

## THE ART HISTORICAL MATERIALS COLLECTION AT MUNCH: COLOURS, BRANDS, LABELS

Irina Crina Anca SANDU<sup>1,\*</sup>, Erika G. SANDBAKKEN<sup>1</sup>, Jin S. FERRER<sup>1</sup>,  
Terje SYVERSEN<sup>2</sup>, Alyssa HULL<sup>3</sup>

<sup>1</sup> MUNCH/Section of Conservation, Edvard Munchs plass 1, 0194 Oslo, Norway

<sup>2</sup> Oslo kommunenes kunstsamling, Kulturetaten, Storgata 25, 0184 Oslo, Norway

<sup>3</sup> Sanford School, 6900 Lancaster Pike, Hockessin, DE 19707, USA

### Abstract

*Edvard Munch (1863-1944) left behind a vast selection of artist materials. This paper presents an overview of this reference collection, now located in a brand-new building in Oslo (Munch museum, MUNCH). The variety and the significant number of items in this unique collection represent an asset that is useful for advancing knowledge of Munch's art, in addition to historic paint and drawing materials. This paper focuses on historical artists' materials, discussing the challenges, the opportunities, and the impact of scientific study. Preliminary investigations indicate that the production of the paint tubes span pre1890s through to at least the 1920s and could stem from the whole period of Munch's career. This collection consists of 956 paint tubes from 20 different manufacturers. Most of them are labelled as oil colours but some as watercolour and tempera paint. Preliminary investigations of a selection of paint samples show that there is a discrepancy between the chemical composition and the brand specification on the labels. In addition to these paint tubes, there are watercolours in the form of dry cakes, and approximately 300 pastels and crayons in all colours from at least seven different brands. This collection provides a unique and important source for future research in modern artists materials from the turn of centuries.*

**Keywords:** Edvard Munch; Art reference collection; Colours; Brands; Manufacturers; Labels

### Introduction

Edvard Munch bequeathed a vast number of artworks and his estate to the city of Oslo in a testament dated 18th of April 1940 [1]. The Munch Museum (MUNCH) has, in addition to this great artistic heritage, a large collection of the painter's painting tools and artists' materials, which is a unique source for research [2-3]. This *reference collection* consists of painting palettes, paint brushes, bottles of various binding media and varnishes, chalk, crayons, pencils, several bags of dry pigments, and a great number of paint tubes [2-4].

In the autumn of 2014, the former Conservation Department began several research projects that focused on paint tubes and drawing materials, with the purpose to catalogue and document this part of the collection and to carry out chemical analyses on the various pigments, fillers, and binders. This project was based on a similar project; on Vittore Grubicy de Dragon's archives and artworks, as part of the FUTURAHMA project [5, 6].

More recently at MUNCH, 200 crayons were studied concurrently with few artworks (sketches for the Aula Magna paintings in Oslo), in collaboration with Hercules Laboratory at Evora University, Portugal within a research project funded by FCT (Foundation for Science and

\* Author for correspondence: irina.sandu@munchmuseet.no

Technology in Portugal). The results from the analytical campaign on the crayons are to be published in another paper of this Special Issue [7].

Crayon samples from the two brands *LeFranc* and *Dr. Fr. Schoenfeld* were also analysed at CNR-ISTM (Consiglio Nazionale delle Ricerche-The Institute of Molecular Science and Technologies) in Perugia [8].

In addition, samples from this reference collection were the main source for investigating the degradation mechanism of Cadmium yellows in a larger study involving several European and American institutions. The *Scream (1910?)* in the MUNCH collection was included in this research project due to its fading phenomenon observed in several areas of the yellow painting layers [9]. Compositional features and the fading of Cadmium yellow pigments are of particular interest because these intense yellows are widely used by late 19th and early 20th century artists such as Vincent Van Gogh, Pablo Picasso, and Henri Matisse [10].

Samples of Synthetic Ultramarine and Cobalt blue and Organic red paint from different brands were investigated in an ongoing research project, involving access to the MOLAB and FIXLAB facilities from IPERION-HS platform. The objective was to study specific deterioration phenomena observed in paintings from the collection, more specifically areas of blue and red colours [11]. The paintings were analysed in 2021 in collaboration with several institutions from Italy and France, belonging to the MOLAB research-group. A selection of 20 red and blue samples from the paint tubes were analysed at the Synchrotron IPANEMA, Paris and some of them will also be analysed in the future in another laboratory in Slovenia (University of Ljubljana, Faculty of Chemistry and Chemical Technology) through FIXLAB access.

This paper focuses on the work performed so far on paint tubes, crayons, and watercolours, for which a larger number of items have been characterised, both for inorganic and organic components. An overview of some relevant aspects of historical information related to the manufacturing processes is given. Furthermore, the opportunities for research and scholarly studies these materials bring will be discussed together with future insights regarding the relevance of the material characterisation of this collection.

#### ***Description of the reference collection***

In addition to the previously mentioned artists' materials, the collection also consists of more than 150 lithographic stones, 9 paint palettes, and 33 bags of dry pigments [3, 4, 12].



**Fig. 1.** Old and new systems of labelling for the tube collection

In Table 1 a list of tubes is given with information on the brands/manufacturers, paint media, possible production date and origin country. With respect to the past, when a simple labelling system was creating to establish the number of the tubes (giving an acronym for the

brand, for the colour and a sequence of numbers 1.1, 1.2 etc. for the order: WNB1.4 = Winsor & Newton blue, fourth tube in the series), the moving to the new building has required a new inventory and labelling system (Fig. 1; WNB1.1 became MM.I.02373 in this new labeling system). This system is also recorded into the CS/TMS database for collection management at MUNCH and it covers more than 900 tubes from 31 different brands.

**Table 1.** List of tubes by brands, manufacturer, paint media on the original label, production date, country and number of items (brands are given in alphabetical order)

Brand	Company	Paint Media (Information from the tube label)	Production date	Origin/ country	Number
<b>Alf Bjercke</b>	Alf Bjercke Fernissfabrikk	Oil	Unknown	Norway	3
<b>Ambor</b>	Morin & Janet	Oil	Unknown	France	301
<b>Arnbak</b>	Detlefsen & Mayers Kemiske laboratorium (Sadolin)	Oil	Unknown	Denmark	12
<b>Blockx</b>	Blockx fils	Oil	After 1865 (the production start of the brand)	Belgium	30
<b>Devoe &amp; Reynolds</b>	Devoe & Reynolds & Co	Oil	Unknown	USA	31
<b>Feins präp. oelfarbe</b>	G.B. Moewes Leon Niethammer	Oil	Unknown	Germany	7
<b>Feinst präp oelfarbe, Lusk &amp; Holtz</b>	Lusk & Holtz Berlin	Oil	Unknown	Germany	11
<b>Feinste Künstler oelfarbe, C. Kreul</b>	C. Kreul	Oil	Unknown	Germany	10
<b>Different brands (Gee Wee Feine Wasserfarbe; Gee Wee Ölfarbe; Pelikan Künstler ölfarbe; Zet Farbe)</b>	Günther Wagner /Pelikan	Oil	Unknown	Germany	35
<b>Pelikan Künstler Wasserfarbe</b>	Günther Wagner /Pelikan	Watercolor	Unknown	Germany	15
<b>LeFranc Bourgeois</b>	LeFranc Bourgeois	Oil	Unknown	France	82
<b>LeFranc Bourgeois</b>	LeFranc Bourgeois	Tempera	Unknown	France	2
<b>Nörmalfärg</b>	Aktierbolaget Wilhelm Becker	Oil	From 1912 (Production start of the brand)	Sweden	14
<b>Newmans</b>	Newman's London	Watercolor	Unknown	England	1
<b>G.B. Moewes</b>	Leonhard Niethammer	Oil	Unknown	Germany	7
<b>Mussini ölfarbe</b>	Schmincke & Co	Oil	Unknown	Germany	32
<b>Reeves</b>	Reeves	Oil	Unknown	England	6
<b>Royal Talens</b>	Rembrandt Talens	Oil	Unknown	Netherlands	15
<b>Sadolin</b>	Detlefsen & Mayers Kemiske laboratorium (Sadolin)	Oil	After 1907-12?	Denmark	10
<b>Schoenfeld</b>	Dr. Fr. Schoenfeld & Co, Düsseldorf	Oil	Unknown	Germany	11
<b>Schmincke tempera</b>	Schmincke & Co	Tempera	Unknown	Germany	7
<b>Students</b>	Reeves	Watercolor	Unknown	England	7
<b>Students'</b>	Landseer	Watercolor	Unknown	England	1
<b>Temperafarbe</b>	Hermann Neisch & Co	Tempera	Unknown	Germany	17

Brand	Company	Paint Media (Information from the tube label)	Production date	Origin/ country	Number
Richard Wurm	Richard Wurm in München	Tempera	Unknown	Germany	8
Vilhelm Pacht	-	Oil	Unknown	Denmark	45
Winsor & Newton	Winsor & Newton	Oil	Unknown	England	216
Winsor & Newton	Winsor & Newton	Watercolor	Unknown	England	20

The crayons in the collection are grouped according to their colours and brands. An example of an overall list is given in Table 2.

**Table 2.** Crayons listed by colours

Colour	Number of items
Blue-violet	40
Yellow orange	55
Red-pink-brown	68
Green	48
Grey-black	24
White	22
Other nuances	18
	<b>257</b>

In an attempt of placing this collection in a historical context and chronology, we have looked into Munch's written documents, such as private letters and receipts. Moreover, databases of artists' materials and available information from the manufacturers provided some information on how to roughly date the production period of the materials based on the changing label designs and shape of the paint tubes [13].

When it comes to statements from Edvard Munch himself, he rarely mentioned his thoughts on the painting materials he used, except for one letter where he wrote about which colourmen he purchased from.<sup>1</sup> In this text, Munch emphasized the fact that he had used *Winsor & Newton* colours, as he regarded this brand as top quality, almost echoing an illustrated price list of *Winsor & Newton's* from 1895. Here, Winsor & Newton was stating that the pigments used in their tube colours were "the most brilliant and durable that can be manufactured," while the oils in the tubes were likewise "of the purest and most perfect quality".

### **Colours, dates, and brands**

#### *Paint tubes*

Collapsible metal paint tubes were invented and patented by the American artist John Rand in 1841. By 1842 collapsible tin tubes in Rand's design were being commercially sold by paint suppliers such as *Winsor and Newton* [13]. The tubes in the MUNCH's collection are of this collapsible type (Fig. 2). In house XRF analysis detected Pb and Sn as metals present in the composition of the caps and metal tube, suggesting the generalized used of a *pewter-like alloy*.

Today, the conditions of both the paint tubes and their contents are quite varied. Some of the tubes have paint that is dried, others still have paints that have buttery consistency, and some are completely liquid [14].

The task of establishing production dates for the different brands is far from being completed. Based on comparisons with the labels on the tubes and historical artist's paints catalogues, the period for the manufacturing of these stretches over many years.

<sup>1</sup> There are several drafts of this letter from Munch, which was the artist's response to a critical article written in *Frankfurter Zeitung*, claiming that Munch's paintings had to be subjected to conservation treatments only a few years after they were painted. Munch considered the article to be a part of a propaganda campaign for the *al fresco* painting technique, as opposed to Munch's oil painting murals.



Fig. 2. Examples of tubes from MUNCH collection

An example of this is Munch’s paint tubes from *Devoe & Reynolds*. This American paint manufacturer, established in 1864, underwent several changes of name and leadership. These changes in the company’s divisions and mergers comport modifications of the label designs (see Table 3 for the timeline). Munch’s *Devoe & Reynolds* tubes have labels that correspond with changes in the company and can therefore be placed within separate chronological periods (Table 3).

Table 3. List of all the tubes from *Davoe & Raynolds* and their classification based on their production dates in separate periods

<b>1864-1892</b>	Separation of Devoe & Raynolds into 2 companies in 1864 Tubes labelled “F.W. Devoe & Co., New York”	1.	DRGR 1.1 – Veronese green
		2.	DRGR 3.1 – zinc green
		3.	DRG 4.1 – Naples yellow (the label partially obscured)
		4.	DRGR 2.2 – emerald green
		5.	DRG 3.1 – perfect yellow
		6.	DRBN 1.1 – raw umber
		7.	DRG 1.1 – lemon yellow
		8.	DRG 6.1 – cadmium pale
		9.	DRGR 6.1 – terre verte
		10.	DRG 5.1 – zinc yellow
		11.	DRR 1.1 – nopal maroon
		12.	DRG 2.1 – cadmium pale
		13.	DRGR 1.1 – sap green
		14.	DRGR 5.1 – olive lake
		15.	DRV 1.1 – mauve
<b>1892-c.1909</b>	Establishment of F.W. Devoe & C.T. Raynolds Co. in 1892 Tubes labelled “F.W. Devoe & C.T. Raynolds Co., New York”	1.	DRG 2.2 – cadmium yellow
		2.	DRHV 2.1 – flake white
		3.	DRBN 2.1 - ?raw sienna
<b>c.1909-1917/1918</b>	Incorporated in NY state in 1909	4.	DRR 4.1 – purple lake (?)

<b>After c.1918</b>	Consolidation of New York and Chicago branches Tubes labelled “Devoe and Raynolds Co., Inc., New York Chicago”	<ol style="list-style-type: none"> <li>1. DRGR 2.1 – emerald green</li> <li>2. DRG 1.2 – lemon yellow</li> <li>3. DRG 1.3 – lemon yellow (missing part of the label)</li> <li>4. DRG 2.3 – cadmium pale</li> <li>5. DRG 6.2 – cadmium pale</li> <li>6. DRR 3.1 – rose madder (?)</li> <li>7. DRR 2.1 – English vermilion</li> <li>8. DRHV 1.1 – Cremona white</li> <li>9. DRHV 1.2 – Cremona white</li> </ol>
<b>Unknown, but post-1892</b>		<ol style="list-style-type: none"> <li>10. DRHV 1.3 – Cremona white (the label is torn)</li> <li>11. DRHV 1.4 – zinc white (label torn)</li> </ol>

Since there are paint tubes in the reference collection that are manufactured from around 1864 to after 1918, one could argue that this collection encompasses materials Munch used throughout his career. However, the labels on the tubes can only give an approximation of when they were manufactured and labelled, not when they were either purchased or used.

Another paint brand represented in the reference collection is the well-known *Pelikan*. The brand and company still exist, and on their web page [15] a historical overview of the many changes in their label design over time is published. Some of these changes happened within a few years and in these cases, it is possible to estimate the production year of the paint tube quite accurately. For example, the trademark (Fig. 3), designed by O. H. W. Hadank in 1922, promotes the *Pelikan* trademark as simplified graphics which was used until 1932.



**Fig. 3.** Trademark of *Pelikan* brand from 1922 and advertisement for *Ambor* paints in *Annuaire de la curiosité et des beaux-arts: Paris, départements, étranger*. Left: 1913 version of the advert. Right: 1914 version of the advert, showing the change of the supplier's name from “Eug. Morin” to “Morin et Janet.”

The majority, equal to one-third of the paint tubes in the reference collection, are *Ambor* paints (Table 1). Interestingly, there is little information on this brand, from “Morin et Janet”, and it seems that it is more or less absent from historical archives for painting materials.<sup>2</sup> The only information available on this particular paint brand was that it was sold by a Parisian artists’ supply on 5 rue Lepic<sup>3</sup>. This shop, which was also a manufacturer, was developed under the management of Eugène Morin, who sold supplies to Picasso and other artists living in Paris at the time [16]. The *Ambor* paints appear to have been produced by J. Janet, as stated in the advertisements of *Ambor* couleurs extra-fines (Fig. 2, “Procédés J. Janet”). Sometime between 1913-1914, Eugène Morin appears to have brought J. Janet in as a full partner, and the firm was

<sup>2</sup> A request for information about the *Ambor* paint tubes was sent to *Centre de Recherche des Musées de France and Institut national du patrimoine*. None of the researchers at these institutions could provide any information about this paint supplier, and the brand was unknown to them.

<sup>3</sup><http://www.metmuseum.org/art/libraries-and-research-centers/leonard-lauder-research-center/cubist-collection/archival-labels/art-supply-shops/morin-et-janet> , accessed on 22.11.2018.

renamed Morin et Janet, still of 5 rue Lepic, Paris. This change is also seen on the label of Munch's *Ambor* paint tubes (Fig. 4).



Fig. 4. Tubes from *Morin et Janet* in the MUNCH collection

#### *Crayons*

Among the crayons in MUNCH's *reference collection*, many have no or illegible labels. Those that are easily readable represent different brands such as *Crayola*, *Le Franc*, *Winsor & Newton*, *Series*, *Dr. Fr. Schoenfeldt*, *Gunther Wagner*, *AW Faber* pastels, *Mengs Pastellfarben*, *Feinste Oelkreide*, *Conté à Paris* (Fig. 5). Some brands have printed year on the labels, e.g., *Rubens* (1903) New York & Paris, *Gold Medal* (1904) New York & Paris, *Crayola* (1914) New York and *Crayola big size* (bf 1914) New York for *Crayola* [7, 17].



Fig. 5. Different brands and colours of the crayons collection

#### *Watercolour boxes*

The reference collection also includes several boxes from *Pelikan* and *Winsor & Newton*, in different paint formulations such as dried cakes, squared or oval, and small tubes (Fig. 6). A special, oval handheld watercolour box is among the many items in the reference collection. The dating is unknown, but a similar box can be seen depicted in a catalogue published sometime in the late 1800s by *Winsor & Newton* (Fig. 6).

#### *Past and ongoing research findings*

The focus of the research projects involving material from the *reference collection* so far has been concerning composition and degradation phenomena, such as Cadmium yellow fading and the darkening of cobalt and synthetic ultramarine blue, and organic red paint. These studies

have also included research into the manufacturing processes, herein paint adulteration, and the possible negative effects on the long-term preservation of the artworks.

#### *Binding media in paint tubes*

Four paint tubes labelled as oil paint were analysed using gas chromatography-mass spectroscopy (GC-MS) at Getty Conservation Institute in Los Angeles [18]. The results of the analysis suggested a more complex composition than the traditional oil paint; a mixture of oil with other organic components, such as resin, wax, and/or egg and even gum Arabic were present [8]. Another example is paint tubes labelled as tempera paint where the analysis showed the presence of a complex mixture of drying oil with gum and beeswax, but a few samples also contained a natural resin. In general, the paint tubes labelled as oil paint is confirmed by the identification of drying oil as the binding medium, while the tempera paints contain egg proteins. The drying oils identified by GC-MS are linseed oil in tubes from *Winsor & Newton*, *Lusk and Holtz*. Poppy oil and probably stand oil were identified in tubes from *Richard Wurm*, *Winsor & Newton* and *Mussini*.



**Fig. 6.** Winsor & Newton watercolours boxes in the MUNCH collection

#### *Studies on Cadmium yellow paints*

Samples of both crayons and paint tubes from the *reference collection* were used in the studies into the fading of Cadmium sulphide yellows. Degradation products of this yellow pigment were identified as the main cause of the fading. Among these are cadmium sulphate, cadmium oxalate, and cadmium carbonate [9].

The fading of Cadmium yellow in artworks such as the *Scream* (1910?) is furthermore complicated by the fact that the chemical properties and stability of this pigment may depend on the manufacturing process [19, 20]. The *dry* and *wet* manufacturing methods are the two routes of synthesis for making late 19<sup>th</sup>-early 20<sup>th</sup> century cadmium yellow pigments [10]. Both methods usually led to heterogeneous formulations, in which the pigment is obtained along with other components, including various chlorine compounds, sulphates, and cadmium carbonate. These compounds may be present as either leftover starting reagents, secondary products, or adulterants.



Analyses of the MUNCH's *Scream* revealed that Munch used a Cadmium sulphide yellow pigment produced by the wet process without calcination. The outcome of this research is a great example of the importance of the reference collection, in this case, the paint tubes containing the fading colour, namely the Cadmium yellows. Furthermore, these findings also pointed towards new preventive conservation measures needed for the *Scream* (1910?), where the degradation of the Cadmium yellows may be mitigated by minimizing its exposure to high moisture levels i.e., <45% RH, while keeping the lighting at low LUX values.

#### *Fillers*

The presence of magnesium carbonate as a filler was detected in a few samples taken from *Winsor & Newton*, while cadmium carbonate was detected in other brands. Magnesium carbonate could have been added as a filler in the paint to achieve certain optical and handling properties. When it comes to Cadmium carbonates, on the other hand, studies have shown that this compound might be the result of a reaction between the magnesium carbonate and environmental sulphur gases. The presence of magnesium carbonate in paint formulations is linked to the formation of magnesium sulphates, which can cause water sensitivity in oil paint films [21]. It was still a popular additive well into the second half of the 20<sup>th</sup> century [22]. Surprisingly, Magnesium carbonate was identified in one paint tube labelled Lapis Lazuli, the most expensive pigment. In this case, it seems likely to have been added as a bulking agent by the manufacturer to cut production costs.

#### *Crayons, pastels, or pencils?*

The binding media is the decisive factor for the characterisation of drawing materials. Approximately 250 samples were analysed and the results pointed towards the identification of resins and different types of waxes: beeswax, carnauba, candelilla, Japan waxes, and paraffin [7], but also linseed and palm oil (for *Dr. Fr Schoenfeld*), and safflower and palm oil (*LeFranc* crayons) [17]. The samples from *Dr. Fr Schoenfeld Faber pastels*, *Conté à Paris*, *Crayola*, *Feinste Ölkreide*, and *Günter Wagner* may be considered wax crayons due to the high content of wax [23]. However, the samples from *Dr. Fr. Schoenfeld* additionally contain oil. This composition suggests a hybrid between wax crayons and lithographic pencils [24].

#### *Watercolours*

The binding media in the watercolours were analysed using chromatographic and spectroscopic methods at Getty Conservation Institute in Los Angeles [18]. The main organic components that have been identified are mainly gum Arabic and glucose, both natural polysaccharide materials, well known as binding media for watercolour formulations [25].

## **Conclusions**

Munch was an artist who used new materials available to him, which was in line with his experimental style. The consequences of his experimental painting techniques, and the quality of the artist materials he used, will be investigated in future projects connected to the continuous work analysing the artists' materials.

The *reference collection* described in this paper is a unique source for scientific studies on historical artists' materials, concerning production methods and degradation mechanisms.

Among future research projects at MUNCH related with the original artist materials collection, the following trends can be mentioned:

- studies around manufacturing processes of modern commercial paint formulations and their degradation pathways (e.g., Lead white, French ultramarine, Cobalt blues, Prussian blues, Emerald and Scheele's greens and chromium-based yellows);
- statistical elaboration and modelling of analytical results for furthering comparison between the materials composition of the reference collection and the art objects in the collection;
- studies on degradation phenomena, within the paint layers such as efflorescence, flaking, loss of cohesion, and water sensitivity;

- development of a digital database and inventory of early-commercial paint and drawing materials.

Greater knowledge of the ongoing chemical and physical degradation of the artwork is an essential prerequisite to developing more tailored conservation measures.

## Acknowledgments

The authors are grateful to scientists from several institutions who contributed to the study of this important collection: Joy Mazurek (GCI - Science Department, Los Angeles), Perla Colombini and her team (Pisa University, Italy), Costanza Miliani and her team (CNR & University of Perugia, Italy), Antonio Candeias and his team (Hercules laboratory – Evora University, Portugal), Jennifer Mass (Bard Graduate Center) and Hartmut Kutzke (KHM - UIO, Oslo). FCT (Foundation for Science and Technology in Portugal) is also acknowledged for the funding provided for the research project: *The SCREAM-Touchstone for Heritage Endangered by Salt Crystallization: a Research Enterprise on the Art of Munch* (PTDC/QUI-OUT/31577/2017).

## References

- [1] J.H. Langaard, **Beretninger om virksomheten i femårs-perioden 1946–1951**, Oslo kommunes kunstsamlinger, årbok nummer 1, 1946–1951, 1951, pp. 60–100.
- [2] I.C.A. Sandu, E. Gohde Sandbakken, J. Ferrer, T. Syversen, *Colours, brands, labels and other fancy stuff in the original art historical materials collection at MUNCH*, **First MUNCH2022 International Conference Book of Abstracts**, 21<sup>st</sup>-23<sup>rd</sup> March 2022, Oslo, (oral communication), 2022, 112.
- [3] I.C.A. Sandu, *Art reference materials collection of Edvard MUNCH: an original asset for research and innovation*, **ICCROM "Discovering Samples Archives - Online Poster Session and Roundtable Webinar"**, online, 29th November 2021.
- [4] T. Syversen, J.S. Ferrer, I.C.A. Sandu, E. Storevik Tveit, A. Hull, J. Mazurek, M. Schilling, J. Mass, C. Miliani, L. Monico, *Paint and drawing reference materials collection at Munch Museum: a unique opportunity for interdisciplinary research around modern paint and drawing materials*, **Conference on Modern Oil Paints**, 23-25th of May 2018, Amsterdam, (poster communication), 2018.
- [5] A. Nevin, S. Bellei, R. Fontana, F. Gabrieli, F. Rosi, C. Marchese, M. D’Ayala Valva, D. Kunzelman, E. Buzzegoli, M. Patti, **Futurist Painters - Interdisciplinary Research on Written Sources, Artists’ Materials and Paints**, 2014.
- [6] M. Patti (a cura di) **Oltre il Divisionismo. Tecniche e materiali nell’atelier Benvenuti-Grubicy**, Pacini Editori, (ISBN: 978-88-6315-853-3), Pisa, 2015.
- [7] A. Cardoso, S. Valadas, I.C.A. Sandu, E. Gohde Sandabakken, A. Manhita, C. Miguel, J. Mirao, A.T. Caldeira, A. Candeias, *Creating a database on Munch crayons’ collection*, **First MUNCH2022 International Conference Book of Abstracts**, 21st-23rd March 2022, Oslo, (poster communication), 2022, 63.
- [8] J. la Nasa, F. Sabatini, C. Braccini, I. Degano, F. Modugno, C. Miliani, B. Doherty, F. Rosi, F.T.H. Broers, J. Moles Matinero, I.C.A. Sandu, L. Cartechini, *Integrated analytical study of crayons from the original art materials collection at the MUNCH museum in Oslo*, **Scientific Reports**, **11**(1), 2021, Article Number: 7152, DOI: 10.1038/s41598-021-86031-6.
- [9] L. Monico, L. Cartechini, F. Rosi, A. Chieli, C. Grazia, S. de Meyer, G. Nuyts, Ff. Vanmeert, K. Janssens, M. Cotte, W. de Nolf, G. Falkenberg, I.C.A. Sandu, E. Storevik Tveit, J. Mass, R. Pereira de Freitas, A. Romani, C. Miliani, *Probing the chemistry of CdS paints in The Scream by in situ non-invasive spectroscopies and synchrotron-radiation X-ray techniques*, **Science Advances**, **6**(20), 2020, Article Number: eaay3514, DOI: 10.1126/sciadv.aay3514.

- [10] I. Fiedler, M.A., Bayard, **Artists' Pigments: A Handbook of Their History and Characteristics**, (ed. Feller, R.L.) Oxford University Press, 1986, pp. 65–108.
- [11] J.S. Ferrer, I.C.A. Sandu, T. Syversen, A.M. Cardoso, A. Candeias, C.N. Borca, *Investigating Colour Changes in Red and Blue Paints—A Preliminary Study of Art Materials and Techniques in Edvard Munch's Old Man in Warnemünde (1907)*, **Conservation of Modern Oil Paintings** (Editors: K.J. van den Berg, I. Bonaduce, A. Burnstock, B. Ormsby, L. Carlyle, G. Heydenreich, M. Scharff and K. Keune), Springer Nature, Switzerland AG, 2019, pp. 209-219, doi.org/10.1007/978-3-030-19254-9.
- [12] H. Kutzke, B. Topalova-Casadiago, *Exploring an artist's practice: Edvard Munch's paint tubes*, **The Artist's Process: Technology and Interpretation. Proceedings of the Fourth Symposium of the Art Technological Source Research Working Group**, Archetype Publications Ltd., 2012, pp. 172–175.
- [13] \* \* \*, **Catalogue of colours and materials for oil and watercolour painting, pencil, chalk, and architectural drawing**, Winsor & Newton [WWW Document], 1895, Internet Arch. URL <https://archive.org/details/catalogueofcolou00wins> (accessed 6.16.15).
- [14] G.W.R. Ward, **The Grove Encyclopedia of Materials and Techniques in Art**, Oxford University Press, 2008.
- [15] \* \* \*, [https://www.pelikan.com/pulse/Pulsar/en\\_US\\_INTL.Pelikan.showTimeline.219963./history](https://www.pelikan.com/pulse/Pulsar/en_US_INTL.Pelikan.showTimeline.219963./history);
- [16] E. Cowling, J. Golding, T. Gallery, **Picasso: Sculptor/Painter**. Tate Gallery, 1994;
- [17] F.T.H. Broers, I.C. A Sandu, J.M Matinero, L. Cartechini, B. Doherty, F. Rosi, C. Miliani, J. la Nasa, F. Sabatini, I. Degano, F. Modugno, *Chemical investigation of historical pastels from Edvard Munch's studio*, **TECHNART 2019**, Bruges, 7-10<sup>th</sup> May 2019, poster communication.
- [18] J. Mazurek, E. Gohde Sandbakken, M. Schilling, T. Learner, I.C.A. Sandu, *Binding media analysis of tube paints from Edvard Munch*, **First MUNCH2022 International Conference Book of Abstracts**, 21<sup>st</sup>-23<sup>rd</sup> March 2022, Oslo, (oral communication), 2022, 119.
- [19] J. Mass, E. Pouyet, M. Cotte, F. Meier, A. Mehta, E. Uffelman, U. Plahter, B. Buckley, A. Hull, J. Church, R. Opila, *Cadmium yellow degradation mechanisms in Henri Matisse's Le Bonheur de vivre (1905–06) and the Munch Museum's The Scream (c.1910)*. Part 1: Chemical Speciation as a Function of Depth, **Public Paintings by Edvard Munch and His Contemporaries, Change and Conservation Challenges, Munch 150 Conference Proceedings**, Archetype Press, 2015, pp. 294-307.
- [20] J. Mass, E. Uffelman, B. Buckley, U. Plahter, I. Grimstad, J. Delaney, S.A. Florescu, A.M. Hull, V.M. Andrews, L. Burns, *Cadmium yellow degradation mechanisms in Henri Matisse's Le Bonheur de vivre (1905–06) compared to the Munch Museum's The Scream (c.1910): fluorescence imaging and chemical speciation as a function of depth*. Part 2: Fluorescence Imaging, **Public Paintings by Edvard Munch and His Contemporaries, Change and Conservation Challenges, Munch 150 Conference Proceedings**, Archetype Press, 2015, pp. 308-324.
- [21] G. Silvester, A. Burnstock, L. Megens, T. Learner, G. Chiari, K.J. van den Berg, *A cause of water-sensitivity in modern oil paint films: The formation of magnesium sulphate*, **Studies in Conservation**, **59**, 2014, pp. 38–51, doi:10.1179/2047058413Y.0000000085.
- [22] J.E. Russell, B.W. Singer, J.J. Perry, A. Bacon, *Investigation of the materials found in the studio of Francis Bacon (1909-1992)*, **Studies in Conservation**, **57**, 2012, pp. 195–206, doi:10.1179/2047058412Y.0000000008.

- [23] J. Mass, E. Uffelman, B. Buckley, I. Grimstad, A. Vila, J. Wadum, V. Andrews, L. Burns, S. Florescu, A. Hull, *pXRF and IR Fluorescence Imaging Studies of CdS Alteration in Paintings by Edvard Munch and Henri Matisse in Oslo, Copenhagen, and San Francisco*, **Proceedings of ICOM-CC Joint Working Group Meeting** (Painting and Scientific Research Working Groups), *The Non-Invasive Analysis of Painted Surfaces: Scientific Impact and Conservation Practice*, Smithsonian Institute Press, 2016, pp. 53-64.
- [24] M. Holben Ellis, M. Birgitte Yeh, *The history, use and characteristics of wax based drawing media*, **The Paper Conservator**, vol.22, 1998, 48-55;
- [25] J.H. Townsend, *Analysis of pastel and chalk materials*, **The Paper Conservator**, **22**, 1998, pp. 21-28.
- 

*Received: August 20, 2022*

*Accepted: December 18, 2022*