



# Lacquer Techniques in the Late Joseon Dynasty

Junghae PARK<sup>1</sup> · Jaewan CHOI<sup>2</sup> · Uicheon LEE<sup>3</sup> · Minji KANG<sup>4</sup> · Soochul KIM<sup>5,†</sup>

## ABSTRACT

This study conducted scientific analyses on eight objects of wooden lacquerware to understand the manufacturing techniques of wooden lacquerware in the late Joseon Dynasty. The results of lacquer layer analysis with a microscope and scanning electron microscopy-energy dispersive X-ray spectrometry revealed that most samples were composed of 1–3 lacquer layers. Moreover, a red-colored layer was found to be red ochre and cinnabar, and Fourier-transform infrared spectroscopy analysis was carried out to determine the components of the lacquer layer. The detected components were mostly lacquer and partially cashew shell nut liquid.

**Keywords:** lacquer, lacquer technique, red and black layers, wooden lacquered craftworks, late Joseon Dynasty

## 1. INTRODUCTION

Wooden products, such as furniture or musical instruments, are manufactured by subjecting them to a painting process by lumbering, drying, bonding, and assembling. In particular, the painting process is the final finishing process aimed at beautifying the aesthetics of the product and protecting it from changes in the surrounding environment. Paint can protect wood from contamination, aging, and damage and improve moisture, water, flame, oil, chemical, antibacterial, and abrasion resistance as well as repel insects and prevent defects (Arsyad *et al.*, 2019; DAPA, 2008; Hwang *et al.*, 2018; Kim, 2018;

Kim and Kim, 2021; Kim *et al.*, 2010; Na *et al.*, 2015; Oh and Park, 2015; Park *et al.*, 2018, 2020b, 2021a). Lacquer is a traditional Korean varnish used for a long period owing to its remarkable functions such as waterproofing, antibacterial and heat resistance, and insect repellent and aesthetic aspects (Do and Lee, 1999; Han *et al.*, 2021; Kim, 2007). Lacquerwares seem to have been used since the ancient times of Korea, as they were excavated from the historical sites of Sinchang-dong in Gwangju, the tomb of King Muryeong in Gongju, and the historical sites of Daho-ri in Changwon. Results of recent studies have shown that lacquer was used in burnished red pottery for adhesive during the neolithic

Date Received November 9, 2022, Date Revised November 24, 2022, Date Accepted February 9, 2023

<sup>1</sup> Jinsung Cultural Heritage Conservation, Buyeo 33127, Korea

<sup>2</sup> National Research Institute of Maritime Cultural Heritage Maritime Museum, Taean 32132, Korea

<sup>3</sup> Department of Conservation and Art Bank, National Museum of Modern and Contemporary Art, Cheongju 28501, Korea

<sup>4</sup> Department of Heritage Conservation and Restoration, Graduate School of Cultural Heritage, Korea National University of Cultural Heritage, Buyeo 33115, Korea

<sup>5</sup> Department of Conservation Science, Korea National University of Culture Heritage, Buyeo 33115, Korea

<sup>†</sup> Corresponding author: Soochul KIM (e-mail: oldforest@nuch.ac.kr, <https://orcid.org/0000-0002-3508-8386>)

© Copyright 2023 The Korean Society of Wood Science & Technology. This is an Open-Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

and bronze age. It can be assumed that lacquer has been used since the prehistoric age (Lee *et al.*, 2021) and that lacquerware manufacturing techniques in Korea have been developed over time involving various materials. Moreover, certain techniques may represent lacquerware of a certain era (Kim, 2007).

Lacquerware techniques were developed from ancient times through the unified Silla period. In the Goryeo Dynasty, lacquerware techniques used bone ash, which is a combination of bone powder. Unique styles of lacquerware inlaid with mother-of-pearl proliferated (Han, 2015). In the early Joseon Dynasty, the style of lacquerware reflected that of the Goryeo Dynasty. However, under the influence of Confucianism, it used unique and random locations of flowers and other patterns (Choi *et al.*, 2011). After the 16th-century technical regression, the collapse of the state-led handicraft industry and the development of currency led to the emergence of the private handicraft industry. Patterned ornaments embedded with Confucianism and objects decorated with letters and folk paintings were produced on a large scale (Kim, 2018; Sin, 2013). Indigenous design symbols reflecting folk religion were depicted; however, the surface of the lacquer became rough, and the mother-of-pearl pattern lost its delicacy and preciseness (Sin, 2013).

The tradition of lacquerware continued from ancient times to the Three States period, the Goryeo and Joseon Dynasty, and the present day. The lacquerware technique from the Joseon Dynasty has been investigated mainly based on formality and techniques. Studies and analytic research using scientific methodologies are limited.

Therefore, in this study, lacquerware manufacturing techniques and components analysis were conducted on five objects of wooden lacquerware from the late Joseon Dynasty from the Onyang Folk Museum and three objects of wooden lacquerware from the Jeju Haenyeo Museum to construct a basic database of lacquer techniques of the late Joseon Dynasty.

## 2. MATERIALS and METHODS

### 2.1. Materials

Eight objects of lacquerware (tables, boxes, and barrels) estimated to have been manufactured during the late Joseon Dynasty were selected for analysis (Fig. 1).


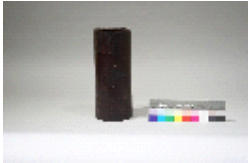





### 2.2. Method

#### 2.2.1. Optical microscope

Optical microscope observations were conducted to determine material characteristics and manufacturing techniques (DM2700P, Leica, Wetzlar, Germany). Eight samples were collected from the lacquerware (Fig. 1). Samples were collected from the natural cracks of lacquerware using scalpels. The samples were fixed on a 15 mm silicone frame and cured with epoxy resin (Epofix, Struers, Ballerup, Denmark) for 24 h (Choi and Kim, 2018; Choi *et al.*, 2022; Lee, 2017). The cured epoxy resin samples were cut using a micro-cutting machine (Minitom, Struers), and slices of 5  $\mu\text{m}$  were crafted using polishing paper. Foreign substances were removed using an ultrasonic cleaner. A slice was placed on a sliding glass, and glycerin (50%, aq. soln.) was inserted and covered with a cover glass to create a pre-*parat* for the lacquer layer observation with transmitted, polarized, and reflected lights.

#### 2.2.2. Scanning electron microscopy-energy dispersive X-ray spectrometry (SEM-EDS)

SEM-EDS analysis was carried out to analyze the components of pigments used in lacquerware. Samples were coated with gold. Data were collected using 20 kV of voltage and at 20 mm of working distance. Colored layers estimated to use pigments were analyzed. SEM (SU3800, Hitachi, Tokyo, Japan) was used to observe high magnification and EDS (Hitachi) was used to ana-

No.	Subject	Picture	No.	Subject	Picture
O-1	Mother-of-Pearl bobbin		O-2	Bamboo tube	
O-3	Dressing stand		O-4	Rice tub	
O-5	Wooden board		J-6	Cabinet	
J-7	Incense burner table		J-8	Ancestral rites table	

**Fig. 1.** Subject of analysis of wooden lacquered craftworks from the late Joseon Dynasty. O: Onyang Folk Museum, J: Jeju Haenyeo Museum.

lyze the main components of colored layers.

### 2.2.3. Fourier-transform infrared spectroscopy (FT-IR)

FT-IR analysis was conducted to confirm the main components of lacquer. Data were collected in attenuated total reflection mode, 4 cm<sup>-1</sup> of the resolution, 400–4,000 cm<sup>-1</sup> of range, and 32 scans. Analyzed spectra were compared with the standard database and other preceding research data.

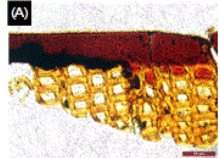
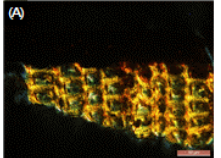
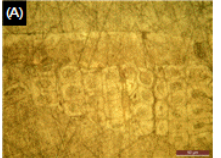
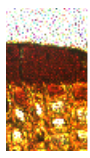
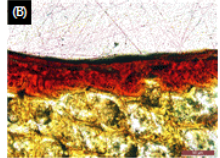
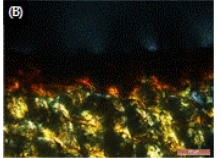
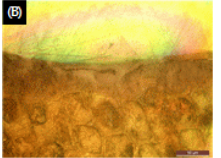

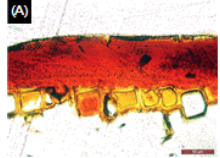
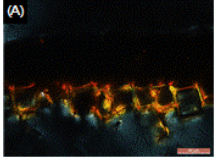
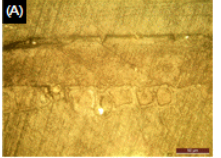

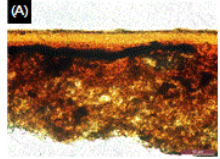
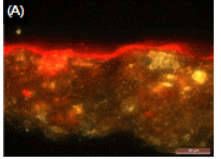
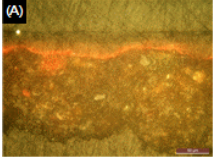
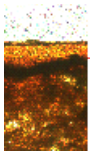
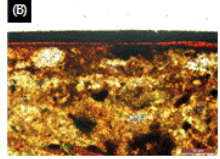
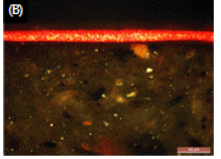
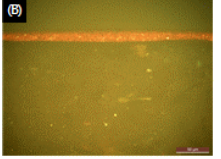
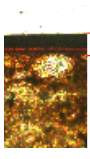
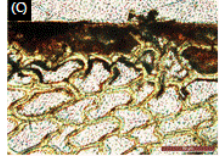
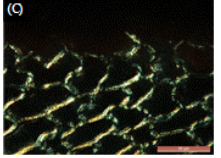
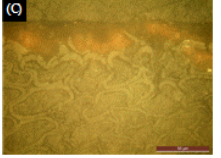
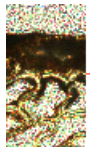
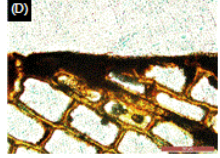
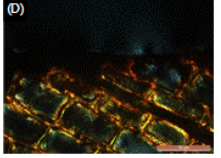
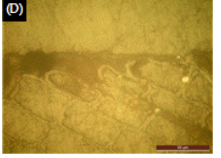
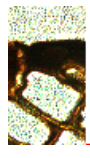
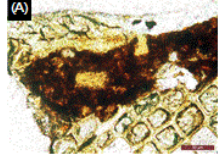
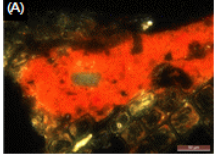
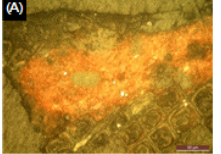
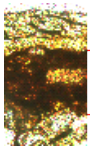
## 3. RESULTS and DISCUSSION

### 3.1. Optical microscope

Through optical microscope observation, one lacquer

layer was detected from a mother-of-pearl bobbin (O-1), bamboo tube (O-2), cabinet (J-6), and incense burner table (J-7; Fig. 2). The thickness of the lacquer layer was 40 μm in the mother-of-pearl bobbin, 30 μm in the bamboo tube, 20 μm in the cabinet, and 15 μm in the incense burner table. Crystal structures from wood were detected through polarized light observation. Mineral and pigment particles were not detected. Therefore, it is estimated that the mother-of-pearl bobbin, bamboo tube, cabinet, and incense burner table were made of wood and varnished only once.

Two lacquer layers were observed in a dressing stand (O-3). The observed thickness of the dressing stand was 14 μm (first layer) and 66 μm (second layer) in a dressing stand (O-3). Crystal structures from wood were detected through polarized light observation. Mineral

No.	Transmitted light (× 400)	Polarized light (× 400)	Reflected light (× 400)	Lacquer layer (× 400)
O-1				
O-2				
O-3				
O-4				
O-5				
J-6				
J-7				
J-8				

**Fig. 2.** Microscopic observation results by a layer of wooden lacquered craftworks from the late Joseon Dynasty. B: base layer, L: lacquer layer, R: red colored layer.

and pigment particles were not detected. Therefore, a dressing stand (O-3) was estimated to be made of wood and varnished twice.

Three lacquer layers were observed in the rice tub (O-4) and wooden board (O-5). The observed thickness of the rice tub (O-4) was 180  $\mu\text{m}$  (base layer), 20  $\mu\text{m}$  (red-colored layer), and 15  $\mu\text{m}$  (lacquer layer). The observed thickness of the wooden board (O-5) was 320  $\mu\text{m}$  (base layer), 10  $\mu\text{m}$  (lacquer layer), and 15  $\mu\text{m}$  (red-colored layer). Through polarized light observation, we detected mineral particles in the lacquer-clay mixed layer and red pigment particles in a red-colored layer. Through reflected light observation, we determined a red-colored layer. Therefore, it is estimated that the rice tub (O-4) was varnished on a wooden base in the consecutive order of the lacquer-clay layer, red-colored layer, and lacquer layer. A wooden board (O-5) was varnished on a wooden base in the consecutive order of the lacquer-clay layer, lacquer layer, and red-colored layer.

Two lacquer layers were observed in the ancestral rites table (J-8). The observed thickness of the ancestral rites table (J-8) was 80  $\mu\text{m}$  (red-colored layer) and 50  $\mu\text{m}$  (lacquer layer). Crystal particles of wood and red pigment particles were detected through polarized light observation. Furthermore, a red-colored layer was detected through reflected light observation. Therefore, the ancestral rites table (J-8) was varnished on a wooden base in consecutive order of the red-colored layer and lacquer layer.

### 3.2. Scanning electron microscopy-energy dispersive X-ray spectrometry (SEM-EDS)

According to the results of SEM-EDS, carbon and oxygen were detected from the lacquer layer of the mother-of-pearl bobbin (O-1), bamboo tub (O-2), and dressing stand (O-3; Fig. 3). A small amount of silicon and aluminum was also detected. Therefore, the lacquer

layer was painted only with lacquer and without other inorganic pigment and lacquer clay.

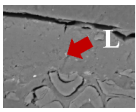
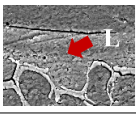
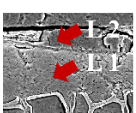

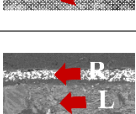
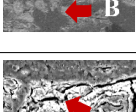
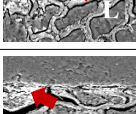
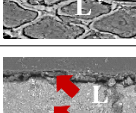
Carbon, oxygen, silicon, and aluminum were detected from the cabinet (J-6) and incense burner table (J-7). Therefore, it was assumed that mineral was used in the base and lacquer layer.

Carbon and oxygen were detected from the lacquer layer of the rice tub (O-4), wooden board (O-5), and ancestral rites table (J-8). Silicon and aluminum were detected from the base layer of the rice tub (O-4) and wooden board (O-5). Also, iron was detected from the red-colored layer of the rice tub (O-4) and ancestral rites table (J-8). Mercury and sulfur were detected from the red-colored layer of the wooden board (O-5).

Among red pigments with iron as a main component, red ochre and hematite were determined, whereas among those with mercury as a main component, cinnabar was identified. Therefore, it was assumed that the red-colored layers of the rice tub (O-4) and ancestral rites table (J-8) were made with red ochre or hematite and the red-colored layer of the wooden board (O-5) was made with cinnabar (National Research Institute of Cultural Heritage, 2020).

### 3.3. Fourier-transform infrared spectroscopy (FT-IR)

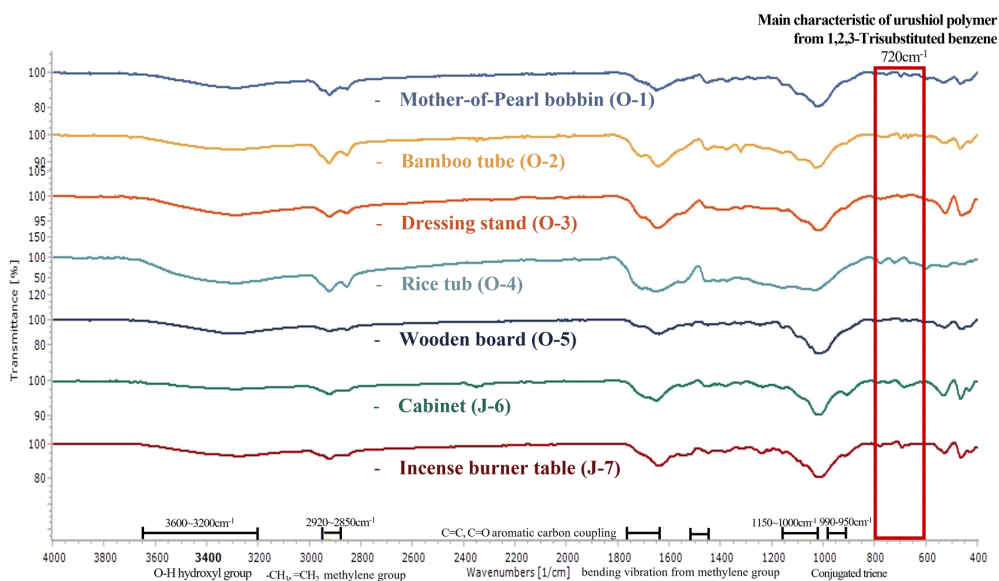
As shown in Fig. 4, the following results of FT-IR in the mother-of-pearl bobbin (O-1), bamboo tube (O-2), dressing stand (O-3), rice tub (O-4), wooden board (O-5), cabinet (J-6), and incense burner table (J-7) were detected: 3,600–3,200  $\text{cm}^{-1}$  (-OH, hydroxyl group), 2,920–2,850  $\text{cm}^{-1}$  (-CH<sub>3</sub>, = CH<sub>2</sub>, methylene group), 1,700  $\text{cm}^{-1}$  (C = C, aromatic carbon coupling), 1,455  $\text{cm}^{-1}$  (CH<sub>3</sub>, = CH<sub>2</sub>, bending vibration of methylene group), 1,000–1,150  $\text{cm}^{-1}$  (-OH, hydroxyl group), 990–950  $\text{cm}^{-1}$  (conjugated triene) and 720  $\text{cm}^{-1}$  peaks (1,2,3-trisubstituted benzene). According to previous research and the FT-IR spectrum of lacquer built in this laboratory, as

No.		Element content (%)													
		C	O	Na	Al	Si	K	Ca	Mg	S	Cl	Hg	Fe	Pb	
O-1		L	77.94	20.36	0.30	-	-	0.31	0.95	0.14	-	-	-	-	-
O-2		L	80.39	17.52	0.48	-	-	0.37	0.46	-	0.21	0.58	-	-	-
O-3		L1	80.88	16.19	-	0.38	0.73	-	0.20	-	0.50	1.10	-	-	-
		L2	81.45	17.47	0.21	-	0.06	0.17	0.49	-	-	0.16	-	-	-
O-4		L	76.48	19.21	0.85	1.02	1.22	0.62	-	-	-	0.52	-	-	-
		R	58.83	17.0	0.25	0.39	0.47	0.19	0.24	0.12	-	0.18	-	22.32	-
		B	54.49	23.33	0.92	3.90	10.96	5.58	-	-	-	0.82	-	-	-
O-5		R	45.55	5.53	0.10	0.10	0.13	-	0.34	-	6.82	-	41.53	-	-
		L	75.98	22.85	0.37	0.18	0.21	-	-	-	-	0.40	-	-	-
		B	36.78	34.96	3.24	6.22	16.46	0.31	1.60	0.20	0.23	-	-	-	-
J-6		L	44.72	29.26	0.26	9.72	10.17	0.45	0.90	0.22	0.29	0.13	-	3.89	-
J-7		L	63.71	18.77	-	5.80	8.86	0.26	0.26	0.32	0.07	0.35	-	1.60	-
J-8		L	80.33	14.01	0.16	1.74	1.41	0.25	0.40	0.14	0.13	0.09	-	1.33	-
		R	29.95	33.82	0.10	12.32	12.11	0.67	0.22	0.26	0.21	0.12	-	10.21	-

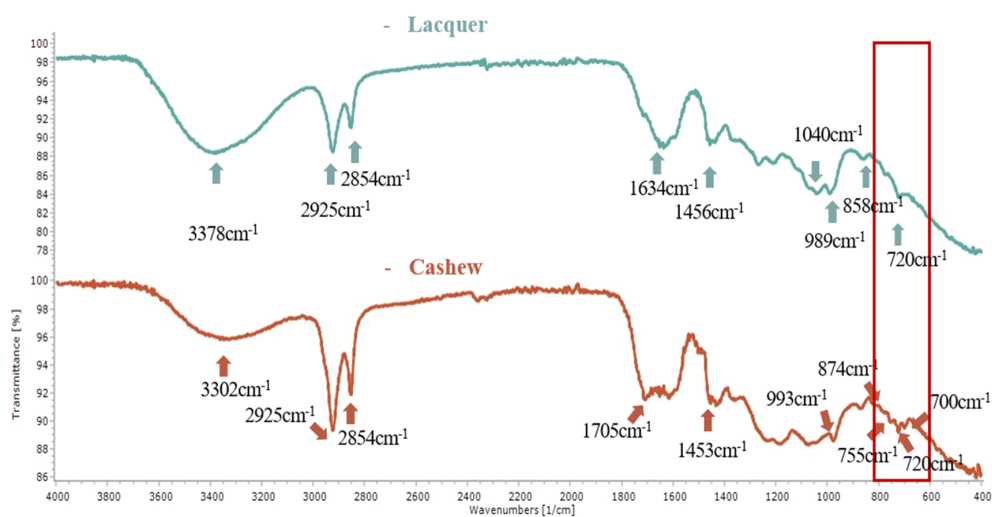
**Fig. 3.** Results of SEM-EDS analysis by a layer of wooden lacquered craftworks from the late Joseon Dynasty (100% total element content). SEM-EDS: scanning electron microscopy-energy dispersive X-ray spectrometry.

shown in Fig. 5, FT-IR peaks of urushiol polymer, which was the main component of lacquer, were detected as follows: 3,600–3,200  $\text{cm}^{-1}$  (absorption peaks from hydroxyl group), 2,925  $\text{cm}^{-1}$ , 2,854  $\text{cm}^{-1}$  (stretching vibration from the methylene group), 1,634  $\text{cm}^{-1}$  (stretching vibration from C = C coupling), 1,456  $\text{cm}^{-1}$  (banding vibration from the methylene group), 989  $\text{cm}^{-1}$  (con-

jugated triene), 858  $\text{cm}^{-1}$  (1,2,3,5-substituted benzene), 720  $\text{cm}^{-1}$  (main characteristic of urushiol polymer from 1,2,3-trisubstituted benzene; Cho *et al.*, 2010; Choi and Kim, 2018; Kim, 2007; Lee, 2021). Compared with the results of previous studies conducted on lacquer FT-IR analysis (Hwang *et al.*, 2018; Kim *et al.*, 2010; Lee and Han, 2017; Lim and Okada, 2018; Park *et al.*, 2020a,



**Fig. 4.** FTIR spectrum for lacquer technique (O-1-5, J-6-7)-lacquer. FTIR: Fourier-transform infrared spectroscopy.



**Fig. 5.** FTIR spectrum for lacquer and cashew (4,000 cm<sup>-1</sup>-400 cm<sup>-1</sup>). FTIR: Fourier-transform infrared spectroscopy.

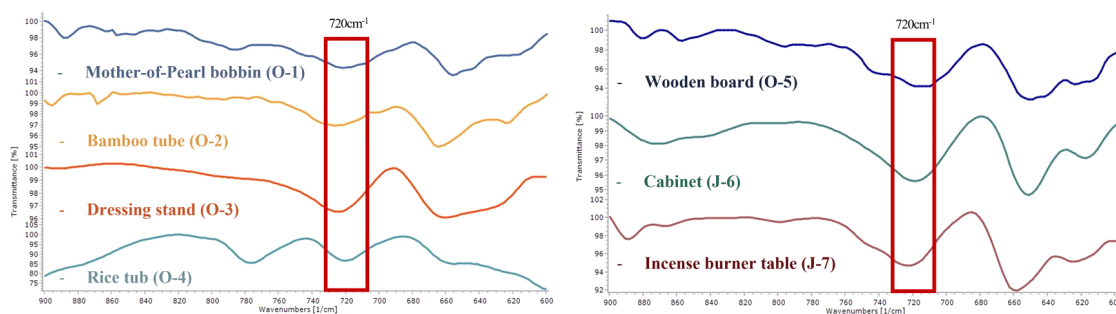
2021b), the peak height differed depending on the content of urushiol in the lacquer coating, drying environment, and UV deterioration. Due to inorganic compo-

nents included in the lower layer of the lacquer coating film and some oxidation products, different spectra were observed in the fingerprint area of 1,000 cm<sup>-1</sup> or less.

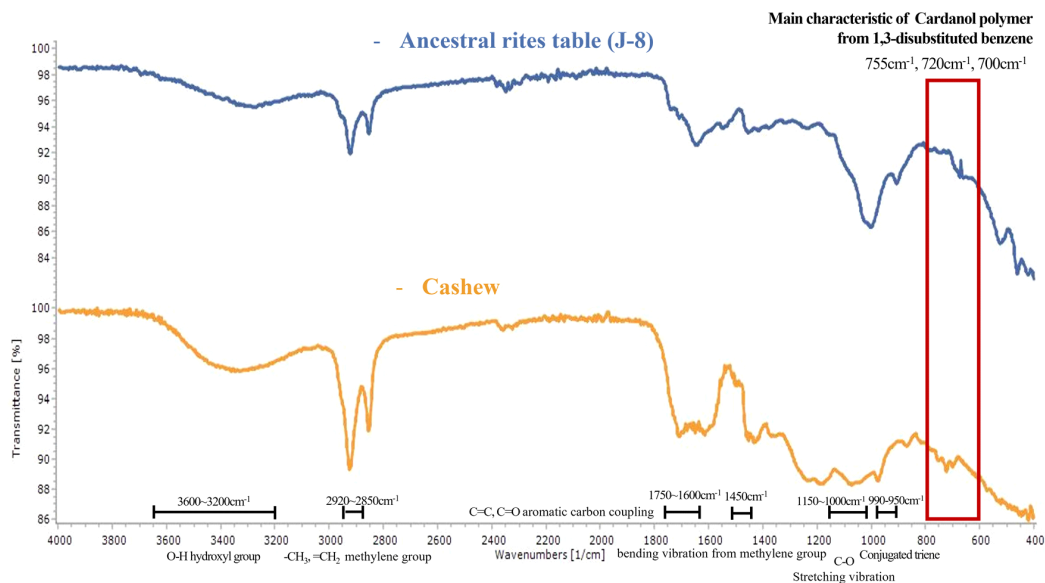
As a result of checking the overall spectrum shown in Fig. 6, in the paints used in O-1-5 and J-6-7, almost the same spectrum as the fingerprint spectrum of the lacquer coating film was observed. Therefore, it was determined that the paints used in O-1-5 and J-6-7 were layered with lacquer.

As shown in Fig. 7, FT-IR peaks were detected from the ancestral rites table (J-8) as 3,560-3,200  $\text{cm}^{-1}$  (-OH,

hydroxyl group), 2,920-2,850  $\text{cm}^{-1}$  (-CH<sub>3</sub>, =CH<sub>2</sub>, methylene group), 1,750-1,600  $\text{cm}^{-1}$  (stretching vibration from C = C and C = O coupling), 1,450  $\text{cm}^{-1}$  (bending vibration from the methylene group), broad band of 1,150-1,000  $\text{cm}^{-1}$  (hydroxyl group), 950-900  $\text{cm}^{-1}$  (conjugated triene), 874  $\text{cm}^{-1}$  (1,2,3,5-substituted benzene), and 755  $\text{cm}^{-1}$ , 720  $\text{cm}^{-1}$ , 700  $\text{cm}^{-1}$  (1,3-disubstituted benzene). This demonstrates a spectrum pattern similar



**Fig. 6.** FTIR spectrum for lacquer technique (O-1-5, J-6-7; 900  $\text{cm}^{-1}$ -600  $\text{cm}^{-1}$ ). FTIR: Fourier-transform infrared spectroscopy.



**Fig. 7.** FTIR spectrum for lacquer technique (J-8)-cashew. FTIR: Fourier-transform infrared spectroscopy.



to that of the lacquer, but sharp peaks are observed in three areas such as  $755\text{ cm}^{-1}$ ,  $720\text{ cm}^{-1}$ , and  $700\text{ cm}^{-1}$  in the fingerprint area of  $1,000\text{ cm}^{-1}$  or less. As shown in Fig. 8, when checking the FT-IR spectrum of lacquer and cashew shell nut liquid built in this laboratory, a distinctive difference was observed. This was concluded to be a characteristic of cardanol polymer, the main component of cashew shell nut liquid. Therefore, it was estimated that the paint used for the ancestral rites table (J-8) was layered with cashew shell nut liquid (Choi and Kim, 2018; Lee, 2021).

#### 4. CONCLUSIONS

In this study, scientific analysis was conducted on eight objects of wooden lacquerware estimated to be made during the late Joseon Dynasty. As result, lacquer was identified in seven objects, whereas cashew shell nut liquid was identified in one object. Cashew shell nut liquid was investigated by Japanese cooperation in 1939. It was used as a varnish for wooden objects owing to its good thermal resistance, oil-proofing, and chemical resistance in modern times (Choi and Kim, 2018; Lee, 2021; Tetsuo, 2007). Therefore, it was expected that the ancestral rites table would be repainted with cashew shell nut liquid in modern times. Also, most of the objects have 1–2 lacquer layers, and partial red-colored

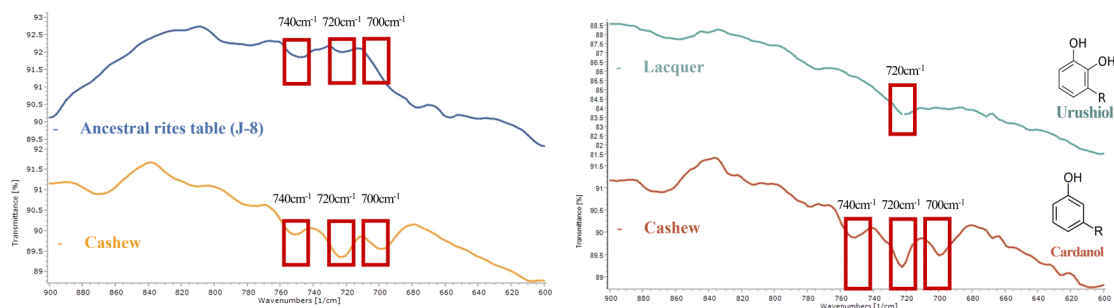
layers were identified.

The research results showed that the lacquerware technique was similar to that of the ancient time during the Goryeo Dynasty; however, it was simplified as it was varnished directly on wooden objects (Lee and Okada, 2016; Lim and Okada, 2018; Yi, 2010; Yi *et al.*, 2014, 2000).

Compared to the early Joseon Dynasty during which lacquer production was state-led, the collapse of the state-led handicraft industry, technical regression, and the development of currency during the late Joseon Dynasty led to a rise of independent and full-time craftsmen and eventually, the emergence of the private handicraft industry (Kim, 2018). Indigenous design symbols reflecting folk religion were made as various wooden lacquerware (Sin, 2013).

Therefore, due to social change and technical regression, lacquerware techniques were simplified; however, the basic techniques of composing lacquer clay and pigment when producing lacquerware were maintained.

Wooden lacquerware manufacturing techniques during the late Joseon Dynasty were investigated through the collection of the Onyang Folk Museum and Jeju Hae-nyeo Museum. These databases can be utilized as a reference for the conservation and restoration of lacquerware manufacturing techniques during the late Joseon Dynasty (Han and Lee, 2021a, 2021b). Furthermore, this



**Fig. 8.** FTIR spectrum for lacquer technique (J-8), lacquer and cashew ( $900\text{ cm}^{-1}$ – $600\text{ cm}^{-1}$ ). FTIR: Fourier-transform infrared spectroscopy.

was expected to complement the lack of analytical data on lacquerware in the late Joseon Dynasty.

## CONFLICT of INTEREST

No potential conflict of interest relevant to this article was reported.

## ACKNOWLEDGMENT

This work was supported by 2020 Academic Research Support Program of Korea National University of Cultural Heritage.

## REFERENCES

- Arsyad, W.O.M., Basri, E., Hendra, D., Trisatya, D.R. 2019. Termite resistance of impregnated jabon wood (*Anthocephalus cadamba* Miq.) with combined impregnant agents. *Journal of the Korean Wood Science and Technology* 47(4): 451-458.
- Cho, N.C., Kim, S.C., Kim, W.H., Shin, Y.S. 2010. A study on the bonding materials used for the great jar of the proto-three kingdoms period from Daechuri site, Pyeongtaek. *Journal of Conservation Science* 26(4): 371-376.
- Choi, J., Kim, S.C. 2018. Analysis of lacquer and CNSL using infrared spectrometer and pyrolysis-GC/MS. *Journal of the Korean Wood Science and Technology* 46(1): 1-9.
- Choi, J., Park, J., Kim, S. 2022. Investigation of wood species and conservation status of wooden seated Amitabha Buddha Triad and Wooden Amitabha Buddha Altarpiece of Yongmunsa temple, Yecheon, Korea (treasure). *Journal of the Korean Wood Science and Technology* 50(3): 193-217.
- Choi, S.C., Kim, S.D., Yi, Y.H., Ko, S.R., Ham, S.W. 2011. Studies on analysis of Joseon lacquer layer. *Journal of Conservation Science* 27(4): 371-380.
- Defense Acquisition Program Administration [DAPA]. 2008. *Paint Standard Practical Handbook*. Defense Acquisition Program Administration, Gwacheon, Korea.
- Do, C.H., Lee, T.Y. 1999. Lacquer coatings on the Koryo Buddhist canon printing wood blocks. *Journal of Conservation Science* 8(1): 33-39.
- Han, J.S. 2015. *Standardization of Traditional Lacquer, Diversification and Development of Mass Production Process*. The Nine Color, Daejeon, Korea. pp. 44-45.
- Han, Y., Lee, S.M. 2021a. Investigation on the awareness and preference for wood culture to promote the value of wood: I. Awareness of wood and cultural experience. *Journal of the Korean Wood Science and Technology* 49(6): 616-642.
- Han, Y., Lee, S.M. 2021b. Investigation on the awareness and preference for wood to promote the value of wood: II. Awareness of wood cultural resources. *Journal of the Korean Wood Science and Technology* 49(6): 643-657.
- Han, Y., Lee, S.M., Choi, J., Park, C.Y. 2021. A study on classification of wood cultural resources in South Korea. *Journal of the Korean Wood Science and Technology* 49(5): 430-452.
- Hwang, I.S., Park, J.H., Kim, S.C. 2018. A study on the optical characteristics according to the lacquer drying conditions for the conservation of lacquerwares. *Journal of the Korean Wood Science and Technology* 46(5): 610-621.
- Kim, H.J. 2018. A study on Ottchil policy in Joseon dynasty. Ph.D. Thesis, Dongbang Culture University, Korea.
- Kim, J.Y., Kim, B.R. 2021. Hygroscopicity and ultraviolet (UV) deterioration characteristics of finished woods. *Journal of the Korean Wood Science and Technology* 49(5): 471-481.
- Kim, S.C. 2007. Analysis and conservation of lacquer wares from archaeological sites in Korea. Ph.D. Thesis, Chungbuk National University, Korea.

- Kim, S.C., Lee, G.H., Kang, H.T., Shin, S.P., Han, M.S. 2010. Lacquer manufacturing method for the wooden coffins of King Muryeong's tomb based on the scientific analysis. *Journal of Conservation Science* 26(3): 247-258.
- Kim, Y.S. 2018. Current researches on the protection of exterior wood from weathering. *Journal of the Korean Wood Science and Technology* 46(5): 449-470.
- Lee, H. 2017. Lacquer layers and making methods of the wooden coffin excavated from the Nongso tomb of Unrimri, Sunchang in Korea. *Journal of Conservation Science* 33(5): 355-362.
- Lee, K.H., Han, G.S. 2017. Study on applying techniques of wooden lacquerware artifacts excavated from Imdang-dong site, Gyeongsan, Korea. *Journal of Conservation Science* 33(2): 61-73.
- Lee, S., Okada, F. 2016. The characteristics of lacquer coating of mother-of-pearl turtle shell lacquerware. *Journal of Conservation Science* 32(2): 109-121.
- Lee, U.C. 2021. Analysis of modern and contemporary wooden furniture painting: A study of cases in Korea modern wooden furniture. M.S. Thesis, Korea National University of Cultural Heritage, Korea.
- Lee, U.C., Park, J.H., Lee, J.H., Kim, S.C. 2021. Study on scientific analysis about red pigment and binder: The Korean ancient red pottery. *Journal of Conservation Science* 37(5): 606-616.
- Lim, J., Okada, F. 2018. Analysis of lacquer coating found from Daesungdong No. 88 tomb of Gimhae. *Journal of Conservation Science* 34(1): 51-57.
- Na, W.J., Cho, S.Y., Kim, D.R., Chung, W.Y. 2015. Water resistance evaluation of the oils coating for conservation of wooden cultural heritage. *Journal of Conservation Science* 31(1): 13-20.
- National Research Institute of Cultural Heritage. 2020. Natural Inorganic Pigment. National Research Institute of Cultural Heritage, Daejeon, Korea.
- Oh, S.W., Park, H.J. 2015. Vacuum pressure treatment of water-soluble melamine resin impregnation for improvement of mechanical property, abrasion resistance and incombustibility on softwood. *Journal of the Korean Wood Science and Technology* 43(6): 792-797.
- Park, J.H., Park, C.H., Kim, S.C. 2021b. A study of different drying condition for conservation of lacquer wares and durability of urushi lacquer coats with enzyme addition. *Journal of the Korea Furniture Society* 32(4): 313-322.
- Park, J.H., Park, J.H., Kim, S.C. 2020a. A study on application of enzyme additives to improve drying speed of Urushi lacquer. *Journal of the Korean Wood Science and Technology* 48(3): 326-344.
- Park, S., Han, Y., Son, D.W. 2020b. Flame retardancy of wood products by spreading concentration and impregnation time of flame retardant. *Journal of the Korean Wood Science and Technology* 48(4): 417-430.
- Park, S., Han, Y., Son, D.W. 2021. Flame retardancy of plywood treated with various water glass concentration and additives. *Journal of the Korean Wood Science and Technology* 49(1): 44-56.
- Park, S.Y., Hong, C.Y., Kim, S.H., Choi, J.H., Lee, H.J., Choi, I.G. 2018. Studies on photoprotection of walnut veneer exposed to UV light. *Journal of the Korean Wood Science and Technology* 46(3): 221-230.
- Sin, H. 2013. A Study on a lacquered relic with mother-of-pearl ornament in the late Choseon dynasty period: Focused on analysis of a lacquered pillow end with mother-of-pearl ornament. *Journal of the Korean Society of Desing Culture* 19(4): 403-414.
- Tetsuo, M.Y.K.S. 2007. Lacquer and macromolecule. *The Polymer* 56(8): 608-613.
- Yi, Y., Park, S., Yun, E., Jung, H. 2014. Production techniques for Goryeo wooden lacquerware. *Conservation Science in Museum* 15: 78-95.
- Yi, Y., Yu, H., Kim, K. 2000. Restoration report of

Junghae PARK et al.

bamboo-plated inkstone case. Conservation Science  
in Museum 2: 35-40.

Korean lacquer wares. M.S. Thesis, Kongju National  
University, Korea.

Yi, Y.H. 2010. A study of the techniques of the ancient