



Innovative packaging solutions for storage and conservation of 20th century cultural heritage of artefacts based on cellulose derivatives

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EDITORIAL

by AIMPLAS (Project coordinator)

We are in the final term of the NEMOSINE project! And all the work carried out during the last fifty-two months is reflected in the exciting results and conclusions obtained.

I am proud to say that the extraordinary commitment and effort of the NEMOSINE consortium allowed us to progress in innovative research activities such as the vinegar syndrome (more properly referred to as acetate film base degradation) in cultural artefacts, as photographic and film, for which there are few precedents. Currently, the film archives do not have factual data about the concentration of Acetic Acid since no precise tools support that. The traditional solutions used are "acid control strips" and "gas detector tubes" these options only provide an approximation data of the concentration of acetic acid. In addition, once the degradation process of the film begins, there is no solution able to slow down, or even stop, the degradation process to extend the life of the film as much as possible.

An archive keeps thousands and thousands of movies, so it is challenging to keep track of all the archived material in real-time.

The NEMOSINE consortium has worked in different research areas to develop a solution allowing precise monitoring of NO_x (Nitrate oxide) and AA (Acetic Acid) gas concentration through the development of electrochemical sensors. Also, an ICT solution has been developed to facilitate the wireless communication of data into software to monitor the data over time and in many films simultaneously. NEMOSINE also developed an acetic acid absorber based on MOFs (Metal-Organic-Frameworks) that has been demonstrated to reduce, inside the box in which the film is stored, the concentration of AA between 40% and 50%, lowering the degradation process.

All these solutions are integrated into a new suited NEMOSINE's box developed in polypropylene, allowing the integration of the electronics, sensors and MOFs.

Now that the work is completed, I am pleased to invite you to the final workshop of the project, where we will present the different results achieved with the support of the organisations participating in the activities execution.

The workshop will take place next Wednesday, the 25th of May. It is a hybrid free event that you can attend in person (in Valencia, Spain) or follows streamed online for the participants that cannot assist. More details about the agenda and the speakers are provided in this newsletter issue.

A special article in this newsletter is also dedicated to our end-users (DFF, IVC and OEAW) who have shared their expectations and the actual benefits of the final project's results for their organisations.

I hope you will enjoy reading this issue, and we look forward to seeing you in Valencia!

Susana Otero Belmar

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NEMOSINE in brief

Grant Agreement n.: 760801

Project Coordinator: AIMPLAS

Project website:
<https://nemosineproject.eu/>

Duration: 52 months

Starting date: 01/02/2018



NEMOSINE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 760801.

NEMOSINE final workshop:

“The NEMOSINE innovative package for cultural heritage preservation”

by Maria Jimenez Cuesta
from PNO Innovation S.I.



The **NEMOSINE project** is coming to an end and therefore preparing for the Final Workshop where the solutions and the innovative package for the 20th-century cultural heritage preservation will be showcased and discussed.

Topics of discussion such as MOFs, Acetic absorbers, sensors and wireless solutions for the preservation of cultural heritage artefacts based on cellulose derivatives will be considered. It will be possible thanks to the participation of research centers, universities and industrial partners.

Moreover, a round table has been organized where experiences of the archives (end users) and other partners participating in this H2020 founded project will be shared with the audience.

We would like you to participate in this free session (online or on-site) by registering now [by clicking here](#).

The workshop will take place on the 25th of May 2022 from 09:00 to 12:00 in AIMPLAS, Plastics Technological Centre, Valencia (Spain) but it will be also streamed online for the participants who cannot assist.

You will find further information about the speakers and the workshop programme at the end of this Newsletter.

The NEMOSINE smart package: the end-user's experiences

by Carolina Salas
from PNO Innovation S.I.

In this issue, we have had the opportunity to interview the three archives participating in the NEMOSINE project. All of them have been involved in the definition of NEMOSINE packaging specifications and in the validation process of the smart package.

By **answering three key questions**, they have shared their expectations and the actual benefits of the project's results for their organisations.

We have talked with:



The **DFF - Deutsches Filminstitut & Filmmuseum** was founded in 1949 and is the oldest and one of the most important institutions in the Federal Republic for the collection, archiving and academic utilisation of films and filmhistorical documentation, as well as for the transmission of film culture and film literacy. Since 2006 it has been the organising institute for the formerly municipal Deutsches Filmmuseum, with its exhibition and cinema facilities and activities.

The film archive department of DFF preserves a collection of more than 20.000 films, which are stored according to modern conservation standards in climate-controlled vaults. The collection is comprised of feature films, short films and documentaries, as well as amateur and experimental films. It includes films from early cinema, the German avant-garde film of the 1920s and 1930s, classics from the cinema of the Weimar Republic, New German Cinema and European auteur cinema.



The **Austrian Academy of Sciences (OeAW)** is Austria's central non-university research and science institution. Founded in 1847 as a learned society, today the OeAW has over 770 members and 1,450 employees dedicated to innovative basic research, interdisciplinary exchange of knowledge and the dissemination of new insights with the aim of contributing to progress in science and society as a whole.

The OeAW operates 28 research institutes in the field of innovative basic research in the arts and humanities and the social and natural sciences. The academy stimulates pioneering research by taking up future-oriented topics and ensuring the preservation and interpretation of cultural heritage. The designated project partner Phonogrammarchiv, an institute of the OeAW, was founded in 1899 and is the oldest audiovisual research archive in the world.



The **Valencian Culture Institute (IVC)** possesses cultural heritage in music, audiovisual, cinematography, theatre, and dance. The Filmoteca Valenciana, created in 1985, is part of the IVC now. Its mission is the safeguarding of the audiovisual heritage and the dissemination of its culture. This means the recopilation, preservation, restoration, cataloguing and dissemination of all the elements generated by a film, from production to diffusion, including the technological devices required. The screening of the universal history of the audiovisual arts is also a main task of the filmoteca.

IVC is a member of the International Federation of Film Archives (FIAP) and of the Association des Cinémathèques Européennes (ACE) and is a partner of the EU funded projects NEMOSINE and CollectionCare.

DFF Deutsches Filminstitut & Filmmuseum

(Frankfurt, Germany)

We talked with: **Kerstin Herlt**



Kerstin holds a master's degree in Roman Philology, Sociology and European Media Studies. She joined the Deutsches Filminstitut in 2001 where she was coordinating the project “f_films”, a database and filmography of female film pioneers in Germany and filmmakers in Europe.

From 2008 to 2017 she was managing the German office of the Association des Cinémathèques Européennes. She has been coordinating ACE's collaboration in EU funded projects such as the European Film Gateway, the WWI film digitization project “European Film Gateway 1914 and the orphan works project FORWARD.

Kerstin Herlt rejoined DFF in 2018 as European Projects Coordinator. Since 2021 she is a member of the Europeana Aggregators Steering Group and the Europeana Supervisory Board.

1

What engaged your organisation in participating in this research project?

The DFF – Deutsches Filminstitut & Filmmuseum is a film heritage institution based in Frankfurt. Its core task is to collect, preserve, restore and make available film heritage. The film archive which is based in Wiesbaden stores over 20,000 works, from feature films, short films, documentaries to amateur and experimental films, covering film production from its early beginning. The collection is continuously growing through purchases, deposits and donations, which increases the pressure and the efforts to ensure the proper conservation of film elements and the preservation of film heritage for future generations.

Due to the own nature of nitrate and acetate film, all film archives share the same dramatic difficulty: while we make our best efforts to extend the life expectancy of films as much as possible, the process of deterioration can only be slowed down, but not stopped. As coordinator of several European projects related to the preservation, digitisation and dissemination of film heritage, the NEMOSINE project offered the opportunity to collaborate in a leading initiative developing pioneering solutions for the storage and conservation of film heritage, bringing together different approaches and partners to address the challenging issue of the conservation of Europe's film heritage.

2

Which were your expectations as end-user? Did the research make in NEMOSINE offer solutions to your needs?

For us film archives, as end-users, initially the expectation for the ‘NEMOSINE smart package’ was to gain an additional, improved conservation method for the cultural heritage artefacts in our collections: both for the cellulose nitrate film materials produced during the first 60 years of film history, (1895 up to the 1950s) as well as the cellulose acetate materials predominant from the 1950s onwards and marketed in limited quantity since the 1910s. As a result of the NEMOSINE project, we expect a low-cost, comprehensive package to effectively combat the so-called vinegar syndrome of acetate film and the nitrate deterioration of early film heritage.

The practical benefits we were expecting from the “NEMOSINE Smart Packages” are:

- ✓ improved long term storage at reduced costs, thanks to notable energy savings compared to conventional film archiving with climate control
- ✓ good conservation performance in difficult, detrimental climate conditions, in warm & humid locations with unavailable climate control
- ✓ prolonged life expectancy for film heritage objects, due to active inhibition of decay processes
- ✓ a new tool for degradation assessment which would facilitate clever collections management

From the beginning, it seemed probable that these benefits and savings were going to be more noticeable and of heightened usefulness for smaller size film collections, and for especially valuable materials in mixed media archives, i.e. in archival collections without the availability of large-scale, energy-efficient cold-storage facilities.

SOLUTIONS OFFERED:

According to the plan, the NEMOSINE research has resulted in improved sensor technology i.e., highly precise monitoring of chemical conditions for cellulose acetate film. The analysis of the data generated is performed through predictive degradation modelling integrated into a software platform, which will help the conservator in the decision-making process. The sensors are combined with a chemically inert, polymer package equipped with targeted adsorption technology: a MOF (Metal Organic Framework) specifically designed to inhibit the film’s decay process and remove the detrimental gaseous by-product **acetic acid** from the film reels’ microenvironment.

Unfortunately, a sensor for tracking degradation of cellulose nitrate film could not be finished in a satisfactory manner, nor was adsorption of NOx - emitted by decaying nitrate film – successfully resolved.

Some further challenges could not be met in the time frame of the project, partly because of hindrances caused by the pandemic situation.

The low-cost availability of the package did prove a major hurdle, mainly because of the cost of the sensor array.

Still outstanding is comprehensive testing of the packages' performance in real-life archival circumstances over sustained periods of time, with a greater diversity of historic film stocks of different ages and makes, to ascertain the reliable long-term performance of the package and its prediction model.

Extended-use testing is still pending, to assess the life-time-cycle of MOF in real life, and to assess the viability of the actual workload for the archivists in maintaining the packages.

3

How research projects such as NEMOSINE could contribute to CH preservation?

In addition to the development of a product such as the NEMOSINE box, the project involved enormous research efforts, as well as an important exchange of ideas and knowledge, which can be very valuable to understanding and dealing with film deterioration.

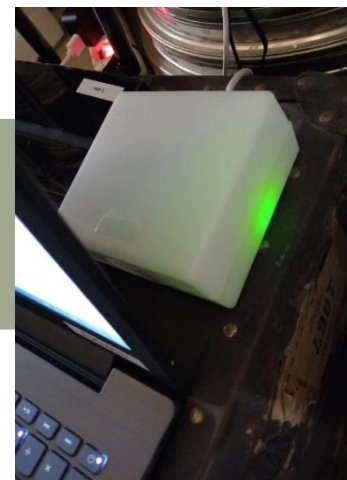
The research and experimentation carried out by partners from different fields were combined with the expertise provided by the film archives and the testing in real conditions in our vaults.

Important progress was made in areas like AA adsorption, AA detection with sensors, and degradation monitoring which can continue to be explored and developed, both together and separately, opening up a range of conservation strategies.

The NEMOSINE package is ground-breaking in incorporating new technologies in a degradation assessment tool, to remotely monitor and manage the collections. In this way, the need for regular inspections of the film materials, which are nearly impossible in the reality of any archive, is enormously reduced. Comprehensive knowledge of the state of conservation of the collections allows the archives to optimize and guide their preservation efforts.



NEMOSINE package with MOF inside a Tyvek® bag.



NEMOSINE Master node

Austrian Academy of Sciences (OEWG)

(Vienna, Austria)

We talked with: **Nadja Wallaszkovits**



Nadja is a specialist in audiovisual restoration, re-recording and digital archiving. She managed the audiovisual department of the Vienna Phonogrammarchiv as a senior researcher and is a consultant for archival technology for various National and International Institutions.

She is currently a professor for Conservation of New Media and the Stuttgart State Academy of Fine arts in Germany, as well as a guest lecturer at the University of Vienna and at the Universities of Applied Sciences in Berlin and Berne.

Nadja is Audio Engineering Society (AES) Past President, Vice Chair of the Technical Committee of the International Association of Sound and Audiovisual Archives (IASA), and member of the IASA Training & Education Committee.

1

What engaged your organisation in participating in this research project?

The Phonogrammarchiv of the Austrian Academy of Sciences (OEWG) is the oldest audiovisual research archive worldwide. Since ever, we have been dealing with the complexity of safeguarding our audiovisual heritage best possibly. During our long international experience with the storage problems of materials based on Cellulose acetate, we have experienced and researched the properties, material behaviour and longtime storage related issues. During the last 30 years, our archive has been active in various international activities and platforms, such as UNESCO, IASA, AES and many more.

Recently, the Phonogrammarchiv has been a project leader of Austrian an innovative research project in cooperation with NOA GmbH company from Austria, with the intention to find solutions for the long-time storage, preservation and conservation of Cellulose acetate materials for audiovisual sources. As a follow-up, OEWG Phonogrammarchiv was invited to join the NEMOSINE project, which our part, was incredibly valuable research to bring forward this challenging topic of heritage conservation.

2

Which were your expectations as end-user? Did the research make in NEMOSINE offer solutions to your needs?

The expected impact on cultural heritage preservation has been very high, as the problem is a worldwide huge issue, dramatically underrated by the politics. More than 75 years of visual and audio memories are in serious danger to be lost due to the natural instability of cellulose acetate

(CA) and cellulose nitrate (CN). So far there are no possibilities to regularly monitor a collection without the disadvantages of handling and opening every single box.

The research carried out in NEMOSINE is a significant contribution to the extension of the life span of films and magnetic tapes based on acetate derivatives.

In contrast to conventional film cans or media boxes, the packages are equipped with the latest sensor & adsorption technology, to monitor decomposition processes and adsorb decomposition products, such as acetic acid.

Our measurements have shown that the sensors work much more accurately than every other acidity monitoring system available for archives so far. Also, within our tests, we have figured out that the MOFS, the metal-organic frameworks shaped to absorb acetic acid, are extremely efficient and able to reduce the outgassing acidity to a factor of a minimum.

3

How research projects such as NEMOSINE could contribute to CH preservation?

In the near future, the research carried out during the NEMOSINE project will significantly contribute to a better understanding of the deterioration mechanisms of cellulose acetate. The option to remotely monitor the climate in the box is extremely helpful for archives.

The NEMOSINE package will not replace current storage systems but will significantly improve them. Monitoring the collection with the help of sensors is a great improvement and will help to save time and handling.

NEMOSINE will allow for frequently inspect the collection, also between periodical inspections. It will enable precise knowledge of the condition of the collection as never reached before.

There is still a lot of testing and improvement work necessary to make the NEMOSINE box a valuable tool for archives. But finally, archives in critical climate zones will especially profit from the NEMOSINE Package.



Testing the NEMOSINE sensor in the laboratory of OEAW



A highly degraded acetate based 35mm film

Filmoteca Valenciana (IVC)

(Valencia, Spain)

We talked with: **Juan Ignacio Lahoz Rodrigo**



Juan Ignacio is the head of conservation of the Filmoteca Valenciana since 2002, responsible for the restorations, preservation, digitization, storage and cataloguing of the filmic materials and is in charge of the equipment and software in the film archive.

He has a degree in Geography and History from the Universitat de València (1986) and he is also a cinematographical historian, specialised in the Valencian film History. He has co-coordinated the project for the consolidation of the preservation of filmography of the Spanish filmmaker Luis García Berlanga (Filmoteca Española and Filmoteca Valenciana).

He is in charge of Filmoteca Valenciana for the EU projects NEMOSINE and CollectionCare. He was also the coordinator of the Spanish editions of the dissemination workshops of the EU funded projects EDCine in Valencia in 2009 and in 2011 of the “Promoting the use of the European Metadata Standards for the Interoperability of filmographic databases (CEN/TC372) and responsible in Filmoteca Valenciana for the EFG1914 EU project. He directed the congress “With regard to Cuesta. I Congress on the beginnings of the Spanish cinema (1896-1920)”, organized by Filmoteca Valenciana in 2005 as part of the project of safeguarding the Valencian producer company Films H.B. Cuesta.

1

What engaged your organisation in participating in this research project?

The reason for engaging in the NEMOSINE project was that it is focused on the main conservation problem of the Film Heritage: the degradation by acetic acid release, also known as vinegar syndrome.

The main commitment of the Filmoteca Valenciana is to safeguard the Valencian Film Heritage. The Valencian country is on the Mediterranean coast, and we have a very high Relative Humidity level, an annual average of 66% and a warm Temperature with averages of 18°C and a daily thermal amplitude of 10°C. This climatology favours the hydrolysis process and the acetic acid release from the acetate base of films, photographs and posters.

Therefore, the main part of our Film Heritage is threatened by the vinegar syndrome, which has destroyed many films, both feature films, documentaries, amateurs and a huge amount of family films that were not conserved in appropriate conditions until their incorporation into the filmoteca collections.

To prevent the vinegar syndrome degradation and dissemination the film archive devotes its staff, special vaults and important economic resources for long term conservation, digitization and even restoration of damaged items. And this effort is carried out with no efficient tools for detecting the

start of the degradation in a preserved film or photography and the risk of environmental contamination of many other materials stored with it, or even a whole vault.

This is a common situation in many archives that hold Cultural Heritage goods based on cellulose derivatives. When AIMPLAS invited Filmoteca Valenciana (IVC) to engage in the NEMOSINE project, we immediately appreciated that it pursued a very efficient and practical solution to manage the problem in film archives. All the project targets, the package, absorbers, sensors and software generated us a great expectation and the will to be part of it.

With the role in the project of end-user and final validator, the Filmoteca Valenciana was going to have the chance of contributing its knowledge and experience to the development of a complete, modern and efficient tool that could improve the management of cinematographic collections as it gives the film archives the capability to monitor and predict their degradation and to make conservation decisions accordingly.

At the end of the project, we will have contrasted and enriched our practical knowledge with scientific research and its application. And we will be proud of having contributed to a great advance in Film Heritage conservation.

2

Which were your expectations as end-user? Did the research make in NEMOSINE offer solutions to your needs?

The main expectation was on the capability to monitor and predict acetate degradation and to make conservation decisions accordingly. Also, saving power by increasing the conservation temperature of audiovisual heritage, which will reduce costs and CO₂ emissions and will extend life expectancy and conservation efficiency to those collections that do not match cold storage or the best conditions for each material.

The achievements of the project are very important:



Film reel damaged with vinegar syndrome and metal package corrosion

- ✓ The MOFs absorbers have been demonstrated to work efficiently in the trials carried out by the audiovisual archives partners of the project. And the absorption inhibits the decay, which increases life expectancy.
- ✓ Trials also showed the accuracy of the sensors developed, both for the acetic acid and nitrogen dioxide. Nevertheless, more trials are needed, particularly to know the life expectancy of the absorbers
- ✓ The monitoring and risk alerts will also make the complex and laborious conservation work more selective and efficient. However, it is not yet a package to be used massively but for singular items or collections.

The project was addressed for the acetic acid release, but the audiovisual archives partners in the project suggested researching the nitrocellulose gas release too. It resulted in a sensor for nitrogen dioxide, which is a very important progress, although it is not enough to monitor all the complexity of the nitrate degradation.

Modularity is another advantage: The size and cost of the sensor forced to design different pieces for the smart package, not an all-in-one solution. This has resulted in the possibility of using the box, the absorbers and the sensors separately and then using the sensors for environmental control too.

3

How research projects such as NEMOSINE could contribute to CH preservation?

NEMOSINE is a perfect example of the innovative improvement that research projects can contribute to Cultural Heritage (CH) preservation. To control the “vinegar syndrome” is crucial for audiovisual heritage and the project successes must be completed; also, the CH based on nitrocellulose requires a development accordant to its complexity, like the one performed for acetic acid.

Research projects are focused on giving solutions to Cultural Heritage preservation common problems and, like NEMOSINE, they result in practical advances. To apply scientific and technological research to CH preservation is an obligation for CH Institutions, so they must be part of such projects as they can get improvements for the material conservation but also to manage their work and satisfy their social compromise.

To develop collaborative projects between research, industrial and CH Institutions is very complex, and it is needed the strong support of the EU, particularly in stimulating and granting projects for the audiovisual heritage area.



Decomposed nitrate film print




HIGH O₂
BARRIER AND
ACTIVE
PACKAGING


ACTIVE ACID
ADSORBERS


GAS
DETECTION
SENSORS


MULTI-SCALE
MODELLING


PACKAGING
WITH MODULAR
DESIGN


CURATIVE
PACKAGES



Highlights

NEMOSINE Final workshop



[REGISTRATIONS HERE](#)

AGENDA



Plenary Session

9:00 Welcome
(PNO & AIMPLAS)

9:05 The NEMOSINE project: from the need to the results
Susana Otero (AIMPLAS)

Research performed and developed innovations

9:20 MOFs and Acetic Absorbers: research and solutions for Cultural Heritage preservation
Adolfo Benedito (AIMPLAS)
Moises Pinto (IST), Vanessa Pereira Pimenta (CNRS-IMAP-Paris), Pierre Tignol (CNRS-IMAP-CRC) and Nathalie Steunou (University of Versailles)

10:00 Sensors and wireless solutions for CH preservation
Ioannis Kakogiannos (IRIS), Abeer El Mohtar (IST) and Federico Ortenzi (Biosensor)

10:20 NEMOSINE socio-economic and environmental impact on the market
Luigi Ranza (PNO)

10:35 Coffee break & posters exhibition

Round table

11:05 Round table discussion: End-users experiences and recommendations
Ignacio Lahoz (IVC), Kerstin Herlt (DFF) and Nadja Wallaszkovits (OEAW)
Moderates: Itziar Carracedo (AIMPLAS)

11:45 Q&A
Carolina Salas (PNO)

12:00 Closure of the event
AIMPLAS

12:05 Light lunch and networking