

EXPERIMENTAL COMPARATIVE STUDY ON THE COMBINATION OF LACQUER ART AND CERAMICS

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ABSTRACT

The purpose of this study is to 1) analyze adhesive firmness, chromatic, temperature comparative and material process characteristics of the combination of lacquer art and ceramics, 2) compare the expressive power of lacquer and pottery in terms of texture from the context of their development, understand the artistic characteristics of the combination of lacquer art and ceramics, and 3) through the case analysis of the application of lacquer in ceramic restoration, understand the artistry and practicability of the combination of lacquer art and ceramics. The study employed a comprehensive experimental approach using X-ray Diffraction (XRD), X-ray Fluorescence (XRF), Scanning Electron Microscopy (SEM), and Energy Dispersive X-ray Spectroscopy (EDX) techniques. Through these methods, a systematic comparison of the properties of lacquer and ceramic cross-layers was conducted, with a focus on the adhesion strength and peel resistance of the two materials. The research provides a solid scientific basis for understanding and improving lacquer-ceramic combination products, which aligns with the growing demand for innovative products in the traditional cultural and creative industries.

The results of the research found that:

- 1) This study can correctly grasp the disintegration information of the combination of lacquer and ceramics, and provide a more powerful scientific basis for the research of lacquer and ceramics protection.
- 2) By changing the physical properties of lacquer, the timeliness of lacquer and pottery creation can be improved.
- 3) The study finds distinct impacts on enhancing the adhesion between paint and pottery by analyzing the composition and structure of different adhesives.

Keywords: lacquer art; ceramic; chromatic

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1. INTRODUCTION

The invention of lacquer ware and pottery is the historical witness of the threshold of human civilisation. China is the country with the most extended history of lacquer ware and ceramics. The expression of its artistic form can be traced back to the ancient times thousands of years ago. People's demand for pottery articles for daily use has changed with the improvement of productivity, and ordinary earthenware cannot meet the needs of storage liquid because of the loose soil and strong water absorption. It is painted in a large area to play a role of isolation, which forms the earliest lacquered pottery. Two kinds of art have permeated the vertical and horizontal time, and their traditional characteristics and properties are retained in today. The combination of lacquer ware and pottery has been completed in several practical cases in history. The earliest one can be traced back to the Lingzhu culture period in A.D. The lacquer ware is formed by pottery and decorated with lacquer. Combining two natural materials has lacquer's delicate and soft beauty and retains clay's simple and antique feeling.

2. OBJECTIVES

1. To analyze the material characteristics, adhesive firmness, difference of color, temperature of the combination of lacquer art and ceramics, to confirm with the analysis results of other instruments, and fully grasp the objective data of the combination of lacquer and ceramics.

2. To compare the expressive force of lacquer and pottery in terms of texture from the context of their development, and observe whether the combination of the two art forms can create new aesthetic value and artistic effect.

3. Through the case analysis of the application of lacquer in ceramic restoration, a new form of artistic expression is provided for the design and application of modern cultural and creative industry, to solve the innovative development of traditional intangible culture.

3. LITERATURE REVIEW

Currently, lacquer and pottery's artistic and creative design is still relatively few in the market, especially for research on composite materials. Professor Changbei of Southeast University, a famous scholar of lacquer art, has succinctly led the development direction of contemporary lacquer art and ceramics based on studying traditional lacquer art (Chang, 2014). The number of studies on the combination of lacquer ware and pottery in China is summarised. The relevant data can be summarized into three aspects; the historical development of ancient ceramic lacquer ware, decorative characteristics, and material innovation. By studying the historical result of the material combination between lacquer and lacquer and combining the chemical attributes of lacquer and porcelain. This paper expounds on several ways of combining porcelain and lacquer art, which advocates new exploration in the new era new environment.

After thousands of years of evolution and accumulation, lacquer and ceramic culture have been exuding the artistic brilliance and unique charm that attracts worldwide attention. Whether traditional or modern, lacquer ware forms the basis of the art form and craft materials. By comparing the two materials, this research gains the feasibility analysis of the basic language and a strong vocabulary of lacquer ware. For the achievements of lacquered-pottery combination at present, the research of lacquered-pottery combination takes time as a clue and summarizes the characteristics of lacquered-pottery materials in different times to discuss, advocating the exploration of the combination between new materials and materials in the new era and new environment (Zheng, 2014). Based on the Nixing pottery cultural creative industry, the feasibility of Nixing pottery essay articles is analyzed from three perspectives: material itself, cultural connotation and functional research, and the special technological value of Nixing pottery essay articles is found (Zhu, 2017).

Chinese ceramics and lacquer decoration from the Shang and Zhou dynasties printed pottery imitation of bronzes, colored porcelain in the Han Dynasty painted pottery also imitated lacquer. Lacquer ware in the lacquer surface often encounters the phenomenon of film warping, curling, falling off, destroying the beauty and integrity of lacquer ware. The reasons for the warp-off of the paint film are complicated and determined by the nature of the lacquer and the external environment (Zhang, 2010). Its internal factors include the degradation of the paint film, the ageing of the adhesive material, the physical and chemical properties of the body and the paint film caused by the thermal expansion coefficient, hygroscopic and dry shrinkage properties of the combined effect of comprehensive factors. All of them compose the mixture of the two exciting studies. It is an ingenious and natural repair technique that is formed by painting broken vessels with prominent lacquer (Gao, 2022). The joint between lacquer and ceramic is the critical point of restoration, which can let those beautiful remnants resurrect and give the original objects a new connotation.

It is a wonderful method of repairing old porcelain by completely sticking it with prominent lacquer and precious ancient utensils with a new aesthetic feeling and vitality. In Japan, porcelain relics are fixed in the way of Golden Calligraphic by bonding with lacquer and decorating with golden powder to form a unique aesthetic feeling and enhance the value of cultural relics, and they paste broken porcelain together (Chang, 2014).

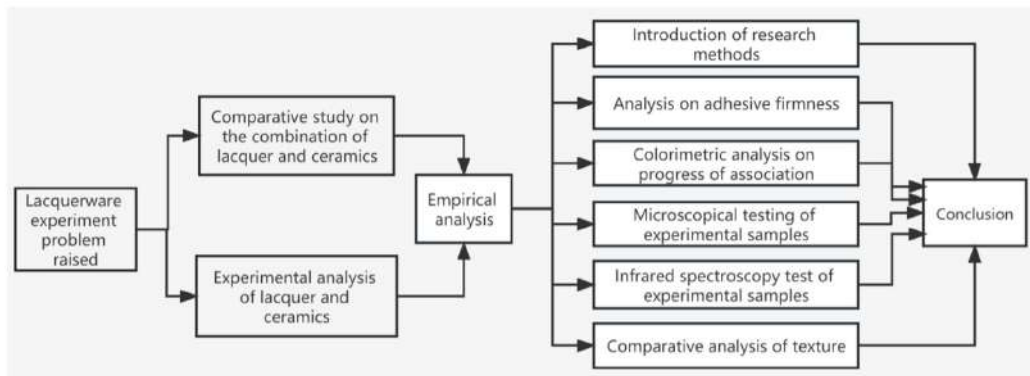
In summary, the literature on the combination of lacquer and ceramics highlights both the historical significance and the contemporary potential of these materials. While there are challenges related to material adhesion and durability, advances in experimental techniques, such as those discussed in this study, offer promising solutions for combining lacquer and ceramics in new and innovative ways. These developments not only preserve traditional craftsmanship but also provide new opportunities for artistic expression and cultural innovation.

4. CONCEPTUAL FRAMEWORK

The practice and verification of the combination of lacquer and ceramics mainly include the following key steps: (Figure 1)

Figure 1

Conceptual Framework



5. RESEARCH METHODOLOGY

1. Samples

The researcher selected five commonly used lacquer additives as samples, and the results of the bond strength optimization were applied in the case of broken repair of ancient ceramics. Through interviews with 10 historians, potters, and scientists, 40 samples with different lacquer layer thicknesses were made, and 4 were selected for data testing.

2. Steps to Repair Residual Parts of Pottery from Ancient Furnace

1) Clean the porcelain section to ensure the porcelain surface is clean. For the porcelain that has been glued, use the boiling method to remove the glue.

2) Paint the clean steam porcelain with filtered raw paint (thin paint).

3) The raw painted porcelain should be put constantly into the drying oven at the temperature of 120°C-150°C for 60 minutes. If the porcelain cross section is very smooth, it can be appropriately adjusted to 160°C-180°C. If the temperature is more than 200°C, the paint will become brittle or carbonic surface.

4) Stitch the constant-temperature-dried porcelain part together with an adequate amount of glue. To avoid displacement, secure it using adhesive tape.

5) After assembled, place it in the shade or another consistent temperature drying area.

6) After assembled and dried, fill the gap and polish it nicely.

7) Decorate with gold or colourful paint.

8) Polishing or sanding of the dry paint surface can be alternated to enhance the smoothness of the paint until the restoration is complete.

Table 1

Steps to Repair Residual Parts of Pottery from Ancient Furnace



3. Technological Innovation as Tools (Table 2)

1) RX-100 digital video microscope (HIROX) was used to analyse and identify the colour organisation of objects, material structure and properties.

2) ALPHA Portable Infrared spectrometer (Bruker) was to analyse its infrared reflection spectrum, this study finds information on the molecular structure composition of the obtained material and the surface composition of the combination of paint and pottery by the different probes.

3) Electrothermal constant temperature blast drying experiment chamber (SUPO) is mainly used to dry samples. The drying time and temperature can be set according to the performance of raw paint.

4) Iris HP350C spectrometer (Supor) is used for data analysis → fundamental infrared spectrogram analysis automatic retrieval → material analysis

Table 2

Equipment



Other tools to work with are a 50*60*50 cm storage box, sandpaper, pencil marker, heat gun, gold brush, thermometer, humidifier, scraper, towel, sponge, turpentine, and colour palette.

Materials are raw paint purchased from Xi' an Raw Paint Research Institute, clay purchased from JING DEZHEN Baitao Hui, LTD., and colour paint from Mianyang city, Sichuan Province

4. Data Collection

The data collected will be analyzed statistically and qualitatively. Analyzed through a combination of related research and literature review, and data analysis, the comparison will be used to obtain unbiased answers and provide the feasibility of the findings. Graphical and statistical methods will be used to demonstrate the effect of the elements contained in the samples on the surface structure of the large lacquer and ceramic materials. According to the specific absorption peak in the infrared spectrum, the position and intensity of the absorption peak of different samples were compared to determine the change of chemical composition and confirm the experimental results.

6. RESULTS

1. Analysis of Firmness of Different Starch Pastes in Lacquer as Adhesives

Before the experimental test, it is necessary to keep the same material, mixing uniformity, baking time, tensile strength, and other strength. Otherwise, the experimental results will be significantly affected.

The Steps of Determination

1) Clean the intersecting surface of the five pieces of standard ceramic samples. Before the experiment, sandpaper is used to polish the bonding surface of the ceramic samples to determine whether the polished surface is clean and smooth, to remove the oxide layer, increase roughness and improve adhesion.

2) Use a paper cup to weigh 30 g of lacquer and divide it into 5 groups. Use different ingredients for each group and mix evenly with a palette knife. The thickness of the coating remains the same level.

3) Apply the mixed lacquer on the adhesive surface of the ceramic test piece and clamp it with an iron clip to prepare five pieces in total. The specimen was placed flat in the oven at 200°C for half an hour and then took out after cooling. The oven time in each model remained the same level.

4) During the tensile test, keep the longitudinal axis of the specimen in the same direction as the tensile force, and hold the specimen vertically placed. In the actual test, keeping the model completely vertical is difficult due to the fixture's connection.

With analyzing and sharing the details of the fix, at present, there are several popular adhesive blending methods:

No.1 raw lacquer +glutinous rice flour mix

No.2 natural lacquer + glutinous rice paste mix

No.3 bare paint + flour mix

No.4 bare paint + dough mix

No.5 directly use raw paint, cooked paint (colour paint)

Through these methods, we can achieve the purpose of bonding; these formulas for bonding have no problem.

Since the starch paste needs to be mixed with the lacquer during use, the lacquer contains a certain amount of moisture, which will change the viscosity of the batter and keep the moisture ratio consistent. Temperature of this test: 28°C; Humidity: 55%; Tensile speed: 3mm/min.

Table 3

Analysis of adhesive firmness

Test sample	Bonding width(cm)	Bonding length(cm)	Bonding area s(m2)	Load at failure of sample(N)	XBond strength(N)	Average bond strength $\frac{1}{X}$ (N/m2)
1	2.00	1.64	3.04	1796.71	6.446	6.3932
2		1.56	3.22	2200.71	7.235	
3		1.67	3.02	2005.36	6.842	
4		1.58	3.12	1807.43	6.656	
5		1.75	2.84	1890.00	4.787	

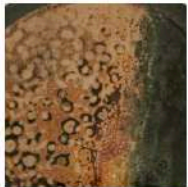

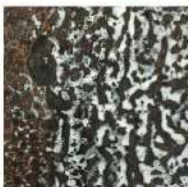

Test results (Table 3): The value of raw paint + different flour paste and Japonica rice paste adhesion through the peel strength test. The analysis shows that no. 2 bare paint + glutinous rice paste has the highest adhesion, no. 1 raw paint + glutinous rice flour, No. 3 raw paint + flour and No. 4 raw paint + dough have average adhesion, and No. 5 directly using bare paint and cooked colour has the lowest adhesion. The adhesion and peeling strength of glutinous rice paste is better than that of glutinous rice flour and flour, but the grain of flour paste is thicker and not delicate enough. When the exact amount is used, the bonding layer is thicker, and the drying is slower. The sticky rice paste is relatively mild with smaller grains, a thinner adhesive layer and faster drying. Accordingly, the proposal is concluded to use japonica rice paste and lacquer to make adhesive.

2. Analysis of the Paint and Pottery Combination by Using Technical Data for Chromaticity

Based on an in-depth analysis of characteristics of material , this study tries different combination effects under the principle of fully mastering the material properties and attributes of lacquer and pottery and constantly exploring its artistic rules (Table 4): Therefore, the art of lacquer pottery has been benignly developed.

Table 4

Basic information and characteristics of lacquer ceramics sample

The sample label	nomenclature	Condition of sample	Description of experiment	Sample photos
M11:20	Lacquer and pottery samples	The fetus is relatively thin, with brown and green materials on the surface.	The clay body was brushed with raw paint and dried at 150 degrees for 30 minutes	
M11:30	Lacquer and pottery samples	Wavy, notches surface paint, semi-rough effect.	Add gold leaf, paint with color paint, add ash. Thickness 1:2 paint to ash ratio.	
M11:40	Lacquer and pottery samples	Marl material, 5 times of paint on the surface of the body, full rough effect.	Add silver foil, xiu paint grinding, 0.5mm between the concave and convex	
M11:50	Lacquer and pottery samples	Wavy, notches surface paint, half rough, half smooth effect.	Intermediate ash 1:5 paint to ash ratio. Dry at 120 degrees for 50 minutes	

Microscope Test of Experimental Samples

Using RX-100 digital video microscope, 130W fluorescent light source and pass filter, the cover glass was placed to capture the lacquer pottery sample. The illumination beam in the microscope was projected to the surface of the observed object from the objective direction and then returned to the objective for imaging after being reflected by the object's surface (Hu, 1994). The researcher needs to place each of the four samples after the combined treatment is completed into the test instrument, and the actual analysis needs to be carried out in a laboratory environment. Scanning the samples through the electron beam and enhancing the wide-angle, high-resolution single-lens observation from 10x will produce high-resolution images that demonstrate the microstructure of the sample surface (Su, 2021).

Table 5

Structure of lacquer ceramic sample by using a microscope

By observing all the samples under the microscope and automatically focusing based on the image contrast performed at each position, the control software will automatically focus the samples according to the standard. Then, the image taken in the source is mixed with sand particles; The four samples were observed at the edge of the source, and the particles were also observed in the source (Table 5). After scanning the data, the surface of the M11:20 lacquer shows a smooth effect, the particles are homogeneous, microstructures are formed in the lacquer coating, and the lacquer content percentage is 80%. The bonding was better, while the M11:50 lacquer coating had a rougher surface, with a higher density of particles in the coating, and contained 40% of the lacquer. The results show that the fineness of the additives added to the varnish affects the degree of bonding. The higher the fineness, the stronger the bond. The average size and size distribution of the particles added to the lacquer affected the bonding quality, and the proportion of particles added should be at most 50% or more. Otherwise, the quality would be affected. In the selection of four samples, the best bonding effect of M11:20, the worst bonding for the M11:50, lacquer ceramic fragments on the proportion of lacquer is less than 50%, or so, there will be a shedding phenomenon.

Test Samples by Infrared Spectroscopy

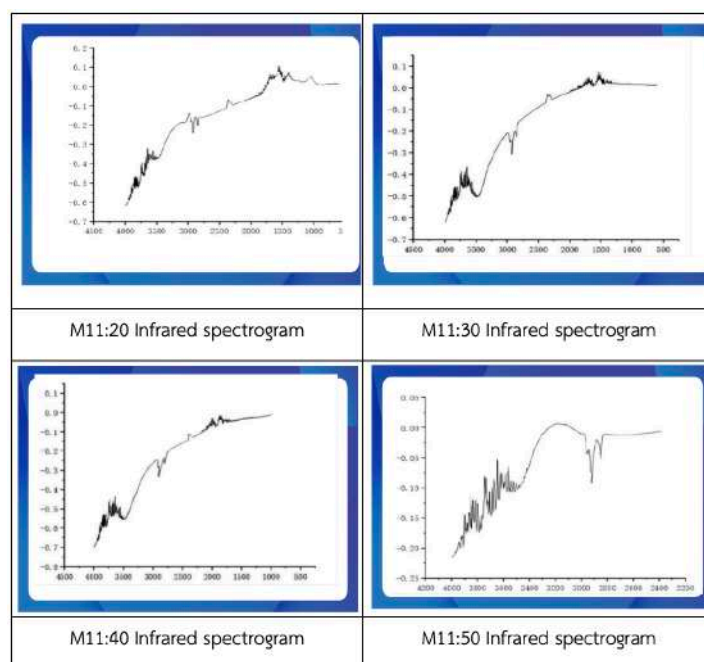
Essentially, infrared spectroscopy is an analytical method to determine the molecular structure of substances and identify compounds based on the relative vibration and molecular rotation of atoms in molecules (Hu, 1994). Infrared spectroscopy also has the characteristics of rapid testing, convenient operation, good repeatability, high sensitivity, less sample dosage, high signal-to-noise ratio, simple instrument

structure, and so on. The infrared spectrogram can be obtained by recording the absorption of infrared light by the molecule.

The test resolution of this experiment was 4 cm^{-1} , the number of scanning times was 64, and the test range was 500-4500 cm^{-1} . The experimental sample is the lacquer on the surface of the implements (Table 6). In a complex sample, the surface gloss degree also greatly influences the analysis result. The sample surface is not smooth, convex, or concave, affecting the measurement result. Therefore, the surface should be smoothed as far as possible.

Table 6

Infrared spectra of experimental samples



Analysis results: Sample M11:20 in the infrared spectral pattern shows higher peak intensity. The peak shape is sharper, indicating that the sample in the four samples of better quality, M11:20 and M11:30 samples of the peak height is more similar to the characteristics of the change not very much; samples of the M11:50 absorption peaks are fragile, indicating that the sample is a more complex chemical composition or severe contamination. The higher the peak absorption value, the purer the lacquer content of the sample, and the lower the peak absorption value, the more chemical components exist in the sample. The infrared spectral pattern of lacquer is usually shown in the wave number range of 4000 to 400 cm^{-1} . Lacquer has been tested at an R-peak wavelength of 2923 cm^{-1} with an average spectral emissivity of 85-90% in the far infrared, effectively absorbing a wide range of materials. In the lacquer, a mixing thickness of 6 millimeters does not affect the combination of paint; more significant than 6 millimeters thickness affects the quality of the combination. Adding 10-50% of

gray particles in the process of ordinary Chinese lacquer can effectively enhance the thickness of the lacquer layer without affecting the quality.

3. Comparison and Analysis of Lacquer and Ceramic Texture

Lacquer and pottery are both symbols that represent Chinese culture and have a worldly artistic language of expression, and the fusion of the two can create a rich variety of works. The organic combination of the texture of pottery and paint material properties can be accomplished when the creator overcomes half of the technical obstacles of pottery and another half of the technical obstacles of paint. Only by studying the technological barriers between the two processes, overcoming the limitations of the two media materials and fully understanding the characteristics of the two processes, can the aesthetic feeling of the two process materials be effectively preserved.

Table 7

Comparison of “lacquer” and “glaze”

Category	The condition of paint and lacquer		The condition of glaze	
The raw material		Liquid harvested from trees is expensive and difficult to obtain.		Mineral raw materials, natural inorganic, chemical elements. The glaze paste is made by grinding and applied to the surface of the body.
Dry hardening		Temperature 20~30 degrees, humidity 70~80% natural dry		High temperature 800~1250 degrees of firing
Adhesion		Can be attached to any kind of clay body, strong adhesion, free from falling.		High temperature burning will never peel off, fragile.
Hardness		Increase hardness over time, afraid of ultraviolet light.		Hard, not afraid of ultraviolet light.
Fire		Using firing to increase adhesion, and then decorative techniques.		Can be formed at one time
Function		Not afraid of water and fire erosion, acid and alkali resistance, insulation, not peeling, do not fade.		The same

Tool		Brush painting, inlay, carve, carve, fill, pile, polish, etc.		The classification of knife head is pointed, round, flat and serrated
Decorative use		It can stick anything sticky, such as metal, eggshell, twinkle, etc., which is called inlay or gold tracing in pottery technique.		The surface of the soil is smooth, but not in processing
Color		Color paint can be overlapped after drying		Various color
Wear and tear		The beauty of primitive simplicity will leave as fading and peeling by years.		Not easy to fading and peeling
Heat insulation		Lacquered with linen for heat insulation.		Can not be combined with other materials at high temperature burning

Through the comparison of raw materials, adhesion, hardness, colour and compatibility of “ lacquer” and “glaze” (Table 7), the study can draw that the application of ceramic glaze on the lacquer is various. The clay owners of pottery have good plasticity, which can make up for the limitations of lacquer in shaping. The plasticity of pottery works is very strong, and a variety of pottery works can be created. This plasticity provides more possibilities for the attachment of lacquer art to express more effects. The comparison shows that the lacquer emphasizes the oriental cultural style, giving people a warm, introverted, elegant feeling. Conversely, Glaze highlights surface luster and mild colors and adapts to diverse stylistic effects. As lacquer and ceramic art have deep-rooted cultural traditions, using lacquer in ceramics can emphasize traditional cultural connotations and oriental aesthetic interests.

7. DISCUSSIONS

1. Analysis of Material Characteristics, Adhesive Firmness, and Color Differences

The focus of this research on material characteristics has provided crucial insights into the molecular interactions between lacquer and ceramics. A key factor in successfully integrating lacquer and ceramic painting technology lies in the strong adhesion of the primer to the ceramic matrix. Traditionally, the painting process spans approximately 45 days. However, experimental results demonstrate that this time can be shortened by a week when applied to ceramic materials.

In terms of ceramic restoration, the strength of lacquer at the joints is essential. The study identifies a mixture of glutinous rice paste and lacquer as the most effective adhesive, due to the fine and impurity-free nature of the rice paste particles. Optimal bonding requires the adhesive layer to be applied in a single coat, as multiple layers can reduce adhesion firmness. Furthermore, selecting the appropriate ceramic carcass density is critical. While the surface texture should be rough to enhance adhesion, the surface density must also be fine to ensure proper bonding. Once the primer is securely attached to the unglazed ceramic surface, the subsequent painting process follows traditional lacquer painting techniques.

2. Comparative Expressive Force of Lacquer and Pottery

By focusing on key elements such as texture, color, and form, the study demonstrates that the combination of lacquer and ceramics can lead to a more dynamic and expressive artistic result. Lacquer's ability to enhance the surface textures of ceramics, coupled with its capacity for vibrant color expression, creates a synergy that enriches the visual complexity of the piece. This fusion brings out the best qualities of both materials lacques smooth, glossy finish and ceramicsearthy, structural formallowing for unique artistic outcomes that are both visually and structurally compelling.

Additionally, the study illustrates how lacquer not only reinforces the structural integrity of broken ceramic pieces but also elevates their visual allure, infusing the object with a renewed sense of beauty. This makes lacquer an invaluable tool in modern restoration practices, where the goal is not only to repair but also to enhance the aesthetic and cultural value of the artifact.

3. The Cultural Connotation and Innovative Application of Combining Lacquer Art and Ceramics

In the broader historical context of cross-cultural integration, the distinct charm of lacquerware, an artistic tradition with deep historical roots, can be appreciated through its evolving relationship with ceramics. This study emphasizes how the application of lacquer in ceramic restoration breathes new life into damaged artifacts, bridging the gap between ancient craftsmanship and contemporary artistic appreciation. The fusion of these two traditional art forms not only modernizes fragmented ceramic pieces but also creates new avenues for artistic expression. This integration allows restored artifacts to resonate in today's cultural and aesthetic landscape, offering more than mere preservation—it introduces fresh interpretations and possibilities.

From a cultural perspective, the combination of lacquer and ceramics holds significant implications. It serves as a bridge between traditional craftsmanship and modern artistic expression, demonstrating how ancient techniques can adapt and continue to thrive in contemporary settings. The merging of lacquer and ceramic traditions generates new cultural characteristics, enriching both mediums and making them more relevant and engaging for contemporary audiences. This process preserves cultural heritage while simultaneously transforming it, ensuring that traditional crafts evolve and remain significant. The inheritance of these traditional techniques thus becomes a reference point for the continued evolution and presentation of craftsmanship in the modern world.

8. ORIGINALITY AND BODY OF THE KNOWLEDGE

The effect of lacquer composition and additives on ceramic-lacquer combinations is analyzed by testing lacquered ceramics under different temperature and humidity conditions. The experimental analysis yields data on the optimal combination of technology, hardness, color, and compatibility of lacquer-ceramic combinations for adhesion. By analysing material properties, exploring aesthetic synergies and demonstrating the practical use of lacquer in ceramic restoration, this provides fertile ground for designers of traditional craft products and artists in the field of contemporary art to express their cultural traditions and innovate contemporary aesthetics. The results of the study improve the effectiveness and stability of lacquer products and provide a more robust scientific basis for research on lacquer conservation.

9. RESEARCH RECOMMENDATION

1. Implication of the Study

Lacquer and ceramic, two kinds of natural materials, not only give the Chinese lacquer paint pottery delicate and gentle but also have the tenacity of clay plain. With the continuous improvement of lacquer making and quality pottery technology, it has developed from single practical coating protection to focus on drawing beautiful patterns and transforming from practical to aesthetic consciousness. The advantages of the two processes are complementary. The integration and promotion of each other can make the works full of vitality and more expressive tension. Its artistic connotation and spiritual meaning have gone beyond the previous level, fully reflecting the uniqueness and diversity of lacquer pottery works.

2. Recommendations for Future Research

1. The application of science and technology to the identification of ancient lacquerware is still in its infancy, and the technology identification method needs to be based on the premise of having a huge database of ancient lacquerware. Some technologies and analysis are not very mature, It is too one-sided to determine the authenticity only through scientific and technological testing data, and it is also necessary to increase high-tech technology to analyze the lacquerware samples to be the database.

2. In-depth study of the fusion of lacquer culture and ceramic tradition in hybrid works, exploring how this hybrid art form can pass on and present traditional East Asian cultural values, aesthetic concepts and aesthetic sensibilities. Encourage artists to utilize their creativity and integrate different artistic elements to create unique hybrid works.

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