# The Conservation Soft Box (CSB): an innovative, efficient and low-cost technique to preserve biological remains

Marco Samadelli[1*], Alice Paladin[1], Massimo Donegá[2], Matilde Veneziano[1], Lara Irene Ibeas[3], Albert Zink[1], Werner Tirler[2]

[1] Institute for Mummy Studies, Eurac Research, Bolzano, Italy. **Corresponding author: marco.samadelli@eurac.edu*
[2] Eco Research, Bolzano, Italy.
[3] Institute for Renewable Energy, Eurac Research, Bolzano, Italy.

## Introduction

The long-term preservation of biological remains within conservation parameters in museum collections is a challenge that confronts specialists with multiple issues from both a conservation and an ethical perspective. In particular, the human remains, which encompass mummified individuals, as well as bones, soft tissue, ashes, hair, and teeth, require special measures due to their delicate organic nature to prevent chemical and microbiological deterioration.
Currently, there are several techniques for the preservation and display of human remains, categorized into two logical-constructive types: 1. active and 2. passive systems. However, these techniques were never designed for truly effective long-term preservation.
Therefore, the **aim** of our study is to develop an innovative solution for the long-term preservation of human remains, that not only meets conservation parameters, but also has the advantage of being multifunctional and low-cost. We have thus designed the **Conservation Soft Box (CSB)** which is a durable and airtight structure (**Fig.1**).

## Methods

### The Conservation Soft Box (CSB)

The Conservation Soft Box (CSB) is made of inert and low-emission polymeric materials e.g., for the baseplate (Plastazote® and Tyvek®), for the support structure (Teflon®), for the barrier film (Polyethylene PE + Ethylene Vinyl alcohol EVOH) (Fig.2). Within the CSB, environmental parameters are customized to optimize conservation treatment. For example, an oxygen-free atmosphere with stable relative humidity can be achieved.
Each individual element composing the CSB was chemically analyzed in order to determine its VOCs emissions and evaluate the level of hazardousness.

### The VOCs analysis

Two classes of VOCs were considered for this project: aldehydes and VOCs, sampled by active sampling with a flow rate of 1 L/min. Aldehydes were analyzed after collection from air on adsorbent cartridges coated with 2, 4 dinitrophenylhydrazine (DNPH) and subsequent analysis of the formed hydrazones by high-performance liquid chromatography (HPLC) with detection by ultraviolet absorption **[1]**. SVOCs were analyzed by sampling on sorbent tubes (Type: Air Toxic Markes ideal for organic molecules in the range of C2 - C14) followed by TD-GC(-MS) **[2] [3]**; this analysis has emerged as one of the most sensitive methods to detect these VOCs and is now one of the most popular methods to measure VOCs in ambient air and workplaces, as well as being free from the use of chemical solvents (green chemistry).

**Fig.1.** Mummified individuals protected inside a CSB with 45% humidified nitrogen.

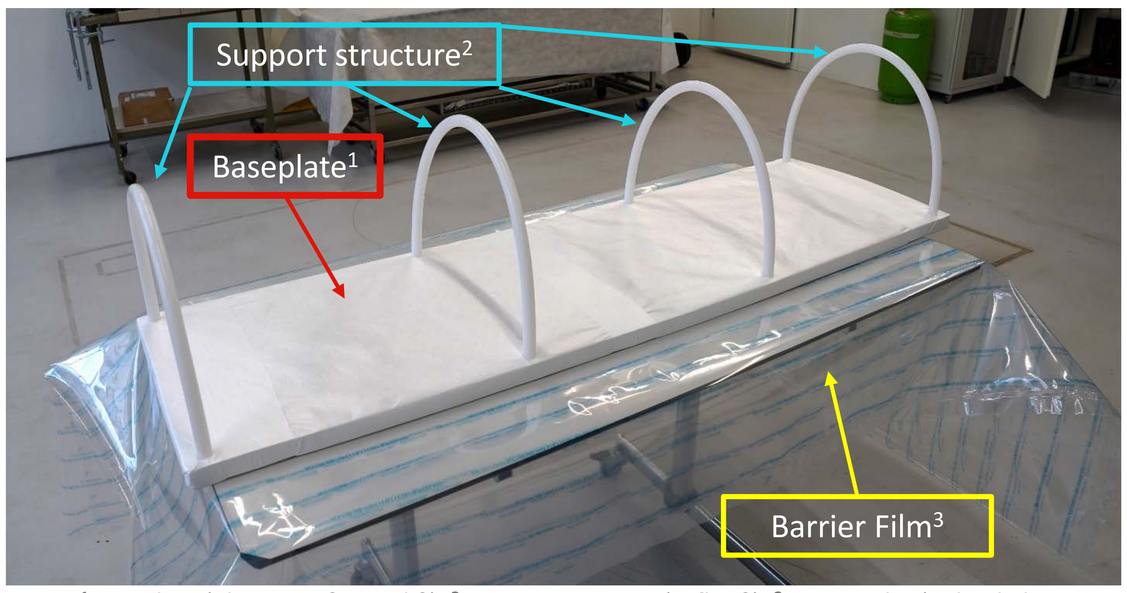


**Fig.2.** [1]Baseplate (Plastazote®, Tyvek®), [2]Support structure (Teflon®), [3]Barrier Film (Polyethylene PE + Ethylene Vinyl alcohol EVOH).

## Results and Discussion

These results (**Tab.1 and 2**) refer to the materials chosen, from all those tested, that gave the best emission values, after three weeks of storage in an oxygen-free atmosphere. The values of the Aldehyde (**Tab.1**) shows that the emissions are significantly lower than the values allowed by the international scientific community dedicated to the conservation of Cultural Heritage. Instead, **Tab.2** shows that VOCs emission are slightly superior (503.41 µg/m3 ) to the allowed limits (358 µg/m3). The CSB also allows the biological remains to be CT-scanned directly inside it, due to the absence of metal elements in the CSB.

| Material | Formaldehyde | Acetaldehyde | Acrolein | Propanal | Benzaldehyde | Isopentanal |
|---|---|---|---|---|---|---|
| | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ |
| Air laboratory | 0.45 | 0.28 | 0.41 | 0,00 | 1.06 | 1.04 |
| Transparent box (PE + Nylon) | 0.79 | 1.06 | 0.15 | 0.04 | 0,00 | 0.22 |
| Black Poliethylene foam (Plastazote® LD 29) | 0.54 | 1.23 | 0.18 | 0.37 | 0.21 | 0.18 |
| Film Poliethylene (Tyvek® 1623E) | 3.24 | 0.65 | 0.95 | 0.09 | 0.62 | 0.29 |
| PTFE Tube (2 cm diameter) | 0.49 | 0.04 | 0.04 | 0.00 | 0.00 | 0.16 |
| **Tot.** (without Air laboratory) | **5.06** | **2.98** | **1.32** | **0.50** | **0.83** | **0.85** |
| **Limits in Cultural Heritage** | <6.24 **[4]** | <36.63 **[4]** | <100 **[5]** | <100 **[5]** | <100 **[5]** | <100 **[5]** |

**Tab.1.** Results of Aldehyde emitted by the materials chosen from the several tested.

| Material | D. methane* | Ethylacetate | Chloroform | Hexane | m+o-Xylene | p-Xylene | Toluene |
|---|---|---|---|---|---|---|---|
| | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ | µg/m$^3$ |
| Air laboratory | <0.5 | <0.5 | <0.5 | <0.5 | 6.63 | 5.07 | <0.5 |
| Transparent box (PE + Nylon) | <0.5 | 4.26 | <0.5 | 7.24 | 3.31 | 3.03 | 18.45 |
| Black Poliethylene foam (Plastazote® LD 29) | <0.5 | 4.66 | <0.5 | 33.42 | 10.09 | 7.47 | 45.95 |
| Film Poliethylene (Tyvek® 1623E) | <0.5 | 3.38 | <0.5 | 33.3 | 60.15 | 59.78 | 47.37 |
| PTFE Tube (2 cm diameter) | <0.5 | 1.06 | <0.5 | 21.4 | 47.56 | 50.38 | 41.15 |
| **TVOCs** (µg/m3) (as hexane - without Air laboratory) | **503.41** | | | | | | |
| **Limits in Cultural Heritage** (µg/m3) | <358 **[4]** | | | | | | |

**Tab.2.** Results of VOCs emitted by the materials chosen from the several tested referenced as hexane. **Dibromochloro methane*.

## Conclusion and Outlook

The versatility of construction and low structural weight give the CSB a great advantage over classical preservation solutions intended for the long-term handling and processing of biological remains. The results of the emission analysis allowed us to select the most suitable materials to be used. The future challenge is to study a solution to further reduce the concentration of VOCs present in the CSB to a threshold of less than 100 µg/m3.

## Reference List

**[1]** ISO 16000-3:2022 Indoor air Part 3: Determination of formaldehyde and other carbonyl compounds in indoor and test chamber air — Active sampling method.
**[2]** ISO 16000-6:2021 Indoor air Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor and test chamber air by active sampling on sorbent tubes, thermal desorption and gas chromatography using MS or MS FID.
**[3]** AN TDTS29 Markes VOC air monitoring technology and its application to contaminated land.
**[4]** Cecily M. Grzywacz (2006), Monitoring for gaseous Pollutants in Museum Environments.
**[5]** Jean Tétreault (1998), Studies of Lead Corrosion in Acetic Acid Environments.

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