

Analysis of Tamamushinuri and new application of lacquer coating

Symposium on Advanced Composite Materials

/Clayteam 4th Seminar

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Sendai

Lacquer

- Mainly produced in east Asia
- Domestic circulation is about 100t/year and more than 95% is imported from China
- A piece of lacquerware about 9,000 years ago in early Jomon era was found in Minamikayabe town, Hokkaido
- Mostly used for surface coating of wooden crafts
- Recently, Cashew lacquer (contains isomer of urushiol) coating is popular because the coating appearance looks like traditional lacquer (Urushiol)

Purpose

- Clarify the relationship between the appearance and the layer structure of Tamamushinuri
- Propose new application of the traditional coating material

Cashew lacquer ▪ ▪ ▪ Natural urethane resin
Traditional lacquer ▪ ▪ ▪ Urushiol (polyphenol)

Samples

Red-tamamushi coating using cashew lacquer (Scale; length 15cm) . . . Multilayered cashew coating is applied on a surface of a tree piece.

Single layer cashew coating on a glass slide . . . Analysis of each layer was done using this sample

Traditional lacquer coatings on PET films.

Analysis

- Optical microscopy . . . analysis of the multilayer coating structure
- X-ray photoelectron spectroscopy (XPS) . . . surface analysis to quantify the surface element
- Infrared spectroscopy (FT-IR) . . . detection of the chemical bonds

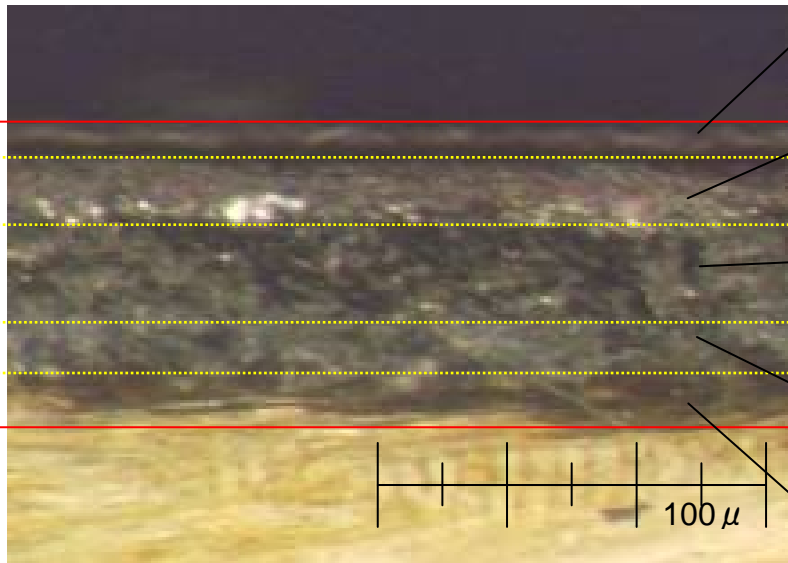
Evaluation of PET film coating layer

- Moisture barrier
- Flexibility

Lacquer coating structure and functions



Scale



No.5 23 μ m

No.4 38 μ m

No.3 59 μ m

No.2 31 μ m

No.1 30 μ m

Total thick 181 μ m

Functions

Top coating
Translucent colored layer

Light scattering

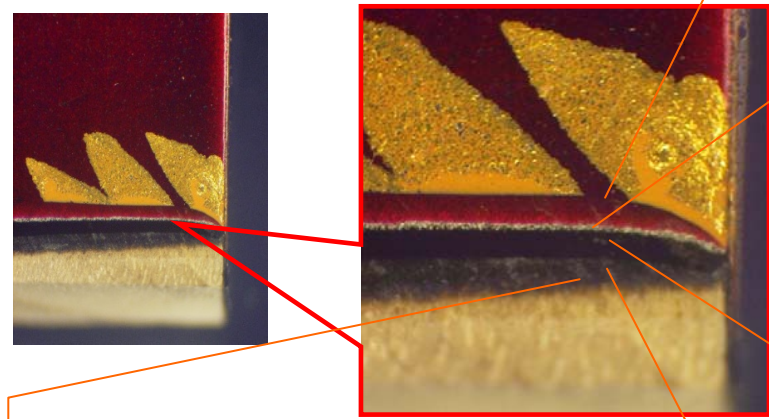
Surfacer
Improvement of durability

Concealment of the substrate

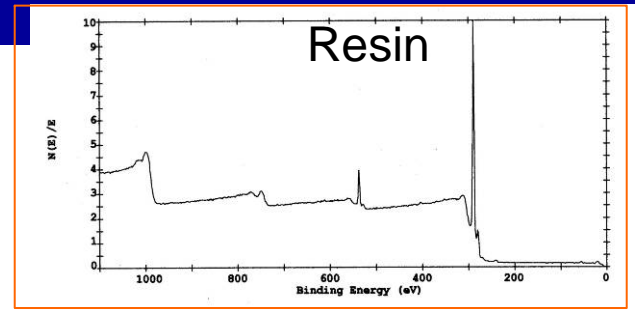
Primer
Barrier of coating liquid
Anchor

Cross-sectional optical micrograph

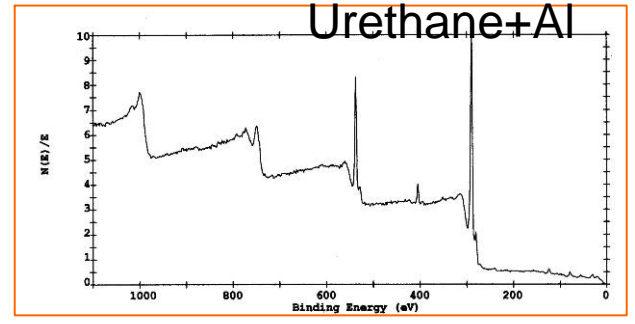
XPS charts



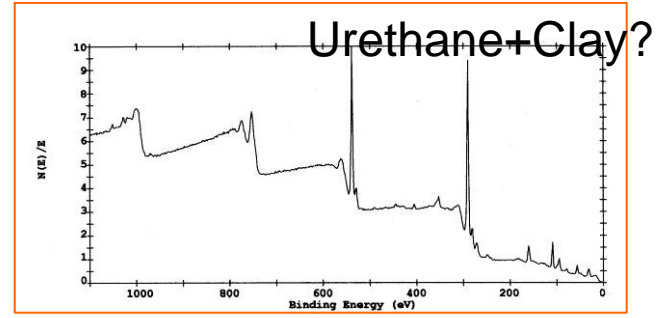
No.5



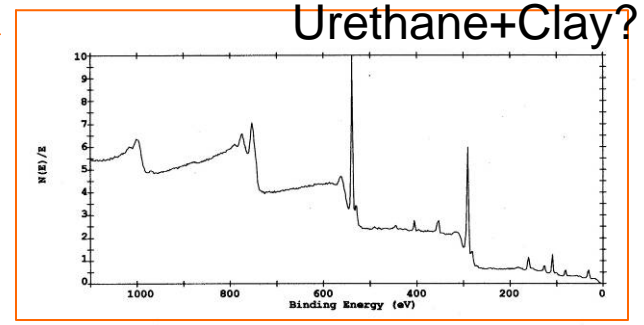
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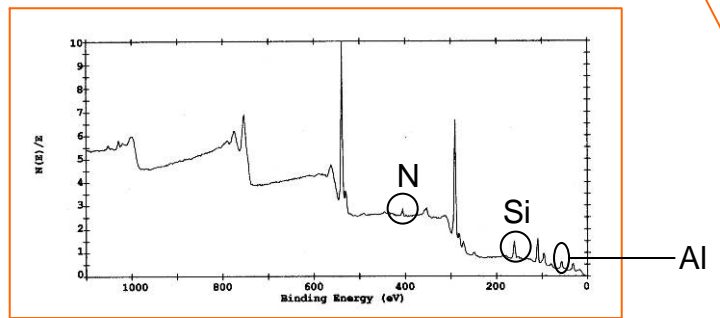
No.3



No.2



Urethane

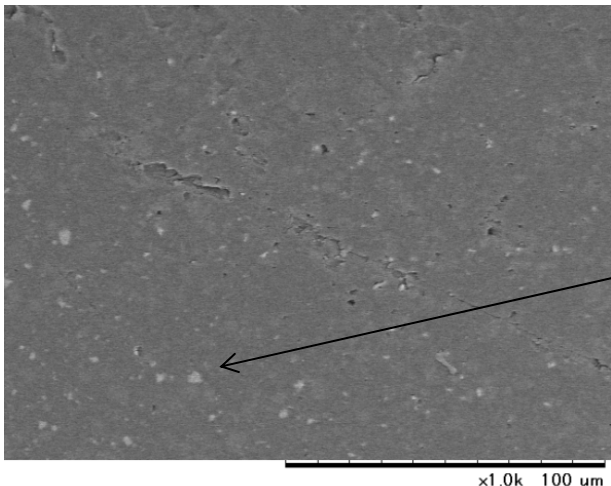


No.1

N, Al, Si are detected in all the layer excluding the exposed layer by XPS

Body pigment

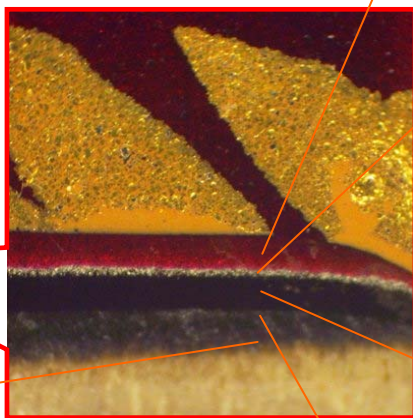
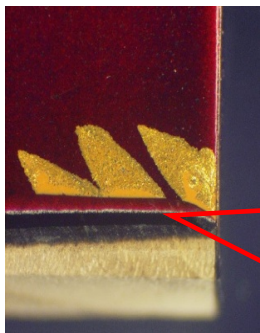
- The crush of insoluble or powdered form, which formulated the purpose of reforming some of the paint coating, the pigments of non-hidden (Referred JIS K5500)
- Kaolin, clay, calcium carbonate, Talc, barium sulfate, bidellite, aluminum hydroxide, etc.



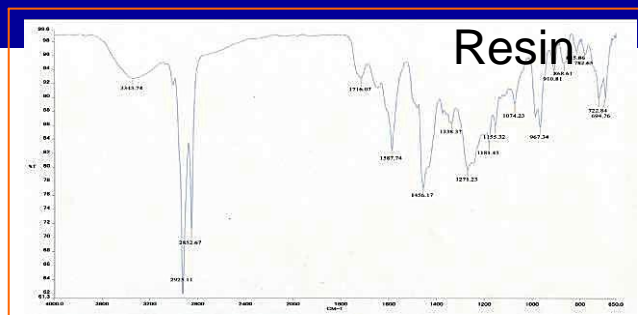
Pigment powder

Scanning electron micrograph of the coating surface

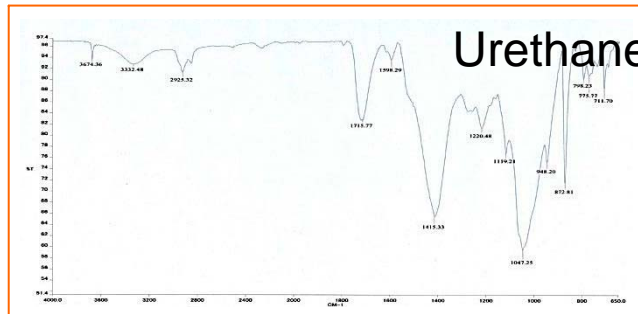
FT-IR spectrum



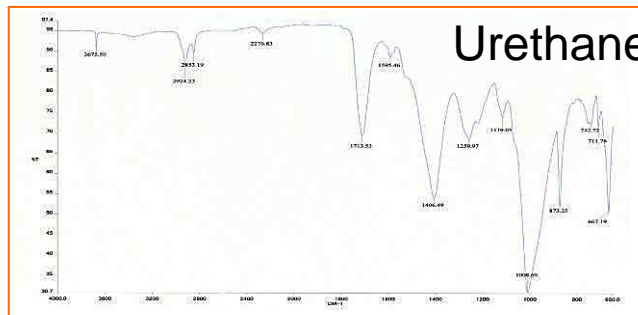
No.5



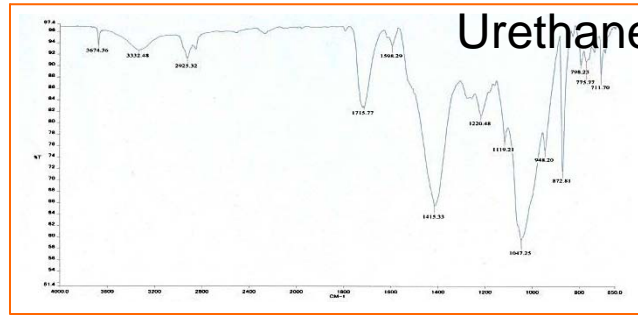
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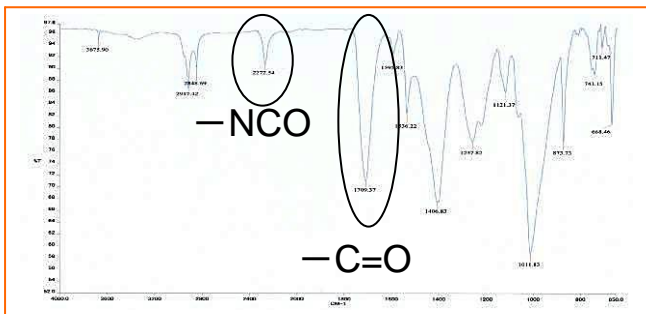
No.3



No.2



Urethane



No.1

—NCO (2270cm^{-1}), —C=O (1700cm^{-1}) peaks are observed excluding the exposed layer by IR-ATR analysis

Analysis results

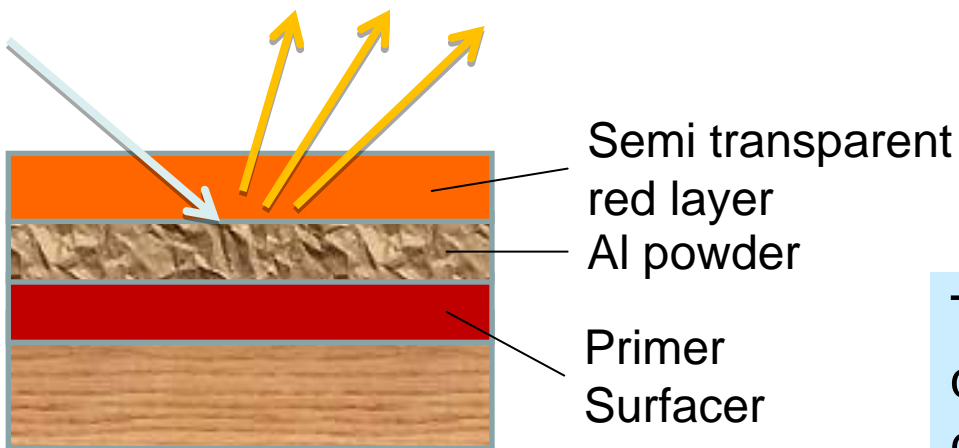
By XPS

- N, Al, Si are detected excluding No.5 layer
- No.4 layer doesn't contain any inorganic elements excluding Al, added as a light refraction agent

by IR

- Cashew lacquer is mainly urethane resin
- No.5 layer is different from other layers

Relationship between the appearance and the structure

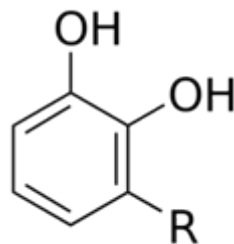
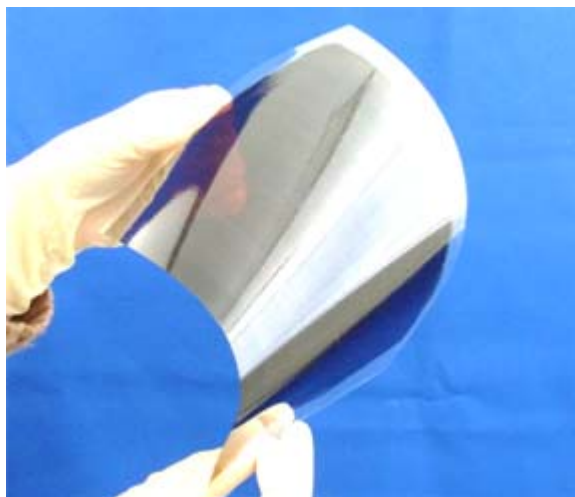


The scattered light creates the unique deep glossy color.

This technique has been used quite a lot on packaging, car coating, and so on.

Japanese patent No. 110460 “ New decorative lacquer coating method ” (1935)

Properties of the lacquer coating layer



- R = $(\text{CH}_2)_{14}\text{CH}_3$
- R = $(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_5\text{CH}_3$
- R = $(\text{CH}_2)_7\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_2\text{CH}_3$
- R = $(\text{CH}_2)_7\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}=\text{CHCH}_3$
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urushiol

Flexible lacquer coating on PET
(China)

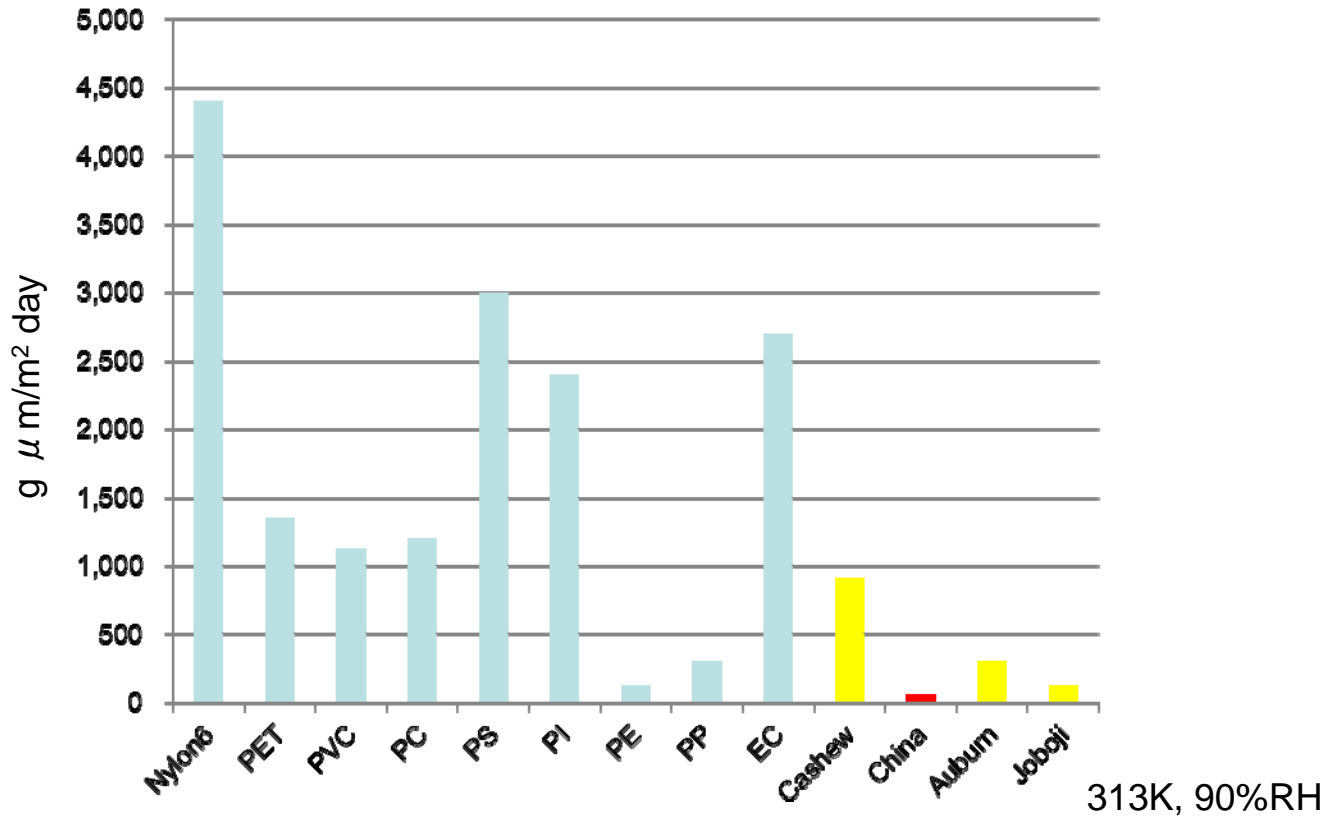
Measured moisture barrier of the PET film with lacquer coating

	Urethane	Cashew	Traditional Lacquer		
			China	Auburn	Joubouii
Thick [μm]	45	65	7	19	15
$\text{g}/\text{m}^2 \cdot \text{day}$	3.43	4.43	3.78	4.59	3.66

※Moisture barrier of PET film (75 μm thick) 6.41g/ $\text{m}^2 \cdot \text{day}$

Adhesion tape peeling test ; Good

Moisture barrier comparison



Required moisture barrier of protection sheets for crystalline silicon solar cells and e-paper is 0.1g/m² day; 638 micrometers China coating calculated to fulfill this level.

Summary -Analysis of Tamamushinuri coating-

- Tamamushinuri has a reasonable multilayer coating structure, and each layer has different functions.
- Tamamushinuri technique has been utilizing with a revolutionary idea to materialize its distinctive gloss color.
- Cashew paint has been uniformly mixed with inorganic particles such as clay.

Summary

-Potential application of lacquer coating-

- Lacquer coating has good adhesion to PET.
- The lacquer coating has good flexibility.
- The lacquer coating has excellent moisture barrier, is considered able to reach the level required for electronic paper and for solar cells.

