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Mercury lamp-Induced Aging Effects on Surface Properties and Microstructure of Four Rosewood Species

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Abstract: This study investigated the effects of mercury lamp-induced aging on the surface properties and microstructure of four rosewood species (*Dalbergia retusa*, *Dalbergia bariensis*, *Pterocarpus macrocarpus*, and *Pterocarpus erinaceus*). Changes in wood color, gloss, roughness, chemical composition, and microscopic morphology during the aging process were systematically analyzed through simulated ultraviolet light-accelerated aging experiments conducted at 60° C for up to 720 hours. The results indicated significant differences in UV radiation responses among the species: *Dalbergia retusa* and *Dalbergia bariensis* demonstrated high photostability, attributed to their abundant antioxidant extracts, exhibiting minimal color changes ($\Delta E \leqslant 3.18$) and limited roughness increases (34.57% - 35.26%). In contrast, *Pterocarpus macrocarpus* and *Pterocarpus erinaceus* displayed notable color fading ($\Delta E = 4.58$) and a 76.06% rise in roughness due to lignin photooxidation and extractive degradation. Fourier-transform infrared (FTIR) spectroscopy revealed chemical alterations, including lignin degradation and carbonyl formation, while environmental scanning electron microscopy (ESEM) observations identified microstructural deterioration, such as catheter wall cracking and crystalline deposition post-aging. The study elucidated the relationship between the photoaging mechanisms and the chemical composition and microstructure of rosewood, offering a scientific foundation for material selection, maintenance, and durability enhancement of rosewood furniture.

Key words: Mercury lamp aging, rosewood, surface properties, FTIR, ESEM.

1. Introduction

As an important renewable natural material, wood plays a vital role in human production and daily life due to its unique biological characteristics, natural grain, and excellent physical and mechanical properties. It has been an essential material in furniture manufacturing, interior decoration, and construction engineering for centuries [1,2]. Its cell wall structure provides a favorable strength-to-weight ratio, while its chemical components, such as cellulose, hemicellulose, and lignin, determine its physical and aesthetic qualities. However, during use, wood is highly susceptible to environmental factors like light, temperature, humidity, and oxygen, which accelerate its aging process [3]. These factors cause surface color changes, such as yellowing or darkening, reduced gloss, increased roughness, and microstructural deterioration, including cracks or pores in cell walls [4]. These changes not only diminish wood's visual appeal but also weaken its mechanical performance and durability, reducing its value as a decorative and structural material. Therefore, studying wood aging mechanisms and their influencing factors is crucial for improving the durability and lifespan of wood products.

Among artificial accelerated aging methods, mercury lamp aging has gained attention for its ability to simulate UV-induced aging. By emitting specific UV wavelengths (e.g., 254 nm and 365 nm), it provides a controllable and adjustable environment, making it a valuable tool for studying wood photo-aging behavior [5,6]. The response to mercury lamp aging varies significantly among wood species, primarily due to differences in density, chemical composition, and microstructure [7]. High-density wood, with its compact cell structure and higher lignin content, generally exhibits greater aging resistance, while low-density wood is more prone to photodegradation. Additionally, wood extractives, such as phenols and flavonoids, may delay aging by absorbing UV light or participating in antioxidant reactions [8]. Research shows that lignin, as the primary photosensitive component, undergoes photo-oxidation under UV exposure, leading to surface darkening and reduced mechanical properties [9]. Thus, mercury lamp aging experiments offer scientific insights into the aging resistance of different wood species and their optimal utilization.

As a cornerstone material in traditional Chinese furniture, rosewood is celebrated for its exceptional properties, including high density, superior dimensional stability, elegant grain patterns, remarkable mechanical strength, uniform structure, and excellent carving suitability [10,11]. These unique physical attributes, combined with its profound cultural significance, have cemented rosewood's pivotal role in Chinese furniture craftsmanship [12]. Renowned for its timeless designs and meticulous artistry, rosewood furniture not only embodies the essence of traditional Chinese culture but also commands a prestigious status in global markets [13]. However, the long-term durability and surface performance of rosewood, particularly the alterations in aesthetics and functionality during aging, remain critical areas necessitating further investigation [14,15]. In practical applications, rosewood furniture frequently encounters challenges such as color fading, surface cracking, and diminished mechanical performance due to environmental factors like light exposure, humidity fluctuations, and temperature variations [16]. These issues not only compromise its visual appeal but also potentially curtail its service life. Consequently, comprehensive research into the aging mechanisms and protective strategies for rosewood is of paramount theoretical and practical importance [17].

Recent advancements in the study of wood photodegradation have significantly enhanced our understanding of the mechanisms underlying UV-induced changes in color and chemical composition [18]. Notably, the light absorption properties of lignin are identified as the primary driver of color alterations [19,20]. Under UV exposure, lignin undergoes photo-oxidation, generating chromophores that result in surface darkening or fading [21]. Concurrently, the photodegradation of hemicellulose and cellulose contributes to increased surface roughness and reduced mechanical integrity [22]. Mercury lamp aging, which emits intense UV radiation, effectively replicates the photodegradation processes that occur under natural outdoor conditions, making it an invaluable tool in related research [23,24]. Empirical studies have demonstrated that different wood species exhibit pronounced variations in color changes and chemical degradation under mercury lamp aging conditions [25]. For instance, certain species exhibit significant darkening, while others may experience fading [26]. Despite these insights, the majority of research has been confined to a limited array of wood types, leaving a comprehensive evaluation of rosewood's aging behavior largely unexplored [27,28]. Given its distinctive chemical composition and structural characteristics, rosewood's photodegradation behavior may markedly differ from that of conventional wood, presenting new avenues for research [29].

In contrast to ordinary wood, rosewood is abundant in extractives, which may profoundly influence its degradation characteristics [30]. These extractives, including phenols, flavonoids, and terpenes, not only impart rosewood with its characteristic color and aroma but may also mitigate photodegradation through antioxidant or UV-absorbing mechanisms [31]. Nevertheless, research in this domain remains scant, particularly concerning the specific roles of extractives in the photodegradation process [32]. Moreover, current methodologies for assessing wood photodegradation—such as colorimetry, glossimetry, infrared spectroscopy, and surface microstructure analysis—require refinement, particularly in their integrated application [33]. For example, the synergistic use of multiple analytical techniques to comprehensively characterize the physicochemical changes during wood aging represents a promising direction for future research [34]. By advancing these evaluation methods, researchers can more precisely elucidate the aging mechanisms of rosewood, thereby providing a robust scientific foundation for its preservation and restoration [35].

This study focuses on four rosewood species—Dalbergia retusa, Dalbergia bariensis, Pterocarpus macrocarpus, and Pterocarpus erinaceus—as research subjects. Employing mercury lamp aging under a constant temperature of 60°C, the wood samples underwent aging treatments of 120, 240, 480, and 720 hours, respectively. The investigation systematically analyzed changes in wood color, gloss, roughness, and microstructure. Environmental scanning electron microscopy (SEM) was utilized to observe surface morphology, while Fourier-transform infrared spectroscopy (FTIR) was employed to probe chemical structural alterations, offering insights into the degradation mechanisms during mercury lamp aging [36,37]. The study aims to elucidate the surface performance evolution of different rosewood species under photodegradation conditions, thereby providing scientific guidance for material selection, usage, and maintenance of rosewood furniture [38]. Additionally, it establishes a theoretical foundation for enhancing the durability and extending the service life of rosewood products [39,40].

2. Materials and Methods

2.1 Materials

According to the Chinese rosewood standard, *Dalbergia* and *Pterocarpus* are important categories of rosewood. This study selects *Dalbergia retusa, Dalbergia bariensis, Pterocarpus macrocarpus, and Pterocarpus erinaceus* as research wood species. The wood samples were provided by Qiaojiadayuan Furniture Co., Ltd. in Taizhou, Jiangsu, with a moisture content controlled at 12% ± 2%. The specimens were processed to dimensions of 120 × 80 × 8 mm, with 10 replicates for each wood type. To ensure a smooth surface, they were manually sanded with 120-, 240-, and 360-grit sandpaper in sequence. For experimental reliability, all specimens were conditioned at 20°C and 50% relative humidity for 14 days until their weight stabilized before undergoing the mercury lamp aging test.

2.2 Mercury Lamp-Induced aging Process

The aging experiment was conducted at the Furniture Materials Laboratory of Nanjing Forestry University, following the ASTM G154-2006 standard titled "Operating Fluorescent UV Lamp Apparatus for Exposure of Nonmetallic Materials." A HE-UVA-2T ultraviolet accelerated aging test chamber was employed, equipped with eight UVA-340 lamps emitting wavelengths in the range of 315–400 nm. The aging temperature was set at 60°C, with an irradiance level of 0.89 W/m². The aging process was divided into four stages, with durations of 120 hours, 240 hours, 480 hours, and 720 hours, respectively. At the conclusion of each stage, the samples were allowed to rest in the chamber for 24 hours before being removed for comprehensive surface performance analysis.

2.3 Appearance Evaluation and Color Measurement

To systematically evaluate the appearance changes of wood under different mercury lamp aging durations, an HP scanner was used to capture surface images before and after aging, as well as at various aging stages. The images were further processed using Photoshop software to enhance contrast and clarity, thereby providing a more intuitive visualization of surface morphological changes during the aging process.

The color measurement of the samples was conducted using a color detector (Model: Capsure, Shanghai Nuocai Trading Co., Ltd., Shanghai, China) to assess the surface color of the hardwood. The light source used was the D65 standard light source, with a correlated color temperature of 6504 K and a standard observation angle of 10°. As wood is a natural material, color variations may exist across different areas of each specimen. Therefore, measurements were consistently taken from the same regions of each specimen—specifically, four corners located 2 cm from the edges. A total of 40 sets of color data (*L**, *a**, *b**, and *C**) were collected, and their average values were calculated. Color change was determined using the following formula:

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Where: ΔE^* represents the total color difference, with larger values indicating greater deviation from the reference sample; ΔL^* represents the brightness difference, where a positive value indicates a brighter appearance than the reference sample, and a negative value indicates a darker appearance; Δa^* represents the change in the red-green axis, where a larger positive value indicates a shift toward red and a negative value indicates a shift toward green; Δb^* represents the change in the yellow-blue axis, where a larger positive value indicates a shift toward yellow and a negative value indicates a shift toward blue.

2.4 Gloss Measurement

In accordance with ASTM D523-2014 [24] and GB/T 4893.6-2013 [25], surface gloss was measured both before and at different stages after aging to analyze its variation. A 3nh intelligent gloss meter (Model: NHB268, Shenzhen 3nh Intelligent Technology Co., Ltd., Shenzhen, China) was employed at a 60° measurement angle. Each specimen underwent two measurements, yielding 20 gloss readings in total, with the average value used to assess the effects of UV aging on the wood surface.

2.5 Surface Roughness Measurement

Following the ISO 21920-2-2021 [26] standard, the surface roughness of the wood was measured before and at various stages after aging. A JB-4C roughness tester (Shanghai Taiming Optical Instrument Co., Ltd., Shanghai, China) was used, with measurements conducted along the fiber direction on the cross-section. The sampling length was set to 2.5 mm, with a total measurement length of 50 mm, divided into four sections. Each specimen was tested twice, yielding 20 sets of Ra values, and the average was calculated to evaluate the impact of aging on surface roughness.

2.6 Fourier Transform Infrared (FTIR) Spectroscopy Analysis

FTIR spectra were recorded using a Bruker ALPHA spectrometer equipped with an ATR (attenuated total reflection) module. The spectra were collected within the range of 4000–400 cm^{-1} at a resolution of 4 cm^{-1}, with each spectrum representing the average of 24 scans. Two samples were selected for each wood type, and three random measurement areas were chosen per sample, resulting in six sets of spectral data. All spectra underwent baseline correction and smoothing, and their average was calculated. The spectra were then normalized using the min-max normalization method. By comparing the normalized average spectra before and after aging, the chemical changes induced by different aging durations were analyzed.

2.7 Environmental Scanning Electron Microscope (ESEM) Analysis

To investigate the effect of UV aging on the microscopic morphology of the wood surface, an environmental scanning electron microscope (FEI, Model: Quanta 250) was used, with the accelerating voltage set to 20 kV. Before the experiment, both aged and unaged wood specimens were fixed onto a metal base using conductive adhesive. An ion sputter coater was then employed to evenly coat the sample surface with a platinum layer, enhancing conductivity and image clarity. The microscopic morphology of the wood surface was subsequently observed and recorded under the microscope, analyzing structural degradation characteristics before and after aging.

2.8 Statistical Analysis

The color parameters L*, a*, b*, and C* were analyzed using SPSS software (IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY, USA). One-way analysis of variance (ANOVA) was performed to assess the statistical significance of UV aging effects on wood color. Levene's test for homogeneity of variances and the Shapiro-Wilk test for normality were conducted to verify the assumptions for two-way ANOVA. Fisher's least significant difference (LSD) test was used for multiple comparisons of treatment means, with the significance level set at $\alpha = 0.05$.

3. Results and Discussion

3.1 Visual aspect and Color Changes

Wood is a light-sensitive material, and exposure to light significantly affects its macroscopic appearance. Fig. 1 illustrates the visual changes in four species of rosewood before and after 120 h, 240 h, 480 h, and 720 h of UV aging. Prior to aging, these four species exhibited distinct differences in color and texture, primarily due to variations in the types and proportions of holocellulose, lignin, and extractives. Comparatively, wood from the *Dalbergia* genus appears darker than that from the *Pterocarpus* genus, likely due to the higher extractive content in the former.

In terms of macroscopic changes before and after aging, the overall differences among the four species were relatively minor, except for *Pterocarpus erinaceus*, which exhibited significant color variation, particularly after 720 hours of UV exposure. Additionally, light exposure may also influence the glossiness and surface roughness of the wood, but these changes are not visually apparent in the images, necessitating further analysis and measurement to quantify their effects.

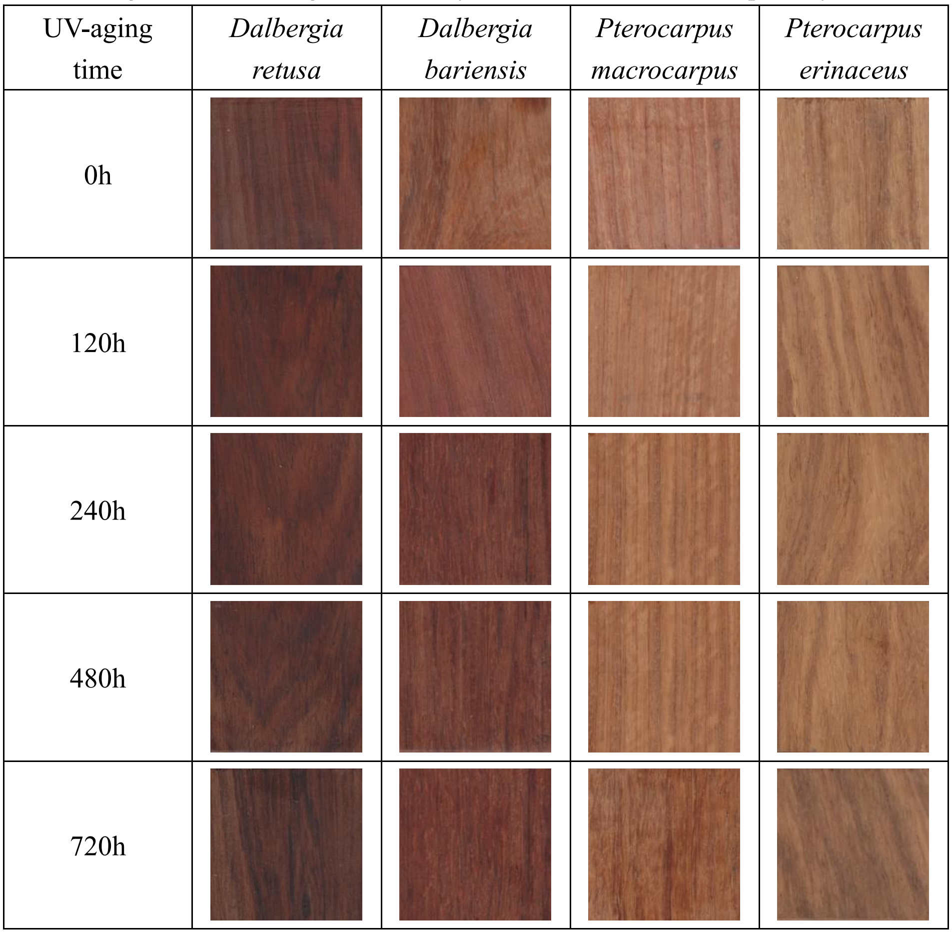


Fig. 1 Visual aspect of 4 species of rosewood before and after different period of UV-aging

Table 1.presents the color changes of four rosewood species (*Dalbergia retusa*, *Dalbergia bariensis*, *Pterocarpus macrocarpus*, and *Pterocarpus erinaceus*) under different UV aging durations (0h, 120h, 240h, 480h, and 720h), measured using four key parameters: L* (lightness), a*

(red-green axis), b* (yellow-blue axis), and C* (color saturation), along with P-values to assess the significance of these changes.

In terms of lightness (L*), *Dalbergia retusa* showed minimal variation (P=0.9053), indicating high resistance to UV aging; *Dalbergia bariensis* exhibited a decline in brightness over time (P=0.012), suggesting darkening of the wood; *Pterocarpus macrocarpus* and *Pterocarpus erinaceus* both experienced significant reductions in brightness (P=0.007 and P=0.001, respectively), with *Pterocarpus erinaceus* showing the most drastic changes.
Regarding the red-green axis (a*), *Dalbergia retusa* peaked at 13.84 at 480h before declining (P=0.048), indicating an initial increase in redness followed by a slight reversal; *Dalbergia bariensis* displayed no significant changes (P=0.081), maintaining a consistent red tone; *Pterocarpus macrocarpus* exhibited a significant increase in a* (P=0.002), becoming progressively redder, whereas *Pterocarpus erinaceus* showed no significant trend (P=0.240) but reached its highest a* value (13.91) at 480h before slightly decreasing.

Table 1 Results of color measurements of 4 species of rosewood before and after different period of UV-aging

UV-aging time		0h	120h	240h	480h	720h	P values
Dalbergia retusa	L*	33.48[a][1] (2.31)[2]	33.17[a] (2.27)	32.88[a] (1.89)	32.85[a] (1.65)	32.71[a] (1.64)	0.905[3]
	a*	12.35[b] (1.36)	12.69[ab] (1.27)	13.07[ab] (1.20)	13.84[a] (0.36)	12.74[ab] (1.06)	0.048
	b*	10.44[a] (0.83)	10.73[a] (0.58)	10.95[a] (1.22)	11.08[a] (1.60)	11.31[a] (0.66)	0.361
	C*	16.18[b] （1.39）	16.64[ab] (1.22)	17.11[ab] (0.81)	17.77[a] (1.03)	17.06[ab] (0.90)	0.026
Dalbergia bariensis	L*	40.03[a] (2.36)	38.17[b] (1.56)	38.11[b] (1.37)	37.64[b] (1.21)	37.47[b] (1.71)	0.012
	a*	16.89[a] (0.89)	17.44[a] (0.74)	17.55[a] (1.32)	17.99[a] (0.38)	18.10[a] (1.42)	0.081
	b*	15.64[a] (1.74)	14.50[a] (0.83)	14.47[a] (0.92)	14.43[a] (1.23)	14.19[a] (0.71)	0.052
	C*	23.06[a] (1.41)	22.69[a] (0.86)	22.76[a] (1.42)	23.08[a] (0.75)	23.02[a] (1.25)	0.942
Pterocarpus macrocarpus	L*	56.32[a] (0.07)	55.64[ab] (1.29)	55.03[ab] （1.47）	54.81[b] （1.05）	54.31[b] (1.41)	0.007
	a*	14.37[c] (1.32)	15.00[bc] (1.40)	15.66[ab] (0.56)	15.74[ab] (0.75)	16.33[a] (1.08)	0.002
	b*	27.55[a] (1.17)	28.45[c] (1.54)	28.56[b] (0.96)	28.72[b] (1.55)	28.23[a] (2.95)	0.621
	C*	31.10[a] (1.13)	32.21[a] (1.18)	32.58[a] (0.71)	32.75[a] (1.57)	32.69[a] (2.05)	0.064

Pterocarpus erinaceus	L*	54.31^{a} (1.70)	53.65^{a} (1.08)	53.47^{a} (1.03)	52.34^{a} (1.47)	50.43^{b} (3.13)	0.001
	a*	12.83^{a} (1.30)	12.94^{a} (0.84)	13.12^{a} (1.51)	13.91^{b} (1.24)	13.45^{c} (0.71)	0.240
	b*	29.13^{a} (0.80)	30.21^{a} (1.68)	30.65^{a} (1.38)	30.37^{a} (2.07)	26.77^{b} (1.55)	<0.001
	C*	31.85^{a} (1.05)	32.88^{a} (1.74)	33.38^{a} (1.33)	33.44^{a} (1.77)	29.96^{b} (1.38)	<0.001

Note: [1] The average of 40 values for L*, a*, b*, and C*, with the same small superscript letters (a–d) within a group, indicates no significant difference based on Fisher's protected LSD test at the 0.05 significance level. [2] The standard deviation of 40 data points. 3 P-value indicates the significance of different influencing factors. The smaller the P-value, the stronger the significance. It is generally considered that when the P-value is less than 0.05, the influencing factors are significant; when the P-value is greater than 0.05, the influencing factors are not significant.

Concerning the yellow-blue axis (b*), *Dalbergia retusa* and *Dalbergia bariensis* showed no significant changes (P=0.361 and P=0.052), indicating stable yellow tones; *Pterocarpus macrocarpus* exhibited little variation (P=0.621), suggesting minimal yellowing; while *Pterocarpus erinaceus* experienced a sharp drop in b* at 720h (P<0.001), indicating a shift towards a bluer hue or significant fading. In terms of color saturation (C*), *Dalbergia retusa* and *Pterocarpus erinaceus* showed significant variations (P=0.026 and P<0.001), with *Pterocarpus erinaceus* experiencing a marked decline at 720h, whereas *Dalbergia bariensis* and *Pterocarpus macrocarpus* displayed no significant change (P=0.942 and P=0.064), indicating stable color saturation.

In total, *Dalbergia retusa* showed strong color stability with minor brightness and saturation changes, peaking in redness at 480h before slightly fading. Dalbergia bariensis darkened over time but maintained a stable hue. *Pterocarpus macrocarpus* became notably redder (a* increase) with slight decreases in brightness and saturation. *Pterocarpus erinaceus* was most susceptible to UV exposure, with significant brightness, saturation, and yellowness reductions, indicating a strong fading tendency. These results highlight variations in light-aging resistance, with *Dalbergia retusa* and *Dalbergia bariensis* being more stable, while *Pterocarpus erinaceus* faded the most.

Fig. 2 shows that all four types of wood undergo color changes (ΔE) during UV aging. *Pterocarpus erinaceus* exhibits the most significant color change, with ΔE reaching a peak of 4.58 at 720 hours, followed by *Dalbergia bariensis* and *Pterocarpus macrocarpus*, with ΔE values of 3.18 and 2.89 at 720 hours, respectively. *Dalbergia retusa* shows the smallest color change, with a ΔE value of 1.23, which is considered negligible and indicates no significant color change.

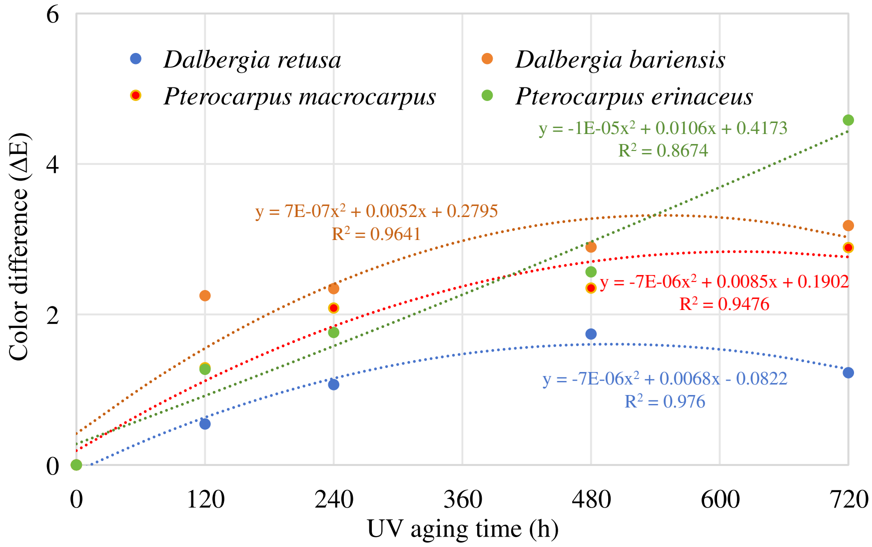


Fig. 2 Color change of 4 species of rosewood before and after different period of UV-aging

Compared to ordinary wood species, the four rosewood types demonstrate superior color stability, with generally lower ΔE values, indicating less color variation and higher durability. This suggests that these woods maintain better color stability over time. The quadratic fitting equations further support this trend: *Pterocarpus erinaceus* has the steepest curve, with the equation $y = -1E\text{-}05x^2 + 0.0106x + 0.4173$ (R^2=0.8674), while *Dalbergia retusa* shows the slowest change, with the equation $y = -7E\text{-}06x^2 + 0.0068x - 0.0822$ (R^2 = 0.976).

A comparative analysis indicates that *Dalbergia* species exhibit better photostability than *Pterocarpus* species. This may be due to the higher content of stable extractives and antioxidants in *Dalbergia* species, which effectively mitigate the impact of UV aging on color [31]. In contrast, *Pterocarpus* species show more pronounced color changes, likely due to the degradation and oxidation of flavonoids and phenolic compounds under UV exposure, leading to rapid discoloration.

3.2 Changes in Glossiness and Roughness

Glossiness is one of the key indicators for evaluating the aesthetic value of wood, and light exposure can lead to a reduction in the surface glossiness of wood. Fig. 3 illustrates the changes in glossiness of four types of wood before aging and after different durations of UV aging. Prior to aging, the glossiness of the four wood types ranged between 2.53 and 2.88 (GU), with the two Dalbergia species exhibiting slightly higher glossiness than the two Pterocarpus species. As the UV aging time increased, the surface glossiness of all four wood types decreased to varying degrees, showing a strong linear relationship. Among them, Dalbergia retusa exhibited the steepest slope in the fitted line, indicating that its surface glossiness was most significantly affected by light exposure. After 720 hours of UV aging, its surface glossiness decreased by 29.09%. The other three wood types experienced a reduction in glossiness ranging from 20.55% to 24.31% after the same aging period.

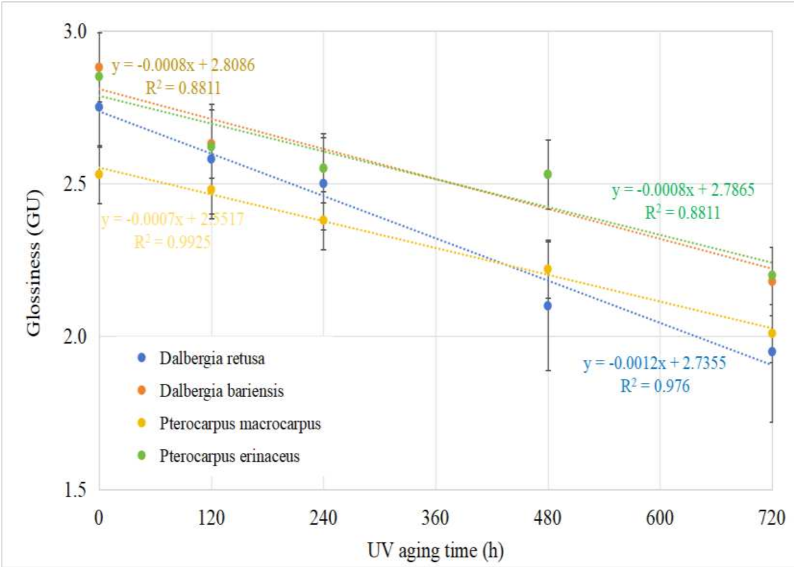


Fig. 3 Glossiness of 4 species of rosewood before and after different period of UV-aging

UV aging leads to a reduction in the glossiness of wood, possibly due to an increase in surface roughness, which diminishes its ability to reflect light in a specular manner. Fig. 4 illustrates the variations in surface roughness (Ra) of four types of wood before UV aging and after different aging durations. Prior to aging, the surface roughness of the four wood types ranged from 1.62 to 2.11 μm, with the two *Dalbergia* species exhibiting slightly lower roughness than the two Pterocarpus species. This result aligns well with the glossiness measurements, indicating that greater surface roughness corresponds to lower glossiness. As the aging duration increased, all four wood types exhibited a clear upward trend in surface roughness, demonstrating a strong linear relationship. Among them, the *Pterocarpus* species showed the most significant increase, with surface roughness reaching 3.17 μm and 3.31 μm after 720 hours of UV aging—representing increases of 50.24% and 76.06%, respectively. In contrast, the *Dalbergia* species experienced a comparatively smaller increase of 34.57% to 35.26% over the same aging period.

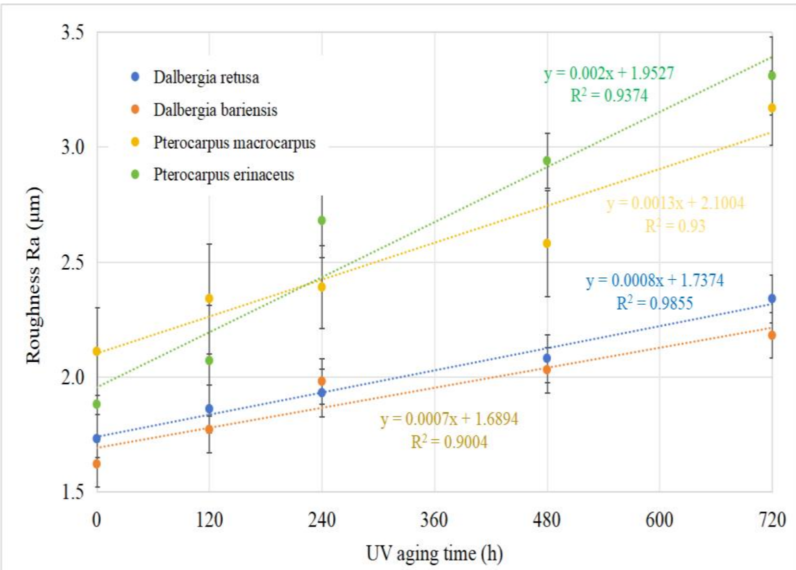
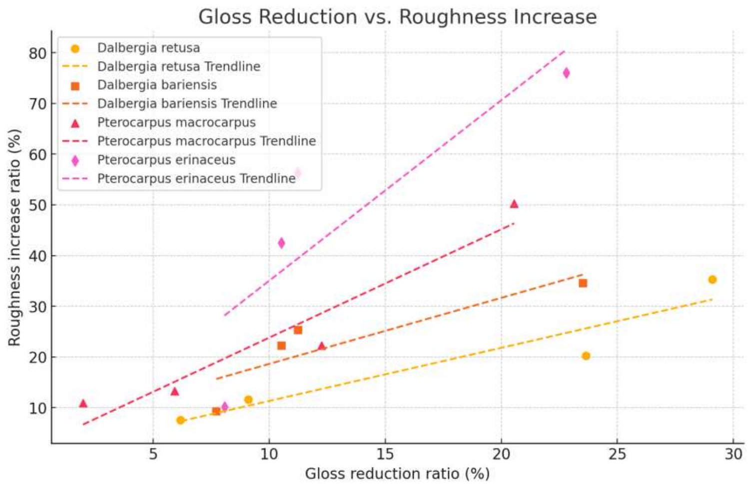


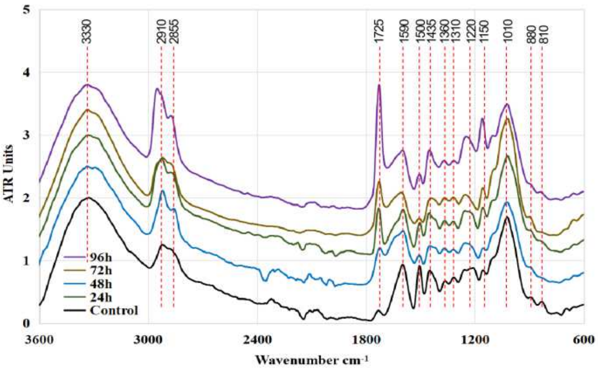
Fig. 4 Roughness of 4 species of rosewood before and after different period of UV-aging

Fig. 5 illustrates the impact of UV aging on the surface properties of four rosewood species), specifically showing the relationship between gloss reduction ratio (%) and Roughness increase ratio (%). The results indicate a clear positive correlation: as gloss decreases due to UV exposure, surface roughness increases. Among the species, *Pterocarpus erinaceus* exhibits the most significant changes, with the fastest roughness increase, suggesting a higher susceptibility to UV-induced surface degradation. In contrast, *Dalbergia retusa* and *Dalbergia bariensis* show more moderate changes, maintaining relatively lower roughness increases under UV exposure, implying better resistance to UV aging. *Pterocarpus macrocarpus* demonstrates an intermediate trend, with a noticeable but not extreme increase in roughness. These findings highlight that UV Aging directly leads to gloss reduction and roughness increase, with distinct differences in UV resistance among wood species. Understanding these variations is crucial when selecting wood materials for applications exposed to prolonged UV radiation.

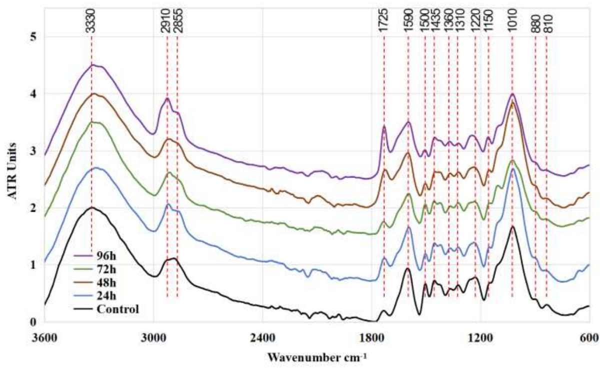


3.3 FTIR Analysis of wood Surface Chemical Changes During UV Aging

FTIR spectroscopy is an essential tool for monitoring the surface chemical changes of wood during UV aging. Fig. 3 shows the characteristic absorption peaks of the four rosewood species, revealing generally similar spectral profiles but varying degrees of change during aging. The main absorption bands include 3330 cm^{-1}, corresponding to the stretching vibrations of hydroxyl (-OH) groups [34-36], indicating changes in hydrogen bonding; 2910 and 2855 cm^{-1}, representing C-H stretching vibrations of methyl and methylene groups[37-38], associated with cellulose and lignin structures; and 1725 cm^{-1}, attributed to carbonyl (C=O) stretching vibrations, mainly from cellulose and hemicellulose[39-41]. The 1590 and 1500 cm^{-1} peaks correspond to the aromatic C=C skeletal vibrations of lignin[42-44], while 1425 cm^{-1} and 1360 cm^{-1} are linked to C-H bending vibrations in cellulose and hemicellulose[45-47]. Additional notable peaks include 1310 cm^{-1} (associated with hemicellulose C-H deformation vibrations), 1220 cm^{-1} and 1010 cm^{-1} (related to C-O stretching vibrations)[48-50], and 880 and 810 cm^{-1}, which correspond to C-H bending vibrations[51-52].



a



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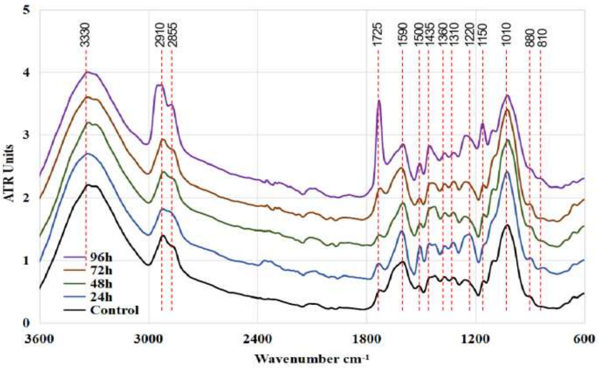
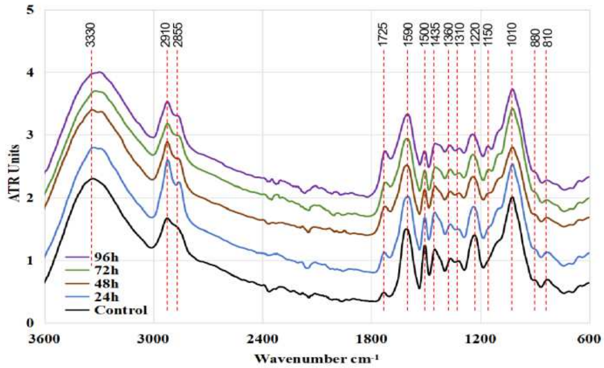


c



d

Among these spectra, the most significant change during UV aging occurs at 1725 cm^{-1}, where the intensity of the carbonyl peak increases over time, signifying oxidative degradation[53-55], particularly in *Dalbergia retusa* and *Pterocarpus macrocarpus*, followed by *Dalbergia bariensis*, while *Pterocarpus erinaceus* exhibits relatively minor changes. Meanwhile, a notable decrease in the 1590 and 1500 cm^{-1} peaks suggests the progressive photodegradation of lignin, potentially leading to quinone formation[56-58]. Compared to ordinary wood species, hardwoods exhibit greater changes at 1725 cm^{-1} but smaller variations at 1590 and 1500 cm^{-1}, likely due to their high extractive content, which interacts with cellulose, hemicellulose, and lignin in photooxidation processes[59-60]. These findings align with those reported by **Chang, Pandey** and **Nzokou** [61-63], further supporting the conclusion that rosewoods possess distinct photodegradation patterns influenced by their unique chemical composition.

3.4 Micro-structural Changes

The changes in glossiness and surface roughness of the wood are attributed to alterations in its surface microstructure [64]. As shown in Fig. 5, the inner walls of the vessels in the four types of rosewood exhibited significant changes after UV aging. Before aging, the inner walls of the vessels were smooth, with evenly distributed pits and mostly intact pit membranes. However, after 96 hours of UV aging, the inner walls of the vessels in all four wood types showed varying degrees of alteration. In particular, *Dalbergia retusa* and *Pterocarpus macrocarpus* exhibited cracking in the inner walls of their vessels, which explains why these two wood types experienced the most significant increase in roughness. Additionally, the inner walls of *Dalbergia bariensis* showed fragmentation of pit membranes. Notably, crystalline deposits were observed in the inner walls of *Pterocarpus erinaceus*, likely resulting from the photo-oxidation of extractives within the wood.

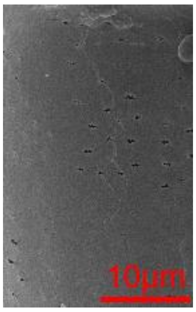
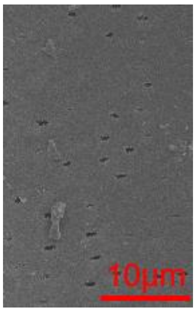
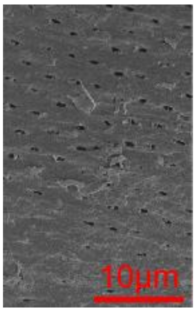
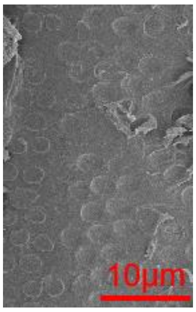
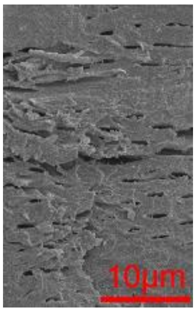
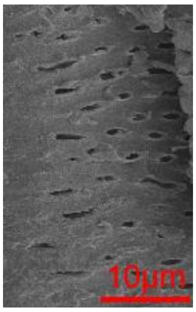
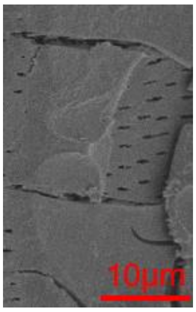
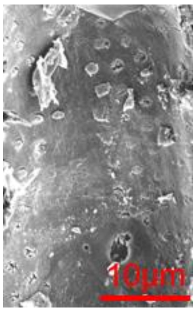
	Dalbergia retusa	*Dalbergia bariensis*	*Pterocarpus macrocarpus*	*Pterocarpus erinaceus*
Control				
UV aged 96h				

Fig.5 Micro-structure of 4 types of rosewood before and after UV aging.

4. Conclusion

This study demonstrated that xenon lamp-induced aging significantly impacted the surface properties and microstructure of *Dalbergia retusa*, *Dalbergia bariensis*, *Pterocarpus macrocarpus*, and *Pterocarpus erinaceus*. Prolonged exposure resulted in notable surface color changes, gloss reduction, and increased roughness, indicating material degradation. Spectrophotometric measurements confirmed gradual darkening and discoloration, while gloss loss suggested surface wear and microstructural deterioration. FTIR analysis revealed chemical composition changes, including lignin degradation and oxidation of functional groups, while ESEM observations showed surface microcracks and structural modifications. These findings suggest that photodegradation and oxidation are the primary mechanisms driving aging-related deterioration. Understanding these effects is crucial for evaluating the durability and long-term aesthetic stability of rosewood species used in furniture, flooring, and decorative applications, providing a scientific basis for preservation and protective treatments.

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