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Development of a Conservation Corrugated Box for Storage of Document Archives

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ABSTRACT

A conservation corrugated box for storing document archives was developed. The specifications of the double-walled E-flute corrugated conservation box were modified from those of the Library of Congress, USA. The Photographic activity test (PAT) of ISO 18916 was used to ensure protection of the archival contents from adverse effects of the container itself. Accelerated aging was conducted to evaluate the conservative properties of the box components. Atomic force microscopy was also used to evaluate changes in the cellulose surface due to accelerated aging.

Key words: *Conservation corrugated box, E-flute, PAT, Accelerated aging, AFM*

1. Introduction

Valuable documental archives must be protected from the adverse effects of chemical substances, physical damage, biological damage, and environmental effects such as high humidity and temperature.[1,2,3] Most valuable archives, in developed countries, are stored in temperature and humidity-controlled environments, and are handled by professionals to prevent them from any physical or biological damages.[4,5,6]

The National Archives of Korea and the National Library of Korea use imported conservation corrugated boxes (CCBs), which cost 10-20 times more than commercial packaging corrugated boxes. However, the superior qualities of imported CCB have not been proven yet with respect to lack of damage to the contents by the CCB itself. The photographic activity test (PAT, ISO 18916) measures the adverse effects of the conservation box on the contents of the box, which could include documents, photographs, films, paintings, etc.

In this study, we recommend specifications for conservation corrugated board for Korean archival institutions after investigating two representative imported CCBs, one domestically developed CCB, and one commercial corrugated packaging board, and after consultation to the specifications of the US

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Library of Congress for CCB.

2. Materials and Methods

Double-walled E-flute conservation corrugated boards imported from the USA (University Products Co.) and Japan (Tokushu Paper Co.) were used as representative of foreign products (Foreign-A and F oreign-B, respectively). Conservation corrugated board was also developed domestically by using liner and medium boards produced by Samhwa Paper Co. (Trial board). A commercial packaging E-flute corrugated board of average quality was selected from various Korean E-flute boards (Commercial box). The PAT, strength properties (ISO methods, Table 1), physical properties (ISO methods, Table 1), and aging properties were evaluated and compared[7)].

Accelerated aging (105oC, 0% RH, 3 weeks of aging) was applied to the specimens, and the changes of their properties were measured. Atomic force microscopy (AFM) was used to evaluate the effects of aging on cellulose[8)].

3. Results and Discussion

The basic properties of the sample corrugated boards are listed in Table 2. The ash contents of Foreign-A and Foreign-B were lower than the Trial board. The ash was composed of calcium carbonate. The commercial box, made from 100% recycled fibers

Table 2. Basic physical properties of the sample corrugated boards

	Basis weight (g/cm^2)	Thickness (μm)	Ash (%)
Foreign-A (USA)	598.82	1721.3	2.3
Foreign-B (Japan)	504.96	1566.75	4.7
Trial board	540.9	1766.13	5.8
Commercial box	546.0	1728.4	10.1

Table 1. ISO methods for strength and physical property evaluation

Properties	ISO Method
Basis weight	ISO 536 Paper and board-Determination of grammage
Thickness, density, bulk	ISO 534 Paper and board-Determination of thickness and apparent bulk density or apparent sheet density
pH	ISO 6588 Paper, board and pulp - Determination of pH of aqueous extract
Tensile strength	ISO 1924-1 Paper and board -Determination of tensile properties - Part 2:Constant rate of elongation method
Folding endurance	ISO 5626 Paper-Determination of folding endurance
Brightness	ISO 2470 Paper, board and pulps-Measurement of diffuse blue reflectance factor (ISO brightness)
Ring crush test	ISO 12192 Paper and board - Compressivestrength - Ring crush method
Edgewise crush resistance	ISO 3037 Corrugated fibreboard - Determination of edgewise crush resistance (Unwaxed edge method)
Flat cruch resistance	ISO 3035 Single-faced and single-wall corrugated fibreboard - Determination of flat crush resistance
Bekk smoothness	ISO 427 Paper and board - Determination of smoothness

Table 3. Liner and medium physical properties of the sample corrugated boards

		Thickness (μm)	Basis weight (g/cm2)	Density (g/cm3)	Bulk (cm3/g)	Breaking length(km)		Folding endurance (count on 1kg)		Burst (Bar)
						MD	CD	MD	CD	
Foreign-A	liner	300.2	226.8	0.76	1.32	6.00	1.62	2,226	128	6.14
	flute	267.5	171.2	0.64	1.56	4.27	2.48	5,824	190	4.20
Foreign-B	liner	210.0	150.4	0.72	1.40	9.29	2.58	4,302	1,019	7.58
	flute	192.4	121.2	0.63	1.59	8.12	3.12	7,441	730	6.04
Trial board	liner	230.0	173.9	0.76	1.32	7.69	3.96	1,561	1,154	5.33
	flute	205.0	153.0	0.75	1.34	8.74	4.50	1,637	1,092	4.44

had the highest amount of ash, which may have included many inorganic impurities in addition to calcium carbonate

Table 3 presents a summary of the liner and medium properties. The breaking lengths of the Trial board along the cross direction (CD) were higher than those of the imported samples. For corrugated board, st rength properties along the CD are very important, because the loading direction is usually along the CD. The folding endurance of the Trial board was lower than that of the others; however, typically >1000 is satisfactory.

We applied accelerated aging to the samples, and evaluated their properties weekly for three weeks. The pH of the samples was measured after separating the liner and the medium (Fig. 1). The Commercial box had neutral pH initially, and became acidic as accelerated aging continued. The other three samples manufactured as conservation corrugated boards, had initial a pH of approximately 9.0, and 21 days later (3 weeks), had a pH of ~8.0. References suggest that one day in a 105oC oven is equivalent to aging for 7-10 years. Therefore, for at least 150 years, we may assume that the pH of these three samples will be higher than neutral (pH 7.0).

Edgewise compression strength (ECT) and flat crush strength are very important properties of corrugated board, and their changes at different accelerated aging times are shown in Figs. 2 and 3. The Trial board had the highest ECT with the imported conservation boxes somewhat lower. The Commercial box had considerably lower ECT, and was not constructed for valuable archives. Flat crush strength had slightly different results; the Trial board had lower value than the imported conservation corrugated boards. However, the Commercial board again had

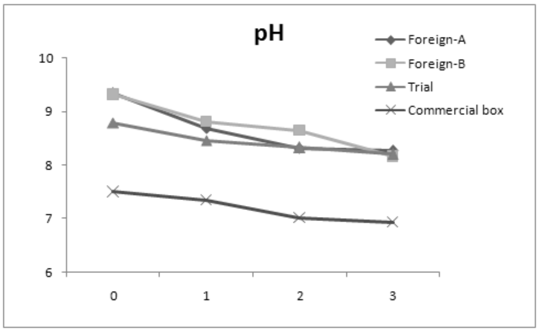

Figure 1.a pH changes in the linerboards of the corrugated boards

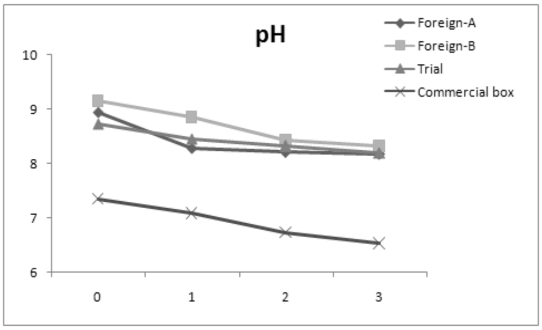

Figure 1.b pH changes in the corrugating medium of the corrugated boards

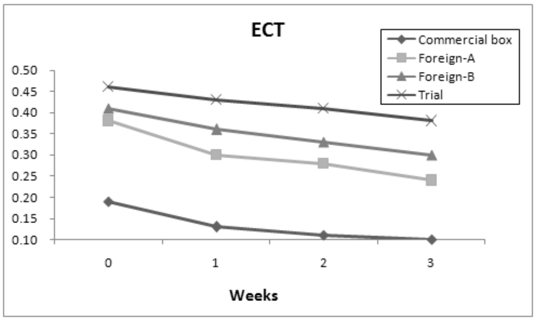

Figure 2. Edgewise compression strength (kN) of the sample boards after accelerated aging.

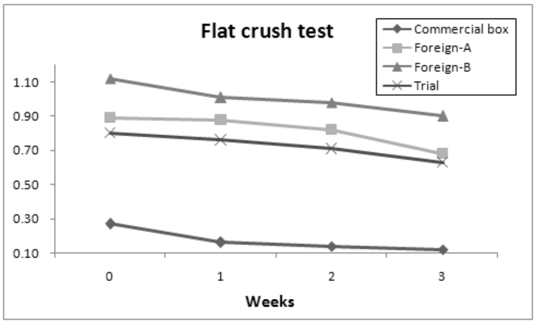

Figure 3. Flat crush strength (kN) of the sample boards after accelerated aging.

significantly lower strength in the flat crush test. Accelerated aging resulted in lower ECT and flat crush strengths for all of the conservation board; however, not to the same degree as the Commercial one. The Commercial box had almost zero strength after two weeks of accelerated aging.

The PAT is intended to evaluate the effects of the corrugated box itself on its contents. A failure of the PAT inicates that the container itself (corrugated board in this study) has the potential to cause deterioration of the contents. We obtained the results of the PAT for the samples by sending a test request to the Image Permanence Institute at Rochester University (Rochester, NY, USA). For reference, we included a dried wooden panel in the PAT from the paulownia tree, which is considered an excellent raw material for archival storage boxes in Korea. The results of the PAT are shown in Table 4. The paulownia wooden panel, which was believed to have excellent properties, gave the worst results. We suggest that the very small amount of

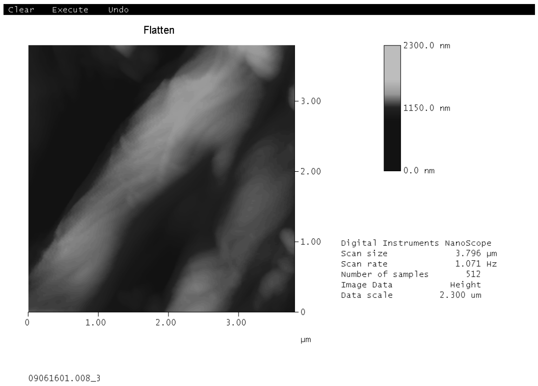

Figure 4.a Accelerated aging at 0 day.

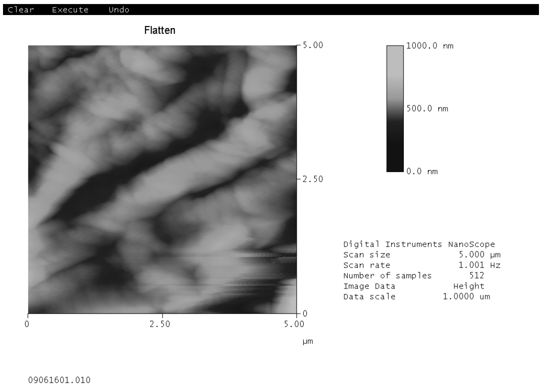

Figure 4.b Accelerated aging at 14 days.

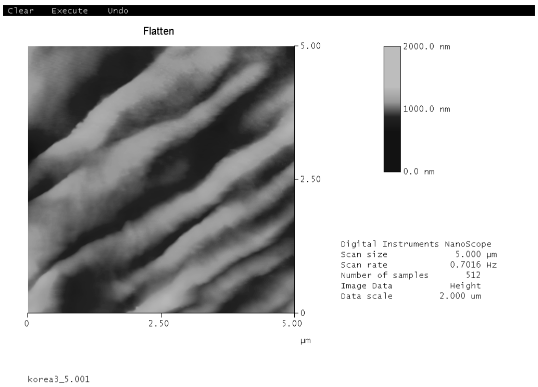

Figure 4.c Accelerated aging at 21 days.

extractives and other organics in the wooden panel nevertheless have emissions over prolonged time period, and these emissions caused failure of the PAT. The imported conservation boards and the Trial board passed the PAT, but the Commercial box did not.

We expected that accelerated aging would result in changes to the fiber properties due to the observed decreases in strength-related properties. Thus, we studied the surficial changes in fiber morphology as a results of aging[8] and conducted AFM on the linerboard of the Trial board (Fig. 4). There were indications of greater wrinkles in more aged fiber; however, the degree of aging may be difficult to quantify.

After comparing the properties of the Trial board to the imported conservation boards, we suggest new specifications for conservation E-flute corrugated board. Draft specifications for the liner and medium of conservation E-flute corrugated board are shown in

Table 5. Draft specifications of liner and medium of conservation E-flute corrugated board.

Test		Requirements	Test Method
Basis Weight (g/㎡)	corrugated fiberboard	500 ± 50	KSMISO 536
	liner	150 ± 10	
	medium	150 ± 10	
water content(%)		8 ± 2	KSMISO 287
Ash(%)		> 3	KSM 7073
pH		> 7.5	KSMISO 6588-1
Lignin(%)		negative	KSMISO 3260
Discoloration(ΔE)		< 5.0	KSMISO 5631
Folding endurance (MD)	liner	> 500	KSMISO 5626
Folding endurance (CD)	liner	> 300	KSMISO 5626
Mullen Bursting (kPa · ㎡/g)	medium	> 340	KSMISO 2758
Breaking length (CD, km)	medium	> 4.0	KSMISO 1924-2 KSMISO 3039
PAT	image interaction	PASS	KSMISO 14523
	staining	PASS	KSMISO 14523
	motting	PASS	KSMISO 14523
corrugated fiberboard	Flat crush resistance (FCT. kN)	> 0.8	Tappi T 808 om-01
	Edgewise compressive strength (ECT. kN)	> 0.4	Tappi T 811 om-02
fiber(%)	softwood : > 60		Tappi T 263 om-88
	hardwood < 40		Tappi T 263 om-88

Table 5, including the results of the PAT and specifications for SwBKP and HwBKP contents.

4. Conclusions and Suggestions

Conservation E-flute corrugated board was developed that had equivalent strength properties to imported conservation corrugated boards, and was in some respects, superior. The developed boards passed the PAT and showed no abnormal behaviors in the accelerated aging test. A draft specification for conservation corrugated board is presented. The manufacturing cost of the devveloped board was 3~5 times less than the purchasing prices of the imported ones.

The use of conservation corrugated board will help to protect archives such as documents, photographs, films, and paintings. More extensive uses of conservation corrugated boards depend on the creativity of the user, for example, storage valuable personal belongings and souvenirs, human cremation ash, personal albums, and cultural assets.

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