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Effect of Corrosion Conditions on the Luster Change of Metallic Yarns and Fabric

- Analysis of Changes in Reflection and Transmission -

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Abstract

The glitter of lamé fabrics containing the metallic yarns may further be altered by Na_2CO_3 aqueous solution at an elevated temperature. In this study, the effect of the corrosion treatment on the yarn luster was evaluated using image analysis.

The alkaline solution treatment was found to be more effective on the aluminum-based specimens than on the silver-based specimens. It was found that corrosion percentage measurement based on the transmission analysis may provide reasonable quantitative index, even if the measurement relies on an indirect method.

Based on the quantitative results, the alkaline treatment condition for the specific specimen would be optimized for a desired glitter modification.

Key Words : luster, metallic yarn, lamé, aluminum, image analysis

I. Introduction

As one of the current textile trends, metallic fabrics or metallic yarns are employed in order to decorate surface of the clothing for futuristic image or sporty image.

Metallic yarns are often prepared via vacuum -deposition of aluminum or other metal element on the polyester film surface. Historically, the metallic thread was constructed by wrapping a metal strip around a fiber core. Lamé yarns or fabrics have been extensively used for various purposes such as evening dress, necktie, curtain, hat decoration, stage costume, and futuristic clothes because of their excellent and splendid metallic gloss. For supported metallic yarn types, the slitted metallic yarn may further be wound on a core yarn or may be twisted with other yarn. The lamé yarns may be woven as warp yarns or filling yarns in a woven fabric.[1)2)3)]

The edges of the metallic slit film yarn are vulnerable to alkaline or acidic solution at an elevated temperature.

In order to prepare desired 3-dimensional patterns by using such properties, the region of the fabric which should not be damaged by the

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chemicals is protected using a small piece of thin plastic film tautly tied by an elastic band or string together with coin or glass marble.

In this study, the surface effect changes which result from the corrosion process by the infiltration of alkaline solution between the polyester films were investigated and deposited metal layer were examined through image analysis.

Finishing techniques, employing corrosion of metallic layer, applied to the lamé yield aesthetically pleasing effect with various patterns. However, in order to select optimum condition for the desired effect of luster change, quantitative evaluation methods are needed.

Therefore, in this study, metallic yarns and lamé fabrics were treated in Na_2CO_3 solutions of 5% or 7%(w/w). Corrosion effect due to the alkaline solution treatment was analyzed based on luster image analysis and transmission image analysis.

II. Experimental Method

1. Specimens

In this study, commercially available metallic yarns and lamé fabrics were used for the experiment. <Table 1>

2. Corrosion Treatment

Based on a preliminary experiment, the concentration levels of the Na_2CO_3 aqueous solutions and the range of treatment period were determined. According to the vulnerability of the lamé to the corrosion treatment, the concentration of the aqueous Na_2CO_3 solutions, 5% or 7%, were selected. Treatment period were also selected according to the specimen characteristics.<Table 2>

<Table 1> Characteristics of samples used for the experiment

Sample No.	Maker Code	Construction	metal specification
1	n. a.*	Lamé fabric (Warp: unsupported metallic yarn, Filling: Polyester Yarn)	n. a.*
2	MA	metallic yarn, supported	Al
3	MK	metallic yarn, unsupported	Al
4	J	metallic yarn, supported	Ag
5	MK	metallic yarn, unsupported	Ag

n. a.*: not available

<Table 2> Treatment conditions

Specimen. No	Conc.	Treatment period, min.				
1	5%	5	10	15	-	-
2	5%	5	10	15	-	-
3	5%	5	10	15	-	-
4	7%	5	10	15	30	40
5	7%	5	10	15	30	40

3. Metal Analysis

In order to confirm the metal components of the lame specimens, metal analysis was implemented.

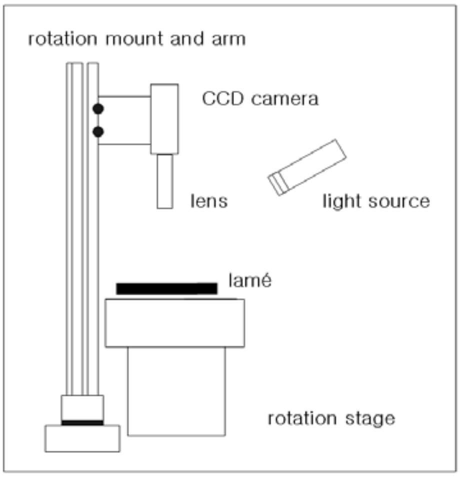
Inside an ion sputter coater (E1030, Hitachi, JAPAN) the specimen was prepared by sputter-coating with Pt. Carbon tape was used to attach each specimen on a FE-SEM(Field Emission Scanning Electron Microscope, S-4700, Hitachi, Japan) holder. Acceleration voltage of 20kV was selected for the observation. EDX(Energy Dispersive X-ray Spectrometer, KEVEX) was used to determine the element for qualitative analysis.

4. Image Acquisition

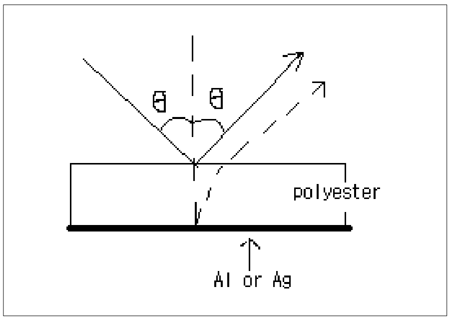
Evaluation of the luster characteristics of specimens was implemented under various reflection modes using a goniometric equipment. A CCD camera, ProgRes C10plus (Jenoptik JENA, Germany), was used for the luster image acquisition.

The CCD used in the camera has 8.93mm interline CCD solid-state image sensor with unit cell size of 3.45x3.45㎛. RGB primary color mosaic filters are used for color filtering. The CCD also employs a peltier cooling device to lower the electrical noise generated during the acquisition. A magnifying lens(type 350N) was attached to the C-mount of the CCD camera. Employed illumination was a flexible goose-neck fiber optic light. The specimen was rotated on top of the goniometric specimen stage.<Fig. 1>

Since the luster of the specimen is dependent on the observation conditions such as intensity and position of the illumination, receiving angle or position, various observation conditions were tried. Luster image of the specimen was acquired under rather lower intensity of the incident illumination than general image acquisition condition, since the main interest is focused on the luster.<Fig. 2>



<Fig. 1> Schematic diagram of the reflection measurement apparatus



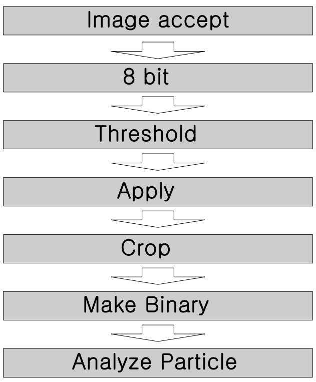
<Fig. 2> Reflection from the metallic film yarn

5. Luster Analysis

Since the direct method of observing the surface luster is strongly dependent on the surface shape and structures of the specimen, it is often difficult to quantitatively analyze the reflected intensity with good experimental repeatability.[5] Therefore, as a supplemental method, which is indirect in nature, transmission mode was employed to observe the status of corroded metallic layer on the polyester film, which is generally transparent[6)7)8)9)].For the quantitative analysis, metallic film yarn specimen was mounted on a slide glass. The specimen slide was placed on a microscope with a CCD camera interfaced to a PC for image acquisition.

6. Image Analysis of Transmission Measurement Mode

An image processing and analysis program[10], ImageJ (National Institute of Health, U.S.A.), was employed to process the acquired images. Image size was adjusted to 270x1542(WxH). Threshold values were 20 for lower threshold and 69 for upper threshold. Make_binary function of the software was subsequently used. <Fig. 3>
Analyze_particle function was used to measure the area of the metallic layer objects. The summation of the values of the objects was used for the calculation of the corrosion.



<Fig. 3> Image analysis flow diagram using ImageJ (NIH, U.S.A.)

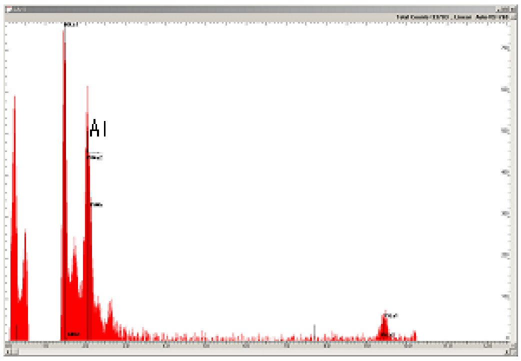
III. Results & Discussion

1. Element analysis

Qualitative analysis of the specimens revealed that specimens No. 1, No. 2, and No. 3 are coated with aluminum, while specimens No. 4, and No.5 are coated with silver. Since the specimen No. 1 is a woven fabric of metallic warp yarns and polyester filament filling yarns, the metallic warp yarns were separated from the fabric for the analysis. <Table 3> <Fig. 4>

<Table 3> Element analysis result using EDS

Specimen No	Maker	Element
1	n.a.	Al
2	MA	Al
3	MK	Al
4	J	Ag
5	MK	Ag



<Fig 4> EDS analysis chart of the specimen No. 1

2. Corrosion analysis

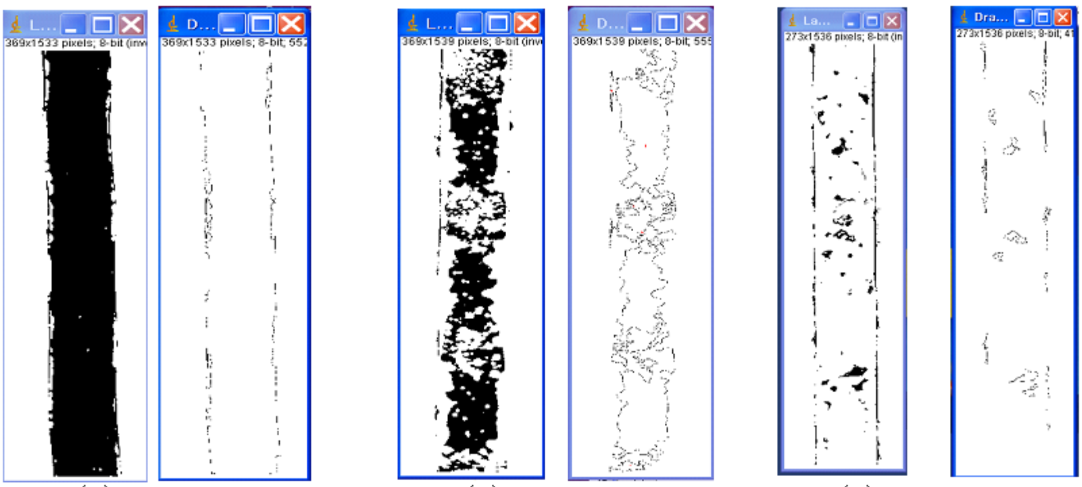
The effect of corrosion treatment on the metallic yarn specimens was analyzed using an image analysis software, ImageJ. The images were acquired under transmission mode, which is an indirect measurement method compared to the direct method of observing surface reflection from the specimen. <Fig. 5>

As shown in <Table 4>, in the case of specimen No. 1, the corrosion percent increased most remarkably. The first 5 minutes period of treatment resulted in 50.7% corrosion, and 10 minutes treatment resulted in 94.7%. In the case of specimen 3, the first 5minutes treatment resulted in 6.2% corrosion, and 15 minutes treatment gave 78.5% corrosion. The corrosion behaviors seemed to be different according to the origin of the specimens, even if the metal element used for the sputter coating are the same. This might be attributed to the production process, such as the stability of protective lamination layer or some other process variables including the sputtering process.

In the case of specimens 4 and 5, the changes were barely recognizable. The changes became noticeable after prolonged treatment period of 30 and 40 minutes. The corrosion percentages were in the low range of 2.2 and 2.6% for the specimens 4 and 5.

3. Reflection Observation

Since the metallic yarn comprised polyester film layers and metallic layer, normal illumination conditions provided similar reflection patterns for the untreated film and for the treated film specimens. This may be attributed to the fact that the CCD photosites were saturated under normal illumination conditions.

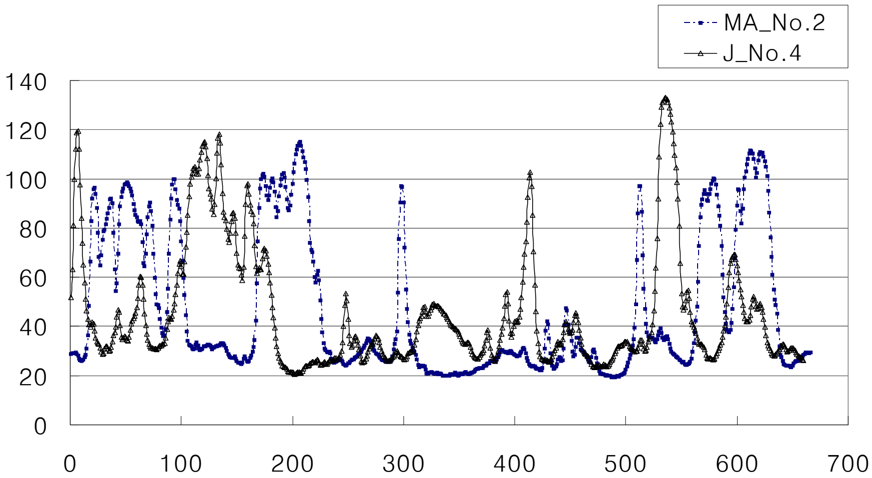


(1) Control (2) 5%, 5min (3)5%, 10min

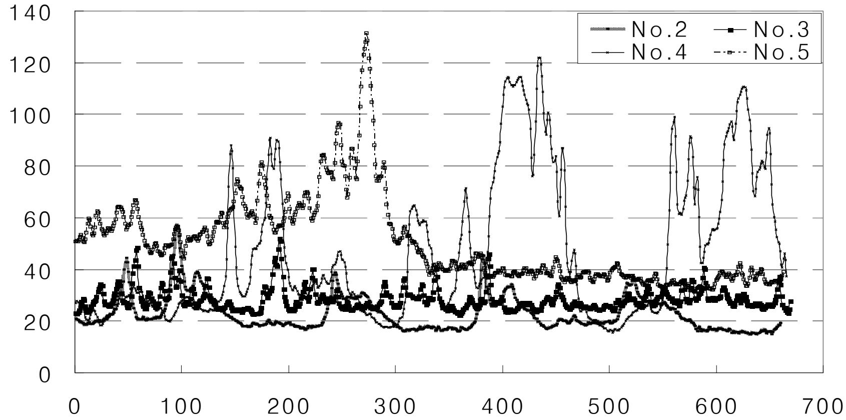
<Fig 5> Image of corroded metallic yarn in alkaline solution (Transmission mode)

<Table 4> Corrosion % of specimens after treatment

Treatmentperiod, min.	No.1	No.2	No.3	No.4	No.5
5	50.7	66.1	6.2	0.1	0.2
10	94.7	65.2	24.7	0.1	0.2
15	98.1	91.8	78.5	0.2	0.3
30	98.2	91.8	78.9	2.4	2.2
40	98.5	92.1	79.1	2.6	2.5



<Fig 6> Reflection mode measurement under low intensity illumination condition



<Fig. 7> Reflection mode measurement under low intensity of illumination

<Fig. 6> shows that the differences between the two specimens, which were treated with corrosion solution, are not readily recognizable under normal illumination condition.

Therefore, the intensity level of the illumination was kept as low as possible in order to detect the differences between the reflection patterns from the intact metallic film and from the corroded metallic film.

In <Fig. 7>, the differences between specimens are readily recognizable. The specimen 4, silver deposited on the polyester film, with corrosion

[a] [b]

<Fig 8> Change of luster by alkaline treatment, specimen No. 2 (a) 5%, 5min, (b) 5%,10min

percentage of 2.4%, shows higher reflection pattern than the specimen 2, aluminum deposited on the polyester film, with corrosion percentage of 65.2%. In the case of specimen 3 versus specimen 5, the reflection intensity level of specimen 5 is higher than that of specimen 3, aluminum deposited on the polyester film.

<Fig. 8> shows the metallic yarn images under reflected light. The one at the right shows signs of corrosion.

IV. Conclusions

Metallic yarns and lamé fabrics have widely been used for various purposes such as evening dress, necktie, hat, stage costume, and futuristic clothes because of their excellent and splendid metallic gloss. For supported metallic yarn types, the slitted metallic yarn may be wound on a core yarn or may be twisted with other yarn. The lamé yarns may be woven as warp yarns or filling yarns in a woven fabric.

The glitter of the fabrics containing the metallic yarns may further be altered by Na_2CO_3 aqueous solution at an elevated temperature. In this study, the effect of the corrosion treatment on the yarn luster was evaluated using image analysis.

The alkaline solution treatment was found to be more effective on the aluminum-based specimens than on the silver-based specimens. It was found that corrosion percentage measurement based on the transmission analysis may provide reasonable quantitative index, even if the measurement relies on an indirect method.

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