deterioration and barrier layers to interdict entry of harmful elements through the housing materials.

In the developmental sequence from equivalence to protection, the design criteria were that enclosure materials should be inert, inactive or chemically compatible with the collections they housed. Certain collections, photographic emulsions and protein-based textiles, for example, required storage in contact with pH-neutral surfaces without the alkaline reserves indicated for papers. In those cases, the reserves were omitted for the same reasons they were added for papers. The criteria were based on a dual concept of the archival enclosure: it would offer as much physical strength and barrier protection as possible and it would prove chemically compatible in contact with collections.

This model of the archival enclosure required that it provide some deterrence against external sources of degradation and would not itself contribute to the deterioration of collections. The new model, developed by the company presenting this report,³ provides active, preventive conservation within the enclosure. It controls and reduces oxidizing gases and their associated acid-based derivatives. Such oxidizing gases may be deteriorative byproducts of the artifacts themselves, or they may be external intrusions, including atmospheric pollutants, discharges from electrostatic copiers, peroxides emitted from oil-based paints or other recognized external sources.

In the presence of oxidizing gases, acids may be formed when moisture is present within the collection environment. Organic-based collections materials, including celluloses, dyes and other complex natural elements, are quite adversely affected by the presence of oxidizing gases. Inorganic collections materials that have naturally occurring reactions with oxidizing environments, in particular metals and mineral collections, can also be considered to be at risk.

Proper chemical filtration and recirculation of the air within a building may accommodate general environmental influences, but the products of inherent vice within collections housings will not be adequately controlled by physical plant design. Similarly, the more effectively sealed the housing, in the innocent service of providing a barrier to external elements, the more concentrated the deteriorative elements in the environment within.

The introduction of a new model of conservation housing, one that can

actively contribute to the preservation of collections, represents a significant conceptual departure in the role of the archival enclosure, and opens a new field of inquiry in preventive conservation.

STRUCTURE

The new product is called MicroChamber™. The papers of this type consist of three or more discrete component layers of 0.10 mm. The boards consist of seven or more layers with a total thickness of 1.5 mm or more.

The transmission surface of MicroChamber™ paper designed to face collections is manufactured with a specific porosity to permit exchange between the internal, active layers and the interiors of collections enclosures. The active layers contain proprietary mixtures of specific activated carbons and alkaline buffers in papers of precise porosities, which function as a trap to neutralize oxidizing gases and their associated acids (Fig. 1). The exterior layer is an alkaline buffered, alkaline pH, sulfur-free and lignin-free conservation paper.

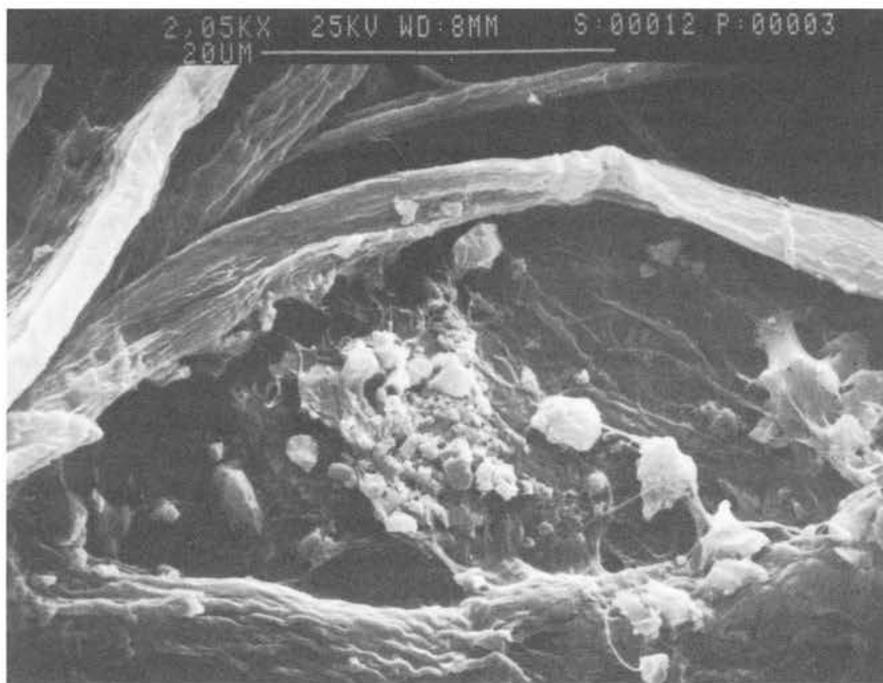


Fig. 1. Scanning electron micrograph of one of the active layers of MicroChamber™ paper. Within the fiber activated carbon coated with alkaline buffering (white) is dispersed.

The layers are formulated to be interdependent in the overall performance of the material.

ACCELERATED AGING

Independent laboratory tests have been performed on MicroChamber™ and conventional housing papers. The test parameters were both externally introduced elements, oxidizing gases and in protocols where the primary deteriorative elements were internal: the byproducts of paper degradation in accelerated aging. These tests indicate a synergistic relationship between the alkaline buffers and the specific activated carbons which, in proprietary mixtures, are components of the active layers of MicroChamber™ housing papers.

In one test of protective enclosures for vintage book papers during accelerated aging, samples of a 30-year-old book paper were enclosed in various housing materials and subjected to 88 hours of accelerated aging at 100°C, after which they were TAPPI-conditioned for more than 26 hours and tested for residual folding strength. The results are values expressed in units of the MIT fold at 1 kg of load. The final results are given in Table 1.

The 30-year-old paper stored in MicroChamber™ B housings exhibited sufficient strength to withstand an average of 15.1 folds. The same paper housed during the test in acid-free, lignin-free alkaline-buffered alpha cellulose enclosures was able to withstand an average of only 6.9 folds. Samples of the same paper housed in commercially available conventional manila file folders withstood an average of 5.1 folds. These test results indicate a greater differential in the strength retained between the book papers aged in MicroChamber™ and traditional alkaline buffered housings than between those papers aged in buffered and acidic housings.

Tests using a paper that had already aged for 30 years under natural conditions indicated a significant differential in results based on which enclosure material had housed the samples. Initial manufacturer's tests, using the same test protocols with new alkaline book papers, had previously shown a similar differential in residual strengths. Together, the results of the two tests indicated that residual strength varied in similar proportions, with both new papers and papers already well into the natural aging cycle, depending on which archival material was used for the enclosure.

HYDROGEN PEROXIDE INCUBATION TEST

Another standard test of MicroChamber™ products was completed by an independent testing laboratory specializing in photographic materials. The

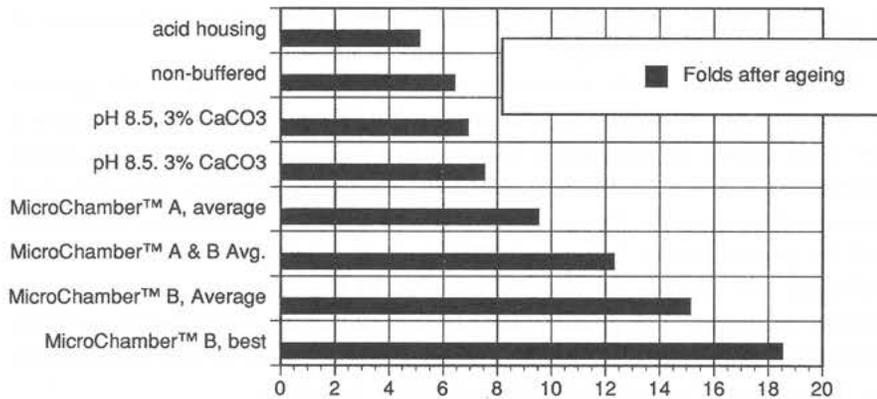


Fig. 2. M.I.T. folding endurance of the paper of a 30-year-old book aged for 88 hours at 100°C in different housings:

1 MicroChamber™ B	best result	18.5
2 same	average	15.1
3 MicroChamber™ A and B	average	12.3
4 MicroChamber™ A	average	9.5
5 conventional buffered (3% CaCO ₃) lignin and sulfur-free housing paper	best result	7.5
6 same	average	6.9
7 conventional neutral non-buffered lignin and sulfur-free housing paper	average	6.4
8 conventional manila folders	average	5.1

hydrogen peroxide incubation test used to evaluate silver photographic image stability is described in ANSI Standard IT 9.15-1992. The test environment is a two-litre desiccator in which monitor emulsions, covered by samples, are subjected to 2000 parts per million hydrogen peroxide for 18 hours at 50°C and 80% relative humidity.

The archival housing samples were tested with respect to their ability to protect the monitor material, an archivally processed microfilm. The use of microfilm as test monitor for the general class of processed commercial photographic materials is based on the observed deterioration of these materials⁴ and because microfilm also provides a sensitive monitor for the detection of undesirable components within the test materials themselves.

Fine-grain silver, dispersed in a gelatin binder and processed to archival standards, has proven a sensitive material for the detection of oxidizing gases. Various studies into the redox blemishes on processed microfilm stored in low-quality cardboard boxes that emitted peroxides as oxidizing gases have appeared in the literature.⁵⁻⁷

The same redox reaction was found to be active when researchers tested processed photographic film placed into a recently painted room where oil-based paints had been used. The curing oil-based paints included large volumes

of oxidizing gases, particularly peroxides, which resulted in the formation of redox blemishes in the image.⁸

The significance of the formation of these redox blemishes on the general silver image can be particularly appreciated with microfilm, which contains a very high density of information confined to a small area. On microfilm, redox blemishes invisible to the naked eye can result in the complete obliteration of letters and even words. The protocols of the test produce Draconian conditions, and the parameters for failure, an 0.05 image density increase on the monitor emulsion, will identify even small quantities of reactive gases penetrating the housing materials. Any product sample that can secure the monitor emulsion under the conditions of ANSI IT9.15-1992 will provide a safe environment for the storage of peroxide-sensitive collection materials.

Test results, reported as changes in silver-image density, are measured by light transmission densitometry through a blue filter, because redox silver deterioration is yellow in color.

Samples not protected by the test material receive full exposure to the testing environment. The image becomes badly degraded and the visual information contained within the microfilm is largely converted to the yellow redox blemish form. If a non-buffered conservation paper is used for protection, the surface area available for reaction is reduced. Samples protected in this way might be defined as showing slightly reduced damage, but generally there is no difference to non-protected samples. A buffered conservation paper provides a clearly better protection. Greater areas of overall grey tonality of the image instead of yellow are the evidence that the presence of an alkaline reserve within the paper reduces some of the redox reaction. Nevertheless, it must be stated that there is significant damage, i.e., yellowing. Only samples protected by a MicroChamberTM product are not affected by the testing.^a

Regarding the density numbers, no change was observed in all samples protected by a MicroChamberTM product. All other samples show increases (i.e., image deterioration) between 0.3 and 1.6.

CONCLUSION

The formulations and fiber structures for the MicroChamberTM papers vary because there are conflicting tasks to be performed. The interior layers must readily accept, capture and neutralize deleterious by-products of deterioration that form as artifacts age, while the exterior layers must keep oxidative and

^a Color photographic prints demonstrating the test results are available upon request from the authors.

acid gases in the surrounding atmosphere at bay. To help achieve this, fiber selection and structure differs throughout the paper structure. Activated carbons can be selected that, when combined with alkaline buffers, are effective against many of the deleterious compounds we wish to capture and neutralize. For the compounds against which activated carbon is not effective, we use a group of alkaline buffers in which pores and molecular cages sized to capture specific molecules have been fabricated. Traditional alkaline buffers must be used with both the activated carbon and the special buffers containing the molecular traps.

Microchamber™ papers are generally composed of multiple, non-laminated layers of paper, which are comprised of a variety of paper fibers, differentially processed and specifically selected to produce the maximum efficiency and performance in the MicroChamber™ paper. Within these layers are traditional alkaline buffers with either activated carbons and/or alkaline buffers specially modified with miniature interconnecting, multidimensional passageways (sized and shaped to accommodate specific molecules), leading to tiny molecular cages, where unwanted molecules of a deleterious nature are captured and neutralized. The efficacy of the various MicroChamber™ papers and boards is based on the interrelated functions performed by the structural components, molecular traps and neutralizing buffers together. We did test activated carbon used without alkaline buffers in conservation quality paper, and the performance was essentially identical to the performance of traditional lignin and sulfur-free alkaline buffered paper.

SUMMARIES

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W. J. Barrow was the first to identify an alkaline reserve as a main parameter of paper permanence. Subsequently, relevant compounds were not only incorporated into quality original-use paper but also into housing materials. Further development concentrated on the structure of such materials, on their porosity, and on specific activated carbon together with the alkaline compound. Recent tests have demonstrated a highly superior protection given by relevant housing materials.

Conservation active de documents d'archives

W. J. Barrow a été le premier à identifier la réserve alcaline comme un facteur essentiel de la permanence du papier. Par la suite des substances appropriées ont été non seulement incorporées dans le papier support du document mais aussi dans les matériaux de rangement. Les développements ultérieurs se sont concentrés sur la structure de tels matériaux, sur leur porosité et sur la

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présence de charbon actif spécifique avec un composé alcalin. Des tests récents ont montré la protection nettement supérieure donnée par des matériaux de rangement appropriés.

Konservierungsaktives Aufbewahrungsmaterial

W. J. Barrow hat zuerst das Vorhandensein einer alkalischen Reserve als wesentlichen Parameter für die Dauerhaftigkeit von Papier entdeckt. In der Folge wurden entsprechende Substanzen nicht nur zur Herstellung von Papier verwendet, das als Informationsträger dient, sondern auch von Papier bzw. Karton für Schutzhüllen. Die weitere Entwicklung konzentrierte sich auf die Struktur solchen Materials, auf seine Gasdurchlässigkeit und auf die Anwesenheit von spezifisch aktivierter Kohle zusammen mit der Puffersubstanz. Neueste Tests haben gezeigt, daß ein entsprechendes Material einen Schutz geben kann, der dem von anderen Materialien weit überlegen ist.

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