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THE KEY ROLE OF INTERDISCIPLINARITY IN
THE CONSERVATION OF FIRE-DAMAGED PAPER
HERITAGE

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THE KEY ROLE OF INTERDISCIPLINARITY IN THE CONSERVATION OF FIRE-DAMAGED PAPER HERITAGE

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Abstract

The project CREMIB – Conservation et Restauration des Manuscrits et des Incunables Brulés – was set up in the years 2019-2021 in the field of paper heritage conservation. The research was aimed at developing an innovative green chemistry treatment for the strengthening of written cultural heritage harmed by fire and excluded from access and even from simple handling because of their fragility.

From the very beginning the project involved humanists, scientists, conservators and was carried out with the collaboration of the staff of libraries keeping charred manuscripts and incunabula, the Médiathèque L'Apostrophe in Chartres (France) and the Library of the Episcopal Seminary in Padua (Italy). Interdisciplinarity played a key role in directing the research towards the development of a nanocomposite formulation compatible with the paper matrix and efficient in limiting the tendency to fragmentation and material loss in charred paper while not changing its historic and optical properties.

Introduction

Fires in buildings housing historical collections of books and papers have occurred throughout history and all over the world. Blazes have been caused by incidental events resulting from poor safety precautions and by the presence of readily flammable materials, such as paper-based collections, as well as by armed conflicts. The impact on written cultural heritage has usually been disastrous. A large part of the books and documents on paper harmed by fire in libraries and archives has been left untouched since the devastations, in very poor condition, as a consequence of their fragility and loss of parts even from simple handling.

The material consistency and the textual information of the charred areas have been generally considered irrecoverable and when applied, traditional conservation methods – mainly based on lining the burnt areas with very thin Japanese paper and adhesive – have not yielded satisfactory results, inducing mechanical stress and affecting legibility. Safeguarding the textual information hidden in the blackened, carbonized areas is instead an important task

as innovative technologies based on multispectral investigations at different wavelengths (i.e. in the visible light, in the ultraviolet and in the infrared bands) are nowadays at our disposal to ‘make the illegible legible’, revealing what the naked eye cannot read any more.

To the aim of contributing to rescue the written heritage damaged by fire kept in libraries and archives and so far excluded from access, a research project called CREMIB — Conservation et REstauration des Manuscrits et des Incunables Brulés — was carried out in the field of nanotechnologies in the years 2019-2022.¹

The CREMIB project: goals and development

The CREMIB project was dedicated to the development of innovative materials and a suitable methodology aimed at strengthening the paper matrix of the charred areas of books and documents damaged by fire. The specific focus was on the conservation of the traditional handmade rag paper, which was the support for writing and printing from the 13th to the 19th century in the Western Latin world. Preventing further fragmentation of the paper and retaining the full legibility of the texts in the areas treated for conservation were the main goals in the research, so to allow a prudent access, to enable their multispectral investigation and their reproduction for the benefit of the largest scholar community.

The project was coordinated by the Institut de Recherche et d’Histoire des Textes — IRHT, CNRS (Paris) and financially supported by DIM ‘Domaine d’intérêt majeur’ — Matériaux anciens et patrimoniaux for my PhD research, co-tutored by the Muséum National d’Histoire Naturelle (MNHN, Paris) — in the field of Science des matériaux and by the Italian University of Padua in the field *Scienza e ingegneria dei materiali e delle nanostrutture*.

Historic, scientific and technical aspects of the project were introduced from the very beginning to the staff of two libraries – the Médiathèque L’Apostrophe in Chartres (France) and the Library of the Episcopal Seminary in Padua (Italy) – and the established dialogue allowed us to involve some historic materials in the research. In particular, the manuscripts belonging to the Municipal Library of Chartres (France) – nowadays held at the Médiathèque L’Apostrophe – and the collection of incunabula² kept in the Library of the Episcopal Seminary in Padua (Italy) were of great interest for us as ‘victims’ of blazes due to American bombing in 1944.

- 1 Melania Zanetti *et al.*, “La restauration des livres et documents endommagés par le feu: nouveaux matériaux et nouvelles méthodes, le projet CREMIB”, *La Revue de la BNU*, 2020, 21, p. 52-59.
- 2 Incunabula are books printed in the earliest period of typography, in the second half of the 15th century and until 31 December 1500.

In Chartres, a very large amount of the hundreds of manuscripts, cartulary and archival documents dating from the early Middle Ages to the 19th century was lost in the fire and only about 200 codices have survived, mainly disbound and in a fragmentary state. Over the past decades, a considerable number of parchment leaves from the most important codices have been recovered and undergone conservation treatment at the Conservation Department of the Bibliothèque nationale de France. Several treated works have already been digitized, identified, virtually rearranged into their original configuration and made available online to the international scientific community in the BVMM virtual library³ created and updated by scholars in the frame of the project called ‘Renaissance virtuelle des manuscrits sinistrés de Chartres’ overseen by the IRHT. In contrast, the issue of the paper manuscripts escaped from the blaze had not been faced so far due to their great fragility, since scorched paper material is prone to fragmentation when subjected to the slightest mechanical stress (**fig. 1**).



Fig. 1. A manuscript damaged in 1944 in the blaze of the Municipal Library in Chartres, nowadays held at the Médiathèque L’Apostrophe in Chartres (Photo by the author)

3 “Étude et renaissance virtuelle d’un fonds de manuscrits sinistrés”, *À la recherche des manuscrits de Chartres* [online]. <<https://www.manuscrits-de-chartres.fr>>, last access: April 2023.

For the same reason, the paper incunabula seriously damaged by fire in the Library of the Episcopal Seminary in Padua had been set aside, pending the formulation of an appropriate interventive procedure (**fig. 2**).



Fig. 2. An incunabulum held at the Library of the Episcopal Seminary in Padua harmed during bombing in the Second World War (Photo by the author)

The methodological approach to the development of a suitable conservation intervention advanced through progressive steps in our research: investigation of burnt historical papers; production of charred paper samples for the experiments, in which composition and degraded condition were comparable to those of the real ones; the development of a reinforcing treatment based on new nanocomposites and its application on samples; preliminary test applications on originals.

Theoretical Premises to the CREMIB project

Theoretical premises were discussed and shared among all, mainly my research supervisors Anne-Laurence Dupont and Alfonso Zoleo, scientists respectively at the Centre de Recherche sur la Conservation (MNHN-CNRS) and at the Padua University, my co-supervisor François Bougard, historian and director of the IRHT and me as book and paper conservator. We were aware that written cultural heritage – even when badly damaged by fire – is part of our ‘tangible cultural heritage’, in other words is to be considered as ‘material evidence of the value of civilisation’, a notion that in Italy was effectively expressed for the

first time by the Commissione Franceschini in the 1960s.⁴ Such an expression includes physical objects – immovable monuments and buildings, movable artworks, archaeological collections, scientific equipment, music instruments, documents, books, objects of the most diverse nature produced by human ingenuity, skill and creativity – made and used by human societies in earlier eras. Now superseded by social and technological developments, through the materials, techniques and structures involved in their production, they reflect the wealth of knowledge, technological progress and craftsmanship of the society that manufactured them. This is the reason why these artefacts are no longer understood merely as tools serving a contingent purpose, and the relationship we establish with them is not simply based on their original function, but instead on their cultural significance, with the aim of understanding and preserving the memory of human civilisation and evolution.

As part of our overall cultural heritage, these artefacts are subject to the important obligations implied by conservation. On one side, we all feel grateful for the privilege of having inherited them, on the other side, we also have the duty to preserve them and to pass them from one generation to the next in the best possible condition, especially in terms of respect for their material authenticity.

The protection of cultural objects from natural ageing (the passage of time) use (anthropic effects) and disasters (like fires are) inducing physico-chemical alterations and leading to their material decay, is therefore a very onerous task. Preservation activities and conservation practices must not only be properly designed in order to be effective in slowing down degradation, but they must also respect the historical value and material features of the objects. This principle was officially reiterated by the International Council of Museums – Committee for Conservation in 2008, when stating that conservation includes ‘all measures and actions aimed at safeguarding tangible cultural heritage while ensuring its accessibility to present and future generations’ and that ‘all measures and actions should respect the significance and the physical properties of the cultural heritage item’.⁵ In the ICOM-CC Resolution, the terms ‘preventive conservation’, ‘remedial conservation’, and ‘restoration’ are distinguished according to the aims of the actions involved and taken as a whole constitute the wider field which encompasses the ‘conservation’ of the tangible cultural heritage.

4 Commissione Franceschini, *Per la salvezza dei beni culturali in Italia. Atti e documenti della Commissione di indagine per la tutela e la valorizzazione del patrimonio storico, archeologico, artistico e del paesaggio*, Roma, Casa Editrice Colombo, 1967.

5 ICOM-CC Resolution. International Council of Museum – Committee for Conservation. *Terminology to characterize the conservation of tangible cultural heritage*, adopted by the ICOM-CC membership at the 15th Triennial Conference, New Delhi, 22-26 September 2008.

The concept of conservation/restoration and its fundamental principles were already identified and expressed by Cesare Brandi some decades ago. As the founder and director of the Italian Istituto Centrale per il Restauro for twenty years, between 1939 and 1959, Brandi played a leading international role in the development of theories and practices in the conservation of works of art. In his main work, *Theory of Restoration*, he defined restoration as ‘il momento metodologico di riconoscimento dell’opera d’arte, nella sua consistenza fisica e nella sua duplice polarità estetica e storica, in vista della sua trasmissione al futuro’;⁶ that is the methodological moment of recognising the work of art, in its physical consistency and in its dual aesthetic and historical polarity, in view of its transmission to the future. It follows that any behaviour toward a work of art, including conservation/restoration intervention, depends on whether the work of art has been recognised as such. And Brandi pointed out also that only the material component of a work of art can be subject to conservation treatment.

Brandi’s definition, formulated more than half a century ago, can be addressed to our entire body of cultural heritage: conservation represents the methodological moment of properly recognising the cultural artefact and it makes sense only in a historical perspective.

Moreover, being directed to the physical consistence of the cultural artefact, the complex issue of its conservation/restoration can only be tackled by developing a deep interdisciplinarity between humanities, natural sciences and technical skills necessary for carrying out treatment procedures.⁷

Interdisciplinarity in cultural heritage conservation

Preservation activities and conservation treatments have been traditionally understood as empirical practices based on experience and hence verifiable through observation rather than theoretically structured academic disciplines. It is true that they do not belong to any single branch of knowledge but rather work in a multidisciplinary framework integrating multifarious aspects which are the object of study in other specific fields.

It seems interesting to me to consider that the terms *multi-* and *inter-*disciplinarity have been under discussion for several decades and have been

⁶ Cesare Brandi, *Teoria del restauro*, Roma, Edizioni di Storia e Letteratura, 1963, p. 34.

⁷ Very interesting and worth of reflections what expressed by Jonathan Ashley-Smith, Head of the Conservation Department at the Victoria and Albert Museum from 1977 to 2002, concerning the progressive loss of the skills necessary to perform high-level conservation treatments in Jonathan Ashley-Smith, “Losing the edge: the risk of a decline in practical conservation skills”, *Journal of the Institute of Conservation*, 2016, 39, p. 119-132.

assigned meanings that are not perfectly interchangeable. According to David Alvarogonzález, multidisciplinary is ‘an activity associated with many, multiple or more than one existing discipline’.⁸ The author recalls the work of Bernard C.K. Choi and Anita W.P. Pak, who expressed how multidisciplinary ‘draws on knowledge from multiple disciplines but stays within their boundaries’.⁹ On the other hand, ‘interdisciplinarity analyses, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole’.¹⁰

Only a real transition from multidisciplinary to interdisciplinarity could make conservation a complete discipline and, seen from this perspective, establishing an effective, dialectical relationship between the humanities and the natural sciences would constitute an important step.

Despite its unquestionable relevance, the scientific investigation involved in conservation in fact runs the risk of being somewhat merely instrumental, aimed at acquiring analytical results that provide answers to questions posed by the humanities (e.g. art history, archaeology, etc.) concerning the composition of certain pigments or lithological samples, textiles, and so on. Scientists are often asked to analyse materials – or even fragments – without having any idea of the context they come from or the purpose their analyses should have for the conservation of the object. It also happens that, once the results of the analyses are available, the relationship between the natural sciences and the humanities is interrupted and only resumes when new analytical results are requested, thus lacking the coordination and coherence that should characterise an effective and sufficiently conscious level of interdisciplinarity.

It is worthwhile stressing that the different disciplines concerned employ different investigative methods. Intuition and qualitative research are important in the humanistic field, since they focus on understanding individual aspects of the particular phenomena. On the other hand, experimentation is at the core of the scientific method: through an inductive process moving from the specific to the general, researchers integrate information to develop a theory or provide a description that can explain the phenomena under observation. Every aspect of science is informed by its reliance on objectivity, evidence, and experiments aimed at demonstrating its validity. The conservator is expected to have a key role, integrating historical and scientific information by means of an examination

8 David Alvarogonzález, “Multidisciplinary, Interdisciplinarity, Transdisciplinarity, and the Sciences”, *International Studies in the Philosophy of the Science*, 2011, vol. 25, n° 4, p. 388.

9 Bernard C.K. Choi and Anita W.P. Pak, “Multidisciplinary, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness”, *Clinical and investigative Medicine*, 2006, 29, p. 351.

10 *Ibid.*

of the cultural object to tailor the most appropriate conservation treatment on a case-by-case basis, proceeding from the anamnesis and providing a diagnosis, and subsequently carrying out the intervention.

The analogy drawn between conservation and medicine is quite frequent and widely used: it is said that through conservation one ‘prolongs the life’ of a work of art and, in general, of cultural heritage artefacts. It is worth reflecting that cultural heritage conservation is concerned with inanimate objects while medicine (human, veterinary or botanical) deals with living organisms. Cultural items can decay more or less rapidly depending on their constituent materials and on the environmental conditions in which they are held, but in any event, they do not die. Moreover, biological organisms are often capable of repairing any damage that may occur to them: a small wound can heal itself without any medical help, whereas a tear in a sheet of paper must always be repaired by a human intervention: it does not heal by itself. Apart from this distinction, the analogy between medicine and conservation is functional in explaining the importance of interdisciplinarity in allowing conservation to emerge from empiricism.

Because of the fundamental role it plays in human society, medicine became familiar with the scientific method well before conservation. For a long time now, its relationship with biology, chemistry and physics has ceased to be merely instrumental, aimed only at the acquisition of analytical results, establishing a more continuous and more dialectical relationship between the natural sciences and medical practices. Moreover, it is an accepted concept in medicine that, even when a general protocol derived from historical experience is established, therapeutic intervention must be tailored on a case-by-case basis, because no two patients are identical, and the same holds true for objects of cultural heritage.

The importance of understanding the materials and techniques used in the manufacture of historical objects is also beyond question, as the fundamental contribution provided by the natural sciences to it. Similarly, the study of anatomy would not have travelled its long path without the contribution of biology, and the same would not have happened to physiology without the contribution of chemistry. And isn’t the anamnestic reconstruction of each patient’s past, analogous to the reconstruction of the history of the objects to be preserved? So history – which also acts as a guide for medicine – is closely related to what might appear to a superficial observer to be a purely factual ‘science’. The use of inverted commas for the word science is not accidental.

Carlo Ginzburg remarks about medicine:

The group of disciplines that we have called circumstantial (including medicine) does not fall within the criteria of scientificity inferable from the Galilean paradigm.

They are eminently qualitative disciplines, which have as their object individual cases, situations and documents, and for this very reason they achieve results that have an ineliminable margin of randomness. Only by carefully observing and recording with extreme precision all the symptoms – the Hippocratic approach affirmed – is it possible to construct precise ‘histories’ of individual diseases.¹¹

Therefore medicine, like conservation, cannot be considered an ‘exact science’, assuming that this expression can have a real and constant application. They are both better suited to the definition of ‘experimental discipline’, since no doctor or conservator, despite acting in accordance with pre-established protocols, can be sure of the effect that the intervention will produce in the individual case. For the fundamental role it plays in human society, medicine already possesses a solid epistemological paradigm in which the relationship between the humanities and the natural sciences appears to be successfully recomposed. Although in the field of conservation this has not yet happened completely, from the outset we have tried to make up for this shortcoming in the CREMIB project.

Interdisciplinarity in CREMIB project

Understanding the significance of the written heritage involved in the project was the first step in CREMIB project and humanities played an important role in it, with particular regard to the history of paper manufacture, codicology and book archaeology, which application allowed us to highlight the goals and the limits of the conservation intervention we intended to develop.

As a result, the preservation of the intrinsic composition of the historical paper was a shared objective, which led to the choice of developing a minimally invasive intervention, limited to the paper charred areas that were in need for it and suitable for being carried out either on free sheets, as in the case of the manuscripts held in Chartres, and on sheets still bound in books, as the damaged incunabula from Padua, working in respect of the polymeric structure of the artefacts.

On these bases, the experimental steps of the project were developed. The contribution of the natural sciences – mainly chemistry and physics – was pivotal and had multiple implications.

The first one was that of ‘bring out’ the content of material information that is the essence of the historical objects. This is far from being obvious in the case

11 Carlo Ginzburg, *Miti, emblemi, spie. Morfologia e storia*, Torino, Einaudi, 1986, p.170-171. Translation by M. Zanetti.

of books and archival documents, whose uniqueness frequently risks being neglected. It is true that a manuscript is perceived as *unicum* by definition, but printed books – as incunabula are – exist in multiple exemplars and to anyone interested in the textual content, the different exemplars of the same text appear identical. A good quality digital reproduction of the text can fully meet the study and research needs of the majority of the scholars, even those of manuscript text scholars. Digitisation is often referred to as a ‘dematerialisation process’ and what is reproduced by that process is obviously the immaterial component of the object,¹² so that the digital reproduction of a document (i.e. its intangible component) can be duplicated in an endless number of copies, indistinguishable from the first and from one another. What continues to make these historical artefacts irreplaceable are their irreproducible material consistency.

In-depth investigation of the historic papers from the Médiathèque L’Apostrophe of Chartres and from the Library of the Episcopal Seminary of Padua was carried out at the CRC and at the Department of Chemical Sciences of the University of Padua, in particular the measure of paper acidity, investigation by optical and scanning electronic microscope (SEM/EDS), spectroscopic techniques (ATR-FTIR and FORS) and X-Ray Powder Diffraction (XRPD) applied to unburned areas and to areas of different degrees of combustion.

The cross-referencing and interpretation of data resulting from the wide range of physico-chemical analyses made it possible to assess the composition of the paper highlighting, at the same time, that no two cellulose fibres were identical, therefore no two sheets of paper were identical in composition (fibers, mineral fillers, sizing) and decay process.

Investigations of paper areas at different degrees of combustion was a very effective way of tracking the progress of paper degradation in terms of fire-induced morphological and chemical changes. The obtained results provided a reference for the production of charred paper samples burnt on hot plate, whose composition and state of decay were comparable to those already observed in burnt historical papers, to the aim to be treated in the experimental step (**fig. 3 and fig. 4**).

12 Zinaida Manžuch, “Ethical Issues in Digitization of Cultural Heritage”, *Journal of Contemporary Archival Studies*, 2017, vol. 4 (2), art. 4; Carlo Federici, “Digitale: toccasana o veleno?”, *La Fabbrica del Libro*, 2012, 18, p. 2-5.



Fig. 3. Paper samples burnt on a hot plate for testing (Photo by the author)

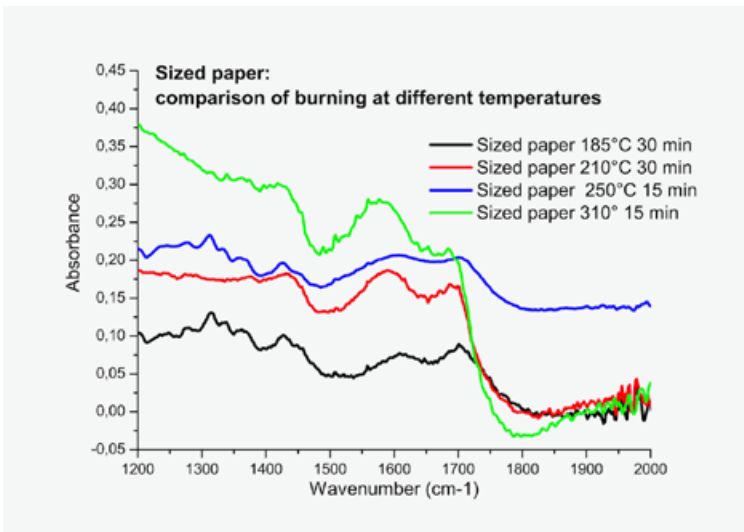


Fig. 4. ATR-IR spectra of paper samples burnt on a hot plate (different temperatures and different burning time) to be compared to the spectra obtained from investigation of the charred historical papers.
(© Alfonso Zoleo, Padua University)

The contribution of specialists from different disciplines (humanists, scientists, conservators) was fundamental also in directing conservation intervention towards appropriate methodologies.

Above all, the issue of reversibility in conservation treatments was tackled in the light of the reflections addressed to it in recent decades.

‘Reversibility: does it exist?’ was the question posed more than twenty years ago at the conference organized by the British Museum¹³ and the issue has recently been taken up again by recalling the definition of reversibility according to thermodynamics.¹⁴ According to one of the most important notions of thermodynamics, a process is *reversible* if, after it has taken place, can be reversed and, when reversed, the system returns into its initial state.

Although in literature, mass media and even in scientific production the reversibility of restoration interventions is often emphasized, full reversible processes are not achievable and the real answer to the question about reversibility in conservation treatment can only be negative: the object cannot be returned to its pretreatment state as the alterations induced by treatment on its chemical composition and physical structure cannot be undone.

Likewise the concept of removability – that is the possibility of separating the materials added by the intervention from the historic artefact without placing it in jeopardy – has to be carefully assessed on case-by-case base.

In the CREMIB project, for example, we aimed at proposing an innovative material that would enter the fragile burnt paper matrix avoiding the formation of deposits/lining on the burnt paper surface and interact with its fire-damaged but still extant cellulose fibres, improving their mechanical performance. Such a process and materials could not really be expected to be removable, primarily because of the extremely weakened condition of the original paper matrix.

Precisely because of these considerations about reversibility and removability, the principle of devising conservation treatments in which the quantity of materials added to the historic artifact could be reduced, thereby retaining as much as possible of the object’s original features, was regarded as imperative.

Great importance was also given to the development of ‘green’ products, sustainable and non-toxic, that would allow the conservation treatment to be carried out in situ, directly in libraries and archives where fragile historical artefacts are usually kept, avoiding the stress and risks associated with moving them.

13 “Reversibility: does it exist?”, in Andrew Oddy and Sara Carroll (ed.), *British Museum occasional papers*, 135, London, British Museum Trustees, 1999.

14 Rita Udina, “Reversibility and the right conservation treatment”, in *INTACH Heritage India – Conservation Insights 2020’ Lectures*, Lucknow, INTACH Conservation Institute, 2021, p.201-210.

On these premises, the field of nanotechnologies was promising to us, putting at our disposal compatible nanostructured materials with very reduced size¹⁵ but increased reactivity and efficiency in comparison to the ones traditionally employed in conservation. The methodology developed in the CREMIB research is based on nanocellulose dispersed in polysiloxanes to form a combined biopolymer-based nanocomposite. When applied to the carbonised areas by airbrush (in low amount <3%) the formulation permeates the whole thickness of the damaged paper matrix, acting as a structural agent that stabilizes and partly restores paper flexibility, while not changing its optical properties and not leading to unwanted effects.

The efficiency of the reinforcing treatment was evaluated by SEM/EDS, ATR-FTIR, FORS and fold to break resistance test, systematically performed on the untreated and treated samples (**fig. 5 and fig. 6**).

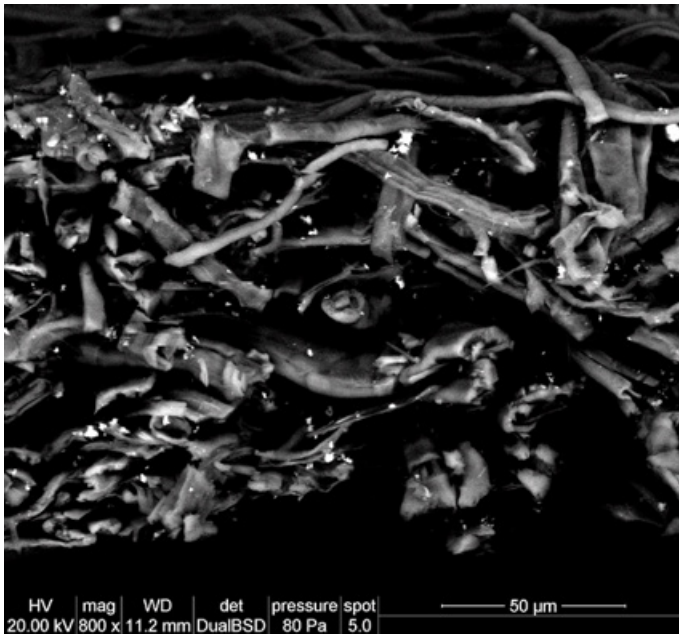


Fig. 5. SEM image (800x) of the cross section of a burnt paper sample.
(© Michele Sacco, Padua University)

15 Nanomaterials have at least one dimension < 100 nanometres (1 nanometre = 10^{-9} metres), the prefix 'nano' meaning 'very small' (from the ancient Greek word *νάνος*).

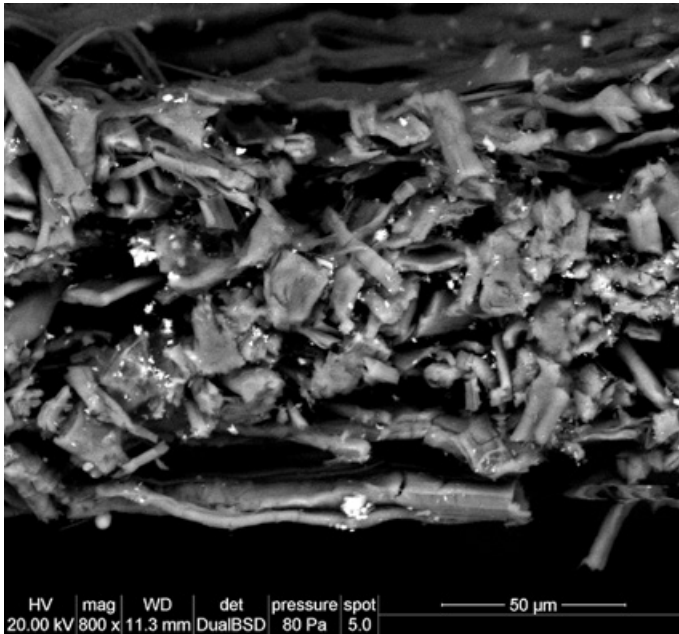


Fig. 6. SEM image (800x) of the cross section of the same burnt sample after the application of the nanocomposite formulation, giving an effect of density increase of the fibrous material.
(© Michele Sacco, Padua University)

As laboratory samples can never fully replicate the complexity of real historical materials in their natural state, the full collaboration of the Médiathèque L’Apostrophe in Chartres and the Library of the Episcopal Seminary of Padua was essential in the last phase of this work to bring the conservation treatment to the originals and out of the confines of the laboratory.

Some handwritten as well as printed fire-damaged papers drawn from historic collections were treated with the new-formulated nanocomposite (**fig. 7**).



Fig. 7. Distribution of the nanocomposite formulation by airbrush on the charred area of a manuscript (Photo by the author)

Imaging investigations in the visible light band, in the ultraviolet and in the infrared bands were performed before and after treatment at the Interdepartmental Centre for the Study of Cultural Heritage – CIBA of the University of Padua.

The comparison of the areas pre- and post- the application confirmed the absence of interference of the formulation composed of nanocellulose and polysiloxane with any imaging investigation, readability and reproduction of the text, which was one of the key concerns of the CREMIB project (fig. 8).

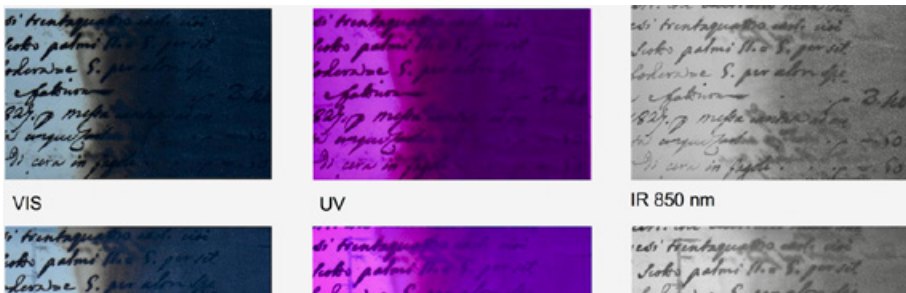


Fig. 8. Multispectral investigations: the charred area of the manuscript before (top) and after (bottom) treatment at visible light, in the UV and IR band. (© Rita Deiana, CIBA, Padua University)

Finally, the suitability of the *in situ* application of the methodology developed in this research was tested by performing the conservation treatment on selected sheets of an 18th century manuscript directly at the Médiathèque L’Apostrophe in Chartres, in the study room closed to the public on the day of treatment.

This opportunity was involving the library staff, my research supervisors and myself, and was the most remarkable result of the dialectic and fruitful interaction between the different skills brought into play in the service of conservation and access to such a fragile cultural heritage.

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