The Diversities in Qing dynasty Coromandel lacquer

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Abstract

Coromandel lacquer is a type of polychrome lacquer where designs carved into the smooth lacquer surface are filled with painted colors. Unlike many other lacquer techniques, Coromandel has a relatively short history and limited written record. To gain a greater understanding of its decorative technique and material usage, extensive technical analysis has been carried out. The technical study included fluorescent light microscopy, pyrolysis-gas chromatography–mass spectrometry with thermally assisted hydrolysis and methylation and scanning electron microscopy with energy dispersive spectroscopy. The scientific outcomes were then compared and contrasted with the relevant historical documents. The results have revealed the complex compositions of the objects studied and have suggested the existence of three major Coromandel groupings.

Keywords: Coromandel lacquer, *kuancai*, scientific analysis, Py-GC/MS, SEM-EDS, historical documents

Introduction

Asian lacquer is a multi-component material with a complex manufacturing process. Due to the intricacy of different lacquer recipes, manufacturing techniques and their unpredictable development over time, many lacquer collections pose conservation challenges. These problems cannot be systematically resolved if one cannot answer the fundamental question, i.e. what is the material composition of lacquer objects? With recently introduced analytical techniques, the identification of lacquer types and its additives has now become possible (Schilling et al. 2014).

Coromandel lacquer is a type of polychrome lacquer unique to China, which was mainly used to decorate large screens and cabinets. Its earliest known mention was in the 16th century lacquer treatise *Xiushilu* under the name *kuancai* (Chang et al. 2007, 168). The technique flourished during the Qing Kangxi period (1662-1772) (Hagelskamp 2016, 25) and it was exported to Europe from the late 17th century until the 19th century (Kesel and Dhont 2002, 24). Coromandel lacquer was selected as the focus study of this project mainly due to its relatively short manufacturing history (late Ming dynasty to the present) and large amount of surviving examples in European collections. Through the study of historical documents and scientific investigation, the present research has identified different manufacturing methods suggests the existence of three major Coromandel groupings.

The present research is an extensive cross-disciplinary study, which derives from the main author's PhD project. It aims to examine historic lacquer objects through scientific analysis in order to understand their material usages and evaluate the accuracy and credibility of historic sources. It introduces a methodology that can be replicated and applied to the study of other lacquer manufacturing techniques. The research results have revealed the complex composition of Coromandel lacquer, broadened our understanding of lacquer production methods and create a foundation for future studies.

Background

Coromandel lacquer is a type of polychrome lacquer where designs carved into the smooth lacquer surface are filled with painted colors (Figure 1) (Wang 1983, 135). It is mainly used to decorate large screens, cabinets (possibly European alternatives to the screens), and only rarely used to create small objects. The production of Coromandel lacquer is a technique that is unique to China and has many different names depending on time and location. In late 17th century Britain it was referred to as 'Bantam work' and in early 18th century France as 'Coromandel' (Burgio et al. 2007, 241). The earliest known mentions of '*vernis de Coromandel'* are in a 1748 document in the *Livre-Journal de Lazare Duvaux, marchand-bijoutier ordinaire du roy, 1748–1758* (Kopplin 2002, 38). In Chinese it is most commonly known as *kuancai* ('cut out color' or 'engraved polychrome'); however, in Yangzhou it is also referred to as *shenke* ('deep carved') and *kehui* ('engraved ash'), in Beijing as *dadiaotian* ('carved and infilled'), and in Suzhou and Shanghai as *keqi* ('incised lacquer'). Of these names, 'Coromandel' is probably the best known, and is therefore the term used in this paper. Similar to Bantam, which is a Javanese port used by the British, Coromandel is an area located on the southeastern coast of India, where one of the trading posts belonging to the East India Company was located, and the term was used to describe *kuancai* due to the mistaken assumption that the trading port was the source of these objects.

Unlike many other lacquer techniques, Coromandel has a relatively short history and limited written record. The earliest known mention of Coromandel lacquer in a Chinese written record comes from the 16th century treatise *Xiushilu*, using the name *kuancai* (Wang 1983, 135). Due to its decoration method, it was placed into the larger category, *diaoloumen*, a category of lacquer techniques that involves decorating the lacquer surface with carving tools (Wang 1983, 135). The text provides very limited information on Coromandel. Even by combining Huang Cheng's (the author of *Xiushilu*) original text together with Yang Ming's 16th century annotations, there is still only a total of 83 characters referring to Coromandel.

Sampling, Methods of Study

A total of 32 samples were collected from 11 targeted research objects dated to the Qing dynasty from four major institutions (Table 1). Cross sections were embedded in Technovit® 2000 LC (methacrylate) for Fluorescent Microscopy and SEM-EDS analysis. They were examined using a Leica DMLB Fluorescent Microscope fitted with a HBO 50W super pressure mercury light source. Visible, ultraviolet and blue light illuminations were used in the study (Figure 2).

The carbon-coated polished cross-sections grounded with conductive carbon tapes were then examined at 20.0 kV with 10 mm working distance using a Hitachi S-3400N scanning electron microscopy (SEM) equipped with a backscattered electron detector and an Oxford Instruments INCA energy dispersive X-ray spectrometer (EDS) with 1 micrometer beam diameter.

Electron probe microanalysis (EPMA) was occasionally implemented to support and confirm the SEM-EDS results. EPMA measurements were performed on a JEOL JXA-8100 system, operated at 15.0 kV with 11 mm working distance and probe current of 50 nanoamps. The instrument was first calibrated for standardization using a single element standard. Galena was used to standardize S and Pb. Corning glass reference samples were analyzed as secondary standards to evaluate data quality.

The organic components of the lacquers were identified using pyrolysis gas chromatography-mass spectrometry using tetramethylammonium hydroxide for thermally-assisted hydrolysis and methylation (THM-Py-GC/MS) (Agilent Technologies 5975C inert MSD/7890A with Frontier Lab PY-2020D double-shot pyrolyzer system).

A survey of the historical literature has identified references to the materials and technology of lacquer in an extensive range of over one hundred sources. The scientific results are compared and contrasted with historical documentations to seek for consistencies and inconsistencies, then compared internally to seek for possible patterns and groupings.

Experimental Results and Discussion

Comparison with information from the historical record

Both consistencies and inconsistencies were discovered between the data available in the historical record and that derived from the scientific analysis of the samples and below are given a few highlights.

- *Consistency – lead particles*

Lead-rich particles were detected in the dark lacquer layer in seven out of eleven targeted research objects. The higher average atomic number of those inclusions causes them to appear brighter in BSE images (Figure 3). The SEM-EDS spot analyses of these lead-rich inclusions indicate the presence of both Pb and S as major elements. A scatter plot for the lead particles confirms that Pb and S are strongly associated, with a strong correlation (R^2 = 0.93). However, there is a known overlap of the S K and Pb M X-ray peaks in the SEM-EDS spectrum, which could create a spurious correlation (Statham 2002, 538). Therefore, to confirm these findings, a series of measurements were carried out using EPMA, which has a much better resolution. Six EPMA spot analyses were collected from the lead particles and a strong correlation between Pb and S , shown in Figure 4, again confirms their strong association. In addition, their Pb/S ratios are close to the 6.5:1 ratio expected for lead(II) sulfate ($PbSO_4$) or lead(II) sulfide (PbS) (Table 2).

This corresponds to various historical records where the addition of lead particles to lacquer layers was mentioned. According to the Ming dynasty text *Wuli xiaoshi (Notes on the Principle of Things)* (Fang 1981*)*, *mituoseng* (litharge, PbO) was added into tung oil as a drying agent. Tung oil is a common drying oil used in lacquer production. Therefore, one should anticipate finding the materials that were mixed in tung oil to also be present in lacquer. This is also recorded in the Ming dynasty document, *Shitian zaji* (*Miscellaneous Records of Shitian*) (Shen 1997) which documents the addition of litharge in a recipe for surface coating lacquer. Litharge may react with the sulfur from the surrounding environment and form the lead sulfur compound discovered in the lacquer surfaces. This may be a possible explanation for the Pb and S rich particles discovered in the lacquer layers.

- *Inconsistency – the discovery of all three lacquer types*

All three lacquer types – qi (or urushi, *Toxicodendron vernicifluum*), laccol (*Toxicodendron succedaneum*) and thitsi (*Gluta usitata*) – were detected in the samples analyzed in this project. Qi was identified in the samples such as S1 and S5 (Table 1) based on the distribution of marker compounds in their gestalt graphs (Figure 5), with series of catechols and hydrocarbons with C_{15} maximum side chain and having C_8 mazzeic acid as the most abundant acid catechol (Schilling et al. 2016, 12). Laccol was identified in samples including P1 and S4 by the presented series of catechols with C_{17} as its maximum chain length and C_{10} arlenic acid as its most abundant acid catechol (Schilling et al. 2016, 10). A thitsi and laccol mixture was identified in both B1 and Coromandel Casket 1's lacquer layers. Thitsi was identified based on the dominant series of alkyl benzenes with C_8 (mazzeic acid) being the most abundant acid catechol (Schilling et al. 2016, 14) (Figure 6). The C_{17} catechol, and the C_{10} arlenic acid presence in the same graph suggest the lacquer layers consist of a mixture of thitsi and laccol.

The presence of qi and laccol in Coromandel samples was anticipated, because qi was traditionally thought to be the principal type of lacquer in China (Heginbotham and Schilling 2011, 97) and laccol lacquer was discovered to constitute a high percentage of Chinese exported lacquer ware in recent analytical studies (Schilling et al. 2014, 131; Körber et al. 2016, 73). The detection of thitsi lacquer in two out of eleven Coromandel research objects, on the other hand, was unanticipated. To date, no historical record has been discovered that indicates the trading of thitsi lacquer from Southeast Asia to China. In addition, the detection of thitsi in Chinese lacquer has never been reported in any publication known to the authors. Furthermore the identification of a thitsi and laccol mixture made the discoveries even less expected.

Possible patterns and groupings

Apart from comparing with historical documentations to seek for consistencies and inconsistencies the scientific result was also examined internally to recognize possible patterns and groupings. The organic and inorganic materials used to produce the Coromandel ground layers are generally similar to one another. As a result, differences between the lacquer layers were the focus of the categorization of groups of Coromandel objects. Principal component analysis (PCA) was implemented on both the THM-Py-GC/MS and SEM-EDS data sets to detect meaningful patterns.

- *Organic components*

Each of the 18 major variables measured using THM-Py-GC/MS were included in principal components analysis: urushi, laccol, laccol and urushi, laccol and thitsi, heat-bodied drying oil, drying oil, protein glue, blood, Anacards carbohydrates, starch carbohydrate, paper carbohydrate, cedar oil, camphor, gum benzoin, Pinaceae, dipterocarpus, tannins, and ester wax. The list of variables and the examined samples was reduced as the data were reviewed. Certain samples were excluded from the analysis; for example, samples with major contamination, and those categories which were detected at a low level (0 to 5 peak area %), as they were unlikely to be technically significant to the overall picture. Its presence is most likely to have been caused by surface contamination. Drying oil was also excluded from the PCA, as it is present in every single Coromandel lacquer layer sample, with an average peak area of 73.3%. Consequently, its presence renders the other variables less clear. Excluding it also eliminates the challenges posed by the samples that include ester wax, which would add to the oil and fatty acids percentage and render the calculation less reliable.

Three major groups emerged from the PCA of the THM-Py-GC/MS results. As shown in the biplots in Figure 7, *Group 1* is associated with urushi; *Group 2* includes those samples where a thitsi and laccol mixture was used as its lacquer recipe; *Group 3* is correlated to the application of laccol lacquer only (Table 3). The result above has a sound cumulative data variance of approximately 82%. The only exception from this grouping is sample S2, as its lacquer layer has an uncertain result (being qi or qi mixed with a small proportion of laccol), according to the PCA mapping, it appears to be close to *Group 1* (qi). This corresponds well with the dominating qi detection in the sample. For the time being S2 will be consider a member of *Group 1* until further data are consolidated and a more definitive interpretation can be suggested.

- *Inorganic components*

The PCA of the THM-Py-GC/MS data yielded three groups essentially based upon the type of lacquer used. The SEM-EDS data for the inorganic components of the lacquer layers was also introduced into the PCA for comparison. The SEM-EDS data was expressed as weight percentages of all elements analyzed, and normalized. Oxygen was omitted, as its identification was only semi-quantitative. The biplots in Figure 8 have been slightly edited to clarify the sample numbers.

Although the PCA of the SEM-EDS data in Figure 8 is not as clearly distributed as the THM-Py-GC/MS in Figure 7, similar patterns for *Group 2* and *Group 3* can be observed, with the group membership remaining the same. *Group 1*, however, is more scattered, with its samples being mainly located between those belonging to *Groups 2* and *3*.

Of the major groupings defined by the SEM-EDS data, *Group 3* is associated with higher percentages of Ca and Mg (average normalized weight percentages of Ca . 39% and 23%, respectively). *Group 1* and *Group 2* are both characterized by relatively high lead content, which is the dominating factor that separates *Group 3*. *Group 2* and *Group 1* are differentiated by the relative amounts of lead, which are higher in *Group 2* (an average of 52 as opposed to 33 normalized weight percent, respectively). The abovementioned result has a sound cumulative data variance of approximately 88%.

The fact that the PCA groupings from both THM-Py-GC/MS and SEM-EDS follow a similar pattern provides confidence in the three identified groups.

Discussion

After carefully examining the representative samples from the three major groups of Coromandel lacquer, both similarities and differences can be observed between them. *Group 1* consists of one single qi layer (average ≈30 μm) containing lead-rich particles. These characteristics are consistent for all five objects in the *Group 1* category (Table 3). The majority of the artifacts in *Group 1* are large twelve-panel folding screens decorated with popular Chinese scenes (eg: birthday celebration for the Royal Mother of the West); these include S1, S2, S3 and S5. The only exception is M1, which is part of a mirror frame that is believed to have been created in England by cutting sections of a larger screen.

Group 2 consists of a single layer of mixed laccol and thitsi (average thickness ≈55 μm) containing lead-rich particles (Table 3). The two representative objects from this group (B1 and C1) are not only similar analytically, they were also both created according to the style of European furniture. Unlike M1 in *Group 1*, which was created by cutting sections of a larger screen, B1 and C1 appeared to have been originally designed in their current form. They are therefore likely to have been commissioned as complete pieces by European merchants for the European market. The documentation in the East India Company's Letter Book supports the idea of the importation of complete cabinets. A 1697 letter records that the Chinese factory was asked to provide 60 cabinets and "20 of engraved work, the ground gold, with landscapes and figures" (Jourdain and Jenyns 1967, 69). The cabinet with engraved decorations on a gold background is a close match to B1 (Figure 1). The use of thitsi for the European commissioned objects may be explained by reasons of economy and budget control (Heginbotham and Schilling 2011, 8). The lead particles may have been added as a drying agent to speed up the slow drying properties of thitsi (Heginbotham and Schilling 2011, 99).

Group 3 consists of three layers of laccol (average ≈98 μm) with no lead-rich particles (see Table 3). Apart from S4, which still maintains its original appearance of a six-panel folding screen, the rest of the group has all been modified through time. P1 and P2 are panels cut out from a larger screen to decorate the palace wall. B2 is a cabinet that was created by reassembling multiple cutouts from a larger screen. A detailed description of how to split the original lacquer panels, reduce their thickness, and veneer the furniture was recorded in 1769's *L'Art du Menuisier* (Moore 2011, 187). In addition, a 1688 standard manual, *A Treatise of Japanning and Varnishing*, also mentioned the creation of new cabinets from old screens and how this new arrangement disregarded the continuity of the original screen designs (Jourdain and Jenyns 1967, 22).

Conclusion

In this study, a group of Coromandel lacquers dated to the 17th and the 18th centuries has been characterized and three major groupings identifiedon the basis of their compositions and technologies. In addition, a comparison between the analytical results and historical texts shows both consistencies and inconsistencies. The extensive understanding gained from the present cross-disciplinary study shows the complexity of Chinese lacquer production and significantly extends our understanding of past manufacturing technologies and material usages of Coromandel lacquers. Not only does this contribute to our appreciation of an important world technological tradition but it can also assist the future design of conservation treatment.

Group 2 appears to represent material commissioned specifically for export to Europe, and its significance is therefore clear. However, the meanings of *Groups 1* and *3* are not currently understood. It is uncertain whether these groupings were related to differences between workshops, provinces, time periods, different qualities of work, purposes, buyers, or other factors. More samples need to be systematically collected, ideally from objects with sound provenance, to verify, strengthen, or even challenge the possible groupings and their meanings as suggested by this project. The current paper only covers a few highlights from a much larger study. More detailed results will be published in future publications.

Acknowledgments

The authors would like to thank Lucia Burgio (Victoria and Albert Museum), Kathleen Garland (Nelson-Atkins Museum), Susanne Gronnow (National Trust), John Hartley (Tankerdale), Kate Hay (Victoria and Albert Museum), Rosalie Kim (V&A Museum), Katy Lithgow (National Trust), Silvia Miklin-Kniefacz, Gill Nason (National Trust), Christopher Rowell (National Trust), Shelagh Vainker (Ashmolean Museum), Siobhan Watts (National Trust) and Ming Wilson (Victoria and Albert Museum) for allowing access to objects in their collections. We would also like to thank our colleagues in the Getty Conservation Institute and the Institute of Archaeology (UCL) for facilitating this study, in particular, Drs. Tom Gregory, Agnese Benzonelli and Dean Sully of UCL and xxxx of the GCI.

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Table List

Table 1: List of Coromandel lacquer objects sampled in this project and their reference code

Name	Reference code	Collection
Cabinet 1	B1	V&A Museum (FE.39:1 to 21-1981)
Cabinet 2	B2	Sissinghurst Castle, National Trust (802607)
Casket 1	C1	V&A Museum (FE.97 to F-1974)
Mirror 1	M1	V&A Museum (W.39:1-1950)
Panel 1	P1	Bundesmobilienverwaltung, Objektstandort: Schloss Schönbrunn (MD 070596/011)
Panel 2	P2	Bundesmobilienverwaltung, Objektstandort: Schloss Schönbrunn (MD 070596/012)
Screen1	S1	V&A Museum (163-1889)
Screen 2	S2	V&A Museum (130-1885)
Screen 3	S3	Nelson-Atkins Museum (32-43)
Screen 4	S4	Erddig Hall, National Trust (1147113.1)
Screen 5	S5	Ashmolean Museum (EAX.5331)

Table 2: EPMA analyses of the lead particles in the lacquer layer (Weight percent)
()

	Spot1	Spot2	Spot3	Spot4	Spot5	Spot6	Ave
Na	0.3	0.6	0.1	0.5	0.4	0.4	0.4
K	3.0	0.7	0.3	0.6	1.3	0.7	1.1
Cl	0.1	0.2	0.1	0.2	0.1	0.1	0.1
Al	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Ca	0.5	1.4	0.2	0.4	0.3	0.3	0.5
S	1.0	0.2	1.7	0.5	0.8	0.5	0.8
Fe	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Pb	5.5	2.1	10.6	3.3	5.2	3.6	5.1
Total	10.8	5.6	13.2	6.1	8.5	5.9	8.3
Pb/S	5.5	8.4	6.3	6.8	6.2	6.6	6.3

Table 3: Summary of analytical data and manufacturing information for the three Coromandel lacquer groups

	Group 1	***Group 2***	***Group 3***
Stratigraphy	1 lacquer layer	1 lacquer layer	3 lacquer layers
Lacquer types	*Toxicodendron vernicifluum*	*Gluta usitata + Toxicodendron succedaneum*	*Toxicodendron succedaneum*
Average thickness	≈30 µm	≈55 µm	Total ≈292.5 µm Single layer ≈98 µm
Lead inclusions	Detected	Detected	Not detected
Objects	M1, S1, S2, S3, S5	B1, S1	B2, P1, P2, S4

Figure List

Figure 1 – Coromandel Cabinet 1, *Accession# FE.39.1 to 21-1981*.
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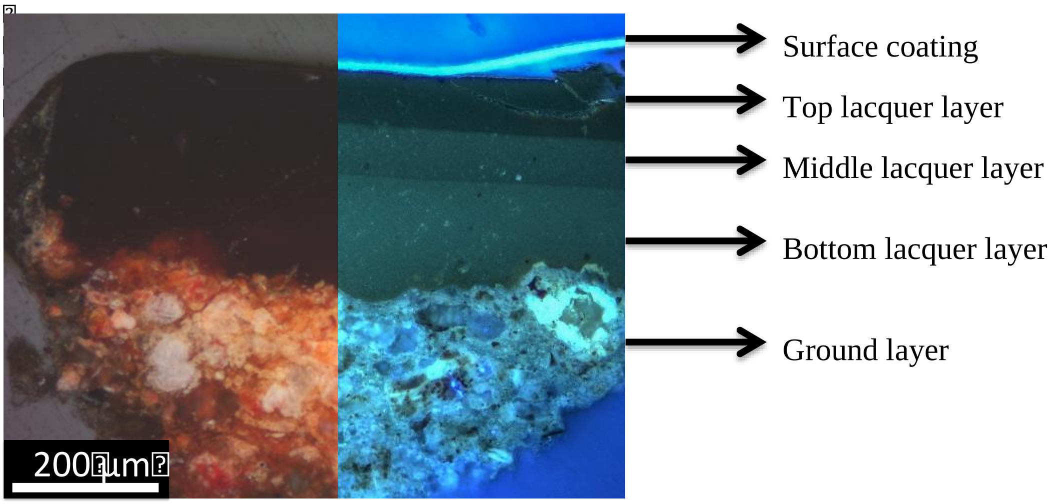

Figure 2 – Cross section photomicrograph for B2 *Accession# 802607* under both visible (left) and UV light (right)
© Sissinghurst Castle, National Trust

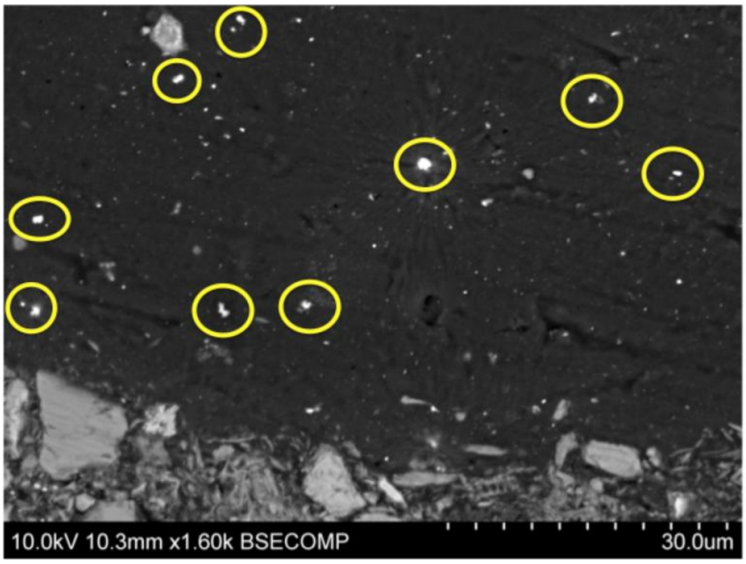

Figure 3: BSE SEM for B1, bright particles rich in Pb and S in the lacquer layer are circled in yellow

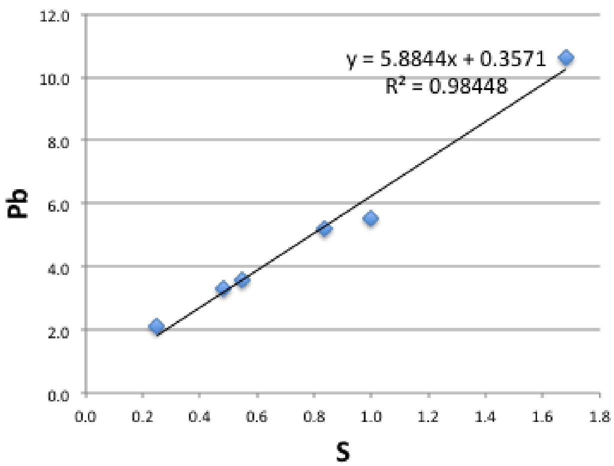

Figure 4 – Scatter plot graph comparing the relationship between Pb and S: EPMA results from the lead particles in the lacquer layers

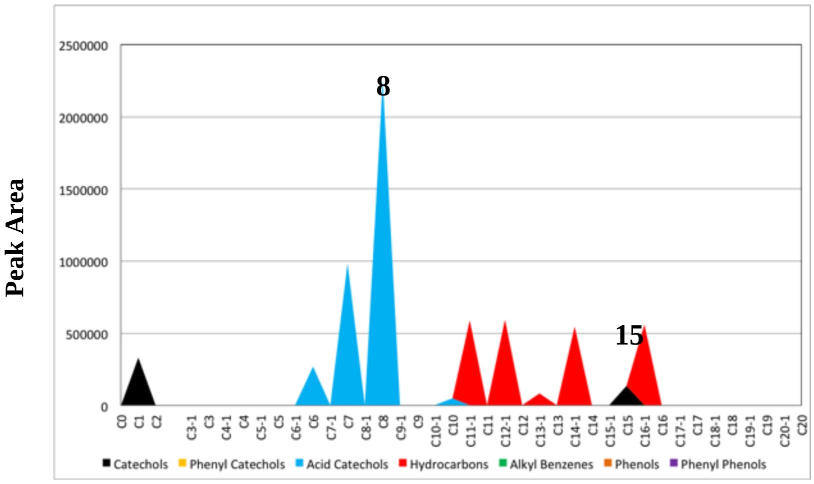

Figure 5 – Gestalt graph of Anacard markers for lacquer layer of object S1 showing the presence of qi lacquer

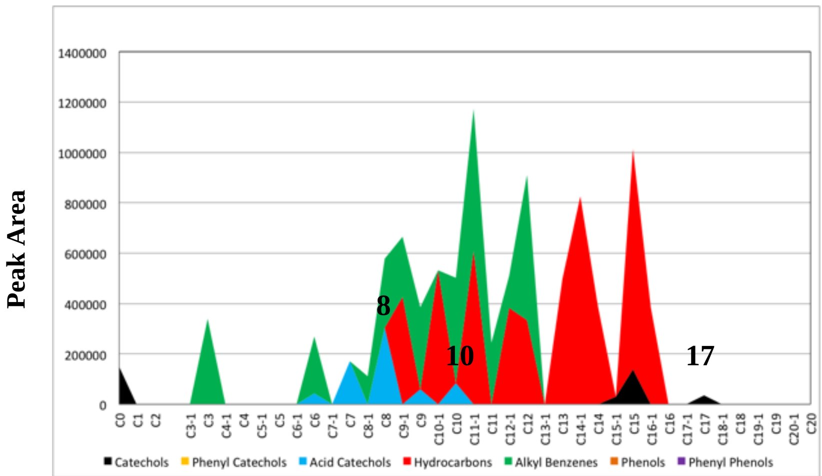

Figure 6 – Gestalt graph of Anacard markers for lacquer layer of C1 showing the presence of both thitsi and possible laccol.

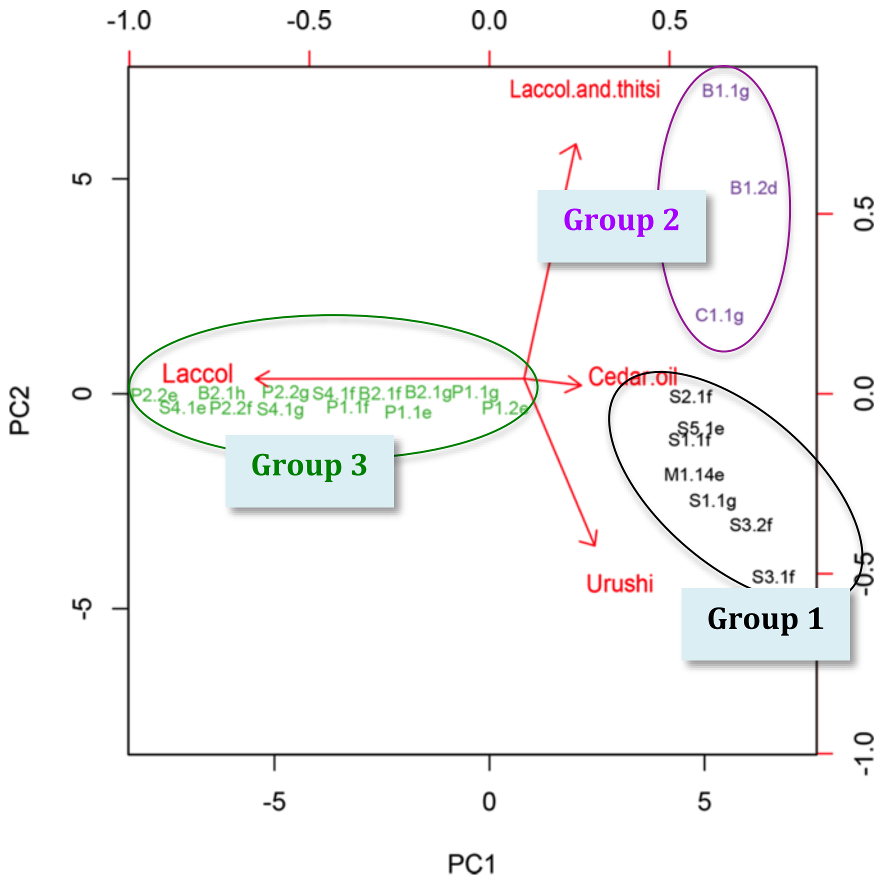

Figure 7 – PCA biplot of the first two principal components for all Coromandel lacquer samples (THM-Py-GC/MS data); The proportion of variance for PC1 is ca. 68% and that for PC2 is ca. 14%. The data was slightly rearranged to allow the plot to be read.

Sample coding: Reference code (Table 1)/sample number/layer order
Eg: P2.2e = Coromandel Panel 2, Sample 2, lacquer layer #b;

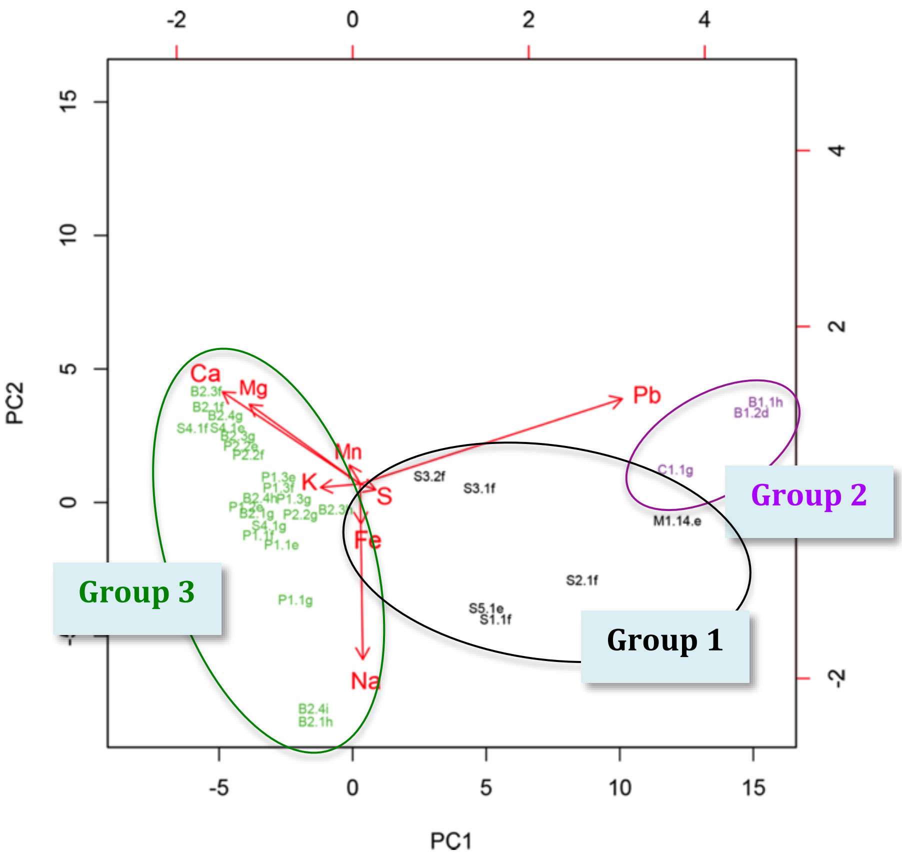

Figure 8 – PCA biplots of the first two principal components for all Coromandel lacquer samples (SEM-EDS data). The data was slightly rearranged allow the plot to be read. The proportion of variance for PC1 is ca. 78% and that for PC2 is ca. 10%.

Sample coding: Reference code (Table 1)/sample number/layer order
Eg: P2.2e = Coromandel Panel 2, Sample 2, lacquer layer #b;