Corn-Based Absorbent Dries Soggy Books

If you've ever accidentally spilled a glass of water on a magazine, then you've got an idea of what happens when an entire book—or even entire book collection—gets soaked, such as from flooding or broken water pipes.

Freeze-drying methods are used for salvaging large numbers of saturated books and documents, while fans, blotters, and open air are the norm for smaller numbers. But time, cost, and convenience can weigh heavily on the minds of library conservators, especially during the first 48 hours of a disaster, when mold growth begins.

Now, a decades-old ARS invention called "Super Slurper" is being pressed into service as the latest new tool for drying wet books—and beating menacing molds to the punch.

Biochemist William M. Doane (retired) and colleagues developed Super Slurper in the 1970s at ARS's National Center for Agricultural Utilization Research in Peoria, Illinois. The patenting of their creation—a cornstarch-and-polyacrylonitrile-based polymer that absorbs up to 2,000 times its weight in liquid—inspired several commercial products, including disposable diapers, fuel filters, absorbent wound dressings, and seed coats.

The latest use, for book and document drying, is the brainchild of Kathleen C. Hayes. Before her recent retirement, she was an information specialist with the Technology Transfer Information Center (TTIC) at ARS's National Agricultural Library (NAL), a 14-story building in Beltsville, Maryland, that houses more than 3 million books, periodicals, and other materials related to agricultural topics.

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According to Kate Hayes, retired ARS information specialist with the Technology Transfer Information Center, tests show that interleaving wet books with Zorbix sheets at 10-page intervals results in getting the book 90 percent dry in 3 hours with three changes of Zorbix.

Super-Slurper Serendipity

Hayes's Super Slurper idea came to her March 21, 2002, while attending "Lessons Learned in Emergencies," a preservation conference hosted by the National Archives and Records Administration in nearby College Park, Maryland. Listening to a speaker discuss fire-suppression systems, Hayes mused that librarians and preservation specialists could look to industries beyond their respective communities for new ways of drying books.

"I then thought about disposable diapers and their ability to wick moisture away from a baby's bottom," recalls Hayes. "The early disposables contained Super Slurper, a product invented a long time ago by ARS. The brain then made the leap to the possibility of using Super Slurper to dry wet books."

Months later, Hayes was put in touch with Nicholas Yeager, an expert in book and document restoration and president of Artifex Equipment, Inc., Penngrove, California. Yeager liked Hayes's idea and decided to give it a try. He placed a paperback book under the faucet for a thorough drenching. He then sprinkled on Super Slurper and subjected the paperback to a press. Sure enough, the polymer worked as Hayes had proposed. It dried 5 sheets of the book in either direction in about 1 minute, though two of the treated pages stuck together.

"I said to Kate, 'Do you know what you have on your hands here?'" recalls Yeager of their phone conversation, to which Hayes replied, "There's got to be a way you can encapsulate this stuff so it doesn't stick to the book."

Bicoastal Brainstorming

To continue and to formalize the collaboration, TTIC signed a material-transfer, cooperative research and development agreement with Artifex in August 2003. Then, in February 2004, Yeager obtained a USDA Small Business Innovation Research (SBIR) grant to further test Super Slurper and gauge its commercial potential.

A first step was to figure out how to make Super Slurper easier to handle and keep it from gluing book pages together when placed between them. Yeager's solution was to change the polymer's flake form into another that could be processed into specially coated, page-size sheets. Another priority was making sure the polymer didn't cause unintended harm, like smudging a treated page's inks and pigments.

Under the SBIR grant, Yeager consulted with, and submitted product samples to, William Orts, research leader of ARS's Bioproduct Chemistry and Engineering Research Unit in Albany, California. Using solvent-based extractions and mass spectrometry analysis, Ort's group checked for Super Slurper residues on books and papers they had treated with the polymer. "We couldn't prove there wasn't any residue on the paper, but we also couldn't find any detectable concentration of it either," says Orts, whose unit specializes in making biodegradable plastics, packaging, and single-use items from wheat, barley, and rice byproducts.

Hayes, meanwhile, talked with experts about Yeager's needs and referred him to organizations set up to assist entrepreneurs. She also drew on NAL's extensive literary resources to generate patent, grant, marketing, supplier, trade name, and other information of use to Artifex's product development. Yeager initially called their new, Super-Slurper-based product "Dri-Gel," but later

Demonstration of the water-absorbing ability of Zorbix sheets. On the left, the product is dry at the start of the test. On the right, the Zorbix is absorbing the water.

changed it to "Zorbix," the name now on a provisional patent listing Yeager and Hayes as joint applicants.

In tests, Yeager observed that Zorbix absorbed up to 50 times its weight in liquid and worked best when pressed firmly onto a wet surface. The drying times he recorded varied according to the number of Zorbix sheets interleaved in the book. At 30 leaves per Zorbix sheet, 12 hours were needed to dry a book with 6 changes of the polymer. Using even more shortens the drying rate. "An ideal balance," says Yeager, "is 1 sheet of Zorbix for every 10 leaves of paper in the book, resulting in getting the book 90 percent dry in 3 hours with 3 changes of Zorbix."

According to Yeager, Zorbix's use can avoid the pitfalls of air drying, such as mold growth and page swelling. Another attractive feature is that Zorbix is reusable up to 10 times and is 70 percent biodegradable, thanks to its cornstarch component. Zorbix stays dry to the touch even after absorbing water, which eventually escapes the polymer as vapor.

Putting Water Back In

From this last observation, Yeager determined Zorbix could also be used as a humidity blanket. For this application, Zorbix is saturated with water, and the escaping vapor rehydrates dry, fragile paper.

Papers made of cellulose fibers require about 7 percent moisture to stay flexible. "If a book has acid in it or is really old, the moisture content can go down to 3 or 4 percent," Yeager says. "The humidity blankets work by relaxing brittle paper that has been folded up but needs to be flattened or that has creases that need to be removed."

University of Iowa Libraries conservator Gary Frost marvels at Zorbix's ability to absorb and release water—a feature he says makes the sheets easier to reuse than the aqueous poultices and blotters he has worked with. "The sheets play the same role more efficiently," he says.

Frost foresees uses for Zorbix beyond those pertaining solely to library-disaster scenarios, like flooding. "I'm confident there's a wider market for it associated with the routine restoration of documents of all kinds." New applications are likely to arise, he adds, as conservators become even more familiar with the product's properties.

Zorbix, together with another Artifex invention called the "Vacme Press," also earned high marks in a disaster-recovery study coordinated by preservation librarian Randy Silverman at the University of Utah's J. Willard Marriott Library in Salt Lake City. In that study, participants from around the world soaked books—ranging in age from the 1700s to the present—in water for 24 hours to simulate floodwater exposure. They dried the books using one of five methods: Zorbix plus the Vacme Press, air-drying, vacuum-pack drying, thermal-vacuum drying, and vacuum-freeze drying. Measurements for paper damage were determined through laboratory tests by the British Library in London and Applied Paper Technology in Atlanta.

"Yeager's technique was among the top-performers in the test, both in not damaging the paper and drying it very flat," reports Silverman. The Czech National Library's thermal method, used in Prague, allowed for books to be dried extremely flat, though at the cost of weakening the paper at the molecular level. The Zorbix-Vacme Press was labor-intensive to use, but no more so than vacuum-packing—used by the British Library. Zorbix-Vacme Press also allowed for flatter drying than vacuum-freeze drying, which participants from Belfor, USA, in Fort Worth, Texas, used, adds Silverman, who published the results in summer 2006.

Yeager debuted Zorbix on a limited scale in March 2006. "We're selling to libraries across the United States," he says, "and our output is increasing."

Besides the Iowa and Utah state-university libraries, other notable clients Yeager says he has filled orders for include the Library of Congress in Washington, D.C., which is among the world's largest. Hurricane Katrina, which hammered the Gulf Coast region in August 2005, also stoked interest in Zorbix, "including some people looking to dry their books at home," says Yeager.

During the first product run, Yeager's staff handmade 2,500 sheets of Zorbix. Now, he is in the final stages of developing a machine for commercial Zorbix production.

Besides helping stave off mold growth within the first 48 hours of water exposure, as well as allowing materials to be dried relatively flat, Zorbix will enable conservators to treat their valuable collections on site.—By **Jan Suszkiw,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS National Program (#306) described on the World Wide Web at www.nps.ars.usda.gov.

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