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Chemical Analysis of Historical Materials and Cultural Heritage Objects

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ABSTRACT

The chemical analysis of historical materials and cultural heritage objects plays a vital role in understanding their composition, provenance, manufacturing techniques, and state of preservation. Short communication studies in this field focus on the rapid dissemination of significant analytical findings obtained from artworks, archaeological artifacts, manuscripts, and architectural materials. This article highlights the application of modern analytical techniques such as X-ray fluorescence (XRF), Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, scanning electron microscopy coupled with energy-dispersive X-ray analysis (SEM–EDX), and chromatography in the non-destructive or minimally invasive examination of heritage objects. Emphasis is placed on the identification of pigments, binders, corrosion products, and degradation pathways that influence conservation strategies. The integration of chemical data with historical and archaeological context provides valuable insights into ancient technologies and trade practices while supporting informed conservation and restoration decisions. By presenting concise yet impactful results, this short communication demonstrates how targeted chemical analyses can significantly contribute to the preservation and interpretation of cultural heritage, while adhering to the ethical requirement of minimal intervention on irreplaceable historical materials.

Keyword: *Cultural Heritage Materials, Chemical Analysis, Non-Destructive Analytical Techniques, Conservation and Restoration, Archaeological and Historical Artifacts*

INTRODUCTION

Cultural heritage objects, including archaeological artifacts, historical manuscripts, paintings, sculptures, textiles, and architectural materials, represent invaluable records of human history, artistic expression, and technological development. Preserving these objects for future generations requires a deep understanding of their material composition, manufacturing techniques, and degradation processes. In this context, chemical analysis has emerged as a fundamental tool in the study and conservation of historical materials and cultural heritage objects.

Historical artifacts are often composed of complex, heterogeneous materials such as pigments, binders, metals, ceramics, stone, glass, paper, and organic substances. Over time, these materials undergo chemical and physical changes due to environmental exposure, aging, biological activity, and past restoration treatments. Chemical analysis enables the identification of original materials as well as alteration products, providing insight into deterioration mechanisms and informing appropriate conservation strategies. Moreover, understanding the chemical composition of heritage objects aids in assessing their authenticity, provenance, and historical significance.

Advances in analytical chemistry and materials science have significantly enhanced the study of cultural heritage. Modern techniques such as X-ray fluorescence (XRF), Raman spectroscopy, Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM) allow detailed characterization of materials with minimal or no sampling. Non-destructive and micro-destructive methods are particularly valuable, as they respect the ethical imperative to preserve the integrity of irreplaceable objects. These techniques can reveal information about pigments used in paintings, alloy compositions of metal artifacts, corrosion layers, binding media, and conservation materials applied during previous interventions.

Chemical analysis also contributes to interdisciplinary research by bridging science with art history, archaeology, and conservation studies. Analytical results, when combined with historical documentation and stylistic analysis, help reconstruct ancient technologies, trade routes, and cultural exchanges. Thus, chemical analysis not only supports conservation efforts but also deepens our understanding of the cultural, technological, and historical contexts of heritage objects, underscoring its essential role in cultural heritage science.

CHEMISTRY AND HIDDEN SECRETS OF HISTORICAL OBJECTS

Every person is looking for explanations for current events in the past, learns from the past, searches for roots and the information that would bring new ideas into his or her life. Any object, which withdraws from the depths of the past, tells the story of its origin, of technology that was used to make it, of habits and lives of people who had used it, of its way over time.

Where once one man was enough - an artist and technologist at the same time, now we need to put together several different fields of human activity. Artists and scientists (such as painters, sculptors, craftsmen, historians, archivists, linguists, physicists, chemists and biologists) are forced to work closely together so that they examine, document, conserve, restore and then finally exhibit objects in its full beauty. Then, monuments and art works can tell their stories for delight and education for all of us. Chemistry thus becomes one little stone of the mosaic of patient work. The work that only from time to time brings excitement and moments of unexpected discoveries.

This collaboration of artists and scientists have its rules, given not only by laws but also by the unwritten ones, which allows to use ingenuity and imagination of artists and combines it with the sobriety of scientific procedures that prevents publishing of discoveries and hypotheses without their verification.

Exploration and preservation of historic and artistic heritage is a field broadly observed and pursued with the photogenic and attractive potential of fame. Therefore, it is necessary to evaluate very carefully and critically all information received and revalidate it from time to time using newly discovered methods and procedures of modern science. The invention of humanity is high, desire for ownership boundless and counterfeiters got busy

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even during the ancient civilizations. One of the most famous counterfeiters operating in the 20th century was "***The Dutchman Han van Meegeren***" as shown in **Figure 1a**. The boom of chemistry and its new methods of analysis, i.e. spectroscopy, had its share on his disclosure.

Many world-famous sights have their mysteries; we should remember for example ***The Shroud of Turin*** as shown in **Figure 1b**. Suspicion of falsification have not missed also ***The Snake Goddess*** originally considered as evidence of the worship of matriarchal divinity of Minoan culture of Crete, now stored in ***Boston Museum*** as shown in **Figure 1c**.

Every day forgotten or previously unknown works of art or lost artifacts are discovered, every day it is necessary to provide care of historical monuments and museum collections. In these cases, the chemistry is one of many fields, but the field that provides irreplaceable information about materials and technologies of the work. Without this knowledge, it is impossible to ensure compatibility of old and new materials used for conservation and restoration of the work.

Figure 1a. The Dutchman Han van Meegeren

Figure 1b The Shroud of Turin

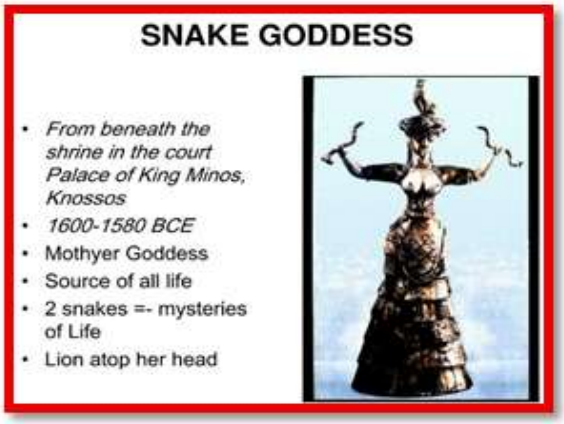

Figure 1c. The Snake Goddess in Boston Museum

Figure 1d. Bečov castle in Western Bohemia

Also, in the Czech Republic there are many historical monuments, for which the scientific research including the chemical one ensures the best conditions for their protection and preservation for future generations. And so now we can follow almost detective search for the fate of ***The Reliquary of St. Maur*** an important Romanesque monument displayed in the ***Bečov castle in Western Bohemia*** as shown in **Figure 1d**.

We can marvel at the skills of our ancestors when looking at the ***Charles Bridge in Prague. Czech Crown Jewels*** reluctantly issued some of their secrets during the mineralogical survey as shown in **Figure 2**, but other unknown is still necessary to find and hopefully also the chemistry will play its role.

Come with us on the path of revealing history and art by non-traditional means and methods of science, enter the world of chemistry, and in the future you can align with many professionals from research institutes, universities, museums, galleries and foundations that reveal the secrets of the past.

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Figure 2. Charles Bridge in Prague. Czech Crown Jewels

SCIENTIFIC RESEARCH OF LANDMARKS, MONUMENTS & HISTORICAL ARTWORK: ANALYSIS PLANNING

For our main purpose, to rescue and restore objects of historical value, we need to focus on comprehensive research of our cultural heritage. Such research is truly interdisciplinary and requires cooperation of chemists, restorers, artists, conservationists, owners and historians. Chemical analysis of materials used for creating all sorts of subjects is one of the most important parts of the research.

There are several characteristics of the object we need to know to be able to carry out the chemical analysis – for example we have to look into the history of the object, we should check its changes in time, place of storage and material in which it was stored, research production technology, previous conservations etc.

The analysis planning process also respects reasons and objectives of the research. We also have to look into chemical mechanisms and interactions especially on the interface between original and modern materials. Knowledge of degradation processes is also essential. Before extracting the testing sample for analysis, one should raise following questions also shown in **Figure 3.**

- *How was the object made?*
- *Where was it made (location)?*
- *What is the objects history?*
- *What is the purpose of our analysis?*
- *What other information we need?*
- *Are all the parts of the object authentic?*
- *Why was it made?*
- *To whom it was intended?*

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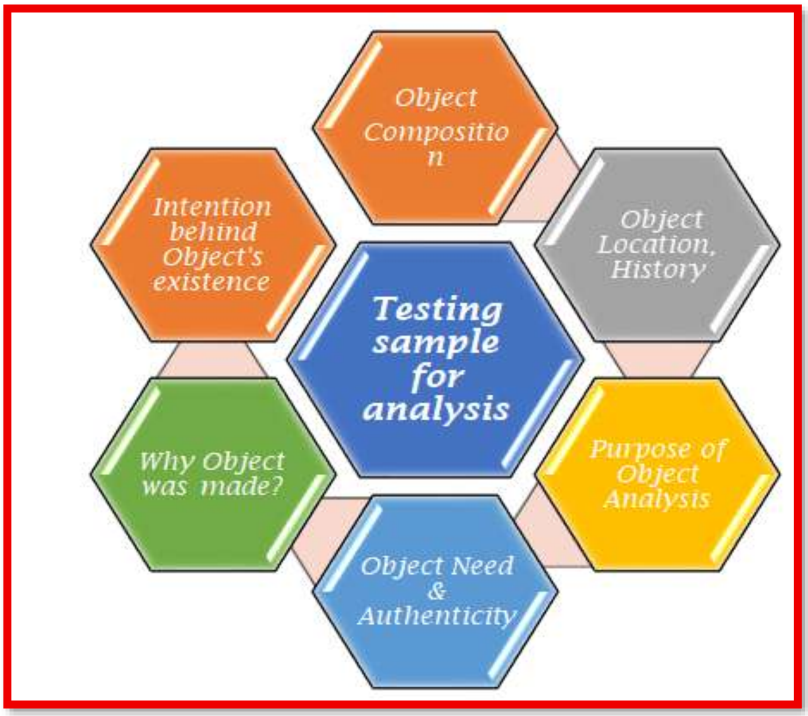

Figure 3. Schematic representation of the studied object

Here, we are able to give some answers thanks to the chemical and physical analytical methods and we can base some answers on consultations with historians. However, scientific research is not able to answer the last two questions; it can only give some useful hints that have to be interpreted by the interdisciplinary team.

PRINCIPLES OF ANALYTICAL METHODS USING ELECTROMAGNETIC RADIATION

Most of the contemporary analytical methods, that are used to research our cultural heritage, should be very gentle and non-destructive. One of the most suitable methods used is *spectroscopy*, which is based on the interaction between matter and radiated energy.

Using spectroscopy, we can inspect not only the microworld, but also cosmic distances, reveal distant past or view the human body painlessly. Spectroscopy is also used in industry and agriculture, in some cases even criminology. Depth insight into the physical world depends on energy and wavelength of radiation that we use to study.

The light that we are able to perceive with our eyes is an electromagnetic radiation of a wavelength of 400-750 *nm*. When we admire the beauty of the country with our eyes, we actually evaluate data, that reach our eyes in the form of an electromagnetic radiation, and we are a sort of "***marching spectrometer***" that uses the sun as a source of radiation, our eyes as a detector, and finally use our brain as an analytical extension.

Similarly, as in the nature, in our spectrometer we must have a source of the radiation, some optical element to disperse the radiation according to its wavelengths. Then we need detector to identify amount and wavelength of radiation that went through the sample or that was reflected or scattered. We also examine, whether the wavelength was changed by this process. Basically, this is the core of spectroscopy.

To understand this better, we will try to sort and categorize all sorts of radiation. Electromagnetic radiation carries a certain amount of energy, in the same time it is also surging. It has waves of different frequencies and frequency is associated with the concept of wavelength as shown in **figure 4a.** The higher frequency radiation, the shorter the wavelength and higher energy. The greater the amount of energy the electromagnetic radiation carries, the more dangerous it is for the living organism. We have radiation of one wavelength; it is called monochromatic. If the radiation carries with it a number and sometimes an infinite number of wavelengths, the radiation is polychromatic as shown in the **figure 4b.** where the dispersion of light as it travels through a triangular prism. Typical polychromatic radiation is sunlight.

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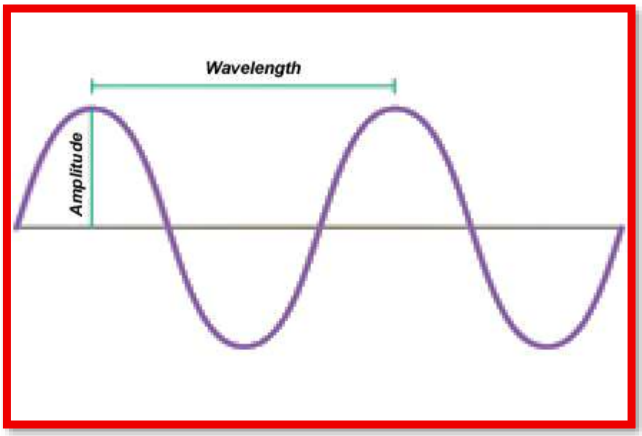

Figure 4a. A Sinusoidal Wave

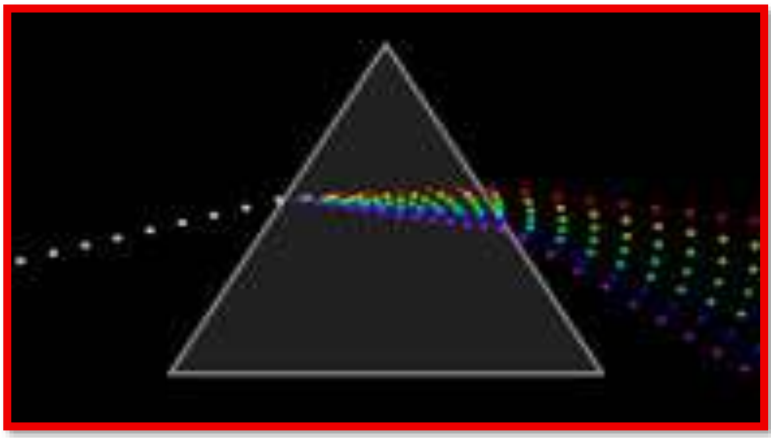

Figure 4b. Dispersion of light as it travels through a triangular prism.

Rays of light break when move from one environment to another. For example, when light falls obliquely on a transparent material like glass or water. Different materials slow down light differently; fracture occurs always under a different angle. In addition to light it applies to all electromagnetic radiation.

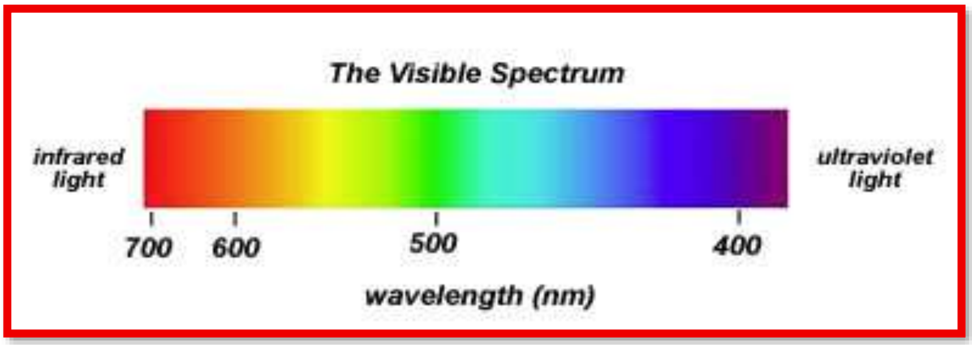

Figure 4c. The Visible Spectrum.

Electromagnetic radiation can be divided according to wavelength or frequency or wavenumber or energy of radiation as shown in **figure 4c.** Mathematically, wavelength (λ), frequency (v), wavenumber ($\overline{v}$) or energy (E) are related to given equation

$$E = nhv = nhc\overline{v} = \frac{nhc}{\lambda}$$

- *Electron radiation, the radiation of elementary particle stream of electrons, the wavelength is very small, in the order of picometer, but it also entails huge amounts of energy that could even kill us,*
- *Ultraviolet (UV), whose wavelength is slightly longer, but still in the tens to hundreds of nanometres and it is also dangerous for us. It radiates the sun, but the human eye cannot perceive*
- *Visible light, or let us call it the light that it lets us live, is the wavelength of 400-750 nm*
- *Infrared (IR) belongs among the long-wavelength radiation with a wavelength (760 nm to 1 mm). It is greater than visible light, but smaller than the microwave radiation. Sources of this type of radiation are heated objects, fire, and of course the sun. In addition to red visible light, it also carries thermal radiation, but we cannot see it, because our eye is not adapted to it.*
- *Microwave radiation has long waves, which allows us for example to examine the parameters of the universe. We also use it in the microwave oven*
- *The Longest waves are radio waves*

The wavelengths used in spectroscopy are very tiny, they are used in order of *micrometers(μm)*, which is a millionth of a meter or even less, which is a nanometer (*nm*). And these small sizes actually bring us

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information that we can very well used in analytical chemistry and also in real life. Radiation can also be divided by the physical phenomena observed, so we have emission radiation, absorption radiation and fluorescence radiation, and all these phenomena can also be used analytically. Do you know what emission of radiation means?

In the microworld, there is everything in constant motion and even we, as we sit still, are in constant move inside. Electrons in us circulate their orbits around the nuclei, atoms ***vibrate chemical bond of molecules***, and all this movement, when we shine on it or when we warm it up, even fastens. If we add some amount of energy into the measured system, "*we lit the infrared light on it*", we excite the system and energy charge increases. However, in nature everything tends to be balanced, so this amount of energy absorbed by the sample initially at its excitation wants to go back and out. Therefore, it is emitted from the sample and that is what we call emission of radiation that can be used analytically, as well as absorption. During the excitation, the molecule must absorb certain amount of energy. When we measure the difference in radiation intensity we obtain information on chemical structure of the sample.

So can we say that spectroscopy is the gift of physics to the chemists; based on the knowledge of spectroscopy, chemists can study radiation emitted or absorbed by the examined samples or objects and identify an unknown substance from the spectrum emitted.

METHODS USED BY THE CHEMICAL ANALYST

In the survey of historical and artistic subjects we usually begin with imaging methods, which allow to capture photographic documentation in a different light - visible, ultraviolet, red and infrared; we can image the x-photographs as well as we show the human body. Further we make pictures with different magnification - technology that refine our vision so that we can explore even small details of the subject. For this, we use optical microscopes, fluorescence microscopy and electron microscopy that led us to the image analysis. Based on the shape and size of fine fractions we can than infer the composition of the monument. **Figure 5a.** shows that cross section of plaster strata observed under visible light, showing the layered structure, texture, and material variations within the plaster, which provide insight into construction techniques, material composition, and possible restoration phases. **Figure 5b.** shows that the cross-section of plaster strata under UV light showing characteristic shellac fluorescence, where the orange layer corresponds to shellac paint and the red fluorescence indicates a mixture of shellac and plaster.

If you need to know what chemicals are present in the examined subject, we have to use another type of analytical method. In this case we will reveal secrets of the chemical structure using the infrared light that can "*poke its nose*" everywhere and measure without the risk of damage of examined sample. This method is especially suitable for analysis of organic compounds, because infrared spectroscopy allows us to observe vibration bonds in molecules.

Figure 5a. Cross section of plaster strata in visible light.

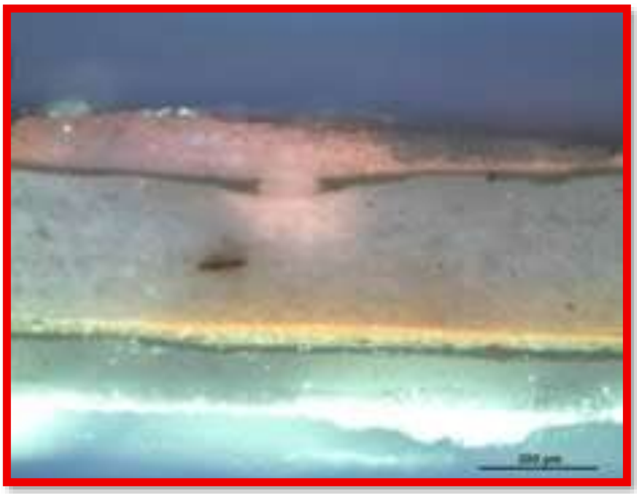

Figure 5b. Cross-section of plaster strata under UV light

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This method allows us to get the information from a relatively small sample, and if it fails, it can provide guidance on how to analyze the sample further and how to get additional amount of information that can then be used by restorers. The principle of this method is the absorption of infrared radiation passing through the sample, which involves changes in rotational and vibrational states of molecules in response to changes in dipole moment of molecules. Analytical output is the infrared spectrum, which is a graphic display of the functional dependence of energy, usually expressed as a percentage of transmittance (T) or absorbance units (A) on the wavelength of incident radiation, respectively, the wavenumber, which is the inverse of wavelength. The absorption bands having peaks at an interval of wave numbers 4000−1500 cm^{-1} are suitable for the identification of functional groups of organic substances (e.g., −OH, C=O, $-NH_2$, $-CH_3$, *etc.*). Bands of 1500−400 cm^{-1} are called "***fingerprint region***". Using the "*Search programs*" and *digital libraries of infrared spectra* it is possible to identify an unknown analyzed substance by comparing the spectra. The shellac IR Spectrum is as shown in the **figure 6**.

To measure spectrum of the investigated sample we need a laboratory instruments called a spectrometer (**link:** *http://en.wikipedia.org/wiki/Spectrometer*) or spectroscope, which process the radiation into spectra thanks to the endowment of mechanics, mathematicians and sophisticated computer programs. From the spectra, we can deduce chemical composition of the investigated objects.

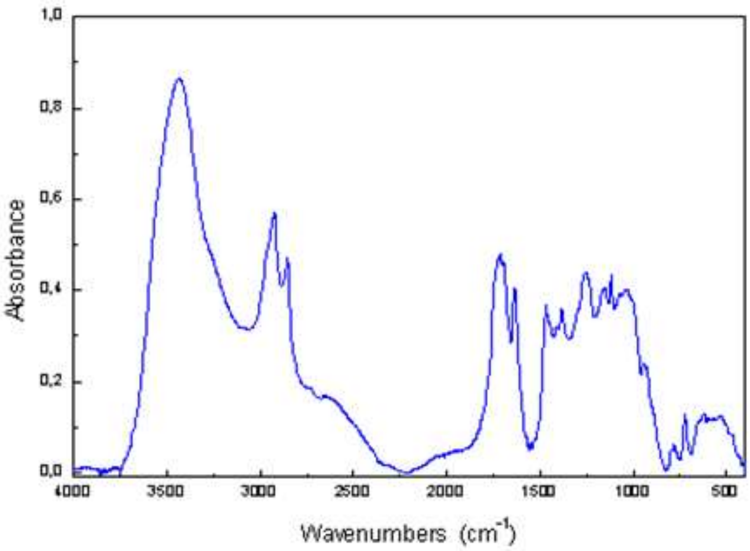

Figure 6. Example of shellac spectrum.

A common laboratory instrument that uses technique of infrared spectroscopy is a Fourier transform infrared (FTIR) spectrometer (**figure 7**).

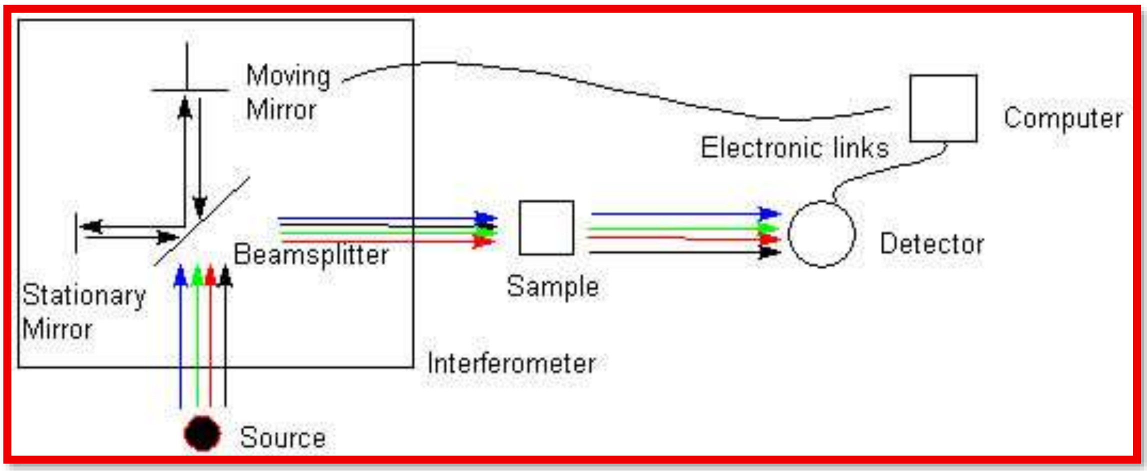

Figure 7. Scheme of Fourier transform infrared spectrometer (FTIR).

This also applies to chemistry, which has applications in industry, agriculture, health care, and other facets of civic life in addition to the investigation of art and historical documents. In essence, each of us is a chemical reactor, and every concept we have is backed by a particular chemical reaction.

Do not be afraid of chemistry, you can come to study for example to ICT Prague. With chemistry, you can experience exciting moments when exploring new worlds. Visit the homepage of the Department of Chemical Technology of Monument Conservation, or watch the videos from "*Open Doors at ICT Prague*", laboratory of ceramics and laboratory of glass

ENVIRONMENTAL CONCERNS AND THREATS

Chemical analysis of historical materials and cultural heritage objects raises important environmental concerns that must be carefully addressed to ensure sustainable research and conservation practices. Traditional analytical methods often involve the use of hazardous chemicals, organic solvents, acids, and reagents that can pose risks to the environment if not managed properly. Improper disposal of laboratory waste may contribute to soil, water, and air pollution. Additionally, energy-intensive analytical instruments increase the carbon footprint of heritage science laboratories.

Sampling practices also present environmental and ethical challenges. Destructive or invasive sampling not only affects the integrity of cultural objects but may generate material waste that cannot be recovered. The transportation of artifacts to analytical facilities further contributes to environmental impact through fuel consumption and emissions.

To mitigate these concerns, modern heritage science increasingly emphasizes green chemistry principles, non-destructive techniques, and in situ analysis. Methods such as portable spectroscopy, micro-analysis, and environmentally benign reagents reduce chemical consumption and waste generation. Improved waste management, recycling protocols, and energy-efficient instrumentation also support sustainable practices. Addressing environmental concerns in chemical analysis ensures responsible stewardship of both cultural heritage and the natural environment, promoting conservation approaches that are ethically sound and environmentally sustainable.

FUTURE PERSPECTIVES

- **Advancement of Non-Destructive Techniques:** Greater reliance on non-invasive and in situ analytical methods to preserve object integrity while obtaining high-quality chemical data.
- **Integration of Green Chemistry:** Adoption of environmentally friendly reagents, minimal solvent usage, and sustainable laboratory practices to reduce environmental impact.
- **Miniaturization and Portability:** Development of portable analytical instruments for on-site analysis, minimizing the need for artifact transport and sampling.
- **High-Resolution and Multi-Modal Analysis:** Combining multiple analytical techniques to achieve comprehensive material characterization at micro- and nano-scales.
- **Artificial Intelligence and Data Science:** Use of machine learning for pattern recognition, material identification, and predictive degradation modeling.
- **Improved Authentication Methods:** Enhanced chemical fingerprinting to distinguish original materials from restorations, forgeries, or later interventions.
- **Interdisciplinary Collaboration:** Stronger integration of chemistry with archaeology, art history, conservation science, and environmental studies.
- **Digital Documentation and Databases:** Creation of global reference databases for historical materials to support comparative studies and long-term conservation planning.

CONCLUSION

Chemical analysis is essential to the research and conservation of historical materials and artifacts from cultural heritage. Researchers can identify original materials, manufacturing procedures, and subsequent interventions or restorations by using analytical techniques like spectroscopy, chromatography, microscopy, and elemental analysis. These insights aid in reconstructing the historical context of objects and evaluating their preservation and authenticity. By exposing deterioration processes, environmental effects, and material incompatibilities, chemical investigations also assist well-informed conservation initiatives. Crucially, the growing use of minimally invasive and non-destructive techniques guarantees that priceless objects are examined without sacrificing their integrity. A multidisciplinary knowledge of cultural legacy is produced by combining chemical data with historical, archaeological, and art-historical evidence. All in all, chemical analysis greatly aids in the sustainable conservation and long-term preservation of cultural material for future generations in addition to deepening understanding of historical technologies and artistic practices.

REFERENCES

1. de Castro, M. L., & Jurado-López, A. (2019). The role of analytical chemists in the research on the cultural heritage. *Talanta*, *205*, 120106.
2. Madariaga, J. M. (2015). Analytical chemistry in the field of cultural heritage. *Analytical Methods*, *7*(12), 4848-4876
3. Bertrand, L., Thoury, M., Gueriau, P., Anheim, É., & Cohen, S. (2021). Deciphering the chemistry of cultural heritage: targeting material properties by coupling spectral imaging with image analysis. *Accounts of Chemical Research*, *54*(13), 2823-2832.
4. Janssens, K., & Van Grieken, R. (Eds.). (2004). *Non-destructive micro analysis of cultural heritage materials* (Vol. 42). Elsevier.
5. Aucouturier, M., & Darque-Ceretti, E. (2007). The surface of cultural heritage artefacts: physicochemical investigations for their knowledge and their conservation. *Chemical Society Reviews*, *36*(10), 1605-1621.
6. Towarek, A., Halicz, L., Matwin, S., & Wagner, B. (2024). Machine learning in analytical chemistry for cultural heritage: A comprehensive review. *Journal of Cultural Heritage*, *70*, 64-70.
7. Mazzeo, R., Roda, A., & Prati, S. (2011). Analytical chemistry for cultural heritage: a key discipline in conservation research. *Analytical and bioanalytical chemistry*, *399*(9), 2885-2887.
8. Gates, G. A. (2014). Discovering the material secrets of art: Tools of cultural heritage science. *Am. Ceram. Soc. Bull*, *93*, 20-27.
9. Greenberg, A. (2002). *The art of chemistry: myths, medicines, and materials*. John Wiley & Sons.
10. Chalupa, R., & Nesměrák, K. (2021). Analytical chemistry reveals secrets of alchemy. *Monatshefte für Chemie-Chemical Monthly*, *152*(9), 1019-1032.
11. Schummer, J., & Spector, T. I. (2007). The visual image of chemistry: Perspectives from the history of art and science. In *The public image of chemistry* (pp. 213-257).
12. Vovk, Y., Merezhko, N., Indutnyi, V., Pirkovich, K., & Lytvynenko, Y. (2022). Determining Dangerous Chemicals on the Surface of Metallic Historical Artifacts. *Eastern-European Journal of Enterprise Technologies*, *6*(12), 120.
13. Bensaude-Vincent, B., & Stengers, I. (1996). *A history of chemistry*. Harvard University Press.
14. Watts, S., Abbott, D., Crombie, D., Gunn, A., & Pensée, A. L. (2008). Science revealed: the hidden story of objects. *Studies in Conservation*, *53*(sup1), 146-150.
15. Giuffrida, M. G., Mazzoli, R., & Pessione, E. (2018). Back to the past: deciphering cultural heritage secrets by protein identification. *Applied microbiology and biotechnology*, *102*(13), 5445-5455.
16. Prus, B., Wilkosz-Mamcarczyk, M., & Salata, T. (2020). Landmarks as cultural heritage assets affecting the distribution of settlements in rural areas—An analysis based on lidar dtm, digital photographs, and historical maps. *Remote sensing*, *12*(11), 1778.
17. Rodriguez-Simón, L., Navas, N., & Manzano, E. (2010). Chemistry in cultural heritage and cultural heritage in chemistry. Research and education. Painter and sculptor: Alonso Cano's projects. In *EDULEARN10 Proceedings* (pp. 1062-1070). IATED.
18. Sharma, B. K. (1981). *Instrumental methods of chemical analysis*. Krishna Prakashan Media.

19. Sangster, A. J. (2018). Fundamentals of Electromagnetic Radiation. In *Compact Slot Array Antennas for Wireless Communications* (pp. 35-56). Cham: Springer International Publishing.
20. Zlotorzynski, A. (1995). The application of microwave radiation to analytical and environmental chemistry. *Critical Reviews in Analytical Chemistry*, *25*(1), 43-76.
21. Drdácký, M., Ševčík, R., Frankeová, D., Koudelková, V., Buzek, J., Eisler, M., & Valach, J. (2024). Degradation mechanisms of mortar and plaster layers. *Materials*, *17*(14), 3419.
22. Brysbaert, A. N. (2004). *Technology and social agency in Bronze Age Aegean and Eastern Mediterranean painted plaster*. University of Glasgow (United Kingdom).
23. Derry, J. (2012). Investigating Shellac. *Project-Based Masters Thesis*.
24. Ahluwalia, V. K. (2023). Infrared spectroscopy. In *Instrumental Methods of Chemical Analysis* (pp. 179-231). Cham: Springer Nature Switzerland.
25. Bitossi, G., Giorgi, R., Mauro, M., Salvadori, B., & Dei, L. (2005). Spectroscopic techniques in cultural heritage conservation: a survey. *Applied Spectroscopy Reviews*, *40*(3), 187-228.