

THE EXAMINATION OF DRAWINGS BY GEORGES SEURAT USING FOURIER TRANSFORM INFRARED MICRO-SPECTROSCOPY (MICRO-FTIR)

TECHNICAL PAPER

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This paper is based on a presentation at the 8th international conference of the Infrared and Raman Users' Group (IRUG) in Vienna, Austria, 26-29 March 2008.

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Drawings by Georges Seurat in the collection of The Museum of Modern Art were examined for a recent exhibition. Fourier transform infrared micro-spectroscopy (micro-FTIR) has found a shellac fixative on all of the drawings examined. It is apparent that Seurat applied this resin because it appears in areas corresponding to the early passages in the drawing composition. Evidence suggests that the fixative was mainly applied to increase the tooth for later applications of conte crayon and to prevent the smudging of lower layers. Typically, the layers of shellac are extremely thin and based on visual appearance and auto-fluorescence suggestive of decolorized shellac. The use of an ultraviolet (UV) illumination attachment on the FTIR microscope made positioning of the aperture a very efficient process that helps locate the shellac. While anecdotal information has suggested conte crayon used by Seurat contains wax, FTIR, UV fluorescence and PyGC-MS did not detect any. These scientific findings accurately reflect information contained in Nicholas-Jacques Conte's original patent from 1795.

1 Introduction

In 2007 the Museum of Modern Art mounted an exhibition featuring the drawings of Georges Seurat.¹ There were some 130 drawings – approximately one quarter of his output in this medium, with about 40% of these works representing his mature period. Included in the exhibition were paintings that in some way related to the drawings. In addition to the typical relationship between drawings and paintings, some of the paintings actually shared a similar visual effect in the method of manufacture with the drawings. For instance, his painting's ground preparation in more than one instance was textured in a manner that helped create the appearance of the chain and laid lines of hand-made paper. It was evident from looking at the museum's holdings, which include both drawings and paintings, that his drawings did have a significant impact on his painting technique. This has been already noted in the literature: some scholars even suggest it was his

received: 30.05.2008
accepted: 06.07.2009

key words:
FTIR, drawings, Georges Seurat

drawing technique that led to his development of *Pointillism*.

As scientific analysis was progressing, it became visually apparent to one of the authors (KB) that once Seurat developed his method he did not stray far from either his materials or his technique: fixative was evident in nearly all of his drawings in local elements in the composition in raking light or under low power magnification. The museum's drawings date mainly from his mature period and are thus indicative of his established procedure. The consistent use of conte crayon in these drawings made identification of the fixative straightforward. Possible contamination from conte in adjacent regions was proven unfounded: anecdotal concerns suggesting it contained a wax binder were proven false both by scientific analysis and the discovery of the original French patent.

2 Experimental

The sampling protocol for these drawings was established as follows: the drawings were examined under magnification and samples that looked like fixative were removed using a scalpel and tungsten needle. Samples were about 50 microns in size and were transferred directly to a diamond compression cell for IR analysis in transmission mode. Sample storage was not attempted because retrieval of such small samples was considered unlikely. The samples were pressed flat in the compression cell and the halves were examined to avoid interference fringes in the spectra. The weight of these samples is not known but they were much less than the recommend target mass for pyrolysis gas chromatography mass-spectrometry (Py-GC-MS).

Fourier transform infrared (FTIR) microscopy with a UV attachment was used to examine samples of fixative. Thermo-Nicolet Nexus 670 FTIR bench with Continuum microscope using 15x objective and an Olympus UV attachment (model U-ULS100HG). Experimental conditions: transmission mode, resolution 4 cm^{-1} , MCTA detector collection range: 4000 – 650 cm^{-1} . The equipment was Thermo-Nicolet.

3 Results and Discussion

The UV attachment is used to guide the IR aperture to regions of interest and facilitates collection of data of pure compounds from heterogeneous samples. When examined by UV, the autofluorescence appeared pale yellow. The band assignments in the unknown correspond well with IRUG

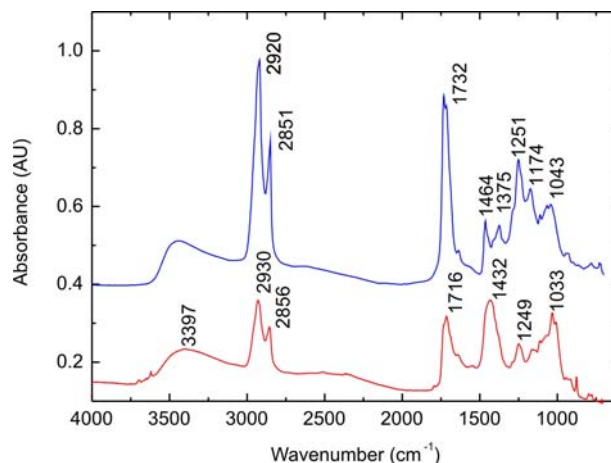


Figure 1: Seurat fixative (bottom) compared to shellac (IRUG reference spectrum INR00233). The carbonyl doublet at 1715 cm^{-1} and 1732 cm^{-1} is characteristic of shellac (present in both spectra) is due to free acid and ester, with the latter confirmed by the ester bending mode at ca. 1250 cm^{-1} . The main difference between the two spectra is the broad absorption at 1432 cm^{-1} , possibly the due calcium carbonate.

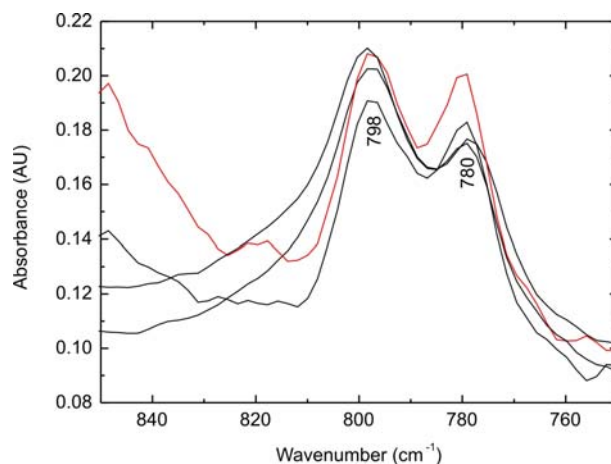


Figure 2: 4 samples of Seurat fixative showing absorptions at 798 cm^{-1} and 780 cm^{-1} characteristic of bleached shellac (specifically) or aged shellac (generally) according to Copestake.



Figure 3: Conte reference samples used in this study: modern conte 1 (bottom); vintage samples 3, 2, 1 (from top to bottom).

reference standards for shellac (Figure 1). In a previous study Copestake² examined a wide variety of shellac resins ranging from minimally refined buttonlac to decolorized and bleached shellac, both fresh and after aging. Using infrared spectroscopy he found two small peaks at 798 cm^{-1} and 778 cm^{-1} common to bleached and non-bleached shellac and a weaker peak at 767 cm^{-1} that was lost after bleaching. He also found these peaks all diminish with light aging. In comparing the 21 shellac reference spectra from the IRUG database (edition 2000), these traits are evident in samples collected in transmission mode but missing or very weak for spectra collected in reflectance mode. In the Seurat fixative samples, only the peak at 767 cm^{-1} is missing, and may suggest bleached shellac with minimal light aging given the strength of the other peaks that remain intact (Figure 2).

Conte crayons thought to be from the early 1900s were examined (Figure 3). The exact age of the samples is not known, but they are thought to be about 25 to 50 years more recent than what Seurat would have used. In looking at the C-H stretch for

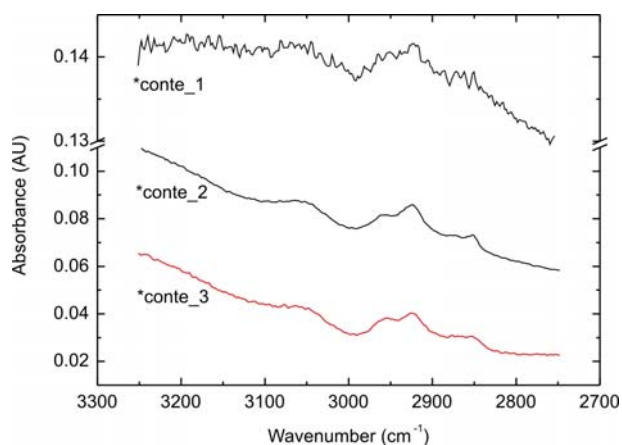


Figure 4: C-H stretch region of vintage samples of Conte 1,2,3 (top to bottom, respectively).

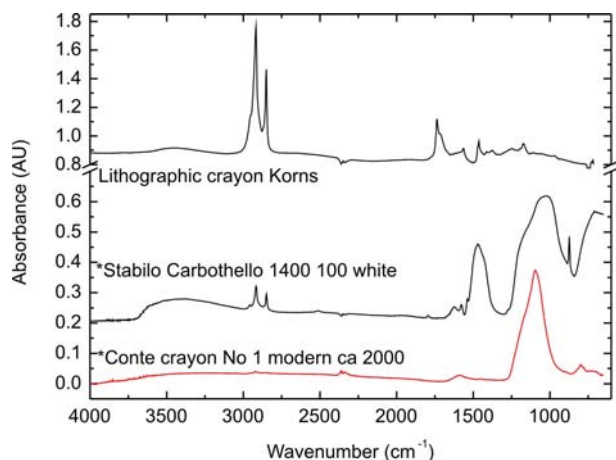


Figure 5: FTIR Spectra of some modern drawing media. Conte 1 (bottom) the broad absorption band at ca. 1000 cm^{-1} indicates Si-O lattice vibrations of silicate.

conte number 1, 2 & 3, all lack significant absorption in the C-H stretch region. (Figure 4). The C-H stretch is as weak as the C-H stretch for black pigments derived from carbonized organic matter. UV excitation did not reveal any autofluorescence but it does for other drawing media that do indicate a C-H stretch (Figure 5). It is interesting to note that it appears modern day (ca. 2000) conte crayon continues to be void of organic binder. Py-GC-MS of the reference samples revealed traces of organic compounds that compared well with levels found in pure lamp black pigment: hydrocarbon fractions varying in molecular size by CH_2 were absent. This suggests that any organic matter found in the vintage conte is not wax but related to the incomplete charring of whatever source was used for the carbon black. The significance of the drawing medium not containing wax will be discussed shortly.

X-ray fluorescence analysis (XRF) does reveal differences between the 'vintage' samples and those found in Seurat's drawings. The Seurat drawings contain silicates (confirmed via FTIR) and iron while the vintage crayons also contain traces of rubidium, strontium and zirconium. Calcium was also present in all of the drawings examined but could not be used to clarify or confirm the carbonate indicated in Figure 1 since the XRF data includes the paper and drawing components. This evidence suggests that the crayon's formulation has varied over time but that, based on IR spectroscopy; any organic matter has always been low and likely the result of incompletely charred organic matter. The trace levels of rubidium, strontium and zirconium are likely indicative of a shift in sourcing the clay and do not reflect a change in physical properties of the material.

The four drawings in MoMA's collection examined in this study are in excellent condition and range in dates from ca. 1879 to ca. 1888. Some appear to have minor evidence of discoloration of the paper support. Areas with a local surface coating fluoresce pale yellow in UV and suggest a dye extracted or bleached material. FTIR data indicates shellac and, according to the work of Copestake, bleached shellac (not decolorized) is specifically indicated by a peak absent at ca. 767 cm^{-1} which is true for all the samples examined. It is insufficient to positively identify an unknown through a *lack* of peaks but some form of shellac, as dilute and water-white as possible makes sense from the perspective of Seurat's technique. From a practical perspective, shellac fixative is logical because it will dry fast. It is also likely Seurat consciously chose a water-white shellac because in some passages there were multiple applications and in higher layers of the drawing composition few or none;

since these drawings were as important to Seurat as his paintings he clearly would not want an uneven appearance across the surface and the best way to achieve this is with a water-white isolating layer. Based on this evidence we are led to conclude that the purpose of the fixative primarily had a practical intent: it was most likely a means to improve tooth for later applications of conte and prevent smudging of the drawing as the composition was being formed. This data provides a strong argument against two assertions that have been made about conte in general and Seurat in particular: the former that the velvety 'feel' of the pencil is attributed to a wax component and the latter that Seurat intended his works to have a 'golden glow' and thus emulate an Old Master style. Rather, the golden glow comes from some works that appear to have yellowed from light damage and thus do not reflect the artist's intent. This is consistent with the current view expressed in the exhibition catalog associated with the exhibition that Seurat was very much a modernist.

The 1795 patent by Nicholas-Jacques Conte granted on January 3 confirms the lack of organic binder in the type of crayon recommended for artist's use. This patent outlines the inventions of a synthetic pencil made of graphite and clay, a pencil dipped in heated tallow for architectural purposes, a set of stick media containing carbon black and clay now commonly called conte crayon and colored pencils. The inventor notes conte crayons are for drawing nature and the figure. According to the patent hardness is controlled by two factors: the ratio of graphite to clay and the temperature of the baking process. To explain the myth of conte containing wax it is possible that some have combined anecdotal evidence of its waxy feel while drawing in conjunction with observations of local staining found in some drawings. Our findings indicate that the observed staining is actually from an isolation layer and for some drawings might have become more visible over time.

The main question in this investigation regarding the use of fixative was answered satisfactorily with micro-FTIR in transmission mode. While a separation method like Py-GC-MS would be ideal the sample available was insufficient. If resources were unlimited, Photoacoustic and Photothermal Beam Deflection Spectroscopy pioneered by Manfred Low³ in the 1980s could have been considered for this research since these are ideal methods for looking at carbon chars. In addition, open architecture X-ray diffraction would provide further information on the structure of the inorganic components. Together these methods might help identify the different formulations used for conte^{1, 2} and 3 and where in drawings pencils of

different hardness were used without the need for removing sample or physically contacting the surface as required by attenuated total reflectance (ATR) FTIR.

4 Acknowledgements

Kind thanks are due to MoMA staff Jodi Hauptman, the curator for Georges Seurat – The Drawings, for involving the conservation department with this exhibition; V erane Tasseau and Ana Martins translated the patent, and Jim Coddington provided valuable comments on the research. Kim Schenk from the National Gallery of Art in Washington D.C. supplied us with the vintage conte samples and Karen Trentelman at the Getty Conservation Institute provided valuable analytical advice.

5 References

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