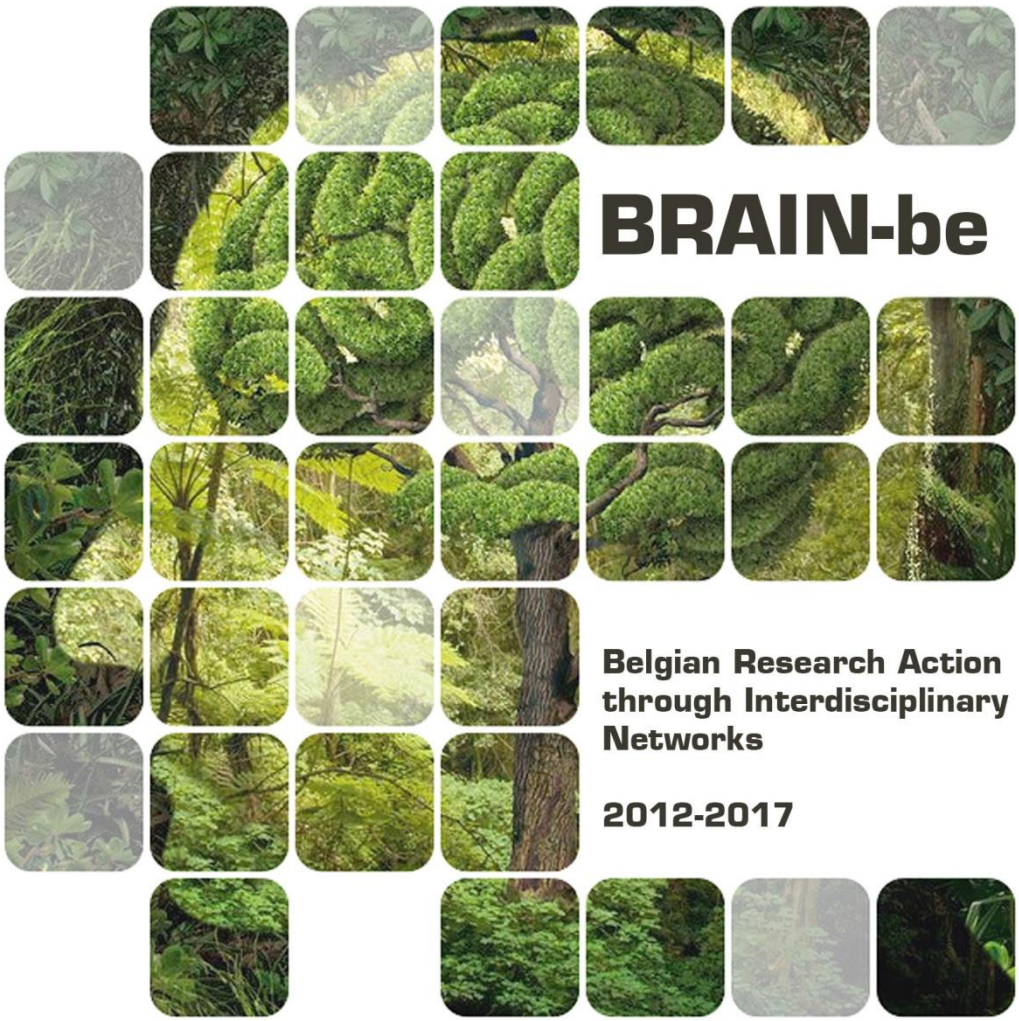

ELinC

European Lacquer in Context. Art-historical, technological and chemical characterisation of European lacquer in federal collections.

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NETWORK PROJECT

ELinC

European Lacquer in Context

Contract - BR/121/A3/ELinC

FINAL REPORT

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1 ABSTRACT

This ELinC network project focused on the technological history of European lacquers, with the emphasis on lacquer made in our regions and with special attention to European lacquered objects in the collections of the Royal Museums of Art and History (RMAH).

The study of European lacquers turned out to be a fascinating puzzle, in which missing pieces were provided by art-historical, chemical or technological examinations of amongst others raw and artificially aged lacquer ingredients, historical lacquer, patents, newspapers, administrative ledgers and historical recipes. However, not yet all missing pieces of the puzzle have been found. More research by comparing larger series of similar objects, comparing different time periods and regions, delving deeper in the recipes, is required to get a full insight in the evolution of European lacquers.

Keywords

European lacquer, *bois de Spa,* interdisciplinary research, biomarkers, natural resins, recipe database, historical sources

2 INTRODUCTION

Since early history, humans have been attracted to the exotic. In 16th century Europe, expanding overseas trading brought a fascination for oriental lacquer. Their deep colours, their attractive gloss, and their durability, built to stand the test of time, was very innovative in the West. With well-established ports in Bruges, Antwerp and Ghent, Flanders became in the 16th century an important transit region. Quickly, the import started to interfere with the local market of luxurious items, initiating a long period of mutual stylistic influence. In the East, lacquered objects were produced with the prospect of export, while in Europe, the production of European lacquers was born. Due to a protectionist policy, however, the export to Europe of the Asian lacquer trees, their resins and most of all the complex workmanship of oriental lacquering, was almost completely inhibited until well in the 19th century. Nevertheless, European craftsmen did succeed in producing lacquer of high quality, using locally available materials and techniques. Since the 17th century, many pieces of European furniture and other products were *japanned* to simulate oriental lacquer. At first, they were quite faithful copies of the imported decorations, but soon the production integrated the influence of European taste and traditions. *Japanning* remained popular until the early 20th century, after which the interest declined, partly due to the rise of synthetic polymers.

European lacquer had been studied to a limited extend before, with focus on technology (Webb, 2000), chemistry (Walch and Koller, 1997) and art history (Forray-Carlier et al., 2014; Huth, 1971; Jones, 2012; Kopplin, 2010a; Wolvesperges, 2000). The interdisciplinary approach of *European Lacquer in Context* (ELinC) project was the next step to a better understanding of the production, history and chemical composition of European lacquers. The ELinC interdisciplinary team, consisted of members of the Royal Institute for Cultural Heritage (KIK-IRPA; promotor), the Royal Museums of Art and History (RMAH) and the University of Antwerp (UA). Each partner had its own specific tasks and had to further develop its expertise, before the interdisciplinary work started. While the three partners deepen their knowledge in their own domain, close collaboration in the study of lacquered objects improved the quality of the entire research project. Emphasis was placed on the study of lacquered objects from our region and/or from the collection of the RMAH.

The KIK-IRPA further developed its expertise in analysing organic binding media, with a particular focus on natural resins, the main constituents of European lacquer. As a large number of samples was needed to be investigated, methods were developed allowing the semi-automatic treatment of the analytical data. At the basis of this lies target libraries of resin biomarkers, permitting the accurate and swift identification of complex resin mixtures, characteristic of European lacquers.

Recipe studies on European lacquers carried out by the UA, were never conducted on such an extended scale as in the ELinC-project. The large number of recipes studied allowed to apply statistical approaches permitting to understand why a difference between recipes for amateurs and professionals was made, leading to new insights in the combined use of certain ingredients, searching for similarities or discrepancies in recipes, all leading to a better insight in the technological process of lacquer making.

The art-historical work of the RMAH shed a new light on the manufacturing of lacquers in the most important lacquer producing centre in Belgium, the village of Spa. To get a better insight in the production and evolution of the so-called *bois de Spa*, art-historical data were combined

with chemical data of the composition of the lacquers and technological information extracted from historical recipes. This thorough study illustrated best the advantages of this interdisciplinary approach, but also a vast number of other objects were studied in detail. About 60 objects from the collection of the RMAH were studied, made in different places and time periods. More art-historical data was gathered on this larger than expected European lacquer collection of the RMAH. To put the lacquer production in context, a larger study was needed, including objects outside the collection and giving insight in the lacquer production and trade in England, France and Belgium.

The study of the historical literature learned that lacquering was carried out by different people from different layers in society, and was an activity also involving an important number of women. The newly discovered lacquer production in Brussels was documented in the activities of Mrs. Louise Ghiesbreght, giving a glimpse of the lacquer business just after Belgium was founded.

To conclude, the expertise of all partners combined lead to new insights in the European lacquer history, composition and technology thanks to the in-depth study of some objects grouped together on stylistically grounds or on a common production centre. The emphasis was placed on the *bois de Spa* and on the 19th century English and English-style black lacquer furniture from the collection of the RMAH.

Results of these studies were presented at the European Lacquer in Context international conference, held in Brussels on 18 and 19 January 2018. The conference provided a platform to international researchers to share their current knowledge on the study and conservation of European lacquers, aiming at gathering people from various fields of expertise: art-historians, chemists, restorers, conservators and a broad audience with an interest in European lacquers. The venue turned out to be an enormous success, with over 120 participants from 17 different countries, and the conference was seen by many participants as a new milestone in the study of European lacquer. A large selection of the oral presentations was collected as peer reviewed papers in a special on-line edition of *Studies in Conservation*. Results were also published and presented at many other occasions.

3 STATE OF THE ART AND OBJECTIVES

As widely different fields of expertise are combined for the thorough study of European lacquer, the state of the art and the objectives of the individual research fields is described for each partner separately after which the global objective is defined.

3.1 Partner 1 (Coordinator; KIK-IRPA)

For the chemical analysis of a lacquered object, a range of analysis methods existed at the start of the research project. The technique of embedding and polishing samples for the visualisation of stratigraphies and the inorganic analysis of cross-sections has been used in KIK-IRPA and elsewhere for many years. However, on the level of interpretation of lacquer structure, in relation with ancient sources on the technology and recipes of lacquer, still most was unrevealed. For this part, the interdisciplinarity of ELinC is an advantage. The technique most used for organic analysis of lacquer is gas chromatography coupled to mass spectrometry, combined with prior pyrolysis of the sample. It returns broad information using only a very small sample. Knowledge was mainly developed in general for the analysis of varnishes or eastern lacquer. On the analysis of western lacquer, only limited literature was published for this versatile technique. Still, the analysis of European lacquer in the ELinC project is based on the broad experience of experts of chromatography of resinous heritage materials.

With thermally hydrolysis and methylation gas chromatography mass spectroscopy (THM-GC/MS), large molecules are fragmented and separated. Some of them tell us more on the ingredients used, the aging or the heating of the material. When more of these biomarkers are described, more can be told on the composition and preparation of the lacquer. When ELinC started, a brand-new knowledge platform, at that time called 'RAdICAL, was just about to be launched by two of the most respected GC/MS experts in the field of GC/MS-analyses on cultural heritage, namely Michael Schilling (GCI) and Henk Van Keulen (RCE),'. This part of the research builds further on their principle of combining the analytical computer programme AMDIS and MS-Excel to better interpret chromatograms. At that time, RAdICAL was limited to the analysis of eastern lacquer. It was an important focus for the ELinC project to contribute to the enlarged 'RAdICAL' platform, now called 'ESCAPE', to share better analysis of European lacquer.

3.2 Partner 2 (UA)

From the late 19th to the third quarter of the 20th centuries, the absence of adequate analytical techniques drew art-historians, conservators, and amateurs towards historical written evidence of contemporary lacquer practices to contextualise their observations. Authors reverted towards historical art technical evidence in printed sources to speculate and reflect on the materials, techniques, and practice of lacquering based on their visual observations. An approach which can be challenged for its scientific value today. Since the last quarter of the 20th century, analytical instrumentation and methods have been greatly improved, allowing the chemical characterisation of lacquer samples with increasing precision.

In 2004, Google Books pioneered with the mass digitisation of historical sources with an open-access policy and global accessibility. The availability of a vast corpus of digitised sources benefited the research towards historical art technology. It opened-up an unprecedented wealth of information which facilitated the search for historical sources and amassing recipes.

The improvement of both the analytical instrumentation and the access to a large corpus of historical art technical sources facilitated the validation of the analytical results by searching for linear relationships with historical written evidence on the practice of lacquering. These relationships are meaningful and contribute to the further understanding of the context and process of the making of the studied lacquer. It provides a broader contextual framework surrounding the studied lacquer object.

Collecting recipes is a well-established practice in art technical research. To overcome the burden of information-overload, scholars created recipe datasets and databases; a well-established research method nowadays (Stols-Witlox, 2014, p. 36). The VERNIX-database containing over 400 varnish and lacquer recipes (http://vernix.citedelamusique.fr). Another example is the Colour Context database, containing circa 5500 historical art technical recipes (www.colourcontext.be). This holistic and transdisciplinary approach between art technical history and art science has demonstrated to be a valuable approach on contextualising the analytical results of historical lacquer (Hermens, 2012). Datasets show to be particularly suitable for amassing and centralising copious amounts of recipe data in an orderly fashion. The significance of amassing recipes in datasets lies in its face-value of the acquired information. They offer new insights and give new meanings on the usage of historical materials, techniques and production procedures which are of primary interest for technical art historians, conservators, and conservation scientists

We questioned whether other methods can be applied to study large recipe datasets than those habitually applied in art technical research:

- Which methods can be applied to the further study of recipe datasets?
- Do these methods allow us to identify and study underlying information which results in novel insights?
- Also, can the results of these new methods be validated and supported by both historical art technical sources and analyses of surviving European lacquerware?

To answer these research questions, the aims of partner 2's research are:

(1) Collect and study an extensive corpus of visual, written, and printed sources on European lacquering for mainly North-West Europe from the 17th to the 19th century; with a primary focus on the recipes.
(2) Collect and create the largest recipe dataset of European lacquer recipes to date.
(3) Using this dataset as a tool to test novel research strategies for technical art history.

The objectives of this study are to assist by describing in detail the method and construction of the dataset and present a proof-of-concept that contributes to our understanding of the sources, lacquer recipes, and compositions by:

A. find novel approaches towards the study of historical recipe databases
B. using these approaches to:
    i. identify and list all encountered historical ingredients, and their respective time and regional nomenclature and context;
    ii. identifying relationships between the historical sources;
    iii. the relationships between ingredients used for the recipes;

Successfully finding novel research methods will further refine the discipline of technical art history (A). The described methods can then be applied to existing and future recipe datasets and should assist future art technical research. The results from goals B-i and ii are relevant to the field of conservation and related disciplines. The identification and knowledge of historical materials and production techniques are of utmost importance. It advances our knowledge on

contemporary materials and methods of the making process and increases our understanding of a studied object of art. The goals B-i, ii, and iii will allow – similar to the 'traditional approach' – drawing direct relationships between the studied lacquerware and contemporary sources, recipes, and production methods. The establishing of relationships between ingredients within recipe compositions (B-iii) will further refine the interpretation of the chemical analysis. By knowing the correlations between ingredients, scholars will have a sturdy guidance for the interpretation of ambiguous markers. Hence, they gain knowledge on which ingredients to look for, or which likely to neglect. Finally, from B-ii, further understanding of the relationships between the various sources should result in acquiring new knowledge about how the information of European lacquering was disseminated between the studied regions within Europe.

3.3 Partner 3 (RMAH)

3.3.1 Research on historical objects

The collection of the RMAH was never inventoried for its lacquered items. The first task for the RMAH team was thus to identify all the lacquered objects kept in the museum in order to make an inventory and a selection of pieces that would be worth to study in an interdisciplinary context. Different sections were investigated: furniture, carriages and sledges, collection of *preciosa*, ceramics and musical instruments. All these sections are under the supervision of different curators.

At the beginning, this inventory and the research on the objects was conditioned by a project of exhibition that had to be abandoned because it did not fit in the museum policy.

3.3.2 Archive and art historical study

Another main aim of the project for the RMAH team was to carry out an archive research on different aspects of lacquer trade and production in the area now called Belgium. Different fields of investigation were evaluated, and for many reasons, the study of the *bois de Spa* seemed at the start already, a not-to-be-missed, largely unexploited subject for the project. The RMAH preserves not only an important collection of *bois de Spa*, but the subject is also important for the history of European lacquers, especially as they were made in Belgium and form part of our cultural heritage.

Other unknown subjects surfaced during the project thanks to thorough archival research. 19th century printed texts and newspapers revealed not only a strong taste for lacquered furniture following international trends during the years 1830 to 1855, but also an unknown local lacquer production. An archive research on patents deposited in the capital in the 19th century on lacquers and varnishes was also started.

- **Spa Woods**

An entire craft tradition developed in Spa, renowned for its springs, starting in the 17th century. It began with walking sticks, than extended by the end of the 17th century and the second quarter of the 18th century to all sorts of attractive fancy goods and small pieces of furniture. There were artefacts for all budgets, and no guest or servant would leave the thermal town without these *jolités* or *bois de Spa*. Following the taste for the exotic, the production of lacquer started up in Spa. The first examples were aiming to imitate the appearance of the Eastern

lacquer's surface, but soon the lacquered *bois de Spa* showed decors in a fully European fashion with, for example, views of Spa.

Despite their historical popularity as souvenirs and today as collector's items, the *bois de Spa* have been rarely studied. Apart from small exhibition catalogues (Dethier and Béguin, 1967–68), articles in the *Histoire et archéologie spadoises*, and leaflets, there is the contribution of Monika Kopplin in her catalogue on European lacquers (Kopplin, 2010, 161–166, 168–180) and the recent book of Lydwine de Moerloose that give a very good general survey on the subject from the 17th century to nowadays (de Moerloose, 2018). A valuable historical study was published in 1898 by Albin Body, an indefatigable historian of the city of Spa (Body, 1898). This historical study undertaken at the end of the 19th century had however never been reconsidered in his whole.

The RMAH houses an important collection of *bois de Spa* with some items of the 18th century, but mostly of the 19th century. Discussions were first held to decide if the items of the 19th century kept at the RMAH, most of them covered with a transparent coating and still showing the grain of the wood, could be considered as lacquered or as painted and varnished. *Bois de Spa* being very important for the beginning of the history of European lacquer in the 17th and 18th century, it was decided to focus the study on the very beginning of this lacquer production till the third quarter of the 18th century studying objects that were undoubtedly lacquered. A better comprehension of the starting of the lacquer art in Spa and evolution in the 18th century was needed and corresponded to an international demand. For the feasibility of the interdisciplinary study, the subject of the research was restrained to imitations of Asiatic lacquers or to items with chinoiserie decoration. Artefacts decorated in a pure European fashion were left aside for our first paper on the subject.

- **Lacquers in Brussels in the 19th century**

At the start of the project, hardly any information was available on lacquer production in our region in the 19th century. To fill this gap, the investigation on the taste for lacquer in Brussels in the 19th century, started for the RMAH researchers by the consultation of the catalogues of national exhibitions of the products of the industry held in Brussels in 1830, 1835, 1841 and 1847 and then of the catalogues of the universal exhibitions held first in London in 1851 and in Paris in 1855. It appeared very soon that a still unnoticed production of lacquer existed in Brussels in the years 1835 to 1850. More information on one lacquer producer, Louise Ghiesbreght, was found in almanacs and newspapers, a full archive research on this lady followed. Unfortunately, no lacquered objects of her could be tracked down, but nevertheless, the international industrialized lacquer production she had to cope with is illustrated by a series of black lacquered objects owned by the RMAH.

The study was the occasion to gain new information on the history of luxury shops in Brussels. Doing so, in the meantime the taste for lacquer in Brussels in the 19th century was documented. The specific research on Mss. Ghiesbreght was also interesting for the history of gender because it gave the chance to trace the carrier of a woman active in the beginning of the 19th century.

Another investigation that was considered worth to conduct was the study of patents on lacquers and varnishes that were deposited in Brussels in the 19th century, subject that was never undertaken prior to this project.

4 METHODOLOGY

4.1 Partner 1 (KIK-IRPA)

4.1.1 Quality control of resins

In the quest for unique biomarkers, allowing the straightforward identification of resins used in European lacquers, a large number of resins and some other ingredients used in lacquers, were purchased and tested for purity and genuineness before usage. Nomenclature of resins can be confusing since botanic species have had different names over time, and in different languages. Sometimes the relation between resin and botanic plant species has been unclear for longer times. For example, some (semi-) fossil resins are named after their region of finding or trading, but not specifying their origin. Additionally, after collection, resins can often not visually be discerned. After all, resins today are sold for their use in varnishes and cosmetic or pharmaceutic applications. In this context, resins are intentionally or not contaminated with additives, or even replaced with other resins to optimize both physical properties and price.

A total of 81 products were purchased or sampled, and analysed with THM-GC/MS. Sandarac in particular was frequently purchased, as modern sandarac apparently has a different composition than the one found in historical objects (see Results). For the reconstruction of lacquers following historical recipes, 74 possible ingredients, mainly natural resins, were purchased via commercial channels. 62 of those were submitted to quality control. The others were either doubles or materials not yet encountered in historical recipes of the period of interest. Analysis of the doubles was only performed in case the first had failed. Following materials were analysed, with the number of samples between brackets: gum tragacanth (2), larch resin (3), amber (1), Manila copal (3), *Picea abies* (L.) H. Karst. resin (3), oil of spike (1), shellac (sticklac, seedlac, buttonlac and pure shellac; 4), colophony (3), Abies alba Mill. resin (1), benzoin gum (3), copaiba balsam (2), mastic (3), gamboge (1), Manila elemi (2), camphor (1), Congo copal (4), Kauri copal (1), South American copal (2), Zanzibar copal (3), African elemi (1), linseed oil (1), boiled linseed oil (1), sandarac (13), tung oil (1), Strasbourg turpentine (1), and Zanzibar copal (1).

Scientific literature sources were consulted during this quality control, but it was also necessary to analyse pure reference materials to compare the bought materials to. These reference resins were only available in small quantities and can hence not serve for the production of mock-up samples themselves. A total of 236 reference materials were sampled in scientific institutions. Reference samples were obtained from the Doerner Institute (München), the Cultural Heritage Agency of the Netherlands (Amsterdam), the Royal Museum for Central Africa (Tervuren), KIK-IRPA (Brussels), and especially from the historical resin collection of the botanical garden in Meise.

A selection of the purchased and approved materials was made, based on their film forming properties. They were then applied to glass plates and artificially aged to be used in the studies discussed below. They were all observed and photographed closely under visual and ultraviolet light for their technical and physical properties before and after aging by partner 2.

4.1.2 Optimisation of the analytical analysis procedure (THM-GC/MS)

- **Pyrolysis temperature optimisation**

Central to the organic analysis of lacquer stands THM-GC/MS, the most important chromatographic technique for this type of research (while variants of this analysis such as sillilation instead of methylation is used widely as well). The sample is placed in a stainless-steel cup, and heated in a pyrolysis oven, where is it hydrolysed and methylated. Doing so, large molecules are broken into fragments for separation on a chromatographic column. The temperature in the pyrolizer is important for the result. If it is too low, large molecules will not break down sufficiently, while at high temperatures interesting biomarkers can be destroyed. The optimum temperature is a compromise between these two phenomena.

In order to optimise the pyrolysis temperature for the chromatographic analysis of European lacquer, thermochemolysis temperature was evaluated for the analysis of natural resins. Five main ingredients of lacquer were studied: sandarac, mastic, colophony, Manila copal and Congo copal. For each, five temperature programs were tested: four fixed temperatures (350, 480, 550, 650°C) and one ultrafast thermal desorption (UFD), in which the temperature rises from 350 to 660°C in 1 min. In total, the integrated signals of 27 molecules, partially characterizing the five resins, were monitored to compare the different methods.

- **GC temperature programme optimisation**

The temperature of the GC oven rises gradually to enable components to pass through the column. The temperature programme in use at KIK-IRPA, was, after the advice of prof.dr. Frédéric Lynen (UGent, promotor PhD thesis Louise Decq) adapted for better separation in the diterpene region at the start of the ELinC project.

- **Sampling optimisation**

When studying lacquered objects, one starts with a close observation in visual and ultraviolet light of the object. This was performed with the Hirox digital microscope, placed on a custom-made stage. When, complementary to this visual inspection, only inorganic analysis is needed, non-destructive analyses can be performed by MA-XRF and XRF. This approach has been followed for the Spa boxes (although completed with limited sampling as well). However, in most cases, stratigraphic analysis and organic analysis were required. In this case, samples will be taken. After a long observation, non-restored and little visible locations were selected for sampling. Different sampling methods were tried, mostly on 20th century lacquered panels present in the laboratory.

- **Artificial aging**

The parameters used for the artificial aging of ingredient films were identical to the ones used at the GCI on Asian lacquer mock-up samples (information shared by Michael Schilling and Marianne Webb, both members of the follow-up committee). They were discussed and agreed upon by the scientific committee.

In total 386 film covered glass plates were artificially aged at KIK-IRPA in an Atlas Weatherometer equipped with a sodium borosilicate inner filter and a CIRA coated soda lime outer filter. They were continuously exposed to intense visual and ultraviolet light for 0, 2, 4, 8,

16, 32 and 64 days (1day = 23.5hours), with a black panel temperature of 40°C, a chamber temperature of 30°C and relative humidity of 50%.

All were applied on series of glass plates to enable artificial aging, in a transparent and a lamp black coloured version. For this, the resins were dissolved in pure ethanol, and if necessary filtered. Lego holders were custom-made to protect the sensitive lacquer surface from water droplets present in the climate chamber when controlling humidity (Fig. 1).

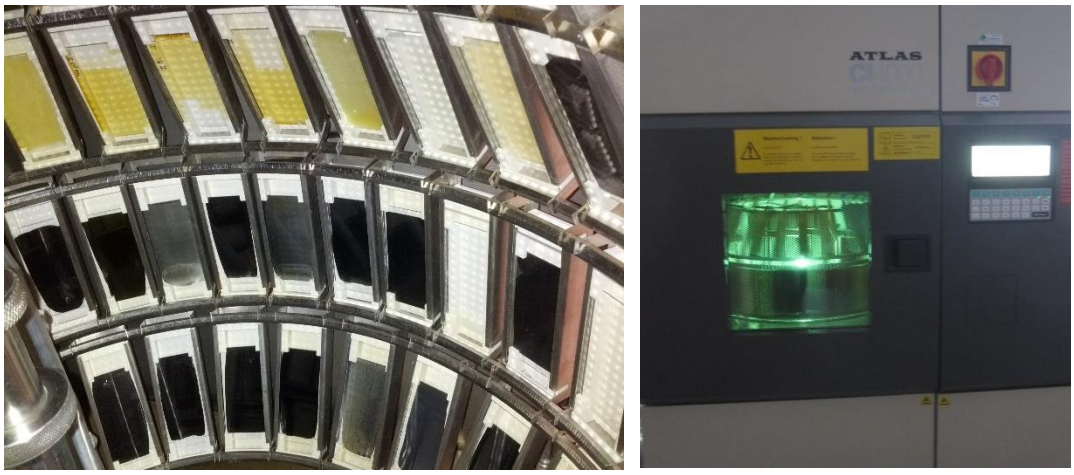


Figure 1. Artificial aging of lacquer ingredients.

4.1.3 Search for new biomarkers

- **Statistical approach**

Better understanding and finding new biomarkers help to improve the interpretation of the THM-GC/MS measurements of lacquer layers. Two strategies were followed in the search for new markers. A first strategy uses a statistical approach. The concept was to use methods developed in chemometry to compare groups of chromatograms to identify the consistent differences between them. As a proof of concept, four different copals were analysed and compared with each other using statistical methods. The same method can also be used to compare, for example, boiled oil and non-boiled oil, or to compare groups of similar mock-up varnishes. Important for this method is that all chromatograms have sufficient similarities, and are recorded in identical circumstances.

- **Marker library compiled of artificially aged ingredients**

A second method is based on artificially aged ingredients. In this study, a marker database was created in a semi-automated way starting from chromatograms of different reference samples of ingredients of European lacquer, before, during and after artificial aging. Focus was put on the main organic ingredients present in 18th century lacquer recipes. With such a library, samples can be scanned for a large number of marker-candidates, and the most important new markers can be returned to the expert community. Without any chemical identification, peaks are compared and recognized as they match with peaks found in reference samples.

A total of 32 materials, used in the production of European lacquer, was used in this study. 24 of them are those described above, suitable for artificial aging: colophony (*Pinus* sp.), spruce resin (*Picea abies*), fir resin (*Abies alba*), shellac, sticklac, buttonlac, seedlac, mastic, elemi, copaiba balsam, sandarac, larch resin (*Larix decidua*, often referred to with the ambiguous term

Venetian turpentine), Sumatra benzoin (*Styrax* sp.), gamboge (*Garcinia morella*), Kauri copal (*Agathis australis*), South American copal (fresh and fossile; *Hymenaea coubaril*), Congo copal (*Guibourtia demeusei* (Harms) J. Leonard), Madagascar copal, Manila copal (*Agathis dammara* (Lamb.) Rich. & A. Rich.), East African copal, tung oil, boiled linseed oil and tragacanth gum (Table I).

For practical reasons, some materials were not artificially aged. They were not present in sufficient amounts or in time, were too volatile, did not dissolve or did not form a film on the glass plate. Their chromatograms were added to the data without artificial aging: Zanzibar copal (4 samples), Baltic amber (3), historical turpentine (*Pistacia therebinthus*) (2), incense (oliban) (2) Strassbourg turpentine (*Abies alba*) (2), oil of spike (1), Siam benzoin (4) and pine turpentine (2). It has been observed that sandarac as sold today seems to deviate from sandarac found in historical objects (see Results). For this reason, four sandarac samples from historical collections were included (4). Finally, also the blank chromatograms recorded during analysis of all previously described samples were added to the dataset. In total 419 chromatograms were used to compile the marker library.

After compiling this library, it was tested on a series of mock-up samples. These samples are varnishes made by students of the *Technische Hochschule* in Cologne on the basis of historical recipes and provided by a member of the follow-up committee.

- **Objects: selection for analysis**

During the project, 44 lacquered objects were selected for chemical analysis, 4 of which were already (partly) investigated during the preparation of this project. 22 of these objects came from the collections of the Royal Museums of Art and History in Brussels. The selection of the objects was made in consultation with the three partners. Some objects were only examined historically, or technologically, but a large number of objects was also selected for chemical research. With the prospect of discovering a coherent historical, technological and chemical story that would bring fascinating new insights on lacquer production or lacquer collections in Belgium, groups of related objects were preferred. For example, 3 sledges were chosen, 8 similar 19th-century black pieces of furniture, 4 17th-century objects made by Willem Kick in the Netherlands, and 18 18th-century lacquered *Bois de Spa*. In support of the historical analysis or restoration, the pre-ELinC study was completed. Additionally, a few more single objects were studied, to ensure a more representative, broad study of lacquer in our region: a clock in restoration, whose results can be compared with the cabinet-secretary studied during the pre-ELinC study; a white cabinet attributed by the owner to the famous German lacquerer with Belgian roots, Gerard Dagly; a table by the famous Pierre Gole, ebenist at the French court and born in the early 17th century in the Netherlands, one of the earliest lacquered items produced and conserved in our region; a piano, lacquered in Brussels around 1900; a set of Delft vases, curiously covered with lacquer decoration on a unknown date. The table below provides an overview of items studied and samples taken. While the type of analysis depended on the specific questions, usually general characterisation with stratigraphy and inorganic and organic analysis were combined.

Table I. Overview of objects sampled.

KIK-IRPA file	collection	description object	inv.nr.	Number of samples	KIK-IRPA sample nr	sample date	KIK-IRPA cross section nr
19th century black English (or English style) furniture							
2017.13426	RMAH	Folding table. Black 19th C, English	M069	14	P224.043B; P224.097; P224.098; P224.099; P224.100; P225.001; P225.001bis; P225.002; P225.003; P225.004; P225.005	12/7/2016; 13/7/2016; 16/11/2016	C86.041, C86.042, C86.043
2017.13427		Arm chair. Black 19th C, English	M070	7	P225.017; P225.018; P225.019; P225.020; P225.021; P225.022	12/7/2016; 24/11/2016	C86.044
2017.13428		Chair. Black 19th C, English	M073	4	P225.006; P225.007; P225.008	12/7/2016; 16/11/2016	C86.045
2017.13429		Chair. Black 19th C, English	M074	5	P225.031, P225.032, P225.033, P225.034	12/7/2016; 24/11/2016	C86.046
2017.13430		Chair. Black 19th C, English or French	M075a	4	P225.023, P225.024, P225.025	7/12/2016; 24/11/2016	C86.047
2017.13431		Chair. Black 19th C, English or French	M076	2	P225.026	7/12/2016; 24/11/2016	C86.048
2017.13432		Glove box. Black 19th C	Bi146	1		12/7/2016	C86.049
2017.13433		Spandrel. Black 19th C	M072A	1		13/7/2016	C86.055
Sledges							
2017.13435	RMAH	Sledge. Red, 18th C, Low Countries	Tr1868	8	P224.070, P224.071, P224.072, P224.073, P224.074, P224.075, P224.076	13/7/2016; 28/9/2016	C86.050
2017.13436		Sledge. Turtoise shell imitation – silver leaf 18th C, Liège	Tr88	2	-	13/7/2016	C86.051, C86.052

2017.13437		Sledge. Green, black, gold, aventurine 18th C, France	Tr41	17	P224.043C, P224.043D, P224.056, P224.057, P224.058, P224.059, P224.060, P224.061, P224.062, P224.063, P224.064, P224.065, P224.066, P224.067, P224.068, P224.069	13/7/2016; 27/9/2016; 28/9/2016	C86.053, C86.054, C86.063
Willem Kick							
2017.13541	museum fur lackkunst munster	Willem Kick. Larger chest. Floral motifs and Prudentia	GSL-2016-2	18	P236.004 to P236.012, P237.090 to P237.094, P237.100, P239.001 to P239.003	3/4/2017 and external	C86.090, C86.091, C96.025, C95.089
2017.13542		Willem Kick. Metal plate with bird motives	Krg19372?	1	P236.013	3/4/2017	C86.121
2017.13543		Willem Kick. Small chest	-	6	P237.087, P236.051, P236.052, P237.015, P237.016, P237.017	3/4/2017	C86.122, C86.123
2017.13544		Willem Kick. Cabinet	gsl2017-1	7	P237.018 to P237.022, P237.053, P237.054	3/4/2017	C96.002, C86.124, C86.125
Bois de Spa							
2017.13438	RMAH	Bois de Spa. White (yellow; imaginary landscape), 18th C, Spa	F4773	4	P225.027, P225.028, P225.029, P225.030	24/11/2016	
2017.13439	RMAH	Bois de Spa. black quadrille with rocaille pattern and chinoiserie	2013.010.001	5	P237.095 to P237.099	3/10/2017	C96.030, C96.031
2017.13545	Musée de la ville d'eaux, Spa	Blue green box with chinoiserie (8.5x19x13cm)	B235	11	P237.023 to P237.032, P237.089	19/4/2017, 6/9/2017	C96.003, C96.004
2017.13546		Black with chinoiserie. Re-lacquered	18B	1	P237.033	19/4/2017	
2017.13547		Bois de Spa. blue box	12B	2	P237.034, P237.035	19/4/2017	C96.005, C96.006
2017.13548		Bois de Spa. white box	B30	9	P237.036 to P237.044	19/4/2017	C96.007, C96.008

2017.13549		Bois de Spa. black quadrile, chinoiserie	B278	4	P237.045 to P237.047, P237.088	19/4/2017, 5/9/2017	C96.009
2017.13550		Bois de Spa. Necessaire à parfum	B1077	3	P237.048 to P237.050	19/4/2017	C96.010
2017.13551		Bois de Spa. Turtoise imitation with chinoiserie. Relacquered.	B13	2	P237.051, P237.052	19/4/2017	
2017.13552		Bois de Spa. round white box	A46	2	P237.053, P237.054	19/4/2017	C96.011
2017.13553		Bois de Spa. black rocaille quadrille chinoiserie	16B	6	P237.055 to P237.060	19/4/2017	C96.012, C96.013, C96.014
2017.13554		Bois de Spa (exterior restored)	B6	3	P237.061 to P237.063	19/4/2017	C96.015
2017.13555		Bois de Spa (exterior restored)	B28	1	P237.064	19/4/2017	
2017.13556		Bois de Spa. black quadrille with chinoiserie (crossed pattern at border)	9B	5	P237.065 to P237.069	19/4/2017	C96.016, C96.017, C96.018, C96.019
2017.13557		Bois de Spa. black quadrille with rocaille pattern	17B	8	P237.070 to P237.077	19/4/2017	C96.027, C96.020, C96.028, C96.021
2017.13558		Bois de Spa. black quadrille with rocaille pattern (exterior restored)	15B	3	P237.078 to P237.080	19/4/2017	C96.022
2017.13559		Bois de Spa. Small chest from quadrille	-	1	P237.081	19/4/2017	C96.023
2017.13560		Bois de Spa. turtoise quadrille (not restored)	7B	3	P237.082 to P237.084	19/4/2017	C96.029
Single study items							
2017.13420	RMAH	Clock. Black, 18th C, England	RMAH G3020	5	P225.096; P225.097	19/5/2016; external	C86.029, C86.030, C86.031, C86.087, C86.088
2017.13424	private collection B. P.-B.	White cabinet, attributed to Dagly. 18th century	-	4	P237.001; P237.002; P237.003; P237.004	External	
2017.13425	Antwerp provincial collection	Table by Pierre Gole. black 17th century burgauté lacquer	Sm720	2	P237.085; P237.086	External	C96.001

2017.13434	RMAH (MIM)	Piano. Black Ca.1900, Brussels	2003. 021	10	P224.077, P224.078, P237.005, P237.006, P237.007, P237.008, P237.009, P237.010, P237.011, P237.012, P237.013, P237.014	30/9/2016; 5/5/2017	C86.061, C86.062, C96.024
2017.13511	RMAH	Three lacquered vases. Delft vase floral motives; black- 18 or 19th C	G675A, G675B, G674	15	P225.079 to P225.093	7/3/2017	C86.089, C96.026, C86.084
ELinC pre - study (extended)							
2010.10799 2017.13419	RMAH	Cabinet-secretary. Black, 18th C, England	RMAH G3024	17 (6 pre-ELinC)	P196.027; P196.028; P196.029; P196.030; P196.031; P196.032	17/9/2010; 23/2/2016; 11/3/2016; 19/5/2016	C68.200, C77.001, C77.002, C77.121, C77.122, C81.200, C86.001, C86.005, C86.006, C86.007, C86.008, C86.009, C86.010, C86.011, C86.027, C86.028
2010.10799 2017.13422	RMAH	Secretary. Black 19th C, French or English?	V0015	6 (3 pre-ELinC)	P196.019; P196.020; P196.021	17/9/2010; 29/1/2016; 4/4/2016	C86.026, C86.015, C86.016, C86.017, 86.018, C68.192, C68.193, C68.194, C86.023
2010.10799 2017.13423	RMAH	Showcase. Black 19th C, French or English?	G6386	2 pre-ELinC	P196.025; P196.026	17/9/2010	C68.198, C68.199
2010.10799 2017.13421	RMAH	Secretary signed 'Latz' . Black, 19th century	-	5 (3 pre-ELinC)	P196.022; P196.023; P196.024	17/9/2010; 29/1/2016	C68.195, C68.196, C77.804, C68.197, C86.024, C86.025

4.2 Partner 2 (UA)

4.2.1 Historical sources and recipes

The study of technical art history has come a long way (Hermens, 2012). The inventions and innovations of analytical methods and new art technical research possibilities have driven art technical studies to an increasing complexity; where multidisciplinary expertise became a necessity. The necessity of a multi-perspective approach towards the object of study has recently been argued for by among others Stijnman, Whitney, Lehmann, and Hermens. They argue that technical art history should only be approached interdisciplinary, and preferably transdisciplinary, thus in a holistic manner (Hermens, 2012).

The ELinC project reflects such a symbiosis between different disciplines. ELinC provided a multidisciplinary platform towards the characterisation of the European lacquering technology on an art historical, art technological, and chemical level. The approach towards art technical studies is best executed by the convergence of the various historical sources and methods available. Among others, Stijnman and Lehmann propose to study historical art techniques by using five sources and approaches for knowledge-acquisition (Lehmann, 2009):

1. *Documentary research*: during which historical written descriptions of the making process are studied;
2. *Visual evidence*: the study of static or dynamic visual evidence such as prints, or audio-visual materials of the making process;
3. *Historical objects*: the study and analysis of historical objects to understand the process of the making;
4. *Tacit knowledge*: acquiring tacit knowledge through the reconstruction of historical recipes;
5. *Observation* of the making process.

Four out of five approaches (1-4) are represented into the ELinC-project.

The following paragraphs will discuss the methodology organised according to the four approaches towards art technical research. Additionally, the methodology of constructing the lacquer recipes' dataset is discussed.

- **Documentary research**
  Study of historical art technical sources

For collecting historical lacquer recipes for the recipes' dataset, primary and secondary sources were searched, collected, and studied without focussing on a particular genre of sources. Hence, the utilised sources are diverse, ranging from artists' manuscripts (notebooks), archival documentation, manuals, recipe books, and encyclopaedias (Table II). A preliminary bibliography of historical sources on European lacquering was sourced from citations from the extensive review of past art technical studies related to the topic.

The printed and written sources for recipe-collection are regionally limited to North-West Europe (Netherlands, France, Germany, the United Kingdom, and Ireland). The period ranges from the early development of European lacquer at the start of the 17th century to the late 19th century. The motivation to limit this study to the late 19th century is due to the recipes' 'compositional revolution' of European lacquers starting from the second half of the 19th century. The introduction of novel materials such as synthetic resins and production techniques such as spray application from then onwards were in favour

of the traditional plant-exudate materials and techniques for lacquer making. Several exceptions to the limitations for the period and regions were made. Influential works from the Southern region of Europe (Italy), such as the early works of Cennino Cennini (c. 1390), the Bolognese Manuscript (15th century; Padua manuscript, *'Ricette per far ogni sorte di colori'*, Padua, Bibliotheca dell'Universita MS 993), and Giovanna Battista Armenini (c. 1586/1587), were included.

Additionally, these sources were combined with a variety of other art technical sources on European lacquering, some of which have never been studied before. The sources were accessed through online databases such as Google Books, Internet Archive, Gallia, HathiTrust, Europeana, and the 17th-18th Century Burney Newspaper Collection. Online databases, such as the VERNIX-database (http://vernix.citedelamusique.fr) and the ARTECHNE-database (https://artechne.wp.hum.uu.nl/artechne-database/), were used to collect further information on the recipes.

Although the focus of this study are lacquer recipes, the selected sources are studied as a whole. The paratext surrounding the recipes is crucial for understanding the broader context of the source(Stols-Witlox, 2014, p. 76). Also, a broad contemporary context is needed to support observations and form hypotheses and conclusions. Therefore, an additional circa 220 historical sources relating to the tradition of lacquering from the 17th to the 19th century were carefully read and studied.

Equally important was the study of literature dealing broadly with the subject of European lacquering from more recent times (late 19th century and onwards). Sources like Seeligmann and Zieke (1910), Tschirch (1900), and Hurst (1892) distinguish themselves from early modern sources by a more critical and scientific approach since these authors were still knowledgeable of traditional materials and methods of lacquer making (Hurst, 1901, 1892; Seeligmann and Zieke, 1910; Tschirch, 1900). The publications provide among other clues towards the historical nomenclature of ingredients and their respective botanical origin, as well as a better understanding of the ingredients chemical and physical features and lacquer production process.

Table II. The historical sources used for the acquisition of historical recipes on European lacquering.

Country	Published at	Author	Date	Short title
IT	Padua	Cennino Cennini	c. 1390	I'll libro dell'Arte
IT	Bologna	Anonymous	1st quarter or mid-15th c.	Bologna Manuscript
IT	Ravenna	Giovanni Battista Armenini	1586/1587	De veri precetti delle pittura
ENG	London	Theodore De Mayerne	c. 1620-1646	Pictoria, Sculptoria, Tinctoria et qua subalternarum artium spectantia
FR	Paris	Pièrre Le Brun	1635	Recueil des essais des merveilles de la peinture
FR	Lyon	Balthasar de Monconys	1666	Journal des voyages de Monsieur de Monconys
NL	Amsterdam	Athanasius Kircher	1667	China illustrata
ENG	London	John Evelyn Sylva	1664	A discourse of forest-trees and the propagation of timber
FR	Paris	André Félibien	1676	Des principes de l'architecture, de la sculpture, de la peinture et des auteres arts

DE	Leipzig	Johannes Kunckel von Löwenstein	1679	Ars vitraria experimentalis
DE	Nurnberg	Anon.	1707	Die curieuse Kunst und Werck-Schule
DE	Unknown	Sibylla Augusta of Baden-Baden	c. 1688	Vierfacher Hand-Schrein unterschiedlich-angemerckter
ENG	Oxford	John Stalker and George Parker	1688	A Treatise of Japaning [Sic] and Varnishing
NL	Den Hague	Claude Boutet	1688	Traité de mignature
FR	Paris	Pièrre Pomet	1694	Histoire generale des drogues
ENG	London	C.K.	1697	Art's master = piece
ENG	London	William Salmon	1701	Polygraphice: or, the arts of drawing, [...] varnishing, japaning [...]
IT	Rome	Filippo Bonanni, Italian edition	1720	Trattato sopra la vernice detta communemente cinese
FR	Paris	F. Bonanni, French edition	1723	Traité des vernis [...] qui ressemble parfaitement à celui de la Chine
BE	Brussels	Anonymous, ed. Charles Ferrand	1724	Secrets concernans les arts et metiers
BE	Spa	Nicolas Dagly	1731	Untitled, archival deed
IT	Paris	Bonanni, French edition II	1733	Traité des vernis [...] qui ressemble parfaitement à celui de la Chine
NL	Den Hague	Mattheus Verheijden	c. 1736-1739	Konst en Recept Boek
NL	Rotterdam	J. F. Lindenbergh	1742	De nieuwe verligter [...] en making der fernissen
DE	Jena	Johann Melchior Cröker	1743	Der wohl anführende Mahler
IT	Cremona	Anonymous	1747	Varnishes and very curious secrets
Ireland	Dublin	Anonymous (Carington Bowles)	1749	Arts companion, or a new assistant for the ingenious
IT	Padua	Anonymous	Mid or 2nd half 17th c.	Padua Manuscript
DE	Regensburg	Johann Martin Teuber	1756	Vollständiger Unterricht der gemeinen und höheren Dreh- Kunst
ENG	London	Robert Dossie	1758	The handmaid to the arts
FR	Paris	A. D. Fougeroux de Bondaroy	1761	Art de travailler les cuirs dorés ou argentés
ENG	Mere	William Lander	c. 1763-1843	Untitled, notebook
NL	Leiden	Hendrick Cocq	1771	De konst van [...] der beste soorten van lakken en vernissen
FR	Paris	Delormois	1771	Le Vernisseur Parfait
FR	Paris	Jean-Félix Watin	1772	L'art de faire et d'employer le vernis
DE	Leipzig	Watin (Siegfried L.	1774	Der Staffirmaler oder die Kunst

		Crucius)		anzufstreichen, zu Vergolden und zu Lackiren
FR	Paris	Le Pileur d'Apligny	1779	Bescheibung aller Farbmaterialien
DE(?)	Unknown	Heinrich Dracken(?)	1784(?)	Untitled, manuscript
IT	Rimini	M.A. Alberto Guidotti (Bonanni)	1784	Metodo facile per formare qualunque sia sorta di vernici della Cina
DE	Eltmann	Johann Ludwig Schreck	1789	Von der sogenanten Laccir-Kunst
FR	Paris	Jacques Lacombe	1789	Encyclopédie Méthodique - Arts et métiers
NL	Amsterdam	Johannes Kok	1794	Onderrichting om verscheidene soorten van lakken en vernissen te maaken
UK	London	Anonymous	1801	The artist's assistant; or school of science forming a practical introduction to the polite arts
NL	Leiden	A. Fokke Simonsz	1805	De kunst om in perspectief te tekenen
FR	Liège	Jacqmerre	1833	Patent: Composition pour un nouveau vernis
NL	Amsterdam	Anonymous	1840	Handleiding tot het bereiden van alle soorten van ongekleurde en gekleurde vernissen
FR	Paris	Willent-Bordogni	1844	Méthode complete pour le basson
ENG	London	James Cameron	1886	Oils and varnishes

Study of historical botanical sources

The interpretation and botanical identification of the historical nomenclature of ingredients poses a challenge and is of foremost importance to correctly understand the recipe's formulation and accurately parse it towards a recipes' dataset (Steigenberger, 2013). Particularly for European lacquers, of which the coating mostly consists plant exudates such as oils, resins, essential oils, and gums.

To comprehend the botanical origin of historical ingredient terms, recent research papers and books describing botanics from the 17th and 18th centuries were studied (Bauhin, 1623; Parkinson and Cotes, 1640). These publications provide contemporary knowledge of various plants and exudates, their associated nomenclature and synonyms, and morphological descriptions and illustrations. Based on the above, it is possible to identify and relate an historical ingredient to its contemporary counterpart.

Authors of historical sources give sensory descriptions to instruct the reader and the potential buyer of ingredient on the physical appearance and features of ingredients. Also, it appears that fraudulent practices were prevalent throughout the studied period from the 17th to the 19th century (Dietemann et al., 2019). For example, in the first paragraph of Stalker and Parker's treatise, the authors warn the reader for fraudulent practices and obdurate market vendors: *"And that no one may impose upon you in the Price or Goodness of your Drugs; that your Spirits be very strong, your Gums and Metals of the best; take this following account, as your only security against all cousenage and imposture"* (Stalker and Parker, 1688, p. 39). Consequently, authors go to great extent to provide descriptive details of the raw ingredients such as shape, colour, clarity, fracture, sense of smell, and others. Based upon these sensory details, the reader and potential customer should have the proper set of knowledge on how to identify the proper ingredients and distinguish good from bad quality on the market. These descriptions

occasionally contain ingredient-specific characteristics that allows researchers to eliminate different ingredients by deduction.

- **Visual evidence**

Despite their rarity, the visual sources on the art of lacquering provide historical evidence on various aspects of the making process. This study identified four scenes depicting lacquer workshops from two sources. A first are two chalcographies of a lacquer workshop setting from the *Encyclopédie Méthodique - Arts Et Métiers Mécaniques*.(*Encyclopédie Méthodique. Arts Et Métiers Mécaniques*, 1789, p. 255; Lacombe, 1789) This chalcography shows various stages of the lacquer-making process in a workshop setting from the late 18th century. Another example of an illustrated workshop setting is a late 18th century etch '*Der Lackirer*' ('*The lacquer worker*'), depicting different artisans working in what appears the same workshop or room.

Two 19th century prints evidence the labour division between women and men in a professional context was production-stage related. For instance, two late 19th century etchings illustrate the gender division of labour within the Blüthner's workshop (Leipzig, Germany). One illustrates men polishing heavy pianos (Figure 1) while another depicts women lacquering light-weight violins (Figure 2) ("Stratton's Geigenfabruk in Gohlis Bei Leipzig," 1873, p. 312).

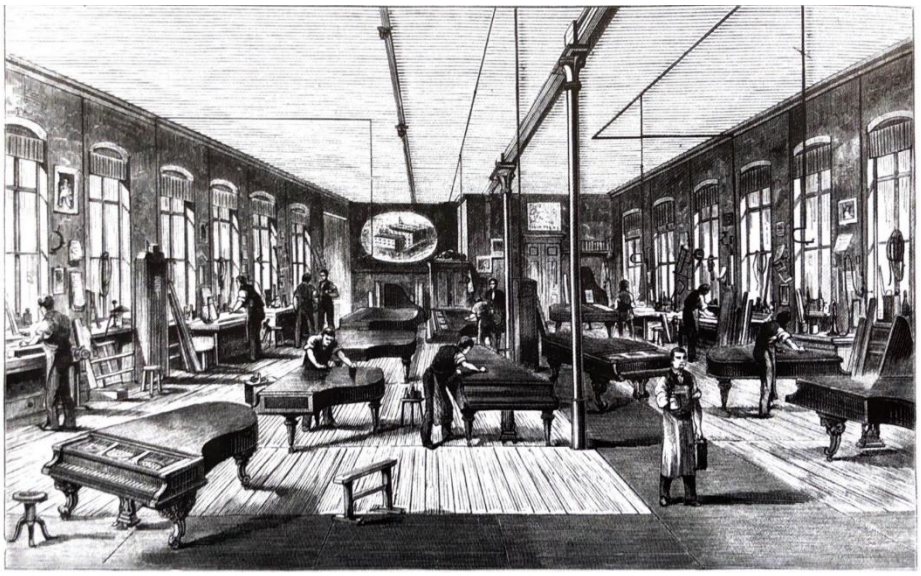


Figure 1. Polishing room of F. J. Blüther, Leipzig.

Figure 2. Paint and lacquering room in the violin factory of J. F. Stratton, Gohlis, Leipzig (DE).

- **Historical objects**

Crosschecking the validity of the written content of historical sources requires the support of instrumental analysis of samples from preserved lacquered objects. Therefore, a selection of objects was made from public and private collections (table I).

- **Tacit knowledge**
  - *Single ingredient mock-ups*

31 ingredients were used to create mock-ups of single-component lacquers to acquire practical experience and familiarisation with the materials. Also, the mock-ups served for the chemical characterisation during the various stages of artificially ageing. Series of 14 to 28 mock-ups for each of the 31 ingredients were produced: 7 (or 14) uncharged and 7 (or 14) charged with lampblack (Figure 3). The samples charged with lampblack intended to verify whether charged lacquers age differently from transparent lacquers. For this purpose, only ingredients from analytically verified botanical origins were used. Solid ingredients were dissolved in pure ethanol whereas liquid ingredients (e.g. linseed oil, oil of turpentine) were used pure. A total of 434 single-ingredient lacquer mock-ups were made and qualitatively evaluated before analysis.

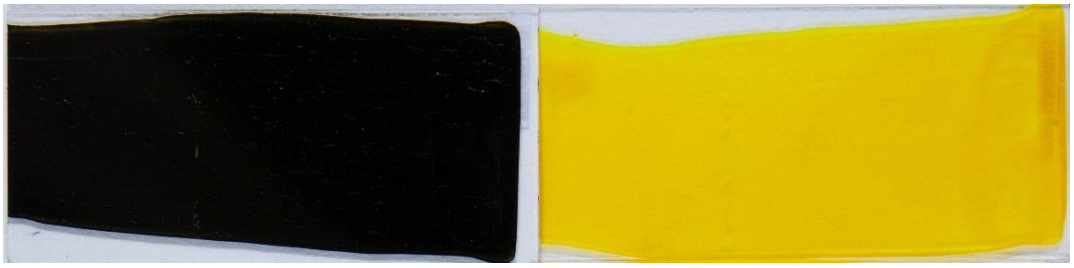


Figure 3. Example of two single-ingredient mock-ups created with gamboge (genus *Garcinia*, dissolved in ethanol). Left, gamboge charged with lampblack; right pure gamboge coating. Both samples are applied on a float-glass substrate. @UA

- *Reconstruction of historical recipes*

The translation of historical written and visual evidence by reworking historical recipes results in unwritten bodily experiences which can then be evaluated throughout the process of the making in a real-world context (Smith 2012). It allows today's scholars to close in on the contemporary artisans' bodily experience by the process of creation and physical interaction with materials (i.e. artisans' epistemology). Within this study such bodily experiences were acquired by experimentation with ingredients, the creation of mock-ups, and reworking historical recipes.

A selection of recipes has been reconstructed from various region and time periods (in cooperation with the *Technische Hochschule Köln*, Cologne, Germany under the guidance of Andreas Krupa). To minimise uncontrollable variables, the process of reworking did not focus on re-enactment. Instead, recipes were reworked within a modern laboratory setting and the procedures and tools used for the making were executed with laboratory equipment. The application of the prepared lacquers was done by hand with a sable brush.

Table III. Reworked historical lacquer recipes.

Source	Recipe name, page number(s)	Success?
Kircher, Amsterdam, 1667	De making en bereiding van tvernis, om verscheide dingen glad en glansig te maken, 267-268	Yes
Stalker and Parker, Oxford, 1688	The best white varnish, 10-11	Yes
Stalker and Parker, Oxford, 1688	To make a white varnish much inferior to the former, 12-13	Yes
Stalker and Parker, Oxford, 1688	To make red-japan, 24	Yes
C.K., London, 1697	White Varnish, how to make it, 35-36	Yes
Anon. (Kunckel), Nurnberg, 1696	Chinesescher oder Lac-fürnis auf eine andere Art, 21	Yes
Cröker, Jena, 1729	Ein Chinesischer fürnis, 222-223	Yes
Jackson, London, 1749	White varnish or amber-varnish, from a manuscript of Mr. Boyle, 35-36	Yes
Cröker, Nurnberg, 1743	Ein anderer gutter spick oel fürnis, p. 15-16	Yes
Jackson, London, 1749	Varnish in japanning on wood, to mix with several colours, 42	No
Jackson, London, 1749	The white Varnish, 44-45	Yes
Verheijden, Amsterdam, 1794	Een andere maniere om verlakt te maken, 32-33	Yes
Schreck, Eltmann, 1798	Den chinesische lacc zu allerhand farben, f. 9, variant I	Yes
Schreck, Eltmann, 1798	Den chinesische lacc zu allerhand farben, f. 9, variant II	Yes
Schreck, Eltmann, 1798	Den chinesische lacc zu allerhand farben, f. 9, variant III	Yes
Schreck, Eltmann, 1798	Chineser lacc, f. 10-11	Yes
Simonz, unknown, 1805	Van het japans verlakken van metaalen, 78	No
Grebber, Amsterdam, 1840	Barnsteen-vernis, 29-30	No

Finally, a collection of 36 reworked lacquer recipes were studied at the Cologne Institute of Conservation Sciences to study the liquid and cured lacquers.

4.2.2 Construction of the recipe dataset

From past large-scale recipe studies we have learned that these studies mainly used software suitable for the construction of databases, like FileMaker Pro by Minor, or spreadsheet-based software such as Microsoft Excel used by Maria Brunskog in Uppsala in 2018. Both software types are well-suited to collect and organise large quantities of data although a statistical and analytical approach is limited, complicated or not possible due to the software's functionality limitations.

The software's requirements are to collect, organise, analyse, interpret, and present the results in a visual manner. Additionally, we identified three additional workflow and interpretative related requirements: (1)Learning curve: a fast learning curve for using the software was conditional. (2) Flexibility: the software should be capable of exporting the dataset towards a research subjective format and construction without altering the root-dataset (3) Dynamically: furthermore the software needs to allow minor and intermediate changes on the dataset's structure and construction; it should allow adjustments during the workflow of recipe collecting without having negative repercussions on the already gathered data.

IBM's Statistical Package for the Social Sciences software (SPSS® , *Ibm Spss Statistics for Windows*, 25 ed., Armonk, New York: IBM Corp, 2018) was considered as most suitable for this task. Hence, SPSS allows variables and values to be created and changed throughout the course of recipe collecting without significant implications for the already existing dataset. For the sake of clear visualisation of the statistical data the data is visualised using other software packages compatible with the data format or export-formats of SPSS and Microsoft Office Excel files: JMP Pro 14 (*Jmp Pro® for Windows*, 14 ed. (Cary, North Carolina: SAS Institute Inc, 2018), Matlab 2018a (*Matlab for Windows*, R2018a ed. Natick, Massachusetts: The Mathworks inc, 2018), and Python programming language (*The Python Language Reference*, 2.7 ed.).

The dataset, called Recipe Dataset (RD), is constructed to contain sources and recipes' contextual information for each recipe. Hence, the RD is the essential linkage to trace the recipe's data to its original historical source and text.

Parsing the written recipe's text towards dataset's variables implies that large parts of the written text are to be omitted. Therefore, the linkage between the dataset's recipe entry and its original historical source is paramount. It allows the user to trace back each recipe from the dataset towards its respective source and hence, its broader art technical and historical context.

Each entry of a recipe receives a unique reference number or so-called reference database identification number (Recipe ID). By this ID the complete entry of a recipe can be found within the database. The variables fit into four main context-related groups:

(1) Source context: links the recipe towards its source and its source's contextual information;

(2) Recipe's context: provides general information on the intended use of the recipes and its unique features for use;

(3) Recipe's formulation context: contains information about the composition of the recipe;

(4) Recipe's production context: information about the distinct stages of the making process.

All four context groups are subdivided into various categories. What follows is a list of the selected variables. The choice is for some self-explanatory, while others will be motivated in detail. A schematic overview of the relationship between the context-related groups and their respective variables is shown in Figure 4.

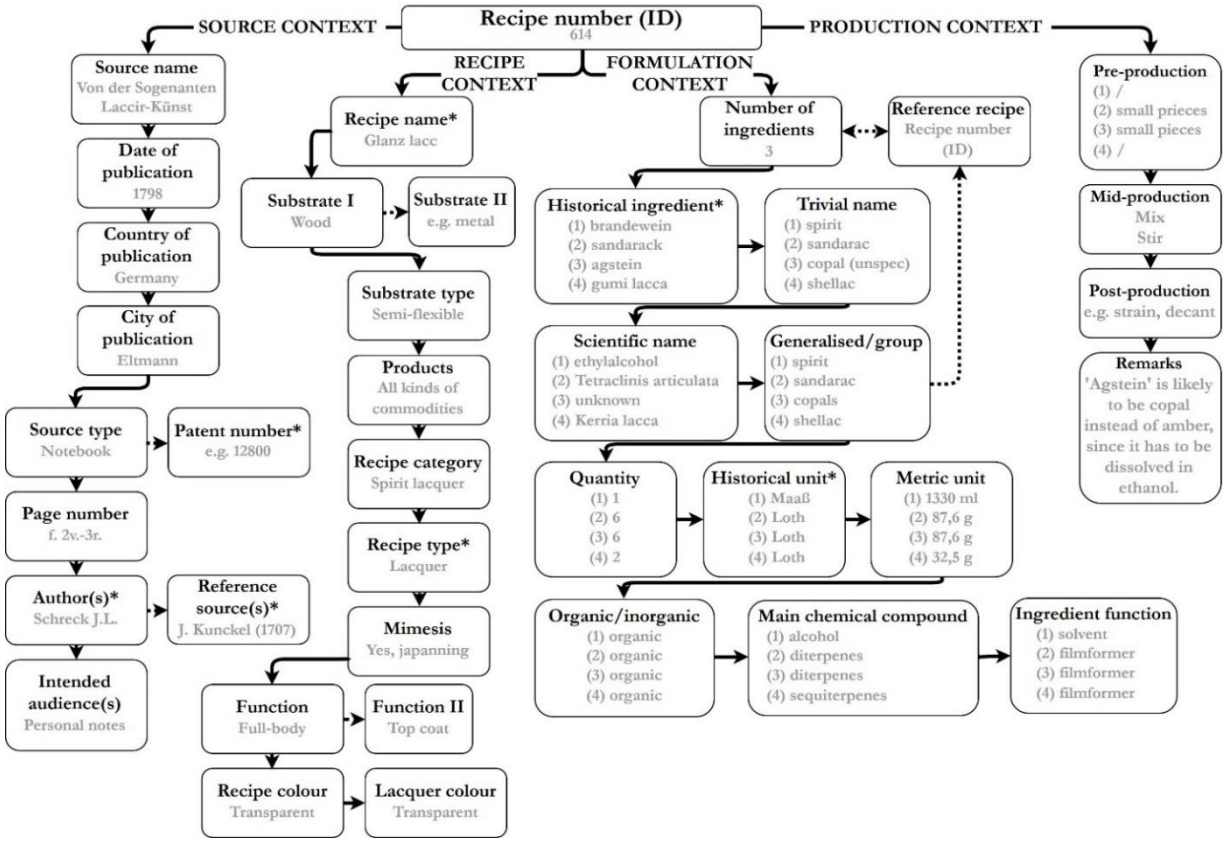


Figure 4. Diagram of the four context groups, their respective variables and example values.

4.2.3 Statistical approach

- **Descriptive statistics**

The general overview is presented by means descriptive statistics. Descriptive statistics quantitatively summarise the data and provide preliminary insights into the features of the recipes, among others the frequencies and distributions in relation to the time and region of publication, the recipe categories, colours, and ingredient numbers. These summative measures are visualised by bar-graphs and box-plots. The results and observations are discussed and contextualised by case-studies from this study, other scholarly research, and historical art technical evidence.

- **Hierarchical clustering**

Hierarchical cluster analysis is a method that searches for relationships in a given dataset based on the similarity and diversity within the data. For preparing the data for the hierarchical cluster analysis, the recipe registration dataset is transformed into a binary recipe-ingredient dataset or matrix. For the analysis, the ingredient-variable with a medium level of accuracy is used to create the binary recipe-ingredient matrix. Ingredients valued as 'unknowns' are excluded from the analysis as this value represents an undetermined ingredient.

In the binary recipe-ingredient matrix, each row represents an individual recipe, and each column represents an individual ingredient. For each recipe, the ingredients receive a binary number according to their presence ('1') or absence ('0') in the recipe (Figure). The result is a sparse binary matrix of 850 lacquer recipes featuring 111 ingredients (850x111). 3747 cells are valued '1', and 91030 cells are valued '0'. Consequently, the filling percentage is 4,06 %. For calculating the similarity between the recipes, the Jaccard similarity algorithm is used.

Recipe n°	Ingredients
2	Spirit
2	Mastic
2	Sandarac
3	Linseed oil
3	Rosin
3	Amber
4	Spirit
4	Sandarac
4	Rosin
4	Anime

Recipe n°	Spirit	Mastic	Sandarac	Linseed Oil	Rosin	Amber	Anime
2	1	1	1	0	0	0	0
3	0	0	0	1	1	1	0
4	1	0	1	0	1	0	1

Figure 6. Transformation of the recipe dataset towards a binary recipe-dataset. Left are the ingredients per recipe enlisted in a column. Right, the transformed binary dataset, where each row represents a recipe and the columns all registered ingredients within the dataset. Ingredients marked by '1' are part of the recipe, whereas '0' indicates the absence of that particular ingredient.

Figure 5 shows the process of hierarchical clustering and starts with all recipes attributed to one single cluster, so-called agglomerative clustering (upper left corner). Then the algorithm calculates the similarity – or proximity – between the individual recipes by a numerical range from 0,000 (no ingredients in common) to 1,000 (compositionally identical). This results in a proximity matrix showing the calculated similarity for all individual recipes (Figure 8. Example of a similarity matrix based on the example given above. Note the expression of similarity ranging from 0 to 1.). Based on the proximity matrix, the relationship between the recipes can be visualised in clusters by a dendrogram (Figure 6), where identical recipes are grouped close to one another in a single cluster (Figure 6, recipes 1-2 and 5-6). Compositionally different recipes will be clustered separately (Figure 6, cluster 1-2 and 5-6); or will be attached to other clusters if they are similar to the recipe but not identical. In the latter case, these recipes compositionally share for example some of the ingredients with the adjacent cluster (Figure 6, cluster 3-4 attached to 5-6). For the hierarchical cluster analysis all 850 recipes are included. The results will be discussed by the number of identified unique and identical recipes within the dataset; whereas the 'proof of concept' of finding relationships between sources is presented by two case-studies.

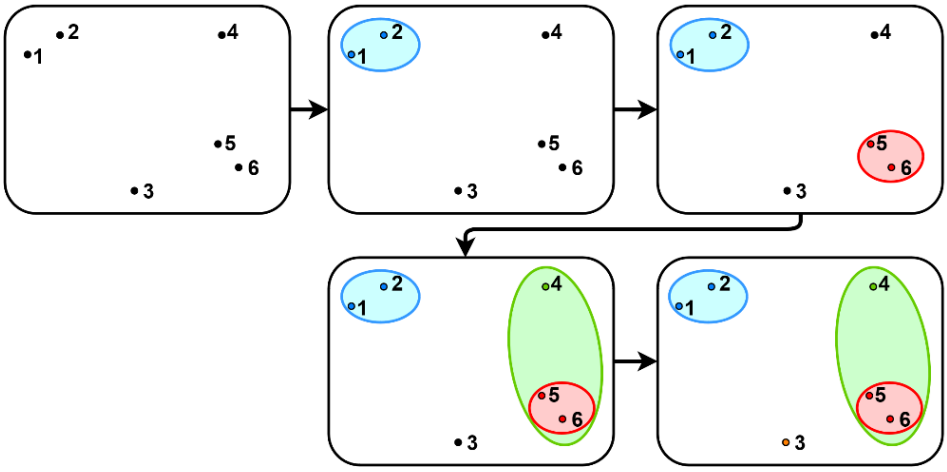


Figure 5. Schematic representation of the process of agglomerative hierarchical clustering. Each numbered dot represents a single recipe.

Recipes	1	2	3	4	5	6
1	1,000	1,000	0,025	0,000	0,000	0,000
2	1,000	1,000	0,025	0,000	0,000	0,000
3	0,025	0,025	1,000	0,025	0,025	0,025
4	0,000	0,000	0,025	1,000	0,750	0,750
5	0,000	0,000	0,025	0,750	1,000	1,000
6	0,000	0,000	0,025	0,750	1,000	1,000

Figure 8. Example of a similarity matrix based on the example given above. Note the expression of similarity ranging from 0 to 1.

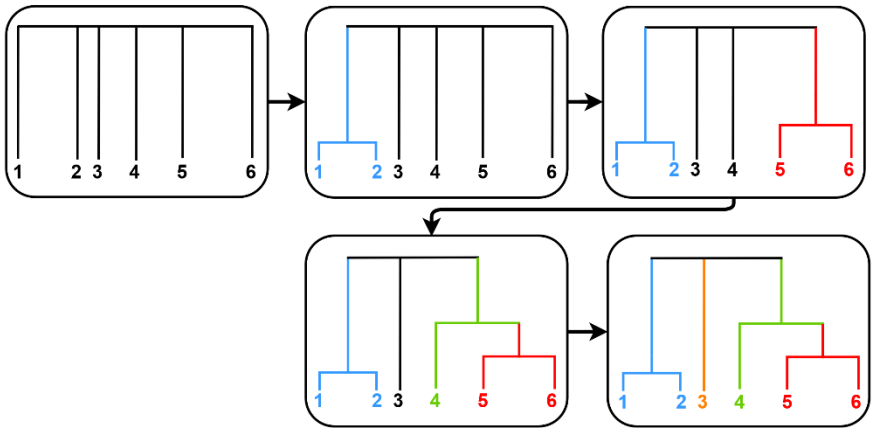


Figure 6. Schematic representation of the hierarchical clustering process visualised by dendrograms following the similarity matrix in Figure 8. Example of a similarity matrix based on the example given above. Note the expression of similarity ranging from 0 to 1..

- **Principal Component Analysis**

In order to determine the relationship between the different ingredients, the dimensional-reduction technique of principal component analysis (PCA) is apprehended on the recipes' data. PCA is a statistical procedure that reduces a large multi-variate dataset of possibly correlated variables into a smaller set of variables, or the so-called principal components (PC). It is a particularly useful technique that aims to discern noise or meaningless information from meaningful information within a large

dataset. The different PCA's will be compared to one another until no further meaningful information can be obtained.

On a practical level, the multi-dimensional recipe dataset will be dimensionally reduced so that this technique will highlight the ingredients that are correlated and uncorrelated to one another within recipe compositions. Hence, PCA reduces the dimensions by discerning the most meaningful ingredients – the principal components – from those that have little to no meaning (noise) within the recipes' compositions while retaining as much information from the initial multi-dimensional dataset as possible. Discerning the meaningful from the meaningless information is computed by the variance between the ingredients. This results in a biplot showing all variables in their relative position to one another. From their relative position, one can distinct positive-correlated, uncorrelated and negative-correlated variables.

Positive-correlated variables are located close to one another and are oriented in the same direction from the centre. Negatively correlated variables are oriented in the opposite direction from one another. In turn, uncorrelated variables are found themselves under an angle of 90°. Two positive-correlated variables, or ingredients, meaning that if one ingredient is present or increases in quantity, the other ingredient is likely to be present or will also increase in quantity with the other ingredient in the lacquer composition. Contrary, negative correlated variables demonstrate an inverse relationship; if one ingredient is present in a lacquer recipe, then the negative-correlated ingredient is likely to be absent. Uncorrelated ingredients are indifferent to one another.

Take for example, the biplot in Figure 7. We notice that the ingredients sandarac and mastic are grouped under a relatively small angle and pointing in the same direction. Hence, both variables are correlated to one another, meaning that if sandarac is present in a recipe composition, it is likely that mastic is also present. Likewise, for the ingredients gamboge and shellac. On the other hand, since the angle between mastic and shellac is circa 90°, these two are uncorrelated. Spirit and linseed oil are negatively correlated since these are placed opposed to one another from the centre. This means that if linseed is present in a recipe composition, spirit will not be present. A similar conclusion can be drawn from mastic and storax.

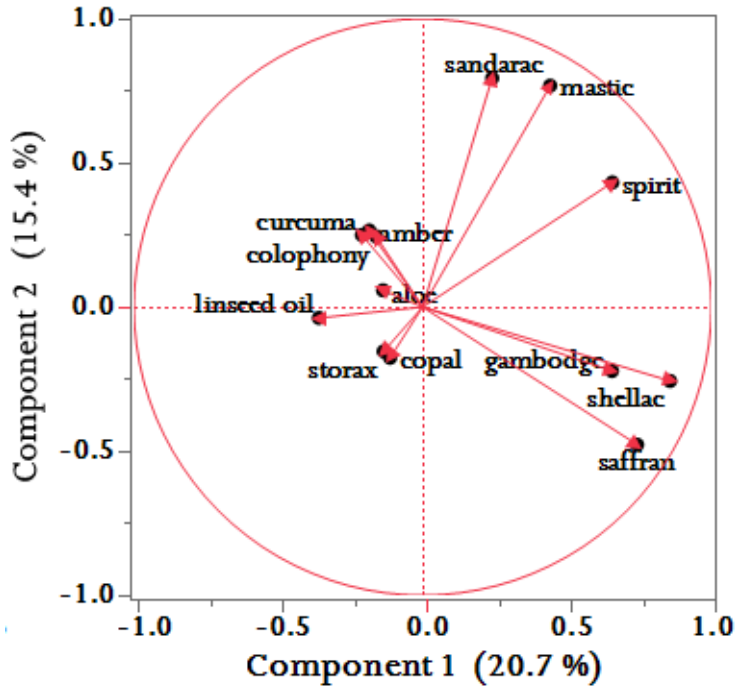


Figure 7. Example of a PCA-biplot. On the Y and X-axis, the explained variance is mentioned in percentages for each principal component.

Since binary numbers (0 and 1) have no variance in between the cases, the variances needed for PCA cannot be obtained from a binary recipe-ingredient dataset, like the one used for hierarchical cluster analysis. Instead, this technique requires a more rigorous data-preparation.

First, the recipe registration dataset is transformed towards a recipe-ingredient-quantity dataset. In this transformed dataset, each row represents an individual recipe, and each column represents an individual ingredient with for each its respective quantity in the recipe. All the historical volumetric and weight data are converted towards the metric system. This is a complex task since historical units are time and region dependent. However, a rough estimate is sufficient because the quantitative data is normalised and mean-centred. Most important is that the ratio's between pound and ounce, or pint and gallon are the same(Cardarelli, 2003; Doursther, 1840; Watson, 1910). Also, all values for the historical units that express certain uncertainties are discarded, such as the values 'unknown', 'unspecified', or ratio-related quantities such as 'parts' or 'fingers'. Next, all ingredients are checked for their total frequency within the dataset. Ingredients occurring less than five times are deleted. Finally, all the recipes are probed to examine whether they contain at least one ingredient after the removal of the ingredients. Recipes with zero ingredients are removed from the dataset.

The data-cleaning has an impact on the dataset. After cleaning, 678 recipes of the 850 recipes remain. From the initial 111 different ingredients, 37 remain. This means that 74 ingredients occur less than five times in all 850 recipes (Table IV). In the next paragraphs, the PCA for all remaining 678 recipes will be explored.

Table IV. Differences in number of ingredients and recipe categories in the dataset before and after cleaning.

Recipe category	Before cleaning	After data-cleaning	Difference
Number of ingredients	111	37	-74
Spirit-based	514	417	-97
Essential-oil-based	157	127	-30
Oil-based	152	112	-40
Resin-based	26	22	-4
Protein-based	1	0	-1

4.3 Partner 3 (RMAH)

4.3.1 Research on the objects in the collection of the RMAH

The art-historical research on the objects from the collection of the RMAH started with an inventory of the lacquered items and gathering of the existing published documentation. Research in the archives of the RMAH and on the context of the production of the objects was made. For many objects, material of comparison was needed what meant travels in Belgium and abroad. Museums in Spa and Liège were visited: *Musées de la Ville d'eaux* in Spa, *Ansembourg Museum*, *Grand Curtius Museum* and *Museum of the Walloon Life in Liege*. Several journeys to Munster were organized in order to visit the *Museum of lacquer Art* and to discuss with Monika Kopplin, director at that time of the museum and the greatest specialist on European lacquer in Europe. Study travels also led us to the *Musée des arts décoratifs* in Paris, to the *V&A* in London, and to the museum *Au fil du papier* in Pont à Mousson. These institutions keep interesting collections of *Bois de Spa* and/or English and French lacquered *papier-maché* of the 19th century. The journey in Pont-à-Mousson was also the occasion to accumulate comparative material for the small stamp boxes and letter cases of our corpus (POST-1761, POST-1767, POST-1779) which were produced certainly by the firm *Adt* and more specifically by the branch established in Pont-à-Mousson in 1871. Private collections of *bois de Spa* were also considered: the private collection of the Canoy family and the one of Barbara and Walter Piert-Borgers in Cologne.

The research on the objects of the RMAH was complicated by the fact that it concerned many different types of artefacts coming from different periods. It was thus difficult to deal with such a large and heterogeneous catalogue and at the same time to be able to arrive to significative results. Therefore, related objects in other collections were taken in consideration.

A systematic photographic campaign by the photographers of the RMAH was undertaken in order to document all the inventoried lacquered objects of the museum. Images under UV-light were taken by the KIK-IRPA in the RMAH. For the UV documentation, only the items selected for the research by the ELinC team were considered.

4.3.2 *Bois de Spa* (Spa wood)

By the end of the 17th century and the second quarter of the 18th century, the production of lacquer in Spa extended to all sorts of attractive fancy goods and small pieces of furniture: writing cases, mirror frames, snuff-boxes, powder boxes, tables, cabinets, Quadrille boxes, cases, dressings cases with fittings, caddies for tea, etc. Since boxes are preserved in larger quantity and are easier to compare to one another than to other more disparate objects, the decision was made to study mainly boxes. Additionally, a microscope with a base of tortoise imitation lacquer and eastern inspired motives was also studied. Thirty-two objects, mainly conserved in Belgian public museums, but also in London,

Munster and Paris, and in two private collections were examined. Seventeen of the objects were chemically analysed.

The historical context and the knowledge of names related to *bois de Spa* is based mainly on archival documents. The documents consulted by historians, mainly Albin Body, included the parish registers of births, notarial deeds, and the registers of the successive mayors listing purchases of gifts for the influential people they wanted to please. Printed texts describing the benefits of the waters and the enjoyment of life in Spa, such as the *Amusemens des eaux de Spa* of 1734 and 1735, generally attributed to Karl Ludwig von Pöllnitz (1692–1775), also offer valuable information on the production of *bois de Spa* (Anon. 1734 and Anon. 1735). For this research a re-evaluation and a study of the here cited primary sources were undertaken, which enabled us to gather new information on varnish makers active in Spa, some of whom were still unknown in the literature.

For the technical, stylistic and iconographical study of the boxes, the precise identification of the sources of inspiration for the chinoiserie decorations was another important objective of the study for the RMAH.

4.3.3 Lacquer in Brussels in the 19th century

For the investigation on the history of taste, production and trade in Brussels in the 19th century, research was carried out mainly with archival and printed sources. Most of the information on the production and taste for lacquers in Brussels was found in the local and national daily press. Other publications like almanacs were also carefully studied, as well as the catalogues on the exhibitions of industrial products and the catalogues of the Universal Exhibitions.

The following newspapers were analyzed at the Press department in the Royal Library of Brussels.
1) L'Indépendant/L'Indépendance Belge (from 1831)
2) Le Globe (1841-1851, with missing years)
3) Le Journal de Bruxelles (from 1841)
4) Journal de la Belgique (1814-183)
5) Le Belge. Ami du Roi et de la Patrie (1825-1847)
6) L"Émancipation (à partir de 1830)
7) Le Libéral (1833-1836)
8) L"Observateur belge (1835-1863)
9) Le Patriote Belge, followed by the Débat Social (1840-1849)

The digitalized newspapers were first consulted. The non-digitalized newspapers were analyzed only for specific years.

Archives of the city of Brussels

For the study of makers and merchants, it was necessary to investigate the archives of the city of Brussels. Were consulted: the "*Registres des patentables*", the iconographical collection of post cards and other illustrated documents, the population ledgers and the "*Bulletins communaux de la ville de Bruxelles*". The study of cadastral surveys and old maps of the city of Brussels was also undertaken in order to better understand the places and districts encountered in the study.

General Archives of the Kingdom (AGR)

The archives of the justice of the peace (*Justice de paix, Vrederechter*) were consulted. The ledgers were however very arduous to analyse. Moreover, the inventories after decease gave lists of furniture in which numerous pieces of painted commodes were mentioned but without any detailed information. We decided therefore to limit the analysis of the ledgers on the key years of the research. The aim was

to try to find information on the probable bankruptcy of Madame Ghiesbreght who is no more registered as a merchant from 1848. Her taxes had been doubled in 1847 what would partly explain the supposed bankruptcy.

According to a responsible of the AGR, they are no archives of the commercial court for the years we were studying.

Archives of the Royal Palace

In the 1830és and1840's the royal family won some lacquered objects at lotteries organized for the exhibitions of the products of the industry and also for charity sales. No trace of these winning lots has been found in the inventories of the royal family. The pieces of furniture and objects were probably offered to the royal or even to the personal entourage.

Catalogues of private sales, RMAH

The Royal Museums of Art and History have an interesting collection of catalogues of private sales in the 19th century that were analysed.

Travelling guides

Traveling guides susceptible to give useful information were systematically consulted. Main references on 19th century European furniture of the years 1830 to 1860 were consulted. According to the results of the archive and newspaper research some question had to be resolved such as the localisation of some works of art, identification of mentioned clients, consultation of specific printed books as the Album des arts utiles et amusants, available in very few European libraries (in Paris, Lyon and London only).

Research was also carried out on the production of lacquered furniture with mother of pearl incrustation in France. This field was very little explored and could give useful information on the background of the production of lacquered items in Brussels that tend to follow the Parisian fashion. Many printed documents available online on the website of the Bibliothèque nationale de France were successfully consulted.

The list of the patents deposited in Brussels were regularly published in the *Bulletin du Musée de l'Industrie* between 1842 and 1883. In this bulletin, that was fully analyzed, small articles on the latest progress of the industry and a review of the European journals on scientific advances related to the development of industry were also published. When considered as probably relevant, the original patents were asked to the National Archives of the State (Cuveliers center in Brussels) and consulted.

5 SCIENTIFIC RESULTS AND RECOMMENDATIONS

5.1 Chemistry of lacquer: Results (Partner 1)

5.1.1 Resins

The analytical results of the quality control of lacquer ingredients, mainly resins, show that a significant number of the commercial resins were impure or incorrectly labelled (table V). 4 were impure (larch, benzoin, copaiba balsam, African elemi), two others possibly impure (Congo copal and Strasbourg turpentine). 15 deviated significantly from the reference material in such a way that they were thought to be incorrectly labelled, including 1 Manila copal, 1 mastic and 13 sandarac samples. However trusted material, also three reference samples were found to be presumably contaminated (one copaiba balsam, one Manila copal and one sandarac).

Table V: Analysis results of commercially available resins. *modern sandarac samples deviated from references. They are discussed as sandarac type 2 below.**Gum tragacanth analysed by Joy Masurek (GCI) with GC/MS. °samples selected for artificial ageing.

Ref.	*Name*	
BLK0001°	Gum tragacanth - *Astragalus gummifer***	accepted
BLK0002°	Larch turpentine	accepted
BLK0003	Amber pieces	accepted
BLK0004°	Manila copal - *Agathis alba*	accepted
BLK0005°	*Picea excelsa* gum - *Picea abies*	accepted
BLK0006	Spike-lavender Oil - *Lavendula spica*	accepted
BLK0007°	Shellac - *Laccifer lacca*	accepted
BLK0008°	Colophony extra light - *Pinus sp.*	accepted
BLK0009°	*Abies alba* resin	accepted
BLK0010	Benzoin - *Styrax benzoin*	accepted
BLK0011	Copaiba balsam - *Copaifera sp.*	impure
BLK0012°	Mastic - *Pistacia lentiscus*	accepted
BLK0013°	Gamboge pieces - *Garcina morella*	accepted
BLK0014°	Elemi - *Canarium luzonicum*	accepted
BLK0015	Camphor powder	accepted
BLK0016	Colophony *Picea abies*	accepted
BLK0017°	Kauri resin	accepted
BLK0018	Tragacanth gum	accepted
BLK0019	Elemi gum	accepted
BLK0020	Copal, Congo black	probably impure
BLK0021	Manila White Copal	incorrectly labelled
BLK0022	Benzoin	impure
BLK0023	Colophony, light	accepted
BLK0024	Sandarac	deviation*
BLK0025	Mastic gum	accepted
BLK0026°	Copaiba Balsam - *Copaifera officinalis*	accepted
BLK0028°	Buttonlac	accepted
BLK0029°	Seedlac	accepted
BLK0030	Venetian turpentine	accepted
BLK0031°	Sticklac	accepted
BLK0032°	Benzoin	accepted
BLK0033	Mastic	incorrectly labelled
BLK0034	*Picae excelsa* (sic)	accepted
BLK0035	Colophony, extra light	accepted
BLK0036	Manila copal	accepted
BLK0038	Frankincense	impure
BLK0039	Linseed oil	accepted
BLK0040°	Tung oil	accepted
BLK0041°	Boiled linseed oil	accepted
BLK0042	Venetian turpentine	impure
BLK0043	Sandarac	deviation*
BLK0044	Strasbourg turpentine	probably impure
BLK0045°	East African copal – 1	accepted
BLK0046	East African copal – 2	accepted
BLK0047	East African copal – 3	accepted
BLK0048°	Sandarac	deviation*
BLK0060	Sandarac	deviation*

BLK0061	Sandarac	deviation*
BLK0062	Sandarac	deviation*
BLK0063	Sandarac	deviation*
BLK0065°	*Hymenaea courbaril* (fresh sample? - Gum animé)	accepted
BLK0066°	Dominican amber (fossil - *Hymenaea courbaril*?)	accepted
BLK0067°	Congo copal 1 (Kinshasa region)	accepted
BLK0068	Congo copal 2 (Kinshasa region)	accepted
BLK0069	Congo copal 3 (Kinshasa region)	accepted
BLK0070°	Madagascar copal	accepted
BLK0072	Sandarac	incorrectly labelled
BLK0073	Sandarac	incorrectly labelled
BLK0074	Sandarac	deviation*
BLK0075	Sandarac	deviation*
BLK0076	Sandarac	incorrectly labelled
BLK0077	Sandarac	incorrectly labelled
BLK0078	Dragon's blood	accepted
BLK0079	Dragon's blood	accepted
BLK0080	Dragon's blood	accepted
BLK0081	Sandarac	deviation*

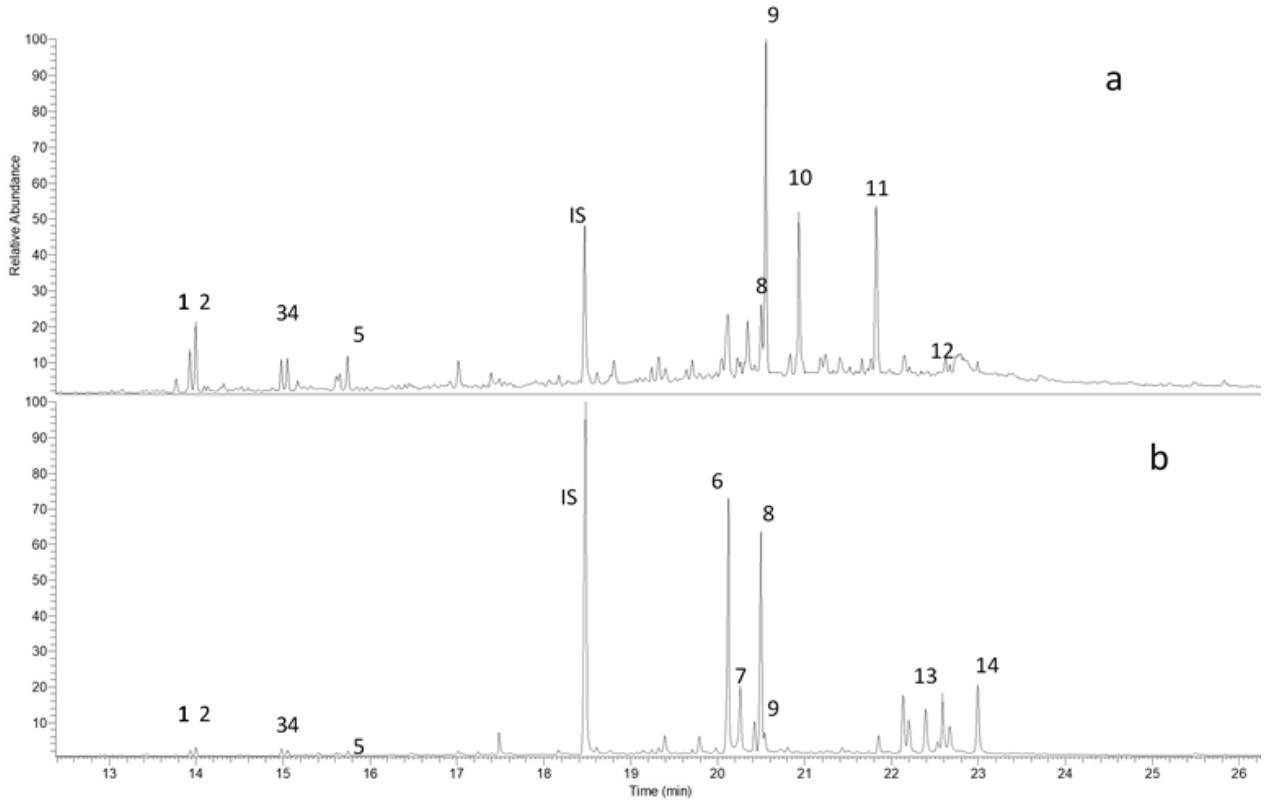


Figure 11. THM-GC/MS chromatogram of one reference sandarac above (historic sample REF0236, collection Botanic Garden Meise) and one commercially available sandarac below (BLK0075), with peaks identified. (1-5) polycommunic acid pyrolysates (van den Berg, van der Horst, and Boon 1999; Scalarone, Lazzari, and Chiantore 2003; van Keulen 2015; van den Berg, Ossebaar, and van Keulen 2002), (IS) heptadecanoic acid methyl ester internal standard, (6) Methyl 3-methyl-(5,5,8a-trimethyl-2-methylene-decahydro-naphthalen-1-yl)-3-methyl-pent-2-enoate (?) (Scalarone, Lazzari, and Chiantore 2003), (7) cis-communate (Chiavari, Montalbani, and Otero 2008;

Steigenberger 2013, 80–88; Scalarone, Lazzari, and Chiantore 2003), (8) trans-communate (Chiavari, Montalbani, and Otero 2008; Steigenberger 2013, 80–88; Scalarone, Lazzari, and Chiantore 2003)[1], (9) sandaracopimaric acid (Chiavari, Montalbani, and Otero 2008; Steigenberger 2013, 80–88; Scalarone, Lazzari, and Chiantore 2003; van Keulen 2015)1, (10) isopimarate (Scalarone, Lazzari, and Chiantore 2003; Steigenberger 2013, 80–88)1, (11) hydroxysandaracopimarate (van Keulen 2015; Steigenberger 2013, 80–88)1 , (12) 12-acetoxy-sandaracopimaric acid, (Steigenberger 2013, 80–88; van Keulen 2015), (13) dimethyl agathate (Scalarone, Lazzari, and Chiantore 2003), (14) methyl 19-norlabda-8(20),13-trien-15oate (Scalarone, Lazzari, and Chiantore 2003).

Sandarac proved to be problematic. 14 samples were analysed: two of them proved not a resin, one was identified as dammar, and one as pine resin; the ten others were all identical in composition. Although quite similar to the reference sandaracs, they showed some important differences.

Sandarac reference material was collected from different institutions and collections, including RCE (1), Vigani cabinet research (1), Doerner institute (1), Royal Museum for Middle Africa (1), KIK-IRPA (1), Botanical Garden Meise (5 in total: 2 Van Heurck collection, 1 Delacre collection , 1 Martius collection and 1 freshly harvested sample). These ten reference samples were harvested in different periods, from the 18th century to very recent. The THM-GC/MS analyses gave a coherent image of marker compounds present in sandarac. The only significant difference between the chromatograms of the genuine sandarac references was the relative proportions of the compounds detected. Characteristic is the detection of polycommunic acid pyrolysates, ferruginol methyl ester, communic acid methyl ester, sandaracopimaric acid methyl ester, methyl isopimarate, 12-acetoxy-sandaracopimaric acid methyl ester, hydroxysandaracopimaric acid methyl ester (Fig. 11), characteristic of sandarac type 1. This observation confirms earlier published research (Koller et al., 1997; Mills and White, 1977; Romero-Noguera et al., 2014; Steigenberger, 2013, pp. 80–88; van den Berg et al., 1999; van Keulen, 2015).

The nine sandarac resins of type 2 bought on today's commercial market, all show a similar chromatogram. Polycommunic acid pyrolysis markers were detected, as well as methylated forms of sandaracopimaric acid, and trans-communic acid. However, hydroxy-sandaracopimaric acid methyl ester, isopimarate and 12-acetoxy sandaracopimarate were not found. Instead, some molecules absent in the references were detected in the analysis of all powder samples, as well as in a methanol extract. These supplementary peaks have been tentatively identified in literature as methyl esters of C13 and C19 oxygenated labdane acids such as agathic, agatholic, agathalic and cupressic acids, or their isomers (Chiavari et al., 2008; Scalarone et al., 2003; Steigenberger, 2013, pp. 80–88). These molecules have been described as markers for true sandarac (Chiavari et al., 2008; Scalarone et al., 2003), but they are not reported in any reference sample yet (Steigenberger, 2013, p. 88).

Taking into account that the one sandarac reference was harvested recently, an explanation of differences in aging is unlikely. One of sandarac's main constituents, communic acid, tends to polymerize to polycommunic acid (Mills and White, 1977), attributing to the solidity of the matrix. The other constituents mainly include pimaranes, known to be resistent to degradation as well as polycommunic acid (Steigenberger, 2013, p. 17). Moreover, published research as well as own tests with type 2 sandarac show that the analysis results do not shift towards reference material analyses after artificial aging (Scalarone et al., 2003). Although it cannot be excluded, a difference in harvesting of the resins is also not likely. *Tetraclinis articulata* (Vahl) Mast. only produces resin after inducing its production by injury. Less variety in constitution is expected in this type of resin production

[1] Also confirmed by NIST Mass spectral search Program for the NIST/EPA/NIH Mass spectral Library

(Langenheim, 2003, p. 31). It is possible that some pre-processing happens, or that sandarac is currently produced by another plant (sub)species than historically.

In the family of *Cupressaceae*, several resin producing species exist. Most known is *Tetraclinis articulata* (Vahl) Mast., producing 'true sandarac', but also the genera *Cupressus*, *Juniperus* and *Callitris* include resin producing species (Langenheim, 2003; Mills and White, 1977; Steigenberger, 2013, p. 17). Several *Callitris* and *Juniperus* reference species have been examined during this study, but a match with the sandarac type 2 was not found. However, similarities have been observed with Manila copal (Chiavari et al., 2008; Scalarone et al., 2003). Members of the genus *Agathis* (*Araucariaceae*) are therefore also a possibility as source of this sandarac type 2.

This topic was one of the first results of the ELinC project. During conferences a strong interest in this awareness of labeling issues, especially by a number of furniture restorers, was noticed. They were concerned on the impact of these findings on their work. These results were also presented at InArt in 2016 and on a poster, at the Society for the Preservation of Natural History Collections (SPNHC), Berlin, 2016.

5.1.2 Method optimization

- **Pyrolysis temperature**

The optimal pyrolysis temperature is the compromise between detection of compounds released at low temperatures and compounds formed at high temperatures. 650°C is too high for both types of compounds, 350°C is best for the first, and 550°C for the second. Fixed temperatures of 480°C or UFD proved to be a consensus in order to detect most marker molecules. UFD was slightly better for the molecules released at low temperatures, while 480°C showed best compounds formed at high temperatures (Fig. 12).

The experiment illustrates the important influence of thermochemolysis temperature on the integrated signal of several resin markers (Table VI). The optimal temperature depends on the molecules of interest. However, fixed temperatures of 550 and 650°C are not ideal as consensus temperature to detect most markers. 350°C could be considered, but a fixed temperature of 480°C or UFD gives best results in detecting the whole series of marker molecules. Temperature optimisation was only performed on resins, not on mixtures or aged lacquer. Indeed, due to more complex interaction with other resins, pigments, oils and gums, responses of the markers to the different thermochemolysis temperatures may change. Some analyses of real-object samples of European lacquer pyrolysed at a temperature of 480°C and with UFD confirm successful analysis.

Table VI. Overview of resin samples used and the markers selected of each. Retention index (completed with published values by van Keulen) and retention time are given, as well as main fragment ions.

Resin (current plant name)	**Marker number**	**Markers**	**Retention Index (retention time)**	**Retention Index** (van Keulen, 2015)	**Characteristic EI fragment ions (m/z)**
Sandarac (*Tetraclinis articulata* (Vahl) Mast.)	1	Poly communic marker b1	1601 (14.52)	1614	161-177-236
	2	Poly communic marker b4		1774	173-188-248
	3	Ferruginol methoxy	1758 (16.29)	2246	189-285-300
	4	Trans-communic acid methyl ester		-	105-121-241-316
	5		2239 (20.93)	2300	121-181-257-316
	6	Sandaracopimaric acid methyl ester		2414	121-346
	7		2257	2507	121-299-314

		Methyl-hydroxy sandaracopimaric acid Sandaracopimaric acid, 12 acetoxy	(21.09) 2265 (21.15) 2413 (22.45) 2511 (23.3)		
Mastic (*Pistacia lentiscus* L.)	8 9 10 11	Mastic compound 5 Mastic component Moronic acid ME Oleanolic acid ME	- (32.04) - (32.27) - (32.96) - (33.17)	- - 3505 3588	219 203-219-262 189-249-468 203-262-468
Colophony (*Pinus taeda* L.)	12 13 14 15 16	Pimaric acid ME Isopimaric acid ME Abietic acid ME Tetradehydroabietic acid 7 methoxy ME Methyl 12-methoxyabieta8,11,13-trien-20oate	2244 (20.97) 2307 (21.53) 2397 (22.31) 2451 (22.79) 2488 (23.13)	- - - - -	121-257-316 241-257-316 241-256-316 227-267-342 269-344
Manila copal (*Agathis dammara* (Lamb.) Rich. & A.Rich.)	17 18 19 20 21 22	Marker 4 Poly communic marker b1 Poly communic marker b4 16.17-bisnordehydroabietic acid ME Agathic acid isomer DME1 Agathic acid isomer DME2	1593 (14.44) 1598 (14.50) 1756 (16.26) 2163 (20.26) 2445 (22.74) 2498 (23.21)	- 1614 1774 - - -	145-160-188-220 161-177-236 173-188-248 211-271 189 121-175-201-288
Congo copal (*Guibourtia demeusei* (Harms) J.Leonard)	23 24 25 26 27	Poly ozic marker C1 Poly ozic marker C2 Copal unknown copalic/entcopalic acid "copal 11"	1637 (14.93) 1733 (16.01) 2141 (20.04) 2315(21.56) 2395 (22.26)	1678 - 2330 -	161-177-236 173-189-248 107-177-305 81-244-303 223-305-318

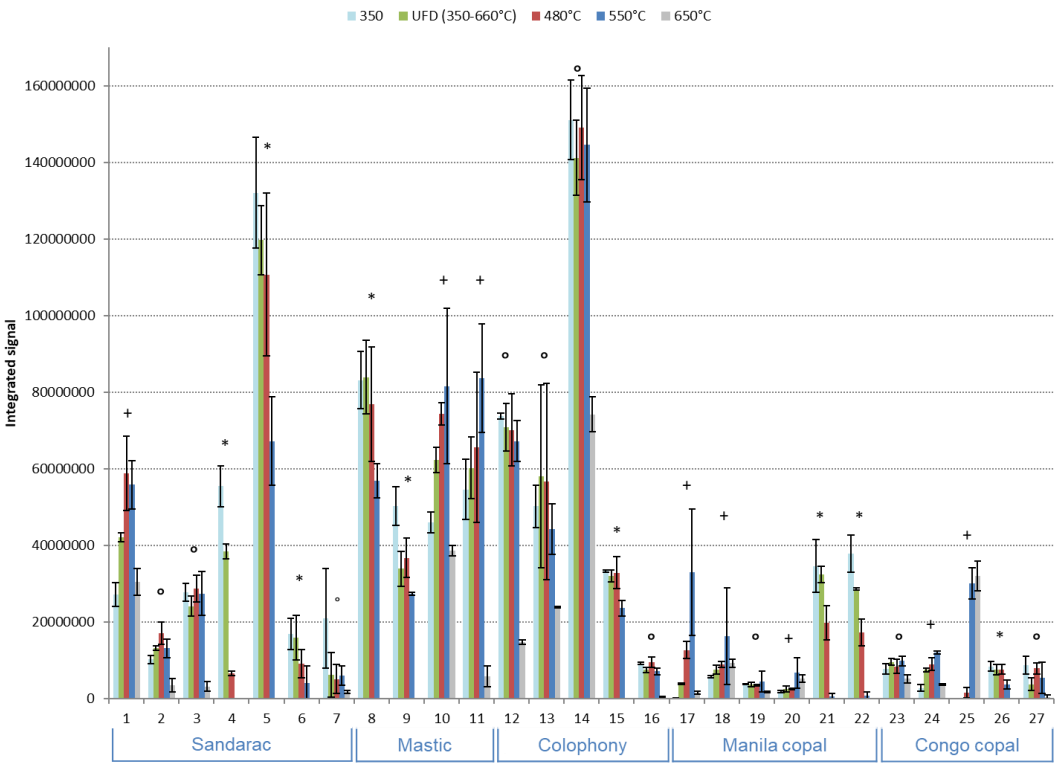


Figure 12. Mean and standard deviation of integrated signal of selected markers for temperature programs 350°C, UFD (350–660°C), 480°C, 550°C and 650°C. *Error flags* of one standard deviation.

Clearly, the optimised temperature is an important result of the chemical part of ELinC. Literature was consulted on temperatures applied elsewhere, and this experiment pinpointed a method afterwards repeated by the Physical Asian lacquer project. The optimized pyrolysis temperature can be used in the analysis of all resinous materials, including painting varnishes.

- **GC temperature programme**

Thermochemolysis was carried out in a Frontier Lab Multi-Shot Pyrolyzer (3030D), in a helium atmosphere, fed with an autoshot sampler AS-1020ET. The interface and the injector of the chromatographic system were kept at 300°C, but the analytical column was directly coupled to the pyrolizer via a custom-made split device (split ratio 20), minimizing dead volume and improving the signal[2]. For the chromatographic separations, a TraceGC gas chromatograph (Thermo), hyphenated with a PolarisQ Ion Trap mass spectrometer (Thermo), was used. Separations were accomplished on a SLB-5ms capillary column (Supelco, 20m x 0.18mm i.d. x 0.18μm film thickness) applying following temperature program: initially the oven temperature was maintained at 35°C for 1 min after pyrolysis. Next, a 10°C/min gradient was applied until 240°C; finally the column was heated to a temperature of 315°C at a rate of 6°C/min; this temperature was maintained during 5 min. Carrier gas was helium at a constant flow of 0.9 mL/min. The MS transfer line temperature was kept at 290°C. Ionization was carried out in the ion volume of the ion trap mass spectrometer under the standard EI positive mode at 70 eV. The scan range was 35-650 amu, with a cycle time of 0.59 s.

[2] Kindly provided by Henk van Keulen, Rijksdienst Cultureel Erfgoed (RCE), Amsterdam, the Netherlands.

The optimised GC temperature programme is now of frequent use in the KIK-IRPA laboratories, for the analysis of varnishes and binder media.

- **Sampling method**

After a RAdICAL workshop, layer by layer sampling was tested and finally frequently used during the ELinC project. For this, micro-chisels (Scope Tools, MTC-200 Circon Stainless steel Chisel, 0.030" cutting edge straight) were purchased in the United States. The powder samples were collected in glass vials, in which during analysis the TMAH solution can be added and mixed. This to avoid contamination and material loss during transfer.

For stratigraphic samples, sampling with different types of hollow needles was tested. This method was satisfactory in laboratory settings, on flat surfaces of lacquer on wood. Best results were obtained with a disposable biopsy punch with inner diameter of 1mm (Kai medical), inserted with the stroke of a hammer on a metal insert. Consequently, the needle was completely embedded in order to make a cross section. However, this method showed some severe downsides when applied on real objects. On some objects, the needle was unable to cut through the complete multi-layered stratigraphy of historical lacquer. This was the case for example in the aventurine lacquer on a sledge, where large copper particles in the lacquer stopped the needle. In the cabinet-secretary we observed that the combination of thick sturdy lacquer with a hard-wooden support resulted in incomplete and highly fragmented or even absent samples. Where sampling was successful, the sample was often compressed. It was difficult to successfully embed and polish such brittle samples in a needle. Although sampling hard materials with a micro-scalpel (as used in sampling of paintings) has its limitations as well, we finally concluded to revert to this method. These samples were stored in plastic sample holders, generally used at KIK-IRPA for samples taken from paintings and polychromies.

Thanks to the ELinC project, layer by layer sampling with a micro-chisel has become an experimented method for the members of the project.

5.1.3 In search of new markers

- **Statistical approach**

A differential expression analysis technology developed for linear modelling of gene expression data was used in combination with thermally assisted hydrolysis and methylation gas chromatography/mass spectrometry (THM-GC/MS) to support the analysis of lacquers and varnishes on historical objects. Exudates from tropical trees, such as Manila copal, sandarac, South American copal, and Congo copal, which were frequently used in finishing layers on decorative objects up to the early 20th century, were compared through this approach (Fig. 13). Highly discriminating features indicate biomarkers that can help to identify copals in resinous lacquers. The approach allows new, more systematic ways for finding biomarkers in the analysis of lacquered objects of art and varnishes.

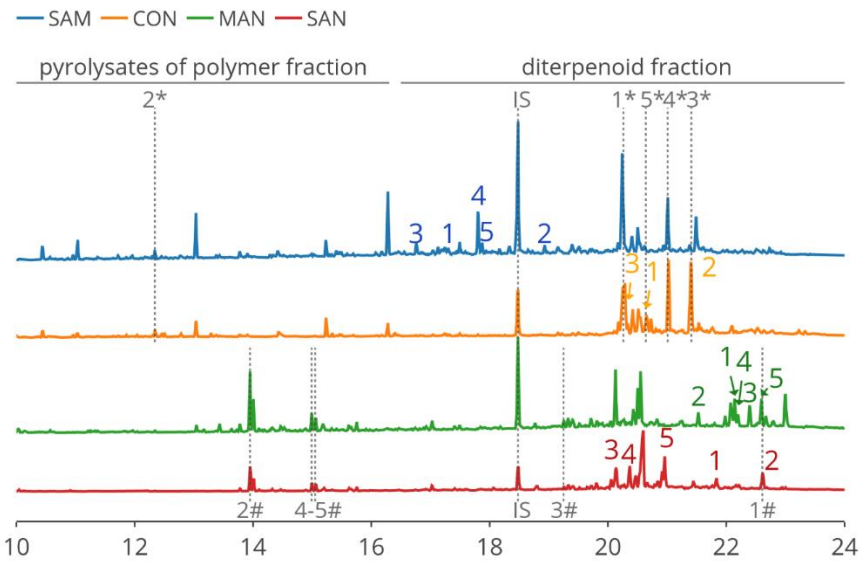


Figure 13. Representative chromatograms from each resin type. The top five features are indicated with numbers for South American copal (SAM, blue), Congo copal (CON, yellow; only three markers were statistically significant), Manila copal (MAN, green), and sandarac (SAN, red), with * for common markers for Congo copal and South American copal (CON, SAM) and # for common markers for sandarac and Manila copal (SAN, MAN).

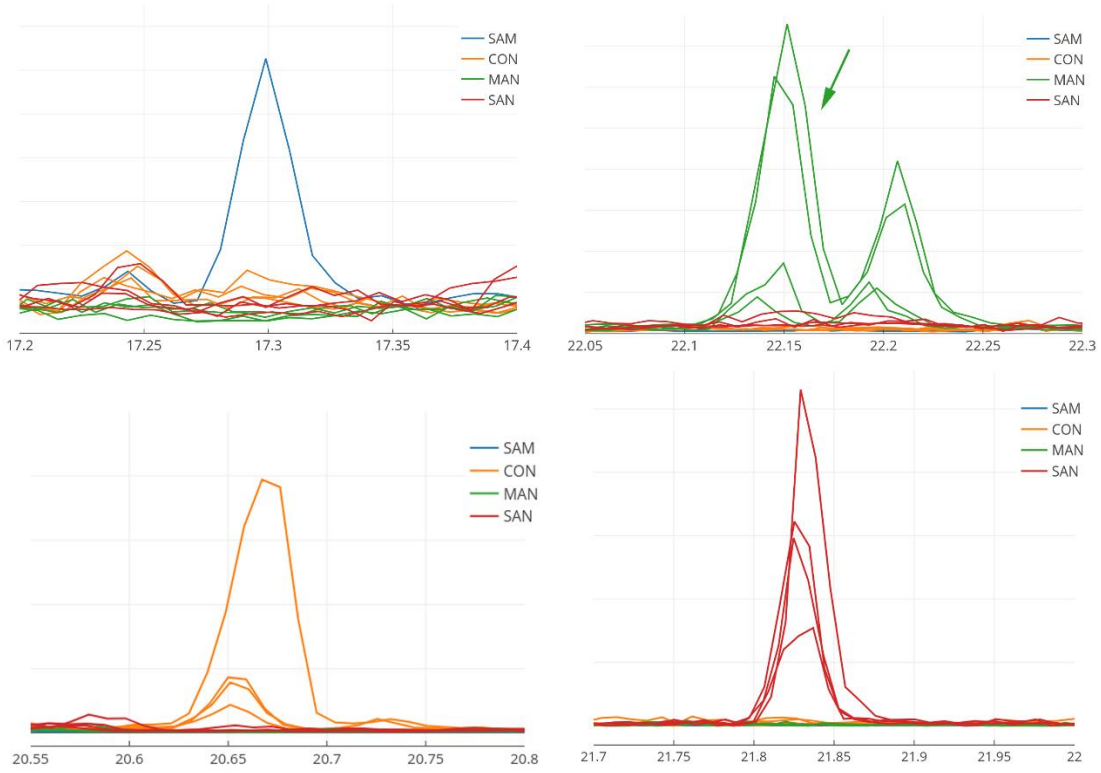


Figure 14. Extracted ion chromatograms (EIC) for most discriminating feature of each resin (SAM1: the best scoring marker to discriminate South American copal from Congo copal, m/z 109 @ 17.30s-RI1904; CON1 the best scoring marker to discriminate Congo copal from South American copal. m/z 189 @21.41s-RI2269; MAN1: the best scoring marker to discriminate Manila copal from sandarac. m/z 287 @ 22.15s-RI2269; SAN1: the best scoring marker to discriminate sandarac from Manila copal, m/z 346 @ 21.8s-RI2409). Repeats not shown. All four EIC illustrate the discriminating power of the listed markers, as only their line graphs show a peak.

As a proof-of-concept, the method to retrieve resin markers in a structural way proves effective, giving priority to markers that are both specific and characteristic for a group of resin samples (Fig. 14). Lists of markers generated this way can be added to libraries to improve the interpretation of complex mixtures. Although the retained features are discriminative and may therefore be applicable for the differentiation of copals, some of them have not yet been structurally elucidated. Doing so will require THM-GC coupled with high-resolution MS and highly challenging preparative pyrolysis GC-MS approaches to allow for advanced structural analysis. This study shows the potential of the combination of THM-GC/MS and bioinformatics in the study of historical coatings on objects of art. The combination of chromatographic feature extraction with differential expression analysis in *limma* is promising; new markers, with a high probability of being discriminating, can be systematically detected with this nontargeted approach. This success opens the door for the systematic search for markers in other cases, such as heat treatment during lacquer preparation, presence of additives, artificial aging, and the discrimination of more groups of copal.

This statistical method of comparing groups of chromatograms has gained a lot of impact in a broad audience of researchers in heritage. This new method comprises an interesting way to compare groups of chromatograms, where big data are systematically explored. This can have applications in many fields. The results were published in a highly rated journal and reached a large public.

- **Marker library compiled of artificially aged ingredients a procedure from chromatogram to an AMDIS marker library**

A new procedure was developed to extract a useful biomarker library from a long series of measurements (Fig. 15). The procedure is based on a few freeware software packages (NIST MS Search, AMDIS and MS PepSearch, Python) and homemade scripts (GCMS-toolbox), and can be summarised in the following steps. 1. *Deconvolution in AMDIS*. After deconvolution, a long list of mass spectra was generated. 2. *Group identical library items*. After conversion to a NIST library, MSPepsearch was used to search within itself for identical mass spectra (MF at least 600). Fine-tuning within the output was executed with a homemade script, in order to group spectra with identical mass spectra and retention index. 3. *Filter to remove unwanted noise peaks*. All markers occurring only once were left out, as well as markers in which the intensity of m/z 207 was at least 90% of highest peak (supposed column bleeding). 4. *Construction of a new AMDIS library*. Each marker is tagged with the name of the ingredient(s) it has been found in, as well as the amount of artificial aging applied. 5. *The final result* is a library of markers that can be used in AMDIS to help interpret chromatograms of historical lacquered (or varnished) objects. Besides a csv file is generated with an overview of biomarkers indicating where they have been found.

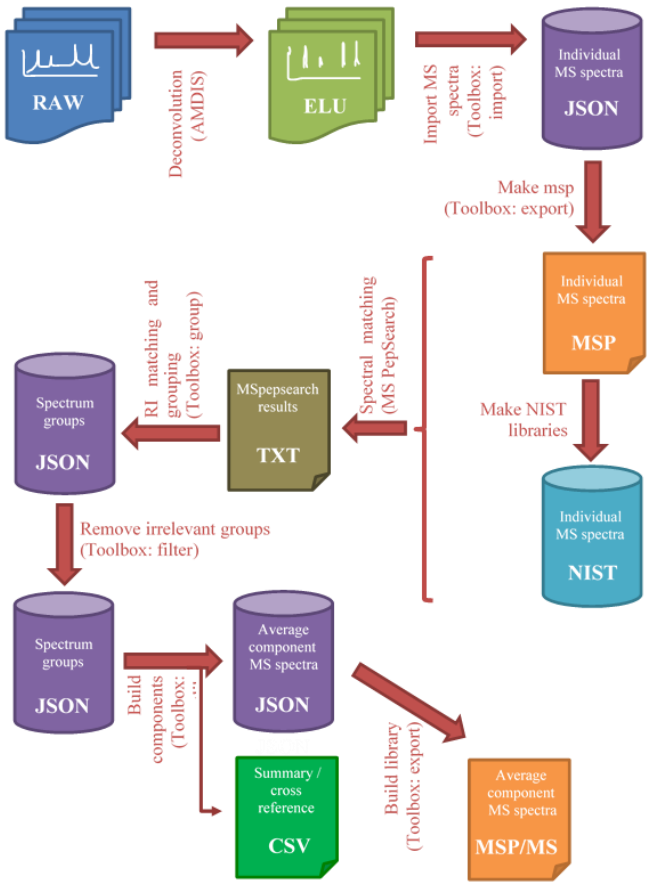


Figure 15. Flow chart of the procedure from chromatograms to AMDIS target library.

The procedure to construct a marker library based on the deconvolution of a large data set of chromatograms of artificially aged ingredients proved highly successful. It is a useful method to find biomarkers in a structured way. The method is distributed among peers, and will be used in similar situations to detect GC/MS-biomarkers.

5.1.4 Chemical analysis of objects

- **Willem Kick** (figure 16)

The objects of Willem Kick are the oldest lacquered objects of the Netherlands that can be attributed to a known lacquerer. These very rare items are situated in 17th century Holland. The ELinC team had the exceptional occasion to study and sample four of them. The sample sizes were minute, and two were rather elaborately restored, making the analysis and interpretation challenging. In accordance with the earlier study of one Kick object in Amsterdam, only limited ingredients could be detected: (heated) *Pinaceae* resin, shellac (in some objects), boiled (?) linseed oil (sometimes minor quantities), and a soot-like pigment, vermillion, possibly camphor, animal glue.

Figure 16. Larger chest by Willem Kick GSL-2016-2. ©Museum für Lackkunst, Munster

- **Sledges** (figure17 and 18)

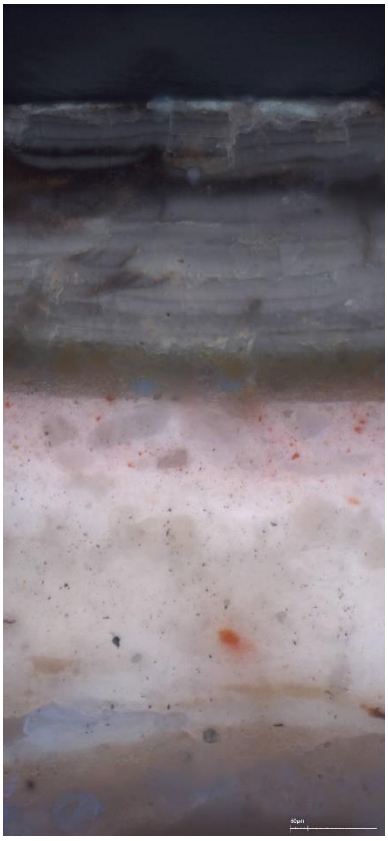


Figure 17. Stratigraphy of the sledge with aventurine decoration TR41, UV image. On top of the green paint numerous varnish layers illustrate the labor-intensive process of aventurine lacquer. @KIK-IRPA

Figure 18. Sledges TR1868, TR88, TR41. @RMAH

To our knowledge, the stratigraphy of lacquered sledges has never been studied in a laboratory context. Three sledges were selected from the RMAH collection (TR41, TR88, TR1868), most suited for the ELinC project. One shows material imitations of tortoise and marble. While this example dates from a later period, these techniques comprised a craft already present in Europe before actual lacquering started, providing a foundation for the new japanning to develop from. Identifying the materials and layers, all still well preserved, gives most interesting reference information for both imitation techniques and lacquering. Ten layers were found, and inorganic components identified, including silver leaf, lead white, beeswax, earth pigment, Prussian blue, lamp black and minium. The binder media were not analysed. A second sledge features a gold chinoiserie decoration on a red background. Its decoration and form perfectly blend eastern influence with European taste and tradition. In this sledge 15 layers were found. Drying oil, a wax and *Pinaceae* resin were detected, as well as Prussian blue, lead white, minium, earth pigments, vermillion and alum used presumably to bare a red lake. It is in appearance a most typical referential sledge whose stratigraphy and composition will facilitate future studies of sledges. The third sledge was selected for its exceptional, labour intensive aventurine decoration. In this technique, small metal particles are sprinkled in multiple layers of transparent varnish, applied on a coloured background. In this sledge, 22 layers were seen, 16 of which original. The green background of Prussian blue, earth, lead-tin yellow type 1 (?), probably verdigris, and Naples yellow was covered with at least seven layers of transparent varnish with copper particles followed with a black overpainting.

- **19th century black English (and English-style) furniture** (figure 18)

Figure 18. Overview of 19th century black lacquerware studied during the ELinC project. @RMAH

For the first time, the objects of this fascinating French-English interaction were subjected to a microscopical and chemical study, in order to compare their build-up with published technological procedures. The synergy of art historical research, archival study on technology and recipes, and laboratory analysis could reveal new insights on this type of objects. A general production method is seen in all papier mâché objects, with papier mâché applied in sheets and a layered lacquer reflecting cyclic stoving of the object. Smaller differences amongst them suggest different workshops and decorators at work. As historically described, the probable use of linseed oil, boiled turpentine, rosin and lamp black was seen in the four pieces in papier mâché of presumably English origin. Lacquer on the slightly later, probably French, wooden chairs is considerably thinner, even when mother of pearl was applied. The lacquer contains copal, oil and *Pinaceae* resin. It would be interesting to compare more objects, preferably of known origin, to better understand how technology in both England and France evolved and how exactly they influenced each other on a technological level. Hence, this study could be a starting point to better understand larger groups of 19th century black lacquered furniture, revealing groups of shared methods, and discerning different regions of production and manufacturers, in England, France and abroad.

Figure 19. Overview of part of the analyzed jolité de Spa; one conserved at RMAH, the others at Musée de la ville d'eaux, Spa @RMAH (Delphine Steyaert)

- ***Bois de Spa*** (figure 19)

One of the most important paint production centers in our region is the village of Spa, where lacquered

jolités were made in the 17th to 20th centuries for the sake of wealthy tourists. A whole group of the Spa objects are stored in the RMAH. Since many of these were decisively affected by restoration, and since the partners of the ELinC project opted for a focus on the earliest period, the study of this subject largely relied on a collection preserved at the *Musée de la ville d'eaux*, Spa. A subset of these was also broadly analysed chemically, by composition of metals, pigments and binders. During this research we found that the heritage sector, conservators, antiques dealers and collectors of these objects have a very high demand for answers in this regard. Many of these boxes discolour and get damaged.

The chemical composition of the lacquer and technology of the construction seems rather stable during the period studied (c. 1689–1770). Generally, the number of materials decreases slightly. In the early Box 1, for example, the analytical results seem to suggest a more elaborate layered stratigraphy and greater diversity in the types of metallic powders and particles, both of which are more time consuming than the techniques of decoration used in later objects. Later items seem to be more limited in the number of layers. Most variability, however, seems rather to occur in the colour of the box. While most lacquers consist of spirit varnishes based on sandarac, *Pinaceae* sp. resin, and shellac, with possibly other ingredients added, shellac is consistently avoided in the lacquerwares of lighter colours.

Table VII. Overview of analysis methods applied to the objects under study. Table of organic materials identified after analysis by THM-GC/MS. x – ingredient clearly present; (x) – ingredient weakly present, traces; ? – ingredient detected but uncertain. Samples that are certainly or likely contaminated are in italics. The analytical results of non-original materials are not shown.

object number	period	object colour	cross sections of interior and exterior	SEM	XRF	MA-XRF	MRS	FTIR	THM-GC/MS (summary of results)													
									layer	oil	shellac	*Pinaceae*	sandarac	cedar	copal	larch	mastic	soot	proteins	elemi	gum benzoin
1	P1	Black	Int. + ext.	x	x	-	X	-	*interior - transparent*	*(x)*	*x*	*x*	*x*	-	-	-	-	*x*	-	-	-
									interior - black	(x)	x	x	x	-	-	-	-	-	x	-	-
2	P1	black	Int.	x	x	-	-	-	interior - black	-	x	x	x	-	-	-	-	x	x	-	-
6	P2	Blue	Int. + ext.	x	x	-	X	x	exterior - blue	(x)	-	x	x	-	-	-	-	-	(x)	-	-
									exterior - transparent	-	-	x	x	-	?	?	x	-	(x)	-	-
									exterior - filling under gold	-	x	x	x	-	?	?	x	-	-	-	?
									interior - black	-	x	x	x	?	-	x	x	x	x	?	?
									interior - black (other location)	-	x	x	x	-	-	x	x	x	-	?	-
									interior - transparent	-	x	x	x	-	-	x	x	x	x	x	-
7	P2	Blue	Int. + ext.	x	x	-	X	x	interior - black	-	-	x	x	-	-	-	-	x	x	-	-
8	P2	light blue	Int. + ext.	x	x	-	X	x	exterior – light blue	X	-	x	x	-	-	-	-	-	x	-	?
									exterior - gold size	X	x	x	-	-	-	-	?	x	-	-	?
									exterior - transparent	X	-	x	(x)	-	?	-	-	-	-	-	-
									exterior - black bottom	(x)	x	x	(x)	-	?	-	-	x	x	-	-
									interior - red and black lacquer (red not original?)	*(x)*	x	*x*	*x*	-	-	-	-	*x*	*x*	-	-
9	P2	black	Ext.	x	x	-	-	x	exterior - black with filling of raised decoration	-	x	x	x	-	-	-	-	x	-	-	-

									interior - black (weak)	?	?	x	x	?	-	-	-	x	x	-	-
10	P2	white	Ext.	x	x	-	X	-	*interior - black (contaminated by restoration with alkyd)*	-	-	*x?*	x	-	-	*x*	-	x	-	-	-
11	P2	tortoise	Int.	x	x	-	-	x	interior - transparent	-	x	x	x	-	X	-	?	x	(x)	?	-
									interior - black	-	x	x	x	-	X	-	?	x	x	-	-
15	P3	black	-	x	x	-	-	x	interior - red	-	?	x	x	-	(x)	-	x	-	x	-	-
14	P3	black	Ext.	x	x	-	-	-	interior - transparent	-	x	x	x	-	-	-	-	x	-	-	-
									interior - black	-	x	x	x	-	-	-	-	x	x	-	-
13	P3	black	Ext.	x	x	-	X	-	exterior small box - transparent	-	x	x	x	-	-	-	-	x	x	-	?
									interior small box - black	-	x	x	x	-	-	x	-	x	x	-	-
16	P3	black	Ext.	x	x	-	-	-	*exterior - all layers (probably contaminated by restoration)*	*(x)*	x	*x*	*x*	-	-	-	-	-	*x*	-	-
17	P3	tortoise	-	x	x	-	-	-	interior - red	-	x	x	x	-	-	-	-	-	-	-	-
18	P3	tortoise	Int. + ext.	x	x	-	X	x	exterior main box - transparent	?	x	x	x	-	-	-	-	-	x	-	-
									interior main box - black (weak)	-	-	x	x	-	-	-	-	x	-	-	-
									interior main box - black	-	x	x	x	-	-	-	-	x	x	-	-
									interior main box - transparent (weak)	-	-	x	x	-	-	-	-	x	-	-	-
18bis	P3	black	Ext.	x	-	-	-	-	exterior small box - black	(x)	x	x	x	-	-	-	-	x	x	-	-
									exterior small box - black	-	x	x	x	-	-	-	-	x	-	-	-
									interior small box - red	-	-	(x)	x	-	-	-	-	-	-	-	-
19	P3	black	Int.	x	-	x	-	-	interior - black	-	-	x	x	-	-	-	x	x	x	-	-
									interior - transparent	(x)	-	x	x	-	-	-	x	x	(x)	-	-
20	P4	black	Ext.	x	x	-	-	x	exterior - black	?	x	x	x	-	-	-	?	-	-	-	-
21	P4	black	-	x	x	-	-	x	interior - red	-	-	x	x	-	-	?	-	x	x	-	-

- **Single study items**

  - Long case clock with chinoiserie decoration G3020 (figure 20)

While visually clearly related to English production, this impressive clock with high quality chinoiserie lacquer decoration remarkably features a clockwork indicated to be sold in Belgium (signed "Rousseau à Bruxelles"). The decoration, originally mainly blue in colour, has darkened over time. In support of the (limited) conservation treatment and the more elaborate historical research, the stratigraphy was elucidated and analysed. 13 layers were found, 6 of which original. The blue base is made of smalt, and also carbon black and vermillion were found. The organic composition was not determined. Historical research shows links with English lacquer and revealed the clockwork to be English as well, despite its inscription.

Figure 20. 18th century, English long case clock with chinoiserie decoration. @RMAH

  - White 'Dagly' cabinet (figure 21)

Figure 21. White cabinet attributed by the owner to Gérard Dagly. 18th century Germany. © Private collection, Köln.

A multi-disciplinary and multi-analytical study of a white lacquered cabinet from a private collection has shed new light on its materials and techniques. Stylistically this lacquered cabinet can be situated in the late 17th or early 18th century tradition of white European lacquers. Inspired by trendsetting white lacquer works of Gérard Dagly and Martin Schnell, this Western cabinet with decorative hinges, corner mounts, and motives such as the dancing boy, chrysanthemums and flying wildlife clearly aims to imitate the exotic atmosphere of Far Eastern lacquerware. Microscopy, SEM, Py-GC/MS, MA-XRF were all applied to study this fascinating object. Thanks to a fruitful collaboration between UA and Denmark, there was an opportunity to perform Terahertz Time-domain Imaging

as well. On the wood, a lead white layer with a small amount of smalt is applied, followed by a smalt rich layer for the blue decoration. Over the complete surface, an organic layer is present. Finally, vermillion serves as an underground for the metallic particles.

The results of the cross-sections' examination (VIS, UV, SEM-EDX) and XRF element mapping show no anachronisms or anomalies in the observed materials and techniques. The smalt blue decoration on lead white background was visualised with all techniques. VIS-microscopy and SEM-EDX shows that this background layer was mixed with a small quantity of smalt. This suggests that smalt could be used as an optical brightener, creating a blueish hue which increases the perceived optical brightness. Vermillion was used for all red colours and to build up a low relief for the brass metal powder. The Terahertz-TDI imaging equipment allowed us to explore the instrument's possibilities and limitations for the ELinC-project's technical research. The Thz-images are consistent with the cross sections and revealed no irregularities. Only original materials and techniques were present.

THM-GC/MS analysis of the white background indicate the use of a drying oil as a binder. The transparent varnish, sampled underneath the fire gilded hinge on the upper right, indicate the use sandarac and mastic in the varnish layer. Only a small quantity of fatty acids is present. The fatty acids could be migrated from the underlying oil paint, or could suggest the use of a polishing suspension for the varnish's topcoat, consisting of a non-drying oil with small abrasive particles. Many 17th and 18th century recipes mention the use of sandarac and mastic as main ingredients but are often joined with other products such as camphor and spike oil. The latter two being both volatile and become undetectable over time.

A spirit varnish with a high content of sandarac, and mastic as plasticiser, becomes a glossy lacquer finish after polishing. These physical aspects, combined with a bright white background, resulted in a brilliant white porcelain look. Contours of prominent blue and red scenery decorations were highlighted by a raised brass-particle line scattering the light. This resulted in a contemporary trendy cabinet and would make it a fashionable centre piece to any late 17th century room.

The lead white background layer contains a drying oil. The transparent and glossy finish consists of sandarac with (probably) mastic. Only small quantities of fatty acids were detected, indicating a spirit varnish.

- Table by Pierre Gole with polychrome marqueterie with flowers, animals, jewels and masks, with burgauté black lacquer - Sm720 (figure 22)

This table is one of the oldest European lacquer objects in a Belgian collection. It was made in 1663 by the skilful ebenist Pierre Gole. The ELinC project was privileged to be able to chemically analyse a sample of this rare object possessed by the province of Antwerp, former collection of Smith-Van Gelder. In the black burgauté lacquer were found shellac (of the still impure type e.g. sticklac or buttonlac), and aged pine resin.

Figure 22. Table by Pierre Gole. black 17th century burgauté lacquer ©Province of Antwerp

- Piano -2003.021 (figure 23)

The piano is the most recent lacquered object of the study. The black piano, dating from 1900, is lacquered in Brussels with elaborate chinoiserie decoration. Five layers were seen: the piano was originally covered with a plain black lacquer coating. Then, a 200μm thick chalk preparation layer is applied, followed by a new black layer and two transparent layers. Binder analysis shows oil in the first black layer, glue in the chalk preparation, Pinaceae resin in the second black layer, and a wax on top (both transparent layers were analysed together).

Figure 23. Piano. Black Ca.1900, Brussels ©MIM, Brussels

- Three lacquered vases -G675A, G675B, G674 (figure 24)

The three vases (see further for art-historical information) were studied to learn more on the technique and period of lacquering. 17 samples were taken to determine stratigraphy, and organic and inorganic composition. The lacquer composition proved very sensitive to water and interacts with embedding resin. As a result, the two cross sections are of rather poor quality and difficult to read. What is clear, however, is the following

Figure 24. Set of three Delft vases covered with lacquered floral motives; 18th or 19th century © RMAH

stratigraphy: a thin transparent adhesive, a 20μm thick layer rich in black pigment, followed by a 20-90μm layer of a less pigment charged layer, still containing black pigment. Where decoration is present, the relief material (chalk, lead white), metal leaf adhesive (chalk, barium sulphate) and the decoration are seen. Then, a fluorescent transparent layer is applied. The presence of barium sulphate already indicate a lacquer of the 19th century (or later). During analysis, some indications seem to suggest the presence of a (synthetic?) colorant.

5.2 Recipe database for a better understanding of European lacquers (Partner 2)

5.2.1 Overview and descriptive statistics

The dataset amounts 920 recipes from the set regions and period, as stated earlier. It consists of 850 lacquer recipes and 70 recipes on the production of ground and isolation layers, gold-sizes, ingredients (e.g. clarification procedures), polishing procedures, and pigment preparation. Fig. 25 shows the distribution of the lacquer recipes (n = 850) across the countries according to their current geographical borders. We notice that most recipes within the dataset originate from Germany (365), followed by the United Kingdom (153) France, (146), the Netherlands (100), Italy (85), and Belgium (1).

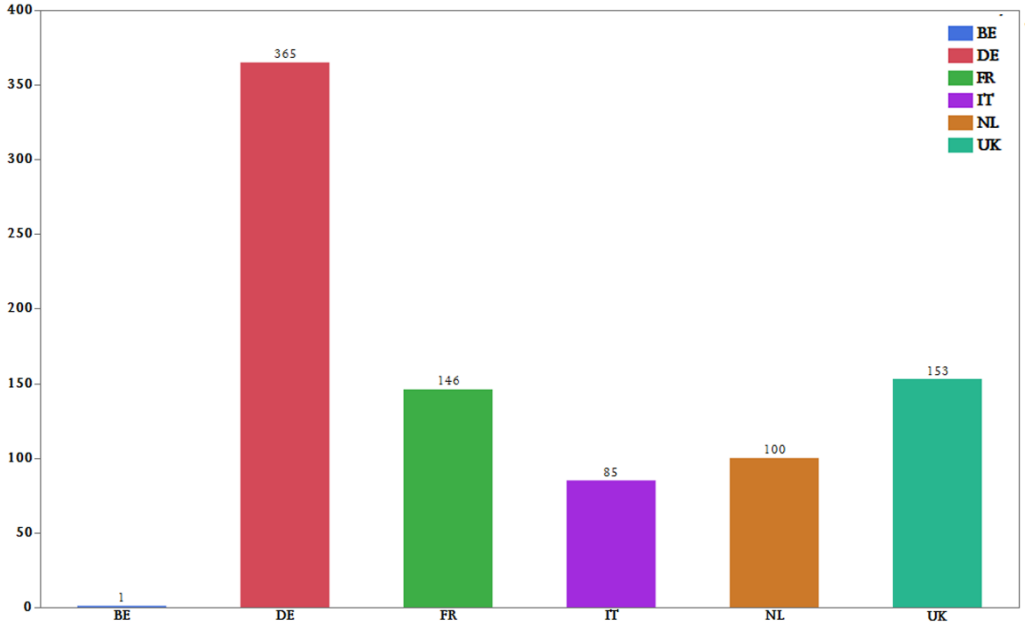


Figure 25. Distribution of the recipes according to the country of publication of their respective source (lacquer recipe count x countries, n = 850).

Looking at the distribution of the recipes with their date of publication, we notice that most collected recipes are located throughout the period 1675-1800 (n = 749, Fig. 26). Few recipes date before this period (< 1675). The decreasing number of recipes seen after 1800 caused by the period limitations of this study. Reason is the low number of surviving sources with recipes for North-West Europe from before 1700. The earliest European lacquer recipe aiming to imitate the Oriental counterpart appeared in 1667 by Kirchner, who himself learned this recipe from Père Jamart (Kirchner, 1667, pp. 220–221). For England, the earliest recipe dates from De Sylva in 1670 (Evelyn, 1670, pp. 198–199). From then onwards, lacquer recipes chronologically appeared in Leipzig, Germany (Kunckel von Löwenstein, 1679), Oxford (Stalker and Parker, 1688), Paris and Nuremberg (Boutet, 1688) and London (C.K., 1697, pp. 45–94). Recipes dated before 1651 are not genuinely lacquer recipes for the purpose to imitate Oriental lacquer, instead these concern 'vernix' recipes.

At the turn of the 17th century and onwards, the frequency of publications with (imitation) lacquer recipes appear to increase within the North-Western part of the continent progressively. The aforementioned is seen by the surge of recipes in the database across the different countries from the second half of the 17th century onwards (Fig. 26).

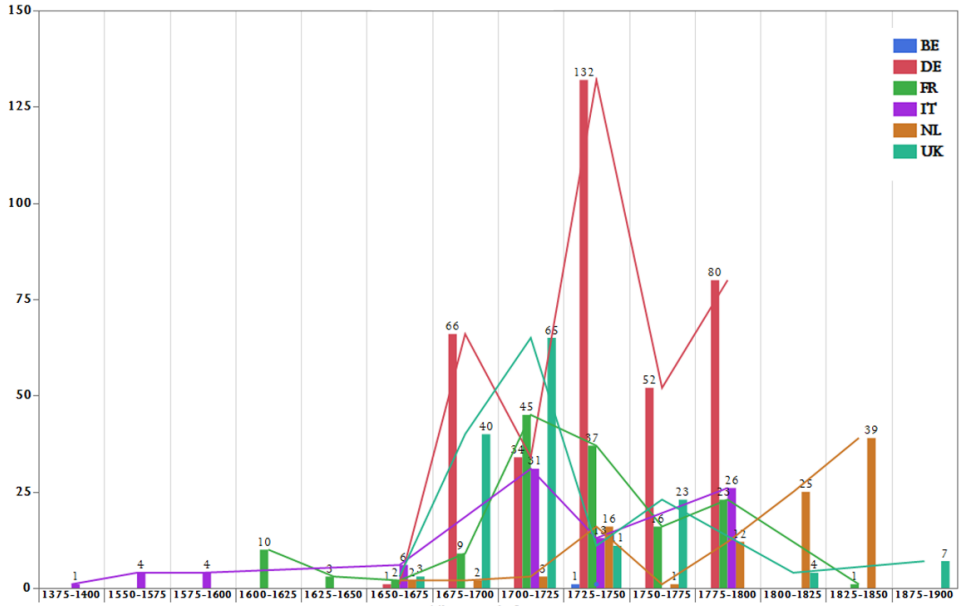


Figure 26. Bar-graph with trend-lines illustrating an increase in the number of recipes from the last quarter of the 17th century and peaking throughout the 18th century (recipe count x country, n = 850).

When looking at the distribution of these categories in the dataset (Fig. 27), we observe that the most represented recipe category is spirit-based lacquers (514), followed by essential oil (157), oil (152), resin (26), and protein (1).

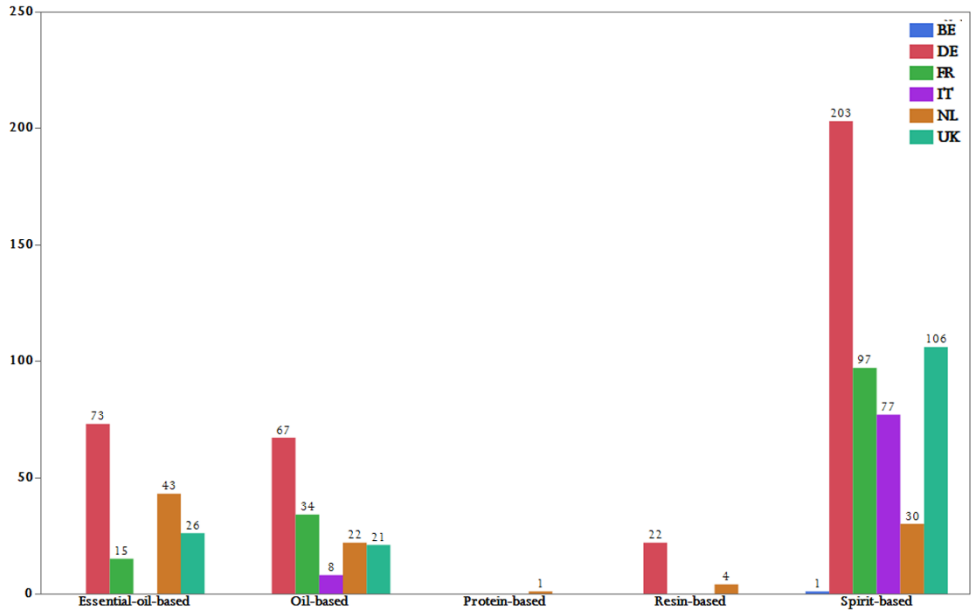


Figure 27. Distribution of the five recipe categories held in the dataset (recipe count x category, n = 850).

Fig. 28 shows a rise in recipes across the different categories throughout the 18th century. Only the selected number of resin-based recipes (25) appear to decline from the early 18th century onwards and to disappear in the 19th century completely. Again, this trend of growth recipes is related to their respective increase in recipe-frequency in the sources for this period, as was shown in Fig. 26.

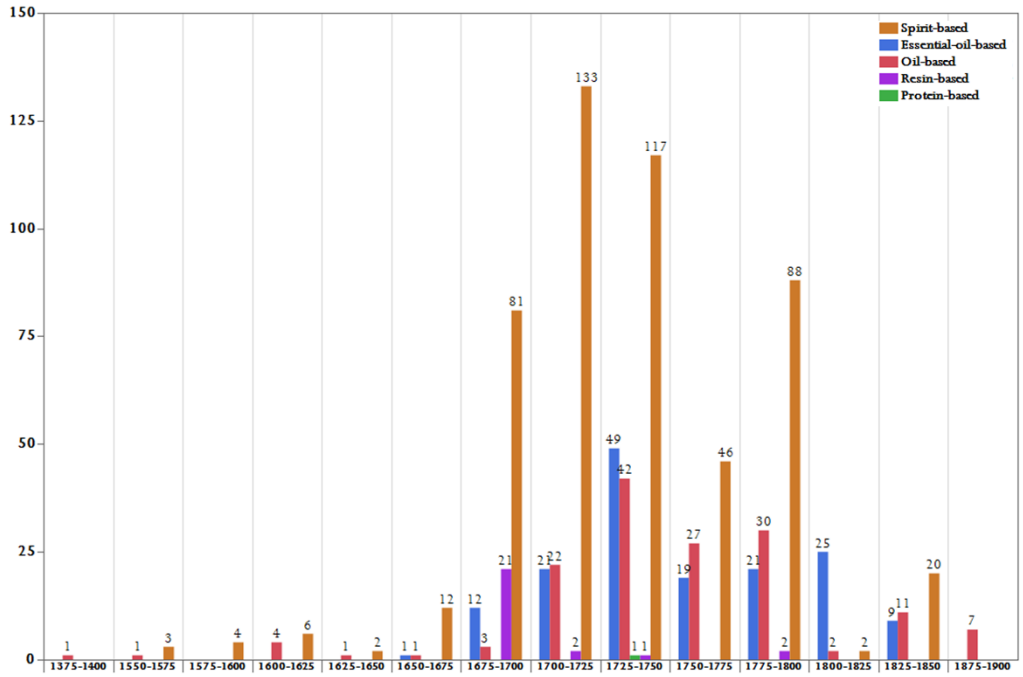


Figure 28. Distribution of the recipe categories over the different time periods (count recipe category x time, n = 850).

Notable is the high number of spirit-based recipes across all different time-periods, peaking throughout the late 17th and 18th centuries. The first and second most common recipe category within the dataset across time and regions are spirit- and essential-oil based lacquers. Respectively, spirit-based recipes represent 60 %, and essential-oil recipes 18%, of the total number of collected recipes. As both spirit and essential-oil based recipes are classified as solvent-based recipes, the total account of solvent-based recipes within the dataset equals 78%. This percentage raises the question of why such a high number of solvent-based recipes are present compared to the oil-based recipes?

From the demographic perspective, the interest for the art of lacquering was wide. It was practiced by both genders at different ages (children, adults) and by all social classes (C.K., 1697; Kirkham, 1980, p. 49; Stalker and Parker, 1688; "Stratton's Geigenfabruk in Gohlis Bei Leipzig," 1873). Furthermore, Watin stated that spirit lacquers are less expensive to make than oil-based lacquers. The fact that Watin explicitly makes this comment does suggest that the price difference between the lacquer categories for some was decisive. Therefore, the popularity of solvent-based lacquer recipes, and particularly spirit-based lacquers, might be in part be explained by the lower production cost when performing the art of lacquering.

Also, the incentives to make lacquers was wide-ranging; from a leisure activity, to educational reasons, to professional purposes. Since it was so widely practiced, the level of practical knowledge and experience of the art likewise varied greatly. Authors appear to have anticipated on this wide variety of knowledge and expertise. For the little or uninitiated, the prerequisites for making solvent-based lacquers are much lower than those for producing oil-based lacquers. Making solvent-based lacquers most often consists of mixing solid ingredients with liquid ingredients until dissolved. It can be executed successfully by simply following the recipe's instructions.

Contrary, oil-based lacquers are more complex to make. Notwithstanding that not all oil-based lacquers required to be heated, the resin-based lacquers do, as there is no solvent present in the recipe to dissolve and mix the solid resin ingredients. The process of heating oil, oil-resin mixtures, and resinous materials was a perilous operation. Heating inflammable ingredients that produce highly inflammable vapours on fire involved risks. Therefore, practical experience with heat-related production processes was a desirable prerequisite for the on-the-spot assessment of the ingredients or mixtures' reactions in order to anticipate adequately if the process run out of control. Beginners and aspiring lacquer makers likely had little knowledge on discerning these reactions and how to cope with them.

Visual sources, such as the print from the *Encyclopédie Méthodique - Arts Et Métiers Mécaniques* (1789) and the print by Johann Leitner (late 18th century), show that artisans were well aware of fire hazards. Consequently, it dictated the spatial configuration and the design of appliances within the professional lacquer workshop. Such facilities and practical workshop's organizational aspects were for practical or financial reasons, likely out of reach for debuting and amateur lacquer makers, whom often performed the art of lacquering at home.

Finally, production related laws influenced the popularity of recipe categories. During the late 18th century in Paris, and as proposed likely in Spa, both amateur and professional lacquer makers were subjected to restrictive policies regarding the production of oil-based lacquers in urban regions. The measures were not only implied for the public's safety, but also for avoiding the annoyance of smelly fumes and the high risk of fires. According to Watin, the production of spirit-based lacquers was of lesser concern.

The above shows that authors were aware of the risks, ongoing policies and the knowledge and experience related limitations for aspiring lacquerers. Authors like among others Stalker and Parker (1688), Cocq (1771), Watin (1772) and Le

Pileur (1779) explicitly wrote down their awareness of the above. To such extent, that Cocq and Le Pileur consciously chose to disseminate less fire-hazardous production methods. It demonstrates that authors with professional backgrounds searched for middle grounds and discerned their own acquired intellectual and practical knowledge to the level for aspiring and amateur audiences.

5.2.2 Hierarchical clustering

- **Identical recipe compositions**

The cluster analysis resulted in the identification of both identical and unique recipes. A first observation is that from the 850 lacquer recipes, 451 cases or 53%, were identified as recipe compositions that have at least one other recipe with an identical composition within the dataset. Of the 451 duplicate cases, 124 different recipe compositions are distinguished. Including the 124 different recipe compositions from the duplicate list to the remaining 399 unique recipe compositions, this results in 523 unique recipes or 61,5% of 850.

Reasons for this high number of unique recipe compositions might be diverse. A first aspect, although assumed low in number, is the erroneous ingredient attributions by the author of this chapter related to the medium accuracy ingredient variable. These inevitable errors are intrinsic to recipe studies due to the ambiguous terminology and involving uncertainties. Such errors might result in either a unique recipe composition or in another recipe's duplicate. Second, the identified 111 different substances allow for a high number of unique combinations.

Finally, the period of the late 17th and 18th centuries are marked by historical experimentation. In this context, Klein and Lefèvre use the example of Robert Boyle to show that experimental history did not require a structured presentation of facts (Klein and Lefèvre, 2007, p. 24). The authors state that if the experimenters were unable to create order in the facts, they present them as they came to mind and hand, declining 'a methodological way'. Robert Boyle (1627-1691) himself wrote letters which revealed recipes on European lacquering. Hence, Boyle was a highly regarded source of inspiration for several authors that wrote on the art technical aspects of lacquering. One of the oldest known printed sources on lacquering by Johannes Kunckel might be evidence of Boyle's method. Under the chapter *'Von allerhand nuβlichen kunststücken und Experimenten'*, Kunckel sums up over 30 different recipes and recipe variations for making lacquers (Kunckel von Löwenstein, 1679, pp. 26–31). For example, the seven different recipes to make red lacquer (*'Roth Lacc'*) are listed one after the other without an explanation to why these differ nor whether for different purposes they

serve.(Kunckel von Löwenstein, 1679, pp. 39–40) That such experiments took place in the mind and hands of both authors without practical experience as well as experienced artisans should be little surprising. The rise of European lacquering was initially prompted from encounter with an unknown material that had unimaginable qualities to Europeans. The fascination for the unique material characteristics and qualities of Oriental lacquers, sparked a common drive to find and create a European lacquer that incorporated all the qualities of its Oriental counterpart. Hence, searching for the 'perfect recipe' required an extensive theoretical and practical experimentation with substances and production procedures known to European artisans and authors. Additionally, throughout the period studied, the exploration and discoveries of the botanical kingdom in both Eastern and Western regions deluged the market scene with new natural substances which in turn had to be subjected to experimentation. All in the name of finding a recipe that shared the unique features of Oriental lacquer.

- **Identical recipe clusters and relationships**

From the study of the clustered recipes, this technique was able to cluster identical recipes together and hence mark potential relationships between the sources. For instance, the chronological relationship between the treatise of Stalker and Parker (1688, London), C.K. (1697), and Salmon (1701) was already known and has been rightfully clustered together (Figure29) (Silverman et al., 2019). However, the cluster also indicated a relationship with a recipe from the Arts Companion (1749, London). The author does confirm that the information in the work was sourced from other works, but except for 'the Great Mr. Boyle', the author reveals no other source material. One of the recipes is called 'The white Varnish', which indeed ties to Stalker and Parker's 'Best White-varnish' recipe.(*Arts Companion, or a New Assistant for the Ingenious. In Three Parts*, 1749, pp. 44–45; Stalker and Parker, 1688, pp. 10–11)

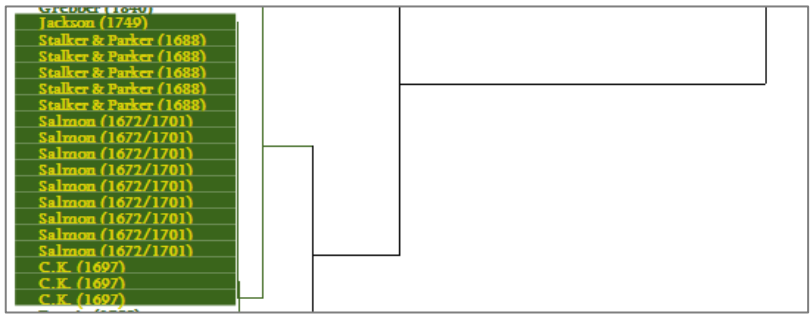


Figure 29. One cluster of identical recipes labelled by the authors. We observe that there is a relationship between Stalker and Parker, C.K., Salmon and the anonymous source called 'Jackson'.

Another cluster contains the most reoccurring recipe composition in the dataset, sharing 30 times an identical recipe. This two-component spirit-shellac recipe is one of the least complicated recipes within the dataset. Not only because of the two ingredients but also to production technically: one must mix the shellac at the recommended quantity with the spirit and once dissolved and strained, it is ready to use (Stalker and Parker, 1688, p. 10). It demonstrates that the resulting clusters should not be taken at face value, but that revaluation of the clustered sources is necessary to validate the relationship.

Table VIII. List of historical sources mentioning the identical two-component recipe spirit-shellac.

	Date	Author; page(s)	City, country
1	1667	Kircher, 267-268	Amsterdam, NL
2	1670	Sylva, 198	London, ENG
3	1679	Kunckel; 28	Leipzig, DE
4	1688	Stalker & Parker, 9-10	London, ENG
5	1696	Anon.; 4, 7	Nuremberg, DE
6	1697	C.K. (1697)	London, ENG
7	1701	Salmon (1672/1701)	London, ENG
8	1720	Bonanni (1720/23/33)	Rome, IT
9	1743	Cröker, 234	Jena, DE
10	1747	Anonymous	Cremona, IT
11	1756	Teuber (1756)	Regensburg, DE
12	1758	Dossie (1758)	London, ENG
13	1774	Crucius (1774)	Leipzig, DE
14	1784	Guidotti (1784)	Rimini, IT
15	1798	Schreck (1798)	Amsterdam, NL
16	1833	Jacqmerre (1833)	Brussels, BE
17	1840	Grebber (1840)	Amsterdam, NL

For example, the earliest written account for this recipe is found Kircher's publication (1667, Amsterdam, Table VIII), whom himself received this secretive recipe from the Augustinian Eustache Jamart. Jamart claimed that the materials shellac is very similar – if not the same – to the materials and production method of the *'gleaming splendor'* of Chinese lacquers.

Due to this recipe's simplicity of two frequently used components, a coincidental relationship between the different recipes and sources is possible. Therefore, this cluster is indicative, and further textual analysis of all the clustered recipes is necessary (Table IX). From this textual study, and the sources' paratext with citations towards other authors and sources, the cluster, in fact, identified four

different strains based on this one particular recipe (Fig. 30). Although several are confirmed relationships, some are dubious. For example, Kunckel possibly copied this recipe from Kircher, as he has been in contact with Kunckel for several times. Throughout his publication, Kunckel refers several times to Kircher's ('Kircherus') work *Oedipus Aegyptiacus.* However, Kunckel does not reveal his source for the lacquer recipes throughout his work, so this remains hypothetically. Similarly, Crucius translated the work of Watin, who in turn was familiar with Kircher's *China Illustrata* (Although the recipe shows little resemblance to Kircher's formulation).

Table IX. List of the clustered sources mentioning the spirit-shellac recipe.

	Date	Author; page(s)	City, country	Recipe
1	1667	Kircher, 267-268	Amsterdam, NL	Kircher refers to Eustachius Jamart: "Hic superassundatur Spirit. Vini optimèrectificatus ad quatuor digitorum eminentiam."
2	1670	Sylva, 198-199	London, ENG	Sylva does not refer to the origin of the recipe but does mention to be aware of Kircher's publication about this lacquer recipe.
3	1679	Kunckel; 28	Leipzig, DE	Although Kunckel does not refer to the origin of his recipe, Kunckel refers several times to a work of Kircher.
4	1688	Stalker & Parker, 9-10	London, ENG	'To make Shell-Lacc-varnish'
5	1696	Anon.; 4, 7	Nuremberg, DE	'Ein andere Art von Lac-fürnis/mit welchem man rothe und dunckele farben anmachen/und folgends überstreichen und beglänzen kan'
6	1697	C.K.; 35	London, ENG	'Shell Lac-Varnish, how to make it'
7	1701	Salmon, 868	London, ENG	'To make Shell-Lacc-varnish'
8	1720	Bonanni, 6	Rome, IT	'che sopravanzi quattro deta'
9	1743	Cröker, 234	Jena, DE	'Ein Indianischer fürnis'
10	1747	Manuscript 4 (H 113), Library Trivulziana, Milan	Cremona, IT	'che avanzi lo spirito di sopra la gomma otto dita'
11	1756	Teuber, 210	Regensburg, DE	'der vierte ist ein gutter harter fürnis'
12	1758	Dossie, 177	London, ENG	'Add to it one quart of rectified spirit of wine'

13	1774	Crucius, 127	Leipzig, DE	'Den fürniβ aus Gummilack'
14	1784	Guidotti, 89	Rimini, IT	'che sopravanzi la medesima quattro dita almeno'
15	1798	Schreck, fol. 1v.	Amsterdam, NL	'Eine andere Arth'
16	1840	Grebber, p. 11	Amsterdam, NL	'Shellak 4 deelen, alcohol 20 deelen'

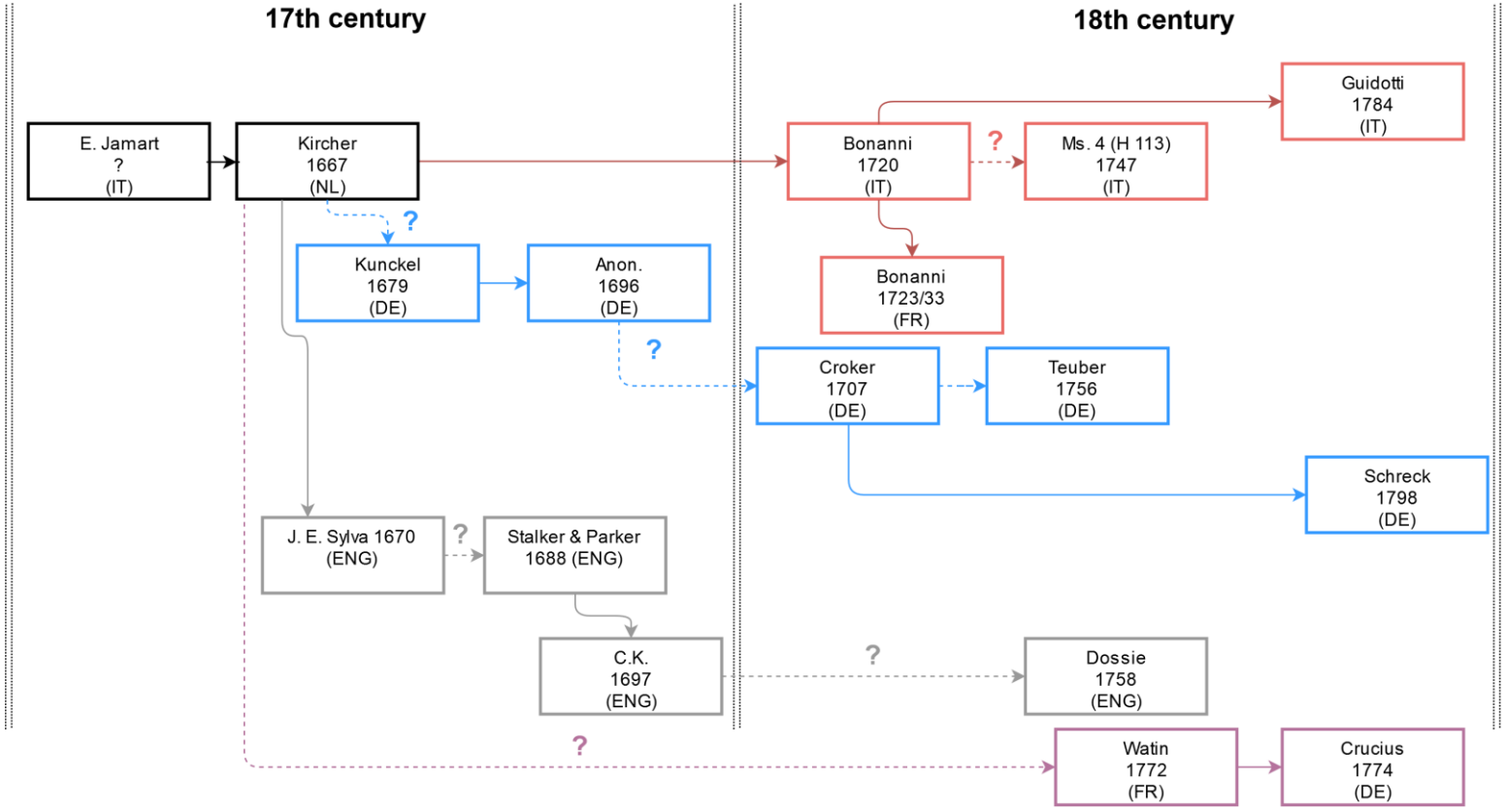


Figure 30. Relationship diagram based on the spirit-shellac cluster. Dotted lines indicate a non-confirmed relationship between the sources.

- **Case-study Johann Ludwig Schreck (1789)**

Despite it is part of the *Historical Lacquer Compositions and Instruction Sheets in the Collection of the Museum Für Lackkunst*, Johann Ludwig Schreck's publication has never been studied in the context of European lacquers before(Kopplin, 2010b; Michaelsen and Buchholz, 2006, p. 279). The lack of citations might be related to the fact that any bibliographical information remains unknown and the difficulties of reading and transcribing the written text. Schreck does not explicitly refer to his sources of information making this work an excellent case to test the performance of hierarchical clustering as a method to search for relationships between sources.

At first sight, Schreck's notebook appears to be constructed as a draft-version written with the intention for press publication. The notebook consists of handwritten title page, including a title and sub-title, the location (Eltmann, DE) and the year 1789 (Figure31). Below the subtitle the author's name and occupation are mentioned: 'Johann Ludwig Schreck, Chijrurgus der Chijmie únd Medicin Practicant in Eltmann' (surgeon in chemistry and chemist). Throughout the work, the recipes are framed between lead point margins and lack in-text corrections, footnotes, or margin notes. Recipes are numbered individually and titled on unnumbered folios. The notebook contains a list of spirit and oil-based recipes and several recipes for staining wood (Michaelsen and Buchholz, 2006, p. 279).

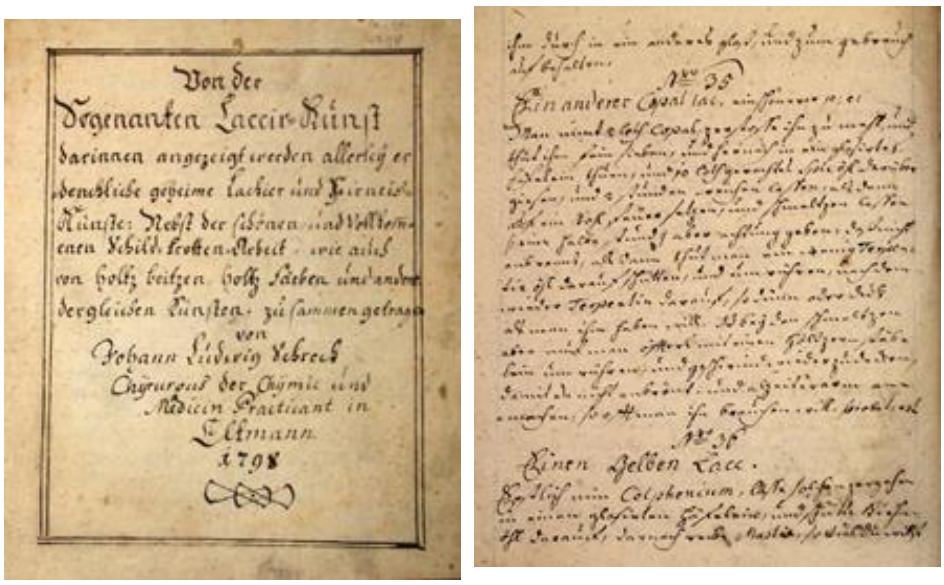


Figure 31. Left, the title page (f1 r.) as written by Johann Ludwig Schreck, including title, subtitle, the author's name, place of publication and date of publication. Right, an example (f12 v.) of how Schreck presents the recipes using numbering and titling, similarly to the work of Johann Kunckel (1707). © Courtesy of Museum für Lackkunst

Upon analysing the dendrogram, it becomes apparent that there is a relationship between the recipes written by Schreck and Kunckel's work, which was, without doubt, an influential work orbiting in art technological circles throughout Europe in the 17th century. By comparing the different editions of Kunckel with Schreck's notebook, it is clear that Schreck's recipes follow the recipe's chronology of the edition of 1707.(Kunckel von Löwenstein, 1707)

Schreck does not appear to have changed or adapted Kunckel's recipes on a compositional level although in many cases he scaled down the recipes by halving the quantity of the

ingredients. Schreck occasionally reduces the units used by Kunckel from 'unze' ('ounce') towards 'loth'. When we compare the written descriptions of recipes from the original source by Kunckel, it comes to notice that Schreck remains largely true to the original text. However, Schreck did personalise the recipes by replacing the -symbol (i.e. recipe) by a full out written 'Nimm' ('Take'). Furthermore, we observe an interesting shift in nomenclature. Schreck codifies the ingredients in Kunkel's work towards his own contemporary vernacular language. For example, recipe 39 from Schreck is a copy of recipe "LXIII Chinsesischer fürnis" by Kunckel. Schreck uses the term 'sandarack' whereas Kunkel systematically uses 'sandarac'.(Kunckel von Löwenstein, 1707, p. 29)

- **Conclusion**

The above demonstrates that hierarchical cluster analysis does indeed assist in finding relationships between the vast amount of data contained by the 850 recipes within the dataset. However, these clusters are formed based on the recipes' similarities but are not necessarily indicative of a relationship between different sources. As seen with the case of the shellac-spirit recipe cluster, there is no particular relationship between Watin and Watin's German edition and the other sources related to this recipe, except for the uncertain relation towards Kircher. This case shows that these clusters only indicate which recipes are similar and that the original text of the recipes and the surrounding paratext should always be studied in order to discern the true relationship of the recipes' composition and their respective sources.

The case-study of the manuscript by Schreck shows that hierarchical clustering was also useful for tracing the origin of recipes. Schreck copied his recipes from the 1707 edition from Kunckel. The fact that it has been neatly written, and that it was almost copied verbatim indicates that Schreck not solely relied on his memory but likely took his time to copy the recipes with Kunckel's source aside.

Despite this technique identified identical recipe, this study did not cover looking at adjacent clusters revealing potentially more subtle relationships between recipes and therefore sources. This is an important aspect for future study.

5.2.3 PCA of 678 recipes

As stated in the methodology for PCA, the data within the dataset is 'cleaned' and resulted in a remainder of 678 recipes. Figure shows the biplot for PC1 vs PC2. In the PC1 and PC2 biplot, we distinguish three groups:

1. Top-half: linseed oil, minium, white vitriol, massicot, asphaltum, anime;
2. Right-side: gamboge, dragon's blood, saffron, annatto;
3. Lower-half: spirit

The linseed oil group and the spirit group are opposed to each other. The colourant group is placed perpendicular between the spirit and linseed oil-groups. The comparison of other principal components contributes little to our further understanding of the relationships between ingredients.

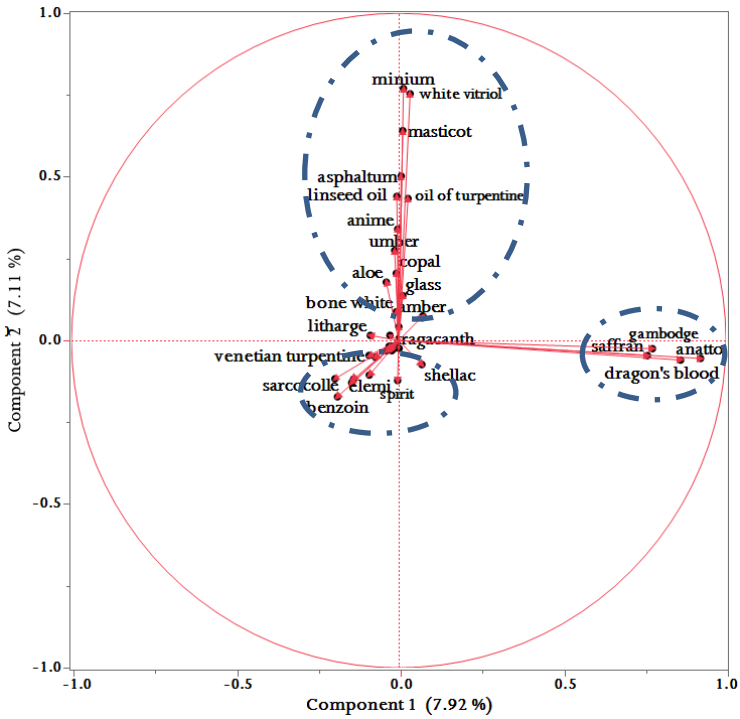


Figure 32. PCA-biplots of the 678 recipes. The three distinct groups are marked by blue-dotted circles.

The biplot in Figure shows a negative correlation between the ingredients spirit and linseed oil. It agrees with the incompatible chemical characteristics of both: spirit is polar while linseed-oil is non-polar. As a result, the materials repel each other and mixing is excluded.

The group on the top-side demonstrates several ingredients show a positive correlation to one another. Although the following ingredients are often used as pigments, the correlation of linseed oil with massicot (PbO), minium (Pb_3O_4), white vitriol ($ZnSO_4$) (Stalker and Parker, 1688, p. 72) these must be interpreted as drier-substances.(Augerson, 2011). In this context, 'Couperose' refers to copperas, which is a ferrous sulfate, also called green vitriol ($FeSO_4$)(Eastaugh et al., 2004, p. 137). For example, Bonanni refers to litharge and a vitriol type for this purpose:

'For oil to dry quickly, there are ones that add powdered litharge and boil it together, a mineral or sort of vitriol that comes from Germany, which is called couperose; at last, the lesser oil the quicklier it dries, & the harder and more durable it becomes like the one from China.'

Under the chapter 'Vernis qui approache plus que tous les autres, de celui de la Chine', Bonanni states: '*Pour que l'huile seche promptement, il y en a qui ont coutume de joinder à la litarge pulverise, avec laquelle ils la sont bouillir un mineral ou espece de vitriol qui naît en Allemagne qu'on appelle couperose ; enfin moins il y aura d'huile, plus le vernis sechera facilement, & plus il sera dur & inalterable comme celui de la chine*.'(Bonanni, 1723, p. 147). Watin states that 'couperose' should be added carefully as it tends to cause yellowing: '[M]ais il en faut mettre avec précaution, parce que la couperose étant un sel, son acide ou son humidité récente fait jaunir en séchant la colour, & en ternit la beauté.'(Watin, 1772)

Another ingredient within this group is glass. Within the dataset it is mentioned in powdered form in recipes by Cröker (*'Venedische glass'* and *'Chrystallen glass'*) and an anonymous Dutch source from 1840 (*'glaspoeder'*). (Cröker, 1743, pp. 55,56,59-60,68,69,164-165,212,486;

Handleiding Tot Het Bereiden Van Alle Soorten Van Ongekleurde En Gekleurde Vernissen, 1840, p. 6,23,44) Historically it is often throughout the production of lacquers. Powdered and fractured glass particles are added spirit-resin mixtures to prevent the resin from sticking to the bottom of the recipient and facilitate dissolving.(Tingry, 1803, p. 137)

Another positive correlation confirming the above is related to the colouring substance asphaltum, often used to create black lacquers.(Ballardie, 1998) It is known as a poor dryer and is therefore often combined with driers such as those mentioned above.

The last group consists of the yellow and red colourants saffron, annatto, gamboge, and dragon's blood. These are principally used to create coloured lacquers. Although these colourants can be found individually within a gold-lacquer recipe, we notice that these are often combined (Figure 3333). The fact that these ingredients are positively correlated is indicative for their combined use. By combining different colourants, usually in spirit-based varnishes (Fig. 34), the maker has more control over the desired colour.

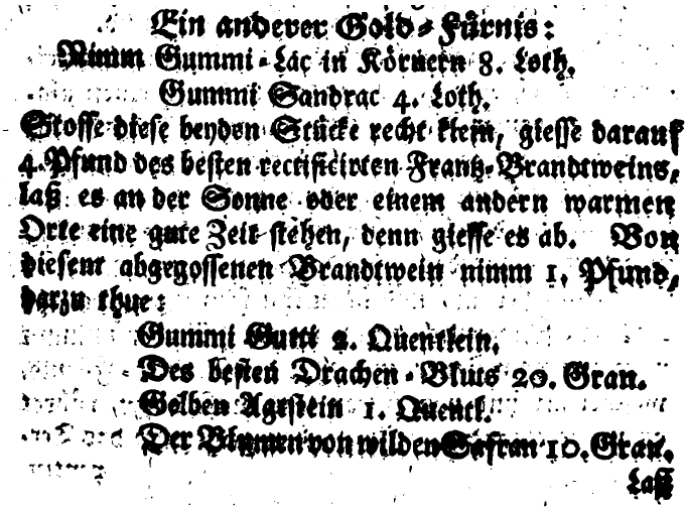

Ein andever Gold-Fürnis:
Nimm Gummi-Lac in Körnern 8. Loth,
Gummi Sandrac 4. Loth,
Stosse diese beyden Stücke recht klein, giesse darauf
4. Pfund des besten rectificirten Franz-Brandtweins,
laß es an der Sonne oder einem andern warmen
Orte eine gute Zeit stehen, denn giesse es ab. Von
diesem abgegossenen Brandtwein nimm 1. Pfund,
darzu thue:
Gummi Gutti 2. Quentlein,
Des besten Drachen-Bluts 20. Gran,
Gelben Agstein 1. Quentl.
Der Blumen von wilden Safran 10. Gran,
Laß

Figure 33. Extract from Cröker (1743) illustrating the combined use of red and yellow colourants. For this recipe gamboge (*'Gummi Gutti'*), dragon's blood (*'Drachen-Bluts'*), and saffron (*'Blumen von Wilden Safran'*) is needed.

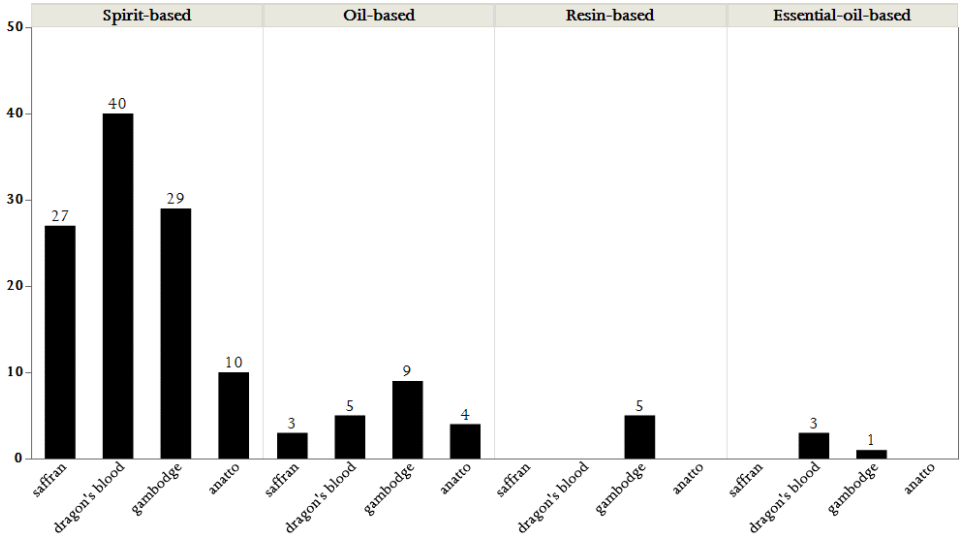


Figure 34. Frequencies of the positively correlated colourants in relation to the recipe categories.

To conclude, from a chemical perspective the negative correlation between spirit and linseed oil is explained by these substances being chemically incompatible (except when used with emulgators or surfactants, alhough these were either unknown or not used in early modern times). The relationship between linseed oil and the drier substances is supported by historical art technical evidence as well as recent research papers. The above serves as a 'positive control', indicating that PCA does reflect meaningful results that can be validated by both chemical and art technical evidence.

- **PCA of the spirit-based lacquers**

The PCA-biplot of PC1 and PC2 for the spirit-based varnishes indicates three groups of positive correlated ingredients (Figure 35). Like in the previous paragraph, the colourants gamboge, annatto, saffron, and dragon's blood are grouped together. In another group, we distinct the ingredients sandarac, elemi, venetian turpentine, colophony, copal, benzoin, and mastic. Notable are the ingredients seedlac and shellac, which are more pronounced in the PC1 and PC3 biplot (Figure 3636). In the latter biplot, the gum tragacanth and sugar are strongly correlated to each other.

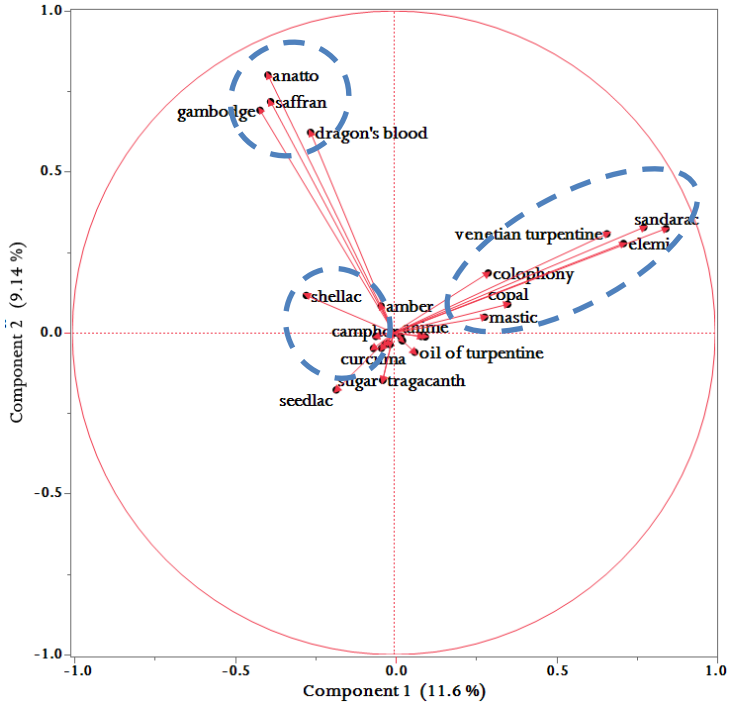


Figure 35. Biplot of PC1 and PC2 for the spirit-based lacquers.

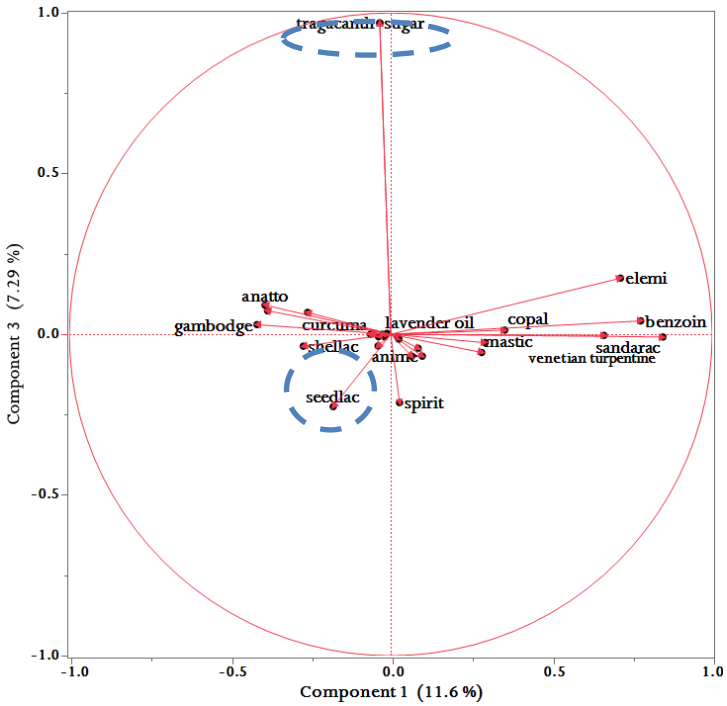


Figure 36. Biplot of PC1 and PC3.

The group with elemi, mastic, venetian turpentine, colophony, copal, sandarac and benzoin at the right can be interpreted from the perspective of sandarac, benzoin, and copal. The last three are frequently used ingredients within lacquer recipes due to their good film-forming properties and their capability of producing a glossy layer. However, these substances have little elastic properties and are prone to cracking over time, deteriorating the layer's integrity and its main aesthetical qualities such as the transparency/translucency and gloss (see for instance Figure 377). An anonymous Dutch source from 1777 explicitly states: *'since sandarac is hard, it is prone to cracking'* (Anon, 1977, p.18).

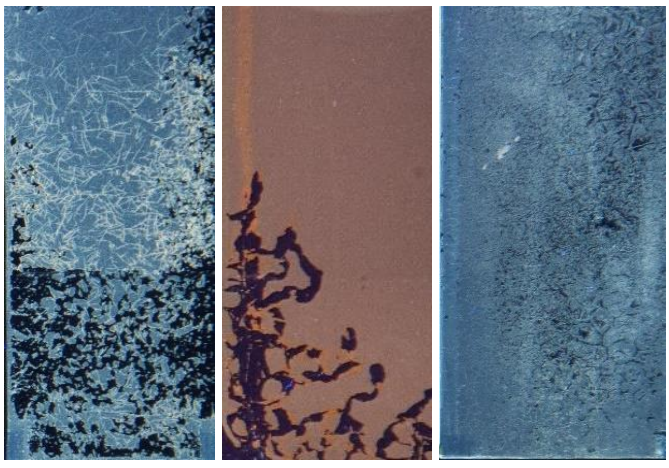


Figure 37. Extensive cracking and delamination of the single-ingredient mock-ups after artificial ageing. Photo's under UV-light to show the cracking patterns. From left to right: sandarac (BLK0048), Sumatra benzoin (BLK0032), and South-American copal (BLK0065).

To prevent cracking, other ingredients like elemi and Venetian turpentine can be added for their plasticising functions, as was shown by the studies of Walch and Koller and Baumer (Table X) and this research (Silvermann, 2019; Walch 1997).

Table X. List of analytical results of European lacquer samples. Ingredients in bold have a plasticising function within the recipe's composition.

Authors	Period	Object or location	Identified ingredients
Koller, Baumer	Baroque, rococo	Marble imitation, church St. Alto	Sandarac, **larch-turpentine**
		Eshenhole	Sandarac, **larch-turpentine**
		Ettal	Sandarac, **larch-turpentine**
		Tegersee	Sandarac, **larch-turpentine**
		Rott am Inn	Sandarac, **larch-turpentine**
		Pulpit Holycross church Landsberg/lech	Sandarac, **larch-turpentine**
		Altar	Sandarac, **larch-turpentine, mastic, elemi**
		Baluster Wieskirche	Sandarac, **larch-turpentine, mastic, elemi**
		Mensa altar St. Nikolaus chapel	Sandarac, **larch-turpentine, mastic, elemi**
		Crowning high altar Alte Kapelle	Sandarac, **larch-turpentine, mastic, elemi**
		Church Oberndorf	Sandarac, **larch-turpentine, mastic, elemi**
		Interior Holycross church Landsberg/lech	Sandarac, **mastic, elemi**
		Altar	Sandarac, **camphor**
		Ambergs School Chruch	Sandarac, **larch-turpentine, mastic**, copal
		Ratisbon Alte Kapelle	Sandarac, **mastic**, copal
Cattersel et al.	Late 17th c.	Cabinet	Sandarac, **mastic, pine-resin?**
Koller, Walch, Baumer	1705-1707	Lacquer room Residential Palace Rastatt	Sandarac, shellac, **larch turpentine, pistachio turpentine** (*Pistacia terebinthus* L.)
	1715-1727	Mirror frame	Sandarac, shellac, **larch turpentine**
Steyaert et al.	Late 17th, early 18th c.	Box 1	Sandarac, shellac, **pine resin**
	Early 18th c.	Box 6	Sandarac, **pine-resin, mastic** (copal? **larch?**)
	Early 18th c.	Box 6	Sandarac, shellac, **pine-resin, larch, mastic, elemi**
	Early 18th c.	Box 8	Shellac, **pine-resin**, (sandarac?)
	Early 18th c.	Box 11	Shellac, **pine-resin**, sandarac, copal, **mastic?**
	From c. 1735	Box 14	Shellac, **pine-resin, sandarac**
	From c. 1735	Box 13	Shellac, **pine-resin, sandarac**
	From c. 1735	Box 18	Shellac, **pine-resin, sandarac**
	From c. 1735	Box 18	Sandarac, **pine-resin**
	From c. 1735	Box 19	Sandarac, pine-resin, mastic
Warnow	1767	Bamboo chairs	Sandarac, **mastic,** colophony or **turpentine**

For example, the brittle characteristic of pure sandarac and the need for adding a plasticiser was a known fact. For instance, Johannes Kok (1794) underscored the reciprocal relationship between sandarac and mastic (Figure 3838).

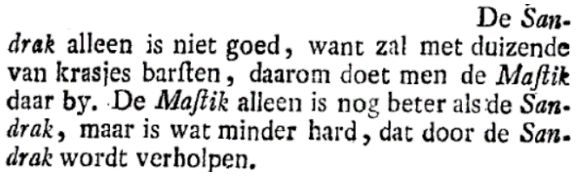

De *San-*
drak alleen is niet goed, want zal met duizende van krasjes barſten, daarom doet men de *Maſtik* daar by. De *Maſtik* alleen is nog beter als de *San-*
drak, maar is wat minder hard, dat door de *San-*
drak wordt verholpen.

Figure 38. Citation of Johannes Kok on the relationship between sandarac and mastic: "*The sandarac alone is of no good, because it will crack in thousands of pieces, therefore mastic is added. Mastic alone is even better as sandarac, but is less hard, which is prevented by the sandarac*".

Azémard et al. claim shellac was used as a plasticiser for sandarac. Although the plasticising function of shellac is unknown, recipe compositions of sandarac with shellac have been observed within the case-studies of *Bois de Spa* by Steyaert et al. and Koller, Walch, and Baumer (Table X). These cases demonstrate that the combination sandarac-shellac were used. However, it contrasts with the biplot's negative correlation of sandarac with seedlac and shellac (Figure 3636), and Watin statement:

'[sandarac] is the base of all spirit-varnishes, except for those made with shellac' (Watin, 1772)

The final group of sugar and tragacanth gum are positively correlated due to all being dissolvable in water. Due to the latter, this group is negatively correlated to spirit. Water in general, has to be avoided with spirit at all costs, as it imparts the quality of the drying and causes blooming of the lacquer layer:

[T]he less flegm or watery parts are in them (ed. spirit) ; and the less of watery parts are in the Varnish, the sooner it dries, and is fit for polishing, is more permanent, and will come to the greater and better gloss (Stalker en Parker, 1688).

5.3 The history of European lacquer (Partner 3)

5.3.1 Inventory on the objects of the RMAH

More than sixty lacquered art objects of different kind and size were inventoried. They date from the 18th to the 20th century and originate from different West European places (France, England, Belgium, South Netherlandish Countries, Principality of Liège, Austria, Italy). Most of the objects are only known by small catalogues notes. They are very few publications concerning the museum's lacquer decoration. Publications on comparable objects than those inventoried and kept in other museums or private collections were available, but not for every kind of object. Some items that were thought as European lacquer revealed to be Asian.

Department European Arts, collection Furniture

- **Two 18th century lacquered English pieces of furniture**
  - Long case clock (Fig. 39), Inv. G3020, c. 1765, 280 x 60 x 30 cm, Great Britain, probably London, Godtschalk legacy of 1905. The mention *Aegidius Rousseau à Bruxelles* is incised on the dial (Fraiture, 2009, pp. 250, 561). An archive mention on Aegidius Rousseau was found in the AGR in Brussels, T 459-8185/A.
  - Secretary cabinet (Fig. 40), inv. G.3024, end of the 18th century, beginning of the 19th century, 237 x 104 x 60 cm close, 237 x 194 x 60 open, Great Britain, probably London, Godtschalck legacy of 1905.

Figure 39. Long case clock. © RMAH

Figure 40. Secretary cabinet. © RMAH

The museum houses two typical lacquered English pieces of furniture, a longcase clock and a secretary cabinet (Fig. 39 and Fig. 40). They both were acquired in the 19th century by the sisters Godtschalk and legated to the museum in 1905. No information on their prior history is known but they could have arrived in Belgium (then South Netherlandish Countries) already in the 18th century as indicated by Brussels' newspapers of the time making publicity for products of English provenance. Very little studies on English japanned furniture of the 18th century other than general comments are available today. One maker of lacquer working in London, Gilles Grendey, is however known thanks to important archival data that were first published in 1935 (Symonds, 1935 ; Ordoñez Goded, 2011). His most famous ordering was for the Duke of Infantado in Spain. He supplied a suite of over seventy-seven pieces of furniture with scarlet red lacquer and chinoiserie decoration in the late 1730s. This suite was exposed in the castle at Lazcano (Fig. 41) in northern Spain probably after 1884 but partially sold in the 1930's.

Figure 41. Interior of the castle of Lazcano.

Some pieces attributed to him are in prestigious museums (V&A, Chicago Art Institute, MET). On the art market, items supposedly coming for Grendey workshop recently attained very high prices. A chemical and technical research of four items signed or attributed to Grendey owned by the Metropolitan Museum of Art was presented during the ELinC conference in January 2018 and was published in the postprints (Silverman, Rizzo and Caro 2019).

The longcase clock of the RMAH museum is from this same tradition of English japanning but of a bit later date and has a blue lacquered background instead of a scarlet red one as for the renowned examples of Grendey exported to Spain. The clock would be of a later date but still from the period of activity of Grendey. It is comparable to quantities of other longcase clocks, most of them being from London or attributed to a Londoner lacquer workshop or at least English of the 18th century. For the joinery of the case, its profile and molding, the long case clock of the RMAH shows many striking similarities with a clock kept at the Art Institute in Chicago Inv. C.1770. The two cases probably come from the same joinery workshop. The lacquer decoration of the two clocks is also comparable but presents some stylistic disparities.

The bureau secretary kept in RMAH is also a testimony of a type of lacquered furniture that was produced in London since at least the 1730s. The style of the lacquered decoration shows direct connection with other lacquered pieces of furniture coming from London, and more specifically with Londoner bureau secretaries, but the piece of the RMAH shows a stylization, and also a clumsiness in the representation of some scenes, that lead to think to a late date in the 18th century or even to the beginning of the 19th century.

The long case clock and the bureau secretary were in restoration at the University of Antwerp during the project. The first results on the bureau secretary were already published in 2014 (Saverwyns et al. 2014). Results of the deeper interdisciplinary research during ELinC are still to be published.

- **Two *secrétaire en pente*, of supposedly French origin**
  - *Secrétaire en pente*, with two rows of drawers (Fig. 42), inv. V.0015, probably Paris, probably first half of the 19th century, 93 x 76,5 x 43 cm, Vermeersh legacy of 1911.
  - *Secrétaire en pente* (Fig. 43), with no inventory number, double stamp of I.P. Latz. Probably Paris, unoriginal lacquer decoration from the end of the 19th century or of the beginning of the 20th century.

Figure 42. *Secrétaire en pente*. ©RMAH

Figure 43. *Secrétaire en pente*. ©RMAH

Two lacquered *secrétaire en pente* are kept in a storage room of the RMAH. One has two rows of drawers instead of the more habitual formula of one row of drawers. Without taking the lacquered decoration into account, the design of the two secretaries would tend to designate pieces of furniture of the time of Louis XV of France.

The secretary V.0015 was restored at the University of Antwerp. According to the technical study and the report of treatment, all the nails, locks and handles are of 19th century making. The inscription "Paris" incised on the locks tend to indicate a French provenance. The lacquer decoration with raised and flat chinoiserie decoration is the original decoration. The inspiration clearly comes from Chinese lacquers of the 18th or the 19th century. The decoration recalls English models of lacquered chinoiserie more than French examples. A possibility would be a fabrication in Paris by English artisans. Records of makers of lacquer with Anglo-Saxon names active in Paris were found in French printed sources dating of the end of the 1810's until the 1840's (Decq et al. 2019). According to chemical analyses published in 2014, there is no contradiction for a dating in the first half of the 19th century (Saverwyns et al. 2014).

For the other secretary, a double stamp was found on the lower edge of the front panel: "I.P. Latz". Jean Paul Latz (1691-1754) is one of the great commode makers of the period of Louis XV of France. Native of the region of Cologne, he arrived in Paris in 1719. He is known for the very high quality of his marqueteries and bronzes. The originality of the stamp on the secretary of the RMAH is doubtful even if nothing could infirm or confirm it (contacts with a specialist of Latz in Dresden were taken). The work of the wood and the assembly could be of the 18th century but also of a later date.

The inspiration for the landscape on the foreground of the lacquered decoration would be Japanese while the landscape in the background with an open perspective would be Chinese. Analysis done in 2014 and during the ELinC project confirms that the lacquered decoration dates from after 1883 (Saverwyns et al. 2014). No other finishing layer was found underneath this lacquer.

The secretary would deserve a study with radiography and technical drawing since historical repairs and historical re-using of pieces of furniture is an interesting subject of study as pointed out during a seminar hold in Paris in 2016 (*Reconstruire les techniques et les savoir faire d'ateliers, Vernis, laques & pigments*, Thursday 12 May, 2016, Paris, Centre Alexandre Koyré).

- **Black lacquered furniture and decorative objects with mother-of-pearl decoration, 19th century, England (Fig. 44)**
  - Guéridon, inv. M. 69, H. 72,5 cm. England, 1840-1850. Acquired in 1977 from Mrs Oostens-Polet for the decoration of the hotel Bellevue, at the request of the curator Ghislaine Dervaux-Van Ussel.
  - Gondola chair, M.70, h. 88,5 cm. England, 1840-1850. Also acquired from Mrs Oostens-Polet in 1977 for the Hotel Bellevue.
  - Chairs, M73 and M74. England, 1840-1850. Unknown provenance, probably also acquired in 1977.
  - Letter case, M.71, England, 1840-1850. Acquired in 1977, from the haute couture house Wittamer-De Camps for the Hôtel Bellevue.
  - Fire screens M.72a and M72b, England, 1840-1850. Acquisition in 1977 from Wittamer-De Camps house, for the Hotel Bellevue.
  - Glove box. Bi146, England, 1840-1850. Acquisition in 1977 (from the Wittamer-De Camps house), for the Hotel Bellevue.
  - Pairs of turned wooden chairs in black lacquer, M75 a and M75b, probably French. 1850-1900.
  - Turned turned wooden chairs in black lacquer, M76, probably French. 1850-1900.

Figure 44. Black lacquered furniture and decorative objects with mother-of-pearl decoration in the collection of the RMAH. © RMAH

This set of 19th-century furniture in black lacquer, on papier-mâché or on turned wood, has been subjected to an in-depth observational, historical and chemical study (see also higher). The group includes four black lacquered pieces of furniture, two hand screens, one glove-box, all in papier-mâché with integrated mother-of-pearl decoration, and three black lacquered wooden chairs (two of which forming a pair) (Derveaux- Van Ussel 1979 : 82 (cat.62, with ill. p.94), 84-85 (cat.68, with ill. p.95)). The papier-mâché items with mother-of-pearl decoration form a homogeneous group that can be dated around 1840-1850 while the wooden chairs are stylistically distinct and would be of the second half of the 19th century. The objects were acquired by the museum in 1977 from at least two private collectors to decorate the hotel Bellevue in Brussels, which was attached to the Royal Museum for Art and History from 1977

until 1998. Historical data to determine their country of origin and place of original acquisition are absent.

Several museums including the V&A museum and many others in Great Britain, the museum *Au Fil du papier* of Pont-à-Mousson and the *Musée des arts décoratifs* in Paris do have a large collection of lacquered objects decorated with of mother of pearl, gilded and painted decoration dating from the middle of the 19th century often from unknown origin (Jones, 2012, pp. 278–279; s.n., 2008, pp. 64–66). As for the series of black lacquers with mother of pearl kept in the RMAH, many of the objects are decorated with floral arrangement which could have been influenced by the Nagasaki style in Japan (Impey and Jörg, 2005, pp. 209–227; Papist-Matsuo, 2016, pp. 116–121). Some decorative details recall the Japanese Namban lacquers of the 17th century (Kopplin 2010, 84). In the absence of a manufacturer's mark or a scientific analysis of the japan varnish found on contemporary examples from each country, it is often difficult to distinguish the products of one country from another, and attributions are largely based on stylistic grounds alone.

The model of the turned wooden chairs (M75a, M75b and M76) would rather appear to be French. This type of chair was introduced in the 1830s and was produced in large quantities in the second part of the 19th-century in France. Similarly constructed but stylistically different chairs, were made also in England (Payne 2013, 172, upper right figure). Although made entirely of wood, their decoration and general appearance resemble the objects in papier-mâché.

The research on these objects was published in the postprints of the ELinC conference. It benefited from the fine contribution of Yvonne Jones, the specialist of English japanned papier-mâché and tinware (Jones, Y. Japanned Papier Mâché and Tinware, c.1740-1940. Woodbridge, Suffolk: Antique Collectors' Club Ltd.. 2012).

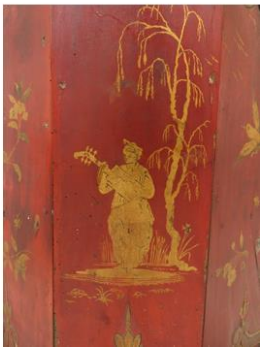
- **Carriages, hypomobile, sledges**

Worth to study as well are some of the many black carriages of the large collection of the RMAH. According to Catherine Rommelaere, specialist of the Belgian hypomobile, none of the carriages kept in RMAH were still carrying their original coating of black lacquer. All of them had been carefully stripped and relacquered for the occasion of special events. Samples could only testify of later coatings. On the contrary, many sledges still have their original decoration, sometimes covered with an overpainting. A technical and chemical study was undertaken on some of them (see higher). The sledges TR.41, TR.88, TR.1868 were particularly interesting (Figure 45).

- Sledge in C, inv. Tr. 41, France, 212 cm x 102 cm x 125 cm, Louis XV style, by 1750.
- Sledge, inv. TR. 88, 116 cm x 179 cm x 88 cm, second half of the 18th century, Liège.
- Sledge,TR.1868, 130 cm x 153 cm x 98 cm, 18th century

Table XI. Overview of some of the lacquered sledges in the collection of the RMAH, studied within the project.

 © RMAH  ©RMAH	The original lacquered decoration of sledge inv. 41 is hidden by an overpainting. Gilded sunrays on a green almond underground are however still visible in the lacunas. The Louis XV style of this decoration matches with the gilded carved rococo frame. The sunrays are made of gilded metallic particles glued on the background. The technique is called *aventurine*. The relief of those particles is quite thick and is clearly perceptible under the overpaint.
  © RMAH	The surface of the panels of Sledge TR. 88 is covered with a lacquered imitation of tortoiseshell and a large strip representing a frieze in grisaille. The ornamental grisaille frieze shows figures of antiques dogs evolving in large foliate scrolls animated with dogs, fishes and grotesque masks. The shadows of the volumes are represented in order to give a *trompe l'œil* effect of a carved relief.
 © RMAH	Sledge TR.1868 is described in the archives of the RMAH as coming from Antwerp. The red background is animated by a chinoiserie decoration. A scene of gathering with two Chinese women provided with a small net is represented on one side. One the other side, a woman holding an umbrella leans toward a sitting man accompanied by a dog. On one of the two front panels, a female musician plays a stringed instrument with a rectangular sound box (a Chinese pipa ?) The figures are arranged in Asian landscapes with scattered

  ©RMAH	threes, rocks, fences, plants and birds.

- **Commode and *meuble d'appui* of French origin**
  - Commode, inv. 9449, France, Charles Joseph Dufour, 84 x 140 x 53 cm, walnut three, oak, rosewood, stamped « C. I. Dufour » and three times J-M-E-, the warranty mark of the Parisian "Jurande" of the cabinetmakers.
  - Support furniture (*meuble d'appui*) with only one door, inv. M.16, 133 x 87 x 49 cm, unknown provenance, France ? 18th century for the frontal panel and 19th century or later for the piece of furniture. Painted scene on a gilded background: Venus lying on a chair before a shell, winged putti, and rococo painted framing around the scene. The great arms of France and Navarra carried by winged putti are not original.

Some pieces of furniture dated of the 18th century are good witnesses of the practice of reuse of already existing lacquered panels of Asian or European provenance. They were not selected for further chemical or technical studies because of their many overpaintings and their poor state of conservation (M.016) or because the lacquered panels were of Asian origin (inv. 9449).

- **Collection of preciosa** (Fig. 45)
  - Toilet bag, inv. G. 1348, Paris, ca. 1775, Godtschalck Legacy of 1905. Lacquered metal, raised chinoirerie decoration on red background.
  - Toilet bag, inv. 7618, Paris ca. 1775, purchase in 1944 from Miss Potvin. Lacquered metal, raised chinoirerie decoration on bright blue background.
  - Toilet bag, inv. V.2880, Paris 1756-1762, Vermeersch donation of 1911. Lacquered papier mâche, bordeau background, painted country scene with a young shepherd and a billy goat on one face and a windmill and a horse on the other.
  - Needle case, inv. G01388, Godtschalck Legacy of 1905.Lacquered papier mâché with painted miniature, shepherdesses and shepherd playing a flute in a county landscape.
  - Needle case, inv. G.1389, Godtschalck Legacy of 1905. Lacquered papier mâché with painted miniature, county landscape with small figures and constructions in the background.
  - Small round box (bonbonniere of tobacco box), inv. G.1281, Godtschalck Legacy of 1905, tavern scene, lacquered papier mâché.
  - Small round box, inv. 8120, France 1755. Lacquered papier mâché, three putti eating grapes and drinking wine.
  - Small round box, inv. V.2799, France 19th century, Vemeersch donation of 1911. Scène galante, lacquered papier mâché.

- Tattingshuttel, inv. G.3111, 1750-1800, Paris, Godtschalck Legacy of 1915, wood, black lacquered background, raised chinoiserie decoration imitating Japanese lacquers. On one side fishing scene with two figures, on the other side, two figures in a hamlet of fishermen by a lake.

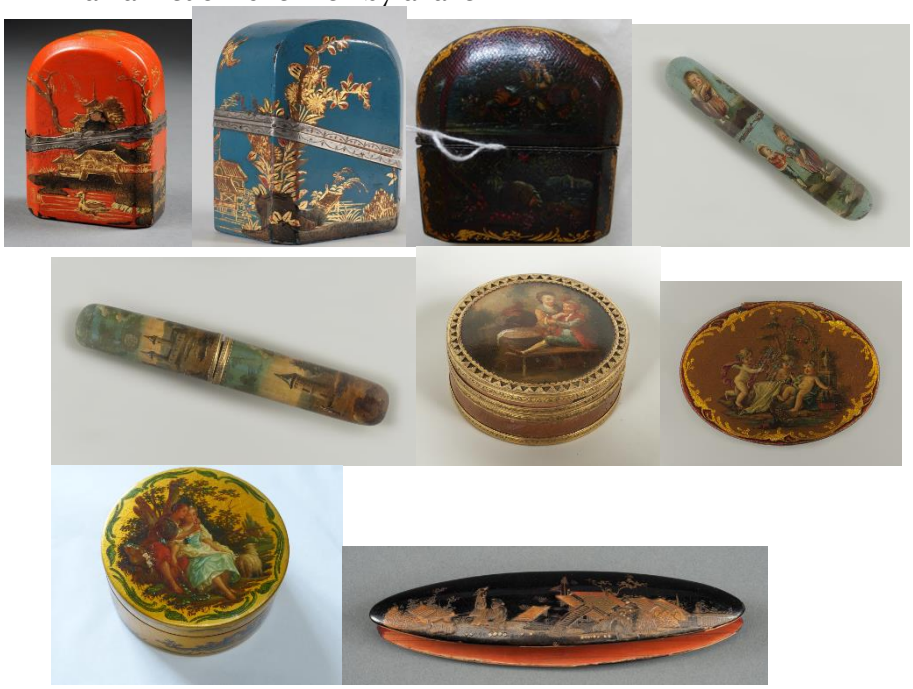


Figure 45. Collection of preciosa of the RMAH. © RMAH and RMAH, D. Steyaert (G.01388 and V. 2799)

For the collection of the 18th century preciosa (Fig.45), some pieces of the RMAH are very similar to some that were presented at Paris in 2014 at the *Musée des arts décoratifs "Le secret de la laque française"* (2014). A technical and chemical study was published in the catalogue of the exhibition alongside the art-historical research. Some pieces of the RMAH are so much alike that they can be considered as coming from the same workshops. Other seemed 19th century imitations of 18th century genuine pieces (inv. V.2799). But whatever the case, because no samples could be taken from these precious objects for obvious reason of conservation, the research on the lacquered *preciosa* was not deepened.

- **Musical instruments**
  - Harp, inv. 0246 (Fig. 46), France, c. 1800, Cousineau Father & Son. Lacquered wood without background, decoration of Chinoiserie in relief.
  - Harp, inv. 4420 (Fig. 47), London, 1801-1850, J.& J. Erart. Black background, gilded decoration with antique figures (*transfer printing*, Jones 2012,p.64)
  - Piano droit (Fig. 48), inv. 2003.021, Jean-Baptiste Oor (1846-1940), Bruxelles, c. 1900.

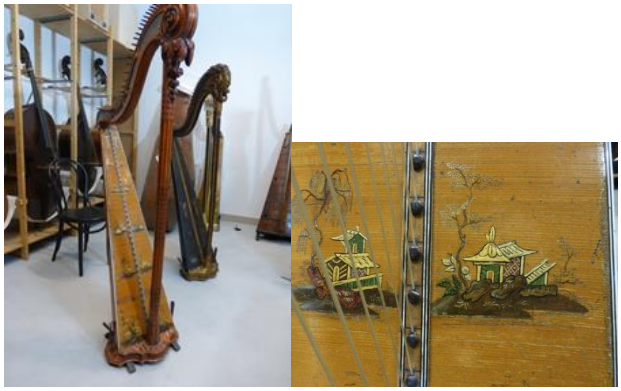


Figure 46. Harp, inv. 0246. © RMAH, D. Steyaert

Figure 47. Harp, inv. 4420. © RMAH, D. Steyaert

Figure 48. Piano droit, inv. 2003.021.© RMAH, S. Egan

The sections of the Musical instrument museum (MIM) were also investigated during the inventory. Two harps, one by the firm Cousineau, and the other by the firm Erart, were selected for their rich lacquered decoration but not further analysed. Cousineau Father and Son from Paris, and J. and J. Erart in London are well known maker of string instruments of the end of the 18th and beginning of the 19th century.

The piano dated around 1900 (inv. 2003.021) shows, on top of his lacquered covering, a surprising additional lacquered decoration with flat and raised chinoiserie. The decoration must have been executed by a professional or a very skilled amateur most probably on ordering by the owner rather than by the fabricant of the piano. The maker of the piano, Jean-Baptiste Oor, opened a piano factory in Brussels in 1871. Although he won various prices at the universal exhibitions, his pianos are considered as of medium quality contrary to those of his son Lucien Oor (1877-1949) renowned for their better quality. The lacquered decoration seems to date from the period of the fabrication of the piano (c. 1900) and was chemically characterised.

In the decoration of this piano, masculine and feminine figures of Chinese musicians, go players, dancers, walkers, drinkers of tea, children, evolve in an Asiatic garden with pavilions, rocks, trees, plants, cranes, birds of prey, peacocks, rivers bridges, fences. The decoration seems inspired by black and gold lacquered Chinese screens without copying it.

The black lacquer of the piano is damaged and shows a leather aspect: it has lost its gloss and has a crackled surface.

- **Ceramic, lacquered Delft stoneware** (Fig. 49)
  - G.674
  - G.675 A & B

Figure 49. Lacquered Delft stoneware in the collection of the RMAH. ©RMAH

The collection of ceramic of the museum has a set of three very interesting Delft stoneware vases of the 18th century whose blue decoration was completely covered with a black lacquer decoration at a previously unknown date (Fig. 49). The black lacquer coating is animated with a painted and gilded decoration that stands in an unusual quite strong relief against the black background. Vase G. 674 has a particularly rich ornamentation with Chinese figures of men of different status and children in a landscape of rocks, trees, a small pavilion. The scene is surrounded in the base and the top by large flowery branches of peonies. The vases G.675 A&B are very similar to G.674 but only with plants and rocks without any human figure or construction. A bird with big red and black eyes is represented on vase G.675B. These three vases can be compared with two black lacquered porcelain vases that were studied for an exhibition in 2003 (Kopplin 2003, p. 42, cat. 9a and 9b, notes written by Eva Strober**).** Both vases, that are in Het Princessehof, National Museum of Ceramics collection in Leeuwarden, show a decoration of red and white peonies and a big bird that stand against a black lacquered background. The two vases are lacquered only on one half. The other half is invisible when the vases stand against a wall. The vases of the RMAH are fully lacquered.

Lacquered ceramics were produced in China and Japan as well. The *Staatliche Kunstsammlungen* in Dresden has a very important collection of Arita and Irami porcelain and of other proveniences of around 1700 that testify of this industry (Eva Strober, `Chinesche und japanische Porzellane mit Lackdekoren in der Dresdener Porzellansammlung`, in Kopplin 2003, p. 27-43).

- **Spa woods**
  - Inv. 2013.010.001, Spa between 1735 and 1750
  - Inv. F4773, Spa, 2nd half of the 18th century
  - Inv. F. 11774
  - Inv. 2013.010.002 Small box with flowers in Louis XVI style,2nd half of the 18th c.
  - Inv. F.011.324
  - Inv. F.3992

Among the RMAH collection of *bois de Spa*, some of them attracted attention because they were of the 18th century or because they presented a particularly interesting decoration. Box F4773 with its scene inspired by Teniers paintings painted with a feather in Indian ink on a pale background is representative of a type of box that was made in Spa in the 18th century (de Moerloose 2018). Unrestored as it was, it could be sampled for chemical analysis. Inv. 2013.10.1 is another 18th century box fitting into our research. Despite it was completely overpainted on its exterior, box Inv. 2013.10.1 was representative of the items with chinoiserie decoration that were made between 1735 to 1750. It served as starting point for a more general research on *bois de Spa* with chinoiserie decoration from 1689 to the third quarter of the 18th century.

5.3.2 Lacquered bois de Spa with Chinoiserie decoration from the end of the 17th century to the third quarter of the 18th century

As explained in the part Methodology, thirty Spa boxes with chinoiserie decoration were studied. Seventeen were chemically analysed. On one hand, archive and historical printed sources were consulted in order to gain new information on makers of lacquerware and on the context of production. On the other hand, it was also important to make a stylistic and iconographical study to better understand the evolution of the *bois de Spa* with chinoiserie decoration.

- Some makers of lacquer in Spa

The accounts of the mayors form the richest sources of information on the names of local makers of lacquer. The first known mention of Spa lacquer imitating Asian examples is dated 1689: 'bought for Rousseau, manufacturer of varnish, two boxes in varnish of China'. The same year, Mathieu Xhrouet is paid for a mirror frame in 'varnish of China'. From 1703, the specification 'of China' disappears from the lists of the mayors in favor of the more general qualification 'varnished', 'in our varnish of Spa' or in the term 'vernis à la mode', suggesting that they started to consider the method of lacquering as a general part of craftsmanship in Spa. It became thus difficult to understand the type of decoration made by the maker. The colour of the background could give some indications. Items described as black, red, blue or red tortoiseshell likely refer to lacquered objects with chinoiserie decoration. 'White porcelain' can refer either to white lacquers with chinoiserie decoration or to lacquers with Indian ink drawings of purely European inspiration.

Although the *Amusemens des eaux de Spa* of 1734 indicate that most of the inhabitants of Spa were involved in the production of *bois de Spa* (Anon. 1734, 179), not more than around forty names were counted in connection with the production of bois de Spa or the more general activity of painting and drawing in Spa for the period studied. However, in the absence of signatures or workshop related marks, and the lack of precise descriptions in the archival documents, we have avoided linking any of the *fabriquants de vernis* listed here with any of the studied boxes.

As explained above, Hubert Rousseau (1647–1702) and Mathieu Xhrouet (1647–1721) are the earliest known artisans to be recorded as making lacquerwares with chinoiserie decoration in 1689. Both were also making wooden items with mother-of-pearl decoration (Body 1898, 23, 25, 48–50). *Bois de Spa* in bare wood with mother-of-pearl decoration were produced in Spa since as early as the 1630's. They were made till the years 1730's.

Gérard (1660–1715) and Jacques Dagly (1665–1728), natives of Spa, are the two brothers who made an international career as lacquerers in Berlin and Paris starting from 1686/87 to 1689, respectively (Wolvesperges 1995; Kopplin 2015). However, they are not known as having produced lacquerwares in Spa. The present research helped to clarify the role of other members of the Dagly family working in Spa within the field of lacquering. The most important of the Dagly active in Spa, is certainly their cousin Nicolas Dagly (1651–1736) who was living at the White Pigeon at least since 1709 till his death (Steyaert et. al. 2019). He produced items described as 'in varnish' from at least 1703–1704. He was cited in *Amusemens des eaux des Spa* of 1734 as the best maker of varnishes and as having a peculiar taste for chinoiserie decoration: "Dagly at the White Pigeon made the best varnish, resisting fire and water. This last person had a peculiar taste for fruits and figures of China and Japan that he was making in the most perfect manner, whether flat or embossed." (Anon. 1734, 178)

According to a notarial deed dated 6 December 1731 Nicolas Dagly was then assisted by his wife Catherine de Coo (died in 1737) and their elder son Jean Dagly (1680–1737). Dagly and his wife bequeathed their workshop to Jean to thank him for assisting them in their craft (Body 1898, 67–8). Body mentions one recipe for lacquer found in an old ledger in connection with this notarial deed. Since this 'old ledger' is now lost, there is no proof that the recipe came directly from Nicolas Dagly. The importance of this recipe is however taken well into consideration for the chemical and technical study.

Charles Dagly (1688 – after 7 December 1739) was the second son of Nicolas Dagly. In 1717 representatives of the tsar of Russia ordered a wooden paneling from him to be decorated with black varnish 'worked in the manner that is done in Spa' and 'intermingled with mother of pearl' intended for the ornamentation of a palace in Russia (Body 1898, 55–7). During our research it was found that Charles Dagly had sold Spa lacquerware as a burgher merchant of the city of Aachen since at least 1724. Thus, Charles was most certainly the Dagly who was said to work in Aachen in the *Amusements des eaux d'Aix-la-Chapelle* (Anon. 1736, 241–242). He was still in Aachen in 1739, as testified by a note in which he asks Jean le Drou (1710 –?), a 'vernisseur' in Spa, to pay a debt (Steyaert et al. 2019). According to this last document, metallic powders were sent by Charles Dagly to le Drou in Spa for the execution of cases: '4 packets of yellow powders', '2 packets of straw' [?] and 'one packet of silver powder'. The packet of straw ('palle' in French) might correspond to metal sprinkled particles to decorate the lacquer. This document proves to be important since most of the boxes studied for this project have chinoiserie decoration made with metallic powders and sprinkled metal particles. It is significant that they were sent by Charles Dagly from Aachen since the best metallic powders and particles reputedly came from Nuremberg in Germany. It also confirms what the Amusements des eaux d'Aix-la-Chapelle says about Dagly in Aachen, that he was in fact solely selling boxes from Spa and not varnished items made in Aachen, as was claimed.

A certain Elisabeth Hurlet and her son Jean Lemaire were active in Spa in the 1720s and the 1730s. After the death of her husband Pierre Lemaire in 1715, Elisabeth Hurlet (1680–1741) was left with three young children. As revealed by archive documents, she sold bois de Spa from at least 1725 to 1732 (Steyaert et. al. 2019). The notes in her handwriting mention card game boxes ('cadrille'), toilet sets ('assortiment de toillette' 'garnitures de toillette'), powder boxes ('boitte a poudre'), brushes ('brousse') and small cases ('etuis') in white porcelain, tortoiseshell and red colours and painted imitation of materials that might refer to lacquered

bois de Spa with chinoiserie decoration. Her eldest son Jean Lemaire (1705 – after 1733, 1734?) was making the same type of Spa lacquer as indicated by a note dated 1733 (Steyaert et. al. 2019).

For the period after around 1735, information on bois de Spa in the lists of the purchases of the mayors decreases drastically. The Nouveaux *Amusemens des eaux de Spa* published in 1763 no longer give any name of a maker of lacquerware. Information can still be found in notaries' deeds and old manuscripts written in the eighteenth and the nineteenth century that are archived at the Body Fund in Spa.

For the period after 1750, Jean Gernay (1719–1791) became one of the most important makers of lacquerwares in Spa after his return from Paris in 1756. He was renowned for his very fine paintings in ink on white background but also made lacquerwares with chinoiserie decoration (Body 1898, 93; Paquay, Robert. 1976. "Peintres, décorateurs, tabletiers, tourneurs et autres artisans de 1750 à la Révolution." *Histoire et archéologie spadoises. Musée de la Ville d'Eaux, Villa royale Marie-Henriette, Spa, Bulletin trimestriel*, 7 : 15-26; Kopplin 2005, 170).

- The boxes and their decoration

The lacquered objects studied, dating between the end of the 17th century and the third quarter of the 18th century, were divided into four stylistic periods. An overview of a selection of twenty-three *bois de Spa* is given is given in figure 50.

Figure 50. Overview of 23 objects commented on in this report, classification per period. The numbers refer to those given in Table XII. Photographs are by D. Steyaert ©RMAH except for Box 4: © Tomasz Samek; Box 19: © RMAH and Box 21: © Monique Noé.

No analysis of the wood was undertaken, but observations during this study tend to confirm earlier observations that the indigenous beech was indeed used (de Moerloose 2018). In our selection, all joints are made of rabbets, secured by 1 to 3 small wooden pins with a diameter of 1 to 2 mm., depending on the box size, and glued with a proteinaceous glue. For the period

from the middle of the seventeenth century to c. 1825–1835, de Moerloose also indicates flat seal joints for small boxes (de Moerloose 2018, 186).

Bronze ornaments for keyhole plates and hinges are imitated in the lacquer decoration. The decoration at the sides typically crosses the joint between body and cover of the box, which was not yet the case for the boxes with mother of pearl inlays made previously. This novelty can be only explained by the influence of Japanese lacquers.

Table XII. Overview of the boxes discussed in this report.

Table 1. Overview of most of the boxes discussed in this article. MVES: Musée de la Ville d'Eaux, Spa; IAL: Institut archéologique liégeois, Liège; PC: Private collection Barbara Piert-Borgers and Walter Borgers; RMAH: Royal Museums of Art and History, Brussels; MGCL: Museum Grand Curtius, Liège; MWL: Museum of Walloon Life, Liège.

No.	Loc.	Inv. no.	Description
Period 1			
1*	MVES	B0009	Black box. Oriental landscape with a female figure with feathers, metal powders and sprinkled particles. Red interior (non-original).
2*	MVES	B0006	Black box. Oriental decoration, European woman and Indian man, metal powders and sprinkled part (largely overpainted). Black interior with metal sprinkled particles (original).
3	IAL	I/7122	Black *Quadrille* card game box with 5 small boxes for counters. Oriental landscape with Chinese figure, metal powders and sprinkled particles. Black interior, metal sprinkled particles, small boxes of different colours (red, ivory, beige, green, dark green).
4	PC		Black box. Oriental landscape with David and Goliath, metal powders and metal sprinkled particles. Black interior, metal sprinkled part of rectangular shape.
5	PC		Red tortoiseshell writing case. Oriental landscape with a man dressed with feathers and a woman, metal powders and sprinkled particles. Black interior, metal sprinkled particles.
Period 2			
6*	MVES	B0235	Blue box. Oriental landscape with one figure, metallic powders. Black interior with metal sprinkled partides.
7*	MVES	B0012	Blue box, small. Oriental landscape, metal powders (original with small touch up from restoration). Black interior with metal sprinkled part (overpainted).
8*	MVES	B0030	Pale blue box. Oriental landscape with an European couple on a terrace, painting. Red interior, metal sprinkled particles.
9*	MVES	B0278	Black card game box with 4 small boxes. Oriental decoration with a woman playing *pipa* and a Chinese loving figure, metal powders. Rose interior, painting and silk.
10*	MVES	A0046	White small round box, floral design, painting. Black interior with metal sprinkled particles (overpainted).
11*	MVES	B0007	Brown tortoiseshell box (writing box). Oriental landscape with two 'Chinese' figures, metal powders (revarnished). Black interior, metal sprinkled particles.
12	IAL	I.9420	Black box. Oriental landscape with two European figures possibly influenced by black Delft earthenware, metal powders. Back interior, metal sprinkled partides.
Period 3			
13*	MVES	B0016	Black *Quadrille* game box with 4 small boxes. Two oriental figures in a *rocaille* decoration, metal powders and painting. Black interior, metal particles.
14*	MVES	B0015	Black *Quadrille* game box with 4 small boxes. Two Chinese figures in *rocaille* decoration (restored, revarnished). Black interior, metal sprinkled particles.
15*	MVES	B0018	Black *Quadrille* game box with 4 small boxes. Two Chinese figures in a *rocaille* decoration, metal powders and painting (restored, revarnished). Red interior.
16*	MVES	B0211	4 small black boxes of a *Quadrille* game box. *Rocaille* decoration, metal powders and painting.
17*	MVES	B0013	Red tortoiseshell box (writing box). Two Chinese figures in a *rocaille* decoration, metal powders and painting (restored, revarnished). Red interior.
18*	MVES	B0017	Red tortoiseshell box, two Chinese figures in a *rocaille* decoration, metal powders and painting. Black interior.
19*	RMAH	2013.010001	Box (red tortoiseshell?). Two Chinese figures in a *rocaille* decoration, metal powders and painting (overpainted). Black interior with metal sprinkled particles (original).
Period 4			
20*	MVES	B1077	Black perfume box. Flowering bushes in a *rocaille* decoration, metal powders and painting. Interior garnished with rose velvet.
21*	MVES	B0028	Black *Quadrille* game box. Oriental decoration, painted composition of playing children.
22	MGCL	8/159	Blue writing case. Scene with two Chinese figures sitting at the table, a parasol held by a third figure, pots and exotic landscapes on the sides, metal powders. Black interior.
23	MWL	5015759	Red tortoiseshell base of microscope. Two Chinese figures with a bird and exotic landscapes, metal powders and sprinkled particles.

*: subjected to chemical analysis.

- *Period 1, from the end of the 17th century to the beginning of the 18th century, the influence of Japanese lacquer*

The first known lacquered boxes seem to have been directly influenced by Japanese lacquers (Fig. 50, Boxes 1–5). Slightly bulging lids are a new development with regard to the domed top form for the wood boxes with mother-of pearl-inlays that were already produced in Spa (Canoy 1990, 11). Most of the boxes have a carved border of 13 to 20 mm wide, decorated with gilded ornamental friezes. Four boxes are covered with black lacquer, such as Box 3, which is a very early example of a game box for the card game called Quadrille. It contains five boxes for counters that are bright orange-red, cream white, beige, pale green and dark green (Fig. 51). The

imitation red tortoiseshell in Box 5 was highlighted in matte red at a final stage, a rather unusual feature that gives the box a very vivid appearance (Fig. 50).

Figure 51. Box 3, Quadrille box open with the five little boxes for card game counters. © Ville de Liège (big open box at the left).

The compositions on the top of the boxes share many iconographic details that are placed a bit differently from one box to the other. The large trees and the small isles with the pavilions are direct copies of Japanese export lacquers that are today dated 1680–1730 (Impey and Jörg 2005; Papist-Matsuo 2016). The decoration at the sides of the boxes with either 'Japanese' isles or simple flower bushes and flying insects is again clearly inspired by Japanese examples. In contrast, the ornamental lattice fence, represented on most of the boxes of this period, seems inspired by Chinese Coromandel lacquer or export porcelain. The ornamental motifs of these lattice fences are however of European fashion (Fig. 52).

Figure 52. Box 1, detail, decoration with metal powders and sprinkled metal particles. © D. Steyaert

The scene with David and Goliath on Box 4 is unique in the corpus. Men and women dressed as Indians with feathers on their hips and heads can be seen on several examples (Boxes 1, 2, 5). This suggests that the Japanese lacquers that the Spa manufacturers could have seen – certainly small artefacts such as dishes, teapots, vases or boxes – were likely devoid of human figures. A Chinese figure is represented on large scale on Box 3. Metallic powders and sprinkled metal particles (small metallic fragments), of different colours, sizes and shapes are applied

either on embossed surfaces or on flat surfaces. The metallic surfaces can be locally modulated by glazes. Effects are also given by a variation in the density of the metallic applications.

The interiors of the boxes are covered by a uniform black lacquer decorated with sprinkled metal particles.

- *Period 2, first decades of the 18th century, assimilation of Eastern influences*

While the number of workshops in Spa making lacquerwares increases, production becomes more heterogeneous, and along with it, there is also a variation in quality (Fig. 50, Boxes 6–12). Black boxes remain common, but imitation of tortoiseshell backgrounds appear more frequently. Boxes are also bright blue or pale white-bluish (Boxes 6–8). The main composition on the lids' top is no longer surrounded by an ornamental border as in period 1. It occupies the whole surface, sometimes with a decoration on the corners of typically Asiatic motifs of shippo (Box 8). The representation of Asiatic figures, mostly Chinese or Mongols, starts to be more convincing, even if not corresponding to an exact model, and with types of clothes with diverse provenances (de Moerloose 1987, v.1, 106). Flower bushes on the sides are from then on a common characteristic of all of the boxes (Fig. 53). An effort is first made to vary them in some way, but soon one form of flower bushes with long and elegant stems and a variety of flowers is widely adopted and repeated until the middle of the 18th century.

Figure 53. White-bluish Box 30, front and back side with flowering bushes. © D. Steyaert

As in period 1, metallic decorative effects are still popular for creating scenery such as figures, grounds of the islands, floral and flying wildlife depicted on the lids and sides of the boxes. However, the range of tones of the metallic powders is generally reduced in favour of a gold-like aspect (as in Boxes 6, 8 and 11). Metal sprinkled particles still frequently decorate the inside of the boxes.

Some boxes have a particular decoration. Box 12, for instance, seems to be inspired from black Delft 'porcelain' produced between 1724 and 1740 by the De Metaale pot factory, which imitated Chinese and Japanese porcelains and lacquers (Van Aken-Fehmers 2003, spec. 135) (Fig. 54).

Figure 54. Box 12, detail of the raised and gilded decoration compared to a black Delft earthenware (manufactory De Metaale Pot), c. 1724–1740, Royal Museums of Art and History of Brussels, inv. Nr. Ev. 270 A-E. © RMAH (vase)

Box 9 has many stylistic connections to a large box with a pale bluish background (Box 8) despite the diversity of the technique. For Box 8, the composition was indeed entirely painted and then varnished without any metallic application. A European couple is standing on a built terrace with a staircase. In the black box, number 9, a lady playing a sort of pipa1, a Chinese lute, is accompanied by a Chinese lover, in line with the new taste for gallantries introduced by the French painter Antoine Watteau (1684–1721). Due to the similarity of the exotic landscapes we consider the two boxes to have been made in the same workshop.

Other boxes with pale bluish underground and painted decoration can be compared with Boxes 8 and 9, as two large elegant toilet caskets dated of the middle of the 18th century (illustrations in de Moerloose 2018, 43, 50).

- *Period 3, after c. 1735, chinoiserie in rocaille decoration*

The third phase is characterised by its rococo style (Fig. 50, Boxes 13 to 19). The large number of *bois de Spa* with small scenes of chinoiserie framed by a rich rocaille decoration testify to the great success they encountered. The colour of the backgrounds is mainly black and red tortoiseshell but also vivid red, and blue.

The gilded shells and the grounds are profusely decorated with flowers and also the typical Spa vegetation conceived under the Asiatic influence during the two previous periods (Fig. 55). This vegetation and the flowers are often painted with bright colours, contrasting with the plain gildings, surfaces of silvery and coppery aspect, and metal powdering and shading off effects. The use of metal sprinkled particles is still frequent for the insides but rare on the outside.

Figure 55. Box 18, detail of the central scene with rococo framing. © D. Steyaert

The central compositions are generally reduced to two stiff Chinese figures with a minimum of accessories, separated by one flowering bush or a vase.

Chinese porcelain or porcelain of Meissen by Johann Gregorius Höroldt (1696 –1775) might have been an influence here. The rocaille decoration adopted in most of the boxes seems to have been copied originally from engravings of Gabriel Huquier (1695–1772) after Juste-Aurèle Meissonnier (1695–1750) as for example the project of a canapé for Count Bielinski of 1735 or a table, both published between 1742 and 1748 in the Oeuvre de Juste- Aurèle Meissonnier. Peintre Sculpteur Architecte & Dessinateur de la chambre et Cabinet du Roy (Fuhring 1999, vol. 2, 240, n° 55 and 338, n°51). This collection of engravings contributed to the diffusion of the rocaille style in Europe. The bois de Spa with this type of rocaille decoration could have thus been produced since 1735 but was more probably in the 1740s and 1750s.

- *Period 4, after 1750, French influence*

In this period, an evolution is observed in the rocaille decoration corresponding to the evolution of the rocaille style in general, as shown by Box 20 (Fig. 50) and a tea box in the Victoria and Albert Museum, London (Inv. W.20 & A to G-1914). The colour palette evolves toward intense blue–green or pale yellow even when black and tortoiseshell imitation remained popular options. Entirely painted compositions with chinoiserie decoration inspired from engravings or painted compositions, mainly French, become common in the second half of the eighteenth century (Kopplin 2005, 168, 173–180). Box 21 (Fig. 50) with Chinese children playing in a landscape would illustrate this tendency.

Other types of chinoiserie decoration with metallic applications but without the rocaille frame were also produced in this period as testified by Box 22 (Fig. 50), a blue writing case. This box can be dated 1760–1770, as shown by the composition directly inspired from an engraving of Jean-Baptiste Pillement (1728–1808). The engraving was published around 1760 in *The Ladies Amusement or Whole Art of Japanning Made Easy* by Robert Sayer. The microscope in Museum of the Walloon life ('Box' 23, Fig. 50) dated from 1766 has a lacquered base of fine quality. The figurative scene and landscapes are made with metal powders in golden, silver and copper colours but also with metal sprinkled particles as mainly in the first period (Fig. 56).

Figure 56. Detail of the lacquer decoration on the base of a microscope dated 1766 (Box 23). © D. Steyaert

- Summary of the material, technical and recipe research

Our material and technical research revealed for the first time the methods and materials used by the artisans in Spa. The boxes in endemic beechwood are decorated with metals, and with pigments frequently used in this period such as lead white, lamp black, Prussian blue and vermilion.

The lacquers are in most cases composed of spirit varnishes, combining the ingredients sandarac, Pinaceae resin and shellac, throughout the entire period studied. Other additional resins were found less frequently: larix resin, copal, elemi, and mastic. In light-coloured lacquer shellac was avoided.

The use of spirit varnishes might reflect the high demand for the Spa boxes; using the faster curing spirit varnishes instead of oil-based varnishes significantly increases the production rate. This base composition of shellac, pine resin, and sandarac was widely applied by different workshops and artisans for a variety of lacquer colours on bois de Spa. Since the earliest sources mentioning this rare composition have been found in contemporary German recipe books, one might ask whether the technological knowledge for the Spa lacquer production originated in Germany. Indeed, two Dagly brothers made their careers at the court in Berlin and could have shared technical information with their family in Spa. The historical research also showed other ties to Germany: metallic particles were sent from Aachen to Spa and fully lacquered objects from Spa were sold in Aachen.

The complete research, clearly showing the integrated approach of the art-historical study, recipe research and chemical analyses of a selected number of *Bois de Spa* was published in the special on-line issue of Studies in Conservation as post-prints to the ELInC2018 conference.

5.3.3 Lacquer in Brussels in the 19th century

- **The case a Mrs. Ghiesbreght, a maker and shopkeeper of lacquerwares**

The research in the newspapers, almanac and archives of the city of Brussels allowed to gather biographical data's on Louise Baudelet, wife of Mr. Ghiesbreght, recorded as a producer and seller of imitation of Chinese and Japanese lacquerwares. She is the older daughter of Caroline de Boeck and Guillaume Baudelet a "marchand de Mode", a fashion shopkeeper whose shop was situated in one of the two main commercial streets of Brussels (*rue de la Madeleine*). Guillaume Baudelet died in 1801 while his two daughters Louise and Charlotte were five and two years old. The widow Caroline de Boeck kept the shop until at least 1802 but in 1812 and 1816 she is recorded as a simple needlewoman. She died in 1817. Louise Baudelet is recorded as a teacher in 1835. She started her career of manufacturer of lacquerware in 1835 with the Exhibition of the Products of the Industry in Brussels during which she obtained a medal. In 1836 she married Henri Ghiesbreght, son of a clockmaker and office manager at the Ministry of Justice. A bit less than three months later, she opened a boutique and used the daily papers to announce the new opening.

The shop was located downtown, on the boulevard of Antwerp, in a newly rebuilt area remote from the streets with the luxury shops. The advantage of the area was that it was located very near the *Allée verte* (Green Walk), and also to the first train station of Belgium, that had just been inaugurated. The *Allée verte was* the aristocratic promenade of the good society of Brussels at that time. In 1840, Mrs. Ghiesbreght moved, not far away from there, on the boulevard of the Botanical Garden.

To promote her products and shop she uses the press in an extensive way. Five titles from 1830 to 1860 were analysed. The most interesting information was published in the "*Indépendant*" a daily paper who started in 1831 shortly after the foundation of Belgium and which became one of the most read newspapers in Belgium. Moreover, it attained soon an international audience and by the middle of the 19th century it was red in most of the European capitals thanks to the quality of the international actuality provided by a large network of correspondents.

From September 1836 until December 1842, Mrs. Ghiesbreght publishes a great deal of advertisement for her shop and this mostly for the New Year gifts. Whole long articles on her boutique and activity were also published. They were written by journalists wanting to inform their readers of the best shops in town. We can also wonder if articles were not written by Mrs. Ghiesbreght herself for a price by line, possibility that was given by the journal. Each text introduces each time new information, according to the development of the shop but also to keep the attention of the readers and encourage them to visit the boutique. Mrs. Ghiesbreght has to suffer some competition in 1842 by a certain Mss Ligy. This engenders a real battle by advertisement in the daily press. Advertisements and articles stop completely from January 1843 although Ghiesbreght continues her activity till 1848.

Ghiesbreght participated to the exhibitions of 1835 and 1841. She won a medal of bronze of the first class in 1835 and a medal of vermeil in 1841, the best distinction after the medal of gold. By a system of competition with medals to win, those national exhibitions were organized

to stimulate the development of the industry. They are the ancestor of the Universal exhibitions, the first having being organized in London in 1851 at Christal Palace.

No pieces of furniture nor any objects of her hand are identified yet but it seemed interesting to study the case in a profound way, on one hand because nothing was known about this activity and on the other hand because it gives valuable information on the taste of European lacquer from the 1830's to the 1860's.

Thanks to the advertisements and articles we can have a good idea of what type of articles she was selling. She presented her production as "Imitation of Chinese and Japanese products". She was first selling mostly lacquered tables, "toilettes" supposedly dressing glasses or dressing boxes, "cabarets", many types of boxes, vases of Japanese forms. In her first advertisements she also makes publicity for carpets, fabric to cover sofas, embroidered textile and flowers and fruits in wax and paper. The pieces are described as being in boiled leather, tinplate and wood. By boiled leather we probably have to understand papier-mâché.

In 1837, she advertises as usual for a large range of objects of fantasy for domestic use mainly. They are said convenient for New year gifts but also for tombola. Tombolas were indeed organized for charity. Ghiesbreght proposes herself also for the execution on demand of complete sets of furniture and paintings for sitting rooms in the Chinese genre.

At the exhibition of 1841 in Brussels she exposes 20 objects: articles of fantasy but also pieces of furniture of the king that she was certainly executing on demand. These pieces of furniture were highly prized by the jury and commented with much details. Since 1835, she had thus the time to forge an illustrious clientele. She also developed an activity of restorer of lacquered old items. The old lacquers she had in hand gave her the opportunity to study and reproduce the techniques and designs.

Since the beginning, she claims to reproduce Asian lacquers in an exact way and to take distance with the frenchified imitations produced in Paris.

In an interview of 1841, she pretended that she was in possession of the true secret of the Chinese lacquer, but the one of the good times, before the 18th century, period in which the quality of the Chinese lacquers started to decrease. Ghiesbreght was praised for the very refined execution of the lacquer and the decoration, and for giving the same attention to all items, being of small or great size. Her pieces of furniture and objects are described as picture-furniture for rich and distinguish sitting rooms and of opulent and artistic quality. The quality of the products, the solidity of the varnish, the purity and exactness of the design and the richness of the ornaments are always put forward.

Her shop is described as a real cabinet of curiosity, a real Chinese bazar, one of the most curious shop of the capital. It is so big that one visit is not enough for seeing everything. The prices are said to have been moderate or at last equivalent to the Parisian prizes for simply black lacquered items without decoration. The production addressed to a wealthy clientele but also to less doted purses.

She had thus a great activity. In the official ledgers, no trace of help in the making of her products were found, but according to the catalogue of the exhibition of 1841 she was occupying a quite great deal of workers in and outside her workshop. The workers were executing the bare objects in wood, *papier maché* or tinplate and were preparing the varnishes

and ground colors. Mrs. Ghiesbreght was executing herself the last layers with the design and gilded decoration.

Our lacquer maker had to suffer some competition. English products, mostly tables and objects of fantasy were sold in some English shops of the capital but the offer of English lacquered product seems in fact to rise a bit later than her period of activity at the end of the 1840's and mostly shortly before and after the universal exhibition of London in 1851.

For the exhibition of 1841, she is not the only one to expose lacquered items. There is also a Marie Heris of Brussels who presents a table, a Japanese imitation with an ornamentation in strong relief. In 1847, Mrs. Heris is there again but not our Mrs. Ghiesbreght. Mrs. Heris presents six lacquered items either with Japanese or Chinese painting showing that a careful distinction was made between the two types of Asian lacquers.

The type of black lacquered furniture made and sold by Mrs. Ghiesbreght and made in England, was also produced in France, Germany, the Netherlands and elsewhere, as well as in America and Russia. The set with mother of pearl incrustation of RMAH is of c. 1850. It is certainly English but could have been sold in Brussels in an English shop, as testify by mentions in the newspapers.

During the exhibition of the products of the Industry organized in Brussels in 1847, the objects of the Brussel's exhibitors considered of mediocre quality were compared to the English products. The latter are judged far superior to those made on the continent. That signs the end of the small production of lacquer in Brussels. Meanwhile English exportations of lacquered products in Brussels raise and culminate with the Universal Exhibition of 1851 in London. Frequent arrivals of genuine Chinese and Japanese objects in Antwerp are probably also responsible of the decrease of interest on European lacquer.

- **Lacquer trade in Brussels in the 19th century**

In Belgium, from the beginning of the 18th century, lacquered goods were imported from England. Newspapers of the years 1760 in Brussels make publicity for English product on sale in Brussels. Not much is known of these imports, but in the following century, from 1846 to 1851, the house of Woolbert, a shop of English commodities, 61 rue de la Madeleine in Brussels, was selling among others "delightful tables in papier mâché with incrustations of mother of pearl that imitates beautifully the Chinese lacquer". In 1851, you could find there "a nice assortment of objects for New Year gifts in English lacquer of China, that had just come from England" . In 1851, they were claiming to have just received "a large variety of objects of the Exhibition of London, in inlaid Anglo-Japanese lacquer". The shop closed in 1856.

The main competitor of the house Woolbert in Brussels was Corr Vander Maeren and Company, which had an English warehouse since 1824, at 14 Longue rue de l'Ecuyer, and another shop in Amsterdam. Corr Vander Maeren was selling products of his own large manufacturing concern established in Sheffield U.K. He was selling a great choice of English hardware, including tables and fancy goods in "lacquer of China", "English lacquer of China" or "English lacquer of Japan". He began advertising in 1850, but mostly in 1851, the year of the Universal Exhibition in London. After the exhibition, his products also came from Birminghan .

From 1852, the Mechi house of London was running advertisements in the Belgian daily press for his shop located at Leadenhall street in London. Mechi was selling among others "all the

objects in imitation of the lacquer of China." The house claimed that their shops were "visited by all the foreigners visiting London, and are considered as something that must have been seen when visiting the great metropolis of the trade and industry".

The import of a large variety of English lacquer of early industrial production in Brussels meant important competition with the local specialized production, started in 1835, that lasted at least until 1851. The lacquerers in Brussels working at an artisanal scale were eager to reproduce Chinese and Japanese lacquers and to distinguish themselves from the French and English lacquers.

In the announcements published in the daily press until 1857, mentions of 18th century lacquered commodes or secretaries of presumably French provenance, and already considered costly antiquities, can be found occasionally, but shops did not explicitly advertise for the new, more affordable lacquers produced in France. Establishments such as the shops of M. Guilmard and M. Grousse sold furniture and fancy goods, including lacquered tables, *tables à ouvrages*, tea tables, boxes, writing tables, from unspecified provenience. Perhaps some of those lacquers were produced in Paris.

The serials and news items published in the Belgian press gives also information on the perception of old lacquered furniture versus new European lacquers. The first, which are prized on the market of antiquity, are associated with the aristocracy of the ancient regime while the second are more fashionable pieces of furniture set in luxurious shops or interiors, being in an isolated way or in homogenous ensembles.

The French writer Alexandre Dumas had a *jardin d'hiver* in his house of Brussels « orné de lanternes chinoises, de vases japonais, d'armoires de laque, de yatagans, de cricks et d'armures ». The « armoires de laque » are however probably made up with Asiatic lacquer but could be European. The Alexander Dumas interior corresponds to a taste of the time described in 1834 : « La salle à manger de l'homme riche, aux goûts de poète et d'artiste est un véritable bazar, où il réunit les curiosités de toutes les époques. »

- **Black lacquers with mother of pearl incrustation in the 19th century in Paris**

In Paris, after a period of lull the fashion for lacquerware with chinoiserie seem to reborn by 1829. This taste develops with the influence of England. English furniture that was appreciated for it comfort and considered as more suited to the new bourgeoisie and the reduced fortunes. In contrast with the leading position of France in lacquer production during the 18th century (Dossie, 1764, pp. xvi–xvii), after the defeat of Napoleon at Waterloo in 1815, France was forced to follow a more modest industrial policy. In the first decade afterwards they pursued more protectionist politics. The British Empire took full advantage of this situation and expanded its industrial and political influence throughout Europe (Van Binnebeke, 2015). This sudden increase in British power could explain why, in France, craftsmen started to adopt English styles of pearl decoration, possibly by using imported English technology, craftsmen, or readymade cut-outs of mother-of-pearl(Jones, 2012, p. 51)[8](Jones, 2012, p. 51).

In France, varnished furniture and fancy goods with mother of pearl incrustation were prohibited from importation from 1842 and until at least October 1861 (Decq et. al. 2019). More specifically, wooden tea tables, bookcases, *tables à ouvrage* and *outrages en bois* (such as game boxes, tea boxes, tobacco boxes and sewing boxes), with inlays in ivory, tortoiseshell or mother of pearl, were considered "*tabletterie*" and were thus prohibited . Most probably, the

regulation applied to both wooden and papier mâché items. Similar objects without incrustation but with "paintings in gold" or with "gold mixed with diverse colours" were considered furniture or fine haberdashery and accepted with a tax of 15% imposed. Earlier already, in 1837, specific prohibitions existed, but not for varnished items with inlays. It seems that in 1842 new specifications were needed to react to a changing situation, perhaps as a protectionist response to rising English imports. The restrictions could have supported the development of the imitation of the English products. Earlier already, in 1837, specific prohibitions existed, but not for varnished items with inlays. It seems that in 1842 new specifications were needed to react to a changing situation, perhaps as a protectionist response to rising English imports. The restrictions could have supported the development of the imitation of the English products. However, in a policy of favouring French labour supply, ready-sawn mother of pearl was subject to exorbitant taxes (40 to 100 francs per 100 kg) which was not always the case for raw shells, depending on their type and provenance (2 to 50 francs per 100 kg). In turn, laquer work or items in "Chinese varnish" were taxed at 15% of their value by British customs when exported to Great Britain. In turn, lacquer work or items in "Chinese varnish" were taxed at 15% of their value by British customs when exported to Great Britain.

In the usual absence of manufacture marks and the lack of archives, it is difficult to know to what extent and from when French craftsmen were imitating English products. Some useful elements can be found in contemporary printed texts. In France, according to the catalogues of the exhibitions of the products of the French industry, the production of varnished tinware (*tôle vernie*) never ceased, but lacquered pieces of furniture or fancy goods in wood or in *carton* were present only from 1819 onwards, as we can see from the exhibition stand of William Smith of Paris (Deck et. al. 2019). (s.n., 1819, p. 318). According to the journal *La Mode, revue des modes,* lacquered furniture or fancy goods imitating Chinese lacquers were fully fashionable in 1829. At the same time, English products started to be appreciated for their handiness and comfort, a criterion to which the new lacquered items were responding. In 1834, the printed sources clearly illustrate the importance of japanned furniture and its growing French production. At the French Industrial exhibition, two stands with lacquered items were represented by men and women with Anglo-Saxon names (Messr. Terrot and William, and Mmes. Kesler and Barn) all settled in Paris . The lacquers of Drugeau-Maucher imitated either the English type or the Chinese type. Pearl decoration seemed in vogue in France as in England: a lacquered table decorated with mother of pearl "inlays" and relief was shown, and described as an exact imitation of the Chinese type. Meanwhile, Hérard-Devilliers was said to have developed a new type of inlay in mother of pearl for his imitations of Chinese lacquers. A contemporary encyclopaedia gives additional information on lacquers produced by M. de Villers in Paris. De Villers was making Chinese and English lacquers on wood, tin and *carton,* in which mother of pearl decoration was combined with *gildings* and *colours*. The best objects would be those with only mother of pearl decoration, without any gilding or painting. De Villers was making his black backgrounds with copal or karabé/amber. The mother of pearl was inlaid in the lacquer and not glued on the support with a mordant as is the case for the table and chairs of the RMAH. The aforementioned firm of Jennens and Bettridge had a showroom in Paris, at least in 1839 (Jones, 2012, p. 144). At the national exhibition in Paris of 1839, the Frenchman Osmond won a bronze medal for his furniture imitating Chinese lacquers and then a silver medal in 1844 for a "rich collection of lacquered furniture that reproduces with success the Chinese or Japanese type" . The Japanese type corresponds most probably to lacquers in the Nagasaki style with mother of pearl incrustations and motifs of blossoming trees, flowers, birds

and vine branches. In 1844, Charles Mainfroy, known for making lacquers of all styles, (Ledoux-Lebard, 1984, p. 457), won a bronze medal at the exhibition of 1844 for a laminated papier mâché production using a hydraulic or screw press, enabling him to reproduce all forms with moulds in metal or on wooden mandrels. His innovation rendered the papier mâché impervious, and therefore suitable for furniture, as well as apartment or carriage panels, as already produced in the English industry.

At the Universal Exhibitions of 1851, 1855 and thereafter, lacquers produced by different countries exhibited side by side. French lacquers were absent from the first Universal Exhibition of 1851, but well represented as of 1855. The competition of the exhibitions seemed to encourage the French producers to improve their imitation of the English lacquers, considered superior, while the English factories enhanced the artistic quality of their products, being criticized by the French jury in 1851. The report of the French commission states papier mâché to be exclusively English while wood was used in China, Japan, Paris, Amsterdam, Vienna and Brussels, which was in fact certainly not the case. At the Universal Exhibition of 1855, the French manufacturers all presented lacquered wood or papier mâché with mother of pearl incrustation (Paris 1855: 479). The lacquers of Mainfroy were said to be of good quality and inexpensive, allowing him to export in large scale. The English Jennens and Bettridge of Birmingham were honoured at length, for the fabrication of papier mâché by superposition of *making-paper* (Paris 1855: 479-480), the *best method* as described earlier. It indicates that this method was not yet extensively adopted in France. However, given the knowledge that Mainfroy as Parisian won a medal in 1844 for his laminated papier mâché, and that both layered and pulped paper were described in England, it is unlikely that French lacquers can distinguish themselves by the technique of the papier mâché – pulped paper for France and papier mâché in sheets for England. While the worldwide exported products of Jennens and Bettridge were distinguished by the jury in 1855 for "their perfect smooth surfaces, the exact polish and the beauty of the black backgrounds that can be compared to the most beautiful results obtained in Japan and India", in 1867, the quality of the French lacquers is judged equivalent to the English by an English jury (Jones, 2012, p. 286).

- **Patents on lacquers and varnishes deposited in Brussels in the 19th century**

Around 40 patents on varnishes and lacquers deposited in Brussels in the 19th century were selected for further study. In Belgium in that period, the patents were not subjected to any control nor on their innovative character nor on their effectiveness. More than 60% of the patents deposited in the capital originate outside Belgium. They were conceived in England, France, Germany, the USA and Australia.

The collected data reflects the survival of the artisanal sector in the production of varnishes and lacquers, but by the end of the 19th century, they have a much more industrial character and fully reflect the advances in technology.

CONCLUSION and RECOMMENDATIONS

The ELinC-project has proven that to thoroughly study European lacquers an interdisciplinary approach is obligatory. Results obtained by chemical analyses reinforce the art-historical studies, recipe studies help to interpret chemical results in their historical context, narrowing down the results of the recipe studies can be based on art-historical evidence e.g. if a production centre can be identified, etc. This cross-fertilisation between completely different fields of expertise pushed the research to new boundaries.

The research on a large selection of related objects, either *Bois de Spa* or black furniture allows to delve deeper into the history and technology of the objects and permits to discover distinctions between them, not possible when only analysing a limited number of objects. As such an evolution in lacquer technology could be seen, especially for the *Bois de Spa*. In the earliest period the influence of the East was outspoken, but it evolves towards more European themes later on. Spirit varnishes were favoured throughout the period studied, likely because of their faster drying speed compared to oil varnishes, shedding a light on the production process and speed. A popular recipe used in Spa was based on a mixture of shellac, pine resin and sandarac, which is a fairly rare composition, that can be traced back to contemporary German recipe books. It might well be that the technological knowledge for lacquering in Spa found its origin in Germany.

The results obtained can have a major and broad impact on further (international) studies not only of European lacquer, but also for a better understanding of resins and varnishes, of museum objects or of the study of recipes in the broader sense. The inventory of the objects in the museum, the historical findings, the analytical optimisations, the defining of new biomarkers, and the many recipes put into the database, will without doubt support future researchers.

This result illustrates the advantages of the Brain-project, and in our opinion this kind of interdisciplinary research should be further stimulated. A drawback of these projects is their limited duration. There is off course the new gained knowledge, or experience, that can be applied in different fields beside the study of lacquers, but also in the field of European lacquers much more is to discover and exploited. But as the financing of the network stops, it is really hard to keep the network alive. A kind of follow-up project, building on the knowledge and experienced gained would be more than welcome, for this, and likely other Brain-projects, in which long-term funding is needed to obtain the maximum of results.

6 DISSEMINATION AND VALORISATION

6.1 Global platform to share data

At the start of the project, the plan was to set up a working database that would link photos, cross-sections, historical data, measurements and associated varnish recipes. There was also a plan to share this data publicly via this platform. Although this work platform was indeed created, a lot has been adjusted along the way to the original design due to a number of technological obstacles. Because of software protection, it is not possible to share chromatograms as measured and to make them visible on such a platform. For the thorough

methodical analysis of recipe books, it turned out that a different kind of database was needed in SPSS, as a result of which recipes were no longer present on the original platform. A large number of objects were entered into this environment with photographs and descriptions, and it was possible, during the project to share information and to find photographs and detailed information about each object for the members of the project. Objects studied from the RMAH can be found via their own image database, available via the website of the museum. Setting up an on-line platform to share analytical results turned out to be too complicated and too time-consuming. Sharing of this information will however be done in the future, when tools to do so become available. The Belspo financed project HESCIDA (Heritage Science Data Archive; hescida.kikirpa.be) will be a first step in that direction. The shared platform was further used to manage the extensive list of resins and other ingredients purchased for the project and to share analysis reports with the partners to maximize discussion around each object. Upon closer inspection, it was decided to share the research results with the outside world in a more classical way through lectures, publications and posters. The more technical reports of the individual objects are also sent to the owners of the objects. Results of these studies will in the future also be made available through the HESCIDA platform.

6.2 Nexus research/teaching University of Antwerp

The gained experiences and acquired knowledge from the ElinC project's partner University of Antwerp have been consolidated in the new curriculum of the department Conservation-Restoration (UA). From the academic year 2019-2020, Vincent Cattersel is titular and lecturer of the bachelor's programme Object and Context II.B, where written/visual/sensory historical art technical sources are approached critically and studied (6 ECTS).

Another nexus is the course on the characterisation of coating materials which is taught within the Object en Materie III (third Bachelor).

6.3 Research development University of Antwerp

The gained experiences and acquired knowledge from the ElinC project's partner University of Antwerp led to the establishment of the research sub-group 'Research On the Origin of Historical Techniques' (*ROOHTS,* January 2019), under the research-group ARCHES ('Antwerp Cultural Heritage Sciences'). This research group is led by Natalie Ortega-Saez and Vincent Cattersel and focusses on art technical research through the study of historical sources, reworking historical recipes (re-enactment), and dissemination of knowledge in Early Modern Europe. The ROOHTS summer school is open to post-graduates, doctors, post-docs. A first international summer school on historical art technical studies, themed 'Burgundian Black' (1-5 July 2019), was organised in collaboration with the Utrecht University (research group ARTECHNE; Prof. Sven Dupré and Dr Jenny Boulboullé), the University of Amsterdam (Prof. Erma Hermens and Drs Birgit Reissland), the Cultural Heritage Agency of The Netherlands (with Art Proaño Gaibor), and Museum Hof van Busleyden (Malines; Collaboration with curator Dr Samuel Mareel and Marijke Wienen). The ROOHTS summer schools will be organised annually; next edition is planned for July 2020.

6.4 Contribution to ESCAPE, a tool for the semi-automatic interpretation of Py-GC/MS results of heritage objects

As explained earlier in the text, use is made for the interpretation of GC/MS chromatograms of the ESCAPE system, developed by Michael Schilling (GCI, USA) and Henk van Keulen (RCE, The Netherlands). This heart of the system is formed by an extensive database containing aged

biomarkers amongst others of natural resins. Through our extensive study of natural resins and the statistical search towards unique biomarkers for them, an important number of new biomarkers became available. These willbe discussed with the ESCAPE administrators, and incorporated in the database, making the database more performant. As this database is free of access and open to researchers in the field of cultural heritage, data will in an indirect way be used by many people globally.

6.5 Oral and poster presentations

Below are listed dissemination and valorisation opportunities of the ELinC project. Collaborating closely together, most of the publications and presentations are the fruits of the three ELinC partners working together.

Various nominations, posters and a conference were provided throughout the project to draw attention to the project and to share research results with the scientific world.

- Hong Kong 2014 – Poster, introduction to the project. Congress of the International Institute for the Conservation of Historic and Artistic Works (IIC) in Hong Kong.
  Louise Decq, Vincent Cattersel, Charles Indekeu, Emile Van Binnebeke, Delphine Steyaert, Wim Fremout, Steven Saverwyns, *European Lacquers. Art-historical, technological and analytical study of European lacquer in Belgian federal collections*. IIC Congress 2014 Hong Kong. An Unbroken History: Conserving East Asian Workshop of Art and Heritage, 22-26 September 2014, City Hall, Hong Kong, China.
- Amsterdam 2014 – Oral presentation of the first results of ELinC. 12th International Symposium on Wood and Furniture Conservation, Stichting Ebenist, Rijksmuseum.
  Louise Decq, Vincent Cattersel, Charles Indekeu, Emile Van Binnebeke, Delphine Steyaert, Wim Fremout, Steven Saverwyns, *Natural resins in European lacquerware: a systematic approach (European Lacquer in Context – ELinC project)*. Symposium on Furniture Finishes. Past, present and future of transparent wood coatings, 14-15 November 2014, Rijksmuseum Amsterdam, The Netherlands.
- Chicago 2015 – Presentation. Data analysis of pyrograms and the quality control of resins. Users' Group for Mass Spectrometry and Chromatography (MaSC) meeting.
  Louise Decq, Michael Schilling, Frederic Lynen, Wim Fremout, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, Steven Saverwyns, *Natural resins in European lacquerware: a systematic Py-GC/MS quality control*. Seventh MaSC Workshop and Meeting, 21 – 22 May 2015, The Art Institute of Chicago, Chicago, Illinois, USA.
- Würzburg 2015 – Poster on white lacquer. Verband der Restauratoren (VdR)
  Vincent Cattersel, Louise Decq, Wim Fremout, Geert Van der Snickt, Stijn Legrand, Corinna Ludovica Koch Dandolo, Peter Uhd Jepsen, Charles Indekeu, Emile Van Binnebeke, Delphine Steyaert, Steven Saverwyns. *White European Lacquer: a case-study*. 6-8 November 2015.
- Ghent 2016 - Oral presentation on quality control, method optimisation and biomarkers: 2nd International Conference on Innovation in Art Research and Technology (inArt)
  Louise Decq, Vincent Cattersel, Delphine Steyaert, Michael Schilling, Frederic Lynen, Viviane Leyman, Charles Indekeu, Emile Van Binnebeke, Wim Fremout and Steven Saverwyns. *Development of an analytical procedure for the analysis of European lacquer*. 21-25 March 2016, Ghent.
- Ghent 2016 - Poster presentation on rheology of lacquer: 2nd International Conference on Innovation in Art Research and Technology (inArt)
  Vincent Cattersel, Louise Decq, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, Wim Fremout and Steven Saverwyns. *Go with the flow: A preliminary rheological study to 17th century clear varnish recipes and components*. 21-25 March 2016, Ghent.

- Paris 2016 – Oral presentations and round table discussion: Seminar on varnishes "Vernis, laques & pigment. Réconstruire les techniques et les savoir-faire d'ateliers. Laques et vernis dans la culture consumériste, XVIe-XVIIIe siècle"
  Delphine Steyaert, Louise Decq. Présentation des recherches en cours. 12 May 2016, Paris.
- Brussels 2016 – Oral presentation on the progress of ELinC for the colleagues of the KIK-IRPA institute, Middagen van het KIK
  Louise Decq, Agathe Fanost, Steven Saverwyns. *Het ELinC-project*, 19 May 2016, Brussels.
- Berlin 2016 - Poster presentation of quality control and resin collections. Society for the Preservation of Natural History Collection (SPNHC)
  Louise Decq, Piet Stoffelen, Viviane Leyman, Vincent Cattersel, Charles Indekeu, Delphine Steyaert, Emile Van Binnebeke, Wim Fremout, Steven Saverwyns. *Natural resins sold today: A quality control study. Natural history collections as historical reference material*. 20-25 June 2016, Berlin.
- Brussels 2016 – Poster presentation of pyrolysis temperature optimization. 4th international congress chemistry for cultural Heritage (ChemCH)
  Louise Decq, Vincent Cattersel, Delphine Steyaert, Michael Schilling, Frederic Lynen, Charles Indekeu, Emile Van Binnebeke, Wim Fremout and Steven Saverwyns. *Optimisation of pyrolysis temperature for chromatographic analysis of natural resins*. 6-8 July 2016, Brussels
- Ghent 2017 – Oral presentation on 19th century lacquer production and trade in Brussels, at Studiedag Historisch Interieur en Ontwerp.
  Delphine Steyaert, Vincent Cattersel, Louise Decq, Emile van Binnebeke, Charles Indekeu, Steven Saverwyns. *Laques à Bruxelles 1835-1855*. 27 April 2017, Ghent.
- Évora, 2017 Oral presentation on the way from chromatograms to a structured library, at 8th meeting of the Users' Group for Mass Spectrometry and Chromatography (MaSC).
  Louise Decq, Wim Fremout, Frederic Lynen, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, Steven Saverwyns. *An untargeted search for markers using AMDIS: Construction of a structured library of components present in artificially aged lacquer ingredients*. 26–30 September 2017, Évora, Portugal.
- Brussels, 2018 - Oral presentation on all results of chemical research of ELinC project at conference ELinC2018
  Louise Decq, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, Wim Fremout, Frederic Lynen, Steven Saverwyns. *Chemical analysis of European lacquer. Unravelling the history of a lacquered object*. An overview was given on different activities during this project, including the semi-automatic differentiation of copals, the compilation of the component library of artificially aged resins, the study of varnishes on Spa boxes and the study of black 19th century furniture. 18-19 January 2018, Brussels.
- Brussels, 2019 – Oral presentation for the colleagues of the KIK-IRPA institute "Middagen van het KIK"
  Louise Decq, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, Wim Fremout, Frederic Lynen, Steven Saverwyns. HET ELINC-PROJECT. Wat hebben we geleerd?" 11 April 2019, Brussels.
- Ottawa, 2019 – Oral presentation on metabolomics approach for biomarker detection at 9th MaSC (Users' Group for Mass Spectrometry and Chromatography) Workshop and Meeting.
  Louise Decq, Wim Fremout, Frederic Lynen, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, Steven Saverwyns. Metabolomics in the analysis of European lacquer . 6-7 June 2019, Ottawa, Canada.
- Brussels, 2019 – Oral presentation on Lacquer in Brussels in the 19th century
  Delphine Steyaert, Louise Decq. Laques à Bruxelles . 19 November 2019, Société royale d'archéologie de Bruxelles, Brussels.

- Ghent, 2020 (upcoming) – Abstract accepted for oral presentation for the 16th International Symposium on Hyphenated Techniques in Chromatography and Separation Technology (**HTC16)** Louise Decq, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, Wim Fremout, Steven Saverwyns, Peter Vandenabeele, Frederic Lynen. *Methods for the systematic search for THM-GC/MS biomarkers for the chemical analysis of European lacquer*. 29-31 January 2020, Ghent.

6.6 Conference ELinC2018

A two-day conference (18-19 January 2018) was held to disseminate results of the ELinC project and to give the opportunity to hear and meet other people working on the study of European lacquers. The aim was to reach a diverse audience, as diverse as the ELinC-team was itself; art-historians, restorers, chemists, conservators,... With almost 120 participants spanning different disciplines this target was met. All presenters had the opportunity to publish afterward in the peer-reviewed journal *Studies in Conservation* in a special conference issue dedicated to the study of European lacquer. 19 contributions were finally accepted for publication. A copy of the journal has been added to this report.

Programme

- Monika Kopplin, *New Discoveries and Insights into Willem Kick's Workshop in Amsterdam*
- Noémie Etienne, *Edited objects: a material reception of lacquer in 18th Century*
- Filip Suchomel, *Johann Adalbert Kratochvile (1670-1721) and his two "Indian" interiors in Bohemia*
- Sonia Ocaña-Ruiz, *The impact of European lacquer in colonial Mexico in the 18th Century*
- Henk van Keulen, Michael Schilling, *AMDIS and Excel: a powerful combination for evaluating Py-GC/MS results from European lacquers*
- Miriam Rampazzo, *16th century Venetian lacquerware: lacquer analysis in sunk-panel bookbindings*
- Maria João Petisca, Catherine Matsen, *Lisbon as seen from China – Conundrums of a set of lacquered nesting tables*
- Lorenzo Appolonia, Roberta Bianchi, Linda Josephine Lucarelli, Stefano Volpin *"Alla China"lacquers: technical features of the exotism tale in Piedmont*
- Elise Andersson, Paul van Duin *Controlled removal of a degraded secondary varnish on European lacquer*
- Verena Roßmann, *A Cabinet on stand in Asian style (around 1710) from Weikersheim Palace – Investigation of the European lacquer and its conservation*
- Elena Viola, Francesca Spagnoli, Maria Beatrice Failla, Riccardo Bellan, Anna Piccirillo, Roberta Bianchi **,** *From the original to the imitation: study and restoration of a Japanese cabinet from the La Marmora collection*
- Irmela Breidenstein *The use of Aquazol 500 as a reversible infilling material for European Lacquer. A case study*
- Delphine Steyaert, Emile van Binnebeke, Vincent Cattersel, Louise Decq, Charles Indekeu, Wim Fremout, Steven Saverwyns, *Lacquers in Belgium. Study of lacquerware from the Royal Museums of Art and History and of Spa Woods with Chinoiserie Decoration*

- Michèle Seehafer, *Imitation of the Unknown: 'The Princess's Lacquered Chamber' at Rosenborg Castle*
- Marta Ajmar *Looking into Renaissance Venetian lacquer*
- Pierre Boesiger *Painted decoration on the Chinese and French lacquer of an 18th century chest of drawers: when one overflows widely on the other*
- Louise Decq, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile van Binnebeke, Wim Fremout, Frederic Lynen, Steven Saverwyns, *Chemical analysis of European lacquer. Unravelling the history of a lacquered object.*
- Patrick Dietemann, Ursula Baumer, Charlotte Höpker, Katharina von Miller, *Disappearing high-grade natural resins in lacquer analysis – how can the interpretation of analyses be improved?*
- Ursula Baumer, Patrick Dietemann, Katharina von Miller, Charlotte Höpker, *On the use of Bistre in transparent wood varnishes - Analysis, application and reconstruction*
- Vincent Cattersel, Charles Indekeu, Joost Caen, Guy Bovyn, Louise Decq, Emile van Binnebeke, Delphine Steyaert, Wim Fremout, Steven Saverwyns, *Collecting recipes: a dataset as a multipurpose research tool*
- Sara Aveni, Alessandro Gatti, Loredana Mannina, Tommaso Poli, Maria Beatrice Failla *A japanned telescope from Cavour Castle in Santena: study and conservation treatment of an 18th century scientific instrument*
- Jan Dorscheid, Julia Köhler, Michiel de Vlam, Ineke Joosten, Henk van Keulen, Paul van Duin *Dutch inlayed aventurine decoration: study, analysis, and conservation*
- Carola Klinzmann, *Aventurine lacquer on a baroque furniture ensemble from Kassel/Germany*
- Cathy Silverman, Adriana Rizzo, Federico Caro, *An investigation of eighteenth century English japanned furniture in the collection of The Metropolitan Museum of Art*

Poster session

- Paola Croveri, Eliano Diana, Ilaria Bonaduce, Valentina Gucciardi, *A restored Coromandel Screen from the Royal Residences of Piedmont (Italy): scientific investigations on the lacquer making technique*
- Eliano Diana, Anna Piccirillo, Tommaso Poli, *Infrared spectroscopy for the investigation of lacquer: a survey*
- Valentina Gucciardi, Federica Moretti, Eliano Diana, Paola Croveri, Maria Beatrice Failla, Paola Manchinu, Roberta Bianchi, Paolo Luciani , *The study and restoration of a Coromandel Screen from Camillo Cavour's Castle in the Piedmont collection.*
- Brigitte Hagedorn, Lacquer panels japanned by the Princess Elizabeth of England
- Kamilla Kalinina, Anna Petrakova, *Lacquers in illusionistic restoration of ancient Greek vase-painting in the 18th-19th centuries*
- Samuel Luterbacher, *Surfaces for reflection: Nanban Lacquer in the Iberian World*
- Cathy Silverman, Louisa Smieska ,*Scanning X-Ray Fluorescence for the Investigation of Japanned Surfaces*
- Marianne Webb,*The Reconstruction and Natural Aging of 18th century European Lacquer Recipies*

6.7 Publications

6.7.1 Peer review

- Louise Decq, Frederic Lynen, Michael Schilling, Wim Fremout, Vincent Cattersel, Delphine Steyaert, Charles Indekeu, Emile Van Binnebeke, and Steven Saverwyns. **2016**. 'The Analysis of European Lacquer: Optimization of Thermochemolysis Temperature of Natural Resins'. Applied Physics A 122 (12): 1007. https://doi.org/10.1007/s00339-016-0550-5.
- Louise Decq, Emmanuel Abatih, Henk van Keulen, Viviane Leyman, Vincent Cattersel, Delphine Steyaert, Emile Van Binnebeke, Wim Fremout, Steven Saverwyns, and Frederic Lynen. **2019**. 'Non-Targeted Pattern Recognition in the Search for Pyrolysis Gas Chromatography/Mass Spectrometry Resin Markers in Historic Lacquered Objects.' Analytical Chemistry, May, acs.analchem.9b00240. https://doi.org/10.1021/acs.analchem.9b00240.
- Louise Decq, Yvonne Jones, Delphine Steyaert, Vincent Cattersel, Charles Indekeu, Emile Van Binnebeke, Wim Fremout, Steven Saverwyns, and Frédéric Lynen. **2019**. 'Black Lacquered Papier Mâché and Turned Wooden Furniture: Unravelling the Art History, Technology and Chemistry in Nineteenth Century Japanning Industry'. Studies in Conservation 64 (sup1): S31–44.
- Delphine Steyaert, Louise Decq, Vincent Cattersel, Emile Van Binnebeke, Charles Indekeu, Wim Fremout, and Steven Saverwyns. **2019**. 'Japanning in Spa at the End of the 17th Century to the Middle of the 18th Century: Historical Context and Materials of the Lacquered Bois de Spa'. Studies in Conservation 64 (sup1): S14–30.

6.7.2 Not peer-reviewed

- Vincent Cattersel, Louise Decq, Charles Indekeu, Emile Van Binnebeke, Delphine Steyaert, Wim Fremout and Steven Saverwyns. European Lacquer in Context, an interdisciplinary and systematic approach to the study of the tradition of European lacquering, in Furniture Finishes, postprints of International Symposium on Wood and Furniture Conservation. Miko Vasques Dias, Stichting Ebenist, Amsterdam, **2015**: 56–62.
- Vincent Cattersel, Louise Decq, Mónica Solórzano Kraemer. Was haben Sie denn da, Vincent Cattersel, Louise Decq und Mónica Solórzano Kraemer? Gum Animé. Restauro : Zeitschrift für Kunsttechniken, Restaurierung und Museumsfragen. Mitteilungen der IADA; Vol. 122 (1), **2016**: 6-7.
- Corinna Ludovica Koch Dandolo, Vincent Cattersel and Peter Uhd Jepsen, Dandolo, CLK, Cattersel, V & Jepsen, PU 2015, Terahertz Time-domain Imaging Of A 17th Century Lacquered Cabinet: A Contribution To European Lacquerwares Characterization. In: Proceedings of IRMMW-THz 2015. IEEE, 40th International Conference on Infrared, Millimeter, and Terahertz Waves, Hong Kong, 23/08/2015. https://doi.org/10.1109/IRMMW-THz.2015.7327534
- Louise Decq. European Lacquer in Context (ELinC): art-historical, technological and chemical characterization of European lacquer in Federal collections. Vol.1, nr.1, p6 (August 2015). Introduction to ELinC project in ICOM-CC Scientific Research Working Group Newsletter.

6.7.3 Upcoming

- Delphine Steyaert, Vincent Cattersel, Louise Decq, Emile van Binnebeke, Charles Indekeu, Steven Saverwyns. *Laques à Bruxelles 1835-1855*. Presented in Ghent in 2017 (Studiedag Historisch Interieur en Design) and in Brussels in 2019 (Conference for the Société royale d'Archéologie de Bruxelles). Publication for the *Bulletin de la Société royale d'archéologie de Bruxelles* or for an other scientific revue. In preparation.
- Delphine Steyaert, Vincent Cattersel, Louise Decq, Emile van Binnebeke, Charles Indekeu, Steven Saverwyns. Summary of the research on bois de Spa with addition of non published research for *Liège museum*, *Bulletin des Musées de la Ville de Liège*.
- Vincent Cattersel, Charles Indekeu, Joost Caen, Guy Bovyn, Louise Decq, Emile van Binnebeke, Delphine Steyaert, Wim Fremout, Steven Saverwyns. Collecting recipes: a dataset as a multipurpose research tool. In preparation.
- Wim Fremout, Louise Decq, , Peter Vandenabeele, Frederic Lynen, Andreas Krupa , Emile van Binnebeke, Delphine Steyaert, Vincent Cattersel, Steven Saverwyns Datamining for (py-) GC/MS datasets. From chromatogram to target library. In preparation.
- Louise Decq, , Frederic Lynen, Peter Vandenabeele, Wim Fremout, Vincent Cattersel, Emile van Binnebeke, Delphine Steyaert, Steven Saverwyns, Quality control of natural resins. In preparation
- Vincent Cattersel writes his **PhD** on the study of historical sources of varnish recipes
- Louise Decq writes her **PhD** on the new ways of chemical analysis of lacquers. Both doctoral studies are based on the research performed within ELinC project.

6.8 Other valorisation and prospects

- 2014 Paris - Recent Advances in Characterizing Asian Lacquer (RAdICAL) workshop. Interactive participation, 7-11 July 2014, at Centre de Recherche et de Restauration des Musées de France (C2RMF)
- 2016 Breda - Attended conference: "Interscience conference pyrolysis analytical info session with network event". Interscience Breda 13 october 2016.
- 2019 Ottawa – 9th MaSC (Users' Group for Mass Spectrometry and Chromatography) workshop on pyrolysis analysis of resins and off-gasing of heritage materials. 3-5 June 2019, Ottawa, Canada.
- 2020 Los Angeles - new biomarkers will be added to ESCAPE, at GCI. First semester 2020.
- 2020 Dissemination of **recipe database**.

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9 ANNEXES

None