LUPINE PUBLISHERS

Journal Of Anthropological And Archaeological Sciences

DOI: 10.32474/JAAS.2021.05.000225

ISSN: 2690-5752

Mini Review

The Importance of Analytical Techniques in the Characterization of Archaeological and Historical Textile Art Objects

Recep Karadag*

Istanbul Aydin University, Faculty of Fine Arts, Istanbul, Turkey

***Corresponding author:** Recep Karadag, Istanbul Aydin University, Faculty of Fine Arts, Istanbul, Turkey

Received: November 23, 2021 **Published:** December 02, 2021

Introduction

Analytical techniques and scientific methodologies were used for the characterization of archeological and historical art objects for a long time. These techniques and methodologies have helped to date and characterization of the artifacts. Analysis of artifacts, including trace element analysis, can provide information regarding provenance as well as the technology employed in the preparation of the materials and the manufacture of the objects. A very sensitive analysis may thus provide a chemical "fingerprint" of an object, a society, or a cultural group. On the other hand, detailed and precise chemical analysis can also provide insight into the processes involved in the deterioration of the materials of historical and archeological objects [1]. Archeological and historical textiles give huge important knowledge for the social, technological, and economic factors of past societies.

Dyes are among the most significant components in works of textile art and archaeological findings. In the scientific examination of historical artifacts, the identification of natural coloring compounds (dyestuffs) is a challenging task, due to the complexity of their chemical composition and the possible presence of mixtures of chromospheres and degradation products [2]. However, their determination and solution are possible with today's analysis techniques and expert scientists in this field.

Analytical Techniques

Many analytical techniques are used for characterization in historical and archeological textile art objects. These analytical techniques, generally, fall under two groups. One of them is spectroscopic techniques and the other is chromatographic techniques. There is a wide range of more specialized spectroscopic and chromatographic techniques which characterize the chemical composition of textile art objects.

Spectroscopic techniques

Elemental composition and atomic percentages, mordant metal at pigment or dye is analyzed with X-ray fluorescence (XRF) in the art objects. Metal threads of the textile objects both qualitatively and quantitatively the elements present and also identify the crystalline structure of the mineral can be identified with X-ray diffraction (XRD). Energy-dispersive X-ray spectroscopy (EDS, EDX, or EDXRF) is an analytical technique used for the elemental analysis or chemical characterization of a sample [3].

Advances techniques [(Fourier transform infrared spectroscopy (FTIR), Raman, surface-enhanced Raman spectroscopy (SERS), surface-enhanced resonance Raman spectroscopy (SERRS), and secondary ion mass spectrometry (SIMS)] are applied to the analysis of dyed textiles. These techniques are used for elemental composition and atomic percentages of the elements present in the art objects [4].

SEM/EDX is the best known and most widely used surface analytical technique. High-resolution images of surface topography and the analysis depth are commonly around 1–2μm and give quantitative results in the art objects. The corrosion layers, particularly the structure of the Ag2S layer and the base material (alloy, gilt, ungilt silver, gold-gilded, and silver or copper alloy) on the metal yarns and metal threads in the Topkapi Place Museum were investigated by SEM-EDX. The results indicate that using wt.% ratios, without any corrections, may indicate if an alloy was formed or a layered structure is present [5,6].

Chromatographic techniques

Historical and archaeological textiles are among the most crucial and vulnerable records of our social and cultural history. Analysis of organic colorants found in these materials is unquestionably one of the most powerful tools to understand historical developments,

cultural exchanges, and progress in science and technology [7]. Chromatographic analyses use for analysis of coloring compounds (dyestuffs) in the archeological and historical textiles. Natural organic dyes (plant, insect, and snail), discovered through the ingenuity and persistence of mankind, can resist brightly for centuries or millennia and may be found hidden in such diverse places as the roots of a plant, a parasitic insect, and the secretions of a sea snail. There are many sources of dyestuffs of plant, insect, and snail origin in the world. However, the number used is not very large. According to the analyses of historical textiles found in archaeological excavations and museums, the main dyestuff sources used can be summarized under three groups.

Dye Plants

Madder (*Rubia tinctorum L. or Rubiacae family roots*) was used for red colors and its shades.

a) Weld (*Reseda luteola L.*), sawwort (*Serratula tinctoria L.*), dyer's broom (*Genistia tinctoria L.*), spurge flax (*Daphne gnidium L.*), young fustic (*Cotinus coggygria Scop.*), dyer's buckthorn (*Rhamnus saxatilis* Jacq. or other buckthorn fruit sources of yellow dyes) and many yellow dye plants were used for yellow colors. In addition, yellow dye plants were used together with indigo plants to dye green colors and tones.

b) Woad (*Isatis tinctoria L.*), dyer's knotweed (*Polgonum tinctoria AIT*), platanillo (*Indigofera suffruticosa Miller*) indigo shrub (*Indigofera tinctoria L.*), or indigo dye plants were used for blue colors and its shades.

c) Pomegranate (*Punica granatum L.*), Cutch tree (*Acacia catechu L.*), Sicilian sumac (*Rush coriaria L*), gallnut (*Quercus infectoria Olivier or Quercus sp.*), etc. were used for brown and black colors and their shades.

Dye insects

American cochineal (*Dactylopius coccus Costa*), Ararat kermes (*Porphyrophora hameli BRANDT*), Mediterranean kermes (*Kermes vermilio PLANCHON*), lac (*Kerria lacca Kerr*), and Polish kermes (*Porphyrophora polonica L.*) were used for dark red colors and its shades. In addition to the insect dyes, indigo dyes were used for purple colors. Also, insect dyes and indigo dyes were used together and obtained in purple colors and their shades.

Dye Snails

The snails (*Bolinus brandaris L., Hexaplex trunculus L., and Stramonita haemastoma L.*) were used for purple colors.

a) Historical textiles had been analyzed by high-performance liquid chromatography coupled with spectrophotometric and tandem mass spectrometric detection in the National Museum in Warsaw. According to the dyestuff analysis of some textile collections in this museum had been determined dyed with Polish kermes and American cochineal in red colors [8].

b) Belong seventeenth-century Arraiolos carpets from the National Museum of Machado de Castro had been analyzed by high-performance liquid chromatography with UV–VIS diode array detection (HPLC–DAD) and HPLC–mass spectrometry (LC-MS). Spurge flax and weld had been determined in yellow colors [9].

c) Many 16th-19th historical silk brocade fabrics had been analyzed in the Topkapi Place museum with HPLC-DAD and TLC. Coloring compounds (dyestuffs) and dye sources of coloring compounds had been determined. It had been determined that the analyzed textiles objects were dyed with insect dyes and plant dyes [10-12].

Chromatographic techniques are used for the identification of organic coloring compounds in historical and archeological textiles. Performance Liquid Chromatography with Diode Array Detector (HPLC-DAD) and High-Performance Liquid Chromatography with Mass Spectrometric Detector (HPLC-MS) are important chromatography techniques for dyestuffs (coloring compounds) analyzing in the ancient textiles. The technique had been used for sensitive and selective analysis of main classes of natural dyes used in ancient times for dyeing textiles red anthraquinones, yellow flavonoids, and known degradation products of flavonols hydroxybenzoic acids [13].

LC with MS detection was used for red anthraquinones, yellow flavonoids, and known degradation products of flavonols hydroxybenzoic acids in the dyestuffs analysis of archeological textiles [13]. Coloring compounds were analyzed by HPLC with fluorescence detection in the Coptic textiles. Madder, weld, woad, and tannin dye plants had been determined in the Coptic textiles [14].

Belong to fourth to twelfth century AD dyestuff analysis of Coptic textiles in Warsaw National Museum had been analyzed with reversed-phase HPLC (high-performance liquid chromatography) with UV-Vis detection and fluorescence detection. Dyeing with lac, madder, young fustic, weld, yellow dyes, woad, etc. had been determined in the textiles [15].

Ancient textiles have gained great relevance in the field of archeology as a material of considerable potential to reconstruct crucial aspects of social, technological, and economic factors of past societies. From the archeological point of view, the mineralized textile analyzed offers clear evidence for the presence of luxury textiles made of gold and dyed with shellfish purple in the eruption that destroyed Pompeii in AD 79 [16]. The chemical analysis of the textiles from wadi Murabba'at had been identified dyed with Hexaplex trunculus sea mollusk [17]. High-performance liquid chromatography (HPLC) coupled to diode-array detection are used to investigate samples removed from a painted decoration of a burial kline and a textile fragment, both found in Koru tumulus (fifth century BCE) in Daskyleion. The archaeological samples had been dyed with Murex trunculus mollusks [18].

Conclusion

Textile-dyeing has been practiced since prehistoric times, using dyes that are extracted from both plant and animal (insect and snail) sources. Modern analytical techniques make it possible to identify individual dye components from textiles that are thousands of years old. Besides understanding past technological capability in general and the dyeing industry in particular, the study of dyes extends our knowledge regarding trade networks, the economic and social status of the owners, and changing fashions. Natural organic coloring compounds had been used to prepare inks and natural organic lake pigments, and most of all dyed historical and archeological fabrics. Dye plants, dye insects, and dye snails were used in the historical and archeological textiles. Dyestuffs (coloring compounds), dye sources application methods give valuable information about textile technologies and procedures.

The content of metal threads, alloys, and solid metals is analyzed by spectroscopic methods. The elements and element ratios of metal threads, alloys, and solid metals contain very important data of the period in which they were produced.

Dyestuffs and metal threads of archaeological and historical textiles are analyzed with spectroscopic and chromatographic methods. The analysis results reflect the social, and cultural structure of the society which belongs to. Determining the characterization of archaeological and historical textiles also guides restoration and conservation methods.

Advanced analytical techniques and expert scientists in the field are needed to determine the characterization of archaeological and historical textiles.

References

1. Lahanier Ch, Preusser FD, Zelst LV (1986) Study and conservation of museum objects: Use of classical analytical techniques. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms 14(1): 1-9.
2. Degano I, Ribechini E, Modugno F, Colombini MP (2009) Analytical Methods for the Characterization of Organic Dyes in Artworks and in Historical Textiles. Applied Spectroscopy Reviews 44(5): 363–410.
3. Osman E, Zidan Y, Kamal N (2014) Using the Microscopic and Spectroscopic Techniques to Identify and Characterize Archeological Artıfacts. International Journal of Conservation Science 5(4): 459-468.
4. Smith M, Karen Thompson K, Lennard F (2017) A literature review of analytical techniques for materials characterization of painted textiles Part 2: spectroscopic and chromatographic analytical instrumentation. Journal of the Institute of Conservation 40(3): 252-266.
5. Oraltay RG, Karadag R (2020) Surface Investigation of Metal Threads and Solid Metals of Ottoman Textiles in the Topkapi Palace Museum. Studies in Conservation 65(1): 59-64.
6. Kahraman N, Karadag R (2017) Characterization of Sixteenth to Nineteenth Century Ottoman Silk Brocades by Scanning Electron Microscopy-Energy Dispersive XRay Spectroscopy and High-Performance Liquid Chromatography. Analytical Letters 50(10): 1553-1567.
7. Shahid M, Wertz J, Degano I, Aceto M, Khan MI, et al (2019) Analytical methods for determination of anthraquinone dyes in historical textiles: A review. Analytica Chimica Acta 1083: 58-87.
8. Katarzyna L and Maciej J (2016) Identification of Polish cochineal (Porphyrophora polonica L.) in historical textiles by high-performance liquid chromatography coupled with spectrophotometric and tandem mass spectrometric detection. Anal Bioanal Chem 408(12): 3349–3358.
9. Marques R, Sousa MM, Oliveira MC, Melo MJ (2009) Characterization of weld (Reseda luteola L.) and spurge flax (Daphne gnidium L.) by high-performance liquid chromatography–diode array detection–mass spectrometry in Arraiolos historical textiles. Journal of Chromatography A 1216(9): 1395-1402.
10. Karadag R (2014) Some Non-Destructive and Micro Analytical Methods for the Conservation on Textiles from Cultural Heritage. Proceedings of the 19th International Conference on Cultural Heritage and New Technologies 1–12.
11. Karadag R, Torgan T, Taskopru, Yıldız Y (2015) Characterization of Dyestuffs and Metals from Selected 16–17th-Century Ottoman Silk Brocades by RP-HPLC-DAD and FESEM-EDX. Journal of Liquid Chromatography & Related Technologies 38(5): 591–599.
12. Karadag R, Torgan E, Yildiz Y (2012) Analyses of Dye, Weaving and Metal Thread in Ottoman Silk Brocades and Their Reproduction. Textile Society of America Symposium Proceedings, Washington, DC 1–13.
13. Surowice I, Szostek B, Trojanowicz M (2007) HPLC-MS of anthraquinoids, flavonoids, and their degradation products in analysis of natural dyes in archeological objects. Journal of Separation Science 30(13): 2070-2079.
14. Surowiec I, Orska Gawryś J, Biesaga M, Trojanowicz M, Hutta M, et al (2003) Identification of Natural Dyestuff in Archeological Coptic Textiles by HPLC with Fluorescence Detection. Analytical Letters 36(6): 1211-1229.
15. Trojanowicz M, Orska Gawry J, Surowiec I, Szostek B, Urbaniak Walczak K, et al (2004) Chromatographic Investigation of Dyes Extracted from Coptic Textiles from the National Museum in Warsaw. Studies in Conservation 49(2): 115-130.
16. Ciccola A, Serafini I, Ripanti F, Vincenti F, Coletti F, Bianco A , Fasolato C , Montesano C, Galli M , Curini R and Postorino P (2020) Dyes from the Ashes: Discovering and Characterizing Natural Dyes from Mineralized Textiles. Molecules 25 (6): 1417-1422.
17. Sukenik N, Varvak A, Amar Z, Iluz D (2015) Chemical analysis of Murex-dyed textiles from wadi Murabba'at, Israel. Journal of Archaeological Science 3: 565-570.
18. Papliaka ZE, Konstanta A, Karapanagiotis I, Karadag R, Akyol AA, Dimitrios Mantzouris D, Tsiamyrtzis P (2017) FTIR imaging and HPLC reveal ancient painting and dyeing techniques of molluskan purple. Archaeol Anthropol Sci 9: 197-208.

DOI: 10.32474/JAAS.2021.05.000225