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A retrospective exhibition of Yves Gaucher's work was recently organized by the Musée d'art contemporain de Montréal. This exhibition, which opened in 2003, was the starting point for a research project on the studio painting materials of the artist. The three main aspects of the project were: to gather documentary information about the artist's technique, to develop a database of the materials found in his studio, and to analyse selected paint materials from the studio to determine their chemical composition. A total of 375 samples were taken from the studio, documented in a database, and archived for future use. Analysis of 36 of the purest materials was undertaken using scanning electron microscopy combined with energy dispersive spectroscopy (SEM/EDX), Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD) and polarized light microscopy (PLM). The documentation and analysis provided information about the working methods and materials of the artist. Gaucher used a wide range of modern materials; three different types of acrylic media and a large number of pigments were identified. The pigments included organic compounds such as naphthol reds, Hansa yellows and phthalocyanine green, among others. Inorganic materials included pigments such as cadmium reds and yellows, iron oxides and ultramarine blue, as well as an unusual extender, nepheline syenite, a sodium potassium aluminum silicate.

Cet article présente les résultats d'une recherche sur les matériaux employés dans les peintures d'Yves Gaucher, dont le point de départ a été marqué par une exposition rétrospective de ses œuvres au Musée d'art contemporain de Montréal en 2003. Le projet a été réalisé en trois phases, consistant en une recherche documentaire sur les matériaux et méthodes de travail de l'artiste, suivie de l'échantillonnage et de la création d'une base de données sur les matériaux trouvés dans son studio, et enfin, de l'analyse d'une partie de ces échantillons afin d'en déterminer leur composition chimique. Au total, 375 échantillons ont été prélevés dans le studio de l'artiste. L'information recueillie sur ces échantillons a ensuite été entrée dans une base de données et archivée pour de futures références. Trente-six des échantillons les plus purs ont été analysés par microscopie électronique à balayage couplée à la spectroscopie des rayons X par dispersion d'énergie, ainsi que par diffraction des rayons X, spectroscopie infrarouge à transformée de Fourier (IR-TF), et microscopie à lumière polarisée. L'examen et l'analyse ont permis de mettre en lumière les méthodes de travail et les matériaux utilisés par l'artiste. Les données concernant les médiums acryliques, les pigments et les préparations dont se servait l'artiste sont présentées. Yves Gaucher employait une variété de matériaux : trois types de médium acrylique ainsi qu'un grand nombre de pigments ont été identifiés parmi les échantillons sélectionnés. Parmi les pigments, on retrouve entre autres des composés organiques tels que des rouges naphtols, des jaunes Hansa et un vert de phtalocyanine. Les matériaux inorganiques incluent des rouges et des jaunes de cadmium, des oxydes de fer et du bleu d'outremer, ainsi qu'une charge plutôt inhabituelle : la syénite néphélinique, un silicate de sodium, de potassium et d'aluminium.

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Introduction

Yves Gaucher (1934-2000) is one of Canada's most important abstract painters and printmakers. Gaucher was born in Montreal in 1934 and during the 1950s he studied at the École des beaux arts de Montréal under the tutelage of printmaker Albert Dumouchel. By the mid-1960s Gaucher had successfully circulated his work in national and international exhibitions and had received a number of prestigious awards. In 1966 he joined the department of Fine Arts at Sir George Williams University, now Concordia University, where he taught for 34 years.[1,2,3]

In the late 1960s, Gaucher produced a series of grey-on-grey paintings that has been described as one of the great achievements in Canadian art.[4] He went on to explore horizontal and vertical colour bands as well as diagonals. In the late 1980s, Gaucher produced a series of works known as the "Dark Paintings" that investigate the use of dark values and earth tones. In the early 1990s he carried out the "Pale Paintings" dominated by yellow, red, and blue.[4] When Gaucher injured his shoulder in 1997, he lost some mobility and this contributed to his adoption of collage as a new medium. Although his oeuvre shows a wide range of colours and formats, his works all share what has been described as "an uncommon formal purity and austerity."[5] **Figure 1** shows an acrylic painting from 1967-1968 entitled *Signals Red Heat (été 66)*. Gaucher's paintings and prints are found in collections around the world, including those of the Museum of Modern Art in New York, the Victoria and Albert Museum in London, and most major Canadian galleries.[1]

In preparation for a major retrospective exhibition at the Musée d'art contemporain de Montréal which opened in 2003, Gaucher's estate undertook the huge task of organizing his studio that had been left untouched since his death in 2000. As shown in **Figure 2**, hundreds of containers of paint used by the artist were found in the studio. This provided a unique opportunity to document Gaucher's studio, to collect samples of painting materials for analysis, and to archive samples for future study.

Although Gaucher has long been considered an important Canadian artist, this research represents the first study of his painting materials. The study contributes to the interpretation of

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Figure 1. Yves Gaucher, *Signals Red Heat (été 66)*, 1967-1968, © SODART, 2005. Acrylic on canvas, 183 cm x 183 cm. Collection Musée d'art contemporain de Montréal. Photo: MACM.

Gaucher's painted oeuvre by allowing a better understanding of his materials and working methods. Knowledge of Gaucher's materials will also assist in the conservation and display of his paintings, and will provide comparative information that will be of interest in any future examination of the paintings themselves. This project has focused solely on the materials that Gaucher used in his paintings. It is important to note that his contribution to the field of printmaking is also significant, and an examination of his printmaking materials and techniques would be an interesting area for future study.

The first step in the project was to gather and record documentary information on Gaucher's painting materials and techniques. Following this, a selection of the painting materials was analysed.

Documentary Information

The following is a summary of information on Gaucher's materials and techniques that was gathered from written sources, discussions with his family, colleagues, and paint manufacturer and from labels found on the containers in his studio.

Stretchers, Canvas and Preparatory Layers

Gaucher produced his acrylic paintings on canvas supports.[6,7] Prior to 1988, Gaucher either fabricated his stretchers himself, or he had them custom made by fellow artist, Marc Garneau. Most often, Gaucher used strainers, that is, non-expandable stretchers, that were usually made of lime wood. For very large formats, Gaucher would sometimes order his strainers from a window-making factory.[6] From 1988 onwards, Gaucher had his strainers made by Mathieu Gaudet, at Faux-Cadre Canal in Montreal, who generally used sequoia wood. Although sequoia is more expensive than other types of wood usually used in the fabrication of stretchers/strainers , it possesses excellent qualities such as strength, lightness, and resistance to environmental change and wood boring insects. According to Gaudet, this type of wood is especially suitable for large formats, as the sequoia tree grows very tall and provides long, straight boards that can easily support the weight of large canvases.[7]

Figure 2. Yves Gaucher's Montreal studio, November 2002. Photo: Marie-Chantale Poisson.

For very large format paintings on canvas, Gaucher would build a collapsible strainer: an assembly of two or three strainers held together by steel plates that were screwed at the top and bottom of the joints between the sections. This allowed him to transport the painting out of his studio by dismantling the strainer assembly and actually "folding" the painting.[7] Interestingly, the dimensions of each section were not symmetrical; Gaucher would determine the size of the strainer according to the painted design on the front in order that the joints would be aligned with certain lines or geometrical forms. This method would prevent eventual strainer marks in the canvas or paint layers from creating a visual distraction for the viewer.[7]

Gaucher generally used a heavy weight, plain weave, cotton duck canvas as a support for his paintings. He stretched the canvases himself, using staples to secure the edges to the strainer. He would prepare the canvas surface using three to four coats of acrylic ground and would re-stretch the canvas between each coat to ensure the tautness of the support.[7] Ground samples from Liquitex, Chromatech and Golden were found in the studio.

Paints

An artist of his times, Gaucher chose to paint with acrylics. According to colleagues and family members, he used primarily Chromatech and Liquitex paints.[8,9] This is borne out by the materials found in his studio. 40% of all the containers were labeled, with the majority coming from Chromatech (134). A smaller number were from Liquitex (20), one was from Golden, and a bag of filler material was from Indusmin Limited.

Chromatech, a small Montreal-based, artist-owned company, that is now out of business, supplied materials to artists such as Yves Gaucher, Claude Tousignant, and Guy Pellerin. Chromatech was founded in 1979 by Michael Towe. Mr. Towe is an artist and chemical engineer who started making paints, first for himself, and later for other artists.[9] Mr. Towe was Gaucher's paint maker from 1980 until the mid-1990s. Gaucher's interest in materials led him to work with Michael Towe to develop special paint mixtures for his specific applications.[9]

The acrylics supplied by Chromatech were made with Rhoplex emulsions from Rohm & Haas. Based on his archive of old receipts, Mr. Towe reported using five different acrylic emulsions, either alone or in combination, at various times between the founding of his company in 1979 and its closure in the 1990s.[9] The Rhoplex acrylic emulsions that he employed were the following: AC-33, AC-64, AC-234, AC-264, and AC-507. From 1979 to 1982, Mr. Towe used AC-33. He also tried AC-234 briefly around those years, but did not use it for very long as he found the resulting paint to be too soft.[9] Between 1984 and 1985, Mr. Towe used a mixture of AC-33 and AC-64. By 1986, he began using AC-64 alone, as he grew dissatisfied with the softness of the paint yielded by mixing it with AC-33. He also tried AC-507 for a short time during this period. Mr. Towe switched to AC-264 when production of AC-64 was discontinued in the early 1990s.

According to the literature,[10-15] and information from Rohm & Haas,[16] Rhoplex AC-33 and AC-234 are based on the acrylic emulsion poly(ethyl acrylate/methyl methacrylate), which henceforth shall be abbreviated to poly(ea/mma); while Rhoplex AC-64, AC-264 and AC-507 are based on poly(n-butyl acrylate/methyl methacrylate), henceforth referred to as poly(n-ba/mma). This indicates that Chromatech paints from 1979 to about 1982 should have a medium composed of poly(ea/mma). Between 1984 and 1985, they should be a mixture of poly(ea/mma) and poly(n-ba/mma). From about 1986 onward, the paints should contain poly(n-ba/mma). According to Mr. Towe, additives to the paint included: a fungicide, wetting and dispersive agents, and ammonia as a pH buffer.

Mr. Towe indicated that he used a range of pigments from various suppliers, including BASF, Rogers, Dominion Colors, Harrison & Crossfield, and Waters, among others. All apparently passed the ASTM requirements for acrylic artists' paints. The labels on the pigment containers in the studio are a useful source of information about the contents. However, it is important to note that Gaucher often re-used his containers, so that the contents do not necessarily correspond to the label. Also, some labels give only commercial names and do not provide information about the pigment composition.

Discussions with Guy Pellerin[17] revealed that Gaucher sometimes added a mineral filler, nepheline syenite (known under the brand name of Minex), to impart a specific texture to his paint. A partially used bag of this filler was found in Gaucher's studio, suggesting that he did indeed use nepheline syenite in his works. Michael Towe also indicated that Chromatech used nepheline syenite as a filler in some paints, and in fact, according to his son, Benoît Gaucher, Gaucher adopted the use of this material on the advice of Mr. Towe.[9]

Painting Technique

Until the 1980s, Gaucher executed his paintings using a spray gun combined with a hard-edge technique to create geometrical designs. From the 1980s onwards, Gaucher used paint rollers, a technique that he found more practical and less toxic in use than a spray gun.[18] When using a roller, Gaucher executed the painting quickly to ensure the evenness of the paint layer. His works are highly finished, with little evidence of texture in the paint or of the canvas support. The brushes found in Gaucher's studio were apparently used only for his works on paper; there is no evidence that he used brushes for his paintings.

In a 1966 interview with Lisa Balfour from the Montreal Star, Gaucher explained how he executed his paintings. He indicated that his works were not planned in advance; he would paint the background colour and let the colour field "talk to him" before deciding what geometrical configuration would be projected on it.[19] This observation period also allowed Gaucher to see the colour evolve as it dried, after which he would either keep the initial colour or modify it with another layer of paint.[6]

Gaucher did not want his paintings to be framed. In order to keep the visible canvas tacking edges clean and not have them interfere with the reading of the piece, he often masked them with tape prior to applying the paint.

Signatures and Titles

In many cases, Gaucher signed his paintings on the back of the canvas using a black pencil, including the date and sometimes the title. Although his use of letters and numbers to title his paintings is well known, the significance of this personal code is not fully understood. One reference to the meaning of his titles, in an exhibition catalogue from 1969, states that "the color mix is followed by the date (month and year)."[20] This order was sometimes inverted. For example, a painting entitled "D-67 R-1" indicates that "the ground colour is a red admixture, which was used for the first time (R-1), and it was painted in December, 1967."[20]

Analysis of Gaucher's Painting Materials

Sampling

Sampling of the painting materials in Gaucher's Montreal studio took place during November, 2002. **Figure 2** shows the studio at the time of sampling. Samples of all of the painting materials found in the studio - ranging from the various paint containers, to pots and bags - were transferred to chemically stable glass vials. Of the 375 samples taken, 357 included paint and/or medium, nine consisted of additives or fillers, five were grounds, and four were miscellaneous materials. A database was created, recording the colour (as assessed visually), container type, and inscriptions (both Gaucher's personal inscriptions and labels from the paint manufacturers) for each sample.

A group of 36 samples was selected for chemical analysis. These included samples from the most intensely coloured paints and from containers with various types of labels. The colour, paint manufacturer and inscription on the container for each sample are listed in the **Results** section.

Experimental

Samples of wet materials were painted out on microscope slides and left to air dry in a dust-free chamber over a period of two weeks prior to analysis. The samples were analysed using the following techniques: scanning electron microscopy combined with energy dispersive spectroscopy (SEM/EDS), Fourier Transform Infrared (FTIR) spectroscopy; X-ray diffraction (XRD); and polarized light microscopy (PLM).

Fragments of each sample were mounted on a carbon planchet and analysed by scanning electron microscopy/X-ray energy spectrometry (SEM/EDS) using an Hitachi 3500-N scanning electron microscope equipped with an Oxford Inca X-ray microanalysis system. Using this technique, elemental analysis of small volumes, down to a few cubic micrometers, can be obtained for elements from boron to uranium with a sensitivity of approximately 1%.

The samples were also analysed by Fourier transform infrared spectroscopy (FTIR) using a Bomem Michelson MB-100 spectrometer equipped with a 2 mm diameter wide band mercury cadmium telluride (MCT) detector and a microbeam sample compartment which provides a 1.13 mm beam size at the focus. The samples were mounted on a Spectra-Tech low pressure diamond anvil microsample cell for analysis. The diamond anvil cell contains two Type IIA diamonds, with a 0.6 mm diameter free working area. Spectra were acquired from 4000 to 400 cm^{-1}, by co-adding 200 interferograms. The binding medium as well as some pigments and fillers were identified using this technique.

In some cases, a Spectra-Tech IR-Plan infrared microscope accessory interfaced to a Bomem Michelson MB-120 spectrometer was used to look at specific areas of inhomogeneous samples. The spectrometer is equipped with a 0.25 mm diameter narrow band MCT detector. The samples were mounted on one half of a low pressure diamond anvil microsample cell placed on the microscope stage and areas of interest were chosen using a 100 μm circular aperture. Spectra were acquired from 4000 to 660 cm^{-1}, by co-adding 200 interferograms.

For certain samples, the binding medium was extracted from the pigments in order to obtain an infrared spectrum of the medium without interferences from pigment absorptions. In order to extract the medium, a small amount of dried paint was placed in a centrifuge vial with reagent grade acetone or chloroform, allowed to stand for 15 minutes and centrifuged. The supernant was filtered through a 0.2 micron filter on the tip of a 1 mL glass syringe and the solvent was allowed to evaporate. The resulting residue was analysed by FTIR spectroscopy.

The samples were also analysed by X-ray diffraction (XRD) using a Rigaku RTP 300 RC rotating anode generator with a cobalt target, operated at 45 kV and 160 mA. The samples were mounted on glass sample holders and analysed by diffractometry. The diffractometer included a goniometer with a scintillation counter probe interfaced to a computer. A dispersion slit and a sample slit of 0.5° and a receiving slit of 0.15 mm were used. An angular range of 2θ = 3-120° with a step scanning width of 0.05° was employed. The major crystalline components (pigments and fillers) in the samples were identified using this technique.

Finally, the samples were examined by polarized light microscopy (PLM) using a Leica DMRX polarizing light microscope. The samples were mounted in Cargille meltmount medium (n=1.66) and pigments and fillers were characterized on the basis of their optical and morphological properties.

Results

Identification of Medium

<u>Paint and Ground Samples</u>

According to the results of FTIR spectroscopy, all of the pigmented samples (30 paints and three grounds) were based on an acrylic medium. The Chromatech samples could be distinguished from the Liquitex paints based on the type of acrylic used.

The acrylics could be categorized into three types based on the C-H stretching bands, a characteristic region in the infrared spectrum for the identification of acrylics. The C-H stretching regions for each type of acrylic are shown in **Figure 3**. All the samples matched one of these three types. Within each of the three groups, solvent extractions were performed on a typical sample to obtain a pure spectrum of the medium. In this way, the composition of the three types was determined. For example, an acetone extraction of a grey paint containing the “type 1” acrylic gave a spectrum that matched reference spectra of poly(n-butyl acrylate/methyl methacrylate), i.e. poly(n-ba/mma). **Figure 4** shows the spectrum of the acetone extract of the paint compared to a standard spectrum of poly(n-ba/mma).

The “type 1” acrylic, composed of poly(n-ba/mma) was found in 12 out of the 17 Chromatech samples. The “type 2” acrylic was found in the remaining 5 Chromatech samples. Based on the results of FTIR spectroscopy, the acrylic likely contains n-butyl acrylate, methyl methacrylate and ethyl methacrylate. Because this is a complex mixture, confirmation of the composition using another technique would be necessary. The “type 3” acrylic was found in all of the Liquitex samples (both the paint and the ground) and in the Golden ground sample and corresponds to poly(ethyl acrylate/methyl methacrylate), or poly(ea/mma). This information is summarized in **Table I**.

Varnish and Mixing Medium Samples

Two samples of mixing medium from Chromatech and one varnish from Liquitex were examined. The results are also found in **Table I**. Both of the Chromatech mixing medium samples were based on poly(n-ba/mma), as found in the majority of the Chromatech paints. The sample labeled "matte medium" contained cristabolite (a form of silicon dioxide) as a matting agent. The sample labeled "opaque medium" was also found to contain mineral matting agents: an amphibole mineral (such as tremolite), lizardite, and possibly cristabolite were identified.

The varnish from Liquitex is based on poly(ea/mma). It also contains silicates, likely as a matting agent. Although the Liquitex label indicated that "hard wax" was present, analysis using FTIR spectroscopy did not identify wax in either hexane or acetone extracts of the varnish.

Identification of Pigments, Fillers, and Accessory Materials

The analysis showed that Gaucher's studio contained a range of modern pigments. Thirty different pigments, fillers and accessory materials were identified (**Table II**). The results are summarized in the following discussion. The sample numbers listed in the table correspond to the numbering system in the database; the samples will be referred to by these numbers in this paper.

Red and Orange Paints

Seven different red and orange paints were examined. Three of the red paints were in Chromatech containers, while three other red paints and one orange paint were in Liquitex jars. The pigments identified in the Chromatech samples (naphthol red and iron oxide red) corresponded to the label inscriptions and are listed in **Table II**. The paints were very pure and had no fillers or white pigments added. Three of the four Liquitex samples had Liquitex lids and the labels on the jars corresponded to the identified contents, except for the additional presence of a calcium carbonate filler in several samples (the coloured pigments included cadmium red/orange,[21] naphthol red and iron oxide red). Sample 252, however, had an unlabeled lid and was in an older style of Liquitex container, suggesting that the paint in the container may not correspond to the label; in fact, the label says that Pigment Red 5 is present but the analysis showed a different Naphthol red (Pigment Red 170).

Table I: Binding Medium of Paint, Ground, Mixing Medium and Varnish Samples

Label *	Number of Samples	Acrylic Resin	Acrylic Type
C	12 of 16 paint samples 1 of 1 ground sample 2 samples of mixing medium	n-ba/mma	1
C	5 of 17 paint samples	likely n-ba/mma/ea	2
L	14 of 14 paint samples 1 of 1 ground sample 1 of 1 varnish sample	ea/mma	3
G	1 of 1 ground sample	ea/mma	3

* C - Chromatech, L - Liquitex, G - Golden

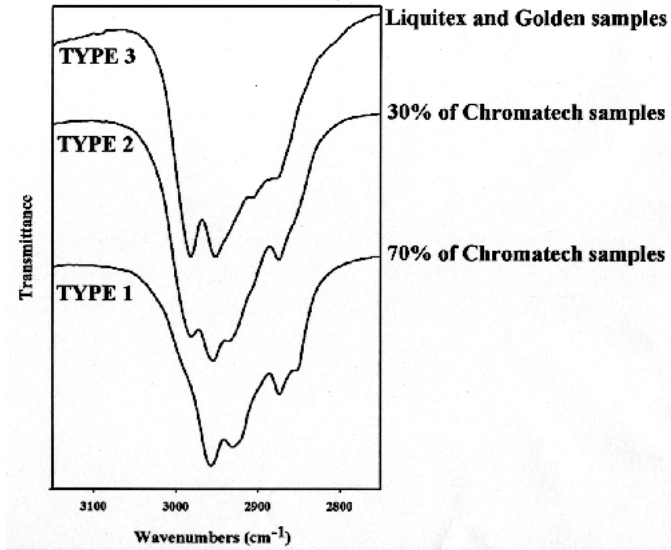

Figure 3. Partial FTIR spectra showing the C-H stretching region for the three types of acrylic medium identified.

Purple Paints

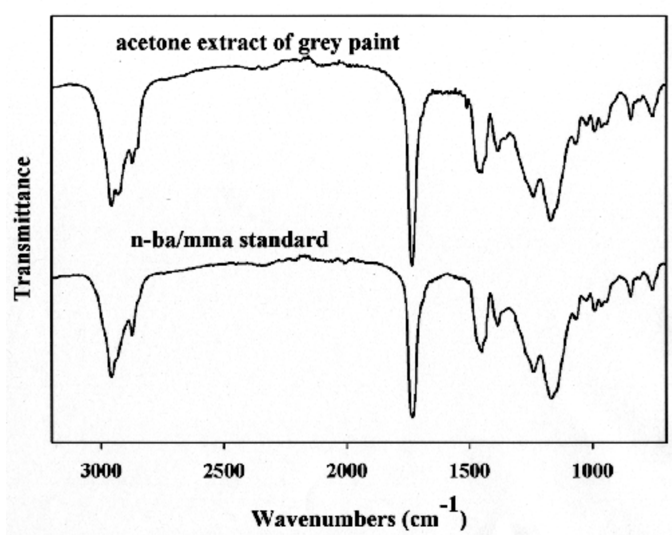

Figure 4. Upper trace shows the FTIR spectrum of the acetone extract of a grey paint sample and the lower trace shows a standard spectrum of poly(n-ba/mma). The spectra are a good match, both in the C-H region and the fingerprint region for acrylics (approximately 1100-700 cm^{-1}).

Two purple paint samples were examined, both of which were found in Chromatech containers. Sample 340, labeled "Acra violet," had a reddish-purple hue and was pigmented with quinacridone magenta. Sample 332, labeled "Dioxide Purple" had a purplish blue hue and was pigmented with a mixture of dioxazine violet and quinacridone magenta. This paint also contained nepheline syenite, a mineral extender described in more detail in the section on fillers and accessory materials.

Blue Paints

Four blue paints were examined, two in Chromatech containers and two in Liquitex jars. Both Chromatech samples were found to be pigmented with ultramarine blue, corresponding to the labels on the containers. Other pigments or fillers were also present, including nepheline syenite, kaolin and titanium white (rutile). The composition of the Liquitex sample labeled "Cobalt blue, Oxides of Cobalt and Aluminum" was found to be consistent with the label. Examination of the paint by polarized light microscopy showed that the majority of the blue particles had characteristics consistent with cobalt blue, but that a small amount of an unidentified turquoise pigment was also present. The Liquitex sample labeled "Cerulean Blue, Oxides of Cobalt and Chromium," suggested that it corresponded to Pigment Blue 36, a substituted cobalt blue (a mixed metal oxide spinel of cobalt, aluminum and chromium). Elemental analysis of the paint indicated that it does contain cobalt, aluminum, and chromium, but also an important quantity of zinc. The diffraction patterns of the mixed metal oxide spinels were very similar, and the exact composition of the blue pigment was not determined. The best X-ray diffraction match is a zinc substituted cobalt blue; however, the fact that chromium was identified suggests that there is also chromium substitution. In addition to the substituted cobalt blue, the sample contained aluminum oxide, calcium carbonate (calcite), and similarly to the other Liquitex blue sample, a small amount of an unidentified turquoise pigment.

Green Paints

Five green paints were examined, one in a Chromatech container and four in Liquitex jars. X-ray diffraction of the Chromatech sample that was labeled "Cobalt Green" indicated that the paint was pigmented with a mixed metal oxide spinel. The exact composition of the spinel was not determined; however, based on the elemental analysis and the diffraction pattern, the pigment is probably a zinc titanium spinel with nickel and cobalt substitution. This corresponds to the pigment cobalt green (Pigment Green 50). Titanium white (rutile form) was also present. The four green Liquitex paints had quite varied compositions, listed in **Table II**, which corresponded to the Liquitex labels on the jars. Three green pigments identified were: phthalocyanine green; chromium oxide green; and nitroso green.

Yellow Paints

Four yellow paints were examined, two in Chromatech containers and two in Liquitex containers. The Chromatech sample labeled "Hansa Yellow" did, in fact, contain this pigment, while the sample labeled "Perm. Yell. Deep" contained not only Hansa Yellow but also diarylide yellow and nepheline syenite. One of the Liquitex samples, labeled "pure hydrous iron oxide," contained this pigment (goethite) but also contained a calcium carbonate filler. Similarly, the other Liquitex sample contained cadmium yellow with barium sulphate and calcium carbonate, but was described as "cadmium sulphide co-precipitated with barium sulphate," with no mention of the calcium carbonate filler.

Brown, Grey and Black Paints

Three brown samples (two from Chromatech and one from Liquitex) contained iron oxide pigments. The black and grey samples were each from Chromatech. The black consisted of carbon black, while the grey contained primarily quartz and nepheline syenite, with only a trace of black pigment.

White Paints and Grounds

Two samples of white paint from Chromatech and one from Liquitex were examined. All three were found to be pigmented with titanium white (rutile form). Three types of ground or gesso were examined: a gesso from Chromatech, a ground from Liquitex, and a gesso from Golden. All contained titanium white (rutile) but, as shown in **Table II**, each had different mixtures of fillers or additives in them.

Fillers and Accessory Materials

As described in the previous sections, a number of fillers and accessory materials were found mixed with the pigments in the paint samples. These were: calcium carbonate (calcite and aragonite), barium sulphate, aluminum oxide, kaolin, quartz, and nepheline syenite. Barium sulfate was found only in the cadmium colours, suggesting that they were probably cadmium lithopones and that the barium sulfate was co-precipitated with the cadmium pigment.[22] Although most of these fillers and accessory materials are commonly found in paints, the presence of nepheline syenite (Minex) is more unusual. Nepheline syenite is a feldspar mineral mixture, containing primarily albite, with smaller amounts of microcline and nepheline.[23] Analysis by XRD of a sample of powder from the bag of Minex, found in Gaucher's studio, confirmed that it was composed primarily of albite, microcline, and nepheline. This raw material provided a valuable reference and allowed the identification of nepheline syenite in six of the Chromatech paint samples: grey (sample 5); blue (sample 366), purple (sample 332), yellow (sample 278) and a gesso sample (305).

Discussion and Conclusions

Three different types of acrylic medium were found in the samples taken from Yves Gaucher's studio. The Chromatech materials could be distinguished from the Liquitex materials based on the type of acrylic resin used. All Liquitex samples (14

Table II: Pigments and Fillers Identified in Paint and Ground Samples

Colour	No.	Manufacturer; Inscription*	Pigments and Fillers Identified
Red and Orange	10	Chromatech; Naphthol Crimson	naphthol red (Pigment Red 7)
	11	Chromatech; Naphthol Red Med	naphthol red (Pigment Red 112)
	343	Chromatech; Red Oxide Deep	iron oxide red (haematite)
	244	Liquitex; Cadmium orange; Cadmium Sulfo-Selenide coprecipitated with Barium Sulfate	cadmium red/orange[21] barium sulfate
	251	Liquitex; Cadmium Red Medium; Cadmium Sulfo-Selenide coprecipitated with Barium Sulfate	cadmium red/orange[21] calcium carbonate (calcite) barium sulfate
	252	Liquitex; Naphthol ITR Crimson; Arylamide Azo Red C.I. Pigment Red 5	naphthol red (Pigment Red 170)
	348	Liquitex; Red Oxide; Iron Oxide Pigment	iron oxide red (haematite) calcium carbonate (calcite)
Purple	332	Chromatech; Dioxide Purple	dioxazine violet (Pigment Violet 23) quinacridone magenta (Pigment Red 122) nepheline syenite
	340	Chromatech; Acra violet	quinacridone magenta (Pigment Red 122)
Blue	344	Chromatech; Ultramarine blue [G or 6]	ultramarine blue nepheline syenite kaolin (trace)
	366	Chromatech; Ultramarine blue R	ultramarine blue titanium white (rutile) nepheline syenite
	280	Liquitex; Cobalt blue; Oxides of cobalt and Aluminium	cobalt blue (cobalt aluminim oxide) aluminium oxide unidentified turquoise pigment (trace)
	281	Liquitex; Cerulean Blue; Oxides of Cobalt and Chromium	substituted cobalt blue aluminum oxide calcium carbonate (calcite) unidentified turquoise pigment
Green	20	Chromatech; Cobalt Green	cobalt green (spinel mixed metal oxide, Pigment Green 50) titanium white (rutile)
	240	Liquitex; Chlorinated copper phthalocyanine C.I. Pigment Green 7	phthalocyanine green (Pigment Green 7)
	276	Liquitex; Hooker's Green; Ferric Nitroso Betaphtenol, C.I. Pigment Green 8	Pigment Green B (nitroso pigment, Pigment Green 8)
	277	Liquitex; Chr. Green OX - Anhydrous Chromic Oxide; chromium Oxide Green	chromium oxide green calcium carbonate (calcite)

* as transcribed from the container labels

Colour	No.	Manufacturer; Inscription*	Pigments and Fillers Identified
	311	Liquitex; Permanent Green Light; Cadmium-Barium Sulfide and Phthalocyanine Green	phthalocyanine green (Pigment Green 7) cadmium yellow barium sulfate calcium carbonate (calcite)
Yellow	278	Chromatech; Perm. Yell. Deep	hansa yellow 10G (Pigment Yellow 3) diarylide yellow (Pigment Yellow 83) nepheline syenite
	279	Chromatech; Hansa Yellow	hansa yellow 10G (Pigment Yellow 3)
	242	Liquitex; Cadmium Sulfide co precipitated with Barium Sulfate; Cadmium yellow Light	cadmium yellow barium sulfate calcium carbonate (calcite)
	274	Liquitex; Yellow Oxide; Pure Hydrous Iron Oxide	yellow iron oxide (goethite) calcium carbonate (calcite)
Brown, Grey and Black	31	Chromatech; Raw Umber	yellow to brown iron oxide pigment kaolin
	346	Chromatech; Raw Sienna	yellow iron oxide (goethite) kaolin quartz
	243	Liquitex; Burnt Sienna; Roasted earth pigment	red iron oxide pigment (haematite) quartz
	5	Chromatech; Lumigray	quartz nepheline syenite trace of black pigment (possibly graphite)
	6	Chromatech; Lamp Black	carbon black
White and Ground	210	Chromatech; Transparent White	titanium white (rutile)
	345	Chromatech; Titanium white	titanium white (rutile) kaolin
	250	Liquitex; titanium white; Titanium Oxide	titanium white (rutile)
	305	Chromatech; Gesso	titanium white (rutile) nepheline syenite (composed of albite, microcline, and nepheline)
	303	Liquitex; Ready-to-use Painting Ground-Flexible Acrylic Polymer Base, brilliant white, contains no lead	titanium white (rutile) kaolin calcium carbonate (calcite)
	304	Golden; Gesso acrylique	titanium white (rutile) calcium carbonate (aragonite form with small amount of calcite form)

* as transcribed from the container labels

paints, 1 ground and 1 varnish) and the Golden sample (1 gesso) had a medium based on poly(ethyl acrylate/methyl methacrylate). Two different types of Chromatech medium were identified: 12 of the 16 paint samples, 1 ground sample and 2 mixing medium samples had a medium based on poly(n-butyl acrylate/methyl methacrylate). The remaining 5 paint samples had a more complex medium, likely containing n-butyl acrylate, methyl methacrylate and ethyl methacrylate.

The use of poly(ea/mma) in the Liquitex and Golden paint samples is characteristic of acrylic formulations manufactured up to the late 1980s.[15] A study of artists' acrylic varnishes and media at CCI in the early 1990s showed that older Liquitex samples were based on poly(ea/mma), while newer ones were based on poly(n-ba/mma).[13] The medium found in the majority of the Chromatech paints, poly(n-ba/mma), is consistent with Rhoplex AC-64 or AC-264, used by Chromatech from 1986 onwards. The medium found in a smaller proportion of the Chromatech samples, containing n-butyl acrylate, ethyl acrylate, and methyl methacrylate, could correspond to the mixture of AC-33 and AC-64 used by Chromatech between 1984 and 1985. According to Gaucher's son,[8] a pink paint, not used in Gaucher's works since the 1960s, was found in the studio, indicating that some of the paint mixtures were very old. It is possible then, that some paints from the mid-1980s have also remained in his studio. However, it is also possible that these Chromatech samples represent paints or media that were mixed together by Gaucher.

It is interesting to observe that Gaucher used several different acrylic formulations in his paintings. This may have been due to availability or to technical or handling reasons. It would be expected that works he produced using the poly(n-ba/mma) medium would be slightly tougher, more hydrophobic, and more resistant to dirt than those using the poly(ea/mma) medium.[10,15] It is important to note that, in this study of Gaucher's paint medium, only the major components of the acrylic formulation were identified using FTIR spectroscopy. Acrylics have a number of low concentration additives that will affect their properties. As described earlier, Michael Towe of Chromatech provided a list of materials that he added to his acrylic paints to modify their properties. Future work on Gaucher's paint medium could include analysis using a separation technique such as pyrolysis gas chromatography/mass spectrometry to confirm the composition of the polymer base and provide information about additives to the medium.[14,15] It would also be interesting to analyse the yellowish exudates or drips found on some of Gaucher's paintings, to determine whether of not this phenomenon is related to the acrylic medium used.

The documentation and analysis show that Gaucher's studio contained a wide range of modern pigments. Thirty different pigments, fillers, and accessory materials were identified. In the ASTM standard specifications for artists' acrylic emulsion paints,[24] all but two of these pigments are considered permanent and to have excellent or very good light-fastness ratings. The less stable pigments identified were Pigment Green B (nitroso pigment, Pigment Green 8), which has only fair light fastness, and dioxazine violet (Pigment Violet 23), which is rated fair to very good, depending on the shade. Since these pigments were found in Gaucher's studio and were likely used in his paintings, the potential fading of green and violet pigments should be considered when choosing storage and display conditions, as well as duration of exposure for Gaucher's works.

Because many of Gaucher's pigments are organic, it is important to point out that some pigments show poor resistance to organic solvents. Thus not only the acrylic binder, but specific pigments will be sensitive to solvent action. This may have an impact on cleaning methods. For example, Pigment Red 7 (a type of naphthol red) and Pigment Yellow 3 (Hansa yellow 10G) show solubility in a number of organic solvents, including mineral spirits.[25]

Although most of the fillers identified in the pigment mixtures are commonly found in paints, the presence of nepheline syenite is more unusual. The bag found in Gaucher's studio, labeled "Minex Indusmin nepheline syenite" indicates it is from Indusmin Limited, the most important producer of the material, located in Nephton, Ontario, north of Toronto. The major uses of the mineral are in glass and ceramics, although it is also used as a low cost extender pigment for industrial paints.[23] As described previously, both Michael Towe of Chromatech and Gaucher himself added nepheline syenite to some paints in order to produce a specific texture. Nepheline syenite filler was found in six of the Chromatech paints some of these being grey, blue, purple, and yellow paints, as well as white gesso. From these results, there is no clear trend indicating that the filler was used in particular colours. Now that nepheline syenite has been identified in Gaucher's studio paints, it would be interesting to examine a sampling of his paintings to determine to what extent this filler was used. Visual examination of some of his paintings at the Musée d'art contemporain de Montréal showed that certain surfaces have a subtle grainy texture and a slight sheen, that is perhaps caused by the presence of this mineral filler. It would also be useful to analyse paint materials from Chromatech that were used by other artists to determine whether or not the filler was exclusive to paints used by Gaucher.

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