W 11: NEMOSINE - THE FUTURE OF MEDIA STORAGE

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

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- WP4/WP5: Sensors based on nanotechnology, including electronic wireless devices, for degradation process monitoring
  Mathematical modeling of the degradation process

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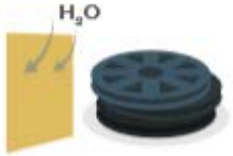
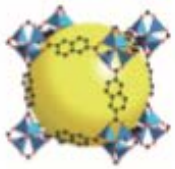
NEMOSINE RESEARCH ROUTE

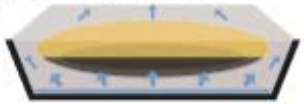
WP6 High barrier package to protect CH against Water vapour control.



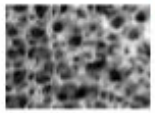


WP2 Acetic acid absorbers supported in fractionalized MOFs.

WP3 Controlled release of active substances to minimize the growing of fungus.



WP1/WP7 Design of a **smart package** for long time CH (movies, posters, photographs and slides) storage at room temperature.



WP3 High specific surface (opencells foams electrospinning nanofiber) structures containing MOF absorbers and antifungal additives.

WP4/WP5 Sensors based nanotechnology, including electronic wireles devices, for degradation process monitoring. Degradation mathematical modelling.

WP2: Acetic acid absorbers supported in fractionalised MOfs

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What is a MOF (metal organic framework)?

- *Metal-organic frameworks* (MOFs) are 3D-microporous materials that are composed of both organic and inorganic components in a rigid periodic networked structure
- Potential applications in gas adsorption and separation technologies
- Recently MOFs have shown to have a significantly better performance in capturing highly volatile acetic acid, in the presence of moisture, than other conventional adsorbents in conditions normally found in museum and archives.
- It has been proven that a special method of functionalisation can enhance the interactions with acetic acid without increasing the affinity for water.

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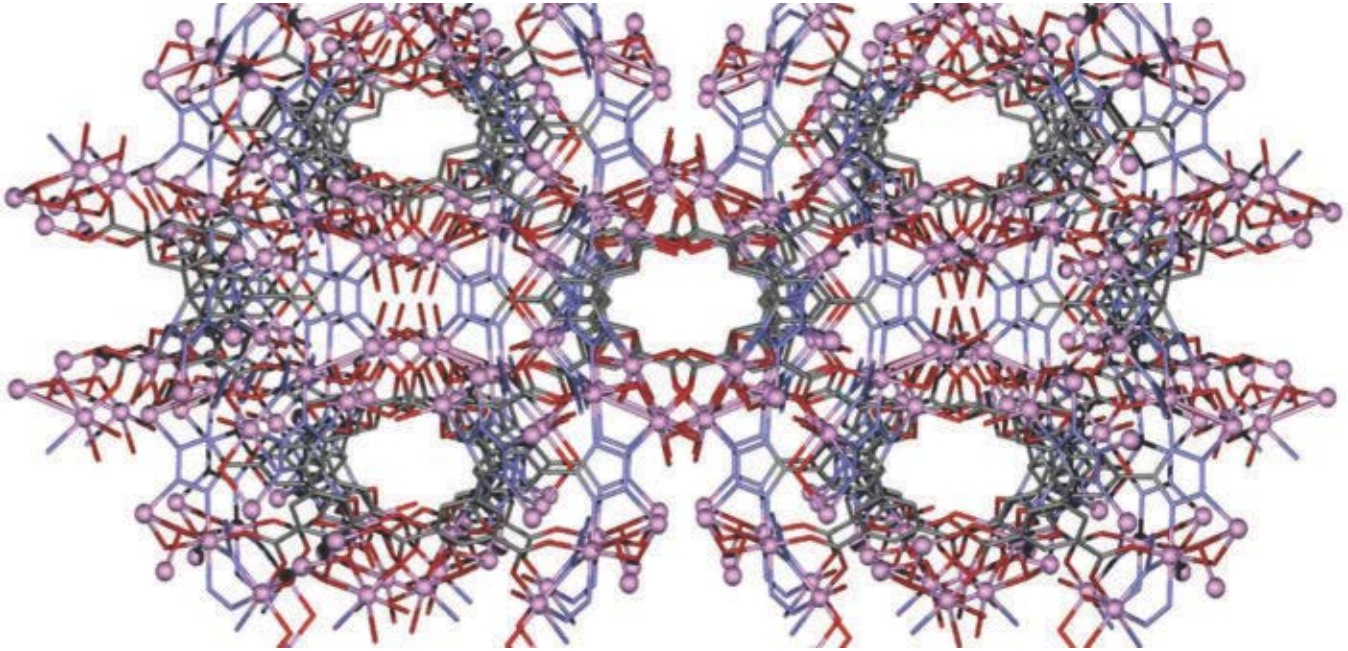
What is a MOF (metal organic framework)?

- The metal ions form nodes that bind the arms of the organic linkers together to form a repeating, cage-like structure. Due to this hollow structure, MOFs have an extraordinarily large internal surface area.



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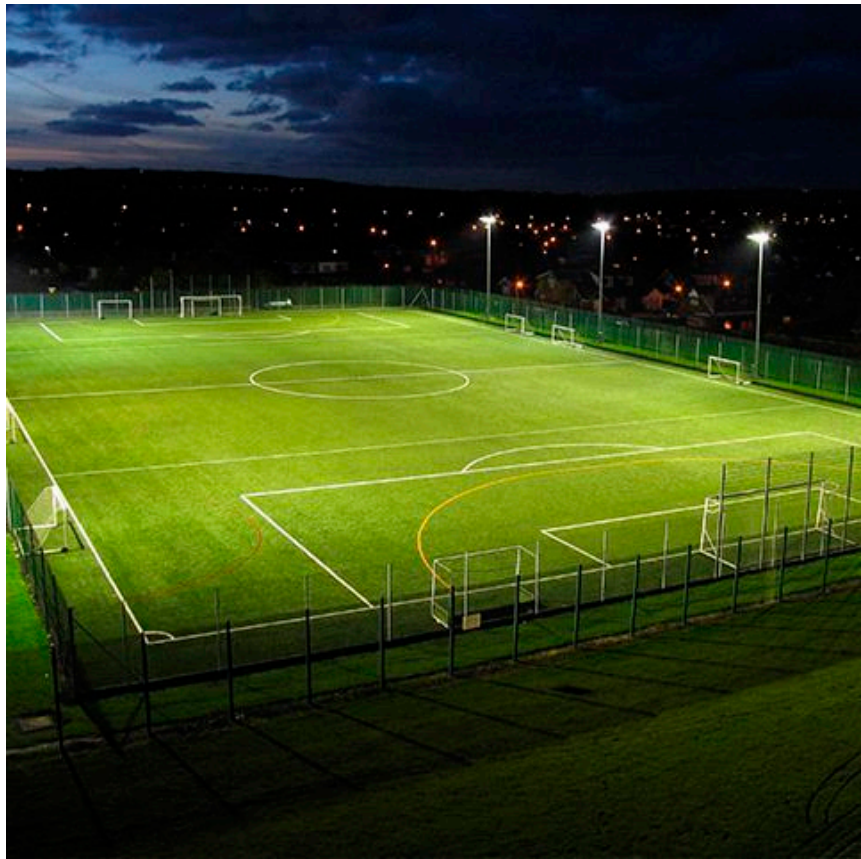
What is a MOF (metal organic framework)?

- Researchers have synthesized MOFs that feature a surface area of more than 7000 square meters per gram. To put this into context, if you could lay out the available surface area in a teaspoon of this material (around a gram of solid), it would cover an entire soccer field.



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Monel reactor for the synthesis of 1st and 2nd generation MOFs

PrometheanParticles

Formulating solutions with nanomaterials

cnrs advancing the frontiers

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Advantages of MOFs in conservation of CH artefacts

- MOFs can be shaped to individual needs
- non-odour additives
- MOFs offer unique structural diversity in contrast to other porous materials – uniform pore structures; atomic-level structural uniformity; tunable porosity; extensive varieties; and flexibility in network topology, geometry, dimension, and chemical functionality.
- This allows researchers the successful control of framework topology, porosity, and functionality

Challenges:

- cost-effective synthesis,
- optimized activation conditions and
- synthesis in green solvents

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WP3:
Controlled release of active substances to minimize the growing of fungus

High specific surface (opencell foams: electro-spinning nano fiber) structures containing MOF absorbers and antifungal additives

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MOFs integration in innovative structures

- Development of nanofiber (electrospinning) carriers:
- components, foams and cellulose paper sheets with incorporated selected MOFs & antifungals with controlled release mechanism coming from WP2 in order to produce innovative acetic acid adsorbers and active packaging for releasing non-aggressive active substances to minimize the growing of fungus.

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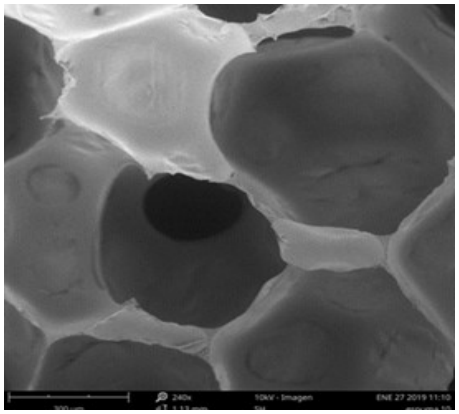
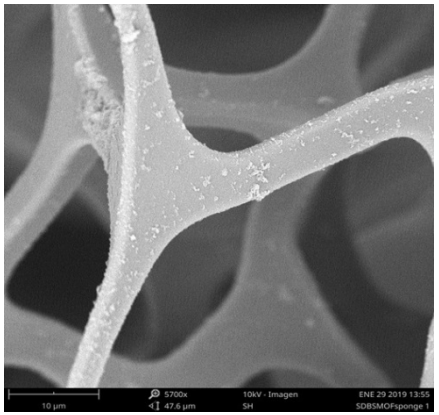
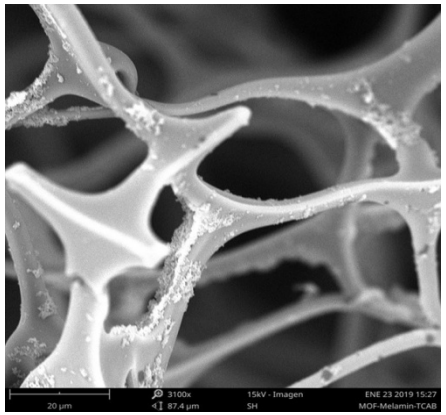
MOFs integration in innovative structures

- Suitable materials that meet the requirements for adsorbers and antifungals nanofibrous carriers were found
- Two types of nanofibrous carriers were developed, optimized and tested:
  - The carrier with incorporated selected types of MOFs for the absorption of acetic acid.
  - The carrier with antimycotic effects to prevent the growth of fungi on artefacts.







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Advantages of MOFs integration in innovative structures:

- polymeric materials (foams, sheets) that will meet the requirements for both, adsorbers and antifungals
- nanofibrous carriers: capture and release components in one material
- can be individually shaped by incorporating the chemicals needed to shape the climate within the box (other future chemicals and applications)
- Contactless

Challenges:

- Amount of chemicals (adsorbers & antifungals) which can be incorporated (Carriers containing 15%w/w of additives)
- Reach the performance of more than 85% of non-imbibed MOF or antifungals

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WP4/WP5:
Sensors based on nanotechnology, including electronic wireless devices, for degradation process monitoring

Mathematical modeling of the degradation process

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Sensors based on nanotechnology, for degradation process monitoring

- Development of nanosensors to monitor the main gases involved in CH deterioration.
- Development of high sensitive multisensor arrays to monitor degradative gases (O2, NO, and Acetic Acid) produced by CH artefacts.
- Optimize the sensitivity and specificity of the sensors using nanostructures/ nanoparticles and different array configuration.

BIOSENSOR

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Sensors based on nanotechnology, for degradation process monitoring

- To generate algorithms/software to process the signal
- Further integration with wireless RFID system in WP5
- The complete solution for the NEMOSINE box: based on multi-nano sensors for different gases (mainly acetic acid and nitric oxide) and a control software platform that simulates degradation processes and then predicts accurate protective treatments
- Low power consumption

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Measuring of outgassing chemicals

- Which outgassing chemicals are relevant?
- Finding gases that are typical first signs for certain film types degradation behaviour
- Identification of Nitrate
- The complete solution for storage boxes proposed by NEMOSINE is based on multi-nano sensors for different gases (mainly acetic acid and nitric oxide) and a control software platform that simulates degradation processes and then predict accurate protective treatments.

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Measuring of outgassing chemicals

- SPME *Solid Phase Micro Extraction* coupled to GC/MS
- Non-destructive measurement of the substances outgassing from a film pack / magnetic tape/ lacquer disc, etc.
- Allows a semi-quantitative detection of most of the typical substances of the individual medium
- First measurements performed within the original boxes
- Measurement of the outgassings is including the outgassing chemicals from the box = reality scenario

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Measuring of outgassing chemicals

- SPME *Solid - phase Micro Extraction* coupled to GC-MS

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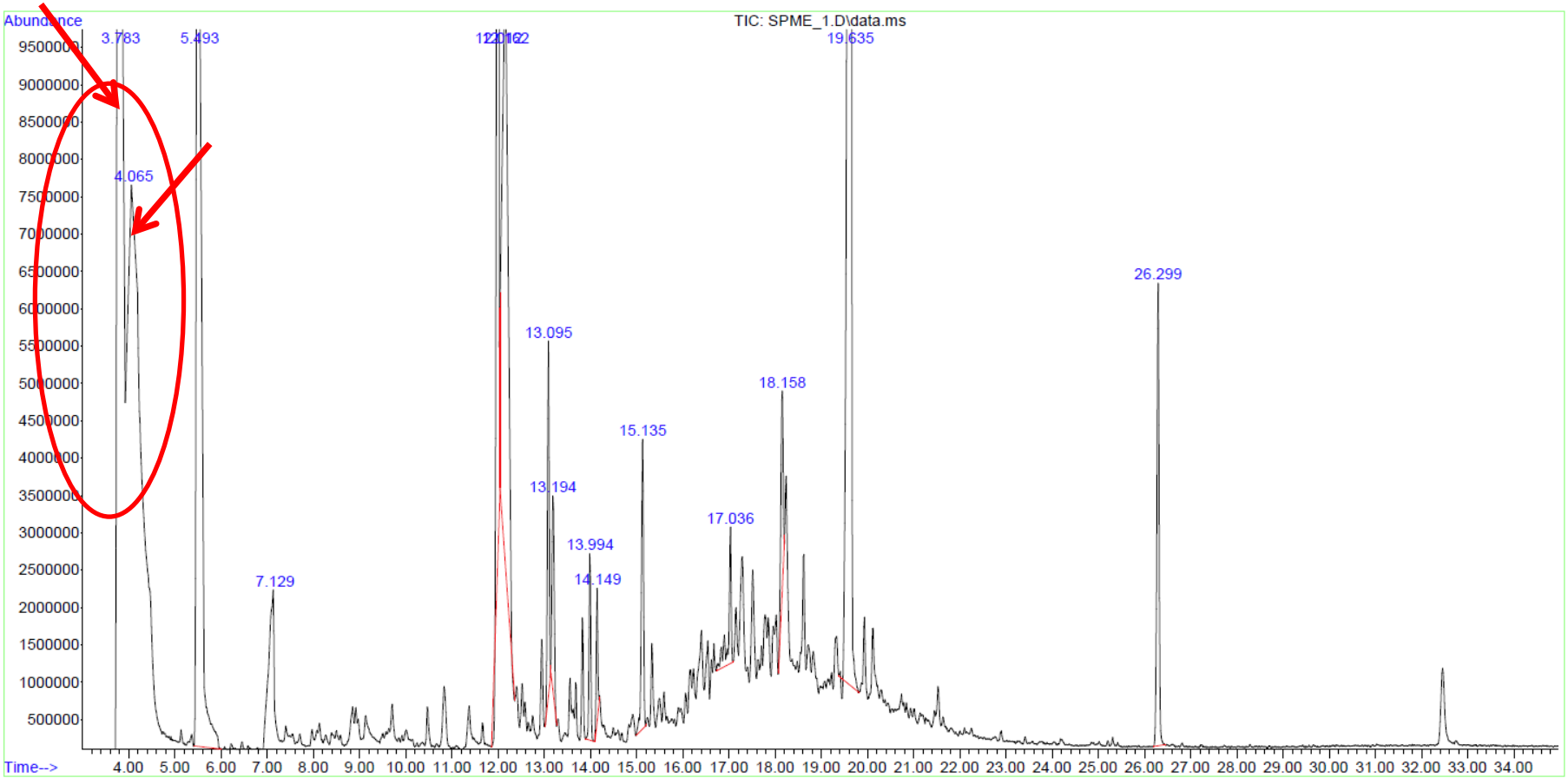
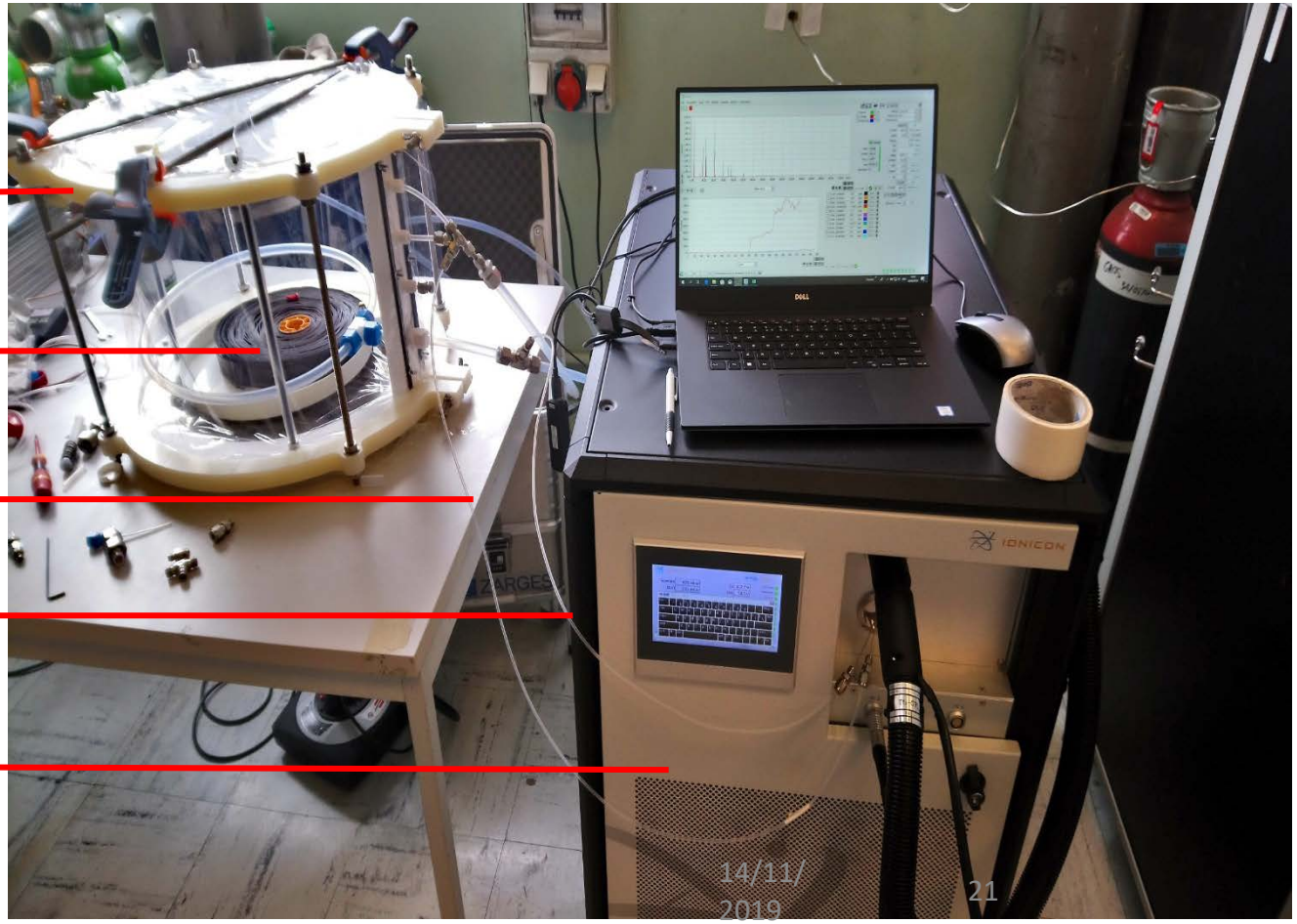
Film DIF 3.01.35.04: La parola amore esiste: AGFA Gevaert, 1998
Cellulose Acetate, “La parola esiste”, 35mm positive copy with sound (variable area, stereo, Dolby SR, bilateral), color, edgecode: „AGS 133 3910 01“. **Ph 6,0**

Instrument : GCMS 2
Sample Name: Film 90
Misc Info :
Vial Number: 1



Experimental set up – Testing of the prototype sensor



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Accuracy of the pH paper:

- Sensitivity is depending on temperature and humidity
- Without humidity, no measurement of pH is possible!
- Sensitivity depending on the pore size of the paper
- While pH paper is great for quick qualitative work, it fails at highly accurate quantitative work
- Litmus paper can give you a quick check but needs manual handling and is time-consuming
- Inaccurate for Nitrate deterioration monitoring!

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Problem with out gassing chemicals:

- Media can have been cleaned/ treated with protective substances
- Detected chemicals can have a very big variance, even with media of the same brand name
- Decomposition byproducts develop and change over time

WP4/WP5:

Mathematical modeling of the degradation process

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Mathematical modeling of the degradation process

- Define the elements needed for modeling of film deterioration
- The developed models will provide a prediction that will contribute to the software developmen), where the software will process data coming from the state-of-theart sensorized packaging by applying the predictive model to inform the conservator when and what action(s) need to be taken.
- This will give the platform a range of data processing and real time decision support functionalities helping the decision-making process conducting to the preservation of CH works of art.
- In a shorter term, the packaging systems would be able to work as diagnosis devices to understand the deterioration status of selected archetype CH assets to properly help the archive personnel to select among different conservation strategies

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General findings:

- CA composition seems to be comparatively more uniform, similar chemicals detected (plasticisers)
- Differences in detected chemicals seem to be more the result of different ageing stages and cleaning treatments than of production process
- Nitrate films: Detected chemicals have a very big variance, plasticiser mixtures that have been used are very different;
- Nitrate films contain a comparatively large amount of alkanes compared to CA, comparatively inconsistent in film base composition

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General findings:

- Other chemicals than acetic acid are outgassing in significantly higher amounts than acetic acid
- More quantitavie measurements and compimentary methods are required to describe the degradation model
- Existing high quality packaging solutions do not provide an inert environment

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Summary:

- Modular intelligent packaging solution for Cultural Heritage materials and artefacts
- Analog physical object based archiving will become digital, once these packages are in general use
- Most probably this project is one of the last chances to do basic research on these materials within a consortium of 15 high ranking project partners

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THANK YOU FOR YOUR ATTENTION!

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