Paintings in the laboratory: scientific examination for art history and conservation

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Summary

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This doctoral dissertation consists of twelve articles and an introductory chapter ‘Perspectives on the evolution of science for art history and conservation, and its current state,’ written specifically for this publication. The twelve articles were previously published between 1975 and 2005 in different journals, exhibition catalogues and books. They deal with painting technique in the seventeenth century, primarily as practised in the Netherlands.

The precise material-technical investigation of paintings provides insight into various aspects of the creation and life of an artwork. The research methods of the physical sciences – chemical and physical analyses, microscopy – make an important contribution to the preservation of art objects. The use of the results of such research has increasingly come to play an integral role in the decision-making around conservation. Knowledge concerning painting technique and workshop practice, obtained by technical investigations, is necessary as we attempt - in conservation and restoration - to approach as closely as possible the image that was originally intended by the artist. This knowledge contributes to the history of art, for example in dealing with questions of attribution. The results of the research that produces insights into the process of making the art object also constitute a link between object and public.

The first introductory article presents a brief summary of the early history of the research on artworks. Aspects of the investigations using the methods of the physical sciences in the service of conservation are elucidated. As part of a pure interest in and admiration for the art of classical antiquity, the way art works had been made aroused interest as early as the Renaissance. In the late eighteenth century, Greek and Roman objects were analysed by the chemist Martin Heinrich Klaproth in Berlin. In the nineteenth century Napoleon took scientists with him on his expeditions, for instance to Egypt. It was soon evident that the decay of the objects necessitated research on methods of preserving them. In addition, concerns about forged antiquities also played a role.

In 1888 the first museum chemical laboratory was set up in Berlin. Only in 1922 was this followed by a second, at the British Museum in London. Others eventually followed. In the Netherlands a specialized laboratory was founded in 1963, the Centraal Laboratorium voor Onderzoek van Voorwerpen van Kunst en Wetenschap (Central Laboratory). Like the Institute Royal Patrimoine Artistique (IRPA) in Brussels, founded in 1934 and the model for the Central Laboratory, it was not connected to a museum. The founders of the Central Laboratory were for the most part themselves scientists, as was Paul Coremans, the founder of IRPA. Arthur van Schendel (subsequently Director of the Rijksmuseum) played a major role in the creation of the Central Laboratory. Like Coremans, he found that the investigation and restoration of art objects required an interdisciplinary collaboration between scientists, restorers and conservators or art historians. Communication is the basis and precondition for achieving a good outcome in the collective commitment to the preservation of vulnerable art objects. The scientific researcher has to know the art object to be investigated – ‘paintings in the laboratory’ – not only the samples to be analysed, taken from the painting. And although this means overstepping the lines of division between the different provinces of the specialists involved, one is made aware as a result of the particular character of each of these disciplines.

Because the ‘art world’ is dispersed over the entire world and because so many different disciplines have been involved, it is extremely important that the researcher’s investigations should be precisely recorded and published in intelligible language. Over the course of years the number of articles with scientific results published in the service of conservation and art history has increased dramatically. As well as ‘Studies in Conservation’, museum journals and catalogues now accept articles on painting technique.

The development and application of technical, scientific research for the purpose of serving conservation and art history over the last forty years is outlined. In addition, as examples of new instrumentation, and of the potential of such developments for the investigation of art works, there is a discussion of some instrumental analytical techniques that are not routinely applied. The change in the demands of the role of the conservator-restorer is touched on: to what extent was – and is – he or she expected to be familiar with the technical research and to include this in his/her own investigation prior to decisions on conservation and restoration. Where does ‘low tech’ end – i.e. investigations using the naked eye, whether assisted or not - and where does ‘high tech’ begin? Observations and results always have to be interpreted. Although the boundaries between art history, conservation and restoration still exist, fortunately they have become more blurred.

The second article (the first of the articles published previously), ‘Halcyon Days for Art History’ shows how a close comparison of paint cross-sections under the microscope can, in certain cases, contribute to the dating of pictures. A Rembrandtesque painting, Haman before Esther from the Muzeul Naţional de Artă al României in Bucharest, was examined and restored in The Netherlands, after it had been damaged during the ‘revolution’ in Rumania in 1989. In 1969 an X-radiograph had revealed another picture, with more or less the same composition as the visible work, hidden beneath the present one. The Rembrandt Research Project tentatively dated the underlying picture to around 1635 and it was said to be possibly by Rembrandt’s hand. The top painting can, on stylistic grounds, be dated to the 1660s. Analysis of paint samples from the ground layers of the picture, compared with samples from known works by Rembrandt, confirmed that the underlying Haman before Esther, at least, is by Rembrandt, and dates from c. 1633. The picture was, on Rembrandt’s death, left behind in his studio in an unfinished state.

The third article, ‘Grounds in Rembrandt’s workshop and in paintings by his contemporaries’ describes the systematic examination of the use of preparatory layers on panels and canvases by Rembrandt and his workshop. The research was
prompted by the question whether the so-called quartz ground was unique to Rembrandt and his studio. The examination comprises ground samples from more than sixty panels and 153 canvases formerly attributed to Rembrandt. The results of the examination were compared to those of the examination of pictures by other seventeenth-century artists. The investigation of the grounds of 153 paintings on canvas demonstrated that the traditional ‘double ground’ of grey on red constituted half of this number. Theodore Turquet De Mayerne described this traditional way of preparing canvases in recipes in an extensive collection of notes concerning technical aspects of art, the earliest dated entry being 1620. De Mayerne was physician to James I in England. The investigation showed that this traditional ground was used from the 1630s onwards, not only by Rembrandt and his workshop. The examination of the not exactly identical ‘double grounds’ provided supporting evidence in cases of attribution and dating. Namely, it was sometimes possible to find comparable characteristics in the top - lead white containing - layer of the grounds in different paintings to permit suggestions as to whether the paint used for them came from the same batch.

45 of the paintings attributed to Rembrandt and on canvases were proved to have been painted on a single ground with high quartz content. The Night Watch proved to be the first painting primed with this material. A quartz ground was not found in paintings by artists active in Amsterdam between 1640 (the start of the painting of the Night watch) and 1669 (the year of Rembrandt’s death) that had no affiliation with Rembrandt’s workshop. The idea that a canvas with a particular ground was used exclusively in Rembrandt’s workshop implies with considerable certainty that the supports for paintings were prepared there. The suggestion that quartz grounds must be specific to Rembrandt and his workshop was confirmed by the investigation, providing a strong supplementary criterion for attributing paintings with quartz grounds to painters working in his studio including the master himself, around or after 1640.

Quartz was identified using thin sections for examination under the microscope in transmitted and polarized light, with X-ray diffraction (XRD) and scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDX) directly on the paint cross-section.

1 ‘Earth Matters. The origin of the material used for the preparation of the Night Watch and many other canvases in Rembrandt’s workshop after 1640’ is a continuation of the work on grounds used in Rembrandt’s workshop, now expanding the search for the possible explanations for Rembrandt’s use of a quartz ground and for the origin of the material. The first mention of this ground in a Dutch manuscript is by Simon Eikelenberg in 1679. Foreign authors refer to the use of potter’s clay in the first half of the 17th century, but their recipes were apparently not followed in Holland. The relation between Rembrandt and potters, great users of clay, is discussed, as they were members of the same guild, St. Lucas’s. The types of clay deposits along the rivers and in the coastal area of the Netherlands are reviewed from the point of view of the potters and manufacturers of bricks and tiles working in various parts of the country. The working properties of the clays, in mixtures or with well-chosen admixtures of sand and chalk, are discussed in relation to the products to be made. The tiny samples removable from paintings restrict the ability to identify the types of clay and sand by standard procedures in geological research. Quartz is identified in a thin section of the sample, or in dispersed sample material, using microscopy and x-ray diffraction (XRD); elements are detected by scanning electron microscopy-energy dispersive x-ray spectrometry (SEM-EDX) analysis on a paint cross section. An (uncertain) estimation of the clay minerals present was made from the SEM-EDX analyses. With XRD equipment optimized for the identification of clay minerals at the Royal Netherlands Institute for Sea Research (NIOZ), more detailed information was obtained. Apart from alpha quartz and calcite, the clay minerals chlorite, mica, kaolinite were detected plus feldspar and amphibole. The findings support the use of fluvial clay by Rembrandt, similar to the clay used for bricks, tiles, and earthenware. The quartz ground had desirable properties in colour and suppleness, and it was cheaper than the traditional ‘double ground’, (also described in this article) which required expensive lead white.

1 ‘In the beginning there was red’ is based on the question: why bother with applying a red paint layer when a grey one will hide it? The question concerns the traditional double grounds. The author, in an attempt to answer this question, expands on relations between the preparatory red layer on (canvas) paintings and the red ground found on polychrome stone sculpture, mural paintings and gilded objects from periods preceding the seventeenth century. Pliny indicates that the red will be absorbed by the plaster. The Mayerne is anxious about drying. Chemical analyses have shown, that red pigments with drying properties were indeed sometimes added to the oil, instead of red earth. De Mayerne also mentions the low cost of the red material. The author expands on the earliest use of colour in antiquity. That colour was red. The caves where the objects were discovered indicate symbolic thought. The author’s hypothesis is that the use of red has a long tradition and that the use of red continued, even when symbolic meaning of the colour was lost, through rule-of-thumb methods under the strong restrictions of the Guilds.

1 ‘Investigation of the use of the binding medium by Rembrandt’ is about the special paint effects in Rembrandt’s paintings. Investigation showed that Rembrandt obtained the impasto character of the paint in his pictures by underpainting passages thickly with paint with a high lead white content. For answering the question about the composition and workability of Rembrandt’s paints, special attention is paid to the binding medium used and to dryers. The binding medium would have the greatest influence on style. Glazes and other effects, for instance thick, smalt-containing layers, were analysed as well. The paintings investigated stem from the period late in Rembrandt’s career. Chemical analyses (PyMS, FTIR, HPLC, SEM-EDX) on samples from these paintings showed that the main constituent of the paint was a drying oil, with - depending on the colour of the paint - tiny additions of egg, animal glue or gum. Such additions would change the consistency of the paint. The admixtures were necessary for technical reasons. The physical properties of the starting materials for making paint, the pigments, differed significantly in the seventeenth century. The author discusses the rheological (flow) properties of Rembrandt’s paint. A few rheological measurements were done with freshly prepared reconstruction of paint from the period.
'Towards identification of brown discolouration on green paint' from 1975 focuses on green paint where certain passages have a brown appearance. Lucas van Leyden’s The Last Judgement, Museum De Lakenhal, Leiden, was studied. The reason for the darkening of green passages is not always directly obvious. In studying cross sections of green paint layers, it is sometimes ascertained that the green is either covered with or embedded in a brown-coloured substance. In an attempt to determine whether this is to be attributed to discolouration of the green paint, the eventual presence and the exact location of copper in this brown substance were investigated. The scanning electron microscope with x-ray microanalyzer accessory (wave dispersion) was used. Some results of preliminary tests are given in order to indicate the possibilities and the limitations of this method for this purpose.

The 1975 examination of green to brown discolouration was repeated in 2010: “Towards identification of brown discolouration on green paint’ revisited.” Instrumental analytical techniques had improved over the years and so the new analytical research proved that copper was present in the brown top paint and thus that the brown layer was originally green. Therefore the 1975 results were confirmed by those of 2010, now using scanning electron microscopy with energy dispersive X-ray analysis. Other origins of the discolouration of green paint layers are given as well: the darkening can be caused by the darkening of the oil-medium itself in a medium-rich layer. The presence of a few scattered copper green pigment particles proves that this brown layer is original. The advantage of the renewed examination, in 2010, is that individual layers in the paint cross-section are much more clearly visible and can easily be presented in colour. The instrumentation has obviously become more user-friendly.

“The foliage tends almost to blue’ deals with discoloursations from green to blue, a type of change in colour often seen in flower paintings. We know from early written sources that some of the pigments used by the artists were not light-fast. Paintings by Willem van Aelst, Pieter Snyers, Jacob van Huysum and others were investigated. Pigments that were not light-fast and over cleaning in the past were found to be responsible for the colour changes.

‘Scanning electron-microscopy as an aid in the study of blanching.’ Over a ten-year period, fifteen paintings by Claude Lorraine and Gaspard Dughet were examined by stereomicroscopy, polarized light microscopy of paint cross-sections, micro-chemical analysis, electron microprobe analysis with x-ray diffraction, gas-liquid chromatography, and scanning electron microscopy in an investigation of blanching. The study is accompanied by many photographs and a chart providing a detailed comparative analysis of the paintings. Although Dughet's paintings have only one or two paint layers while Claude's have many superimposed layers, both painters used a mixed, water-in-oil medium and hygroscopic pigments. The investigators examined the holes and pits in the paint layers, but found that although numerous pits make paint films look more opaque or white, porosity alone cannot explain blanching. They found that paintings with blanching had inherent paint film defects, which were worsened by cleaning and relining using polar solvents, including water. Polar solvents extract polar substances from the paint.

‘Frans Hals: a Technical Examination’ was based on the investigation of forty paintings attributed by Seymour Slive to Frans Hals. The examination started in the Frans Halsmuseum in the 1980s, when eight of Fans Hals’ paintings were restored in the museum. Hallmarks of Hals’ painting technique became apparent, some of them in common use in seventeenth century Dutch painting, others typical for Hals. The supports of the paintings - panel, canvas - and preparatory and paint layers were examined and analysed. In most cases, Hals appeared to have used a light coloured painting ground, comparable in hue with what one finds on panels: the Haarlem painters obviously stuck to their traditions. The sequence of application of the paint layers could be established and therefore the way of working, namely - most times - from the back to the details at the front. Hals had a spontaneous way of working, not only in the last touches, but also in the first layout of his paintings. Changes due to alteration were found as well. Also, some of the heraldry could be proved to be later additions.

‘Judith Leyster: a technical examination of her work’ is a first attempt to describe the painting technique of Judith Leyster. The description is based on detailed technical examination and analysis of sixteen oil paintings. These include six signed (four of them dated) works, which provide key points of reference, as well as several problematic attributions. Despite the heterogeneous styles of the paintings examined - which has been explained as eclectic - common characteristics, which may be considered hallmarks of Leyster's painting technique, are found. Comparisons are made with the painting technique of Frans Hals, her purported teacher around 1629, providing further insights into the studio practices of Haarlem painters in this period.

‘Scientific examination of Vermeer’s Girl with the Pearl Earring’ is a report on part of the research conducted on this painting prior to its restoration in 1994. The painting had been poorly treated in the past. Restoration materials used in the past often contained water, which most likely caused deterioration of the picture prior to the restoration of 1994. Loose chips of paint attached to the varnish surface could be used for the technical examination. Special consideration was given to the dark background, which appeared spotty. It became apparent that the background, as well as other parts of the painting, was applied on a layer of dark paint. The surface paint was originally translucent. In this semi-transparent paint, indigo and [weld] (an organic yellow pigment) were identified, which together must have given a greenish hue to the glaze. Apart from the painting technique the materials used in previous restorations were identified so that they could be taken into account in the conservation and restoration process to be conducted. For this research the following analytical techniques were applied: microscopy, SEM-EDX, FTIR, HPLC, DTMS and Py-TMAH-GCMS.