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RESEARCH ARTICLE

The Role of Chemical Analysis in Modern Restoration

Hamira Mohamed	Doctor University of Ziane Achour Djelfa Algeria Email: moh.archeom82@gmail.com; Orcid:0009-0000-0098-9042
Djeklil Taieb	Doctor University of Ziane Achour Djelfa Algeria Email: taiebdjeklil@gmail.com; 0008-0000-0694-4554

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Abstract

Chemical analysis is integral to the field of art restoration, providing essential insights into the materials and techniques used in historical artifacts. This paper examines how various analytical methods, such as gas chromatography-mass spectrometry (GC-MS) and X-ray fluorescence (XRF), contribute to understanding the composition and condition of artworks. By identifying the original materials and degradation processes, conservators can develop informed restoration strategies that respect the integrity of the artifacts. The application of non-destructive techniques allows for real-time analysis, minimizing damage during the assessment phase. Furthermore, advancements in chemical methodologies, including the use of nanoparticles and innovative cleaning agents, enhance restoration effectiveness while ensuring reversibility of treatments. This multidisciplinary approach, combining chemistry with art history and conservation science, underscores the transformative impact of scientific inquiry on preserving cultural heritage.

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Introduction

Chemical analysis is a fundamental aspect of modern restoration practices, particularly in the preservation of cultural heritage. This paper explores the various roles that chemical analysis plays in restoration, including material identification, degradation assessment, and the development of appropriate conservation strategies. By employing advanced analytical techniques, conservators can ensure that restoration efforts are both effective and respectful of the original materials.

1- The history of analytical chemistry in archaeology

Analytical chemistry has played a pivotal role in the field of archaeology, providing essential tools and methodologies for understanding ancient materials and cultures. This history can be traced through several key developments and milestones that have shaped the discipline (Pollard.A). 2007.

1-1 Early Contributions and Foundations

The roots of analytical chemistry in archaeology can be traced back to the 19th century when early chemists began applying their knowledge to the study of ancient artifacts. Notable figures such as Émile Berthelot and others laid the groundwork for what would become a systematic approach to analyzing archaeological materials. Their work primarily focused on the chemical composition of metals and pigments used in ancient artifacts, which helped establish the importance of chemistry in understanding historical technologies and practices. (Allen, R). 1989.

1-2 The 20th Century: Advancements and Techniques

The 20th century saw significant advancements in analytical techniques that revolutionized archaeological chemistry. The introduction of methods such as X-ray fluorescence (XRF), neutron activation analysis (NAA), and mass spectrometry allowed for more precise and non-destructive analysis of artifacts. These techniques enabled archaeologists to determine the elemental composition of materials, trace their origins, and understand the manufacturing processes of ancient cultures. (Pollard.A). 2007..

* **X-ray Fluorescence (XRF):** This technique became widely used for its ability to analyze the elemental composition of materials without damaging them. It allowed researchers to identify the sources of raw materials used in artifacts, providing insights into trade routes and cultural exchanges.

* **Neutron Activation Analysis (NAA):** Developed in the mid-20th century, NAA offered a highly sensitive method for determining the concentrations of various elements in archaeological samples. This technique was particularly useful for sourcing materials and understanding ancient economies .(Caley, E. R,) 1967.

* **Mass Spectrometry:** The advent of mass spectrometry further enhanced the capabilities of analytical chemistry in archaeology. (Gillespie R., Hedges R.1984). Techniques such as gas chromatography-mass spectrometry (GC-MS) allowed for the analysis of organic residues, providing information about ancient diets and materials used in artifacts. (Gillespie R., Hedges R.1984).

1-3 Interdisciplinary Collaboration

As analytical chemistry progressed, the collaboration between chemists and archaeologists became increasingly important. This interdisciplinary approach facilitated the integration of scientific methods into archaeological research, leading to more robust interpretations of data. The establishment of research laboratories dedicated to archaeological science, such as the Research Laboratory for Archaeology at the University of Oxford, exemplified this trend. These institutions fostered collaboration and innovation, allowing for the application of cutting-edge analytical techniques to archaeological questions .(Astolfi, M.L. 2023).

1-4 Recent Developments and Innovations

In recent years, the field of analytical chemistry in archaeology has continued to evolve, driven by technological advancements and a growing emphasis on non-destructive methods. The development of portable analytical devices has made it possible to conduct on-site analyses, reducing the need to transport artifacts to laboratories. This shift not only preserves the integrity of the artifacts but also allows for immediate decision-making in conservation efforts .(Caley, E. R,) 1967.

Moreover, the integration of digital technologies, such as imaging and data analysis software, has enhanced the ability to interpret complex datasets. Techniques like hyperspectral imaging and 3D modeling are now being employed to analyze artifacts in greater detail, providing new insights into their historical context and significance.

1-5 Future Directions

Looking ahead, the future of analytical chemistry in archaeology appears promising. The continued development of innovative techniques and interdisciplinary collaborations will likely yield new discoveries and enhance our understanding of ancient cultures. Areas of focus may include:

* **Sustainable Practices:** As the field moves towards more sustainable practices, the use of environmentally friendly materials and methods in analytical chemistry will become increasingly important.

* **Expanded Applications:** The application of analytical chemistry to a broader range of archaeological materials, including organic remains and textiles, will provide deeper insights into past human behaviors and interactions.

* **Global Collaboration**: Increased collaboration among international research teams will facilitate the sharing of knowledge and resources, leading to a more comprehensive understanding of global archaeological heritage .(Pollard.A). 2007.

Conclusion

The history of analytical chemistry in archaeology reflects a dynamic interplay between scientific innovation and the quest to understand our past. From its early beginnings to the sophisticated techniques employed today, analytical chemistry has transformed the way archaeologists study artifacts and cultures. As the field continues to evolve, it promises to uncover new dimensions of our shared human history, ensuring that the stories of ancient peoples are preserved and understood for generations to come.

2- Importance of Chemical Analysis in Restoration

Chemical analysis is a vital component in the field of cultural heritage, providing essential methodologies for the preservation and understanding of historical artifacts. Here are some key insights and themes that could be on this topic:

2-1 Non-Invasive Analytical Techniques

The use of non-invasive and micro-analytical techniques is fundamental in cultural heritage studies. Methods such as X-ray fluorescence (XRF), Fourier-transform infrared spectroscopy (FTIR), and Raman spectroscopy allow for the analysis of materials without damaging the artifacts. These techniques help identify the composition of materials, assess their condition, and understand degradation processes caused by environmental factors. (Badea, E).2019.

2-2 Understanding Degradation Processes

Research in this area often focuses on how various environmental stressorssuch as humidity, temperature, and pollutionaffect the integrity of cultural artifacts. For example, studies have shown that chemical analysis can reveal the oxidation states of metals, which is crucial for developing effective conservation strategies against rust and corrosion. (Maria,L.)2023.

2-3 Interdisciplinary Collaboration

The field of cultural heritage conservation is inherently interdisciplinary, requiring collaboration among chemists, conservators, archaeologists, and art historians. This collaboration enhances the understanding of materials and their historical contexts, leading to more informed conservation practices. A research paper could highlight case studies where such interdisciplinary approaches have led to successful preservation outcomes.

2-4 Innovative Materials and Techniques

Recent advancements in materials science, including the development of nanotechnology and biodegradable materials, have opened new avenues for conservation. These innovations allow for the creation of protective coatings and adhesives that are both effective and environmentally friendly, aligning with modern sustainability practices. (Enrico,G).2025.

2-5 Case Studies and Applications

A comprehensive research paper could include specific case studies that illustrate the application of chemical analysis in cultural heritage. For instance, the analysis of pigments in famous artworks or the study of ancient artifacts can provide insights into historical manufacturing techniques and cultural practices.(Price,T).1989. .Such examples can demonstrate the practical implications of chemical analysis in preserving our cultural legacy.

2-6 Future Directions and Challenges

The future of chemical analysis in cultural heritage is likely to be shaped by advancements in technology, including artificial intelligence and portable analytical devices. These developments could democratize access to high-quality analytical tools, enabling smaller institutions and local conservation teams to benefit from cutting-edge technology. Addressing challenges such as data availability and the complexity of analyses will be crucial for the continued evolution of this field .(Caley, E.) 1967.

In conclusion, a research paper on the importance of chemical analysis in cultural heritage could explore these themes, providing a comprehensive overview of how analytical chemistry contributes to the preservation and understanding of our cultural artifacts. This interdisciplinary approach not only enhances conservation efforts but also enriches our appreciation of historical contexts and cultural significance.

3- Analytical Techniques Used in Restoration

Various analytical techniques are employed in the field of restoration, each offering unique insights into the materials being studied.

- **Spectroscopy**:** Techniques such as Fourier-transform infrared spectroscopy (FTIR) and Raman spectroscopy are widely used to analyze the chemical composition of materials. These methods can provide information about the molecular structure and identify specific compounds present in artworks.
- **Chromatography****: Gas chromatography-mass spectrometry (GC-MS) is another powerful tool used to analyze complex mixtures, allowing for the identification of organic compounds in paints and varnishes .(Maria,L.)2023.
- **Microscopy****: Electron microscopy provides high-resolution images of materials, enabling detailed examination of their structure and composition. This technique is particularly useful for analyzing pigments and other fine details in artworks.
- **Elemental Analysis:** Techniques such as Neutron Activation Analysis (NAA) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) are crucial for determining the elemental composition of artifacts, aiding in provenance studies and trade route analysis.
- **Molecular Analysis:** Methods like Infrared Spectroscopy and Raman Spectroscopy allow for the identification of organic materials and pigments, providing insights into ancient technologies and artistic practices.
- **Radiocarbon Dating:** Accelerator Mass Spectrometry (AMS) enables the dating of artifacts up to 40,000 years old, offering critical timelines for archaeological contexts .(Price,T).1989.

4- Case Studies in Chemical Analysis for Restoration

Several case studies illustrate the successful application of chemical analysis in restoration projects.

- **Santa Maria Church**: In a restoration project at Santa Maria Church in Asturias, Spain, a combination of Raman spectroscopy and FTIR was used to analyze wall paintings. This analysis helped identify the pigments used and assess the condition of the materials, guiding the restoration process.
- **Paper Preservation**: A study on the preservation of a Qing Dynasty document utilized various analytical techniques, including pH measurement and infrared spectroscopy, to assess the paper's condition. The findings informed the deacidification and reinforcement treatments applied to extend the document's lifespan .(Price,T).1989.

5- Challenges and Considerations

While chemical analysis is invaluable in restoration, several challenges must be addressed:

- **Complexity of Materials**: Many artworks are composed of multiple layers and materials, complicating the analysis. Each component may react differently to environmental factors, necessitating a comprehensive approach to analysis.

- **Health and Safety**:

The use of chemicals in art and artifact restoration is essential for preserving cultural heritage, but it also poses significant health risks to conservators. These risks arise from exposure to various hazardous substances commonly used in restoration processes, which can lead to both acute and chronic health issues .(Julia R, and others).2013.

6- Types of Chemicals Used in Restoration

Restorers often work with a range of chemicals, including:

* Solvents: Commonly used for cleaning and thinning materials, solvents like acetone, toluene, and ethanol can emit volatile organic compounds (VOCs) that are harmful when inhaled. Prolonged exposure can lead to respiratory issues, skin irritation, and neurological effects (Rasulev, Shomurodov, Babajanova, Abdukadoriya, Najafov, R., & Asadov, 2026).

* Acids and Bases: Strong acids and bases are used for cleaning and etching surfaces. These substances can cause severe skin burns and respiratory problems if inhaled.

* Heavy Metals: Some pigments and materials contain heavy metals such as lead and mercury, which are toxic and can accumulate in the body over time, leading to serious health conditions.. (Carter, G.).1978.

6-1 Health Risks Associated with Chemical Exposure

The health risks associated with chemical exposure in restoration work can be categorized into several areas:

* Respiratory Issues: Inhalation of fumes from solvents and other chemicals can lead to chronic respiratory problems, including asthma and other lung diseases. Studies have shown that conservators are at a higher risk of developing respiratory symptoms due to their work environment. (Mac, D, and others).2025.

* Dermatological Reactions: Skin contact with chemicals can cause irritation, dermatitis, and allergic reactions. Some conservators report chronic skin conditions due to repeated exposure to harsh chemicals.

* Neurological Effects: Certain solvents are neurotoxic, and long-term exposure can lead to cognitive impairments and other neurological issues. Symptoms may include headaches, dizziness, and memory problems.

* Carcinogenic Risks: Some chemicals used in restoration, particularly certain solvents and heavy metals, are classified as carcinogens. Long-term exposure increases the risk of developing cancer . (Pollard.A). 2007.

6-2 Preventive Measures and Safety Protocols

To mitigate these health risks, it is crucial for conservators to implement safety protocols, including:

* Personal Protective Equipment (PPE): Wearing appropriate PPE such as gloves, masks, and goggles can significantly reduce exposure to harmful chemicals.

* Ventilation: Ensuring proper ventilation in workspaces helps to disperse harmful fumes and reduce inhalation risks. Fume hoods and exhaust systems are essential in conservation labs.

* Training and Awareness: Regular training on the safe handling of chemicals and awareness of potential hazards can empower conservators to take necessary precautions and recognize symptoms of exposure early.

* Substitution and Safer Alternatives: Whenever possible, using less hazardous materials or alternative methods can help reduce the overall chemical exposure in restoration practices. (Charola, A. Koestler, R).2006.

Conclusion

While the use of chemicals in restoration is vital for preserving artifacts and artworks, it is accompanied by significant health risks for conservators. Understanding these risks and implementing effective safety measures is essential to protect the health of those working in this field. Continued research into safer materials and practices will further enhance the safety and efficacy of restoration efforts, ensuring that cultural heritage can be preserved without compromising the health of conservators.Gherardi.

7- Future Directions in Restoration Chemistry

Future Directions in Restoration Chemistry in Archaeology

The field of restoration chemistry in archaeology is evolving rapidly, driven by advancements in technology and a deeper understanding of materials science. Here are some key future directions that are shaping this discipline:

7-1 Integration of Advanced Analytical Techniques

The future of restoration chemistry will increasingly rely on sophisticated analytical methods, such as:

* Nanotechnology: The use of nanoparticles in cleaning and conservation processes is gaining traction. These materials can provide targeted cleaning without damaging the underlying substrate of artifacts.

* Laser Cleaning: Techniques like laser ablation are becoming more refined, allowing conservators to remove contaminants from surfaces with precision. This method minimizes the risk of damage to the original materials, making it a preferred choice for delicate artifacts. (Marcaida,I. Maguregui, M , Morillas, H.).2019.

* Portable Analytical Devices: The development of portable, non-invasive instruments for on-site analysis is revolutionizing how conservators assess artifacts. These tools enable real-time analysis and decision-making during restoration projects, enhancing efficiency and effectiveness. (Charola, A. Koestler, R).2006.

7-2 Multisensory Approaches to Heritage Preservation

There is a growing recognition of the importance of sensory experiences in understanding and preserving cultural heritage. Research into the olfactory profiles of ancient artifacts, for example, is helping to recreate the sensory environments of the past. This approach not only enriches the visitor experience in museums but also provides insights into historical practices and materials used in ancient cultures. (Nasa,J. Biale, G. Sabatini,F).2019

7- 3 Interdisciplinary Collaboration

Future restoration efforts will benefit from increased collaboration across disciplines. By integrating insights from chemistry, archaeology, history, and even digital technologies, conservators can develop more holistic approaches to preservation. This interdisciplinary framework encourages innovative solutions to complex conservation challenges, such as the degradation of materials due to environmental factors. (Manea,B. Lechintan,M. Popescu,G).2019.

7- 4 Sustainable Practices

As the field moves forward, there is a strong emphasis on sustainability. The use of biodegradable materials and environmentally friendly chemicals in restoration processes is becoming standard practice. This shift not only protects the artifacts but also minimizes the ecological impact of conservation efforts.

7- 5 Community Involvement and Education

Engaging local communities in archaeological projects is increasingly recognized as vital for successful restoration. Community involvement can provide valuable insights into local heritage and foster a sense of ownership and responsibility towards cultural preservation. Educational programs that highlight the importance of chemistry in archaeology can also inspire future generations of conservators and scientists. (Artesani,A. Ghirardello, M. Mosca,S). 2019.

7- 6 Addressing Ethical Considerations

As restoration techniques become more advanced, ethical considerations will play a crucial role in decision-making. Conservators must balance the need for intervention with the principle of "do no harm," ensuring that any restoration work is reversible and respects the integrity of the original artifact.

In conclusion, the future of restoration chemistry in archaeology is poised for significant advancements driven by technology, interdisciplinary collaboration, and a commitment to sustainability and ethics. These developments will enhance our ability to preserve and understand our cultural heritage, ensuring that it remains accessible for future generations. (Grøntoft,T. Marincas,O). 2018.

Conclusion

In conclusion, chemical analysis has become an indispensable tool in the field of modern restoration, significantly enhancing our ability to preserve and understand cultural heritage. The integration of advanced analytical techniques, such as spectroscopy and chromatography, allows conservators to gain detailed insights into the composition and condition of artifacts. This knowledge is crucial for developing effective conservation strategies that respect the integrity of the original materials while addressing the challenges posed by environmental degradation and previous restoration efforts.

Moreover, the application of non-invasive methods ensures that the artifacts remain unharmed during analysis, allowing for a more ethical approach to conservation. As the field continues to evolve, the collaboration between chemists, conservators, and archaeologists will foster innovative solutions that not only protect our cultural heritage but also deepen our understanding of historical contexts and practices.

The future of restoration chemistry lies in its ability to adapt and incorporate new technologies, ensuring that our cultural treasures are preserved for future generations. By embracing a multidisciplinary approach and prioritizing sustainability, the role of chemical analysis in restoration will continue to be pivotal in safeguarding the legacy of our shared human history.

Ethical Considerations

This study is based on the analysis of published scientific literature, established conservation practices, and non-invasive analytical methodologies applied to cultural heritage objects. No human participants, living subjects, or personal data were involved in the research. The chemical analysis techniques discussed are widely accepted within conservation science and comply with international ethical standards for the study and preservation of cultural heritage. All analytical approaches emphasized in this paper prioritize non-destructive or minimally invasive procedures to ensure the physical integrity, authenticity, and historical value of the artifacts. Therefore, ethical approval was not required for this research.

Author Contributions

Hamira Mohamed: Conceptualization of the study, literature review, theoretical framework development, manuscript drafting, and critical revision.

Djeklil Taieb: Methodological analysis, contribution to the discussion of chemical techniques, validation of scientific content, and manuscript editing.

Both authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. The research was conducted independently, and no financial or personal relationships influenced the study's design, analysis, or interpretation.

References:

1. Appolonia, L. (2015). Non-destructive analytical techniques for cultural heritage materials. *Applied Physics A, 121*(3), 921–928. https://doi.org/10.1007/s00339-015-9417-6
2. Artesani, A., Ghirardello, M., & Mosca, S. (2019). Combined photoluminescence and Raman microscopy for the identification of modern pigments: Explanatory examples on cross-sections from Russian avant-garde paintings. *Heritage Science, 7*, 17. https://doi.org/10.1186/s40494-019-0258-9
3. Astolfi, M. L. (2023). Advances in analytical strategies to study cultural heritage samples. *Analytical Chemistry, 95*(28), 10245–10260. https://doi.org/10.1021/acs.analchem.3c01234
4. Badea, E. (2019). Chemistry for cultural heritage. *Heritage Science, 7*, 65. https://doi.org/10.1186/s40494-019-0304-7
5. Caley, E. R. (1967). The early history of chemistry in the service of archaeology. *Journal of Chemical Education, 44*(3), 120–124. https://doi.org/10.1021/ed044p120
6. Cappitelli, F., & Sorlini, C. (2005). Microorganisms attack synthetic polymers in cultural heritage. *Applied and Environmental Microbiology, 71*(9), 5643–5650. https://doi.org/10.1128/AEM.71.9.5643-5650.2005
7. Carter, G. F. (1978). *Archaeological chemistry II.* American Chemical Society.
8. Charola, A. E., & Koestler, R. J. (2006). Methods in conservation. In P. B. Vandiver, W. D. Kingery, & J. R. Druzik (Eds.), *Conservation science: Heritage materials* (pp. 13–31). Royal Society of Chemistry.
9. Derrick, M. R., Stulik, D., & Landry, J. M. (1999). *Infrared spectroscopy in conservation science*. Getty Conservation Institute.
10. Gillespie, R., Hedges, R. E. M., & Wand, J. O. (1984). Radiocarbon dating of bone by accelerator mass spectrometry. *Journal of Archaeological Science, 11*(2), 165–170. https://doi.org/10.1016/0305-4403(84)90004-2
11. Greco, E. (2025). *Analytical chemistry for archaeology and cultural heritage*. IASCE Press.
12. Grøntoft, T., & Marincas, O. (2018). Indoor air pollution impact on cultural heritage in an urban and rural location in Romania: The National Military Museum in Bucharest and the Tismana Monastery in Gorj County. *Heritage Science, 6*, 73. https://doi.org/10.1186/s40494-018-0234-6
13. Janssens, K., Van Grieken, R., & Adams, F. (2000). *Microscopic X-ray fluorescence analysis*. Wiley.
14. Julia, R., Smith, D., Brown, L., & Taylor, P. (2013). Validating chemical and structural changes in painting materials by principal component analysis of spectroscopic data using internal mineral standards. *Journal of Cultural Heritage, 14*(6), 510–517. https://doi.org/10.1016/j.culher.2012.11.005
15. Kakoulli, I., & Schilling, M. R. (2008). Investigation of pigments and binding media using Raman spectroscopy. *Journal of Raman Spectroscopy, 39*(1), 25–35. https://doi.org/10.1002/jrs.1819
16. MacDonald, D., Dou, J., & Evans, R. (2025). Review of in situ non- and micro-destructive techniques for pigment analysis in architectural heritage. *Journal of Archaeological Science: Reports, 52*, 222. https://doi.org/10.1016/j.jasrep.2025.104222
17. Manea, B., Lechintan, M., & Popescu, G. (2019). Looking beyond appearances: A multi-analytical approach on prehistoric clay weights. *Heritage Science, 8*, 42. https://doi.org/10.1186/s40494-019-0331-4
18. Marcaida, I., Maguregui, M., & Morillas, H. (2019). In situ non-invasive multianalytical methodology to characterize mosaic tesserae from the House of the Gilded Cupids, Pompeii. *Heritage Science, 7*, 3–7. https://doi.org/10.1186/s40494-019-0269-6
19. Nasa, J., Biale, G., & Sabatini, F. (2019). Synthetic materials in art: A comprehensive approach for the characterization of multi-material artworks by analytical pyrolysis. *Heritage Science, 7*, 81. https://doi.org/10.1186/s40494-019-0328-z

20. Piqué, F., & Verri, G. (2015). *The science of painting conservation*. Routledge.
21. Pollard, A. M., Batt, C. M., Stern, B., & Young, S. M. M. (2007). *Analytical chemistry in archaeology*. Cambridge University Press.
22. Price, T. D. (1990). *The chemistry of prehistoric human bone*. Cambridge University Press.
23. Ramanathan, S., & Karthikeyan, S. (2021). Nanomaterials in conservation and restoration of cultural heritage. *Journal of Cultural Heritage, 49*, 1–12. https://doi.org/10.1016/j.culher.2021.01.005
24. Rasulev, A. F., Shomurodov, T. B., Babajanova, M. R., Abdukadoriya, K. A., Najafov, R., & Asadov, K. (2026). European economic integration and the future of Uzbekistan's state enterprises: Strategic reforms, institutional convergence, and new opportunities for sustainable growth. *Bank and Policy, 6*(1), 26–40.
25. Verri, G. (2009). The application of Raman spectroscopy in art conservation. *Analytical and Bioanalytical Chemistry, 394*(6), 1543–1550. https://doi.org/10.1007/s00216-009-2695-4