

# Causes of Wrinkle in Silky Wallpaper and Its Solution

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## ABSTRACT

The purpose of this study is to investigate the cause of fine wrinkles occurred in silky wallpaper and its solution. The characteristics of base papers, wallpapers and adhesives (conventional and modified) were evaluated to find the possibility for the occurrence of fine wrinkles. It was found that the base papers and wallpapers did not cause the occurrence of silky wallpaper. It was concluded that the fine wrinkles in silky wallpaper was caused by the nonuniform distribution of adhesive, the localized shrinkage of adhesive and the breaking the balance between the resistance of wallpaper and shrinkage of adhesive. Three possible solutions for the prevention of the occurrence of fine wrinkles in silky paper were recommended.

**Keywords** : *silky wallpaper, base paper, PVC sheet, non-woven, dimensional change, wrinkle, adhesive, shrinkage*

## 1. Introduction

The papering walls and ceiling is a peculiar culture which is limited to Asia countries. Especially it could not be separated from the housing life in Korea. The demand of wall paper is increased constantly as the living in an apartment is expanded recently in China. The wallpaper printed on paper was mainly used for the papering in the past. However more luxury and durable wallpaper is preferred recently due to the movement of propensity to consume that pursue the higher quality and feeling. There were also many changes in the raw materials for wallpaper. Most popular in the construction company is the silky wallpaper at these days. The silky wallpaper is made

by the coating PVC on the fine paper and medium grade paper, and then the embossing and printing processes are followed. Another movement is that most wallpaper companies and construction companies preferred to environmentally friendly wallpaper that the emission of VOCs is minimized for resident's health.

The old newsprint and/or hanji was used for the underlining before the wallpaper is applied on the wall long time ago. However the nonwoven is mostly used as an underlining material recently by the construction companies. The other trend is that the papering is usually carried out by the specialized companies and mechanized partially for the papering. There were many changes in papering environment due to such

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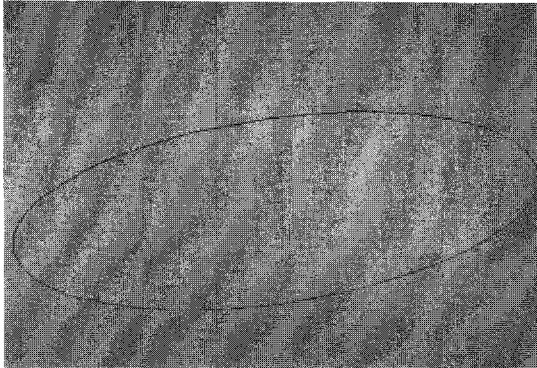


Fig. 1. Fine wrinkle occurred in silky wallpaper.

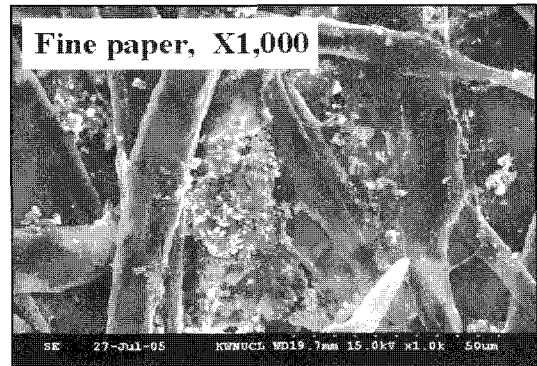


Fig. 2. Micrograph of fine paper.

trend, and the occurrence of tiny defects can cause a serious damage in the image of the construction companies due to the complication of the tastes of consumer.

One of serious problem occurred recently in the apartment construction site of most construction companies was the formation of fine wrinkles in silky wallpaper (Fig. 1). Most construction companies and cooperation companies had tried to solve the problem in several ways. However, they could not elucidated the cause of defect, and shifted the responsibility for such problem on to each other repeatedly. Thus, this study was carried out to elucidate the cause of fine wrinkle in silky wallpaper and find the proper means to solve it.

## 2. Experimental

The characteristics of base paper (fine paper and medium grade paper), wallpapers and adhesives are evaluated in order to elucidate the potential and the causes of fine wrinkles in silky wallpaper. The dimensional changes by the adhesives (conventional and modified) application for wallpapers (PVC coated and printed with water-base and oil-base ink) were also measured. The papering experiments were carried out for the several wallpapers (Seoul Wallpaper Co., Ltd.) and adhesives (Envichem) to investigate the possibility of the occurrence of fine wrinkles. The effect of nonwoven type on the occurrence of fine wrinkles also studied.

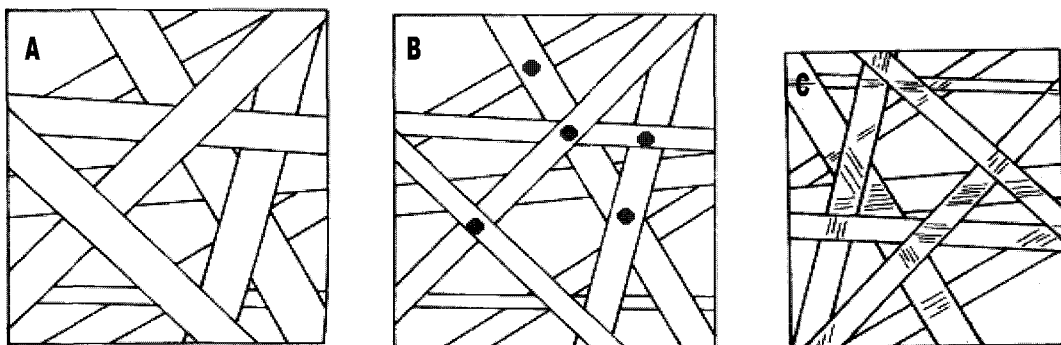


Fig. 3. Dimensional change with drying of base paper.

A) Swollen state, B) Fiber shrank with restrained drying, C) Fiber and paper shrank with free drying.

**Table 1. Physical properties of base paper**

Wall paper	Base paper	Thickness (mm)	Grammage (g/m <sup>2</sup> )	Formation index	Stiffness (gf/cm)		Size Stöckigt (sec.)	Contact angle (°)	Wetting energy (mN/m)
					MD	CD			
A	Medium grade 1	0.157	104	119.6	5.7	3.3	90.89	66.29	29.27
	Medium grade 2	0.145	100	118.6	5.3	2.4	86.5	68.24	26.98
B	Medium grade 3	0.171	98	120.6	7.9	2.8	79.15	66.18	29.48
	Fine paper	0.145	112	131	5.8	3.1	109.71	82.12	9.98
C	Medium grade 4	0.169	103	117.4	6	2.8	160.7	82.39	9.63

### 3. Results and Discussions

#### 3.1 Relation between the characteristics of base paper and the occurrence of fine wrinkles

The pulp fiber is used as a main raw material for base paper of wallpaper, and mineral filler, sizing agent and retention aid are also added to control the characteristics of base paper (Fig. 2). The chemical pulp for fine paper manufacturing is consisted of cellulose and hemicelluloses, and these have strong water affinity. The dimensional change of fiber by the moisture occur at a right angle to the fiber axis due to the orientation of micro fibrils in S<sub>2</sub> layer of cell wall. If the adhesive is applied on the base paper side, the

fibers will be swell and expanded in CD. The wallpaper will be drew tightly due to the shrinkage in the region between the bonded fibers by drying because wallpaper is fixed on the wall and the shrinkage of wallpaper is limited (Fig. 3). One can easily understand that there is no any causes for the occurrence of fine wrinkles in base paper. The mineral fillers are located between fibers can be observed in fine paper (Fig. 4). However we can see that more surface sizing treatment is applied on base paper (Fig. 5). This surface sizing will improve the bending stiffness and give better dimensional stability.

The physical properties of base paper were summarized in Table 1. The formation of fine paper was better than those of medium grade. The grammages for medium grades and fine paper were

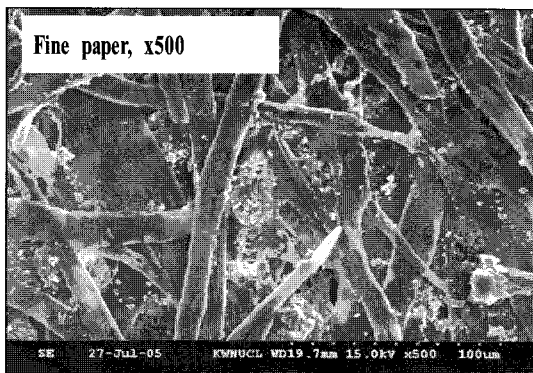


Fig. 4. SEM of fine paper surface.

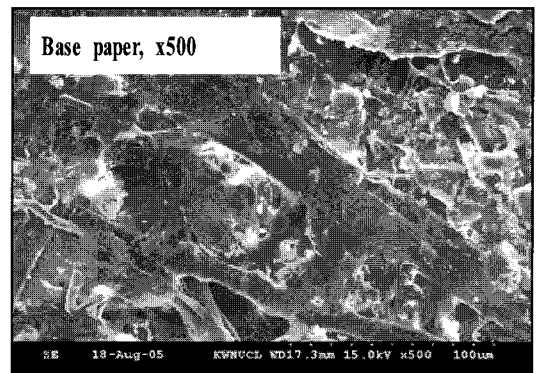


Fig. 5. SEM of base paper for silky wallpaper.

**Table 2. Physical properties of silky wallpaper**

Defect	Company	Model no.	Caliper (mm)	Grammage (g/m <sup>2</sup> )	Stiffness(gf·cm)		Wetting energy (mN/m)	Contact angle( ° )
					MD	CD		
Yes	A	Dp 85101	0.430	339	5.5	3.4	32.07	63.84
		80822	0.346	298	7.8	2.7	30.15	65.52
		8084-4	0.413	360	5.3	2.6	37.63	52.68
		Dp 1011	0.437	386	6.0	3.3	34.03	62.13
	B	7712-2	0.456	363	5.8	2.8	29.80	65.83
No	A	K 33812	0.284	316	7.7	2.8	28.14	67.54
		170181	0.350	366	5.4	2.5	31.31	64.51
		8083-2	0.412	305	6.8	3.4	29.40	65.71
	C	3199-1	0.391	338	5.7	3.3	32.37	63.59
		3205-12	0.358	311	5.4	2.3	25.22	70.10
	B	3208-1	0.373	260	6.2	3.4	26.38	68.74
B	MO 286-2	0.411	312	5.9	2.6	28.00	67.14	

around 100 g/m<sup>2</sup> and 112 g/m<sup>2</sup> respectively. It was not impossible to conclude about the cause of fine wrinkles, because the sizing degree and stiffness did not show any obvious trend.

### 3.2 Characteristics of wallpapers

The coating of PVC increased the thickness and grammage of wallpapers (Table 2), and the coating and printing did not affect on the dimensional changes of

wallpapers (Table 3). However the dimensional changes of wallpapers by the modified adhesive was lower than those by the conventional adhesive. The decrease of dimensional change might be due to the decrease of dimensional change by the lower solid content (ca. 4.3%) than those (17%) of the conventional adhesive. It was thought that the possibility of uniform application of modified adhesive also contributed to prevent the occurrence of

**Table 3. Effect of PVC coating and printing on the dimensional changes of wallpapers**

Adhesive	Surface treatment		Initial dimension (cm)	Expansion after adhesive application		Shrinkage after drying	
				Dimension (cm)	Stretch (%)	Dimension (cm)	Stretch (%)
Conventional	PVC coating	CD	21.1	21.15	0.24	21.09	-0.05
		MD	29.8	29.8	0.00	29.8	0.00
	PVC sheet + water based ink	CD	21.22	21.25	0.14	21.19	-0.14
		MD	29.7	29.7	0.00	29.7	0.00
	PVC sheet + oil based ink	CD	21.3	21.4	0.47	21.2	-0.47
		MD	29.75	29.75	0.00	29.75	0.00
Modified	PVC sheet	CD	21.12	21.12	0.00	21.12	0.00
		MD	29.9	29.9	0.00	29.9	0.00
	PVC coating + water based ink	CD	21.25	21.25	0.00	21.25	0.00
		MD	29.8	29.8	0.00	29.8	0.00
	PVC coating + oil based ink	CD	21.3	21.3	0.00	21.3	0.00
		MD	29.72	29.72	0.00	29.72	0.00

fine wrinkles.

### 3.3 Characteristics of adhesives

The adhesive for papering is made with starch and the adhesion is obtained by the principle illustrated in Fig. 6 (1). The cooking of starch is required to obtain the adhesion properties. The cooking supply the activation energy that is required for the hydration of starch. The starch is swelled by hydration and show the sticky property. The shrinkage of starch adhesive by the drying was thought one of possible cause for the occurrence of fine wrinkle. When the only small amount of starch adhesive was applied, then the effect of the shrinkage of adhesive was not enough to cause problem. However the shrinkage of starch adhesive can affect significantly on the behavior of wallpaper during drying as the amount of adhesive applied is increased. Fig. 7 illustrated the washboarding phenomenon occurred by the excessive application of starch adhesive (1). In this case, the shrinkage force is strong enough which can draw the liner and cause deformation. That is, if wallpaper has high stiffness enough to withstand the deformation by the shrinkage of starch adhesive, and/or only small amount of starch adhesive is applied, the fine wrinkle will not be occurred.

### 3.4 Effect of papering method

The starch adhesive is applied on the wallpaper by the adhesive applicator and then stored for a day in the state of airtight packing with vinyl sheet before

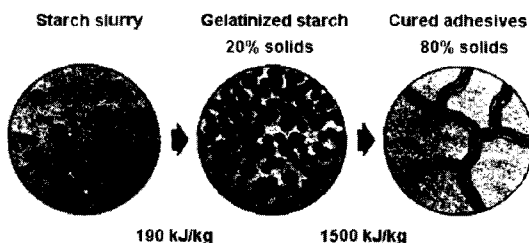


Fig. 6. Curing process of starch adhesive (1).

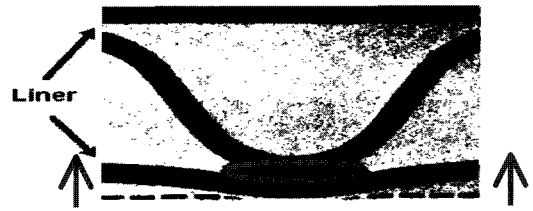


Fig. 7. Washboarding caused by the shrinkage of starch adhesive (1).

papering (Fig. 8). This papering method brought about the formation of macro floc of starch adhesive as shown in Figs. 9 - 12. The most of water in starch adhesive is removed after one day since the adhesive was applied, thus the floc of adhesive was not spread uniformly as shown in Fig. 13. A is the back side of wallpaper with fine wrinkle, and B is the back side of wallpaper without any problem. The macro floc of starch adhesive was observed in both cases. These mean that the occurrence of fine wrinkle is strongly depended on the durability of wallpaper against the shrinkage of starch adhesive. Therefore it is considered that the decrease of adhesive application amount and/or the increase of grammage of wallpaper is good practice for the prevention of the occurrence of fine wrinkle.

The rheology modified starch adhesive supplied

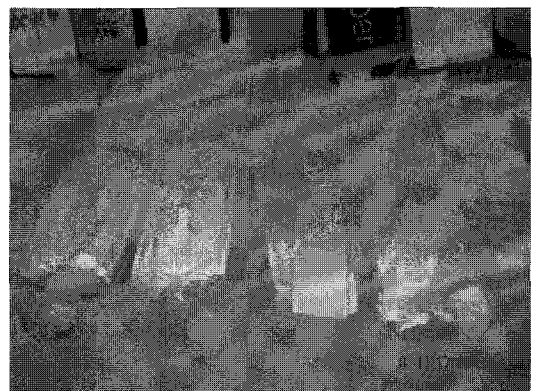
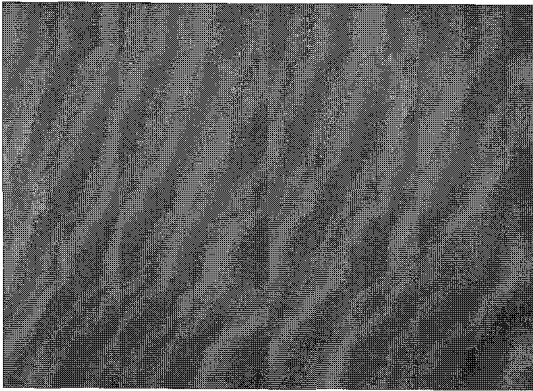


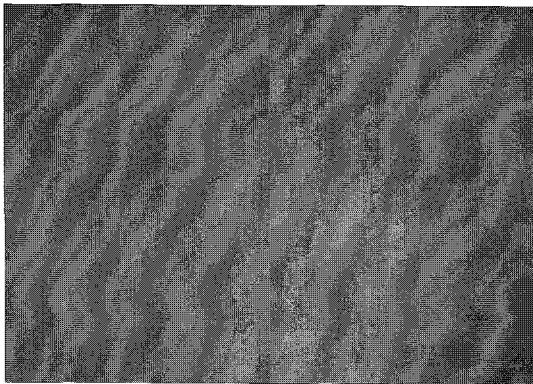
Fig. 8. Stored wallpaper for 1 day after adhesive application.



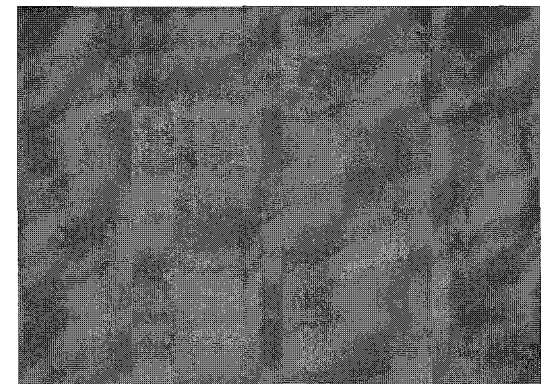
**Fig. 9.** An example of adhesive lump formed during storage.



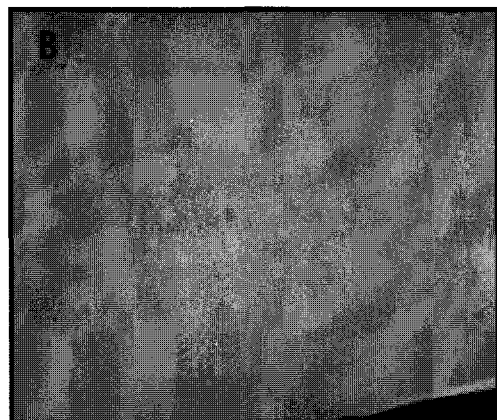
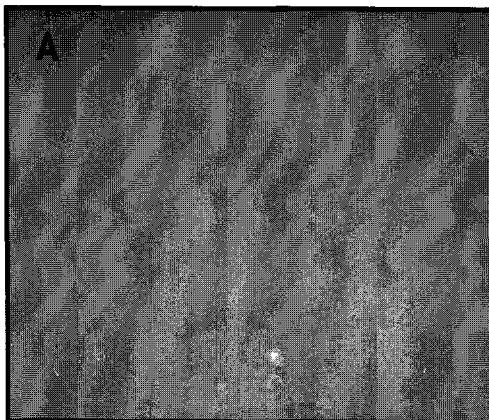
**Fig. 10.** An example of adhesive lump formed during storage.



**Fig. 11.** An example of adhesive lump formed during storage.



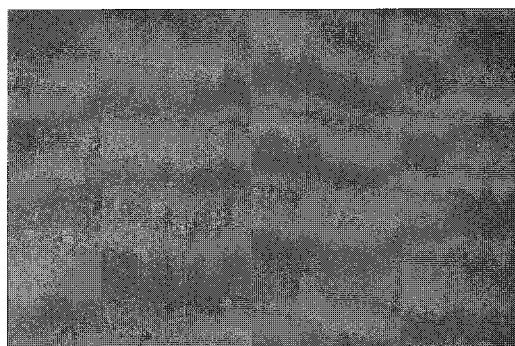
**Fig. 12.** An example of adhesive lump formed during storage.



**Fig. 13.** Back side of silky wallpaper (A : Wrinkles are appeared on the surface, B : Wrinkles are not appeared on the surface).

**Table 4. Characteristics of conventional and modified adhesives**

Properties	Standard (KSF 3217)	Modified adhesive	Conventional adhesive
Bond strength (N/25mm)	> 7.85	21.14	5 -12
Fungal resistance	3	3	-
Formaldehyde emission (ppm)	Not detected	Not detected	Not detected
pH	4.0 - 8.0	6.0 - 7.5	2.0 - 3.5

**Fig. 14. An example of modified starch adhesive application.****Fig. 15. Wrinkles are not observed with the application of modified starch adhesive.**

from Envichem Co. Ltd. was used as an alternative to confirm whether the above interpretation is correct or not. The solid content of modified adhesive was only a fourth and gave better bonding strength significantly (Table 4). The same procedure in adhesive application and storing method were applied for the modified adhesive, but the formation of macro floc of adhesive was not observed after a day since adhesive application (Fig. 14). This result was also obtained for the wallpaper which the fine wrinkle was occurred before (Fig. 15).

## 4. Conclusion

The purpose of this study is to elucidate the cause of the fine wrinkle formation in the silky wallpaper, and find its solution. It was found that the base papers and wallpapers did not cause the occurrence of fine wrinkle in silky wallpaper. It was concluded that the

fine wrinkles in silky wallpaper is caused by the nonuniform distribution of adhesive, the localized shrinkage of adhesive and the breaking the balance between the resistance of wallpaper and shrinkage of adhesive. Therefore it was recommended to prevent the occurrence of fine wrinkle in silky wallpaper as follows : 1) apply the adhesive as small as possible without sacrificing significant bonding strength, 2) prevent the formation of macro floc of adhesive, 3) substitute the rheology modified adhesive having low solid content but high bonding strength for the conventional adhesive.

## Literature Cited

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