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ZFB boxes

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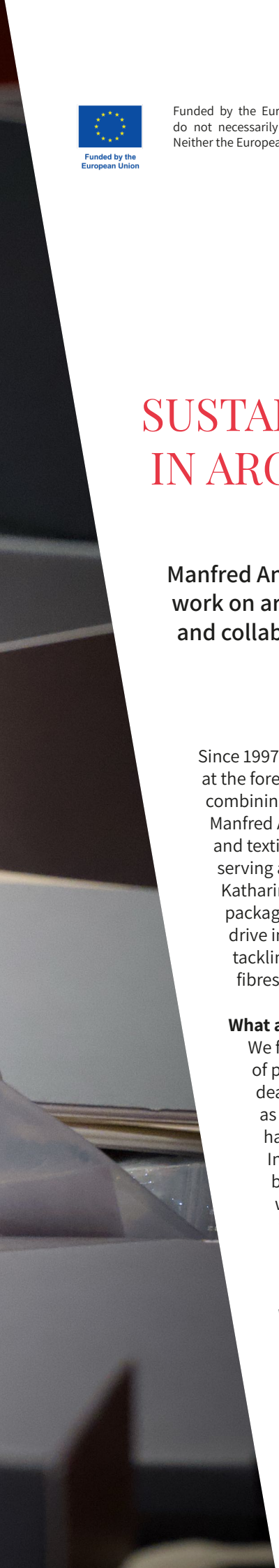
GREENART



SUSTAINABLE INNOVATIONS IN ARCHIVAL PACKAGING

Manfred Anders and Katharina Schuhmann of ZFB discuss their work on archival packaging, sustainable materials, automation and collaboration within EU-funded projects like GREENART.

Since 1997, ZFB Centre for Book Conservation has been at the forefront of archival packaging and paper conservation, combining traditional expertise with cutting-edge research. Manfred Anders, a chemist specialising in cellulose, paper and textile chemistry, has been with ZFB since the beginning, serving as Head of R&D and later as Managing Director. Katharina Schuhmann, an engineer in printing and packaging technologies, joined in 2015. Together, they drive innovation in sustainable packaging materials while tackling the challenges in archival storage, alternative fibres and intelligent packaging solutions.

What are the core services of ZFB?

We focus on the preservation and conservation of paper-based cultural heritage, offering mass deacidification, freeze-drying, surface and dry cleaning, as well as paper and cover restoration. Since 2015, ZFB has also expanded its production of archival boxes. In Germany, these boxes are primarily used for storing books, files, and other written documents. However, we also produce fully customised designs tailored to the storage needs of diverse collection objects, regardless of shape or material. These solutions are particularly beneficial for museums.

What problems in the use of traditional box materials might arise for conservation?

Archival boxes significantly improve storage conditions, offering protection against UV light, mechanical damage, and dust, while providing a buffering effect against humidity fluctuations. To ensure long-term protection, it is recommended to use materials that comply with ISO standard 16245-A. This standard requires lignin-free and alkaline boards made from cellulose-based materials. Achieving the "lignin-free" benchmark (kappa value below 5) typically excludes recycled fibres of unknown origin and composition, as they may not meet the purity and durability criteria. Instead, the industry standard relies on virgin wood fibres. However, given the high energy and water consumption required for pulping, we have explored plant residues as a more sustainable alternative for archival board production. Additionally, the long-term availability of wood as a raw material for paper production is expected to be limited in the coming decades, making alternative sources an important area of research.

What materials do you use for your boxes? Do you foresee any improvements in this aspect?

Currently, we produce archival boxes and enclosures using corrugated and solid boards made from virgin wood fibres — specifically northern bleached

softwood pulp (NBSK) — in compliance with ISO 16245-A requirements. This material is exclusively developed and produced for ZFB, and we maintain continuous collaboration with paper mills and converters. Over the years, we have made significant improvements, particularly in non-fade properties and moisture resistance. As part of the GREENART project, we have explored the potential of fibres from annual plant residuals as a sustainable alternative to replace one or more paper liners in our boards. Additionally, we are investigating the use of polypropylene hollow chamber sheets and bubble boards, particularly those made from recycled or bio-based plastics, as another innovative approach to archival storage materials.

How automated is your custom-made box production and how are you improving it?

ZFB primarily manufactures and distributes archival boxes. Currently, we produce 50,000 to 100,000 archival packaging boxes and aim to scale up to several hundred thousand boxes annually. Over the past years, we have developed a highly automated workflow, creating an extensive library of standard construction templates. For example, when packaging a large collection of books, we use a survey device to measure each book's dimensions. These measurements are seamlessly integrated into our workflow, where all CAD drawings are automatically generated, sent to, and processed by an automated cutting table. However, we collaborate with external die-cutters for large-scale production runs of identical designs. When it comes to custom-made constructions, our product designers develop tailored solutions. We can generate 3D previews and provide physical samples to ensure clear communication with our customers, allowing them to review the design before production begins.

What challenges do the fast-growing plants you are sourcing present?

So far, we have evaluated a wide range of plant fibres and papers, including hemp, abaca, bagasse, flax, jute, wheat straw, cotton, silphia, and mixed agricultural residuals. We have produced our own papers on a lab scale and at a technical centre, while also exploring commercial papers made from these materials. However, we are not directly involved in the planting or farming processes. Many plant fibres were used in paper production before wood pulp became dominant. Our research confirms that they can still produce high-quality papers. To ensure suitability, we have tested them for compliance with ISO 16245-A and assessed their material emissions and impact on cellulose degradation, in collaboration with the University of Ljubljana. Several promising fibres have been identified from a technical perspective. In the final year of our project, the University of Venice and Green Decision will conduct a life cycle assessment on all proposed materials. This will help determine the most sustainable option based on environmental impact. One of the biggest challenges remains cost. Although these fibres are agricultural byproducts, their specialised production in small batches (a few tonnes) makes them more expensive than virgin wood pulp. As with many sustainable choices, it ultimately comes down to deciding what price we are willing to pay for the benefit of our planet and future generations.

What box designs are you developing?

As part of the GREENART project and the previous APACHE (Active and Intelligent Packaging Materials for Cultural Heritage) project, we have developed tightly sealed archival boxes with no holes or slits and additional material layers. Climate chamber tests with cyclic humidity changes have demonstrated that this tight construction provides a two to six times higher buffering effect compared to a standard box.

What types of coatings do you use?

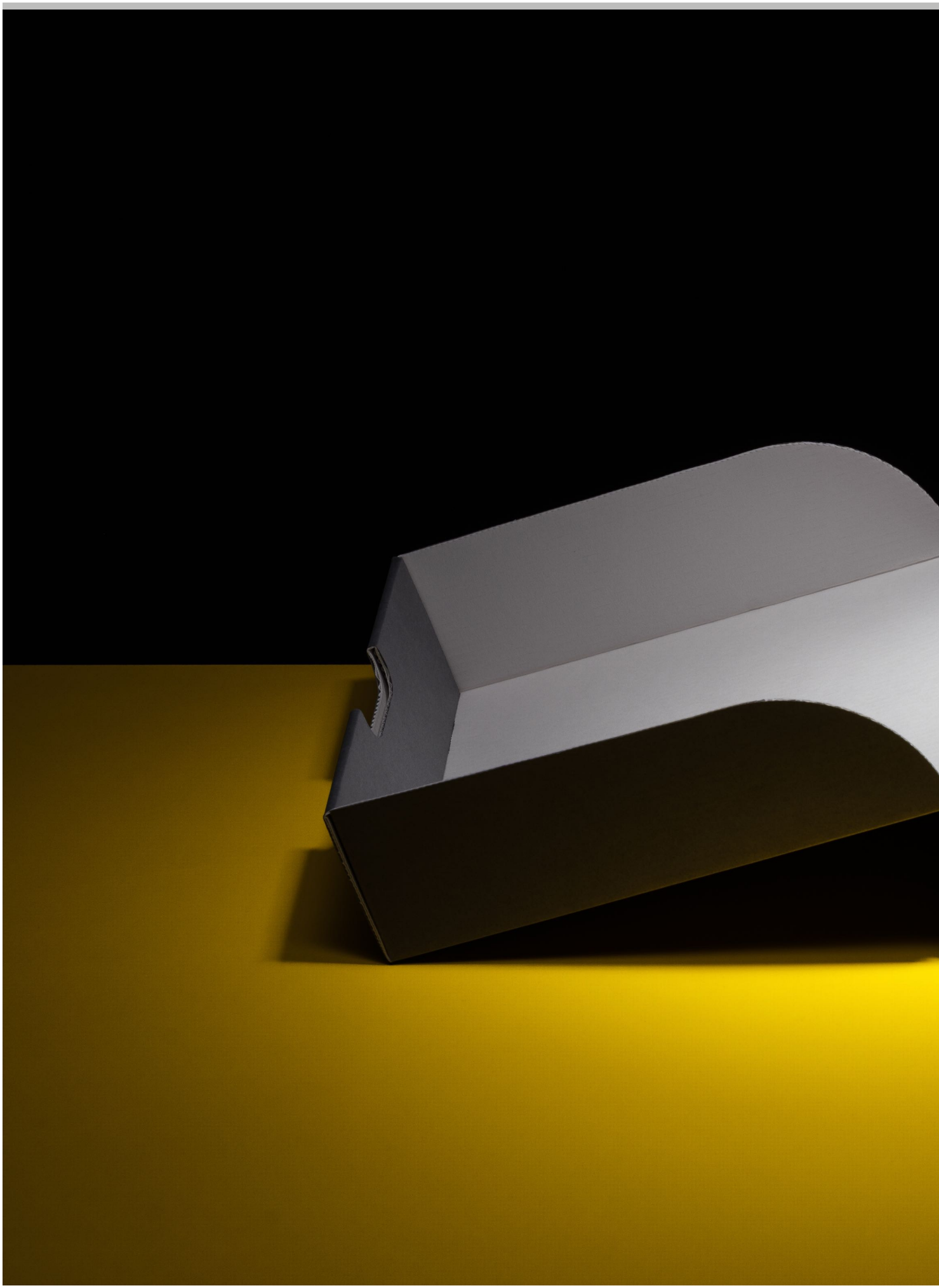
We have tested various coatings, including water-based dispersions, UV-curing varnishes, and bio-based wax coatings to enhance air-tightness and improve the buffering effect. While these coatings improved humidity regulation, tests according to ISO 23404 revealed emissions that slightly degraded cellulose-based objects. For this reason, we cannot currently recommend the tested coatings, but we continue searching for effective and sustainable solutions that balance protection, conservation, and long-term material stability.

Do you plan to standardise the addition of sensors to your boxes?

Yes, we plan to develop optional sensor systems that can be integrated into newly purchased

Katharina Schuhmann

Courtesy ZFB



ZFB box

Courtesy ZFB

and existing archival boxes. In an airtight enclosure, temperature and humidity monitoring are the most critical factors for ensuring the safety of stored objects. By tracking these conditions, we can help prevent deterioration caused by fluctuations in moisture and temperature, which are major risks for paper-based and other sensitive materials.

Can standard boxes be improved?

Yes, they can be equipped with sensors for environmental monitoring or integrated with adsorbing materials developed by other GREENART partners. However, available space inside the box is a limitation — safe integration requires room, typically in the lid or base area. We also explored a refurbishing treatment to reduce harmful emissions from aged, acidic archival boxes. A water-based deacidification solution was developed for spray or brush application directly within collecting institutions. However, our tests showed that this treatment had limited effectiveness while requiring significant effort. Compared to bespoke boxes, standard boxes offer some degree of improvement, but they cannot match the precision fit, tailored protection, and advanced material options of custom-made solutions.

Have you worked on previous EU projects before GREENART?

Over the past ten years, we have contributed to several EU-funded projects led by Piero Baglioni and his team at CSGI (Centre for Colloid and Surface Science) in Florence. In the NanoForArt and NanoRestArt projects, we worked on developing formulations for the protection of leather book bindings, stone and metal surfaces, as well as the consolidation of canvas using in-house-developed nanodispersions and nanocellulose. Since the APACHE project in 2019, our focus has shifted toward active, intelligent and sustainable solutions for improving conventional archival packaging boxes.

How do you collaborate with GREENART project partners?

We closely collaborate with various partners, adapting our approach based on their expertise. We have a strong partnership with the University of Ljubljana, which plays a key role in chemically assessing our proposed materials and solutions. Additionally, we coordinate the integration of greener adsorbing materials and sensors developed by partners such as Chalmers University (Göteborg, Sweden), University College Cork (Ireland) and The Foundation for Research and Technology – Hellas (FORTH, Greece). For museum case studies, we design custom-made boxes that include at least one active component tailored to the specific needs of the stored objects. While the collaboration process varies, scientific institutions primarily focus on research, material testing, and innovation, while museums and institutions provide practical insights and real-world applications. The exchange is dynamic, but the highlight is always the opportunity to meet in person at annual consortium meetings, where interdisciplinary discussions greatly enrich our development process.

Which museums and institutions are testing your products? Have you received any unexpected feedback?

Our novel greener packaging materials are being tested by several prestigious institutions, including the Peggy Guggenheim Collection (Venice, Italy), Hungarian National Museum (Budapest, Hungary), Ministero della Cultura (Rome, Italy), Los Angeles County Museum of Art (LACMA, USA), Slovenian National and University Library (Ljubljana, Slovenia) and the National History Museum (Leipzig, Germany). So far, all institutions have been enthusiastic about testing our packaging solutions. However, since we are still in the middle of the GREENART case studies, we anticipate more detailed feedback in the coming months.

Do you collaborate with other scientific projects?

Yes, ZFB has always been actively involved in internal and national research projects, with a large R&D department for an SME. Beyond archival packaging, our recent research focuses on microfibrillated cellulose production and innovative mass treatments for paper conservation, including paper strengthening and cleaning processes. We would be grateful to continue developing these innovations within the international research network, contributing to future EU projects that support sustainability and conservation advancements.

ZFB factory

Courtesy ZFB


Manfred Anders
Courtesy ZFB