European Lacquer in Context (ELinC). Art-historical, technological and chemical characterisation of European paintwork in federal collections (BR/121/A3/ELinC).

Lacquers have been produced in Asia since prehistoric times, and used to protect and finish a variety of products: furniture, household items, musical instruments, weapons and even buildings. When, via the ports of Antwerp, Ghent and Bruges, the lacquers reached Flanders in the 16th century, this caused a landslide in the local production of luxury goods. Since the export of the raw Asian lacquer was forbidden and especially the extremely complex production process was not understood, European craftsmen looked for alternatives to imitate Asian lacquers. They relied mainly on their expertise in varnishes and imitation materials (such as imitation tortoiseshell, imitation marble), using resins, oils, solvents and pigments known to them. This gave rise to European lacquerwork, which remained popular until the 20th century, after which interest declined as a result of the rise of synthetic polymers.

This network project focused on the history of European lacquerwork, with the emphasis on these made in our regions and with special attention to European lacquerwork in the collections of the Royal Museums of Art and History (RMAH). The lacquers was characterized by the combined forces of art historical, technological and chemical research.

Each partner had its own expertise, which was further developed during the project, before the European lacquers could be closely examined. Once the expertise had been developed, the objects were studied in detail and placed in their art-historical and technological context.

The project was coordinated by the Royal Institute for Cultural Heritage (KIK-IRPA), which was also responsible for the chemical characterisation of the European lacquerware studied. European lacquers consist of a mixture of natural resins dissolved in (essential) oils or solvents. Depending on the varnish, the resins have to be heated, which can lead to changes in composition. The natural ageing of the resins also has a pronounced influence on the chemical composition of the resins. A correct identification of the used resins is based on the identification of biomarkers characteristic for a specific resin. The determination of these biomarkers is a complex task, due to the large variety of resins, with often overlapping components in their composition. The search for unique biomarkers for a specific resin, however, allows the resin to be unambiguously identified. Some of these biomarkers have been described in the scientific literature, but were not sufficient for the characterisation of complex mixtures of heated and aged resins. An important task of the KIK-IRPA was to identify additional biomarkers. For this purpose, 434 mock-up samples had to be made carried out by partner 2 (UA), after a quality control of the bulk resins. This control was carried out by testing the bulk samples against reference samples. The results proved that these tests were necessary. Some resins were not what they were supposed to be, or they were mixed with other (cheaper) resins. Furthermore, the now commercially available sandarac no longer appeared to have the same composition as the historical one. The reason for this remains guesswork, possibly the sandarac is now extracted from another tree family. The historical sandarac is referred to as sandarac type 1, the now available sandarac type 2. The latter type was further used in the mock-up samples. As the composition of the resins changes with ageing, the mock-up samples were artificially aged under the influence of UV light, at constant temperature and humidity.

Because some of the lacquers are not or hardly soluble in solvents, the most appropriate way for the analysis of such samples is gas chromatography coupled with mass spectrometry (GCMS),

with a pyrolysis system as the sample introduction. In the absence of oxygen, the sample is heated to a high temperature, where large molecules break down into smaller fragments, that can be analysed by GCMS. Derivatisation of the samples with tetramethylammonium hydroxide (TMAH) in methanol is necessary to reduce the polarity of some components. During the search for biomarkers, the mock-up samples were therefore analysed with this technique, which initially required optimisation of a number of parameters, of which the pyrolysis temperature was the most important. A new procedure was developed to extract a useful biomarker library from a large series of measurements (a large number of resins). The procedure is based on several freeware software packages (NIST MS Search, AMDIS and MS PepSearch, Python) and self-made scripts (GCMS toolbox). A second way to detect biomarkers is of a statistical nature and based on a differential expression analysis technology developed for linear modelling of gene expression data. This approach allowed new, more systematic ways to find biomarkers in the analysis of lacquered artefacts and varnishes, and was published in the leading journal Analytical Chemistry.

Much information about lacquer composition and lacquer technology is described in historical sources, often recipes. Browsing through hundreds of recipes in search of essential information, similarities or differences between recipes, making connections between them cannot be carried out without including them in a database. Since it is not possible to include recipes as such, partner 2 (UA) has determined which parameters are necessary to build such a database, whereby the link to the original recipes must necessarily be maintained. Information about the sources, the ingredients, the production method, etc. were stored in the database, an immense work, taking into account the fact that historical botanical data and measurements had to be translated into the current nomenclature. A large number of historical sources were consulted, and eventually more than 920 recipes were coded in the database from the early 17th century until the late 19th century, the largest collection of varnish recipes so far studied. This large number of recipes makes it possible to approach them statistically in order to find connections between them or to gain more insight into the recipes used and relationships between the different ingredients. Hierarchical clustering and principal component analysis (PCA) were applied. Technologically it could be deduced from this that in general two types of recipes were used, on the one hand oil-based and on the other hand solvent-based. Furthermore, the first type of recipes is rather aimed at the professional user, the second type also at the amateur. After all, lacquers were made in many layers of the population. The flammable nature of the oil-based lacquering process is more than likely the reason why it was mainly reserved for the professional lacquer maker. Also, the function and combination of certain resins was clearly reflected by or better understood from the PCA results. Hard resins are often combined with softer ones (serving as plasticisers) which reduces their fragility, and oily resins often contain dryers, such as lead-based pigments or glass. Linking recipes allowed to locate sources on which later writers relied on or from where they simply copied recipes.

But also a historical context is essential to understand the lacquered objects. This part of the project was carried out by partner 3 (RMAH). The emphasis was on the one hand on the study of the objects present in the RMAH, which after a thorough inventory turned out to outnumber the originally expected amount. On the other hand, a broader historical context of lacquer production in our regions was outlined, with the emphasis on the most important lacquer centre in Belgium, the village of Spa. By digging through the archives, traces were also found of a

lacquer production in Brussels in the 19th century. Among other things, the sale (and production) of painted objects by a certain Mrs. Ghiesbrecht could be well documented thanks to numerous newspaper reports. This also illustrates that the lacquer industry was not only a men's business, but was also practised by women, as can also be seen in illustrations in the historical sources. The study of patents of European lacquer work deposited in the Brussels in the 19th century also gave a glimpse into the lacquer industry of that period.

The inventory was studied in detail, a selection of which was also chemically and technologically studied by all partners. The combination of these data gave a better understanding of the historical context and of the technology of the lacquer production process. Particularly when a series of objects with common characteristics were studied, interesting results were obtained, as in the case of a series of black lacquered furniture from the 19th century. From the chemical analyses, the application of new industrial processes could be derived, such as cyclic heating of the lacquer layers. The geopolitical dominant position of England in relation to the mainland at the time resulted in a competition between lacquer producers from England and the rest of Europe, which in turn led to rapid innovation and industrialisation in the lacquer process.

As mentioned earlier a lot of attention was paid to the lacquer production at Spa, famous not only for its sources but also for the *Bois de Spa*, lacquered objects sold as souvenirs. In order to be able to focus the research sufficiently, the emphasis was placed on 18th century lacquered boxes with chinoiserie decor. Four different time periods could be distinguished by the art historical research, and also never before published information about lacquer makers from Spa was obtained. Chemical analyses showed that solvent born lacquers based on sandarac and coniferous resins (Pinaceae sp.), often with the addition of shellac, were preferred, presumably because they dry faster than oil varnishes, which illustrates the industrial character of the lacquer production. Few recipes could be linked to the lacquer production in Spa; only two recipes were found based on sandarac, Pinaceae sp. and shellac, dating from the same period as the objects studied, and related to the making of lacquers. These recipes come from German books, from which the question arose to what extent the technology of preparing lacquers in Spa came from Germany. For example, Gerard Dagly, the famous lacquer maker at the Berlin court at the time of the creation of lacquers in Spa, came from the Spa.

From this concise summary it is clear how European lacquerwork was approached from different disciplines, each with a very different nature, but that after further deepening their own specialisation, the different disciplines strengthened each other in this first interdisciplinary study of European lacquerwork in Belgium.

Keywords

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