

Article

Overview of Materials and Techniques of Paintings by Liu Kang Made between 1927 and 1999 from the National Gallery Singapore and Liu Family Collections

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Abstract: This article summarises the extensive research conducted in recent years on the paintings by Liu Kang (1911–2004), a renowned modern Singaporean artist. The investigation considered 97 paintings made between 1927 and 1999 from the National Gallery Singapore and Liu family collections. While detailed results of the analytical studies were presented in a series of publications, the scope of this article comprises an overview of the artist's preferential painting supports and pigments and an outline of the evolution of his working methods. The collected information considerably increases the knowledge about Liu Kang's painting practice and may assist conservators in the diagnosing, treatment, dating and authentication of artworks of uncertain origin. The results demonstrate the importance of comprehensive multi-analytical studies, which combined with documentary sources and art history research, provide a full understanding of the artist's painting practice.

Keywords: Liu Kang; painting supports; pigments; Shanghai Art Academy; Nanyang style



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1. Introduction

Liu Kang (1911–2004) (Figure 1a) obtained an artistic education from Xinhua Arts Academy in Shanghai (1926–1928) and went for further study at the Académie de la Grande Chaumière in Montparnasse, France (1929–1932), where he developed a fascination for impressionism and post-impressionism painting [1–4]. Liu Kang's early artistic achievements in Paris were publicly recognised in 1930 and 1931, when he exhibited at the Salon d'Automne (Figure 1b,c) [5,6]. In 1933, he returned to Shanghai and took up the position of professor at the Shanghai Art Academy, a prestigious art training institution in China at the time [3,7], with his artistic activity focused on developing an individual expression. He lived and worked in Shanghai until 1937, when the Second Sino-Japanese War (1937–1945) broke out, forcing him to move to Malaya. He eventually settled permanently in Singapore in 1945 and continued the artistic development with renewed vigour, leading ultimately to major contributions to the Nanyang style in the 1950s. The Nanyang style was a local art movement that adopted selected principles of the School of Paris and Chinese painting traditions for representing Southeast Asian subject matter [8–10]. Although Liu Kang's further artistic activity was guided by the general principles of the Nanyang style, the artist also searched for new sources of inspiration and passionately expressed himself in special artistic themes unrelated to the tropical flavour, namely, the Huangshan and Guilin mountains in China and nudity. The exploration of these genres triggered unconventional painting approaches, such as exceptionally heavy impastos and a reduced palette of colours, which accentuated some inconsistencies in the artist's oeuvre [11]. Additionally, some technical peculiarities, such as artist's retouching and alteration, as well as painting over earlier compositions or utilising their reverse sides, were integral to Liu Kang's creative process and contributed to the unique character of the artist's works [12].



Figure 1. (a) Archival photograph of Liu Kang from the 1950s showing the artist in the studio; (b) certificate of the artist's participation at the Salon d'Automne in 1930 and in (c) 1931. Liu Kang family collection. Images courtesy of Liu family.

The literature relating to Liu Kang's oeuvre is limited and includes academic dissertations and studies about his professional activity in the context of other Singapore artists or the Nanyang style. Other sources comprise various exhibition catalogues, press releases, interviews and TV documentaries. Moreover, none of the authors have discussed the artist's painting techniques comprehensively or analysed the peculiarities of his working practice. The first attempt at presenting the artist's main artistic achievements is an article by Ho Kok Hoe from 1955 [6]. Ho's publication is also the only one in which the artist's three favourite paint pigments, namely vermilion, viridian and Prussian blue, are briefly mentioned. Two press interviews with Liu Kang conducted by Gretchen Mahbubani [13] and Thiagarajan Kanaga Sabapathy [14] in 1981 enrich our knowledge with anecdotes from the artist's life, which help explain certain aspects of his painting practice. Contrarily, a 1982 TV documentary shows some of his painting materials, but it does not discuss the artist's painting practice [15].

Liu Kang presented his artworks at numerous individual and collective exhibitions. The most important are the first individual exhibition in Singapore in 1957, the retrospective exhibition at the National Museum Singapore in 1981 and exhibitions in Taiwan (1983), Hong Kong (1985), Japan (1997) and China (2000). The catalogues of these exhibitions serve as additional sources of knowledge about Liu Kang. Two of these catalogues, from 1997 [16] and 2000 [1], as well as a monograph from 2011, published in conjunction with an exhibition organised by the National Art Gallery in Singapore [17], contain the most extensive descriptions of Liu Kang's painting style and his artistic inspirations. Other valuable sources of information are Liu Kang's collections of essays, written between 1937 and 1980 and published in 2011 [18], though, unfortunately, the artist was focused on social, cultural and art topics and did not share information about his approach to painting.

The identified sources of information reveal that very little is known about the technical aspects of Liu Kang's painting practice, despite public recognition of the artist as one of the leading figures of the Singapore modern art. In addition, none of Liu Kang's paint tubes have been preserved. Therefore, to compensate for this gap in our knowledge, recent

technical analyses carried out by Lizun et al. have focused on Liu Kang's artistic phases, special themes and case studies, providing a new and comprehensive body of knowledge of his working methods [12,19–27]. In particular, the types of painting supports and the methods of their preparation, as well as the structure and chemical composition of the ground and paint layers, have been identified. In addition, the role of preparatory studies in the artist's creative process and the intriguing features of his painting techniques have been thoroughly explored.

Hence, based on the key technical features—which have been determined—of the artist's working practice, the present article traces the evolution of Liu Kang's preferences with regard to painting materials and techniques through the eight decades of his career. The results may assist in the revision of the provenance and dating of Liu Kang's paintings and clarify the presence of unconventional stylistic and technical solutions. Moreover, the yield data can aid conservation diagnostics and the treatment of his artworks.

2. Materials and Methods

The research focused on 97 of Liu Kang's paintings from the National Gallery Singapore (NGS) and Liu family collections created on canvas and hardboard between 1927 and 1999. The inclusion of 41 paintings from the Liu family collection was an attempt to ensure a balanced representation of the artist's genres, painting materials and techniques from which conclusions can be made.

A total of 448 ground- and paint-layer samples and 152 fibre samples were taken from the study group paintings for analyses.

Research strategy comprised non- and micro-invasive techniques applied to provide a wide array of significant data. However, the scope of the analytical methods differed between the NGS and Liu collections. Aligning with the wishes of the late artist's family, the majority of their paintings were investigated using non-invasive in situ methods, while some invasive analytical techniques were conducted only on selected artworks. For example, to provide an insight into the complex structure of the Paris and Shanghai painting supports, the extraction of fibre and ground-layer samples was applied to 20 NGS paintings, as well as to 35 works from the Liu family collection [21]. This decision was motivated by insufficient data from the NGS paintings, which did not allow the making of correlations between the structure of the textiles and ground layers from the two pivotal artistic phases. On the other hand, not all paintings from the Liu family collection were subjected to invasive sampling of the paint mixtures—in some cases, inventory and imaging were the only techniques employed to support the analyses of the artist's painting process. Nevertheless, in the case of seven NGS paintings, *Slope* (1931), *Portrait of C.Y. Hwang* (1939), *Malay man* (1942), *Bathing in the river* (1947), *Batik workers* (1954), *Fruit sellers* (1969) and *Chinese bridge over river* (c. 1974), this limited analytical approach turned out to be sufficient for providing insights into the technical features of Liu Kang's practice. Table S1 presents a chronological listing of the paintings selected for the study.

As an informative first-step approach, standard technical data were obtained from all paintings, including dimensions, characteristics of the painting supports and surface paint layers. Then, detailed analyses of the canvas structure, such as the weave, density and twist of threads, were performed using a Keyence VHX-6000 digital microscope.

The recto and verso sides of the paintings were photographed with Nikon D90 DSLR and later with D850 DSLR modified cameras with a sensitivity of 360–1100 nm to record the characteristic features of the paintings and to tentatively identify the pigments and determine the sample extraction sites. The photography techniques comprised visible light (VIS), ultraviolet fluorescence (UVF), reflected ultraviolet (UVR), near-infrared (NIR) and infrared false-colour (IRFC) imaging [12,19,20,22–31].

Raking light photography, reflectance transformation imaging (RTI) [32–34] and digital microscopy were used with regard to the possible presence of underlying compositions, which were later visualised with NIR and X-ray radiography (XRR) [12,19,20,22–26] using a Siemens Ysio Max digital system. Hidden paint layers were also revealed with a macro-

X-ray fluorescence (MA-XRF) Bruker M6 Jetstream scanner [19,22]. This instrument and the portable XRF Thermo Scientific™ Niton™ XL3t 970 spectrometer later allowed the initial identification of pigments in the ground and paint layers [20,22,24].

The following step involved the extraction of fibres for morphologic identification and the phloroglucinol stain test carried out using a Leica DMRX polarising microscope (PLM) [21,23,24,26,35]. The stain test determined the presence and concentration of lignin in the natural fibres and allowed the distinguishing between cotton, linen and hemp. Then, ground and paint fragments were taken from the areas of the existing paint losses for the preparation of pigment dispersions and paint layer cross-sections. All samples were photographed using a digital microscope and polarised microscope coupled with a digital camera. The structure of the samples and their organic and inorganic constituents were analysed using PLM [36], field-emission scanning electron microscope with energy dispersive spectroscopy (FE-SEM-EDS) Hitachi SU5000 coupled with Bruker XFlash® 6/60 EDS, followed by total reflectance–Fourier transform infrared spectroscopy (ATR-FTIR) [19–27] using a Bruker Hyperion 3000 FTIR microscope with a mid-band mercury cadmium telluride (MCT) detector connected to a Vertex 80 FTIR spectrometer [19–27]. The processed FTIR spectra were also compared to references in the material collection of the Institute for Conservation, Restoration and Study of Cultural Heritage, Nicolaus Copernicus University, spectral library of the Infrared and Raman Users Group (IRUG) [37], database of ATR-FT-IR spectra of various materials [38] and reference spectra published in the literature.

However, the acquired data did not always result in a positive pigment identification. For instance, some organic reds remain unknown and the potential presence of additional compounds has to be considered; therefore, further investigations involving chromatography and a range of mass and vibrational spectroscopy techniques should be conducted [39,40].

Moreover, the advertisements of the local art materials suppliers gave insights into the possible range of painting materials available to Liu Kang during his artistic phases.

When necessary, the interpretation of the analytical data was cross-referenced with contemporary colourmen catalogues, such as Lefranc, Bourgeois Ainé, Reeves & Sons (R&S), Rowney, Winsor & Newton (W&N) and Royal Talens. The catalogues enabled us to confirm the availability of certain materials. However, conclusions about the brands of materials used by the artist should not be hastily drawn. The archival photographs of the artist at work further expanded our knowledge of his materials and tools, whereas his drawings and watercolours shed light on the development of the compositions from the initial concepts to the completed artworks.

It is worth noting that the adopted naming convention of Liu Kang's artistic phases builds upon the structure of the artist's oeuvre proposed by Chow, Sen and Mo [1]. Hence, his artistic phases correspond to the places where Liu Kang was active or relate to his major contributions.

3. Results and Discussion

3.1. Painting Supports

The vast majority of Liu Kang's paintings were created over commercially prepared and unbranded canvases. The lack of stamps on the examined canvases could imply the purchase by the length from various small-scale retailers who did not brand their products. Manufacturers' stamps, however, with poor print and thus remaining unattributable to any colourmen known to the authors, were found only in two paintings—*Rustic landscape* (1934) and *Village* (1950) [21,24].

Although the research did not point to the brands of the painting supports Liu Kang used in his career, the advertisements of the art materials suppliers consistent with the time period and location of Liu Kang's activities suggest that he might have had access to a range of canvases from local and overseas manufacturers [21,23,24]. Nevertheless, conclusions about their brands should not be hastily drawn.

Reliance on commercial canvases was probably a convenient way for the preparation for painting as it only involved cutting the canvas to the required size and stretching it on the strainer or stretcher. Possibly due to poor quality, many of the original auxiliary supports were replaced by the artist or local framer whom he commissioned for the stretching and framing. This procedure sometimes involved cutting off weakened tacking margins, which necessitated mounting the canvas to the hard support with an adhesive, as in the cases of *French lady* (1931), *Self-portrait* (1931) and *Mount Huangshan* (1996) [12,21,26].

As can be seen from Table S1, linen canvases were frequently employed. However, it is worth noting that cotton canvases were the norm during the Shanghai phase [21]; the analyses highlighted the occasional use of cotton textiles in much later artworks—*Mountain* (1981) and *Mount Huangshan* (1996). Both linen and cotton painting supports are made in plain weave; however, two exceptions are represented by *Mountains* (1991) and *Nude* (1995), which are characterised by a basket-weave structure (Figure 2a,b) [26].

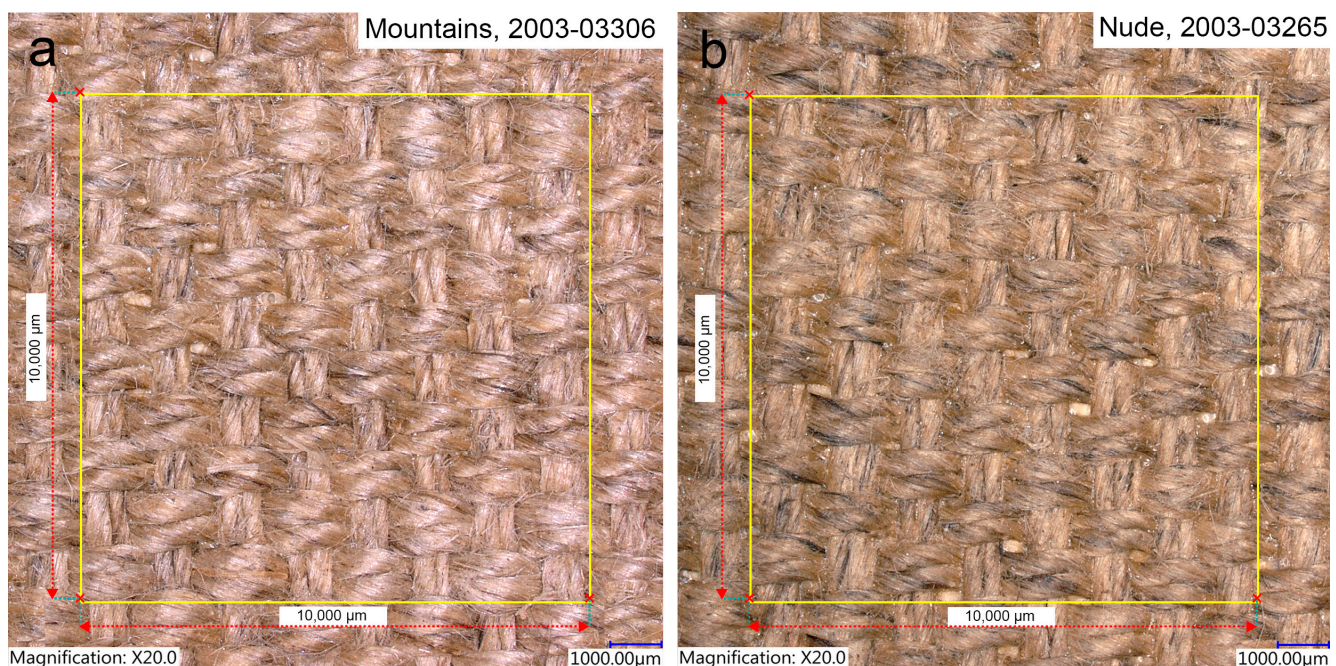


Figure 2. Photomicrographs of basket-weave structure identified in: (a) *Mountains*, 1991; (b) *Nude*, 1995.

The research revealed that Liu Kang utilised the recto and verso sides of his existing artworks for painting. This approach was probably motivated by extreme cost-saving solutions during the Paris phase [21,22] and the non-availability of the painting materials during the period of emigration to Malaya [23], whereas the practice of painting over earlier compositions during the mature years (the 1950s–1990s) likely resulted from the utilisation of unsuccessful and rejected artworks (Table S1) [12].

Hardboard resembling Masonite (pressure-moulded wood fibres) was the second type of painting support employed by Liu Kang, and the earliest documented example of its application is *Portrait of C.Y. Hwang* (1939), which was executed over the textured side (Figure 3a,b). The remarkably consistent use of the hardboards was recorded in the artworks depicting mountainous Chinese landscapes, created between the 1970s and 1990s. The artist seemed to favour utilising the smooth side of the hardboards, which he probably considered adequate for the vigorous handling of the paint with brushes and palette knives, contributing to heavy impastos and robust scraping [26].

Liu Kang's frequent outdoor painting sessions in Paris and Shanghai encouraged the use of small-sized painting supports, which were convenient to carry around [21]. His artistic activities of the 1940s do not show a radical change with regard to the size of painting supports, as he often painted over the recycled Paris and Shanghai artworks [23].

In the 1950s, there was a shift in the size of Liu Kang's paintings, with some exceeding 100 cm in height or width [24]. This observation was additionally corroborated by Frank Sullivan in the introduction to Liu Kang's 1957 exhibition catalogue: "He loves big canvases, over which his brush can sweep and range with firm touch and definite line" [5]. Liu Kang already enjoyed a well-established professional position; hence, it is conceivable that he could have afforded the required painting materials as their availability had improved in Singapore in the 1950s. Thus, the paintings created until the twilight of Liu Kang's artistic career show a variety of sizes, as seen in *Mountain* (1981), which measures 36 × 29.5 cm, and *Beauties at rest II* (1998), which measures 85 × 127 cm [25,26].



Figure 3. Liu Kang, *Portrait of C.Y. Hwang*, 1939, oil on hardboard, 61 × 46.4 cm (a) and detail showing the perforation of the hardboard visible through the paint (b). Painting is a gift of C.Y. Hwang family. Collection of National Gallery Singapore. Image courtesy of National Heritage Board, Singapore.

3.2. Priming Layers

The artist habitually worked on white grounds as they played a fundamental role in the painting process. For instance, a successful employment of the white ground as a colour in Paris paintings reflects an inspiration from Modernists' techniques [22,41,42]. Likewise, as a mature artist, he skilfully exposed the white colour of the ground, which was later pivotal in the batik-inspired painting technique [24].

The structure of the ground layers displays some variability as the artist purchased ready-primed canvases from various suppliers during his oeuvre. However, the painting *Nude* (1927), created during the artist's academic years at Xinhua Arts Academy in Shanghai, is an interesting peculiarity as it shows the bare tacking margins, evidencing an artist's preparation of the painting support (Figure 4a,b). The ground was applied over the cotton canvas as a single layer (Figure 5a,b) composed of chalk (PW18), lithopone (PW5) and/or barium white (PW21) and zinc white (PW4) and some lead white (PW1) bound in drying oil (Figures 5c and 6). Hence, it is conceivable that the craft of the preparation of the canvas for painting was part of his artistic education. However, the analyses of his subsequent painting practice proved Liu Kang's reliance on commercially prepared canvases.

The grounds of the paintings created during the Paris and Shanghai phases are single layered. The grounds from Paris are predominantly made of lead white combined with extenders and drying oil. Absorbent grounds bound in natural glue or semi-absorbent grounds bound in a combination of natural glue and drying oil occur less frequently. Although it is conceivable that the oil originated from the artist's paint, as can be exemplified by *My landlady, Madame Normand* (1932), where oil from the thinned paint had penetrated through to the back of the canvas [21].

As for the grounds from Shanghai, the majority are made of chalk as a principal component combined with additives and bound in drying oil and proteinaceous compound,

suggesting absorbent or semi-absorbent structures. However, the oil detected in the latter might also have come from the paint [21]. The ability of these two types of ground to accelerate the drying of oil paint was probably a key factor determining their use for the outdoor painting sessions and rapid execution at the studio in Paris and Shanghai. It is also possible that the artist appreciated the matt finish of his paintings, which resulted from light scattering on a rough paint surface with lower oil content.



Figure 4. Liu Kang, *Nude*, 1927, oil on canvas, 45 × 60 cm (a) and detail of the painting showing unprimed tacking margins (b). Liu Kang family collection. Images courtesy of Liu family.

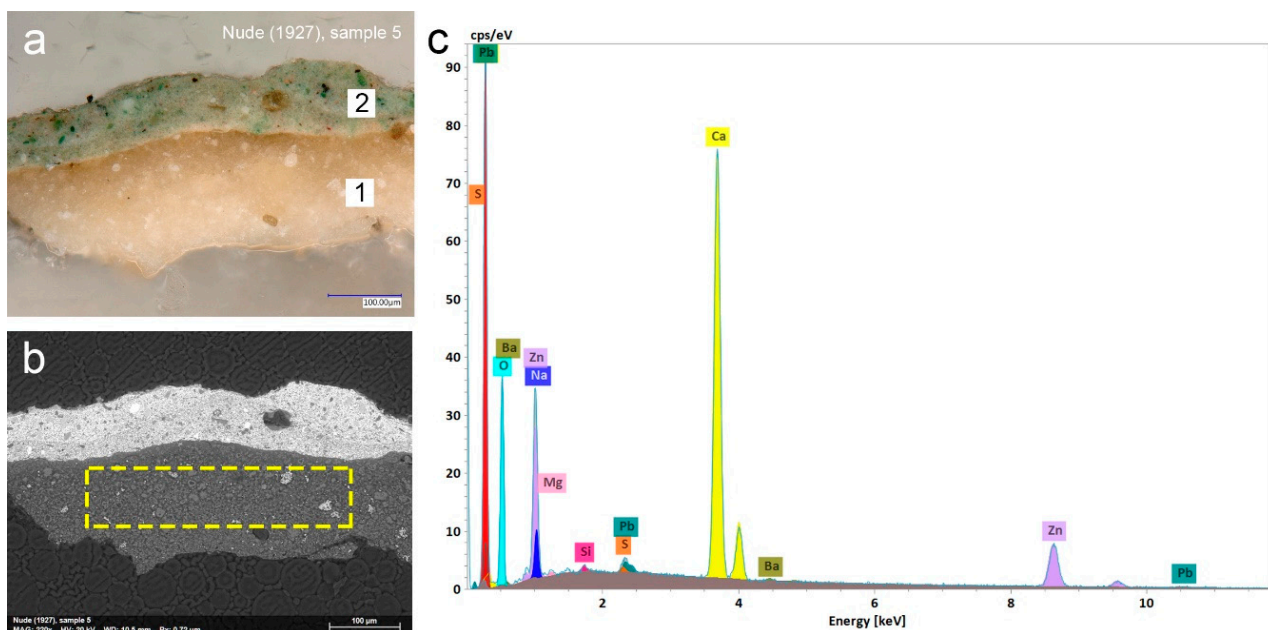


Figure 5. Optical microscopy image of the paint cross-section of sample 5 at × 200 magnification, extracted from *Nude*, 1927, photographed in VIS (a). The image shows the ground layer (1) and paint layer (2). Corresponding backscattered electron image (BSE) of the same sample with marked area of analysis (b) and SEM-EDS spectra of the white ground layer indicating strong Ca and Zn signals, as well as Pb, S and Ba, which can be assigned to chalk, lithopone and/or barium white and zinc white and lead white (c).

The comparative studies of the structures of the painting supports revealed that the artist reused those from Paris and Shanghai in the 1940s, which might have resulted from harsh economic realities during the post-war period and reflects his determination to continue his artistic career [23].

The research revealed that a double-layered oil-based ground was the most common type identified in the paintings created by the artist between the 1950s and 1990s. The constituents of both layers are the same, with the provision that they were mixed in different concentrations. Hence, lead white is the main component of the top layers, whereas chalk

features as the main compound in the bottom layers. Admixtures of lithopone and/or barium white and zinc white and titanium white (PW6) are present in both layers. The artist also employed the canvases primed with an oil-based single layer of zinc white and occasionally used grounds composed of lead white with other common additives. Triple-layered oil-based and single-layered semi-absorbent grounds are interesting peculiarities as they were used only once in the 1950s [24]. Table S2 presents a synoptic overview of the composition of the ground layers.

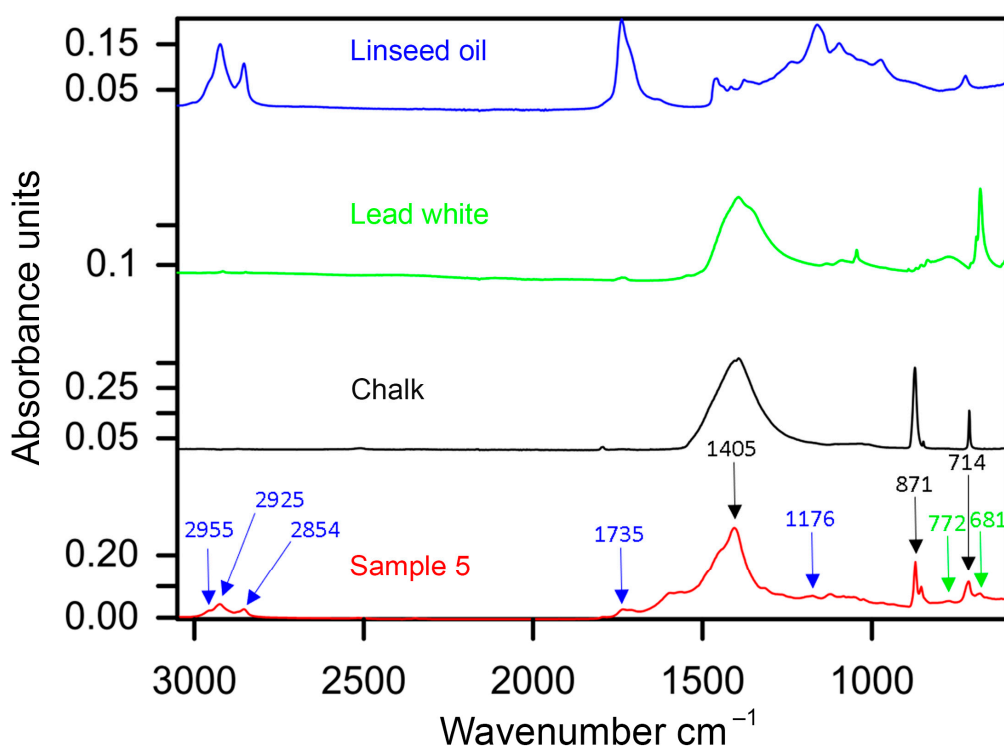


Figure 6. ATR-FTIR spectra of the white ground layer of sample 5 extracted from *Nude*, 1927, with labelled marker peaks of chalk (black), lead white (green), oil (blue) and reference spectra of the same compounds.

As for the hardboards, the artist chose to paint on them directly without the primer [26]. Moreover, as he often recycled earlier paintings, he did not apply an intermediate layer of ground or a uniform coat of paint to create a neutral surface on the recto or verso of the reused paintings [20,23].

3.3. Pigments

Although Liu Kang kept his working process private and none of his paint tubes are preserved, the archival sources provide some clues about the brands of the materials he employed. However, firm conclusions about any links between the archival information and materials used by Liu Kang should not be made because of weak evidence. Nevertheless, tracing some colourmen through the advertisements consistent with the time and location of the artist's activities, his studio photographs and TV documentary allowed better interpretation of certain data derived from the pigment analyses.

The use of Lefranc oil paints during the Paris phase can be speculated based on two pages from the October 1928 Lefranc catalogue the artist had preserved and brought home. The catalogue pages contain a list of oil colours and their prices [20]. However, it is likely that Liu Kang might have had access to a greater range of painting materials, including local and imported brands from Europe and America [21,22].

With regard to the paintings executed in Shanghai, there is no evidence pointing to the brand name of the paints Liu Kang employed during the Shanghai phase. However, the

archival search revealed that paints were widely available from local manufacturers like Marie's and Eagle, as well as W&N and Reeves & Sons R&S [27]. There is also a possibility that Liu Kang used paints purchased during his earlier sojourn in Paris.

As for the post-war period of the late 1940s and 1950s in Singapore, local newspapers', magazines' and trade directories' advertisements showed the availability of R&S, W&N and Royal Talens painting materials. Liu Kang's three favourite pigments of unknown brand—viridian, vermilion and Prussian blue—were mentioned for the first time in the 1955 essay by Ho Kok Hoe [6].

Oil paint tubes from Royal Talens (Van Gogh series), Rowney (Georgian series) and W&N can be seen in the TV documentary, *Portrait of an artist: Liu Kang*, presented on 26 February 1982. Although the design and labelling of Royal Talens and Rowney tubes conform with those manufactured by these companies in the 1980s, the W&N tube appeared much older, supporting the notion that the artist used the old stock paints as well [15,26].

Royal Talens (Rembrandt series) oil paints were evidenced in the photographs of the artist at work taken for his 1997 and 1998 exhibition catalogues [11,43]. In addition, an archival photograph of the artist in his studio taken in the 1990s shows his painting trolley neatly stocked with Royal Talens and Rowney (Georgian series) paint tube box sets [25]. Judging from these visual sources, it can be speculated that the paint brands were used separately or mixed by the artist. It can further be inferred that he may have preferred bulk purchases of paint tubes to avoid interruption to the artistic process.

Colour usually played a more dominant role than the texture in Liu Kang's way of expression. This preference became more evident after he settled in Singapore and exposed himself to the lush tropical landscapes. On the other hand, the special theme of the Huangshan and Guilin mountains (1977–1996) strikes one with a restricted colour scheme while the visual effects are achieved with a rich texture.

The overview of the pigmentary palette employed by the artist throughout his oeuvre enabled us to observe several changes, although it is uncertain if these changes accompanied a stylistic evolution. Nevertheless, Liu Kang's choice of pigments can be charted based on the most common colours found in his paintings. As for the binding medium of the pigment mixtures, drying oil was confirmed in all instances. This finding conforms with the Lefranc 1928 listing of oil paints preserved by Liu Kang, archival photographs and the TV documentary from the 1980s and 1990s, which show some of his oil paint tubes in detail. An overview of the identified pigments in Liu Kang's paint mixtures is presented in Table S3.

3.3.1. Blue

Ultramarine (PB29) and Prussian blue (PB27) are two major blue pigments appearing in Liu Kang's paintings (Figure 7). Ultramarine was commonly used for the depiction of sky and water, while Prussian blue was restricted to the role of a tint for green and black colours and was rarely employed to depict the sky, as is the case of *Zuo La Lu* (1930). Cobalt blue (PB28) was used intermittently from the beginning of Liu Kang's career in Paris until his artistic twilight in the 1990s. Regarding other Co-containing cerulean blue (PB35) and cobalt violet (PV14) (Figure 8), the artist did not seem to have been particularly attracted to them; hence, they appeared only in two paintings dated to 1953 and 1968. Detection of manganese blue (PB33) only in *Scene in Bali* (1953) is an interesting peculiarity; however, this pigment was used as an admixture; therefore, its appearance is considered as accidental. The analyses highlighted the sole use of phthalocyanine blue (PB15) in *Painting kampong* (1954) to depict water and sky. The painting successfully represents the primary batik-inspired technique by Liu Kang [12,24], and blue is the most dominant colour determining the composition of the scene. Further use of phthalocyanine blue by the artist is considered as low as it was detected in three artworks dated to 1986, 1998 and 1999. It appears to have been combined with ultramarine and Prussian blue to alter the hue of the paint mixtures [25,26]. This observation points to the artist's doubts about the permanent incorporation of phthalocyanine blue into his colour palette.

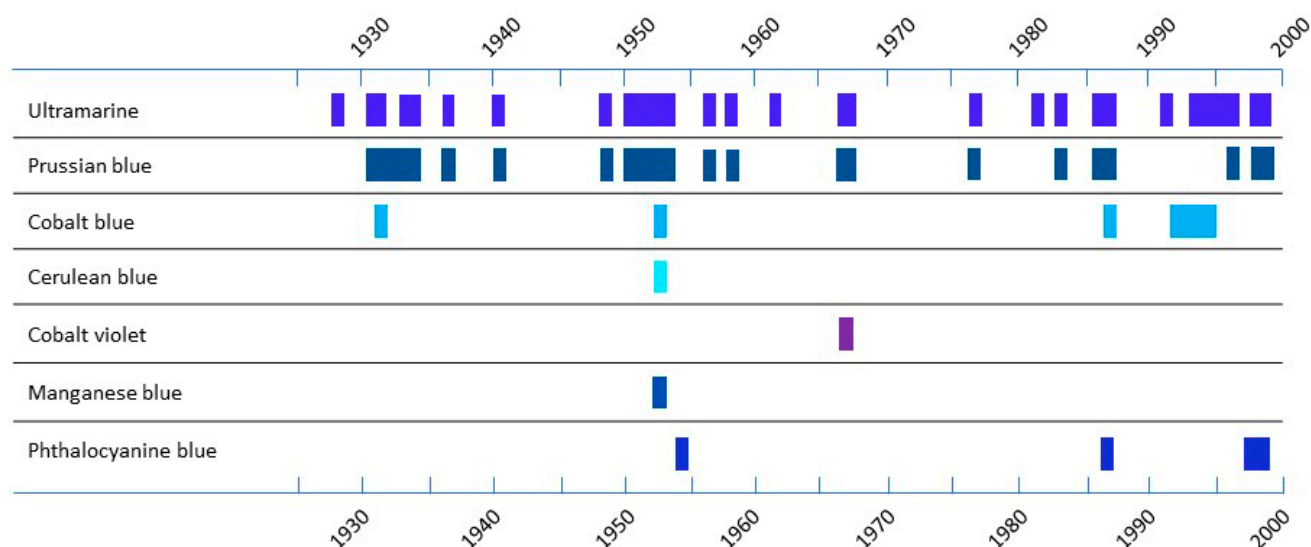


Figure 7. Timeline of Liu Kang's blue pigments.

3.3.2. Green

The analytical results of the green-painted areas showed an uninterrupted use of viridian (PG18) throughout the group of the investigated paintings, reflecting Liu Kang's predilection for vivid colours. The occasional incorporation of phthalocyanine green (PG7), starting in the early 1950s, supports this notion as both pigments have a similar hue. However, phthalocyanine green had never superseded viridian in Liu Kang's colour palette. Emerald green (PG21) appears sparsely and sometimes in combination with viridian. Despite the fact that some grades of emerald green were commercially adulterated with chromium pigments [44,45], the analyses pointed to a partial co-location of copper and chromium in the green passages, enabling us to infer that emerald green was not modified by the manufacturer but mixed on the palette with viridian by the artist. However, its low usage suggests some hesitation in giving this pigment a more pronounced role in the painting process. Nevertheless, due to its high toxicity, emerald green was progressively abandoned and was no longer available from major colourmen by the end of the 1960s [45]. Hence, based on the investigated paint samples, it seems that the artist used this green pigment up until the 1950s [24]. The analyses revealed that some green passages contain a mixture of Prussian blue and chrome yellow (PY34). Such composite paint could have been obtained by the artist on the palette, but it was also available from the colourmen under the name of chrome green (PG15) [46,47]. Similarly, a concomitant presence of viridian and cadmium yellow (PY35) may imply an artist's made mix or a commercially prepared cadmium green (PG14) [47], whereas mixtures of viridian and zinc yellow (PY36) may imply commercial permanent green [47]. Figure 9 shows a summary of Liu Kang's green pigments.

3.3.3. Yellow, Orange and Brown

The artist showed a strong reliance on yellow and red iron-containing earths, which in mixtures with other pigments often made a precise identification challenging. However, yellow ochre (PY43) was confirmed in a few paint samples based on the FTIR detection of additive minerals, such as kaolinite, gypsum and silicate materials [48,49]. Besides iron-containing earths, chrome yellow and other yellow chromate pigments based on Zn, Ba and Sr were often employed by the artist for painting yellow and green areas. Interestingly, their prevailing use was detected in the paintings representing the Paris and Shanghai phases. However, it is also conceivable that Cr-containing yellows were present in the analysed paint samples as commercial admixtures to other pigments like yellow iron-containing earths [49,50], Prussian blue [46] and viridian [47]. The incorporation of

zinc yellow appears unexpectedly, as it was unpopular among artists because of its poor hiding and tinting power [50].

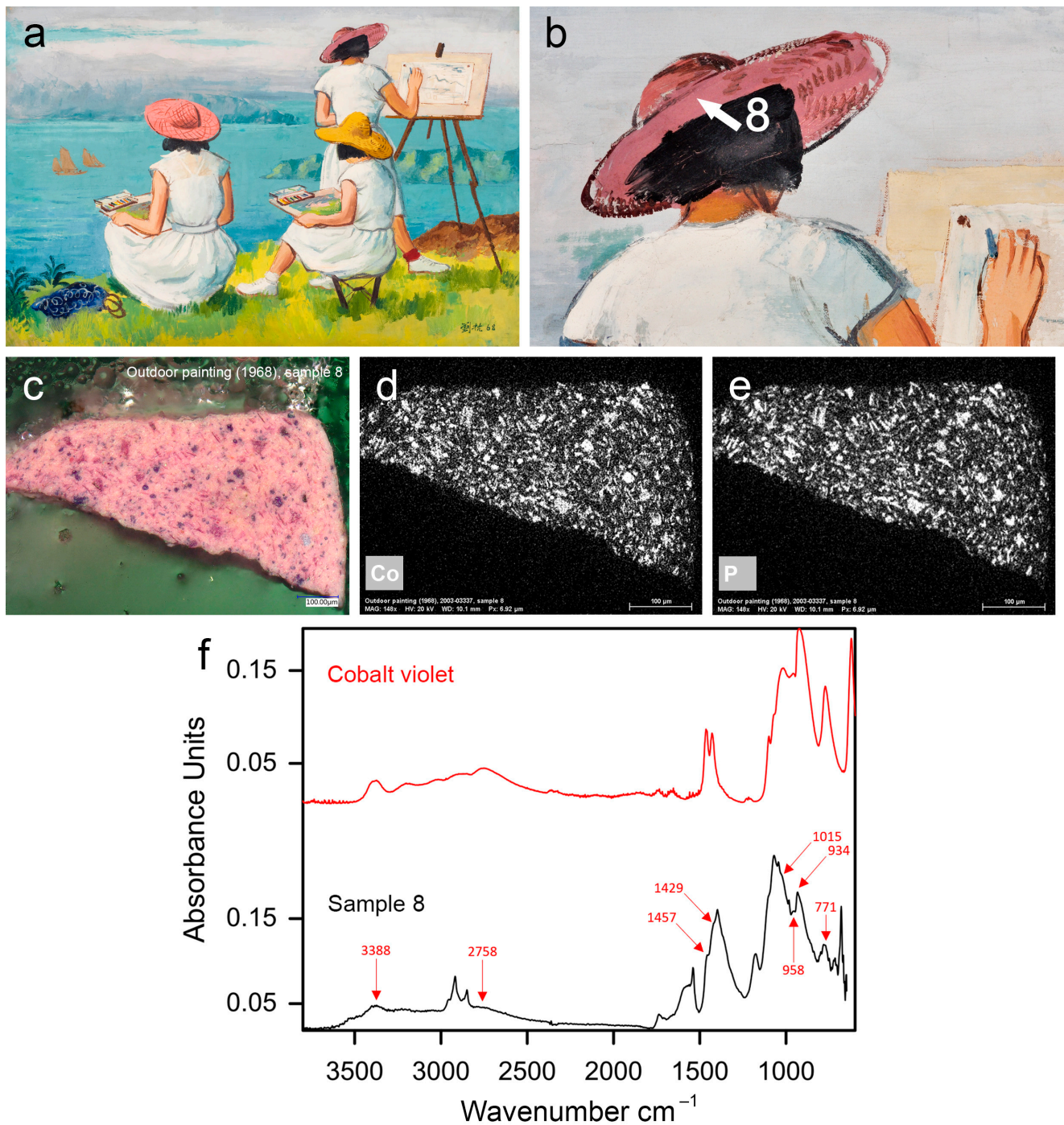


Figure 8. Liu Kang, *Outdoor painting*, 1968, oil on canvas, 85 × 126.5 cm (a) and detail of the painting showing the extraction area of the sample 8 (b), followed by optical microscopy image of the cross-section of the sample at 150× magnification (c), SEM-EDS distribution maps of Co and P (d,e). The concomitant presence of cobalt and phosphorus corresponds to the acicular shape of the red-violet particles of cobalt violet (cobalt phosphate). ATR-FTIR spectra of the sample with labelled marker peaks of cobalt violet and reference spectra of the same pigment (f). Painting (a) is a gift of the artist's family. Collection of National Gallery Singapore. Image courtesy of the National Heritage Board, Singapore.

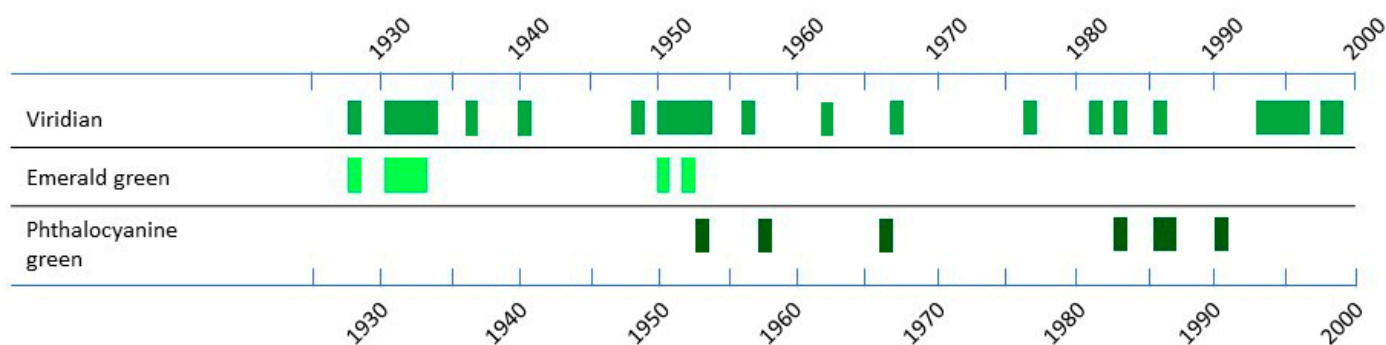


Figure 9. Timeline of Liu Kang's green pigments.

Cd-containing yellows, which could be cadmium yellow or cadmopone (co-precipitated cadmium sulphide and barium sulphate) or zinc-modified light cadmium yellow [51], appeared on Liu Kang's palette as early as in the 1930s and were used infrequently until the 1940s. The analyses revealed that the artist heavily used Cd-containing yellow pigments in the 1950s and 1960s, but their use declined in the following decades.

Cadmium orange (PO20) or its variant were used sparingly and were identified in the paintings from the 1940s, 1950s and 1990s. The earliest incorporation of synthetic organic Hansa yellow 10G (PY3) by Liu Kang was dated to 1932, but the investigation allowed us to infer that it was an isolated example. The artist seemed to have reconsidered inorganic yellow and used Hansa yellow G (PY1) for obtaining green hues in the 1980s and 1990s.

Cobalt yellow (PY40) was identified only in three paintings dated to 1930, 1953 and 1958, suggesting the artist's lack of confidence in this pigment, which was probably because of its undesirable low hiding power in oil medium [52,53].

Brown hues were achieved with yellow and red iron-containing earths additionally modified with other pigments; however, the use of umber (PBr7) for deeper brown hues was positively confirmed in the entire oeuvre of Liu Kang. Figure 10 provides a summary of Liu Kang's yellow and brown pigments.

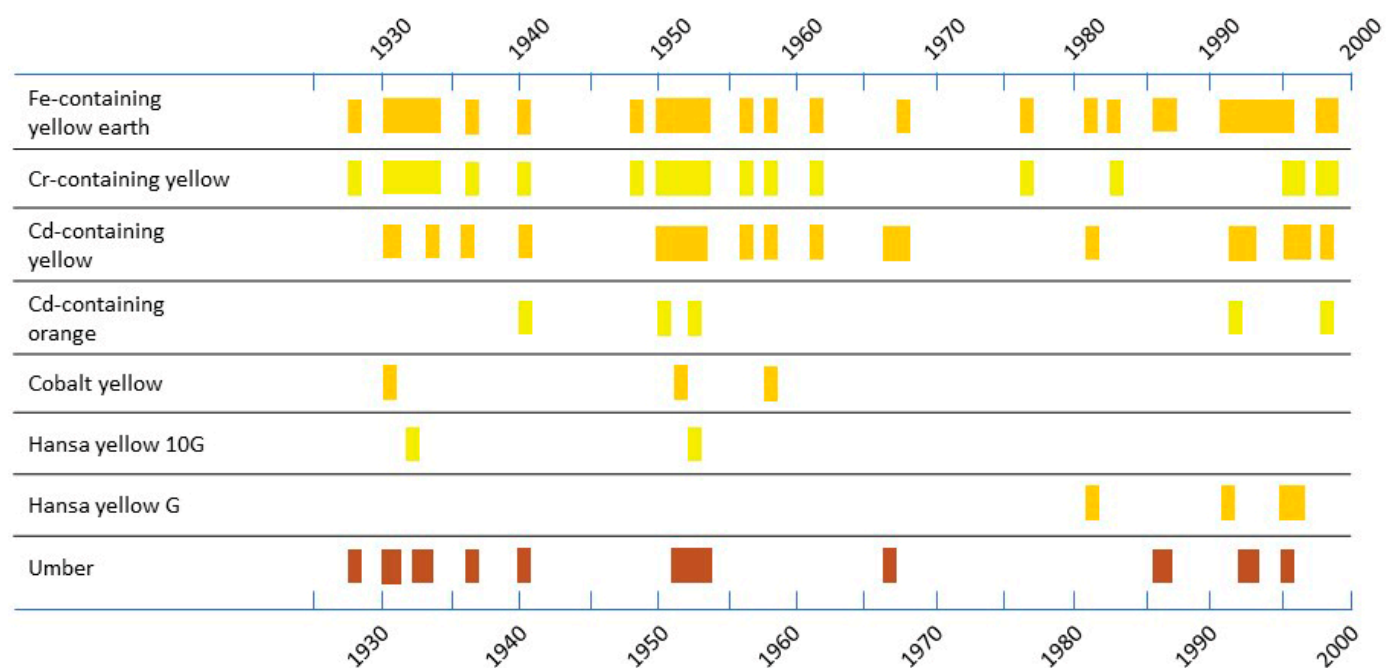


Figure 10. Timeline of Liu Kang's yellow and brown pigments.

3.3.4. Red

The variety of organic reds features strongly all over Liu Kang's artistic career. Despite the challenging identification because of an insufficient suit of FTIR bands and incorporation with other pigments, alizarin crimson (PR83), synthetic alizarin lake (PR83:1), Hansa red (PR3), brazilwood (NR24), geranium lake (PR90:1) and naphthol red AS-D (PR112) were positively confirmed [20,22,24–26]. The artist's predilection for organic reds was probably motivated by their intense brilliance and hue saturation. Regarding the inorganic reds, the artist frequently used red iron-containing earth pigments. It is worth noting that Liu Kang was not attracted much to cadmium-based reds, which were detected in only five paintings (Table S3). Figure 11 shows the use of red pigments by Liu Kang.

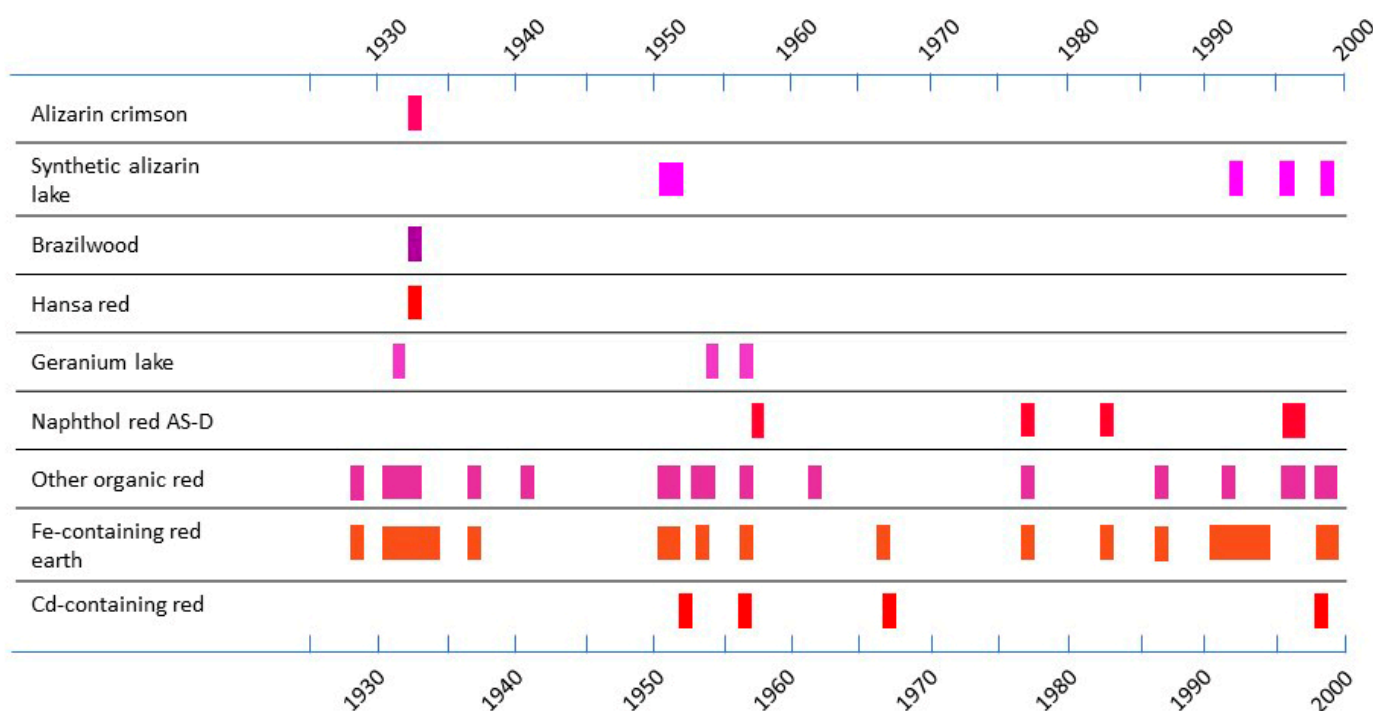


Figure 11. Timeline of Liu Kang's red pigments.

3.3.5. White and Black

White pigments and different extenders were identified in the white-painted areas. For instance, lead white in combination with chalk was predominantly used by Liu Kang during his stay in Paris, whereas lithopone and/or barium white and zinc white were commonly present in the white brushstrokes from the Shanghai phase. The analyses of his post-war paintings from the late 1940s revealed a greater use of lead white admixed with Zn-based compound, while the whites from the paintings created in the 1950s and 1960s showed a balanced presence of lead and zinc whites. However, from the 1970s onwards, the role of lead white on the artist's palette was gradually reduced, probably because of concerns about its toxicity than of decreased availability as the pigment was listed in the catalogues of major colourmen in the 1970s and 1980s [26]. Moreover, it is possible that the artist used old stock paints as he displayed a preference for a bulk purchase [25].

Although lead white was continuously present in the mixtures with other pigments until the 1990s, it was superseded by titanium white in highlights [25,26]. Hence, the role of titanium white in Liu Kang's paintings evolved from a possible commercial admixture characteristic of his early practice to the most frequently employed white pigment in the 1980s and consistently used thereafter.

Chalk presence was detected in different paint mixtures from all investigated artistic phases and themes; however, it is considered to be present as an extender [54]. Similarly, barium white, an inert pigment, is known as a common extender for lead white, lake pig-

ments [55], titanium white [56], chrome yellow [50], earth pigment [49], emerald green [45] and viridian [46]. The recorded occurrences of starch correlate with the high concentration of Sn in the red paint samples and point to the commercial addition of a substrate to the organic reds [57,58] detected in the paintings from the Paris phase [20,22].

Although bone black (PBk9) features strongly in Liu Kang's pigmentary palette, he did not employ pure black brushstrokes. Instead, he often admixed bone black with ultramarine, Prussian blue, cobalt blue, viridian and umber to produce intensive shades. Additionally, the minimal admixture of bone black and carbon black was suspected in other paint mixes to modify their shade. The summary of the use of white and black pigments is presented in Figure 12.

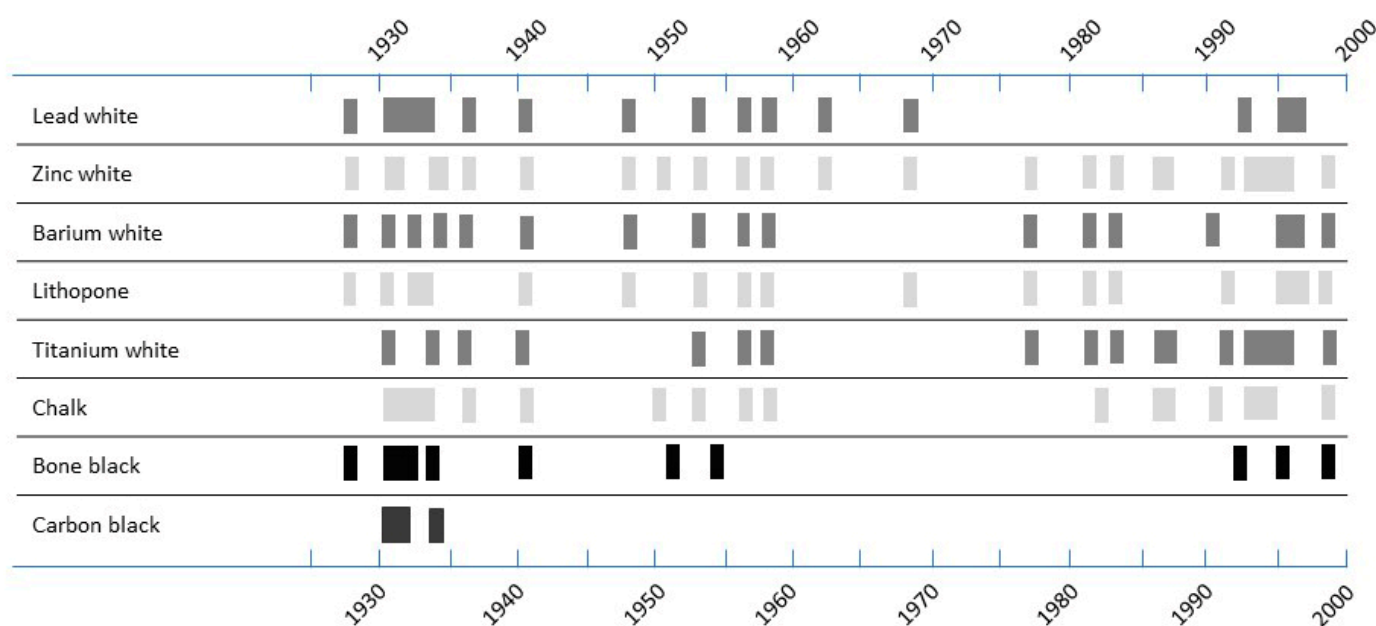


Figure 12. Timeline of Liu Kang's white and black pigments.

3.4. Other Materials

Metal soaps were frequently found in the ground and paint layers containing drying oil as a binder (Tables S2 and S3) [21,22,24–26]. However, it remains uncertain if these compounds result from the reaction of metal ions present in the lead- and zinc-containing pigments with free fatty acids from the oil binder or if the detected metal soaps are the commercial additives to the grounds and paints [59,60]. Nevertheless, their formation may be accelerated by environmental factors like moisture and heat, which are typical for the tropical climate of Singapore and occur in the conservation laboratories as part of the treatment strategy [59,61–63]. Although one would expect accelerated ageing and degradation associated with the presence of the metal soaps in Liu Kang's paintings, no signs of deterioration, such as cleavage, paint loss, disfiguring lumps, reduced opacity and surface efflorescence, have been observed. Nevertheless, the monitoring of the condition of the paintings and further investigation of the metal soaps in Liu Kang's paintings would ensure scientifically supported conservation treatments.

3.5. Development of the Compositions

Small-scale sketching on paper with pencil, crayon, charcoal, pastel, pen and water-colour was an integral part of Liu Kang's development of the artistic ideas prior to painting. The comparative studies of these drawings with the final paintings revealed a distinctive conceptual work of the artist who attempted to design the most satisfactory compositions.

On the other hand, the collected evidence from the 1940s onwards seems to point to a growing role of photography in his artistic process. Although Liu Kang rejected

photography as an art, he was convinced about its merits for capturing interesting subjects and motifs for future reference [64]. Hence, based on analyses of the detailed photographs and preparatory drawing, *Climbing the hill* (1948), depicting St. John's Fort in Malacca, was probably executed in the artist's studio in Singapore [23]. Liu Kang's famous trip to Bali in 1952 resulted in an impressive number of photographs of daily life of local communities. The artist conveniently used these photographs as a reference for designing the compositions of the paintings and depicting details upon his return to Singapore [24]. Liu Kang's continued reliance on photographs and drawings was observed in Huangshan and Guilin landscapes painted between the 1970s and 1990s, as well as in the paintings of nudes from the 1990s [25,26].

Liu Kang's practice of making preparatory underdrawings on the painting supports remains relatively unknown. One reason could be that thickly applied paint effectively limits the visibility of the underdrawings in NIR. On the other hand, preliminary sketching studies enabled the artist to establish the composition on the painting support with effortless brushwork and skip the underdrawing stage, as in the cases of *Countryside in France* (1930), *Village scene* (1931) and *Orchids* (1952) [16]. Nevertheless, a few documented examples of the underdrawing show subtle pencil lines, whereas in *Painting kampong* (1954), the artist scratched the surface of the ground layer, creating barely discernible compositional lines that guided his subsequent paint application. In *Two nudes* (1996), he skilfully integrated red and blue crayon outlines with bold and red paint contours [25].

As for the painting process, *Nude* (1927), executed during a live painting class at the Xinhua Arts Academy in Shanghai, gives a rare insight into Liu Kang's painting skills before graduation. The model was depicted realistically with a proper rendering of shadow and light reflections on her body. However, his handling of the paint with short brushstrokes reflects a lack of confidence and some effort in transferring the subject onto the canvas [25].

Liu Kang's early artistic phases in Paris and Shanghai are mostly characterised by *plein air* execution, which encouraged small formats, spontaneity and wet-on-wet paint application with minimal finishing touches after the paint surface has dried. However, despite these similarities, there are some subtle differences in the approach to painting between these two phases. In Paris, Liu Kang intensively experimented with different paint application techniques. Short, vigorous and descriptive brush touches built the compositions of *Zuo La Lu* (1930) and *Autumn colours* (1930), reflecting the artist's attention to detail. Parallel brushstrokes in *St Gingolph, Lac Lemman, Switzerland* (1929), *Landscape in Switzerland* (1930), *Farmer's house* (1930), *Village scene* (1931) and *Still life with books, Paris* (1931) strongly resemble van Gogh's style (Figure 13a,b). A broad and flat application of paint synthesising forms and colours can be observed in *Boat near the cliff* (1931). The deliberate exposure of the white ground in most of the Paris paintings enhances the brightness of the compositions and contrast between the forms [22]. Overall, Liu Kang's handling of the paint during the Paris phase became increasingly fluid and spontaneous, contrary to the technique observed in *Nude* (1927), executed at the Academy in Shanghai a few years earlier. The variety of the adopted means of expression by the artist during his stay in Paris demonstrates his determination to improve and grow as an artist, despite the circumstances.

Upon return to Shanghai, Liu Kang consolidated the knowledge acquired in Paris and his painting technique became more uniform, showing a predilection for reduced shading, which resulted in flat and simplified forms, such as in the *Rustic landscape* (1934) and *Seascape in China* (1936). However, the occasional need for a description of the forms was achieved by the introduction of expressive outlining resembling Chinese calligraphy, scraping into wet paint, and building moderate impastos where exploiting tonal contrasts would have been inefficient [5,65]. Besides brushes, palette knives proved to be useful for a quick and broad handling of the paint in the outdoor conditions.

The 1940s confirmed the artist's departure from the painting techniques practised in Paris and reflected a strong need to develop his own style. His new aesthetics is best represented by the combination of flattened surfaces with bold lines that negate the illusion

of depth, as in *Nude* (1940) [25]. The increased role of palette knives in the painting process is exemplified in *Malay man* (1942) and *Climbing the hill* (1948) [12,23].



Figure 13. (a) Liu Kang, *Farmer's house*, 1930, oil on canvas, 45.5 × 53.5 cm and (b) corresponding detail showing parallel brushstrokes. (c) Liu Kang, *National day*, 1967, oil on canvas, 86 × 127.5 cm and (d,e) corresponding details showing incorporation of white ground into the colouristic scheme of the composition. Paintings (a,c) are gifts of the artist's family. Collection of National Gallery Singapore. Images courtesy of the National Heritage Board, Singapore.

The artist's painting technique entered a period of a remarkable evolution in the 1950s, resulting in the contribution to the Nanyang style depicting Southeast Asian subject matter by means of an amalgamation of the School of Paris and Chinese traditional ink painting techniques [8–10]. The additional aspect of the style is the batik-inspired stylistic innovation, which successfully accommodated Liu Kang's preference for the exposed colour of white ground (Figure 13c–e). The research enabled us to distinguish between two types of Liu Kang's batik-inspired paintings based on the quality of the technique.

Batik-inspired paintings considered to be of primary quality often featured minimal texture, flatness of the forms and contrast between vivid colours achieved through the exposure of a white ground subsequently reinforced with dark paint outlines, as seen in *Outdoor painting* (1954) and *Fruit sellers* (1969) [12,24]. Where necessary, the artist introduced distinctive scraping strokes into the wet paint to add unique and descriptive elements to the composition. Batik-inspired paintings with a multi-layered paint build-up, pronounced texture and white paint outlines of the forms applied in the final stage of the creative process substituting the absence of the exposed ground layer likely indicate that the technique was of inferior and secondary quality. The observation of these features may imply the presence of the underlying compositions as being a direct cause of the unavailability of the white ground for the newly painted scene [12,24].

The years following Liu Kang's Bali trip are considered the peak that yielded many key paintings in his new style; however, the artist actively searched for new sources of

inspiration, reworked old themes and expanded the repertoire of the forms of expression. The execution of a series of mountainous Chinese landscapes (1977–1996) distinguishes itself from his earlier artistic phases primarily because of the muted palette of colours and abundant use of paint applied in alternate wet-on-wet and wet-on-dry, tight dabbing with brushes and palette knives, giving an impression of dimensionality and rough texture of the rock formations, as can be seen in *Mountain* (1981) [26].

The choice of subject matter and the use of specific painting techniques allowed the artist to convey his own emotions, such as a sense of isolation and a reverence for the power of nature. This aligns with the Eastern approach to painting outlined by Liu Kang in his essay from 1969: “Eastern artists treat natural scenery as the starting point for depicting their emotions” [66]. However, the theme of nudity manifests the Western spirit of the artist who stated in the same essay from 1969: “Western paintings, inheriting the Greek preference for physical might, uphold the beauty of the body as their highest principle. Hence, they have always used human figures as the main subject matter and nature as scenery. The majority of their paintings of human figures are nude paintings” [66]. The theme of nudity in Liu Kang’s paintings from the 1990s demonstrates various painting techniques and styles. Contrary to the theme of the Huangshan and Guilin mountains, the rich texture was successfully paired with the abundance of colours and pointillist finish, resulting in attractive optical effects, as seen in *In conversation* (1999). On the other hand, a flat paint application combined with abbreviated and generalised forms and reduced details, seen in *Nude* (1992) and *Two nudes* (1996), represent an unconventional painting approach. Due to the complex paint application technique and Liu Kang’s deteriorating eyesight between the 1980s and 1990s [13,67,68], the artworks representing both themes were routinely executed in more than one sitting in the studio.

Distinctive features of the artist’s working practice are the retouchings, revisions and recycling of former compositions. Liu Kang habitually retouched the paint losses in his paintings; however, a worsening eye condition might have impacted the colour accuracy of these amendments. Minor and major revisions may indicate that, despite extensive drawing studies and photography preceding the painting, the artist’s concept of the final composition evolved, and in some cases, changes were made in very distinct stages. Financial constraints, changes in availability of art materials, the poor condition of the paintings or a shift in Liu Kang’s personal taste resulted in an unfinished state of artwork, or a rejection of the completed artwork, leading to their being recycled [12].

4. Conclusions

For the first time, an overview of Liu Kang’s painting materials and techniques was conducted based on 97 artworks created by the artist between 1927 and 1999. The systematic multidisciplinary approach revealed a few key aspects of Liu Kang’s painting practice. Linen canvases of varied densities were the artist’s preferred painting supports. Except for *Nude* (1927), the canvases represented a consistent kind of commercial preparation. Although absorbent and semi-absorbent grounds occurred only in paintings originating from Paris and Shanghai, grounds bound in drying oil are prevalent in Liu Kang’s artistic output. Besides textile supports, the artist occasionally used unprimed hardboards resembling Masonite boards. Additionally, Liu Kang’s frequent outdoor painting sessions in Paris and Shanghai led to the use of small-sized painting supports, but as his career progressed, he began to favour larger formats.

The palette of colours is economical, but it is uncertain if these limitations were external, imposed by the availability of the painting materials, or self-imposed for aesthetic reasons. Nevertheless, the research demonstrated that his pigmentary palette evolved over time. In fact, a wide reliance on viridian, ultramarine, Prussian blue, Cr- and Cd-containing yellows, yellow and red Fe-containing earth pigments and organic reds was detected in the course of the paint analyses. The artist introduced—very briefly—manganese blue, phthalocyanine blue and green, reduced the role of lead white by replacing it with titanium white and withdrew emerald green.

Liu Kang strongly relied on preliminary drawings and photographs for the development of artistic ideas. The study revealed variations in his paint application techniques, from small dabs, short or long directional and parallel strokes that sometimes juxtaposed with the exposed ground, to fluid brushwork that evolved into broad and flat application or pointillist finish, impasted wet-on-wet or wet-on-dry execution with both brushes and palette knives. Moreover, the study demonstrated that the artist occasionally departed from established painting convention of the Nanyang style and explored different means of artistic expression, although he remained conservative in his choice of painting materials and avoided experimentation with new paint formulations.

The obtained results may be of great value to conservators and art historians who further explore Liu Kang's painting materials and technique. In particular, the knowledge gained from this comprehensive research may be useful in the dating of undocumented paintings and authenticating works attributed to him. In addition, the presented information sets a foundation for future research focusing on the painting practices of other modern Singapore and Southeast Asian artists.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/heritage6030173/s1>: Table S1: chronological listing of the paintings selected for the study; Table S2: overview of the composition of the ground layers; Table S3: summary of the materials found in the paint mixtures.

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