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

Newsletter | Issue n. 2 | September 2020

EDITORIAL

by AIMPLAS (Project coordinator)

We are already in the 32nd month of execution of the NEMOSINE project, and after having passed the half of the project's expected duration, the consortium has been able to generate the first results related to the development of an intelligent system for the conservation and monitoring of photographic and filmographic material.

The great collaboration experienced among the project partners, including organizations managing large archives, research groups and industries, is contributing to reaching great advances, both in the materials, and in the systems for the preservation of cultural heritage.

After deep investigation in MOFs (Metal-Organic Frameworks) for adsorption of Acetic Acid, as well as in the different ways for its integration as aerogels, micro-foams and non-woven, together with antifungal additives to avoid the growth of molds, progress is being made in new solutions to prevent the deterioration of cultural heritage based on cellulosic materials from photographic and filmographic archives. Likewise, the development of electrochemical sensors for the detection of Acetic Acid (AA) and Nitrogen Oxides (NOx) gases, correlated with the degradation of films based on cellulose acetate and cellulose nitrate, allows monitoring of the photographic and filmographic material to be automated, not only in the archive area but also in the conservation container itself.

Over the coming months, the NEMOSINE consortium will focus on obtaining the first functional prototypes of smart packaging that integrate the different solutions developed, and we hope to be able to show it during the work sessions that we will organize for Spring 2021 in which we would like to be able to count on you.

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

Contents

NEMOSINE in brief

Grant Agreement n.: 760801

Project Coordinator: AIMPLAS

Project website: https://nemosineproject.eu/

Duration: 48 months

Starting date: 01/02/2018

NEMOSINE's smart package: first prototype available

by Centre Technique Industriel de la Plasturgie et des Composites

One of the main objectives of NEMOSINE is to develop an innovative modular and smart package including several functionalities: (a) Metal-organic frameworks (MOFs) open cell foams with acetic acid adsorbents, a chemical resulting from the degradation of cellulose acetate, (b) Sensor to detect the degradative gases inside the box, and (c) An RFID system for remote data analysis.

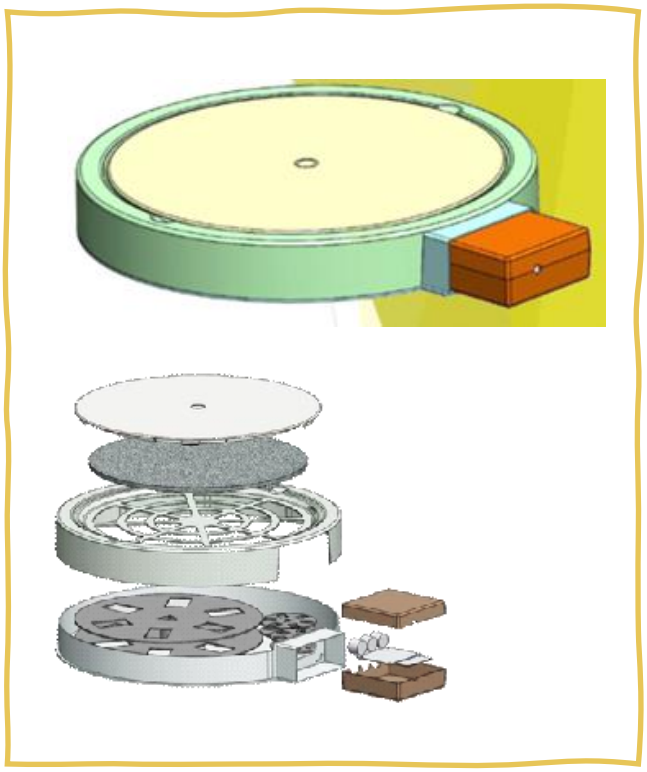
Following the end-user requirements analysis, and according to the production possibilities, it has been concluded that the injection molding process would be the best solution for manufacturing the package.

The design of the new package has a strong relationship with the work carried out within NEMOSINE, including the foams with acetic acid adsorbers, the sensors array and the electronics. For safety reasons, the sensors - as well as the adsorbent foam with the active substance - will not be in direct contact with the cultural object.

During the last months of activity, several concepts for the box have been considered, taking into account the identified needs, mainly:

- A modular package concept allowing a change of sensor array depending on the film stored, cellulose acetate or cellulose nitrate, or use of the box without sensor array
- A height available for film reel of 38 mm
- A circular shape with a diameter of 380 mm
- The size of the sensor and the electronic system to detect the degradative gases
- An easy electronic maintenance and battery change
- A design in agreement with the injection molding technology.

NEMOSINE's objective is to reduce the dimensions of the box as much as possible, as the space to store the films in the shelves is quite limited. The design of the package will also allow for stickability of the different boxes.



Design of the prototype

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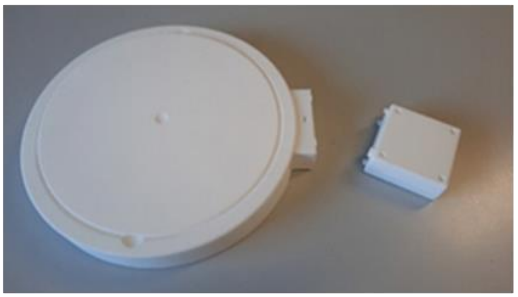
The designed solution also considers a controllable ventilation function, with optional ventilation, in case the end-user chooses not to use it.

3D printing technology was used to easier understand the box design and integration of electronics. A first version of the 3D printed prototype has been prepared using powder sintering of Polyamide 12 (PA12).

The smart package will be chemically inert and made of highly stable package materials, resistant and thoroughly tested to meet the requirements of preserving precious and fragile cultural objects. Several tests were performed with the polypropylene resins: analysis of volatile compounds, liquid extraction, Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA) and thermal aging.

The images below show NEMOSINE's first 3D printed prototype.



NEMOSINE: using nanotechnology for heritage preservation

by Biosensor Srl

Cultural heritage is seriously threatened by the presence of volatile compounds in storage areas that may degrade and/or accelerate the degradation process of old artifacts. This is particularly true for old films for which vinegar syndrome in film archives poses significant conservation problems. Typically, the compounds primarily involved in artefact degeneration are acetic acid and nitrogen oxides (mainly NO and NO_2). Thus, a device that can detect those volatile compounds and simultaneously monitor O_2 levels would be most beneficial in the preservation of cultural heritage.

Biosensor Srl (partner of NEMOSINE) has already developed an array which integrates sensors - based on nanomaterials - for NO, NO_2, (electrochemical) and

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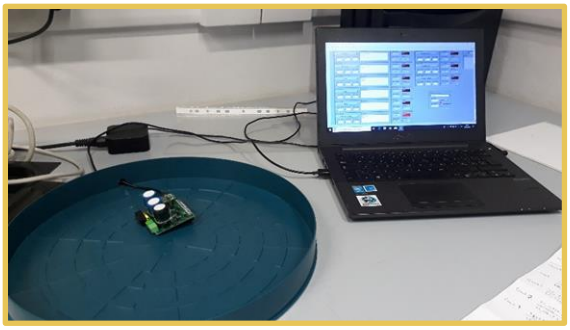
for acetic acid (resistive, based on coupled Zinc oxide Tin oxide/Zinc oxide nanostructured sensors); the array was tested to monitor its performance when challenged with cross interferences of secondary volatile co-pollutants produced by the degradation process of films, but not involved in further degradation processes (such as medium chain alcohols, benzoquinones, phenols). The arrays were then used to analyze, under controlled laboratory conditions, cellulose acetate and cellulose nitrate films provided by members of the consortium (FRATELLI ALINARI I.D.E.A. S.p.A., Österreichische Akademie der Wissenschaften - Phonogrammarchiv, Deutsches Filminstitut & Filmmuseum, Filmoteca Valenciana - Institut Valencià de Cultura and Universidade NOVA de Lisboa).

The values obtained with the acetic acid sensor showed good correlation to the traditional acetic acid monitoring system for films, acid-detecting strips (A-D strips). The volatile compounds sensor array's main advantages over A-D strips are the time required for measurements (15 min with the array vs. 24h with the strips), the reusability of the platform (A-D strips are single-use only) and the possibility to perform remote monitoring of the conditions in the storage area.

As a result of a consultation with experienced archive members during NEMOSINE's meetings, Biosensor Srl engineers have created a software to process the data provided by the **MOS sensors** of the array.

The **software**, which requires minimum processing power and is based on **Open-sources languages**, is able to compensate sensor signals due to non-relevant volatile compounds for **reliable and selective film deterioration monitoring** over long times without need for external human intervention.



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Highlights

Degradation of Cellulose Nitrate at Synchrotron SOLEIL

From 15 to 21 September 2020, researchers from NOVA team developed a scientific research project in the Synchrotron SOLEIL, Saint-Aubin, France.

Entitled "Luminescence imaging and microscopy for the safeguard of cellulose nitrate-based heritage", this project aims to detect and characterize luminescent intermediates generated in the early stages of the degradation of cellulose nitrate. Ultimately, this knowledge will serve the development of early warning tools to monitor CN degradation in heritage collections.

The confocal fluorescence microscope (POLYPHEME) of the DISCO beamline, with its extended wavelength range (180-600 nm), has the potential do detect these early UV absorbing intermediates in valuable heritage microsamples.

This work is performed by studying the main degradation intermediates observed in cellulose nitrate aged references and then by their identification in multilayer systems, namely in cinematographic films provided by NEMOSINE project. Celluloid heritage objects will also be studied to further insight on the influence of plasticizers, fillers, and other additives in cellulose nitrate stability.

MOF 2020 Web virtual conference (21-24 September 2020): Promethean Particles introduced first results of research in Metal Organic Frameworks (MOFs)

Promethean Particles, in the framework of NEMOSINE project, is collaborating in the development of innovative packaging and storage solutions in support of the preservation and conservation of vital historical artefacts and documents.

Utilising its ground-breaking continuous flow production process, Promethean is developing Metal Organic Frameworks (MOFs) which are highly porous materials that are able to selectively adsorb the acetic acid which is responsible for the degradation of cellulose acetate, of which many 20th century audio and visual 'memories' are made. Today, many artefacts are stored in archives or boxes which do not offer adequate protection.

Research scientist at Promethean, Charles Toft, said: "We are working with organisations from across Europe, as part of the NEMOSINE project, to develop innovative packaging solutions that will overcome the challenges that storing documents and artefacts over long periods of time presents".

Promethean is working closely with another project partner that produces MOFs with the required functional properties via a lab-scale batch process. Promethean then adapts the batch method onto its continuous flow reactor systems to manufacture MOFs with the same, or similar, functional properties and facilitate upscaling. Initial performance testing has generated positive results and Promethean is now focused on scaling up the manufacturing process to produce larger quantities, validate the material, and ensure the solution will be commercially viable.

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"A química dos materiais porosos ao serviço do ambiente"

On 15th September 2020, an article in the national Portuguese newspaper "Journal I" highlighted the NEMOSINE project and their efforts to achieve a better conservation solution to the film's archives. The article was written by Moisés Pinto, from ULisboa and member of the NEMOSINE team, that was invited to contribute with an opinion article.

Although the topic of the article was the application of adsorbent materials in a broader context of environmental protection, the participation of IST and ULisboa on the NEMOSINE was emphasized. The article attempts to explain to the wide audience that adsorbent materials are very useful to capture noxious compounds. There are several current challenges that are better known by our societies, like the greenhouse gas CO_2 or the decontamination of water, where adsorbents can play a role. The use of adsorbents on the capture of the acetic acid to achieve smart packages for the conservation of films was presented as a high-end application of this type of materials. The article may increase the public awareness in Portugal to the NEMOSINE project since the news was published with the link to the website.

The article is available at:
https://ionline.sapo.pt/artigo/708797/a-quimica-dos-materiais-porosos-ao-servico-do-ambiente?seccao=Opiniao_i

NEMOSINE presented in the AES Virtual Vienna

Last 4th June 2020, Ms. Nadja Wallaszkovits, from the organisation OEAW, presented the project in occasion of the AES Virtual Vienna.

The presentation, titled "NEMOSINE: The future of media storage: A state of the art packaging concept for storage and conservation of 20th century cultural heritage artefacts based on cellulose derivatives" is available for download in the NEMOSINE project website.

For further information about the event and the speakers, please click this link: https://www.eventscribe.com/2020/VirtualVienna/agenda.asp?pfp=FullSchedule

NEMOSINE presented at EVA 2020

Last 20th July 2020, the NEMOSINE project was presented in the Electronic Imaging & the Visual Arts, EVA 2020 Florence virtual conference.

The presentation "Innovative packaging solutions for storage and conservation of 20th century cultural heritage of artefacts based on cellulose derivatives" was made by Mr. Andrea De Polo Saibanti (from BESKIDPLUS), in the session 2 "NEW SCIENCE AND CULTURE DEVELOPMENTS & APPLICATIONS".

The power point presentation as well as the Progressing of the conference are available for download in the NEMOSINE project website.

STAY TUNED

This **autumn** will see the launch of the new **NEMOSINE video**!

The video will describe the results reached to-date and show images about the **new design of the package and sensors**!

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