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Preservation of Paper Based Materials: Mass Deacidification Methods and Projects

Introduction

When I was first asked to update my 1979 *Library Journal* paper on mass deacidification processes, I thought it would be simple. I could just write "nothing's happened," and go on my way, or just say "there's not yet a good process" and leave it at that. But I found that there is still a lot of controversy regarding deacidification within the preservation profession. In the first month of research into new developments in mass deacidification, I heard or read "morpholine is the only viable process," "I looked at the Canadian Archives project, it looks great," "diethyl zinc is the only way to go," "VPD is the best method of deacidification." I began quickly to realize that the issue has not been settled—and probably won't be for some time.

My other thought, that nothing has happened since 1979, I found was also not true. There have been several developments; two of the three processes are being tested right now, and information will soon be available on their efficacy and licensing for commercial use. I know that this has been said for years, and it may be several more years before one is commercially available, but no longer because there is not a viable working process. We are still in a transitional stage, nothing is yet in an actual operational phase.

First, let's review what a mass deacidification process is, what it does, and how it will benefit libraries that have millions of brittle books. Well, it won't. Mass deacidification does not return a book to its original condition. Deacidifying a brittle books leaves you with a brittle book. "Many researchers dream of finding a fountain of youth"[1] for books, said Richard

Smith, in 1979. But a mass deacidification process cannot guarantee eternal life for books, it can only prolong the life of books that are in a nondeteriorated condition. The book will last longer because the paper is more permanent, but that does not make it more durable so that it can stand longer use.

The term deacidification is actually a misnomer. Acid in the paper is neutralized (the paper is not actually deacidified) and is buffered—i.e., an alkaline reserve is introduced—so that new acid formed in the paper through further degradation or introduced from polluted air will also be neutralized in the future. Acid in paper, introduced in several ways, whether from alum rosin size, bleach used in manufacturing, or in lignin as part of the ground wood pulp, is the catalyst which causes the chemical breakdown of paper. As a catalyst, it is not used up in the chemical reactions and, therefore, is always present to cause further deterioration.

Mass deacidification is the process by which a bound volume or stack of loose sheets can be neutralized and buffered as a whole. The neutralization agent is introduced into the volume as a gas or a liquid which penetrates the entire volume. The gas or liquid is pulled into the paper under a vacuum, the paper deacidified, and the waste products pulled out and destroyed.

There are a few points I would like to make about deacidification processes in general. First, they are highly technical in nature, as you will see in a moment, and require skilled engineers and technicians to set them up and operate them. These professional people are expensive. But these processes' technical apparatus require skills not taught in library school. For this reason, and other safety and health considerations, an off site technical facility will be necessary except in the largest libraries. Besides personnel costs, there are equipment, chemical and handling costs that will necessarily require either cooperative ventures among libraries or a commercial basis of operation.

Second, as I have said, a brittle book would benefit very little from mass deacidification. The ideal time to deacidify a book is when it is new, in good condition, and not yet deteriorated. I think it will be difficult to persuade librarians that a new book needs this kind of attention. It will require a conscious decision that this book has long range value, meets long-term research needs, and is necessary to the collection for permanent retention. An interest is developing in providing mass deacidification services among commercial binders. The paper could be deacidified when the book or serial is bound or rebound, at the time the book is disbound. The book has already been sent outside the building, and the procedures for handling these materials are well-defined. One could perhaps safely assume that if a monograph needs rebinding, it has been used, and therefore is necessary to the collection. However, at the costs estimated, $5 per

book added to an estimated cost of at least $6 for binding, could we justify deacidifying volumes sent for binding, or would there have to be another set of selection criteria? Also, because of the still largely undetermined effect on book structures, bindings, inks, and adhesives, one must still be cautious about sending very valuable books or unique manuscript materials for deacidification. Beside the possible effect of the deacidification process, one must take into account the need for security outside the library. So for the forseeable future, we are faced with several unanswerable questions.

Back to the topic at hand. George Kelly of the Library of Congress and Jonathan Arney, recently of Carnegie-Mellon and now in the paper industry, have identified criteria necessary for a good mass deacidification process. I have borrowed from their lists with slight adjustments and combined information from various sources to compile the following list of criteria for a mass deacidification process:

1. Is the book completely penetrated in a reasonable time?
2. Is the book paper uniformly neutralized?
3. Is the book paper at an adequate pH level?
4. Is an alkaline reserve left in the paper?
5. Does the agent react chemically with the paper and not volatilize out?
6. Is an odor left in the book?
7. Is the treatment process toxic to humans or the environment?
8. Is the treated paper toxic to humans?
9. Are new problems introduced or paper characteristics changed?
10. Is the treatment economically feasible?
11. Can the process be done in-house?
12. Are there exceptions, i.e., books that should not be treated?

The four processes I will be discussing are the vapor phase deacidification, Barrow morpholine, the Wei T'o liquified gas, and the diethyl zinc process.

Vapor Phase Deacidification (VPD)

Although I was not specifically asked to talk about the Langwell VPD method, I am disturbed that it is still being produced and sold, and would like to discuss it briefly.

VPD, or vapor phase deacidification, is sold either as pellets encased in cheesecloth pouches to be placed in archival storage boxes, or in thin porous envelopes which can be used to interleave a book. The solid pellets vaporize to permeate the paper with an alkaline gas which neutralizes the acid in the paper. The pH is raised only to 5.6—not high enough to be really effective. No buffering agent is left in the paper, so there are no

long-term effects. The VPD process is being marketed by Interleaf, Inc., in Minneapolis, and advertisements for it have appeared in recent issues of *Library Scene* and other library publications.

The primary problem with VPD is that the main agent is cyclohexylamine carbonate (CHC), which hydrolyzes (reacts with water in the air) to cyclohexylamine, one of the cyclamates and a well-known carcinogen. This is a health hazard to both library staff and library patrons, because the gas doesn't react chemically with the paper but volatilizes out. Most suppliers have discontinued the sale of VPD. Nancy Gwinn in her article about the Council on Library Resources and preservation reported that Process Materials Corporation has discontinued carrying it,[2] and I would like to reiterate that it should not be used. Langwell's development of the VPD process and its subsequently identified health risks led the Barrow Laboratory scientists to investigate other chemical substances.[3]

Librarians should recognize that they could be liable in a lawsuit if persons were to develop health problems, and this consideration should discourage the use of hazardous substances such as VPD in libraries and archives. Pro VPD articles have been appearing in the literature lately, and there is controversy about the health risks; but until further research is done, and definite documented information is available, I recommend that it not be used.

Morpholine

The Barrow morpholine process has also been very much a topic in the news lately. The recent articles on preservation by Pamela Darling and Sherelyn Ogden[4] in *Library Resources & Technical Services* and by Nancy Gwinn,[5] "CLR and Preservation" in *College & Research Libraries* review the significant contributions W. J. Barrow made to the field of preservation, as does the article by David Roberson[6] in the second volume, *Preservation of Paper and Textiles* published by the American Chemical Society. Barrow was one of the first to recognize and quantify the rate of deterioration of paper and the role of acid and environment in its chemical deterioration. He was also one of the pioneers in the treatment of paper. In many ways, because he was the first and because the field has moved in more technical directions some of his methods have since been discredited. An example of this is cellulose acetate lamination of paper, which if not done to specifications can cause further deterioration and is nonreversible for all practical purposes. He is, however, credited with the two step aqueous deacidification method widely used today. But one of the discredited projects of the Barrow laboratories is the morpholine mass deacidification process.

It has been difficult to lay to rest the topic of morpholine. The Council on Library Resources (CLR) which has put more than $1.67 million into the Barrow laboratory,[7] has patented the process, and vested the patent in the Research Corporation, a non-profit firm which handles many academic patents. CLR has not yet responded to the latest research which would lead them to discontinue promoting the process, but there has recently been a noticeable change. They had been willing to give the equipment, still in the Virginia State Library, to libraries which might find the funds to test the process, and have encouraged libraries to do so. The Research Libraries Group Preservation Committee talked about testing to be done at Stanford or Johns Hopkins, but after consideration, the topic was dropped. In the Winter 1980 issue of *American Archivist*, a Technical Note was published which indicated that the Pacific Northwest Conservation Laboratory of Port Orchard, Washington, would be setting up a deacidification unit using morpholine.[8] However, according to Robert Goldsmith of Research Corporation: "the only work that has been done utilizing our process was done at the Virginia State Library."[9] That project did not come to fruition, as far as I can tell.

With the publication of Nancy Gwinn's article and the Roberson article, the controversy has again surfaced. But more information is now available from current research which shows the limited usefulness and the health hazards of morpholine.

The Library of Congress Preservation Division Research and Testing Laboratories tested paper treated with morpholine in the early 1970s. The test results show that morpholine volatilized out of the paper within two weeks, and more quickly under humid artificial aging conditions. There is also the problem that morpholine leaves no alkaline reserve or buffering agent in the paper and therefore does not prevent future degradation from new acid produced by or introduced into the paper. The process would probably add ten years to the life of a book, but it would have to be repeated at intervals in order to preserve a book over a longer period of time.

The statement by Roberson that a "recent test of twenty treated books at the Library of Congress show that their pH has not declined in two years,"[10] was brought into question by George Kelly of the Library of Congress. He said they had not done any recent testing. Peter Sparks, Chief of the Library of Congress Preservation Division, has also indicated that the implications of the statement that the "Library of Congress Research and Testing Office tested the process extensively and generally corroborated the findings of the lengthy and thorough testing previously carried out by the Barrow lab,"[11] are not true. Having seen the test results from the Library of Congress in the 1977 Barrow final grant report, some of which are discussed in my earlier article, I can also verify that. Because of this implied recommendation of morpholine by the Library of Congress, Peter

Sparks is currently researching morpholine as a chemical substance and intends to publish the results of his research in the near future. In a recent article on an experiment using morpholine to deacidify textiles, it was indicated that it caused discoloring and accelerated loss of strength. (Kerr, N. et al. "Reinforcing Degraded Textiles: Effect of Deacidification on Fabric Deterioration." In *Durability of Macromolecular Materials*, (ACS Symposium Series, no. 95), edited by R.K. Eby, pp. 357-69. Washington, D.C.: American Chemical Society, 1979.)

The most important issue with respect to morpholine is the risk to the health of both staff and patrons which might accrue, especially in cases where libraries might contain many treated books. Because the morpholine volatilizes out of the paper into the atmosphere, it is important that the chemical be harmless and innocuous. As both Nancy Gwinn and the *American Archivist* Technical Report indicate there is no evidence that morpholine is mutagenic or carcinogenic by itself, or that it combines with nitrites in polluted air to create nitrosomorpholine, a carcinogenic substance. However, there is significant evidence that it will convert in the presence of nitrites under aqueous acid conditions (such as in the human stomach) to the carcinogenic state. Nitrites are widely used as food preservatives and are probably present in all stomachs, and breathing morpholine assimilates it into the body thus possibly setting the stage for the critical conversion. This may be overstating the case, but in a test of seven animals, rats showed 100 percent cancer tumor formation when morpholine and nitrites were introduced into their stomachs.[12] We are all aware of the shortcomings of this type of research and the small test sample, but there does seem to be a significant correlation. The Library of Congress staff reported that they developed headaches and nausea when testing morpholine. My feeling is that, overstated or not, we do not want to create any possible risks to our staffs or users. Minimum government standards for the volume of morpholine in the air (20ppm) are met under morpholine process conditions, but it is rumored that the government will be reevaluating that standard, and that the feeling is that any level of morpholine in the air is unsafe, especially in nonventilated areas with stagnant air.

It is ironic that the Barrow scientists began looking at morpholine as an alternative when the VPD process was recognized as a hazardous substance, and that morpholine has now been also recognized as hazardous. Of course, no guilt can be assigned. At the time the Barrow lab was working with morpholine, it was used industrially in many common household products, and was approved as a food additive.

Beside the fact the the morpholine process doesn't really work, and that it is a health hazard, in a humid atmosphere it smells like dead fish. I also hope that it will soon become a dead issue. If you want to know more about the morpholine process, how it was developed or how it works, I

refer you to the references in my 1979 article, and Nancy Gwinn's article gives an excellent account of the history and development of the process in the Barrow laboratories.

Wei T'o Liquified Gas

Mass deacidification has long been one of Richard Smith's research and development interests. His 1970 dissertation for the University of Chicago Graduate Library School addressed the topic of nonaqueous deacidification. In 1972 he patented a nonaqueous process in the United States and Canada. His company, Wei T'o Associates, markets this product as a solution or a spray. Wei T'o is the "ancient Chinese God who protects books against destruction from fire, worms and insects, and robbers, big or small," according to the company letterhead. The deacidification agent in Wei T'o is methyl magnesium carbonate. This same agent is used in the mass deacidification process.

In 1974, Richard Smith was asked by Jan Pidek, head of the Records Conservation Division of the Public Archives and the National Library of Canada, to direct the installation and testing of this mass deacidification process using Wei T'o as the deacidification agent. In 1977, an article on the design of the system was published in the American Chemical Society's work, *Preservation of Paper and Textiles*[13] edited by John Williams. When I recently interviewed Jan Pidek for this paper, he said that the tests had taken longer than anticipated, but that they were very pleased with the results. They were looking for perfection, and had nearly gotten there. I asked about the publication of the test results. He said they were still testing, and wanted to be sure not to jump the gun—as he felt others had done in this field. He anticipates that they will soon go into systematic operational use and within the next six months should have information available for publication. This information will include costs, personnel necessary, testing results, and other types of data that require operational experience. The Canadian project has involved local engineers and technical personnel working with Richard Smith, using his product.

This process is basically different from the morpholine or the Library of Congress diethyl zinc process because it requires that the deacidification agent be introduced as a liquid that impregnates dried books under pressure instead of as a gaseous agent. The solvent in this mass process is methanol and dichlorodifluoro-methane—a nonflammable, nonexplosive, and low hazard chemical. It will clean and rapidly wet closed books; can dissolve and transport the deacidification agent; can be readily removed from books; and it is easily recovered. The paper is buffered with a magnesium carbonate reserve.

This process is actually the least controversial of the three. Problems exist because the books must be moistened by the solvent. As Richard Smith says: "Actually the books are flooded; they are absolutely soaking wet all the way through,"[14] but the deacidification medium is widely used by paper conservators, somewhat modified at the Library of Congress, and the chemistry is recognized to be sound. Because this process does seem to be viable, and the Canadian test successful, a discussion of how it works is useful.

First the books are selected for treatment. Because of the need to wet the books and the solvent used, some books are inappropriate for treatment. These include books containing ball point ink and laminated plastic or artificial leather bindings which might be effected by moisture or heat. Any alcohol-soluble ink causes problems too, as do some colored inks. The print may offset or feather while wet. The selected books are loaded into several wire baskets which hold ten to fifteen books. They are dried for twenty-four hours in a warm air dryer, then loaded into a vacuum dryer to be dried overnight. It is necessary that the books be completely dry because if the deacidification agent reacts with moisture, it precipitates out to a solid state. About twenty-five dried books are loaded into the process chamber at one time. The air in the chamber is evacuated, the pressure equalized between the process and storage tanks, and the deacidification solution pumped out. The books are thoroughly wetted by increasing the pressure. The excess solution is drained out and flash drying commences by evacuating, recovering and condensing the solvent vapors. Richard Smith mentions that this is analogous to the working of a refrigerator. A vacuum pump removes the residual solvent. The books are warmed by warm air, the pressure raised so the doors can be opened, and the books removed. The books are then packed into cardboard cartons and allowed to regain moisture and return to room temperature overnight.

Because of the nature of the solvent, the paper does not swell, and thus does not stress the bindings.

Richard Smith has published this process in several places, and articles are available which go into much greater detail about the mechanics of the system. I am not sure what the next step for implementing this process is. Jan Pidek indicated that the National Library of Canada and the Public Archives of Canada will probably license the process and make it available to other libraries. We are still some time away from test results from the National Library of Canada. Conservation professionals who have seen the setup in Canada think it could be a useful process. It was indicated that there are not any other libraries thinking about using the process at this time. The mechanics of increasing the scale will have to be addressed and could create unforeseen problems. The process will also have to be shown to be cost effective. Estimated costs right now are $4 per book.

The conservation profession feels that objective information is not available. George Kelly remarked in the *Cambridge Conference Preprints* that, "We will look forward to the opportunity to evaluate the results for the pilot trials when they are published." Very little has been written on the Wei T'o liquified gas process except by Richard Smith. To date, an unbiased description of the process or its results has not been published. This has caused a tendency for skepticism in the field, and the publication of results from Canada by less-biased researchers, scientists, and engineers are eagerly awaited. We are in a "wait and see" holding pattern at this time.

Richard Smith says that it is possible that this process can be expanded to include paper strengthening agents for brittle paper, fungicides and other rodent and insect repellants. Richard Smith is doing further research into these possibilities, and tells me he is currently looking for funding.

Diethyl Zinc

Peter Sparks, Chief of the Preservation Division at the Library of Congress, is strongly committed to putting the diethyl zinc process into operation. After many obstacles have recently been overcome, it seems that it will be an effective, viable, mass deacidification process. Further large-scale trials will be held at the NASA Goddard Space Flight Center chamber in Green Belt, Maryland, in April (originally they were planned for October or November, but have been bumped by the space shuttle).

George Kelly, Robert McComb and John Williams, research scientists in the LC Preservation Division Research and Testing Office, began working on developing a mass deacidification process in 1971. They had experimental results that the amines (e.g., morpholine) were ineffective in the long run because they volatilize out of the paper. They turned to an organo-metallic compound, diethyl zinc. By 1972 they were publishing early test results . The first large-scale trials were held in 1978 in the General Electric Space Center in Valley Forge, Pennsylvania. General Electric had been using this chamber to dry flood wet books, were familiar with libraries, and at that time were interested in further services to libraries. There were three trials in 1978, with interesting results.

The processes seemed to work well, but two major problems surfaced. One was the deposit of irridescent ring formation on book covers packed in contact with each other, and the other was the tendency of the diethyl zinc deacidified paper to age more quickly than usual under exposure to ultraviolet light in humid aging tests. The problem with the covers was solved by mechanical means in succeeding trials; spacers of hardware mesh between the books kept the rings from forming. The light sensitivity problem was solved chemically by modifyfing the process to leave zinc carbonate rather than zinc oxide as the alkaline reserve. This was accom-

plished by adding carbon dioxide in a damp state into the chamber after the excess diethyl zinc was destroyed.

The essential points of the process are as follows: 5000 books are loaded on loosely packed shelves spine down for easier gas penetration; spacers of hardware mesh are placed between the books. The books are warmed and dried in a vacuum chamber for three days in order to remove all traces of water. This is very important because diethyl zinc is explosive in the presence of water. After the chamber is at full vacuum, with no leaks (diethyl zinc ignites on reaction with air), the chemical reagent is added. Diethyl zinc is a sensitive leak detector, even an extremely tiny leak will show up as white smoke in the chamber. The smoke settles on the books in the form of a white powder which is a nuisance to clean off. After three days exposure to the vapor, under pressure, the books are completely penetrated, deacidified and buffered. The excess diethyl zinc is then removed from the chamber by adding alcohol. There are to be some variations of this part of the process which will be worked out for the next trial run. The vapor is tested to insure that all the diethyl zinc is gone, and the organic vapors are then pumped from the chamber and moist carbon dioxide is pumped in. After twenty-four hours, the moist carbon dioxide has hydrolyzed the diethyl zinc cellulosate to reform the cellulose and leave zinc carbonate as the alkaline reserve. The chamber is again pumped out and the books removed.

The treatment cycle lasts eight days. As you can see, it is very important that the chamber be monitored for any type of leak. This is not a process that can be done in a library basement. It is, however, a process that can be done in any vacuum chamber, and there are vacuum chambers large enough to hold a Polaris missile.

Test results show that the pH of the book paper is raised to 7.8 and an adequate two percent alkaline reserve is left. This is a relatively mild process which makes it more applicable to items with colored inks. Because the agent is introduced in a vapor state, it does not involve wetting the books and there is little danger of offsetting printed images or of the feathering of ink.

Some anomalies have shown up in the latest test results. Groundwood papers showed increased degradation under dry aging conditions, but performed well under humid conditions. The next series of tests should give further information. Peter Sparks has indicated that the Library of Congress is considering asking several libraries to contribute books for testing so some independent testing on penetration, pH and aesthetic considerations can be done.

The only testing to date has been at the Library of Congress. Test results have been widely published in the library preservation media

together with full discussions of both the problems encountered and the solutions to those problems.

Because the diethyl zinc reacts chemically with the paper and remains in the paper as zinc carbonate, health risks should not be a problem with the treated books. Peter Sparks is researching this further now.

Since 1979, several administrative problems have surfaced. General Electric (GE) no longer has any plans to use the space chamber for books—whether drying flood wet books or for mass deacidification. The GE chemist, Dick Schoulberg, who worked on his project, was very apologetic, but felt that due to the new management nothing could be done at this time. Rumor has it that the chamber is for sale, if anyone is interested. They feel that there isn't any profit in it, and they have been unwilling to take the risk of an incident with the chemical diethyl zinc. The newest approaches to the shipping, handling and costs of diethyl zinc might change their minds. The Library of Congress has turned to government owned NASA chambers. Peter Sparks assures me that there are several that should be available. A commercial library binder indicated interest in offering this service, but felt that the fact that the Library of Congress has gone to internal chambers has effectively kept the private commercial sector out. It remains to be seen what will happen. There are probably chambers available, but where and how available is yet to be determined. The Library of Congress is exploring this process with large industrial firms who may want to set up centralized service centers.

The primary administrative problem has been the transport and handling of diethyl zinc. As I have mentioned, it is a very volatile substance, igniting on contact with air, and explosive on contact with water. The manufacturer, Texas Alkyls, a division of Stauffer Chemical, had been for some time unable to find a satisfactory means of shipping the chemical. They were not willing to take the liability risks of having their truck blow up on the highway; and diethyl zinc tended to corrode standard containers. The problem has recently been solved as indicated in the "Annual Report of the Librarian of Congress, 1980" as published in the *Library of Congress Information Bulletin:* "Continued work by Stauffer Chemical Company, however, has indicated a possible solution to the supply of diethyl zinc in a 50/50 mixture with mineral oil. Hazard tests on this mixture are under way and a laboratory sample is scheduled for testing in May."[17] According to Peter Sparks, this testing was done, and the mixture with mineral oil was successful. The oil nullifies the properties of the diethyl zinc, and as they have very different boiling points, the diethyl zinc can be removed as a gas simply by hooking up a line and pulling a vacuum. Some questions have come up as to the supply of diethyl zinc; Texas Alkyls considered discontinuing its manufacture, but have been persuaded to continue and have come up with cheaper methods of production.

The Library of Congress is moving very quickly to complete another large scale test in the Spring. Funding has been obtained and all is ready to proceed. The intent is to license the process for the private sector. Peter Sparks indicated that there are several interested parties, and that it should move very quickly from here. A report at ALA in Philadelphia (summer 1982) should be available with results of these trials. One question that remains to be seen is whether librarians will be willing to pay the $4 to $5 per book plus handling and shipping. It may be cheaper if larger numbers of books are done at one time in larger chambers. The ideal candidates will be the nonrare books that are still new and relatively undeteriorated, both because of the offsite requirements and the nature of the process. The next few years of experience at the Library of Congress will show us the way. LC has budgeted $50,000 for books from their collections to be deacidified in 1983 and more for 1984.

Conclusions

In my research, I tried to get realistic analyses of the situation from various scientists, conservators and other people in the field. I don't know whether I got any views that were realistic. And I'm not sure what the future prospects are. I think one would need a crystal ball to call this one. My best analysis of the situation is:

1. VPD use should be discontinued; no longer sold, or used.
2. The morpholine process should be dropped because it doesn't work and there are health risks pending further research.
3. We will have to wait to see about the Wei T'o process. It has still not been tested or used on a large scale, and test results are not yet available.
4. Diethyl zinc process will be further tested in the Spring. The problems of available chambers, liability, safety and environmental risks related to its use will have to be solved. It looks like they will be, and this process probably has the most possibilities on a truly mass scale.

In their January/March 1981 *Library Resources & Technical Services* article, Pam Darling and Sherelyn Ogden said, "A degree of skepticism, and even despair, was creeping into the literature by the late seventies as major breakthroughs in the mass treatment area continued not to take place."[18] Imagine my consternation when reference 44 in that article was my 1979 *Library Journal* article. Well, they were right, and I still tend to be skeptical about mass deacidification. But, in many ways, I am more optimistic today than I was two or three years ago because there has been considerable progress in at least a few related areas. More librarians have

come to understand that mass deacidification can only be one small part of any preservation program, and won't solve all, or even most, of our problems, although it may help prevent future ones.

Mass deacidification is not the fountain of youth we're seeking and can't ever be. Our future depends on the developing awareness of publishers, the economics of paper making, the development of information storage techniques such as optical disks, environment controls and complete preservation programs, which may, and probably will one day include mass deacidification.

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Roberson, D.D. "Permanence/Durability Research at the Barrow Laboratory." In *Preservation of Paper and Textiles of Historic and Artistic Value II* (Advances in Chemistry Series, no. 193), edited by John C. Williams, pp. 45-55. Washington, D.C.: American Chemical Society, 1981. (On the Barrow Laboratories; one paragraph on the morpholine process which misrepresents the Library of Congress' position.)

Wei T'o

Rebsamen, Werner. "A Genuine Break-through in Mass Deacidification." *LBI Technology Newsletter* vol. 1, March 1981. (Rehash of Smith articles; description of the process.)

Smith, Richard D. "Mass Deacidification at the Public Archives of Canada." In *The Conservation of Library and Archive Materials and the Graphic Arts Abstracts and Preprints,* p. 131. Cambridge, England: International Conference on the Conservation of Library and Archive Materials and the Graphic Arts, 1980. (Brief description of the mechanics of the process.)

_____. "Progress in Mass Deacidification at the Public Archives of Canada." *Canadian Library Journal* 36(Dec. 1979):325-32. (Statement on why books should be deacidified; description of mechanics of the process and its development.)

_____. "Preservation: Library Need and Industry Opportunity, Part II." *Library Scene* 9(March 1980):10-14. (A not so long version of the *Canadian Library Journal* article.)

_____. "Preserving Our Books; A Chemical Problem." *ChemTech* 11(July 1981):414-17. (With a chemical slant.)

Diethyl Zinc

Kelly, George B. "Mass Deacidification with Diethyl Zinc." *Library Scene* 9(Sept. 1980):6-7. (Development and description of the process; includes recent improvements; thoughts on future developments.)

_____. "Non-Aqueous Deacidification: Treatment En Masse and for the Small Workshop." In *The Conservation of Library and Archive Materials*, pp. 126-30. (Includes description of each process, but concentrates on diethyl zinc; includes criteria for mass deacidification systems.)

Kelly, George B., and Williams, John C. "Inhibition of Light Sensitivity of Papers Treated with Diethyl Zinc." In *Preservation of Paper and Textiles*, pp. 109-17. (The problem of faster aging of treated paper under ultraviolet light in humid conditions; design of experiment, data and solutions.)

DISCUSSION

James Orr (Hertzberg-New Method, Inc., Jacksonville, Illinois): Some time ago when General Electric (GE) had the deacidification program at their Germantown plant, there was a good deal of interest by a number of our customers in the East Coast area to get into a deacidification program. At that time we had some discussion with GE as to whether we could use their chamber. They were evaluating the program. At the same time, we were evaluating it knowing that probably we would handle a great deal of valuable and rare material. So before we progressed, we figured that it would be wise to protect ourselves from possible liability. So, we asked the various libraries that were interested in this if they would be willing to sign a release in the event (maybe not in my lifetime, but in time to come) that something would happen to that material as a result of the deacidification. And at that time there wasn't too much enthusiasm. This turned everybody off. Just about that time the people who manufactured the gas said it was too dangerous to transport so they discontinued the whole thing. We have been trying to follow this very closely as well as developments at the Library of Congress.

There still seems to be quite a bit of interest in deacidification. This takes me back to my old question: I wonder how many people here, to embark on this program, would be willing to sign a release that even if something happened to the material in due time that they would be willing to go along on an experimental basis? That is my question.

Carolyn Harris: I'm not sure that I would. Do you want a show of hands? (*Editor's note:* There was no response.) That may be your answer. That may be one of the problems with setting up a mass deacidification program.